Ministry of Public Works and
Housing of Republic of Indonesia

FEASIBILITY STUDY REPORT

WATER AVAILIBILITY REPORT
VOLUME I

Accelerating Infrastructure Delivery through Better Engineering Services Project (ESP)

Project Preparation Consultant (PPC) Firm for Development of the Way Sekampung Irrigation System in Lampung, Sumatera Island

egis eau in joint venture with KWARSA HEXAGON, PT. TATA GUNA PATRIA CONSULTANT, PERANCANG ADHINUSA

TABLE OF CONTENTS

TABLE OF TABLES

TABLE OF FIGURES

APPENDICES

ABBREVIATION AND ACRONYM

	English	Indonesian
ADB	Asian Development Bank	Bank Pembangunan Asia
AKNOP	Real Need Operation and Maintenance Figures	Angka Kebutuhan Nyata Operasi dan Pemeliharaan
AMDAL	Environmental Impact Assessment	Analisis Mengenai Dampak Lingkungan Hidup
ANDAL	Environmental Impact Analysis	Analisis Dampak Lingkungan Hidup
APW	Agency of Public Works	Dinas Pekerjaan Umum
ASN	State Civil Apparatus	Aparatur Sipil Negara
AWRM	Agency of Water Resource Management	Dinas Pengairan
BAPPEDA	Regional Development Planning Agency	Badan Perencanaan Pembangunan Daerah
BAPPENAS	National Planning and Development Agency	Badan Perencanaan Pembangunan Nasional
BBWS	River Basin Management Organisation	Balai Besar Wilayah Sungai
BIG	Geospatial Information Agency	Badan Informasi Geospasial
BLPHD	Regional Environmental Management Agency	Badan Pengelolaan Lingkungan Hidup Daerah
BM	Bench Mark	Patok Penanda
BMKG	Meteorology and Climatology Agency	Badan Meteorologi dan Klimatologi
BPDAS	Watershed Management Organization	Balai Pengelola Daerah Aliran Sungai
BPDASHL	Centre of the Catchment Area and Protected Forest	Balai Pengelolaan Daerah Aliran Sungai dan Hutan Lindung
BPS	Central Bureau of Statistics	Badan Pusat Statistik
BPSDA	Water Resources Management Center	Balai Pengelolaan Sumber Daya Air
BSN	National Standardization Agency	Badan Standarisasi Nasional
CNVWU	Certain Non-Vertical Work Unit	Satuan Kerja Non Vertikal Tertentu (SNVT)
COVID-19	Corona Virus Disease-19	Corona Virus Disease-19
CP	Control Point	Titik Kontrol
CSIRO	The Commonwealth Scientific and Industrial Research Organization	Organisasi Riset Ilmiah dan Industri Persemakmuran
CSRT	High Resolution Satellite Image	Citra Satelit Resolusi Tinggi
DAK	Special Allocation Fund	Dana Alokasi Khusus
DAS	Watershed	Daerah Aliran Sungai
DCPT	Dutch Cone Penetration Test	Uji Sondir
DED	Detailed Engineering Design	Desain Rinci/Gambar Kerja/Gambar Detail
DELH	Environmental Evaluation Document	Dokumen Evaluasi Lingkungan Hidup
DGFC	Directorate General of Food Crops	Direktorat Jenderal Pertanian Tanaman Pangan
DGRW	Directorate General of Water Resources	Direktorat Jenderal Sumber Daya Air
DGWR	Directorate General of Water Resources	Direktorat Jenderal Sumber Daya Air
DIL	Directorate of Irrigation and Lowland	Direktorat Irigasi dan Rawa
DIPA	Entry List of Implementation Budget	Daftar Isian Pelaksanaan Anggaran
DMI	Domestic Municipal Industry	Industri Kotamadya Domestik

	English	Indonesian
DOMD	Directorate of Operational & Maintenance Development	Direktorat Bina Operasi dan Pemeliharaan
DPH	Hypothetical Significant Impact	Dampak Penting Hipotetik
DPLH	Environmental Management Document	Dokumen Pengelolaan Lingkungan Hidup
DWRM	Directorate of Water Resources Management	Direktorat Bina Penatagunaan Sumber Daya Air
DWRND	Directorate of Water Resources Network Development	Direktorat Pengembangan Jaringan Sumber Daya Air
EA	Executing Agency	Instansi Pelaksana
EFA	Economic and Financial Analysis	Analisa Ekonomi dan Keuangan
EGIS	EGIS EAU	EGIS EAU
EIA	Environmental Impact Assessment	Analisis Dampak Lingkungan Hidup
EIRR	Economic Internal Rate of Return	Tingkat Pengembalian Internal Ekonomi
ENSO	El Nino-Southern Oscillation	El Nino-Osilasi Selatan
EOCC	Economic Opportunity Cost of Capital	Biaya Peluang Ekonomi Modal
ESP	Engineering Services Projects	Proyek Jasa Rekayasa
FGD	Focus Group Discussion	Kelompok Diskusi Terarah
FGU	Farmer Group Union	Serikat Tani
FKP3A	Forum for Water User Farmer Managers	Forum Koordinasi Perkumpulan Petani Pemakai Air
GAPOKTAN	Farmer Group Union	Gabungan Kelompok Tani
GCC	General Conditions of Contract	Ketentuan Umum Kontrak
GCM	Global Climate Change	Perubahan Iklim Global
GDEM	Global Digital Elevation Map	Peta Global Elevasi Digital
GERMAS	Healthy Community Movement	Gerakan Masyarakat Sehat
GIS	Geographic Information System	Sistem Informasi Geografis
GKG	Milled Dry Grain	Gabah Kering Giling
GNKPA	Water Rescue Partnership National Movement	Gerakan Nasional Kemitraan Penyelamatan Air
GOI	Government of Indonesia	Pemerintah Indonesia
GP3A	Water User Farmers Association	Gabungan Perkumpulan Petani Pemakai Air
GP3A	Water User Farmers Association	Gabungan Perkumpulan Petani Pemakai Air
HDI	Human Development Index	Indeks Pembangunan Manusia
HIRADC	Hazard Identification Risk Assessment Determining Control	Identifikasi Bahaya Penilaian Resiko dan Menetapkan Pengendalian
HSWRMA	Human Settlement and Water Resources Management Agency	Dinas Pekerjaan Umum dan Pengelolaan Sumber Daya Air
IC	Irrigation Commission	Komisi Irigasi
IDR	Indonesian Rupiah	Rupiah Indonesia
IEE	Initial Environmental Examination	Kajian Lingkungan Hidup Awal
IMP	Irrigation Management Plan	Rencana Pengelolaan Irigasi

	English	Indonesian
IOD	Indian Ocean Dipole	Samudera Hindia Dipole
IOL	Inventory of Losses	Daftar Kehilangan Aset
IP	Indigenous Peoples	Masyarakat Adat
IPCC	Intergovernmental Panel on Climate Change	Panel Antarpemerintah tentang Perubahan Iklim
IPL	Land Cover Index	Indeks Penutupan Lahan
IPP	Indigenous Peoples Plan	Rencana Penanganan Masyarakat Adat
IR	Involuntary Resettlement	Pemindahan Penduduk Tidak Suka Rela
ITB	Bandung Institute of Technology	Institut Teknologi Bandung
JV	Joint Venture	Bekerja sama
KA-ANDAL	Terms of Reference for Environmental Impact Analysis	Kerangka Acuan Analisis Dampak Lingkungan Hidup
KEPRES	Presidential Statement	Keputusan Presiden
KH	PT Kwarsa Hexagon	PT Kwarsa Hexagon
KP	Design Criteria	Kriteria Perencanaan
KPBU	Government and Business Entity Cooperation	Kerjasama Pemerintah dan Badan Usaha
KPS	Community Care River	Komunitas Peduli Sungai
KPSPI	Committee of Indonesian Appraisal Standards Development	Komite Penyusun Standar Penilaian Indonesia
KRB	Disaster Prone Area	Kawasan Rawan Bencana
KRS	River Regime Coefficient	Koefisien Regime Sungai
KUR	People's Business Credit	Kredit Usaha Rakyat
LA	Loan Agreement	Perjanjian Pinjaman
LARP	Land Acquisition and Resettlement Plan	Rencana Pembebasan Lahan dan Pemukiman Kembali
LGWP	Local Government Work Plans	Rencana Kerja Pemerintah Daerah (RKPD)
LiDAR	Light Detection and Ranging	Metode Inderaja Menggunakan Pulsa Laser
LPWR	Land Preparation Water Requirement	Kabutuhan Air untuk Penyiapan Lahan
MAPPI	Indonesian Professional Appraiser Society	Masyarakat Profesi Penilai Indonesia
MDS	Multi-Dimensional Scaling	Penskalaan Multi Dimensi
MMI	Modified Mercalli Intensity	Skala Modifikasi Intensitas Mercalli
MOA	Ministry of Agriculture	Kementerian Pertanian
MOU	Memorandum of Understanding	Nota Kesepahaman
MPWH	Ministry of Public Works and Housing	Kementerian Pekerjaan Umum dan Perumahan Rakyat
MSDS	Material Safety Data Sheet	Lembar Data Keselamatan Bahan
NGO	Non-Governmental Organization	Organisasi non-pemerintah
NSCWR	National Steering Committee for Water Resources	Komite Pengarah Nasional untuk Sumber Daya Air
NWRC	National Water Resources Council	Dewan Sumber Daya Air Nasional

	English	Indonesian
O&M	Operation and Maintenance	Operasi dan Pemeliharaan
ODP	Open Defecation Free	Bebas Buang Air Besar Sembarangan
P2D2	Regional Government Loans and Decentralization	Pinjaman Pemerintah Daerah dan Desentralisasi
P3K	Contractual Agreement-Based Civil Servant	Pegawai Pemerintah dengan Perjanjian Kerja
PA	PT Perancang Adhinusa	PT Perancang Adhinusa
PAI	Irrigation Asset Management System	Pengelolaan Aset Irigasi
PAM	Project Administration Manual	Manual Administrasi Proyek
PDAM	Local drinking water company	Perusahaan Daerah Air Minum
PERMENTAN	Ministry of Agriculture Regulation	Peraturan Menteri Pertanian
PH	Public Health	Kesehatan Masyarakat
PHBS	Clean and Healthy Life Behaviour	Perilaku Hidup Bersih dan Sehat
PLTA	Hydro power plant	Pembangkit Listrik Tenaga Air
POB	Weir Operator	Petugas Operasi Bendung
POKTAN	Farmer Groups	Kelompok Tani
PPA	Gate keeper	Petugas Pintu Air
PPC	Project Preparation Consultant	Konsultan Persiapan Proyek
PPE	Personal Protective Equipment	Alat Pelindung Diri
PPK	Commitment Officer	Pejabat Pembuat Komitmen
PPL	Agricultural Extension Officer	Petugas Penyuluh Pertanian
PPMB	Research Centre for Disaster Mitigation	Pusat Penelitian Mitigasi dan Bencana
PPPK	Government's Employee with Work Agreement	Pegawai Pemerintah dengan Perjanjian Kerja
PPSIP	Development and Participatory Irrigation Management Systems	Pengembangan dan Pengelolaan Sistem Irigasi Partisipatif
PSDA	Water Source Management Offices	Pengelolaan Sumber Daya Air
PSETK	Profile of Social, Economic, Infrastructure and Institution	Profil Sosial, Ekonomi, Teknis Kelembagaan
PSG	Geological Survey Institute	Pusat Survey Geologi
PT PLN	Electricity State Own Company	Perseroan Terbatas Perusahaan Listrik Negara
PTHL	Daily Freelance Worker	Petugas Tenaga Harian Lepas
PUSKESMAS	Public Health Centre	Pusat Kesehatan Masyarakat
PUSKIM	Central of Housing and Settlement Research	Pusat Penelitian Perumahan dan Pemukiman
PVMBG	Central of Volcanology and Geological Hazard Mitigation	Pusat Vulkanologi Mitigasi dan Bencana Geologi
PWRC	Provincial Water Resources Council	Dewan Sumber Daya Air Provinsi
RBI	Indonesia Topographic Map	Rupa Bumi Indonesia
RISKEDAS	Regional Health Research	Riset Kesehatan Daerah
RKL	Environmental Management Plan and	Rencana Pengelolaan Lingkungan Hidup dan

	English	Indonesian
RPJMD	Provincial Medium-Term Development Plan	Rencana Pembangunan Jangka Menengah Daerah
RPL	Environmental Monitoring Plan	Rencana Pemantauan Lingkungan Hidup
SATKER	Work Unit	Satuan Kerja
SCC	Special Conditions of Contract	Ketentuan Khusus Kontrak
SDR	Sediment Delivery Ratio	Rasio Pelepasan Sedimen
SES	Socio Economic Survey	Survei Sosial Ekonomi
SKPD	Regional Government Work Unit	Satuan Kerja Pemerintah Daerah
SMC	Soil Moisture Capacity	Kapasitas Kelembaban Tanah
SMK3	Management System of Occupational Health and Safety	Sistem Manajemen Keselamatan dan Kesehatan Kerja
SNI	Indonesian National Standard	Standar Nasional Indonesia
SPI	Indonesian Appraisal Standard	Standar Penilaian Indonesia
SPPL	Statement Letter of Ability on Environmental Management and Monitoring	Surat Pernyataan Kesanggupan Pengelolaan dan Pemantauan Lingkungan Hidup
SPS	Safeguard Policy Statement	Pernyataan Kebijakan Perlindungan Sosial
SPT	Standard Penetration Test	Uji Penetrasi Standar
SRI	System of Rice Intensification	Sistem Intensifikasi Padi
TDS	Total Dissolved Solid	Total Padatan Terlarut
TGP	PT Tata Guna Patria	PT Tata Guna Patria
TOR	Terms of Reference	Kerangka acuan
ToT	Trainer of Trainers	Pelatih
TP OP	Co-Administration Task	Tugas Perbantuan Operasi dan Pemeliharaan (TP OP)
TPP	Extension Field Worker	Tenaga Pendamping Petani
TSS	Total Suspended Solid	Total Padatan Tersuspensi
UKL	Environmental Management Measures	Upaya Pengelolaan Lingkungan Hidup
UNFCCC	United Nations Framework Convention on Climate Change	Konvensi Kerangka Kerja PBB tentang Perubahan Iklim
UNILA	University of Lampung	Universitas Lampung
UPIM	Modern Irrigation Management Unit	Unit Pengelola Irigasi Modern
UPL	Environmental Monitoring Measures	Upaya Pemantauan Lingkungan Hidup
UPTD	Technical Implementation Service Unit	Unit Pelaksana Teknis/Daerah
USDA	United States Department of Agriculture	Departemen Pertanian Amerika Serikat
UU	Law	Undang-Undang
UUD	Constitution	Undang-undang Dasar
VAT	Value Added Tax	Pajak Pertambahan Nilai
WHO	World Health Organization	Organisasi Kesehatan Dunia
WLR	Water Layer Replacement	Penggantian Lapisan Air

	English	Indonesian
WRMCT	Water Resources Management Coordination Team	Tim Koordinasi Pengelola Sumber Daya Air (TKPSDA)
WSIS	Way Sekampung Irrigation System	Proyek Modernisasi Irigasi Way Sekampung
WUA	Water Users Association	Asosiasi Pengguna Air
WUAA	Water Users Association Apex	Apex Asosiasi Pengguna Air
WUAF	Water Users Association Federation	Federasi Asosiasi Pengguna Air
WWTP	Waste Water Treatment Plant	Instalasi Pengolahan Air Limbah

EXECUTIVE SUMMARY

The Water Availability Study in this Volume I report consists of 6 major chapters, namely:

Chapter 1. Introduction

Chapter 2. Hydraulic Model Improvement and the Results of Water Availability

Chapter 3. Cascade Reservoirs Multipurpose Optimization

Chapter 4. Design Discharge for Irrigation Canals and Gates

Chapter 5. Travel Times of Way Sekampung Irrigation System

Chapter 6. The Effects of El Niño-Southern Oscillation and Indian Ocean Dipole on the Inflow of Batutegi Reservoir

Chapter 1 contains the context and objectives of the Water Availability Feasibility Study specified in this Volume I report.

Chapter 2 contains information on the improvement of the water balance model carried out at the feasibility study stage. These improvements consist of creating a new sheet with the aim of simplifying and speeding up data reporting per column. The second improvement is the simplification of the water balance and creating a check column as an inspection indicator if there is a change in the water balance model. The third improvement is the refinement of the water allocation of the Batutegi and Way Sekampung reservoirs with the analysis and recommendations on the upper limit, normal limit, critical limit, and flood control limit which are combined into the Batutegi and Way Sekampung Reservoirs Operational Pattern. The fourth improvement is the calculation of daily irrigation water demands and the latest percolation data of 5 mm/day. This chapter ends with a conclusion on the water availability for all scenarios in the Way Sekampung Irrigation System (WSIS) covering an area of 56,854 ha and the potential for area development. Without modernization projects in Scenario 1, the water availability in the Argoguruh Weir can meet the irrigation water demands at IP 287% for WSIS. With projects, as in Scenario 2, the water availability in the Argoguruh Weir can meet the irrigation water demands of 299% IP for WSIS. With modernization projects, land use, and climate change, the water availability in the Argoguruh Weir can meet the irrigation water demands at IP 300% for the WSIS area which is 54,022 ha. Potential IP for the 3 Scenarios can be achieved if cropping season 1 starts in the period Nov I - Dec I. From the water availability results after the modernization projects, extensification can be carried out. From the results of this study, without any major impacts on the WSIS area and the level of the Batutegi reservoir, the recommended expansion is 10,000 ha. Note that the system efficiency in the expansion area must be the same as the canal efficiency after the projects, which is 82%. With this expansion, the area that can be expanded is 27,385 ha.

Chapter 3 contains a literature review to see what optimization methods have been used to overcome the special situation of the Way Sekampung river with the existence of two multipurpose cascade dams. After the problem formulation is studied, the selection of methods and optimization approaches is carried out. The selected optimization variables consist of water availability for the WSIS, raw water, ecological flow, water availability for hydropower and flood control at Batutegi and Way Sekampung dams. The results of the optimization are the Batutegi and Way Sekampung Dam Operational Patterns, where the expenditure is controlled according to the limits for each dam so that all the needs of the selected variables can be fulfilled optimally.

Chapter 4 contains a study of the actual discharge needs in the irrigation plots with the influence of rainfall and daily climatology factors. This value becomes the basic data of irrigation water demands at the intake of the Argoguruh Weir with the modernized primary and secondary canals so that an increase in irrigation canal efficiency is obtained by 82%.

Chapter 5 contains the calculation of the flow travel times from the Argoguruh Weir intake to the furthest front structure on the irrigation secondary canal after the irrigation modernization road map was applied to the Way Sekampung Irrigation for the rehabilitation of irrigation network infrastructure.

Chapter 6 contains a study of the correlation of ENSO and IOD to the inflow of the Batutegi reservoir. A high correlation was obtained from the ENSO and IOD index with the Batutegi reservoir inflow of R^2=0.99. However, the correlation to the projected inflow of the Batutegi reservoir is not reliable, R^2=0.48. Further research is needed to improve the reliability of flow projections using the ENSO and IOD index. If the projection results are reliable, the Batutegi and Way Sekampung reservoirs operation can be carried out even better.

1 - INTRODUCTION

1.1 - Water Availability Study Context

The Way Sekampung Irrigation Area is one of several irrigation areas designated by the Directorate General of Water Resources and the Ministry of Public Works and Housing, as the target of the irrigation modernization program, a national program covering six other irrigation areas under the central government authority. To achieve this proclaimed target, the government utilizes ADB funds from Loan 3455-INO: Accelerating Infrastructure Delivery through Better Engineering Services Project (ESP) in order to carry out preparations for infrastructure development projects involving technical assistance.

In addition to the preliminary report, the PPC for the modernization of the Way Sekampung Irrigation Area has produced three main reports:

1. Master Plan for the Irrigation Modernization Program (Irrigation System Assessment);
2. Feasibility Study (Irrigation System Plan); and
3. Action Plan for the Implementation of Way Sekampung Irrigation Modernization.

The Master Plan was sent in November 2019. The Feasibility Study Report is an intermediate report that precedes the preparation of Detailed Engineering Designs (DEDs) report before the preparation of tender documents. The Feasibility Study Report consists of 6 interrelated volumes:

1. Water Availability
2. Water Management Plan
3. Institutional Development Plan
4. Infrastructure Development Plan
5. Community Development Plan
6. Irrigation System Modernization Plan

This document is a Water Feasibility Study Volume I

1.2 - Water Feasibility Study Objectives

According to terms of reference (TOR), the Water Feasibility Study report discusses:

1. The watershed and the relationship between watershed conditions and water availability;
2. Measures that can be actioned in relation to the provision of irrigation water, including measures those of social, institutional, and physical natures;
3. The effect of climate change on water availability;
4. The condition of the river as a source of water and other conditions that explain the condition of water availability such as water productivity.

The water availability for irrigation from a river depends on the conditions of the watershed including the conditions of land use, soil types, rainfall, and climatology. In recent years, the effects of climate change have had an impact on the amount and timing of water supply.

Regarding the modernization of the WSIS, a detailed analysis of water availability, water demands, and water balance is required. Reliability of water availability is Pillar 1 of the irrigation system modernization and the following steps need to be considered:

- Harmonization of the upstream-downstream relationship: the collection of hydrological data and the preparation of rainfall-runoff model, water balance, and hydraulics modeling. Develop current and future (climate change/urbanization) scenarios and their impacts on water balance, inventory of all water usage, and watershed conservation. Preparation of the SOP for water allocation and the results socialization.

- Preserving the environment, watershed, and irrigation canals: Based on an analysis of the upstream watershed degradation, prepare a management plan for the catchment area in the upstream and irrigation areas. Prepare suggestions and draft guidelines for spatial planning, land use, and environmental conservation (agricultural land protection based on Indonesian Law 41/2009).
- Water allocation: Approximate the initial estimate of water allocation for irrigation and other purposes. Include information on water allocation priorities in the natural resource information and water allocation system.
- Supplying and storing water: Develop a water balance, review other methods that can be used to forecast water demands, rainfall, cropping patterns, and how to implement "real-time water demands, allocation, and loss". Calculate the flow of plans that will be used to prepare the DEDs.
- Supplementary water supply: Review the feasibility of additional water source solutions (dams, lakes, reservoirs, and small farm reservoirs). Determine which resources should be developed, if there is.

Please note that the above topics have been discussed in depth in the Master Plan for Water Availability Volume 2, if detailed information on these topics is required, this report includes its cross-references.

The purpose of the Water Availability Master Plan Volume 2 is to explain the availability of water in the Argoguruh Weir for irrigation in the Way Sekampung area based on the historical data (Scenario 0), the current situation (Scenario 1), the situation in 2021 when the Way Sekampung reservoir is operational (Scenario 2), and the situation in 2040 by taking climate change into account (scenario 3). Accordingly, the report on the Master Plan for Water Availability Volume 2 is structured as follows:

• **Chapter 2 Current and Future Watershed Conditions Regarding Its Water Availability**

This chapter describes the three sub-watersheds needed for water availability analysis. Then it describes the physical characteristics, rainfall, evaporation, upstream water usage for DMI and irrigation, the characteristics of related water reservoirs, and how to consider other water usages in the Argoguruh Weir. If deemed feasible, the historical data situation (Scenario 0), the current situation (Scenario 1), the 2021 situation (Scenario 2), and the 2040 situation (Scenario 3) are also discussed. Especially regarding land use data, water usage for DMI, and rainfall/evaporation.

• **Bab 3 Hydraulic Model**

This chapter describes the hydraulic model, its components, the Mock rainfall-runoff model, operating guidelines for the Batutegi and Way Sekampung reservoirs, water balance calculations, and guidelines to set water allocation priorities.

• **Bab 4 Water Availability Analysis**

This chapter describes the water availability in terms of the most optimal planting intensity by observing its sensitivity to the data considered the least certain: 1) percolation rate; 2) the date of the first planting season; 3) the rice harvest success rate in the first and second seasons in terms of water availability. In addition, this chapter also compares the three scenarios above based on the best planting date, the best harvest for the first and second planting seasons, all of which are based on the water availability aspect. Finally, there is a discussion of additional water sources and their impact on the water availability of large-scale weather systems such as the Indian Ocean Dipole (IOD) and El Niño/La Niña.

• **Bab 5 Conclusion and Recommendation**

This chapter summarizes the main conclusion and recommendations that have implications for the water management plan.

By considering the scope of discussion in Water Availability Master Plan Volume 2 and the Water Feasibility Study Volume 1, the topics that need to be added apart from those discussed in the Master Plan report are:

1. Updates on the hydraulic model and the results of the water availability analysis;
2. Multipurpose cascade reservoir optimization of Batutegi and Way sekampung
3. Planned flow of canals and gates for Way Sekampung Irrigation System
4. Travel times of the Way Sekampung Irrigation System Inflow

These topics were determined based on the consultation with the River Basin Management Organization (BBWS) of Mesuji Sekampung. Basically, each chapter in this report presents each of the above topics.

2 - HYDRAULIC MODEL IMPROVEMENT AND THE RESULTS OF WATER AVAILABILITY

The hydraulic model is a water balance model that is used to simulate the balance and distribution of water in a system. The water balance consists of several modules that each describe one part of the hydrological system: runoff flow from each sub-watershed, evaporation from reservoirs, transpiration from existing vegetation, reservoir outflow, delta (Δ) holding in reservoirs, and finally water availability in Argoguruh Weir.

Several improvements were made to the hydraulic model in the feasibility study stage. These improvements are discussed in the following sections:

1. Results of individual variable analysis
2. Simplified water balance
3. Reservoir water allocation improvement
4. Improvement of irrigation water demand calculation

With these improvements, the results of the water availability produced by the hydraulic model can be analyzed.

2.1 - Model Improvement

2.1.1 - Results of individual variable analysis

The first improvement that has been made is the creation of a "single variable analysis" sheet. The purpose of this sheet is to simplify and speed up the data reporting per column. The "single variable analysis" sheet consists of:

- **Data** (time-series of 10 years of data) from a single column that has been selected by the model user. Examples of complete data can be reviewed in Appendix 1.
- **Automatic conversion** of selected data from flow units [m3/s] to volume units [million m3] and mm/year.
- **Automatic table creation** from the selected time-series data to get the pattern for each year and every month.
- **Automatic table creation of statistical analysis** from the time-series data, annual table to show the largest/smallest monthly figures, largest/smallest annual figures, and probability figures of 50% (on average), 80%, and 20%.
- **Automatic graph creation** of all the tables described above.

The "single variable analysis" sheet has been designed in such a way that hydraulic model users can get information for reporting in tabular and graph form in real time. Thus, the pattern analysis of the desired data can be reported quickly by using a copy-paste method.

2.1.2 - Simplified water balance

The second improvement that has been carried out is the simplification of the global water balance (the upstream of the Batutegi dam to the Argoguruh Weir = global). The global water balance is not changed but is divided into several smaller water balances. In the previous version, the global water balance includes all water (rainfall into runoff using the Mock model) received into the system and out (all raw water demands, irrigation, and evaporation in each reservoir) carried out on the entire system from the upstream of the Batutegi dam until the Argoguruh Weir.

In the latest version, a smaller scale water balance is applied to the Batutegi, Way Sekampung, and Argoguruh sub-watersheds. It also includes a water balance for each dam that flows into the reservoirs, delta storage, evaporation directly from the surface, and the water outflow from the Batutegi and Way Sekampung reservoirs. Thus, the global water balance is the sum of all small-scale water balances.

In addition to this simplification, the latest version selects a 'check' column for each of the smaller water balances. Additional 'check' columns can be found for each water balance at:

- Batutegi sub-watersheds
- Batutegi reservoir
- Way Sekampung sub-watersheds
- Way Sekampung reservoir
- Argoguruh sub-watersheds
- Global water balance from the upstream of the Batutegi dam to the Argoguruh Weir.

The function of the 'check' column is as an inspection indicator if the changes that occur in the model are correct in terms of the water balance. The principle of the global water balance is that the entire volume of water entering the system at (t) time from rainfall-runoff flow (Mock model for the Batutegi, Way Sekampung, and Argoguruh sub-watersheds) plus the storage delta (t) in the Batutegi and Way Sekampung reservoirs is equal to the total volume of water allocated at (t) time to meet all raw water demands in each sub-watersheds, water demands in the air (evaporation), and irrigation water demands in the Way Sekampung Irrigation System.

If the water balance is correct, then all the numbers in the 'check' column = 0. If after the changes in the model are made and the 'check' column is 0, then the water balance has not been met and corrections need to be made until all the time-series numbers in the 'check' column = 0. It is designed in such a way, so model users can easily see if the changes they make meet the correct water balance or not so that the analysis of the model results can be carried out.

2.1.3 - Reservoir water allocation improvement

The third improvement concerns the water allocation from the Batutegi and Way Sekampung reservoirs. The allocation of water from the reservoirs to each downstream depends on various things, such as:

- Whether or not there is a demand for upstream reservoirs
- Elevation of the reservoir water to the operating pattern curve determines the % allocation of water demands upstream of the dam (detailed in Chapter 3).
- Elevation of the reservoir water to the irrigation valve elevation and hydropower plant valve.
- Projection of the delta storage for the Batutegi and Way Sekampung reservoirs. This is the main point in this improvement.

Storage projections in reservoirs can be formulated as:

$$Reservoir\ storage\ (t+1) = Reservoir\ storage\ (t) + Reservoir\ inflow\ (t+1) - Reservoir\ outflow\ (t+1)$$

$Reservoir\ storage\ (t+1)$ [million m3]

$Reservoir\ storage\ (t)$ [million m3]

$Reservoir\ inflow\ (t+1)$ [million m3]: Inflow from the rainfall-runoff conversion projection using the Mock model.

$Reservoir\ outflow\ (t+1)$ [million m3]: Reservoir discharge depends on water demands downstream of the reservoir and **if the storage exceeds the volume on the relative runoff elevation of each dam**.

From the above formula, the improvement lies in the $Reservoir\ outflow\ (t+1)$. Reservoir outflow does not only occur when there are demands downstream of the reservoir. Reservoir outflow or water release from the reservoir is carried out when the demands for water downstream of the reservoir and to prevent dam overflow.

If, after predicting, the water volume (through delta storage) of the reservoir is below the runoff elevation after meeting the downstream water demands, then **the dam will only release water volume according to the downstream demands** of the Batutegi and Way Sekampung dams respectively.

If, after predicting, the water volume (through delta storage) of the reservoir will be above the runoff elevation volume or the overflow threshold, then the dam operation pattern applies a certain discharge pattern so that no runoff occurs in the dam. This can optimize the water being managed because the hydropower outlet not only functions when there is a demand, but the hydropower outlet also functions when the reservoir elevation is approaching and will exceed the overflow threshold.

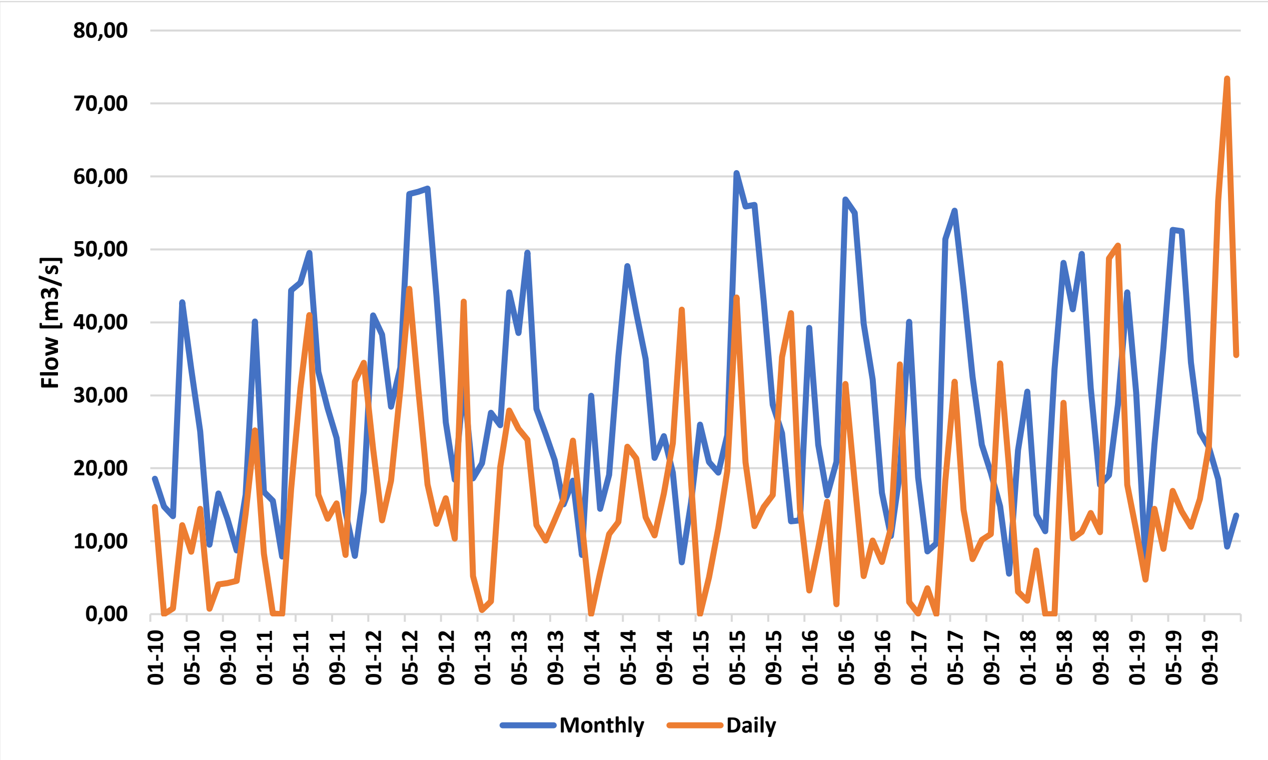
2.1.4 - Improvement of irrigation water demand calculation

Calculation of irrigation water demands in paddy fields is refined by:

- Using daily rainfall calculations, evapotranspiration which previously used bi-weekly calculations.
- Using the latest percolation data from field test results. Now the percolation is 5 mm/day from 2 mm/day.

The following is the difference between daily and bi-weekly (monthly) irrigation water demands:

FIGURE 2–1 COMPARISON OF IRRIGATION WATER DEMANDS USING DAILY AND MONTHLY CALCULATIONS



Source: PPC of Way Sekampung

The graph above shows the calculation of water demand in the rice fields for one cropping year with a total IP of 300% (200% rice and 100% secondary crops). The orange line shows the result of the daily calculation and the blue line is the monthly calculation.

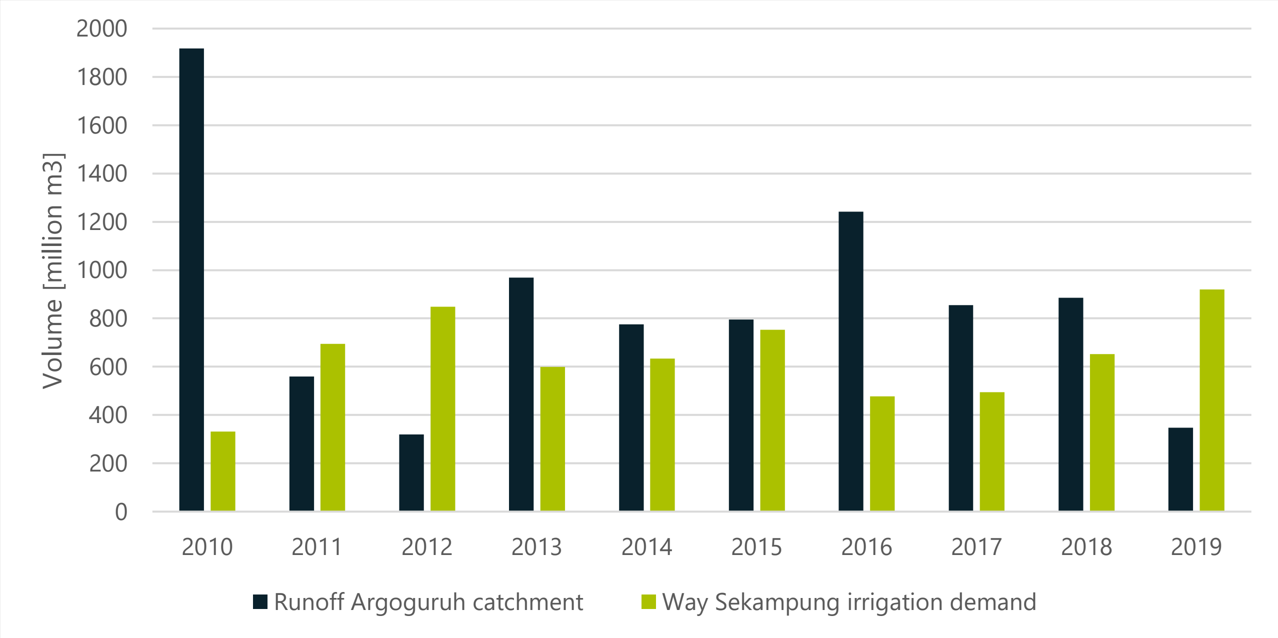
The patterns of the two methods have similarities, but the demand for irrigation water using the daily calculation was smaller than the monthly calculation, except in 2019.

2.2 - Water Availability Results

2.2.1 - Big picture – available water

The water availability to meet the water demands of the Way Sekampung Irrigation System is obtained first from the runoff flow of the Argoguruh sub-watershed which, under certain conditions, is assisted by the Batutegi and Way Sekampung reservoirs. If the runoff flow of the Argoguruh sub-watershed, the result of rainfall conversion using the Mock model, is greater than the water demand at the Argoguruh Weir point, then the upstream of the reservoir system will not discharge water for the water demands of the Argoguruh Weir. The following is the runoff flow pattern in the Argoguruh watershed and the water demands in the Way Sekampung Irrigation System in million m3/year:

FIGURE 2–2 THE RUNOFF FLOW OF ARGOGURUH WATERSHED AND THE AVERAGE WATER DEMAND IN WAY SEKAMPUNG IRRIGATION SYSTEM [MILLION M3/YEAR]



Source: PPC of Way Sekampung

The graph above shows a simulation of the volume of water produced by the Argoguruh watershed and the water demand for the Way Sekampung Irrigation System within 10 years of observation. From the graph above, the average runoff flow of the Argoguruh watershed could meet the average irrigation needs in certain years such as in 2010, 2013, 2014, 2015, 2016, 2017, and 2018. There were times when the runoff flow of the Argoguruh watershed was not quite as good as which were shown in 2011, 2012, and 2019. In those 3 years, two reservoirs upstream of the Argoguruh Weir worked to release water to meet the water needs of the Way Sekampung Irrigation System.

This section of the report analyzes 3 scenarios, namely:

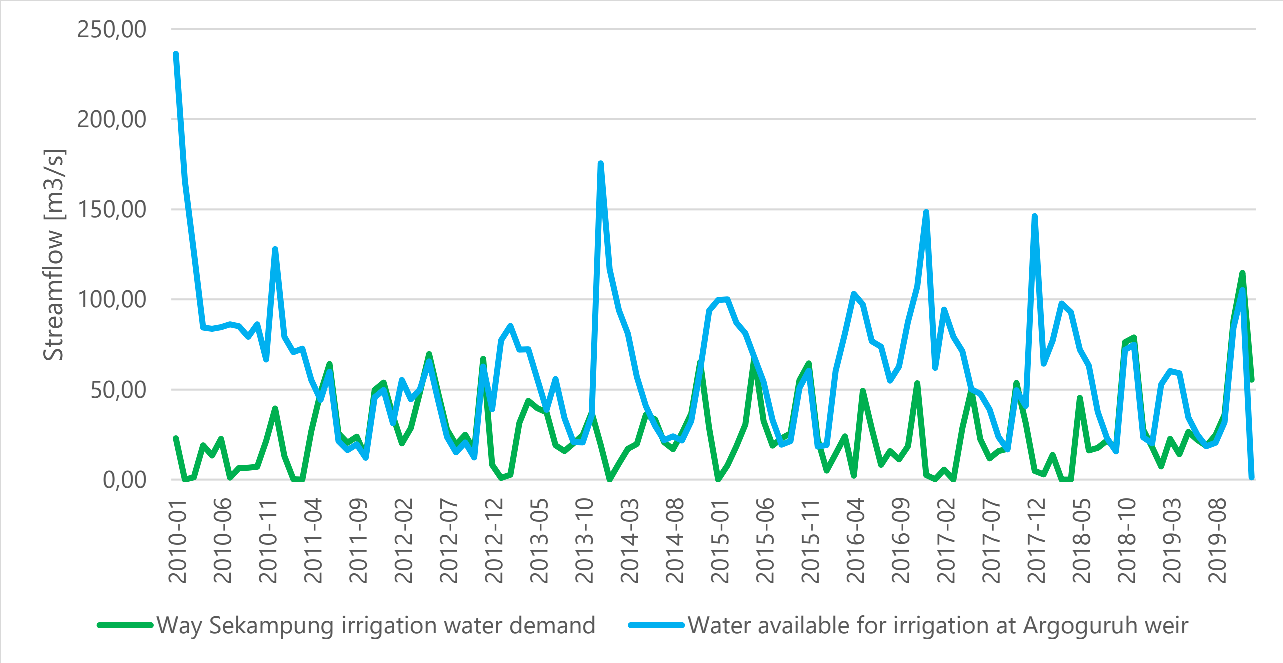
- Scenario 1, without projects, represents the current conditions of the Batutegi and Way Sekampung reservoirs
- Scenario 2, with projects, represents the conditions of the Batutegi reservoir, Way Sekampung reservoir, increasing demand for raw water, and potential expansion of irrigation areas in the Way Sekampung Irrigation System in 2021
- Scenario 3, with projects and climate change, represents the conditions of the climate change potential, the improvement of the water-carrying canals efficiency from Argoguruh Weir to rice fields in 2040

The input data for the planting area for all scenarios above are 113,707 ha (200%) for rice and 56,854 (100%) for secondary crops for one cropping year. This input is simulated for 10 years.

2.2.2 - Scenario 1 without projects

Scenario 1, without projects, is a scenario that simulates the current potential of the Way Sekampung Irrigation System with the presence of Batutegi and Way Sekampung reservoirs, 5.3 mm/day percolation, and no increase in the efficiency of the canal system from the Argoguruh Weir to the rice fields. The results of water availability and demand for this scenario are as follows:

FIGURE 2–3 AVAILABILITY AND DEMAND OF IRRIGATION WATER FOR SCENARIO 1 WITHOUT PROJECTS

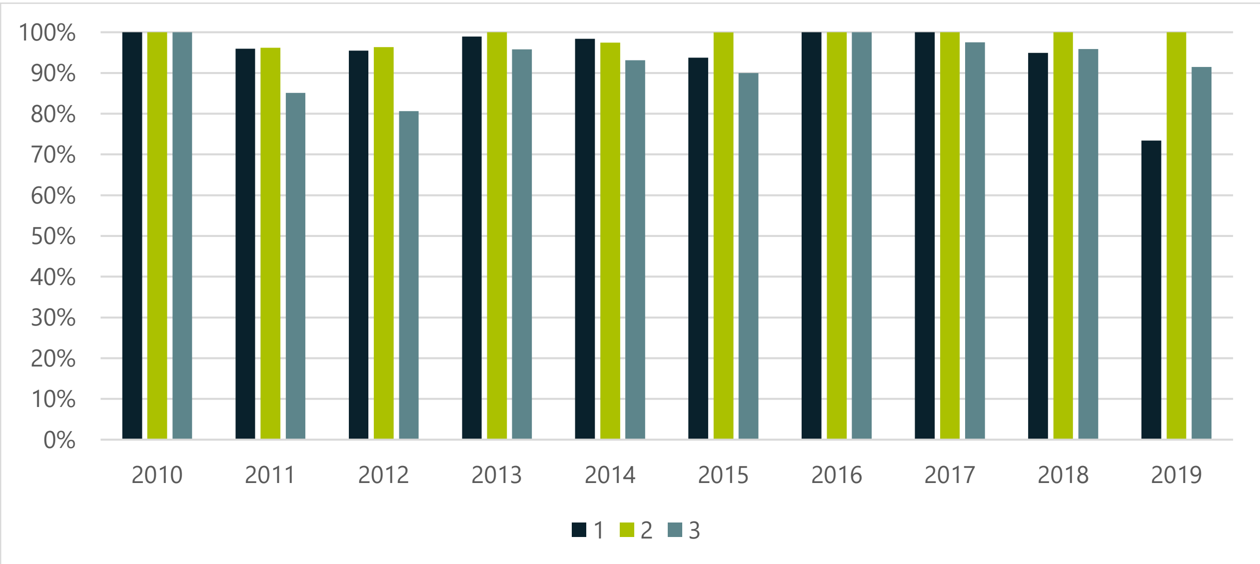


Source: PPC of Way Sekampung

The graph in Figure 2–3 above compares the simulation of water availability and demand at the Argoguruh Weir in current condition, without projects. The black line represents the demand for irrigation water and the green line represents the availability of water in the Argoguruh Weir within 10 years of observational data. The highest irrigation water demand in the Agroguruh Weir was obtained in November 2019 at 114 m3/s.

To see the availability of water for a smaller period, a table has been created showing the availability of water per cropping season within a 10-year simulation as shown in the following graph:

FIGURE 2–4 WATER AVAILABILITY PER CROPPING SEASON FOR SCENARIO 1

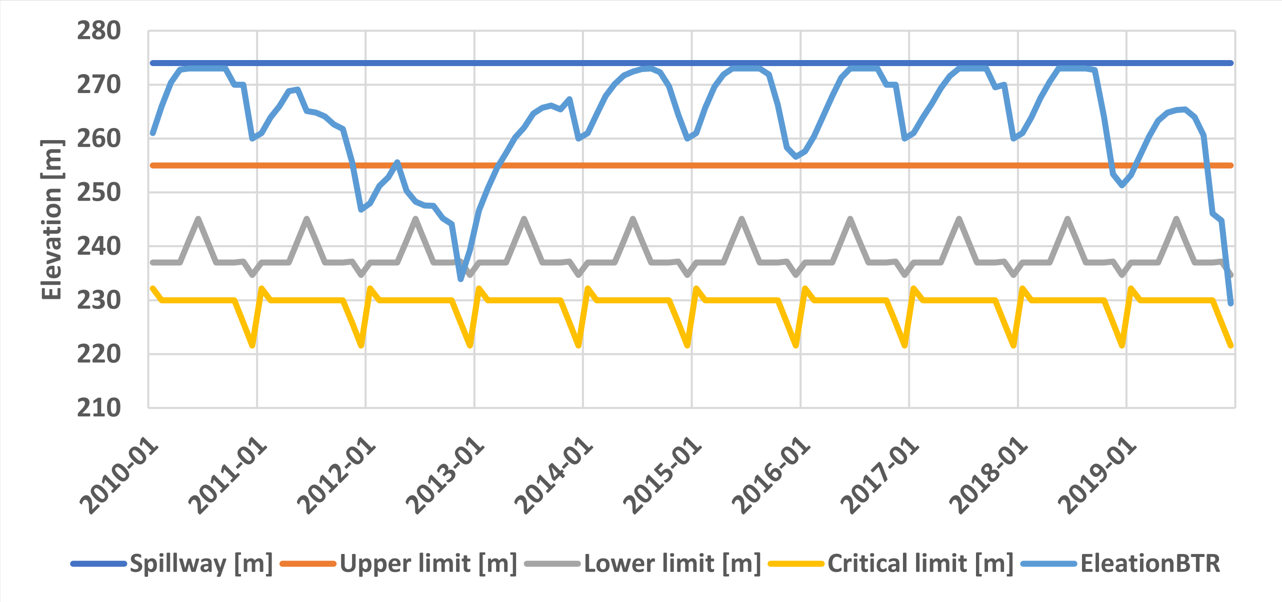


Source: PPC of Way Sekampung

From the graph above, almost every year the water availability in the Argoguruh Weir could not meet the irrigation water demands in the Way Sekampung Irrigation System except in 2010 and 2016. This can be inferred from the graph above. Only in 2010 and 2016 that all water demands in MT 1, MT 2, and MT 3 were met. Thus, for Scenario 1, the **availability of water** is sufficient to obtain a 10-year average Planting Index (IP) of 287%.

The following is an elevation simulation at the Batutegi dam in 10 years of observation:

FIGURE 2–5 BATUTEGI DAM WATER ELEVATION SIMULATION - SCENARIO 1 WITHOUT PROJECTS



Source: PPC of Way Sekampung

From Figure 2–5 above, the Batutegi reservoir has already released water to meet the water demand downstream of the dam based on the Batutegi dam operating pattern. However, without projects, it is not possible to meet the water needs of the 300% IP in the Way Sekampung Irrigation System in a 10-year observation period. Only during the wet years, a 300% IP is achieved.

For Scenario 1 without projects, the simulation is carried out to see the water availability potential in the Agroguruh dam to IP in the Way Sekampung Irrigation System with an area of 56,854 ha. The potential percentage is **287%** (average of 10 years of observation) or the average availability of dam water. Argoguruh can meet irrigation water needs with an area of **163,186 ha** in one cropping year.

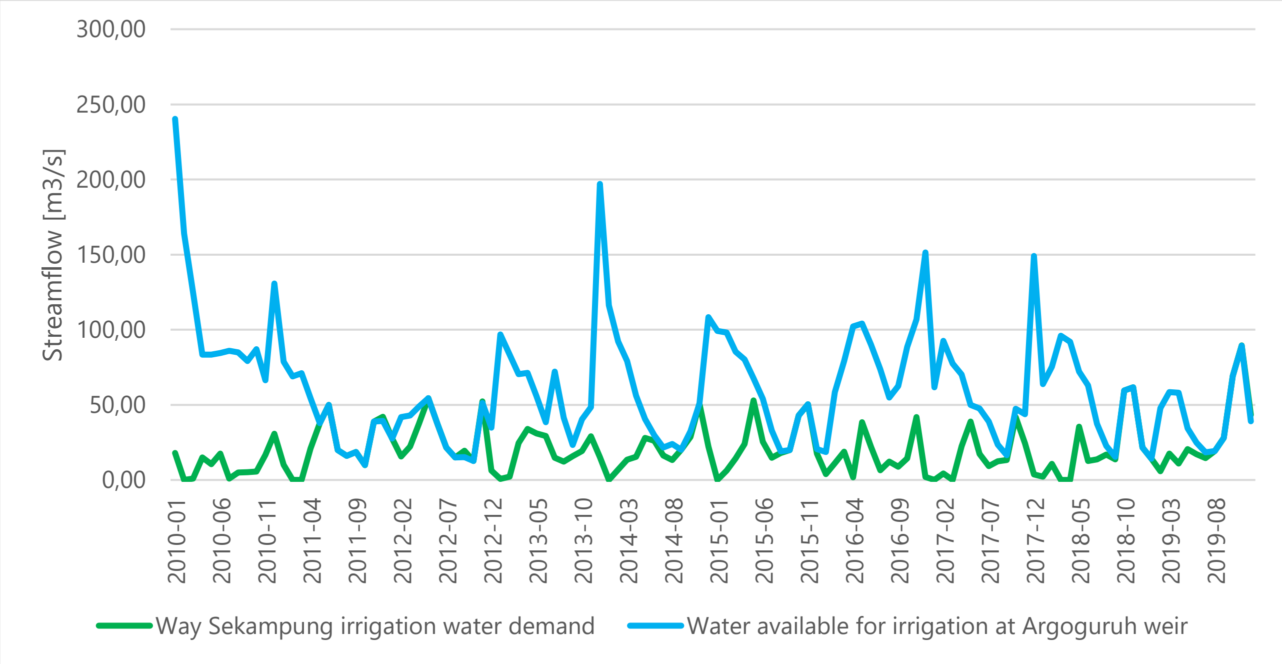
2.2.3 - Scenario 2 with projects

Scenario 2 analyzes the conditions that will exist when the Way Sekampung irrigation modernization project is completed. Scenario 2 also has a demand increase for raw water for Bandar Lampung and the demand for irrigation water in the sub-watershed.

With the projects, an increase in the efficiency of the canal system will be achieved. In this scenario, the increase rate in the efficiency of the canal system becomes 82%.

The first analysis was carried out in the context of intensification in the Way Sekampung Irrigation System which covers 56,854 ha. In this analysis, it can be seen how much is the % IP potential for the Way Sekampung Irrigation System, in terms of the water availability in the Argoguruh Weir, the presence of the Way Sekampung reservoir, and the increase in the efficiency of the canal system. The following is the pattern of availability and demand for irrigation water for 56,854 ha in Scenario 2 with projects:

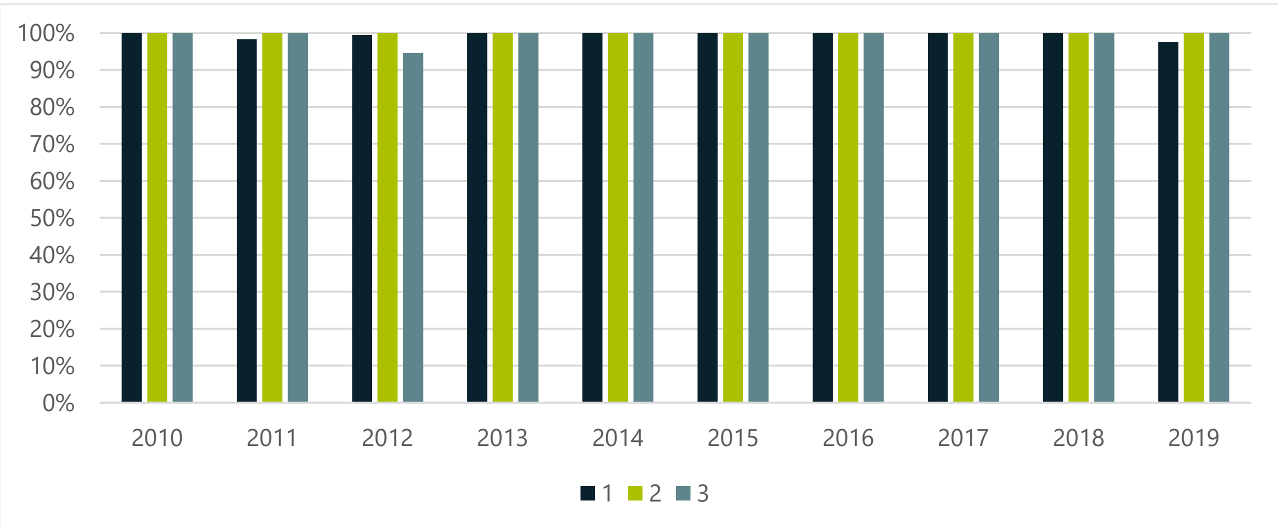
FIGURE 2–6 AVAILABILITY AND DEMAND OF IRRIGATION WATER FOR SCENARIO 2 WITH PROJECTS



Source: PPC of Way Sekampung

The graph above simulates the water availability of the Batutegi and Way Sekampung dams with the water demands in the Way Sekampung Irrigation System. In 10 years of observation, the needs of the Way Sekampung Irrigation System were fully met for most of the time. To see the availability of water for a smaller period, a table has been created showing the availability of water per cropping season for a 10-year simulation as shown in the following graph:

FIGURE 2–7 WATER AVAILABILITY PER CROPPING SEASON FOR SCENARIO 2

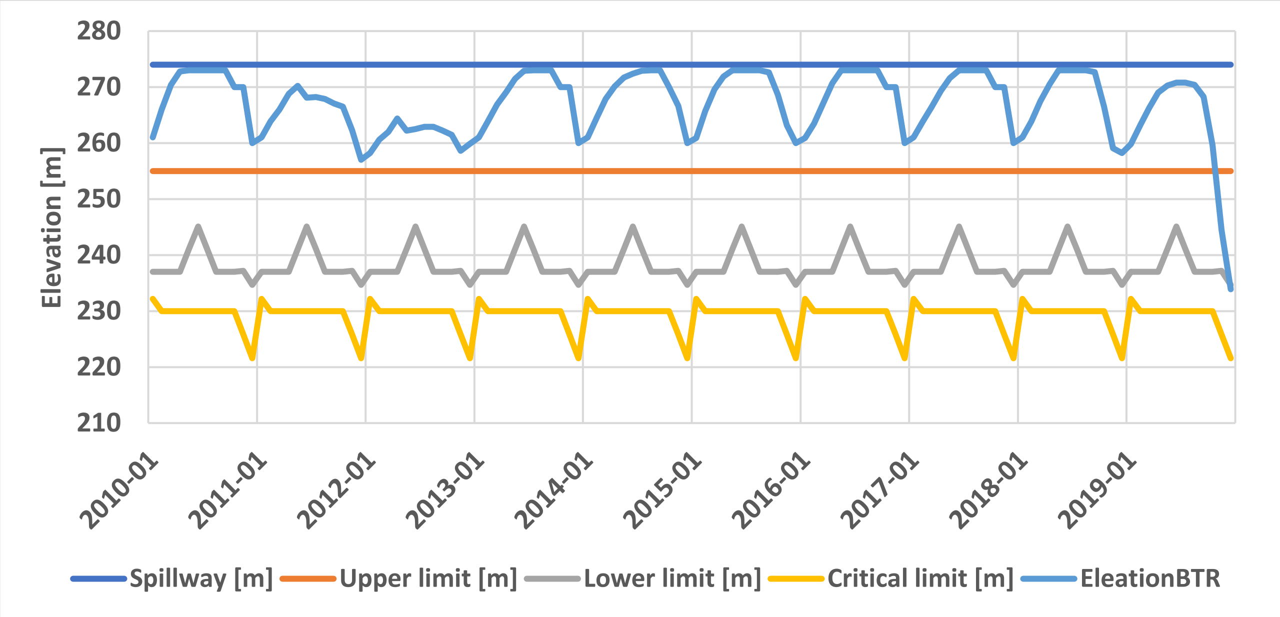


Source: PPC of Way Sekampung

The water availability could meet all irrigation water needs except for MT 1 in 2011, MT 1 in 2012, MT 3 in 2012, and MT 1 in 2019. Thus, the average availability of water in the Argoguruh Weir is sufficient to meet water needs with IP, for an average of 10 years of observation, **299%** or the average availability of water in the Argoguruh Weir is sufficient to meet the irrigation water needs with an area of **169,993 ha** in one cropping year.

To achieve the IP, the Batutegi and Way Sekampung dams discharge water optimally. The following is the elevation in each reservoir during the 10 years of observation:

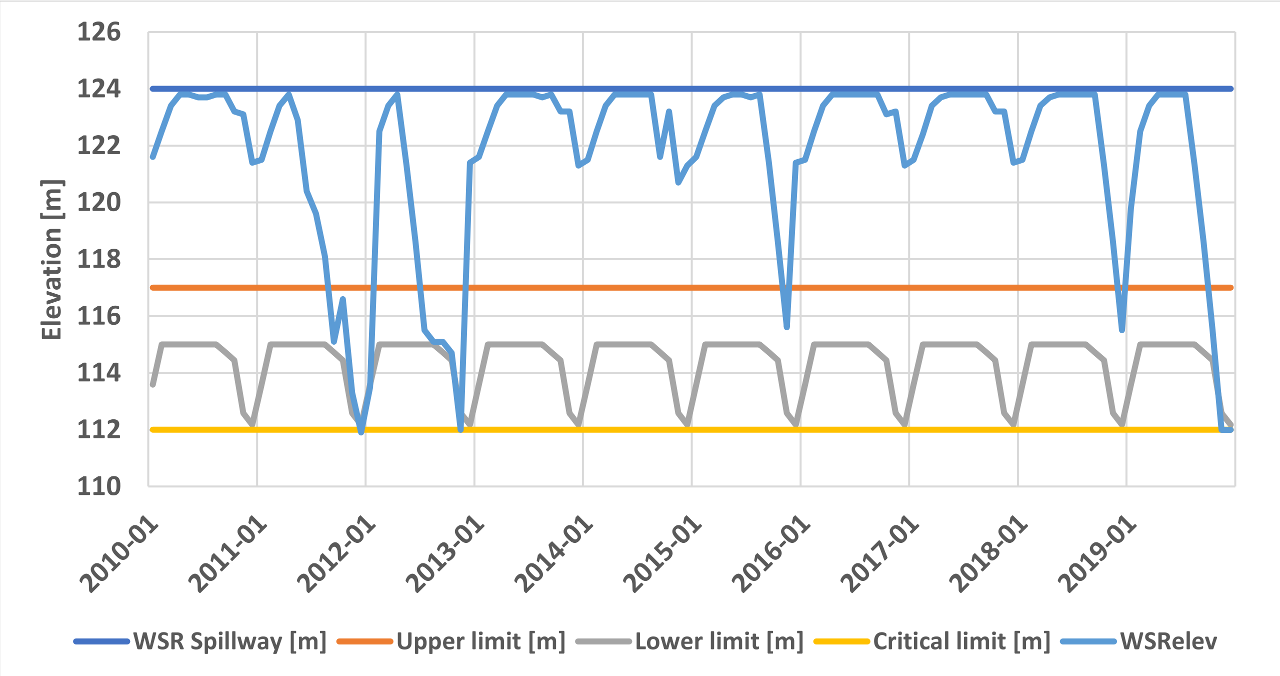
FIGURE 2–8 BATUTEGI DAM WATER ELEVATION SIMULATION - SCENARIO 2 WITH PROJECTS



Source: PPC of Way Sekampung

The graph above shows a simulation of the water level elevation at the Batutegi dam within 10 years of observation. The water level elevation at the Batutegi dam in Scenario 2 is higher than that of Scenario 1, Figure 2–5 shown on page 22. In scenario 2, the lowest dam water level was 233 m in December 2019. This shows that the combination between the existence of the Way Sekampung dam and the increase in the efficiency of the canal system with projects can optimize the discharge of water from the Batutegi dam.

FIGURE 2–9 WAY SEKAMPUNG WATER ELEVATION SIMULATION - SCENARIO 2 WITH PROJECTS



Source: PPC of Way Sekampung

The graph above shows a simulation of the water level elevation (WSRelev) in the Way Sekampung dam within 10 years of observation. The water contribution that can be used, in volume units, from the Way Sekampung reservoir is obtained from the difference between the runoff elevation (124 m) and the irrigation outlet elevation (112 m) is 45 million m3. If referring to Figure 2–2, this volume cannot overcome the water shortage or meet the water demands of the Way Sekampung Irrigation System.

2.2.4 - Scenario 3 with projects, climate change, and land use

Scenario 3 is scenario 2 with some distinctions, such as:

- Climatic conditions with the climate change impact in 2040
- Potential loss of paddy fields due to land use plans

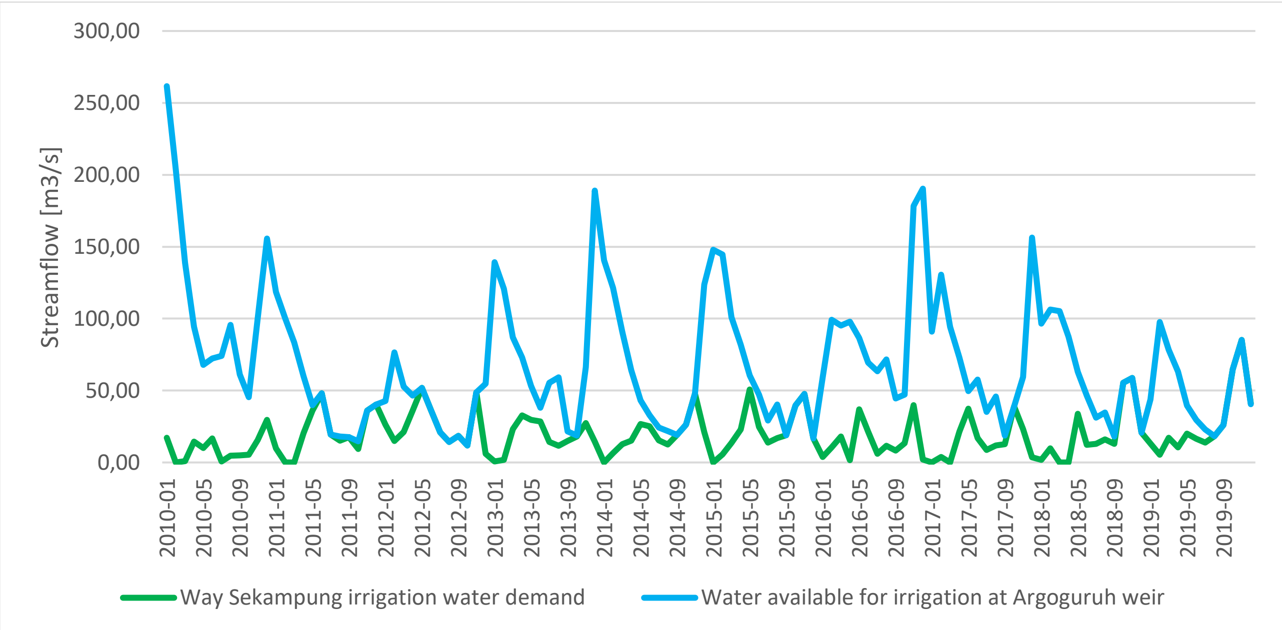
TABLE 2-1 WAY SEKAMPUNG IRRIGATION SYSTEM LAND CONVERSION SCENARIO 3 - 2040

Sekampung Irrigation Scheme	Paddy field to plantation (ha)	Paddy field to urban (ha)	Total conversion (ha)
Batanghari Utara Irrigation Area	45	93	138
Bekri Irrigation Area	143	15	158
Punggur Utara Irrigation Area	963	318	1,281
Raman Utara Irrigation Area	0	319	319
Rumbia Barat Irrigation Area	3	18	21
Sekampung Batanghari Irrigation Area	227	34	261
Sekampung Bunut Irrigation Area	637	17	654
Total of Sekampung irrigation scheme	2,018	814	2,832

Source: Sustainable Food Agricultural Land (LP2B)/Agrarian Affairs and Spatial Planning/National Land Agency (ATR/BPN) 2018 and Lampung Province Spatial Plan

Scenario 3 analyzes the conditions that will potentially exist in 2040. In this scenario, the increase rate of the canal system efficiency is 82%. The first analysis was carried out in the context of intensification in the Way Sekampung Irrigation System which covers 56,854 ha. In this analysis, it can be seen how much water availability potential in the Argoguruh Weir to the demand of irrigation water of 300% IP for the Way Sekampung Irrigation System, with the existence of the reservoir and the increase in the canal system efficiency. The following is the pattern of availability and demand for irrigation water for 54,022 ha in Scenario 3:

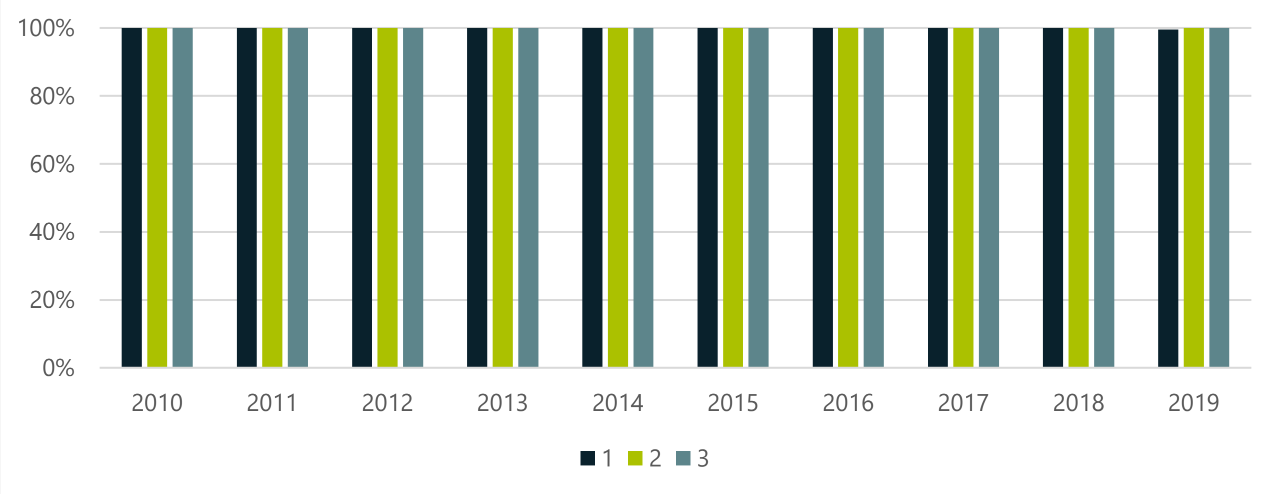
FIGURE 2–10 AVAILABILITY AND DEMAND OF IRRIGATION WATER FOR SCENARIO 3 WITH PROJECTS



Source: PPC of Way Sekampung

The graph above simulates the availability of water in the Batutegi and Way Sekampung dams to the water demand in the Way Sekampung Irrigation System. In 10 years of observation, the needs for the Way Sekampung Irrigation System are met. To see the availability of water for a smaller period, a table has been created showing the availability of water per cropping season within a 10-year simulation as shown in the following graph:

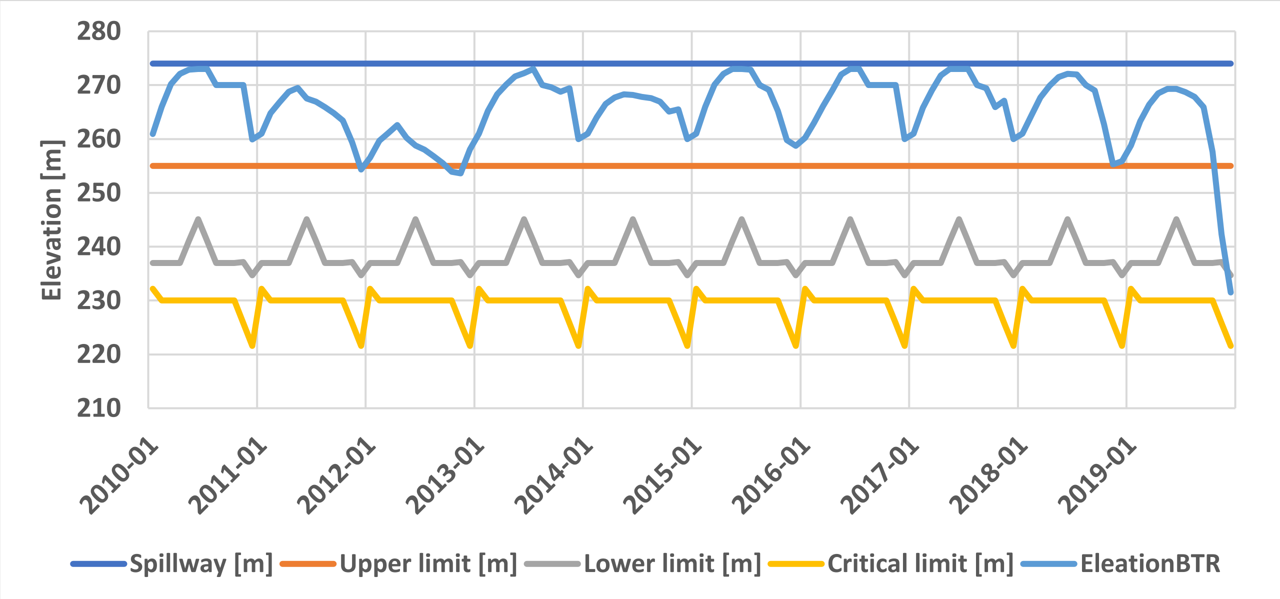
FIGURE 2–11 WATER AVAILABILITY PER CROPPING SEASON FOR SCENARIO 3



Source: PPC of Way Sekampung

The graph above shows the availability of water in the Argoguruh Weir per cropping season. The availability of water in the Argoguruh Weir has met the irrigation water demands. Thus, the average availability of water in the Argoguruh Weir can meet the needs of irrigation water with 300% IP, for an average of 10 years of observation, or the average availability of water in the Argoguruh Weir is sufficient to meet the irrigation water needs with an area of 162,043 ha in one cropping year. To achieve the IP, the Batutegi and Way Sekampung dams discharge water optimally. The following is the elevation in each reservoir during the 10 years of observation:

FIGURE 2–12 BATUTEGI DAM WATER ELEVATION SIMULATION - SCENARIO 3 WITH PROJECTS

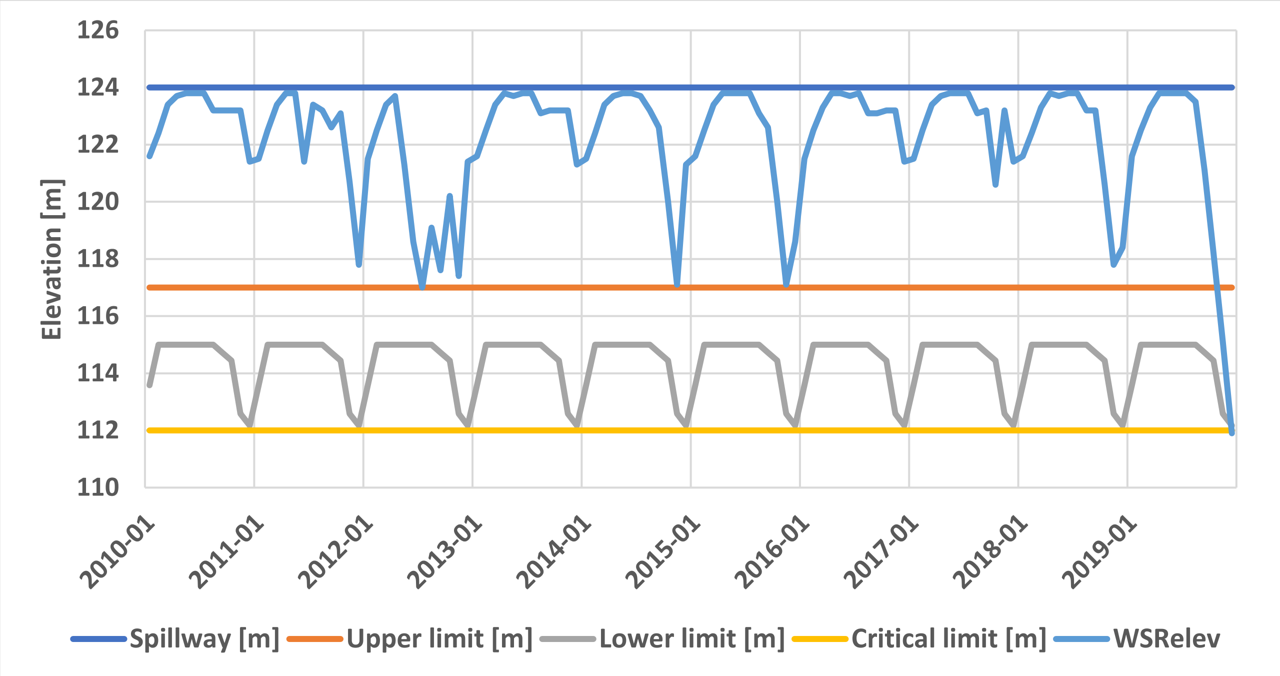


Source: PPC of Way Sekampung

The graph above simulates the water level elevation of the Batutegi reservoir in 10 years of observation. In 2019, the water level of the Batutegi reservoir is approaching the critical curve of the Batutegi dam operating pattern. The impact of climate change can be seen in the simulation of the elevation of the Batutegi reservoir in 2012 and 2013. The impact of climate change results in an extension of the dry season and an increase in the intensity of rainfall in the rainy season. The increase in a long dry season in Scenario 3 results in a longer discharge in the dry season from the Batutegi reservoir. Thus, in 2012 and 2013, the elevation of the Batutegi reservoir was below the simulation of the elevation of the Batutegi reservoir for Scenario 2 as shown in Figure 2–8.

The following is an elevation simulation for the Way Sekampung reservoir:

FIGURE 2–13 WAY SEKAMPUNG DAM WATER ELEVATION SIMULATION - SCENARIO 3 WITH PROJECTS



Source: PPC of Way Sekampung

The graph above simulates the water level elevation of the Way Sekampung reservoir in 10 years of observation. In 2019, the water level of the Way Sekampung reservoir is approaching the critical curve of the Way Sekampung dam operating pattern. The water level pattern in the Batutegi and Way Sekampung reservoirs is the same. In 2019, the water level of the two reservoirs approached the critical curve of each operating pattern. From the analysis of water availability in Scenario 3, it can be concluded that with the modernization projects, the impact of climate change on the Way Sekampung Irrigation System is not significant.

2.3 - Conclusion on Water Availability

TABLE 2-2 CONCLUSION ON WATER AVAILABILITY

Scenario	Description	System efficiency [%]	Daily water demand	
			IP daily	Area [ha]
Scenario 1	Way Sekampung reservoir Without projects	64.8%	287%	163,186
Scenario 2	With projects	82%	299%	169,993
Scenario 3	With projects + Climate change + land use	82%	300%	162,043

Source: PPC of Way Sekampung

2.3.1 - Way Sekampung Irrigation System

Way Sekampung Irrigation System covers an area of 56,854 ha. From the results of the previous analysis, the demand for irrigation water in one year can be met after the irrigation modernization project. However, there are conditions that must be met regarding the planting pattern and the starting date of the cropping season. The first is the ratio of planting patterns in one year for rice to secondary crops per cropping season (MT, *Musim Tanam*).

TABLE 2-3 RATIO OF RICE PER CROPPING SEASON

MT1 % rice area planted \ MT2 % rice area planted -->	40	50	60	70	80	90	100
60	274%	280%	285%	288%	290%	294%	297%
70	278%	285%	287%	290%	294%	297%	297%
80	282%	287%	289%	291%	297%	297%	297%
90	285%	288%	292%	294%	296%	297%	297%
100	288%	290%	295%	295%	295%	297%	299%

Source: PPC of Way Sekampung

The table above shows the average water availability in the Argoguruh Weir over the 10 years of observation. The average water availability in the Argoguruh Weir is sufficient to meet irrigation water demands for 274% IP and sufficient for irrigation water demands for 299% IP.

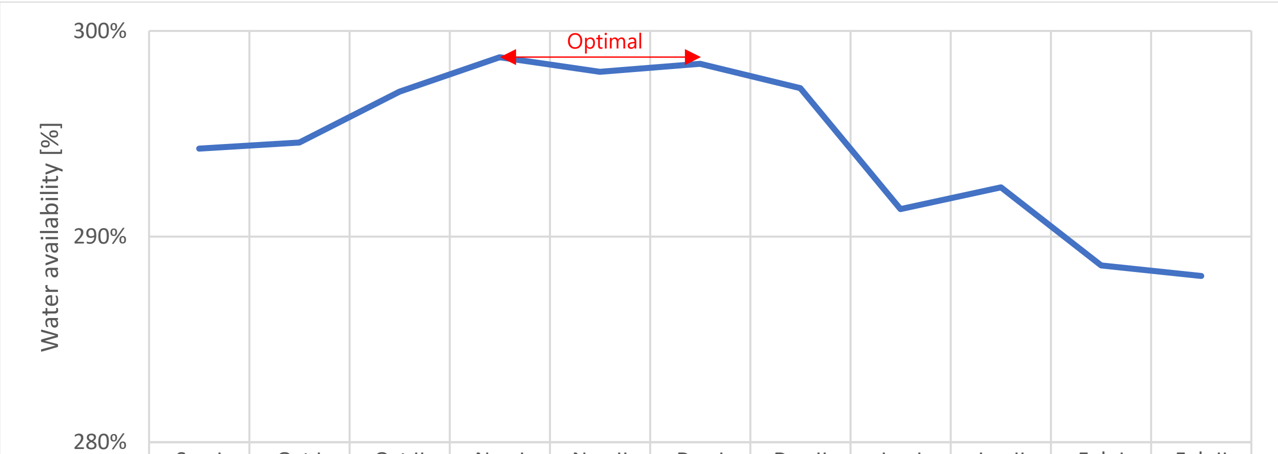
The leftmost column of the table is the percentage ratio of rice in MT 1 and the top row is the percentage ratio of rice in MT 2. If after adding up the percentage of rice for MT 1 and MT 2 does not reach 200%, the remaining percentage will be planted in MT 3. In one year, 200% rice and 100% of secondary crops can be calculated and the results of the water availability and demands can be analyzed. Below are the examples of how to read the table above:

- **80%** rice & 20% secondary crops (100% - 80% = 20% secondary crops) for MT 1
- **60%** rice & 40% secondary crops (100% - 60%= 40% secondary crops) for MT 2
- 60% rice (200% - **80%** rice for MT1 – **60%** rice for MT2 = 60% rice for MT3) & 40% secondary crops (100% - 60% = 40% secondary crops) for MT 3
- The results found that the water availability in the Argoguruh Weir is sufficient to meet the irrigation water demands with an IP of 289%.

The ratio combination of the amount of rice planted in each MT and the rainfall pattern in Lampung resulted in different numbers of irrigation water demands. Thus, **the optimal ratio** carried out in the Way Sekampung Irrigation System is **100% rice in MT1**, **100% rice in MT2**, and **100% secondary crops in MT3** so that the water availability in the Argoguruh Weir can meet irrigation water demands with an IP of 299%.

The second condition after the rice-to-secondary crops ratio per MT, is the planting date for MT1.

FIGURE 2–14 IMPACTS OF PLANTING DATES ON WATER AVAILABILITY IN ARGOGURUH WEIR



	Sep I	Oct I	Oct II	Nov I	Nov II	Dec I	Dec II	Jan I	Jan II	Feb I	Feb II
IP	294%	295%	297%	299%	298%	298%	297%	291%	292%	289%	288%

Source: PPC of Way Sekampung

The graph above shows the average water availability in the Argoguruh Weir for the irrigation water demands if MT1 starts in Sep I to MT1 starts in Feb II during 10 years of observation. From the graph above, it can be concluded that the difference in planting date per cropping season can give a different pattern of water availability in one cropping year. The availability of water in the Argoguruh Weir ranges from 288% for the planting date in Feb II to 299% in Nov I.

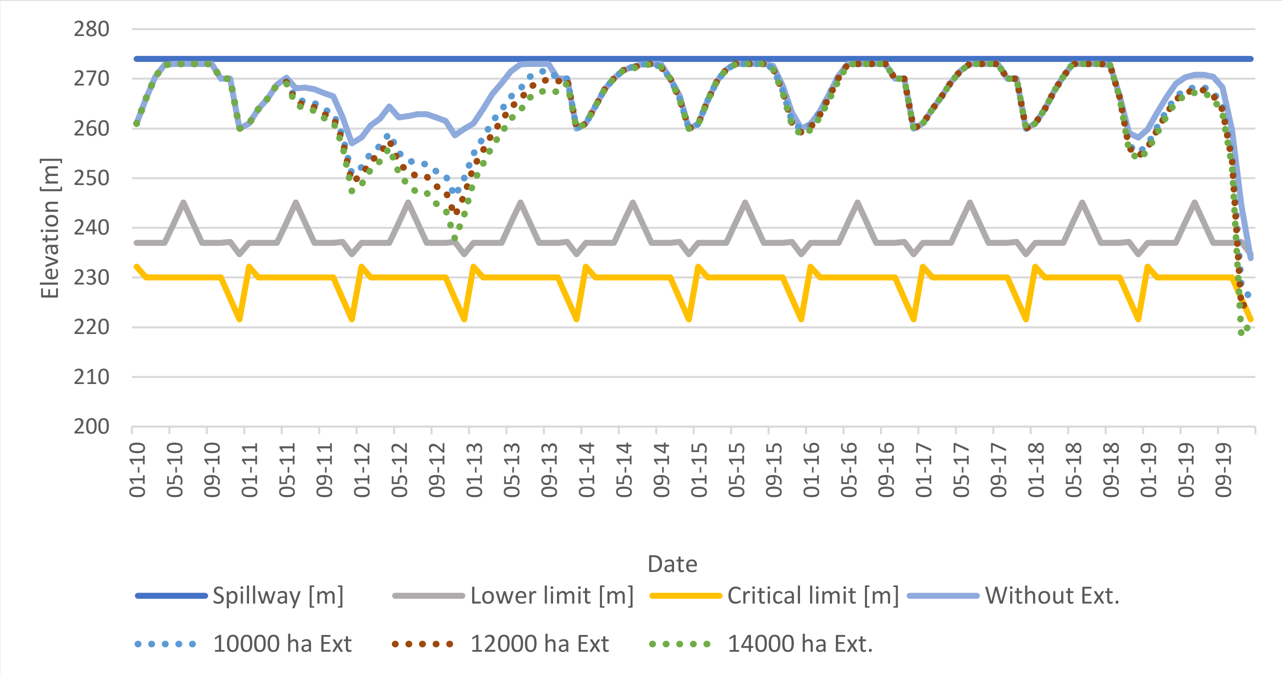
From the graph above, it is inferred that if MT1 is carried out on Nov I, Nov II, and Dec I, the availability of water in the Argoguruh Weir can meet the irrigation water demands with the highest IP potential compared to other MT1 planting dates. From these results, the optimal planting date can be obtained if MT 1 starts between **Nov I – Dec I**.

2.3.2 - Agricultural area expansion

With the Scenario 2 simulation results, 299% IP, and the available water, the expansion of the agricultural area is possible. However, the expansion of the agricultural area will increase the total irrigation water demand in the system and have an impact on the water availability for the Way Sekampung Irrigation System area.

Determination of the amount of agricultural area expansion is carried out by analyzing the impact of agricultural area expansion simulation to the water level in the Batutegi reservoir.

FIGURE 2–15 IMPACTS OF AREA EXPANSION ON THE BATUTEGI RESERVOIR WATER LEVEL



Source: PPC of Way Sekampung

The graph above shows the impact of the agricultural expansion simulation on the elevation of the Batutegi reservoir. Three expansion simulations were attempted with the areas of 10,000 ha, 12,000 ha, and 14,000 ha. It is shown in the graph that as the expansion area increases, the reservoir elevation decreases further below the critical curve for 12,000 ha and 14,000 ha in 2019. Thus, the recommended expansion area is **10,000 ha**. If the expansion plan is carried out, the available water in the Argoguruh weir is sufficient for the WSIS irrigation water demands at IP 297% (down from 299%) and irrigation water demands for agricultural area expansion at IP 281%. The additional area obtained was 27,385 ha from a total area of 169,841 ha to 197,226 ha in one cropping year or three cropping seasons of rice and secondary crops.

This result is obtained if the expansion area has the same canal efficiency system as the modernization project, which is 82% and has the same cropping pattern as the Way Sekampung Irrigation System (planting date and percentage ratio of rice per MT).

3 - MULTIPURPOSE CASCADE RESERVOIR OPTIMIZATION

The upstream area of the Argoguruh catchment has two reservoirs, namely Batutegi and Way Sekampung, both of which have several functions such as: 1) flood control; 2) irrigation water supply; 3) DMI water supply; and 4) hydropower plant.

One of these functions, namely irrigation (and DMI) water supply, is considered to have the highest priority, while the hydropower generator function relies on a constant and definite flow of water especially during the peak hours (17:00 – 22:00).

The flood control function is achieved by keeping the water level below the reservoir threshold so that an adequate spare capacity is available to hold water during peak rainfall. This step is certainly important, especially during the rainy season. During the transition from the rainy season to the dry season, the reservoir water level is usually raised as high as possible so that adequate water is available for irrigation during the dry season.

The question is, in that situation, how to set the most optimal water level and hold it in the reservoir, considering that these two reservoirs are of cascade types, and how to serve their assigned functions. The methodology used is mathematical optimization.

Mathematical optimization is defined as a way of selecting the "best" element (by considering all criteria) from several available alternative sets. These optimization problems are found in various quantitative research disciplines such as computer science, engineering, operation research, and economics.

In short, the cascade reservoir optimization problem is how to maximize or minimize an objective function by selectively determine the hydraulic model input values from a set of allowable values and to calculate the objective function values until the best combination of input values is obtained.

In the study of two cascade reservoirs on the Way Sekampung river, a hydraulic model (see the previous chapter on updating and status) was used to calculate the water balance based on the rainfall-runoff input of three sub-watersheds, DMI and irrigation water demands, and reservoir discharge based on the Reservoir Operation Guidelines (ROR). Reservoir operation optimization is carried out using mathematical optimization methods to find the best option by applying ROR.

Subsequent sections in this chapter include:

1. Literature review to see what optimization methods have been used to solve similar problems;
2. Formulation of the cascade reservoir problems on the Way Sekampung river which has several functions;
3. Selected optimization methods and approaches;
4. Improvements achieved through optimization; and
5. Conclusions and recommendations.

Each topic is discussed below according to its respective sub-chapters:

3.1 - Literature Review

Reservoir operation of a multipurpose reservoir system is very complicated due to many variables that must be considered, its non-linear behavior which does not always go hand in hand, and the conflict of interest between various reservoir functions. The optimization operation of a multipurpose reservoir system requires optimization models and mathematical simulations, which can provide quantitative information to improve the operationalization of water management (Lin and Rutten, 2016).

In the case of two reservoirs where the upstream reservoir is much larger, Broza, V., and Votruba, L. (1989) found that the reservoirs could be optimized independently. It seems that this is the case between the Way Sekampung reservoir and the Batutegi reservoir, which has a volume ten times larger than the Way Sekampung reservoir. In fact, the volume of the Way Sekampung reservoir is only able to serve less than a month when the demand for additional water at the Argoruruh Weir reaches its peak, while the Batutegi reservoir can serve much longer. This means that the discharge released from the Batutegi reservoir is much more important, the functions of the Way Sekampung reservoir as an extra water reservoir for emergencies can only be used if there is a water shortage in the Batutegi reservoir. According to Karczmarek, Z., and Kindler, J. (1982) for multipurpose reservoirs, the strategy is to empty the downstream reservoir first before releasing the water from the upstream reservoir. In other words, keep the water as high as possible. This is to ensure maximum reserves of available water reservoirs and prevent water from escaping out of control.

When using a single-objective optimization method, one approach is to convert all reservoir functions in terms of economic value or avoided damage (flood control) and maximize the economic benefits (e.g., Broza, V., & Vortruba, L., 1989 and Yang, G., S. Guo, P. Liu, L. Li and C. Xu, 2017). A better approach is to use a multi-objective optimization method (e.g., Anand, J., Gosain, A. K., Khosa R., 2018 and Sudiana, R., Yudianto, D., Xiuju, Z., 2017).

Optimization problems can be solved by using Linear Programming (LP), Dynamic Programming (DP), Quadratic Programming (QP), and Non-Linear Programming (NLP). For the optimization model, the LP model mostly presents a trial-and-error solution so that it is difficult to find the real optimal solution for various complexities. The DP technique is more complex but can overcome certain limitations of LP. The non-linear characteristics of a problem as in the case of reservoir optimization can be reflected in a DP formulation. DP applies to multi-objective problems that can be formulated as optimization of a multi-stage decision process. If the control problem is formulated as a quadratic cost function with linear constraints, it can be solved using QP.

Another increasingly preferred alternative is to solve it as a multi-objective optimization problem, which returns a set of Pareto-optimal (or Pareto efficient) solutions instead of one optimal solution. The characterization of the Pareto-optimal solution is that an increase in one objective cannot be achieved without a decrease in at least one of the other objectives (e.g., Kaczmarek, Z. & Kindler, J., 1982 and Yang, G., Guo, S., Liu, P., Li, L., Liu, Z, 2017). The choice of the "best" solution in a set of Pareto-optimal solutions is not considered part of the optimization process because it involves subjective evaluation of what are acceptable compromises between the objectives. In addition, genetic algorithms are also increasingly being applied because they allow simultaneous optimization of several disproportionate and even contradictory objectives. This method can discover several Pareto-optimal solutions in a particular simulation and can help develop suitability assessments and decision-making in various situations (Anand, J., Gosain, A. K., Khosa R. 2018).

Lin and Rutten (2016) proposed Predictive Control (MPC). Optimal control actions are calculated by optimizing the objective function based on the existing constraints. Then, the internal model uses current or future disturbances and current and future control actions to predict the future state of the water system. Obviously, in a reservoir system, reliable rainfall and runoff predictions are needed.

Simulation of reservoir and river systems can be carried out using hydrological models and/or hydraulic models such as HEC-5, HECResSim, MIKE 11, and SOBEK (Lin and Rutten, 2016).

The conclusions of the literature review are:

1. The combination of mathematical optimization methods associated with hydrological/hydraulic models is needed in the case of multipurpose cascade reservoirs to optimize reservoir operation and water management.

2. In reservoir and river simulation systems that are non-linear, non-smooth, and non-continuous, traditional optimization methods will not produce the best solution. Genetic algorithms can help overcome this limitation, although they do not guarantee the "best" solution.

3. Predictive reservoir and river simulation systems that incorporate optimization methods can help make better water management decisions but require reliable rainfall forecasts to run as expected.

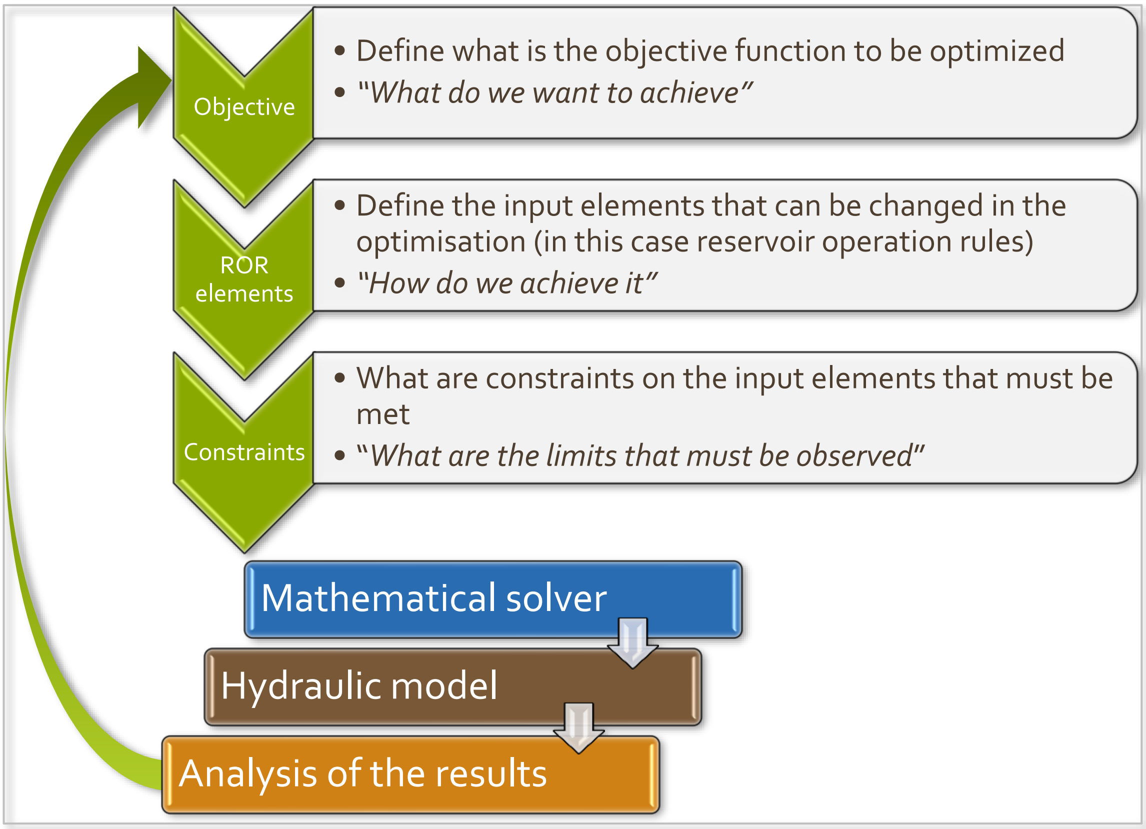
3.2 - Problem Formulation for Batutegi and Way Sekampung Reservoirs

Mathematically, during the formulation of an optimization problem, it is necessary to first define:

- Optimization objective function
- Hydraulic model input that needs to be optimized
- Constraints that apply to input

The process is illustrated in the diagram in Figure 3-1. The first section of the diagram outlines the boundaries of the three mathematical formulations. These constraints are then entered into the mathematical solver tool (an Excel package used for optimization) and the solver tool then changes the selected input cells so that the constraints are appropriate and the solution obtained is the "best" possible alternative.

FIGURE 3–1 OPTIMIZATION APPROACH TO CASCADE RESERVATION OPERATION



Source: PPC of Way Sekampung

3.2.1 - Objective functions

The objective function specifies what optimization needs to be achieved. Considering that irrigation has the highest priority in reservoir operations, it is acceptable to use the aspect of water availability as the basis for determining this objective function, either directly or indirectly. If directly, for example as water availability expressed as cropping intensity where there is sufficient water, then it is difficult to include other reservoir functions in the objective function. Several articles on optimization of cascade reservoirs suggest that all economic value functions be clearly stated (see 3.1 – Literature review).

From an economic point of view, reservoir functions can be expressed in terms of added value or avoided damage and then add the value of each function by weighing the importance of each value before finally obtaining a total value. A possible approach to this is as follows:

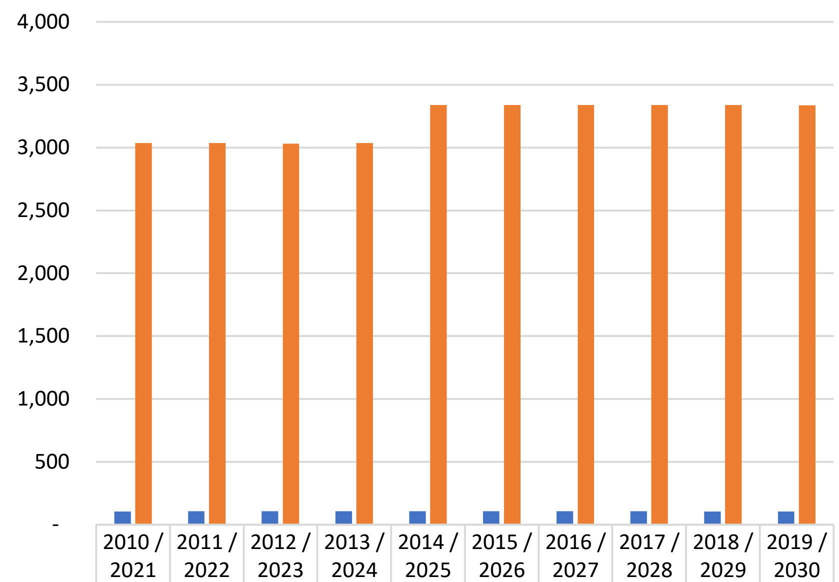
- Irrigation water supply is expressed as the value added to agricultural production (harvest times harvest price at farmer level)
- Value added production of raw water for drinking water (DMI)
- The added value of hydropower generated from reservoirs
- Damage is avoided due to proper operation of reservoirs such as flood control.

The hydraulic model performs two of the most important of the four functions, namely, value-added agricultural production and value-added hydropower. The function of the DMI is limited and always supplied, meaning that in each alternative, the added value is the same and therefore does not contribute to the selection of the best ROR. So, this function is omitted in the optimization objective function.

The flood control function of the reservoir does exist and is expressed in the upper limit operation pattern where the reservoir must release its water until the upper limit elevation is reached. Considering that few flooding problems have been successfully addressed with the existing ROR, there is not much room for improvement, and reservoir operation guidelines related to flood control functions can be maintained as they are today (see 3.2.4 – Flood protection reservoir operation guidelines).

In the preliminary analysis cycle (see also Figure 3-1 that illustrates the cyclical nature of the process) the economic value of irrigation water supply and hydropower produced is used. In the results of the analysis, it is found that the value of hydropower production is much smaller than the added value of agriculture (see Figure 3-2) and the discontinuous behavior of the model implies that the economic value of hydropower production is not very sensitive to changes in ROR. This implies a less-effective optimization.

FIGURE 3–2 HYDROPOWER VALUE ADDED COMPARED TO AGRICULTURE VALUE ADDED (10^9 IDR/YEAR)



	2010 / 2021	2011 / 2022	2012 / 2023	2013 / 2024	2014 / 2025	2015 / 2026	2016 / 2027	2017 / 2028	2018 / 2029	2019 / 2030
hydropower sector [10^9 Rp/year]	104	105	105	105	105	105	105	105	105	103
Agriculture sector production [10^9 Rp/year]	3,036	3,036	3,032	3,036	3,340	3,340	3,340	3,340	3,340	3,336

Source: PPC of Way Sekampung

Therefore, the formulation that is actually used in the next stage is as follows:

Objective function: maximizing the average water availability expressed as cropping intensity over a ten-year period.

Other functions are included by setting additional constraints as follows:

1. Hydropower production is defined as fixed power that must be available at least 98% of the time to generate electricity and the flow rate is set at 10 m3/s for Batutegi and 5 m3/s for Way Sekampung. This shows that, for Way Sekampung, the dependable flow is its maximum flow to drive the turbine, thereby providing a constant production of hydropower. For Batutegi, through the trial-and-error method, the dependable flow (97%) obtained is 10 m3/s. However, because the peak hours are between 17:00 and 22:00, the dependable flow is then considered equivalent to the maximum flow that can be achieved, of course for other days, this flow becomes much lower so that it can be said that the average flow is 10 m3/s.
2. DMI and ecological flow should always be fulfilled.
3. The Rumbia extension is set at 5,000 ha.
4. The harvest pattern is defined as rice – rice – 50% secondary crops in all places if some secondary crops are found in MT1 and MT3, but more in MT2 (the distribution of secondary crops during the cropping season is based on the Regional Technical Implementation Unit (UPTD) biweekly harvest data for 2016-2019).
5. Reservoir operation guidelines (ROR) related to flood control as defined in previous studies are maintained and should be enforced when necessary.
6. The latest data on percolation shows a percolation rate of 5 mm/day (next report on geological research).
7. In Scenario 2, it is assumed that the primary and secondary canal work is in progress and the line efficiency during 2021 will increase to 76%. In the next stage, the work of the canal pair continues to be improved.

3.2.2 - What to optimize

The hydraulics model has many input variables but only the ROR is changed. This means that the monthly elevation value for each water level as well as the percentage of water allocation determined by the guidelines can also vary. Existing water level provisions establish an upper limit upon which the reservoir must release additional water as a precautionary measure when rainfall is at its peak and therefore flood is plausible. This water level elevation should be maintained according to the ROR. In this chapter, water level elevation is expressed as flood control water level elevation. Because this water level does not have a direct impact on water allocation (it is enough to allocate 100% of the demands either when the elevation reaches the upper or lower limit). The hydraulic model determines the upper – middle – critical water level along with the reduction in water allocation as follows:

Upper limit: If it is exceeded, the water demand is 100% met. Once the elevation drops below the upper limit the water allocation is reduced (water allocation ranges from 70% to 100%)

Lower limit: Once the elevation is below this lower limit, the water allocation is further reduced until the allocation ranges from 30% to 70%)

Critical limit: Once the elevation is below this critical limit, water allocation is stopped because there is a possibility that the reservoir will experience water shortage.

For each monthly water level elevation, the respective values are set. The ROR needs to be applied to the Batutegi reservoir and the Way Sekampung reservoir so that there are 2 times 3 times 12 = 72 elevations and 6 percentage of allocations that can be changed as part of the optimization process.

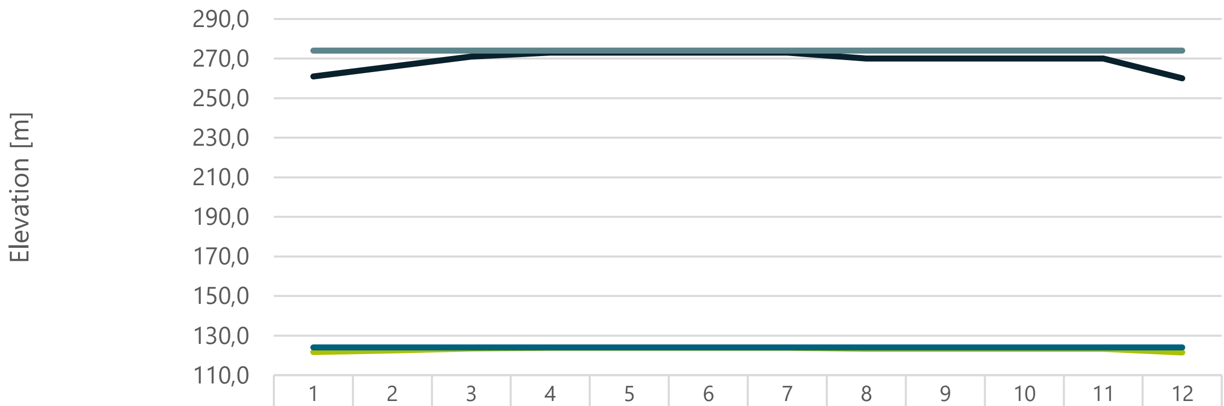
It should be noted that in this approach, it is proposed to consider an additional water level for better handling in the event of water shortage compared to the current ROR by adding one more water level. Water level elevation for flood control in terms of water allocation is considered irrelevant because it has a 100% allocation of demands both above and below its limit. However, it can be used to determine how much additional water must be released before the water level reaches the reservoir threshold. It is concluded that an extra step that allows for various allocations of reservoir water reduction is not to allow the water level elevation to reach its critical limit and on the other hand the existing water demand is served as much as possible.

3.2.3 - Constraints

Apart from the input of the optimization model, only the variables related to the ROR changed during the optimization. This means that as far as optimization is concerned, the relevant constraints are the monthly elevation value of each water level elevation and the percentage of water allocation according to its elevation. As part of the constraints, both lower and upper constraints need to be determined. To avoid overlapping of the water level elevations, the elevation of the upper limit must always be higher than the elevation of the lower limit, and the elevation of the critical limit must always be lower than the elevation of the lower limit.

3.2.4 - Flood protection reservoir operation guidelines

FIGURE 3–3 ROR FLOOD CONTROL ELEVATION



	1	2	3	4	5	6	7	8	9	10	11	12
Flood prot. BTR [m]	261,0	266,0	271,0	273,0	273,0	273,0	273,0	270,0	270,0	270,0	270,0	260,0
Flood prot. WSR [m]	121,6	122,5	123,5	123,8	123,8	123,8	123,8	123,3	123,3	123,3	123,3	121,5
BTR Spillway [m]	274	274	274	274	274	274	274	274	274	274	274	274
WSR Spillway [m]	124	124	124	124	124	124	124	124	124	124	124	124

Source: PPC of Way Sekampung

The flood control water level elevation is used to determine whether it is necessary to release additional water to prevent the water level from reaching the reservoir threshold and starting to overflow.

3.3 - Selected Optimization Method

By considering the non-linear, non-continuous, and non-smooth behaviors of the hydraulic model, the optimization method should be iterative using the evolutionary method because for this type of problem there is no optimization method that has been proven optimal at the global level. Since the hydraulic modeling is performed using a Microsoft Excel tool, the Solver add-in package is selected as a tool or toolkit in this optimization.

In the Microsoft Excel Solver add-in package, there are three possible methods.

1. The Simplex LP Solving method for linear programming uses the Simplex and Multiple Simplex methods with variable boundaries, while the problems with integer constraints use the branch and bound methods, as done by John Watson and Daniel Fylstra, Frontline System, Inc.
2. The GRG Nonlinear Solving method for nonlinear optimization uses the Generalized Reduced Gradient (GRG2) code, developed by Leon Lasdon, University of Texas at Austin, and Alam Warren, Cleveland State University, and improved by Frontline Systems, Inc.

3. The Evolutionary Solving method for non-smooth optimization uses various generic algorithms and local search methods as implemented by several people at Frontline Systems, Inc.

The simplex method is only effective for linear problems. The GRG Nonlinear Solving method requires a smooth/continuous problem. Thus, for hydraulic model optimization problems that are non-linear, non-continuous, and non-smooth, the only alternative is the Evolutionary solving method (based on this problem-solving tool).

3.3.1 - Evolutionary Solving Method

According to its developer, Frontline Systems, Inc., the Evolutionary Solving Method for non-smooth optimization uses various genetic algorithms and local search methods. A genetic or evolutionary algorithm applies the principles of evolution found in nature to problems that hinder the search for an optimal solution to a Solver problem. In a "genetic algorithm," the problem is converted into code in the form of a series of bit strings that the algorithm manipulates. In an "evolutionary algorithm", the decision variables and the problem function are used directly. Most of the Solver products sold in the market are based on evolutionary algorithms. Evolutionary algorithms for optimization differ from "classical" optimization methods in several ways:

- Population-based versus Single Best Solution
- Creating New Solutions through Mutation
- Combining Solutions through Crossover
- Choose Solutions through the principle of "Survival of the Fittest"
- Evolutionary Algorithms Weaknesses

Randomness – First, it is partly based on a random sample. This makes it a non-deterministic method, as a result, it can yield slightly different solutions when applied to different conditions – even if the model does not change. On the other hand, the linear, nonlinear, and integer solver which is also included in the Premium Solver is a deterministic method – this method always produces the same solution if it is started with the same values of the decision variable cells.

Population – Second, if the most classical optimization method maintains a single best solution found so far, then the evolutionary algorithm maintains a population of potential solutions. Only one (or several, with equal goals) of the candidate solutions is declared "best," but other members of the population are declared as "sample points" in other areas of the study space, where a better solution will then be obtained.

The use of a population to search for these solutions helps the evolutionary algorithm avoid being "trapped" in a local optimal solution, even though there may be more optimal solutions outside the current solution environment.

Mutation – Third, inspired by the role of mutations in an organism's DNA in natural evolution – an evolutionary algorithm periodically performs random changes or mutations in one or more members of the current population, which results in a new candidate solution (which can be better or worse than the original existing population members).

There are many ways to "mutate," and Evolutionary Solver uses three different mutation strategies. The result of a mutation can be an infeasible solution, and the Evolutionary Solver tries to "fix" the solution to make it feasible; sometimes this method does work, but not always.

Crossover – Fourth, inspired by the role of sexual reproduction in the evolution of living things – an evolutionary algorithm tries to combine elements of an existing solution to create a new solution, with some features or traits taken from each "parent". Elements of an existing solution (e.g., the values of a decision variable) are combined in a "crossover" operation, which is inspired by the crossing of DNA strands that occurs in the reproduction of biological organisms.

Regarding mutations, there are many ways to perform a crossover operation – some of which are much better than others – and Evolutionary Solver uses multiple variations consisting of two different crossover strategies.

Selection – Fifth, inspired by the role of natural selection in the evolutionary process – an evolutionary algorithm performs a selection process in which the "strongest" or "most fit" members of the population will survive and the "least fit" members will be eliminated. In a constrained optimization problem, the expression "strongest" depends partly on whether a solution is considered feasible (that is, whether it can overcome all constraints), and partly determined by the value of the objective function. The selection process is the step that directs the evolutionary algorithm towards always better solutions.

Weaknesses or drawbacks – The downside of any evolutionary algorithm is that a solution is considered "better" only when compared to others, namely currently known solutions; the algorithm actually does not have the concept of an "optimal solution" or a way to test whether a solution is optimal or not. (For this reason, evolutionary algorithms are best applied to problems when optimization of the problem is difficult or impossible). It also means that an evolutionary algorithm never knows exactly when to stop, regardless of the time span, or the number of iterations or potential solutions, which it wants to explore further.

3.3.2 - Excel Solver

According to *www.dummies.com*, Microsoft Solver applies a loop or iteration method to perform its calculations. Using an iterative approach means that Excel Solver tries a solution, analyzes the results, tries another solution, and so on. However, these repeated iterations are not just guesswork on Solver's part. If so then it will be useless. That's not true at all, Excel Solver checks how the results change with each iteration and, through some sophisticated mathematical process (which, fortunately, goes behind the scenes and doesn't need to be thought about), is usually able to tell which way to go to get a solution. The Excel solver can be used to optimize an Excel spreadsheet model if equipped.

Single Objective Cell: This model has a single objective cell (also called a target cell) that contains formulas that can be used to add, subtract, or set a specific value. For example, increasing the average water availability expressed as cropping intensity.

Variable Cell: The objective cell formula contains a reference to one or more variable cells (also called unknown cells or changed cells). The solver adjusts the cells to obtain the optimal solution for the objective cell formulation. These variable cells include a number of items such as monthly ROR values.

Constraint Cells: Alternatively, there are one or more constraint cells that must meet certain criteria. For example, the minimum and maximum values for the monthly ROR.

3.4 - Improvements of the Optimization Process

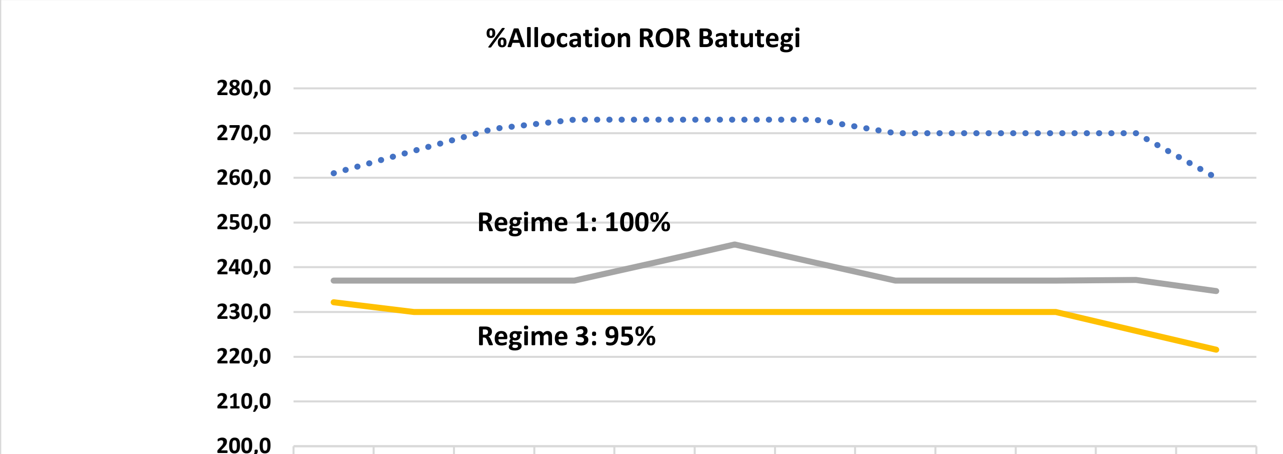
From the starting point of the analysis above, water availability should not be the biggest problem. The two water reservoir systems can handle both the Rumbia extension which covers an area of 5,000 ha and the calendar of the secondary crops 250% rice-rice (50%). In terms of water demand, the water demands "only for rice" is equal to 215% while secondary crops only use 30% of the water used to irrigate rice fields.

In the initial situation, the hydraulic model Scenario 1B (without the Way Sekampung reservoir) is able to provide enough water for 208% of the 215% requested, meaning that there is only a 7% gap to achieve full water availability for a rice-rice planting calendar – (50%) secondary crops.

With the Way Sekampung reservoir and after the optimization of the ROR in Scenario 2, sufficient water can be provided for 213%, meaning that the gap is reduced from 7% to only 2%. Moreover, the dependable electrical capacity that must be available from a flow of 10m3/s in the Batutegi reservoir is able to reach 98%, while for a flow of 5 m3/s in the Way Sekampung reservoir, the permanent electric power is also recorded at 98%.

The optimized ROR rule curves are shown in Figure 3–4 *and* Figure 3–5.

FIGURE 3–4 RESULTS OF THE OPERATIONAL PATTERN FOR BATUTEGI RESERVOIR

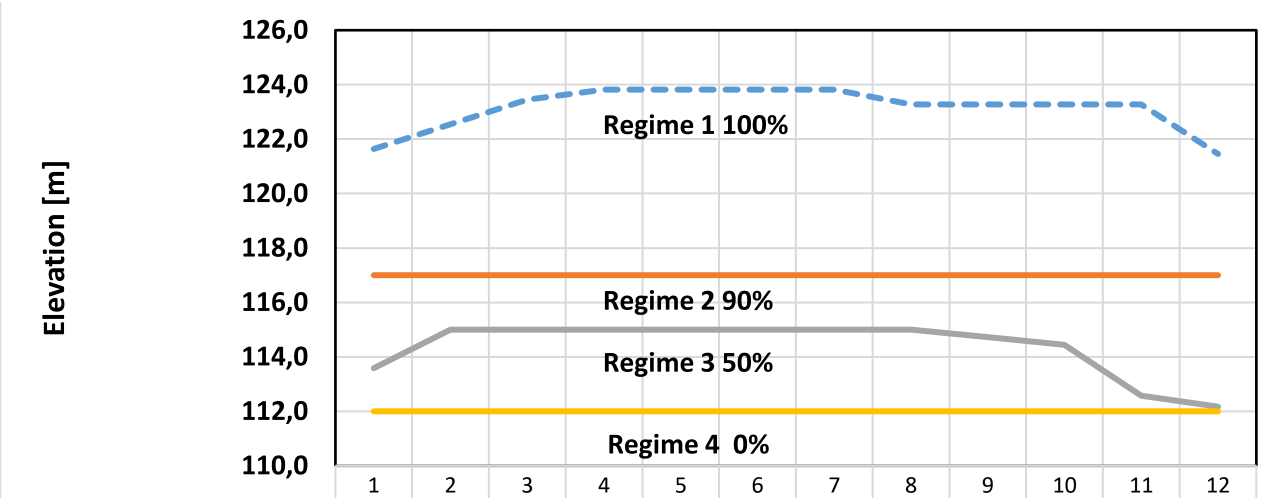


	1	2	3	4	5	6	7	8	9	10	11	12
Flood prot. [m]	261,0	266,0	271,0	273,0	273,0	273,0	273,0	270,0	270,0	270,0	270,0	260,0
Lower limit [m]	237,0	237,0	237,0	237,0	241,1	245,1	241,1	237,0	237,0	237,0	237,2	234,7
Critical limit [m]	232,2	230,0	230,0	230,0	230,0	230,0	230,0	230,0	230,0	230,0	225,8	221,6

Flood prot. [m] **Lower limit [m]** **Critical limit [m]**

Source: PPC of Way Sekampung

FIGURE 3–5 RESULTS OF THE OPERATIONAL PATTERN FOR WAY SEKAMPUNG RESERVOIR

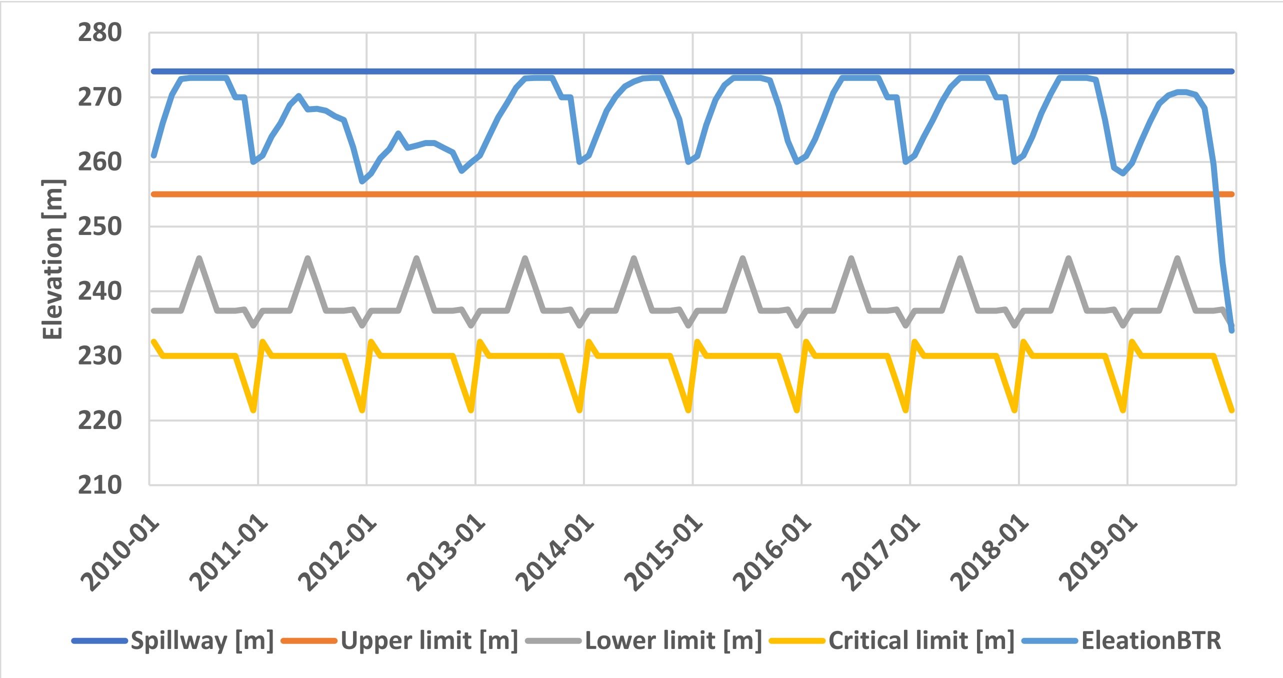


	1	2	3	4	5	6	7	8	9	10	11	12
Flood prot. WSR [m]	121,6	122,5	123,5	123,8	123,8	123,8	123,8	123,3	123,3	123,3	123,3	121,5
Upper limit [m]	117,0	117,0	117,0	117,0	117,0	117,0	117,0	117,0	117,0	117,0	117,0	117,0
Lower limit [m]	113,6	115,0	115,0	115,0	115,0	115,0	115,0	115,0	114,7	114,4	112,6	112,2
Critical limit [m]	112,0	112,0	112,0	112,0	112,0	112,0	112,0	112,0	112,0	112,0	112,0	112,0

Source: PPC of Way Sekampung

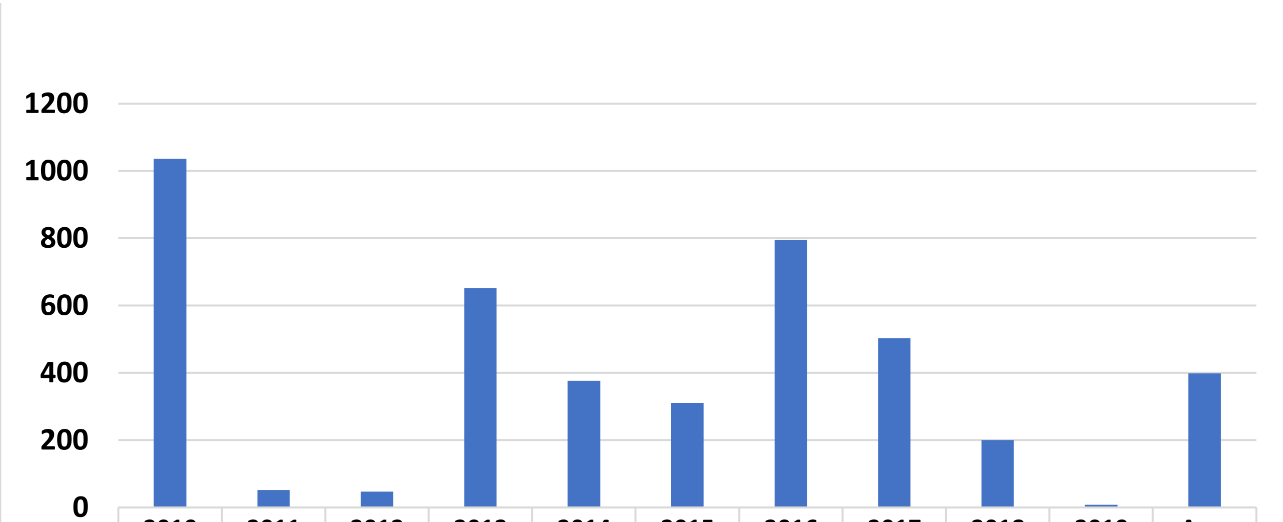
It should be noted that the elevation of the above ROR operational pattern is not always related to water availability. This means that the results of water availability do not always change when the elevation of the operational pattern changes. Therefore, the figures above show the results of the smoothing process. The rest of the peak or trough is considered relevant because if it changes it will affect the final result. The reservoir elevation in Batutegi according to these operating guidelines was recorded to be very low only at the end of 2012, due to two consecutive years of drought. The second half of 2019 was also low, however, this was more due to the underestimation of the runoff predicted using the Mock model, where measurements on the field showed a large amount of runoff over the last few months of 2019. Since the Mock model does not include these results, the outcome is that the run model noted that there was a shortage of water to meet the demand and the water level of the reservoir dropped. See also Figure 3-6.

FIGURE 3–6 BATUTEGI RESERVOIR WATER LEVEL SCENARIO 2



Source: PPC of Way Sekampung

FIGURE 3–7 ADDITIONAL WATER RELEASE AS FLOOD CONTROL IN BATUTEGI RESERVOIR

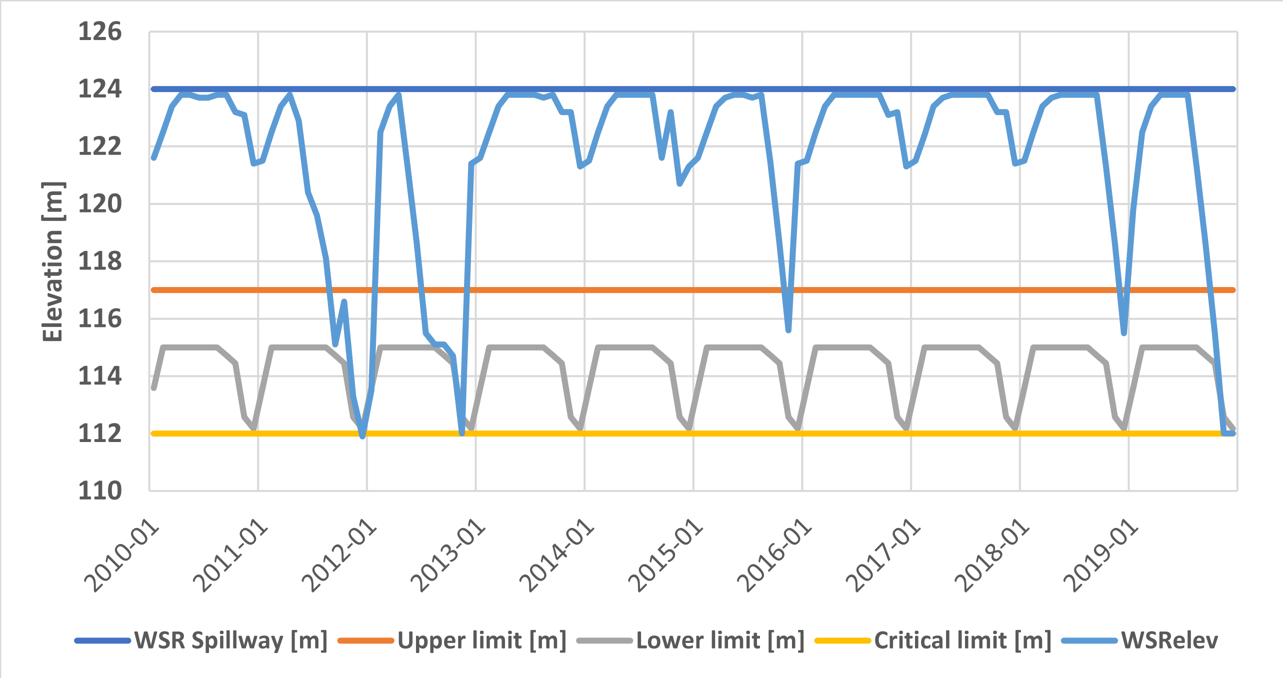


	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Avg.
MCM	1036	52	47	652	377	311	795	503	200	8	398

Source: PPC of Way Sekampung

Figure 3-7 shows the additional water that needs to be released as a flood control measure. In a wet year such as 2010, the additional discharge was 1,036 MCM. In dry years such as 2011, 2012 (recovering water levels that fell sharply), and 2019, the number was recorded at zero. The water level for the Way Sekampung reservoir is shown in Figure 3-8. In 2012, the reservoir experienced a drought, while at other times the full allocation could be served normally, except at the end of 2016 and 2019 when the water allocation fell by 90%.

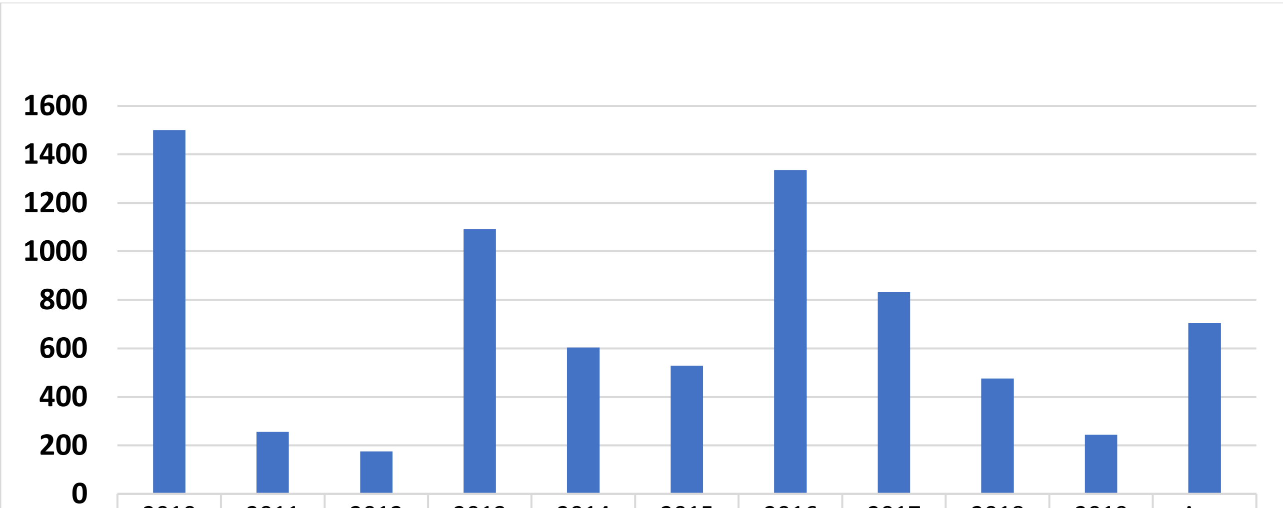
FIGURE 3–8 WAY SEKAMPUNG RESERVOIR WATER LEVEL SCENARIO 2



Source: PPC of Way Sekampung

Additional discharge as flood control in Way Sekampung occurs more frequently and with a larger volume as shown in Figure 3-9.

Figure 3–9 ADDITIONAL WATER RELEASE AS FLOOD CONTROL IN WADUK WAY RESERVOIR



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Avg.
MCM	1500	256	175	1092	604	529	1336	831	475	243	704

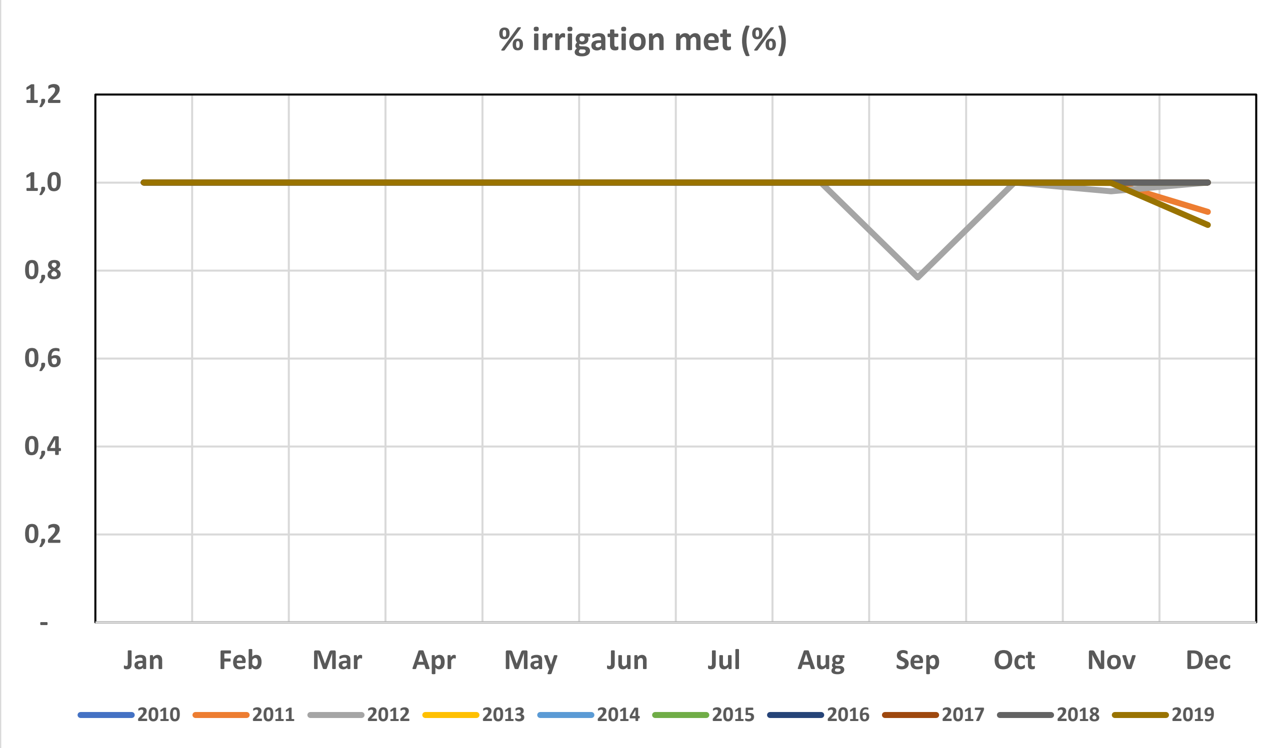
Source: PPC of Way Sekampung

It is interesting to note that overall, the discharge is known to be higher than in the Batutegi reservoir. The reasons are: 1) there is a new catchment area that supports the occurrence of (peak) runoff; and 2) the volume of water in the Batutegi reservoir is much higher and able to hold more water before releasing additional water.

3.5 - Conclusion and Recommendation

- In general, the cascade reservoir system is able to guarantee water availability in Scenario 2. The reservoir was also able to serve all existing demands (100%), except during November-December 2019 and September 2012 where the water availability was slightly reduced to above 80 % (see Figure 3-10).

FIGURE 3–10 PERCENTAGE OF IRRIGATION WATER DEMANDS FULFILLED PER YEAR AND MONTH



Source: PPC of Way Sekampung

- The results of the hydraulic model combined with the Microsoft Excel Solver add-on show promising results:
  - Water availability gap is reduced by 5% compared to Scenario 1B.
  - The desired planting calendar, namely rice–rice–palawija is achieved within 10 years.
  - Fixed electricity that must be available from the hydropower in Batutegi with an average discharge of 10 m3/s reaches 100% and can be used to generate maximum electricity during the peak hours, 17:00 – 22:00.
  - Fixed electricity that must be available from hydropower in Way Sekampung with an average discharge of 5 m3/s was recorded at 96%. Because this number is the maximum value, the turbine that can provide electrical power can be used as a constant source of electricity.
- Reservoir operating guidelines have a limited effect on water availability. It is known that in optimization, many ROR elevations do not affect water availability, but some of them are very important.
- Looking at the complete set of data, it is clear that two consecutive years of drought (2011-2012) have created problems. The only way to solve this problem is to take advantage of rainfall forecasts so that decisions are made based on those forecasts if the allocation needs to be reduced first. For a cropping season, it is better to reduce it to a certain lower allocation than having to face the risk of failure for a whole month, because it will damage the plant itself. The challenge is how to get reliable rainfall predictions for a long period of time. For a period of up to sixteen days, there is a forecast available (Global Forecast System – GFS – from NOAA – see https://www.ncdc.noaa.gov/data-access/model-data/model-datasets/global-forecast-system-gfs). However, it only covers a small part of a growing season. Forecasts based on IOD and El Niño/La Niña can be helpful once the supporting indicators are accurately estimated.

4 - DESIGN DISCHARGE FOR IRRIGATION CANALS AND GATES

4.1 - Methodology

This chapter explains the planned discharge as a basis for determining the capacity of canals and water gates. The planned discharge is calculated based on the irrigation service area in each canal by considering the overall irrigation efficiency value, the water reduction that will occur, and the water demand in the fields.

The amount of water needed in the fields is determined based on the stage of plant growth and the land management method. To determine the amount of water for Net Field Requirement (NFR), it is necessary to consider effective rainfall. Other factors that affect water demand in rice fields are percolation and seepage. Based on the Irrigation Planning Criteria (KP) 03, that one-fifth to one-fourth of the total water taken will be lost before the water reaches the rice fields. Water loss occurs due to exploitation, evaporation, and seepage.

$$KAI = ET + KA + KK$$

Wherein:
KAI : *Kebutuhan Air Irigasi/*Irrigation Water Demands
ET : Evapotranspiration
KA : *Kehilangan Air/*Water Loss
KK : *Kebutuhan Khusus/*Special Needs

To meet the demands of irrigation water, there are two main sources, namely the provision of irrigation water (PAI) and effective rainfall (HE). Besides that, there are other sources that can be utilized, namely the root zone moisture and the contribution of subsurface water. The provision of irrigation water can be seen as the demand for water minus the effective rainfall and the contribution of ground water which can be expressed as follows:

$$PAI = KAI - HE - KAT$$

Wherein:
PAI : *Pemberian Air Irigasi/*Provision of Irrigation Water
KAI : *Kebutuhan Air/*Water Demands
HE : *Hujan Efektif*/Effective Rainfall
KAT : *Kontribusi Air Tanah/*Groundwater Contribution

4.1.1 - Water requirement for rice fields

The period of land cultivation requires the most water compared to the plant growth stage. The need for water for land management is influenced by several factors as follows:

- Soil characteristics,
- Processing time,
- Availability of manpower and livestock as well as,
- Agricultural mechanisms.

The water requirements for preparation can be determined based on the soil depth and soil porosity in the rice fields, as proposed in the following 2013 Irrigation Planning Criteria:

$$PWR = ((Sa-Sb)N*d)/〖10〗^4 + Pd + F1$$

Wherein:
PWR : Water requirement for land preparation (mm)
Sa : Degree of soil saturation after land preparation begins (%)
Sb : Degree of soil saturation before land preparation begins (%)
N : Average soil porosity per soil depth (%)
d : Assumption of soil depth after land preparation (mm)
Pd : Depth of inundation after land preparation work (mm)
F1 : Loss of water in rice fields for 1 day (mm)

The water requirements for land preparation can be determined empirically by 250 mm, including the need for land preparation and for the initial water layer after transplantation is complete (Irrigation Planning Criteria 01). For fields that have not been planted for a long time, the water requirement for land preparation can be determined at 300 mm. Water requirements for field nurseries are included in the water requirements for land preparation.

Analysis of water demand during land cultivation can use the method proposed by Van de Goor and Ziljstra (1968) as follows:

IR=M e^k/((e^k-1))

M=Eo+P

Wherein:

IR : Water requirement for land cultivation (mm/day)
M : Water requirement to replace water loss due to evaporation and percolation in rice fields (mm/day)
Eo : Evaporation potential (mm/day)
P : Percolation (mm/day)
k : Constant
T : Land processing period (days)
S : Water requirement for saturation (mm)
e : Exponent number = 2.7182

4.1.2 - Consumptive use

The use of water for plant needs can be approached by calculating plant evapotranspiration, which is influenced by plant species, plant age, and climatological factors. The evapotranspiration value is the sum of evaporation and transpiration. The value of evapotranspiration can be obtained by the measurements in the field or by empirical formulas. For the purposes of calculating irrigation water demands, a potential evapotranspiration (ETo) value is needed, namely the evapotranspiration that occurs when there is enough water available.

$$ET = kc * ETo$$

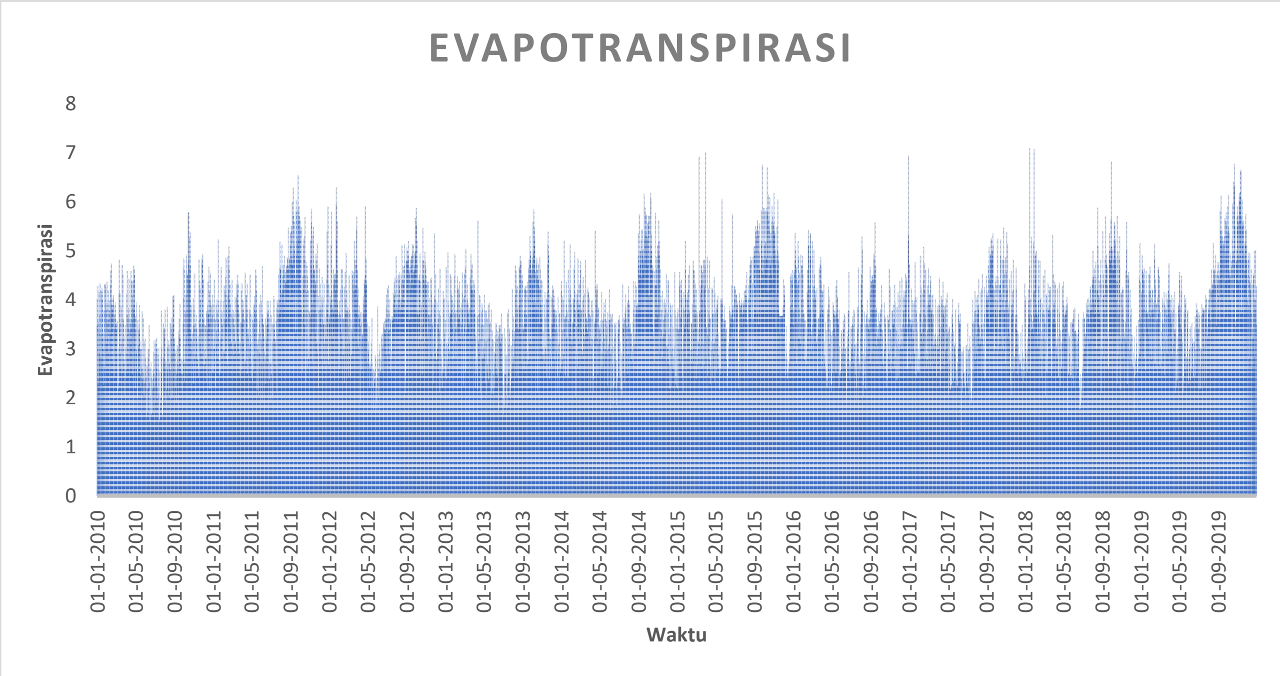
Wherein:

ET : *Evapotranspirasi tanaman*/Plant evapotranspiration (mm/day)
ETo : Evaporation constant/reference plant (mm/day)
kc : Crop intensity of plants

This consumptive water requirement is influenced by the type and age of the plant (plant growth rate). When plants start to grow, the value of consumptive water needs increases according to their growth and reaches its maximum at the time of maximum vegetation growth. After reaching its maximum, which will last for a while depends on the type of plant, the value of consumptive water demands will decrease in line with the maturation of the seeds. Plant characters influence these requirements with plant factor (kc).

The reference plant evapotranspiration used in calculating water demands is presented below:

FIGURE 4–1 PLANT EVAPOTRANSPIRATION [MM/DAY]



Source: PPC of Way Sekampung

4.1.3 - Percolation

The rate of percolation is highly dependent on the properties of the soil. Data regarding percolation will be obtained from soil capability research. The results of geological investigations that have been carried out (presented in a separate report) show that the percolation value in the Way Sekampung irrigated rice field is 5 mm/day.

4.1.4 - Change in water stratification

After fertilizing, it is necessary to schedule water stratification changes as needed. A replacement is estimated to be 2 times 50 mm each in one month and two months after transplantation (or 3.3 mm/day for a ½ month).

4.1.5 - Effective rainfall

There are several ways to determine the contribution of rain to water demands by plants, including empirically and through simulations. The Irrigation Planning Criteria propose an effective rain calculation based on rainfall measurement data at the nearest station, with an observation period of 10 years. The calculation of the effective rainfall here is based on daily rainfall (one-day period), with an 80% chance of occurrence. The equations used to get effective rain are:

$$R\_e=(0,70^*\ R\_80)/1$$

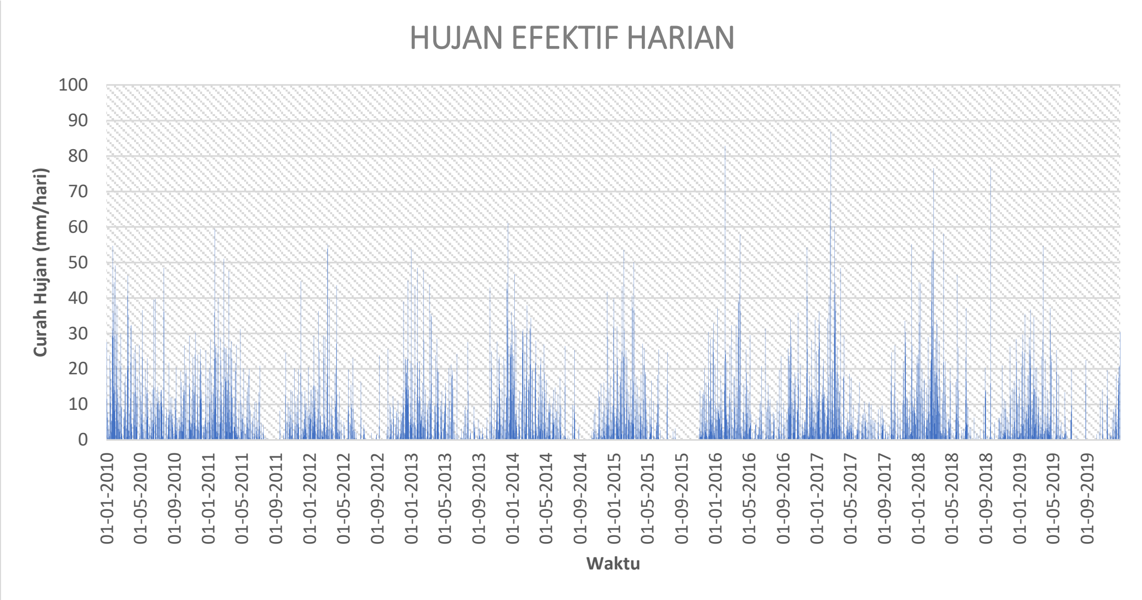
Wherein:

Re : Effective rainfall

R80 : Dependable rainfall 80%

The effective rainfall used in calculating water needs is presented in the following figure:

FIGURE 4–2 EFFECTIVE DAILY RAINFALL



Source: PPC of Way Sekampung

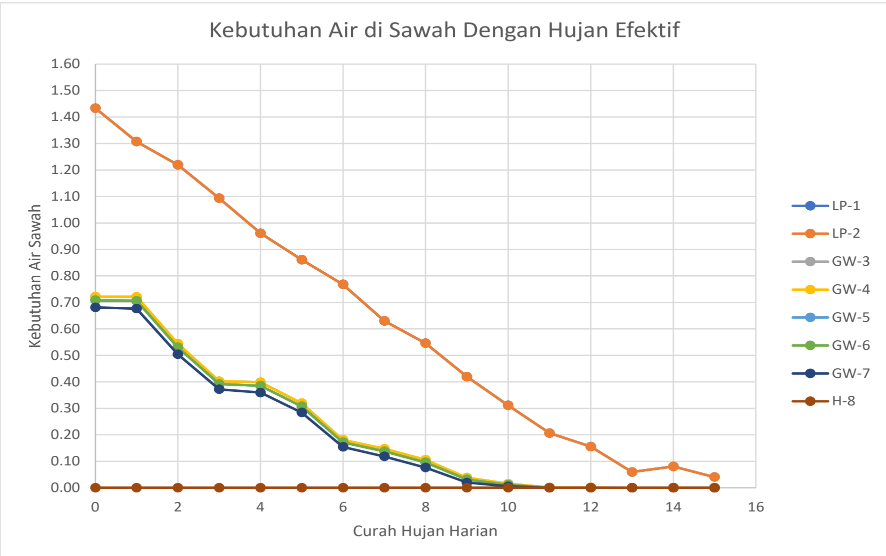
4.1.6 - Irrigation efficiency

Efficiency is the ratio between the discharge of irrigation water arriving at the agricultural fields to the discharge of irrigation water coming out of the inflow gate expressed in percent. This loss is caused by evaporation, exploitation activities, leakage, and seepage. For planning purposes, it is assumed that one-third of the water taken will be lost before it reaches the rice fields. The total irrigation efficiency for rice is taken as 65% (Irrigation Planning Manual, KP-01) with the assumption of 90% efficiency in primary canals, 90% efficiency in secondary canals, and 80% efficiency in tertiary plots. In the calculated model, the efficiency factor after irrigation modernization was considered successfully applied in the Way Sekampung irrigation area, with a value of 83%. In rice fields, the efficiency of agricultural land is not measured but the water balance analysis is taken into account as a requirement for the fields.

4.2 - Irrigation Water Requirements in Tertiary Plots

Irrigation water requirements are influenced by plant varieties, effective daily rainfall, and evapotranspiration values. By using the data of the last 10 years, the value of crop irrigation demands according to the rainfall that occurred is as follows:

FIGURE 4–3 EFFECTIVE DAILY RAINFALL



Source: PPC of Way Sekampung

4.3 - Discharge on Primary Canal Flow

The design discharge requirement for the primary canal is the cumulative amount of water demand in the rice fields with the influence of the irrigation canal efficiency value as a result of modernization projects. Seven primary canals can distribute irrigation water at the highest condition, namely during the planting preparation phase. The design discharge plan is presented in the following table:

TABLE 4-1 DESIGN DISCHARGE IN EACH WAY SEKAMPUNG IRRIGATION SUB-SYSTEM

Irrigation Sub-System	Planned Discharge (m3/s)
BEKRI	10.01
PUNGGUR UTARA	47.98
RUMBIA BARAT	12.63
BATANGHARI UTARA	10.22
RAMAN UTARA	9.39
SEKAMPUNG BUNUT	11.66
SEKAMPUNG BATANGHARI	19.89
Total	121.87

Source: PPC of Way Sekampung

4.4 - Discharge on Secondary Canal Flow

The design discharge requirement for the secondary canal is the cumulative amount of water demand in the rice fields with the influence of the irrigation canal efficiency value as a result of modernization projects. Seven primary canals can distribute irrigation water at the highest condition, namely during the planting preparation phase. The design discharge plan is presented in the following table:

TABLE 4-2 DESIGN DISCHARGE IN EACH WAY SEKAMPUNG IRRIGATION BATANGHARI UTARA SUB-SYSTEM

Secondary	Canal	Total Area	Discharge	UPTD
Batanghari Utara Irrigation Area	BG.0-BG.1 A	4723	10.22	PURBOLINGGO
Batanghari Utara Irrigation Area	BG.1 A-BG.1 B	4700	10.17	PURBOLINGGO
Batanghari Utara Irrigation Area	BG.1 B-BG.1 C	4688	10.14	PURBOLINGGO
Batanghari Utara Irrigation Area	BG.1 C-BG.1	4640	10.04	PURBOLINGGO
Batanghari Utara Irrigation Area	BG.1-BG. 2	4478	9.69	PURBOLINGGO
Batanghari Utara Irrigation Area	BG.2-BG.3 A	4143	8.96	PURBOLINGGO
Batanghari Utara Irrigation Area	BG.3 A-BG.3	4140	8.96	PURBOLINGGO
Batanghari Utara Irrigation Area	BG.3-BG.4 A	4100	8.87	PURBOLINGGO
Batanghari Utara Irrigation Area	BG.4-BG. 5	3582	7.75	PURBOLINGGO
Batanghari Utara Irrigation Area	BG.5-BG. 6	3524	7.62	PURBOLINGGO
Batanghari Utara Irrigation Area	BG.6-BG.7	3202	6.93	PURBOLINGGO
Batanghari Utara Irrigation Area	BG.7-BG.8	2897	6.27	PURBOLINGGO
Batanghari Utara Irrigation Area	BG.8-BG.9 A	2282	4.94	PURBOLINGGO
Batanghari Utara Irrigation Area	BG.9 A-BG.9	2224	4.81	PURBOLINGGO
Batanghari Utara Irrigation Area	BG.9-BG.10 A	2008	4.34	PURBOLINGGO
Batanghari Utara Irrigation Area	BG.10 A-BG.10 B	1978	4.28	PURBOLINGGO
Batanghari Utara Irrigation Area	BG.10 B-BG.10	1873	4.05	PURBOLINGGO
Batanghari Utara Irrigation Area	BG.10-BG.11	1667	3.61	PURBOLINGGO
Batanghari Utara Irrigation Area	BG.11-BG.12	1548	3.35	PURBOLINGGO
Batanghari Utara Irrigation Area	BG.12-BG.13	856	1.85	PURBOLINGGO
Batanghari Utara Irrigation Area	BG.13-BG.14 A	705	1.53	PURBOLINGGO
Batanghari Utara Irrigation Area	BG.14 A-BG.14	676	1.46	PURBOLINGGO
Batanghari Utara Irrigation Area	BG.14-BG.15 A	575	1.24	PURBOLINGGO
Batanghari Utara Irrigation Area	BG.15 A-BG.15	533	1.15	PURBOLINGGO
Batanghari Utara Irrigation Area	BG.16 A-BG.16	254	0.55	PURBOLINGGO
Batanghari Utara Irrigation Area	BG.15-BG.16 A	231	0.50	PURBOLINGGO

Secondary	Canal	Total Area	Discharge	UPTD
Batanghari Utara Irrigation Area	BG.16-BG.17	181	0.39	PURBOLINGGO
Batanghari Utara Irrigation Area	BG.17-BG.18	95	0.21	PURBOLINGGO
Batanghari Utara Irrigation Area	BG.2-BTB.1	128	0.28	PURBOLINGGO
Batanghari Utara Irrigation Area	BG.7-BTP.1	289	0.63	PURBOLINGGO
Batanghari Utara Irrigation Area	BTP.1-BTP.2	145	0.31	PURBOLINGGO
Batanghari Utara Irrigation Area	BG.8-BTK.1	573	1.24	PURBOLINGGO
Batanghari Utara Irrigation Area	BTK.1-BTK.2 A	490	1.06	PURBOLINGGO
Batanghari Utara Irrigation Area	BTK.2 A-BTK.2	412	0.89	PURBOLINGGO
Batanghari Utara Irrigation Area	BTK.2-BTK.3	191	0.41	PURBOLINGGO
Batanghari Utara Irrigation Area	BG.9-BPU.1 A	91	0.20	PURBOLINGGO
Batanghari Utara Irrigation Area	BPU.1 A-BPU. 1	61	0.13	PURBOLINGGO
Batanghari Utara Irrigation Area	BPU.1-BPU. 2	57	0.12	PURBOLINGGO
Batanghari Utara Irrigation Area	BPU.2-BPU. 3	39	0.09	PURBOLINGGO
Batanghari Utara Irrigation Area	BPU.3-BPU. 4	16	0.04	PURBOLINGGO
Batanghari Utara Irrigation Area	BG.4-BTE.1	423	0.91	PURBOLINGGO
Batanghari Utara Irrigation Area	BTE.1-BTE.2	366	0.79	PURBOLINGGO
Batanghari Utara Irrigation Area	BTE.3 A-BTE.3	254	0.55	PURBOLINGGO
Batanghari Utara Irrigation Area	BTE.2-BTE.3 A	139	0.30	PURBOLINGGO
Batanghari Utara Irrigation Area	BG.12-BP.1 A	515	1.11	PURBOLINGGO
Batanghari Utara Irrigation Area	BP.1-BP.2 Ka.1 A	178	0.38	PURBOLINGGO
Batanghari Utara Irrigation Area	BP.2 Ka.1 A-BP.2 Ka.1 B	159	0.34	PURBOLINGGO
Batanghari Utara Irrigation Area	BP.2 Ka.1 B-BP.2 Ka.1	82	0.18	PURBOLINGGO
Batanghari Utara Irrigation Area	BP.1-BP.2 Kr.1	303	0.66	PURBOLINGGO
Batanghari Utara Irrigation Area	BP.2 Kr.1-BP.2 Kr.2	96	0.21	PURBOLINGGO
Batanghari Utara Irrigation Area	BP.2 Kr.2-BP.2 Kr.3	26	0.06	PURBOLINGGO

Source: PPC of Way Sekampung

The results of the discharge calculation in the Bekri, North Pungur, Raman Utara, Rumbia Barat, Sekampung Batanghari, and Sekampung Bunut secondary canals are presented in Appendix 3 of this FS document.

4.5 - Discharge in Potential Area

Supported by the Sekampung reservoir, which will be completed in 2021, the water availability upstream of the Argoguruh Weir has increased quite well. In the calculation model of water availability for irrigation use, the sensitivity value of functional land use outside Way Sekampung irrigation is obtained. For an expansion of 10,000 ha, the maximum flow is 19 m3/s.

4.6 - Conclusion and Recommendation

With the application of proper irrigation water supply in line with the demands of plants in the irrigation tertiary plots, the available volume of water from the Argoguruh sub-watersheds, Batutegi reservoir, and Sekampung reservoir can be utilized for agricultural extensification plans with the aim of increasing annual rice production with rice and secondary crops scenarios.

5 - TRAVEL TIME OF IRRIGATION IN WAY SEKAMPUNG

The arrival times of the flow needed to irrigate all rice fields in the 55,373 ha of Way Sekampung irrigation area are influenced by canal dimension, canal slope, canal surface layer, discharge, and flow speed.

To identify the water travel times from the feeder canal to the tertiary plots, an MS Excel model was created to calculate the length of the canal, canal surface layer, and the flow rate of the irrigation canal in each sub-system of the irrigation area. Basically, the modeling is done starting from Feeder Canal 1 and Feeder Canal 2.

This hydraulic model was created as a parameter that supports the determination of the operating system that will be applied to the Way Sekampung Irrigation System, so that the water flowing in the irrigation canal can be utilized optimally to serve all rice fields in the Way Sekampung irrigation system.

5.1 - Methodology

The equation utilized is the Manning formula. The parameters considered in this analysis are the canal discharge, canal surface layer, canal wet section, and the slope of the canal so that the flow speed in each irrigation channel is obtained. The flow speed will be used to calculate the water travel times from the Feeder Canal to the rice fields.

5.2 - Calculation Model

An example of a calculation model in excel format is compiled with a basic manual as an example of the Bekri irrigation system below:

TABLE 5-1 PHYSICAL PARAMETERS OF WAY SEKAMPUNG IRRIGATION CANALS

Main	Sub-system	Tertiery Area (Ha)	Canal	Total Area	uptd	Panjang Saluran	Hulu	Hilir	Beda E	Slope Saluran (m/m)
DI Bekri	Feeder Canal 2		BKH.0-BBK.0	32481.4	BEKRI	3567	55.87	54.86	1.01	0.000283
DI Bekri	BK.1Ki-1	14.6	BBK.0-BBK.1	4682.2	BEKRI	1304	54.86	55.35	0.49	0.000376
DI Bekri	BK.2Ki-1	23.5	BBK.1-BBK.2	4667.6	BEKRI	2408	55.35	55.18	0.17	0.000071
DI Bekri	BK.3Ki	22.6	BBK.2-BBK.3	4644.1	BEKRI	1139	55.18	54.89	0.29	0.000255
DI Bekri			BBK.3-BBK.4	4358.9	BEKRI	622	54.89	54.52	0.37	0.000595
DI Bekri	BK.5Ki	9.7	BBK.4-BBK.5	3756.0	BEKRI	376	54.52	54.73	0.21	0.000559
DI Bekri	BK.5Ka	34.6			BEKRI					
DI Bekri	BK.6 Ka-1	1.6	BBK.5-BBK.6	3711.7	BEKRI	959	54.73	54.82	0.09	0.000094
DI Bekri	BK.7Ki	35.5	BBK.6-BBK.7	2569.0	BEKRI	1389	54.82	53.27	1.55	0.001116
DI Bekri	BK.8Ki	14.5	BBK.7-BBK.8	2533.5	BEKRI	441	53.27	52.11	1.16	0.002630
DI Bekri	BK.9Ka	11.6	BBK.8-BBK.9	2428.6	BEKRI	555	52.11	50.36	1.75	0.003153
DI Bekri	BK.10Ki	6.6	BBK.9-BBK.10	2417.0	BEKRI	437	50.36	50.18	0.18	0.000412
DI Bekri	BK.10Ka-1	6.6			BEKRI					
DI Bekri	BK.11Ka	23.5	BBK.10-BBK.11	2352.8	BEKRI	304	50.18	50.04	0.14	0.000461
DI Bekri	BK.11Ki	11.0			BEKRI					
DI Bekri	BK.12 Ki	13.5	BBK.11-BBK.12	2318.3	BEKRI	1073	50.04	50.03	0.01	0.000009
DI Bekri	BK.12 Ka.	52.7			BEKRI					
DI Bekri	BK.13Ki	14.6	BBK.12-BBK.13	1699.3	BEKRI	799	50.03	49.16	0.87	0.001089
DI Bekri	BK.13Ka	14.7			BEKRI					
DI Bekri	BK.14Ki	7.6	BBK.13-BBK.14	1670.0	BEKRI	754	49.16	49.02	0.14	0.000186
DI Bekri	BK.14Ka-1	17.5			BEKRI					
DI Bekri	BK.14Ka-2	34.9			BEKRI					

Source: PPC of Way Sekampung

TABLE 5-2 CALCULATION OF FLOW TRAVEL TIMES ON EACH CANAL SECTION

Canal	manning	1/n	b	h	m	Q	h1	A	P	Q1		V (ms-1)	time (minute)
BKH.0-BBK.0	0.02	50	10.78	3	1.5	70.26553	3.274247	51.38833	24.2834	71.26567	ok	1.386806	43
BBK.0-BBK.1	0.02	50	1.60	2	1.25	10.12878	2.417447	11.17298	10.72566	11.12828	ok	0.995999	22
BBK.1-BBK.2	0.02	50	1.60	2	1.25	10.0972	3.505502	20.96948	14.83298	11.09669	ok	0.529183	76
BBK.2-BBK.3	0.02	50	1.60	2	1.25	10.04636	2.631983	12.87034	11.53552	11.04585	ok	0.858241	22
BBK.3-BBK.4	0.02	50	1.60	2	1.25	9.429404	2.110446	8.944195	9.566761	10.4288	ok	1.165986	9
BBK.4-BBK.5	0.02	50	1.60	2	1.25	8.125178	2.012196	8.280681	9.195874	9.12432	ok	1.10188	6
BBK.5-BBK.6	0.02	50	1.60	2	1.25	8.029346	3.006925	16.11308	12.95089	9.028446	ok	0.560318	29
BBK.6-BBK.7	0.02	50	1.60	2	1.25	5.557475	1.454892	4.973714	7.092096	6.557471	ok	1.318425	18
BBK.7-BBK.8	0.02	50	1.60	2	1.25	5.480679	1.167873	3.573504	6.008622	6.480675	ok	1.813535	4
BBK.8-BBK.9	0.02	50	1.60	2	1.25	5.253712	1.095125	3.251324	5.734007	6.253708	ok	1.923434	5
BBK.9-BBK.10	0.02	50	1.60	2	1.25	5.228618	1.805552	6.963903	8.415808	6.228587	ok	0.89441	8
BBK.10-BBK.11	0.02	50	1.60	2	1.25	5.089625	1.739256	6.564074	8.165547	6.089236	ok	0.927661	5
BBK.11-BBK.12	0.02	50	1.60	2	1.25	5.014993	4.16658	28.36702	17.3285	6.014308	ok	0.212018	84
BBK.12-BBK.13	0.02	50	1.60	2	1.25	3.676094	1.237443	3.893992	6.271246	4.676046	ok	1.200836	11
BBK.13-BBK.14	0.02	50	1.60	2	1.25	3.612711	1.891439	7.498227	8.740024	4.612513	ok	0.615147	20

Source: PPC of Way Sekampung

5.3 - Calculation Results of Flow Arrival Time

The calculation results of the arrival time of irrigation water flow are arranged in six main sub-systems namely Punggur Utara, Batanghari Utara, Bekri, Raman Utara, Rumbia Barat, Batanghari Sekampung, and Bunut Sekampung. The results are as follows:

TABLE 5-3 ARRIVAL TIMES OF IRRIGATION FLOW AT BEKRI SUB-SYSTEM CANAL SECTION

System	Section	Distance (m)	Slope	Discharge (m3/s)	Speed (m/s)	Time (minute)	Cumulative Time (hour)
Feeder Canal-2	BKH.0-BBK.0	3522	0.0002	54.49	1.12	52	0.87
Bekri Irrigation Area (main)	BBK.0-BBK.1	1536	0.0003	8.07	0.86	30	1.37
Bekri Irrigation Area (main)	BBK.1-BBK.2	2154	0.0001	8.04	0.50	72	2.57
Bekri Irrigation Area (main)	BBK.2-BBK.3	1136	0.0001	8.01	0.59	32	3.11
Bekri Irrigation Area (main)	BBK.3-BBK.4	667	0.0006	7.53	1.05	11	3.28
Bekri Irrigation Area (main)	BBK.4-BBK.5	371	0.0006	6.39	1.01	6	3.39
Bekri Irrigation Area (main)	BBK.5-BBK.6	955	0.0001	6.32	0.51	31	3.90
Bekri Irrigation Area (main)	BBK.6-BBK.7a	74	0.0018	6.32	1.55	1	3.92
Bekri Irrigation Area (main)	BBK.6-BBK.7	1322	0.0004	4.39	0.85	26	4.35
Bekri Irrigation Area (main)	BBK.7-BBK.8	433	0.0003	4.34	0.73	10	4.52
Bekri Irrigation Area (main)	BBK.8-BBK.9a	167	0.0002	4.34	0.60	5	4.59
Bekri Irrigation Area (main)	BBK.9a-BBK.9	379	0.0004	4.34	0.83	8	4.72
Bekri Irrigation Area (main)	BBK.9-BBK.10	442	0.0004	4.13	0.80	9	4.87
Bekri Irrigation Area (main)	BBK.10-BBK.11	298	0.0005	4.03	0.84	6	4.97
Bekri Irrigation Area (main)	BBK.11-BBK.12	1077	0.0000	3.97	0.19	94	6.53
Bekri Irrigation Area (main)	BBK.12-BBK.13	819	0.0011	2.95	1.06	13	6.75
Bekri Irrigation Area (main)	BBK.13-BBK.14	737	0.0002	2.90	0.57	22	7.11

Source: PPC of Way Sekampung

TABLE 5-4 ARRIVAL TIMES OF IRRIGATION FLOW AT PUNGGUR UTARA SUB-SYSTEM CANAL SECTION

System	Canal	Distance (m)	Slope	Discharge (m3/s)	Speed (m/s)	Time (minute)	Cumulative time (hour)
Feeder Canal-2	BKH.0-BBK.0	3522	0.0002	54.49	1.12	52	0.87
Punggur Utara Irrigation Area (main)	BBk.0 - BPU 1	4604	0.0002	46.43	1.01	76	2.14
Punggur Utara Irrigation Area (main)	BPU 1 - BPU 2	1512	0.0001	46.34	0.87	29	2.62
Punggur Utara Irrigation Area (main)	BPU 2 - BPU 3	2020	0.0008	46.09	1.67	20	2.96
Punggur Utara Irrigation Area (main)	BPU 3 - BPU 4	504	0.0033	45.96	2.68	3	3.01
Punggur Utara Irrigation Area (main)	BPU 4 - BPU 5	2560	0.0005	45.29	1.43	30	3.50
Punggur Utara Irrigation Area (main)	BPU 5 - BPU 6	1500	0.0009	44.61	1.74	14	3.74
Punggur Utara Irrigation Area (main)	BPU 6 - BPU 7	1399	0.0005	43.71	1.38	17	4.03
Punggur Utara Irrigation Area (main)	BPU 7 - BPU 8	2049	0.0000	43.28	0.58	59	5.01
Punggur Utara Irrigation Area (main)	BPU 8 - BPU 9	813	0.0004	38.66	1.29	10	5.19

System	Canal	Distance (m)	Slope	Discharge (m3/s)	Speed (m/s)	Time (minute)	Cumulative time (hour)
Punggur Utara Irrigation Area (main)	BPU 9 - BPU 10	1085	0.0006	38.39	1.42	13	5.40
Punggur Utara Irrigation Area (main)	BPU 10 - BPU 11	771	0.0002	38.06	0.94	14	5.63
Punggur Utara Irrigation Area (main)	BPU 11 - BPU 12	1773	0.0002	34.79	1.02	29	6.11
Punggur Utara Irrigation Area (main)	BPU 12 - BPU 13	924	0.0004	34.47	1.19	13	6.32
Punggur Utara Irrigation Area (main)	BPU 13 - BPU 14	2389	0.0005	33.46	1.32	30	6.83
Punggur Utara Irrigation Area (main)	BPU 14 - BPU 15	907	0.0014	33.00	1.83	8	6.97
Punggur Utara Irrigation Area (main)	BPU 15 - BPU 16	1071	0.0007	31.51	1.49	12	7.17
Punggur Utara Irrigation Area (main)	BPU 16 - BPU 17	1814	0.0009	28.79	1.59	19	7.48
Punggur Utara Irrigation Area (main)	BPU 17 - BPU 18	1035	0.0005	26.66	1.28	14	7.71
Punggur Utara Irrigation Area (main)	BPU 18 - BPU 19	1622	0.0005	26.61	1.25	22	8.07
Punggur Utara Irrigation Area (main)	BPU 19 - BPU 20	490	0.0023	25.53	2.09	4	8.13
Punggur Utara Irrigation Area (main)	BPU 20 - BPU 21	993	0.0019	24.74	1.98	8	8.27
Punggur Utara Irrigation Area (main)	BPU 21 - BPU 22	1500	0.0000	24.30	0.48	52	9.14
Punggur Utara Irrigation Area (main)	BPU 22 - BPU 23	1706	0.0004	7.10	0.91	31	9.66
Punggur Utara Irrigation Area (main)	BPU 23 - BPU 23A	392	0.0006	2.78	0.79	8	9.80
Punggur Utara Irrigation Area (main)	BPU 23 - BPU 24	1147	0.0005	4.28	0.86	22	10.17
Punggur Utara Irrigation Area (main)	BPU 24 - BPU 25	2221	0.0002	3.73	0.65	57	11.13
Punggur Utara Irrigation Area (main)	BPU 25 - BPU 25A	75	0.0024	0.83	1.06	1	11.15
Punggur Utara Irrigation Area (main)	BPU 25 - BPU 26	2476	0.0007	2.25	0.87	47	11.94

Source: PPC of Way Sekampung

TABLE 5-5 ARRIVAL TIMES OF IRRIGATION FLOW AT RUMBIA BARAT SUB-SYSTTEM CANAL SECTION

System	Canal	Distance (m)	Slope	Discharge (m3/s)	Speed (m/s)	Time (minute)	Cumulative Time(hour)
Punggur Utara Irrigation Area (main)	BPU 21 - BPU 22	1500	0.0000	24.30	0.48	52	9.14
Rumbia Barat Irrigation Area (main)	BPU 22 - BRB 1f	524	0.0000	2.90	0.23	38	9.77
Rumbia Barat Irrigation Area (main)	BRB 1 - BRB 2	1987	0.0001	8.13	0.59	56	10.71
Rumbia Barat Irrigation Area (main)	BRB 2 - BRB 3	450	0.0004	8.01	0.90	8	10.85
Rumbia Barat Irrigation Area (main)	BRB 3 - BRB 4	1808	0.0002	4.30	0.61	49	11.67
Rumbia Barat Irrigation Area (main)	BRB 4 - BRB 5	1152	0.0001	4.22	0.45	42	12.37
Rumbia Barat Irrigation Area (main)	BRB 5 - BRB 6b	37	0.0003	4.22	0.66	1	12.39
Rumbia Barat Irrigation Area (main)	BRB 6 - BRB 7	681	0.0003	3.53	0.68	17	12.67
Rumbia Barat Irrigation Area (main)	BRB 7 - BRB 8	90	0.0006	1.92	0.68	2	12.71
Rumbia Barat Irrigation Area (main)	BRB 8 - BRB 9	1556	0.0004	1.60	0.59	44	13.44

Source: PPC of Way Sekampung

TABLE 5-6 ARRIVAL TIMES OF IRRIGATION FLOW AT NORTH SAMAN SUB-SYSTEM CANAL SECTION

System	Canal	Distance (m)	Slope	Discharge (m3/s)	Speed (m/s)	Time (minute)	Cumulative Time (hour)
Raman Utara Irrigation Area (main)	BRU 0 - BRU 1A	2374	0.0007	7.30	1.11	36	0.60
Raman Utara Irrigation Area (main)	BRU 1A - BRU 1B	2804	0.0005	7.24	0.99	47	1.39
Raman Utara Irrigation Area (main)	BRU 1B - BRU 1C	333	0.0007	7.17	1.07	5	1.47
Raman Utara Irrigation Area (main)	BRU 1C - BRU 1	767	0.0000	7.15	0.33	39	2.12
Raman Utara Irrigation Area (main)	BRU 1 - BRU 2	742	0.0008	6.97	1.11	11	2.31
Raman Utara Irrigation Area (main)	BRU 2 - BRU 3	1407	0.0003	6.92	0.82	29	2.79
Raman Utara Irrigation Area (main)	BRU 3 - BRU 4	937	0.0002	6.77	0.64	24	3.19
Raman Utara Irrigation Area (main)	BRU 4 - BRU 5	659	0.0002	5.10	0.62	18	3.49
Raman Utara Irrigation Area (main)	BRU 5 - BRU 6	899	0.0001	5.02	0.53	28	3.96
Raman Utara Irrigation Area (main)	BRU 6 - BRU 7	1098	0.0001	4.94	0.54	34	4.53
Raman Utara Irrigation Area (main)	BRU 7 - BRU 8	962	0.0006	4.67	0.93	17	4.82
Raman Utara Irrigation Area (main)	BRU 8 - BRU 9	1104	0.0000	4.54	0.36	51	5.67
Raman Utara Irrigation Area (main)	BRU 9 - BRU 10	1425	0.0001	3.44	0.49	49	6.49
Raman Utara Irrigation Area (main)	BRU 10 - BRU 11	1397	0.0004	3.29	0.72	32	7.02
Raman Utara Irrigation Area (main)	BRU 11 - BRU 12d	1174	0.0004	3.29	0.71	28	7.48
Raman Utara Irrigation Area (main)	BRU 12d - BRU 12	766	0.0006	3.29	0.87	15	7.73
Raman Utara Irrigation Area (main)	BRU 12 - BRU 13	1302	0.0008	1.66	0.77	28	8.19
Raman Utara Irrigation Area (main)	BRU 13 - BRU 14A	494	0.0008	1.33	0.77	11	8.37
Raman Utara Irrigation Area (main)	BRU 14A - BRU 14	1242	0.0000	1.18	0.23	92	9.91
Raman Utara Irrigation Area (main)	BRU 14 - BRU 15	1037	0.0006	1.04	0.66	26	10.34
Raman Utara Irrigation Area (main)	BRU 15 - BRU 16	1308	0.0002	0.71	0.38	57	11.29
Raman Utara Irrigation Area (main)	BRU 16 - BRU 17	1028	0.0004	0.65	0.51	33	11.84
Raman Utara Irrigation Area (main)	BRU 17 - BRU 18	721	0.0004	0.51	0.47	26	12.27

System	Canal	Distance (m)	Slope	Discharge (m3/s)	Speed (m/s)	Time (minute)	Cumulative Time (hour)
Raman Utara Irrigation Area (main)	BRU 18 - BRU 19a	187	0.0002	0.26	0.28	11	12.46
Raman Utara Irrigation Area (main)	BRU 19a - BRU 19A	30	0.0017	0.26	0.68	1	12.47
Raman Utara Irrigation Area (main)	BRU 19A - BRU 19	1242	0.0010	0.23	0.55	38	13.10

Source: PPC of Way Sekampung

TABLE 5-7 ARRIVAL TIMES OF IRRIGATION FLOW AT SEKAMPUNG BUNUT SUB-SYSTEM CANAL SECTION

System	Canal	Distance (m)	Slope	Discharge (m3/s)	Speed (m/s)	Time (minute	Cumulative Time (hour)
Feeder Canal-1	BKH.0-BKH.1	7742	0.0002	40.14	0.99	130	2.16
Feeder Canal-1	BKH.1-BKH.2	1358	0.0003	40.01	1.15	20	2.49
Sekampung Bunut Irrigation Area (main)	BKH.2-BKH.3d	1160	0.0001	40.01	0.78	25	2.91
Sekampung Bunut Irrigation Area (main)	BKH.3d-BKH.3	1958	0.0009	40.01	1.58	21	3.25
Sekampung Bunut Irrigation Area (main)	BKH.3-BKB.1 A	3539	0.0001	4.89	0.43	138	5.55
Sekampung Bunut Irrigation Area (main)	BKB.1 A-BKB.1	1242	0.0000	4.81	0.37	56	6.48
Sekampung Bunut Irrigation Area (main)	BKB.1-BKB.2 A	1007	0.0001	4.58	0.46	37	7.09
Sekampung Bunut Irrigation Area (main)	BKB.2 A-BKB.2 B	720	0.0000	4.52	0.30	40	7.77
Sekampung Bunut Irrigation Area (main)	BKB.2 B-BKB.2 C	887	0.0000	4.47	0.27	54	8.67
Sekampung Bunut Irrigation Area (main)	BKB.2 C-BKB.2	239	0.0000	4.42	0.34	12	8.86
Sekampung Bunut Irrigation Area (main)	BKB.2-BKB.3 A	274	0.0020	4.40	1.37	3	8.92
Sekampung Bunut Irrigation Area (main)	BKB.3 A-BKB.3 B	1887	0.0002	4.37	0.62	50	9.75
Sekampung Bunut Irrigation Area (main)	BKB.3 B-BKB.3	387	0.0003	4.27	0.70	9	9.91
Sekampung Bunut Irrigation Area (main)	BKB.3-BKB.4	1533	0.0002	3.50	0.53	48	10.71
Sekampung Bunut Irrigation Area (main)	BKB.4-BKB.5 A	2057	0.0005	3.38	0.83	41	11.39
Sekampung Bunut Irrigation Area (main)	BKB.5 A-BKB.5	334	0.0001	3.25	0.37	15	11.65
Sekampung Bunut Irrigation Area (main)	BKB.5-BKB.6	1742	0.0003	3.15	0.69	42	12.35
Sekampung Bunut Irrigation Area (main)	BKb.6-BKB.7	1807	0.0001	2.11	0.46	66	13.45
Sekampung Bunut Irrigation Area (main)	BKB.7 -BKB.8 A	497	0.0003	1.50	0.55	15	13.71
Sekampung Bunut Irrigation Area (main)	BKB.8 A-BKB.8 B	354	0.0002	1.44	0.44	13	13.93
Sekampung Bunut Irrigation Area (main)	BKB.8 B-BKB.8 C	419	0.0001	1.43	0.39	18	14.23
Sekampung Bunut Irrigation Area (main)	BKB.8 C-BKB.8 D	699	0.0003	1.42	0.51	23	14.61
Sekampung Bunut Irrigation Area (main)	BKB.8 D-BKB.8	661	0.0009	1.38	0.81	14	14.84
Sekampung Bunut Irrigation Area (main)	BKb.8-BKb.9	1533	0.0005	1.07	0.61	42	15.54
Sekampung Bunut Irrigation Area (main)	BKb.9-BKb.10A	1111	0.0011	0.51	0.69	27	15.98
Sekampung Bunut Irrigation Area (main)	BKB.10 A-BKB.10	392	0.0008	0.45	0.60	11	16.16
Sekampung Bunut Irrigation Area (main)	BKB.10-BKB.11 A	626	0.0006	0.29	0.49	21	16.52
Sekampung Bunut Irrigation Area (main)	BKB.11 A-BKB.11	866	0.0014	0.14	0.54	27	16.96
Sekampung Bunut Irrigation Area (main)	BKB.11-BKB.12	1659	0.0008	0.06	0.36	76	18.24

Source: PPC of Way Sekampung

TABLE 5-8 ARRIVAL TIMES OF IRRIGATION FLOW OF IRRIGATION FLOW AT SEKAMPUNG BATANGHARI SUB-SYSTEM CANAL SECTION

System	Canal	Distance (m)	Slope	Discharge (m3/s)	Speed (m/s)	Time (minute)	Cumulative Time (hour)
Feeder Canal-1	BKH.0-BKH.1	7742	0.0002	40.14	0.99	130	2.16
Feeder Canal-1	BKH.1-BKH.2	1358	0.0003	40.01	1.15	20	2.49
Sekampung Batanghari Irrigation Area (main)	BKH.2-BKBH.1	1508	0.0001	15.44	0.55	46	3.25
Sekampung Batanghari Irrigation Area (main)	BKBH.1-BKBH.2	759	0.0007	15.44	1.28	10	3.42
Sekampung Batanghari Irrigation Area (main)	BKBH.2-BKBH.3	1108	0.0010	14.88	1.44	13	3.63
Sekampung Batanghari Irrigation Area (main)	BKBH.3-BKBH.4 A	1893	0.0000	14.64	0.36	88	5.10
Sekampung Batanghari Irrigation Area (main)	BKBH.4 A-BKBH.4	443	0.0004	14.59	1.04	7	5.22
Sekampung Batanghari Irrigation Area (main)	BKBH.4-BKBH.5 A	1455	0.0010	14.59	1.45	17	5.50
Sekampung Batanghari Irrigation Area (main)	BKBH.5 A-BKBH.5	337	0.0036	14.17	2.21	3	5.54
Sekampung Batanghari Irrigation Area (main)	BKBH.5-BKBH.6 A	1337	0.0002	13.27	0.81	27	6.00
Sekampung Batanghari Irrigation Area (main)	BKBH.6 A-BKBH.6	709	0.0003	13.17	0.89	13	6.22
Sekampung Batanghari Irrigation Area (main)	BKBH.6-BKBH.7 A	1901	0.0008	12.73	1.28	25	6.63
Sekampung Batanghari Irrigation Area (main)	BKBH.7 A-BKBH.7	620	0.0007	12.61	1.21	9	6.77
Sekampung Batanghari Irrigation Area (main)	BKBH.7-BKBH.8 A	1636	0.0002	11.95	0.83	33	7.32
Sekampung Batanghari Irrigation Area (main)	BKBH.8 A-BKBH.8 B	238	0.0016	11.86	1.64	2	7.36
Sekampung Batanghari Irrigation Area (main)	BKBH.8 B-BKBH.8 C	593	0.0003	11.81	0.95	10	7.53
Sekampung Batanghari Irrigation Area (main)	BKBH.8 C-BKBH.8 D	675	0.0005	11.77	1.08	10	7.71
Sekampung Batanghari Irrigation Area (main)	BKBH.8 D-BKBH.8	581	0.0014	11.65	1.59	6	7.81
Sekampung Batanghari Irrigation Area (main)	BKBH.8-BKBH.9	2947	0.0001	9.14	0.52	95	9.38

System	Canal	Distance (m)	Slope	Discharge (m3/s)	Speed (m/s)	Time (minute)	Cumulative Time (hour)
Sekampung Batanghari Irrigation Area (main)	BKBH.9-BKBH.10 A	1753	0.0003	8.42	0.85	35	9.96
Sekampung Batanghari Irrigation Area (main)	BKBH.10 A-BKBH.10	138	0.0076	8.15	2.69	1	9.97
Sekampung Batanghari Irrigation Area (main)	BKBH.10-BKBH.11 A	657	0.0004	7.87	0.88	12	10.18
Sekampung Batanghari Irrigation Area (main)	BKBH.11 A-BKBH.11	1324	0.0003	7.66	0.79	28	10.65
Sekampung Batanghari Irrigation Area (main)	BKBH.11-BKBH.12	1539	0.0000	7.22	0.36	72	11.85
Sekampung Batanghari Irrigation Area (main)	BKBH.12-BKBH.13	628	0.0001	6.11	0.44	24	12.25
Sekampung Batanghari Irrigation Area (main)	BKBH.14 A'-BKBH.14 A	1808	0.0002	4.50	0.65	47	13.03
Sekampung Batanghari Irrigation Area (main)	BKBH.14 A-BKBH.14 B	481	0.0001	4.31	0.54	15	13.28
Sekampung Batanghari Irrigation Area (main)	BKBH.14 B-BKBH.14 C	303	0.0012	4.17	1.13	4	13.35
Sekampung Batanghari Irrigation Area (main)	BKBH.14 C-BKBH.14	1027	0.0002	4.14	0.63	27	13.80
Sekampung Batanghari Irrigation Area (main)	BKBH.14-BKBH.15 A	935	0.0009	1.01	0.75	21	14.15
Sekampung Batanghari Irrigation Area (main)	BKBH.15 A-BKBH.15 B	723	0.0005	0.90	0.58	21	14.50
Sekampung Batanghari Irrigation Area (main)	BKBH.15 B-BKBH.15 C	742	0.0003	0.88	0.46	27	14.94
Sekampung Batanghari Irrigation Area (main)	BKBH.15 D-BKBH.15	524	0.0005	0.79	0.55	16	15.21
Sekampung Batanghari Irrigation Area (main)	BKBH.15-BKBH.16 A	1192	0.0011	0.60	0.70	28	15.68
Sekampung Batanghari Irrigation Area (main)	BKBH.16 A-BKBH.16 B	20	0.0022	0.57	0.90	0	15.69
Sekampung Batanghari Irrigation Area (main)	BKBH.16 B-BKBH.16	429	0.0004	0.53	0.46	16	15.95

Source: PPC of Way Sekampung

TABLE 5-9 ARRIVAL TIMES OF IRRIGATION FLOW AT BATANGHARI UTARA SUB-SYSTEM CANAL SECTION

System	Canal	Distance (m)	Slope	Discharge (m3/s)	Speed(m/s)	Time(minute)	Cumulative Time (hour)
Batanghari Utara Irrigation Area (main)	BG.0-BG.1 A	5346	0.0001	8.44	0.57	157	2.61
Batanghari Utara Irrigation Area (main)	BG.1 A-BG.1 B	1908	0.0001	8.41	0.49	66	3.71
Batanghari Utara Irrigation Area (main)	BG.1 B-BG.1 C	3567	0.0000	8.40	0.41	145	6.12
Batanghari Utara Irrigation Area (main)	BG.1 C-BG.1	174	0.0015	8.32	1.36	2	6.16
Batanghari Utara Irrigation Area (main)	BG.1-BG. 2	1323	0.0000	8.05	0.27	81	7.51
Batanghari Utara Irrigation Area (main)	BG.2-BG.3 A	363	0.0009	7.34	1.12	5	7.60
Batanghari Utara Irrigation Area (main)	BG.3 A-BG.3	336	0.0003	7.33	0.73	8	7.73
Batanghari Utara Irrigation Area (main)	BG.3-BG.4 A	722	0.0012	7.26	1.23	10	7.89
Batanghari Utara Irrigation Area (main)	BG.4A-BG.4	40	0.0013	7.10	1.23	1	7.90
Batanghari Utara Irrigation Area (main)	BG.4-BG. 5	205	0.0017	6.40	1.35	3	7.95
Batanghari Utara Irrigation Area (main)	BG.5-BG. 6	1826	0.0001	6.31	0.54	56	8.88
Batanghari Utara Irrigation Area (main)	BG.6-BG.7	1158	0.0006	5.80	0.92	21	9.23
Batanghari Utara Irrigation Area (main)	BG.7-BG.8	327	0.0003	5.18	0.72	8	9.36
Batanghari Utara Irrigation Area (main)	BG.8-BG.9 A	1489	0.0000	4.07	0.17	146	11.79
Batanghari Utara Irrigation Area (main)	BG.9 A-BG.9	1109	0.0001	4.00	0.50	37	12.40
Batanghari Utara Irrigation Area (main)	BG.9-BG.10 A	746	0.0004	3.63	0.75	17	12.68
Batanghari Utara Irrigation Area (main)	BG.10 A-BG.10 B	113	0.0004	3.58	0.71	3	12.72
Batanghari Utara Irrigation Area (main)	BG.10 B-BG.10	1172	0.0001	3.41	0.35	56	13.66
Batanghari Utara Irrigation Area (main)	BG.10-BG.11	1408	0.0001	3.07	0.49	47	14.45
Batanghari Utara Irrigation Area (main)	BG.11-BG.12	828	0.0003	2.87	0.66	21	14.80
Batanghari Utara Irrigation Area (main)	BG.12-BG.13	1195	0.0004	1.59	0.64	31	15.32
Batanghari Utara Irrigation Area (main)	BG.13-BG.14 A	580	0.0001	1.34	0.36	27	15.77
Batanghari Utara Irrigation Area (main)	BG.14 A-BG.14	272	0.0003	1.29	0.52	9	15.92
Batanghari Utara Irrigation Area (main)	BG.14-BG.15 A	811	0.0001	1.13	0.37	37	16.53
Batanghari Utara Irrigation Area (main)	BG.15 A-BG.15	1294	0.0007	0.89	0.66	33	17.08
Batanghari Utara Irrigation Area (main)	BG.15-BG.16 A	1730	0.0025	0.43	0.85	34	17.65
Batanghari Utara Irrigation Area (main)	BG.16 A-BG.16	587	0.0016	0.39	0.70	14	17.88
Batanghari Utara Irrigation Area (main)	BG.16-BG.17	917	0.0010	0.30	0.59	26	18.31
Batanghari Utara Irrigation Area (main)	BG.17-BG.18	747	0.0052	0.16	0.87	14	18.55

Source: PPC of Way Sekampung

5.4 - Conclusion and Recommendation

The flow arrival time is applied to the Irrigation Management System (SIPASI) to have control of the suitable time, which is aligned with the farmer's irrigation cropping plan.

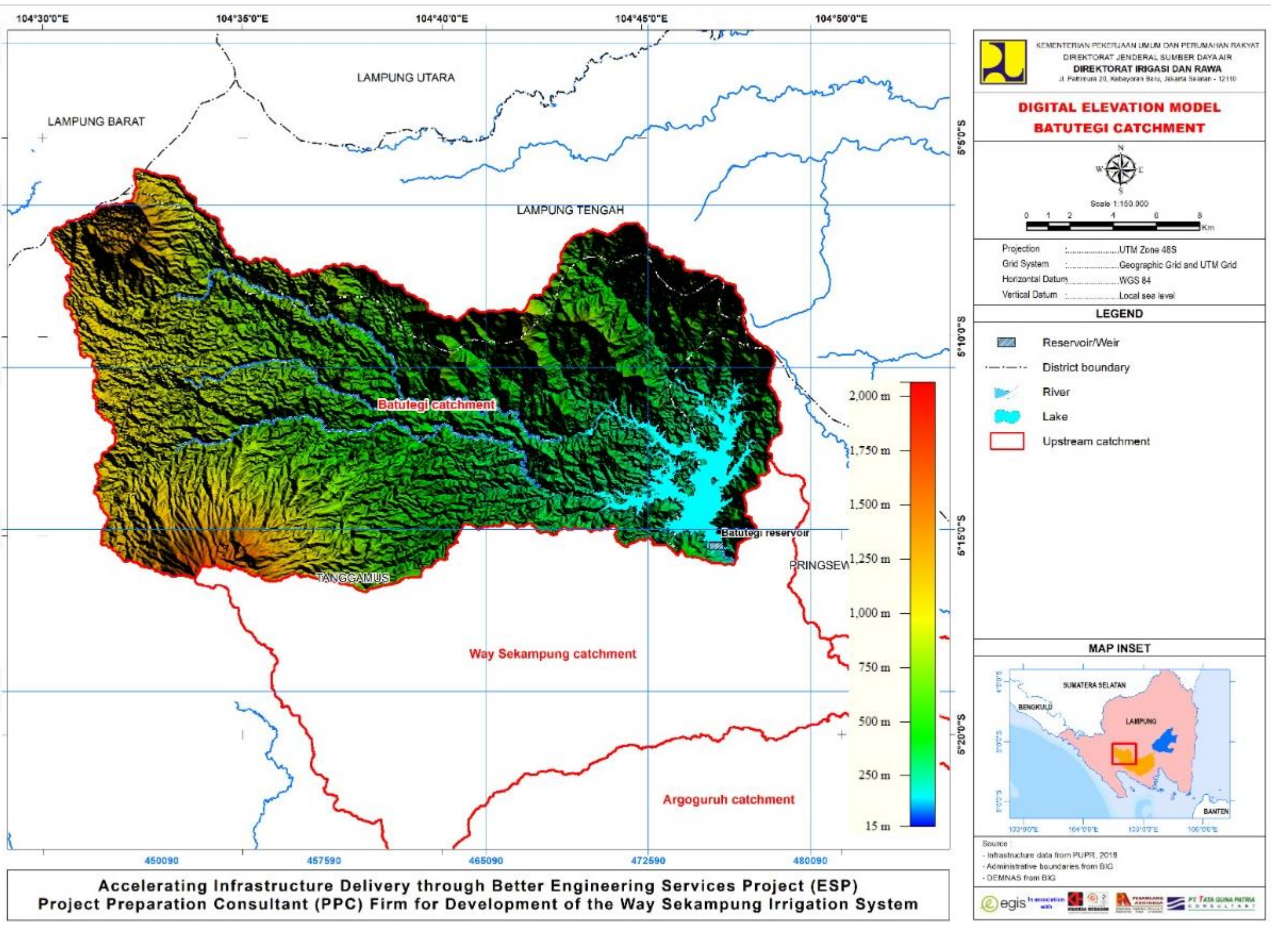
6 - THE EFFECTS OF EL NIÑO-SOUTHERN OSCILLATION AND INDIAN OCEAN DIPOLE ON THE INFLOW OF BATUTEGI RESERVOIR

6.1 - Preface

Climate and rainfall in Sumatra are influenced by monsoons and are prone to sea surface temperature anomalies. The most well-known fact to date is the climate disturbance caused by El Niño and La Niña anomalies to sea surface temperatures. It has been proven that a strong El Niño causes drought in Indonesia and a strong La Niña causes flooding. This is known as the El Niño-Southern Oscillation (ENSO). ENSO is related to the difference in seawater temperature between the Eastern Pacific Ocean near Latin America and the Western Pacific Ocean near Papua. A less widely known fact is the existence of another oceanic system that affects the climate in Sumatra, namely the Indian Ocean Dipole (IOD) which is related to the difference in sea surface temperature between the West Indian Ocean near the African continent and the East Indian Ocean near Sumatra. This article explains how these two phenomena are related to the inflow of the Batutegi reservoir (higher rainfall = higher flow) (Figure 6–1).

Multiple regression analysis has been applied to the available monthly data of the Batutegi reservoir inflow. Apparently, about 96% of the variance of the Batutegi reservoir inflow can be explained by the changes in the ENSO and IOD indices over time. Since long-term predictions of ENSO and IOD are available, this strong correlation opens the possibility of long-term prediction of the Batutegi reservoir inflow based on available ENSO and IOD indices. The conclusion from the prediction results is still not reliable.

FIGURE 6–1 BATUTEGI WATERSHED LOCATION



Source: PPC of Way Sekampung

6.2 - El Niño-Southern Oscillation (ENSO)

El Niño and La Niña are opposite phases of the natural climate pattern in the Tropical Pacific Ocean. The ENSO pattern in the Tropical Pacific Ocean can be in one of three phases:

- El Niño,
- Neutral, or
- La Niña.

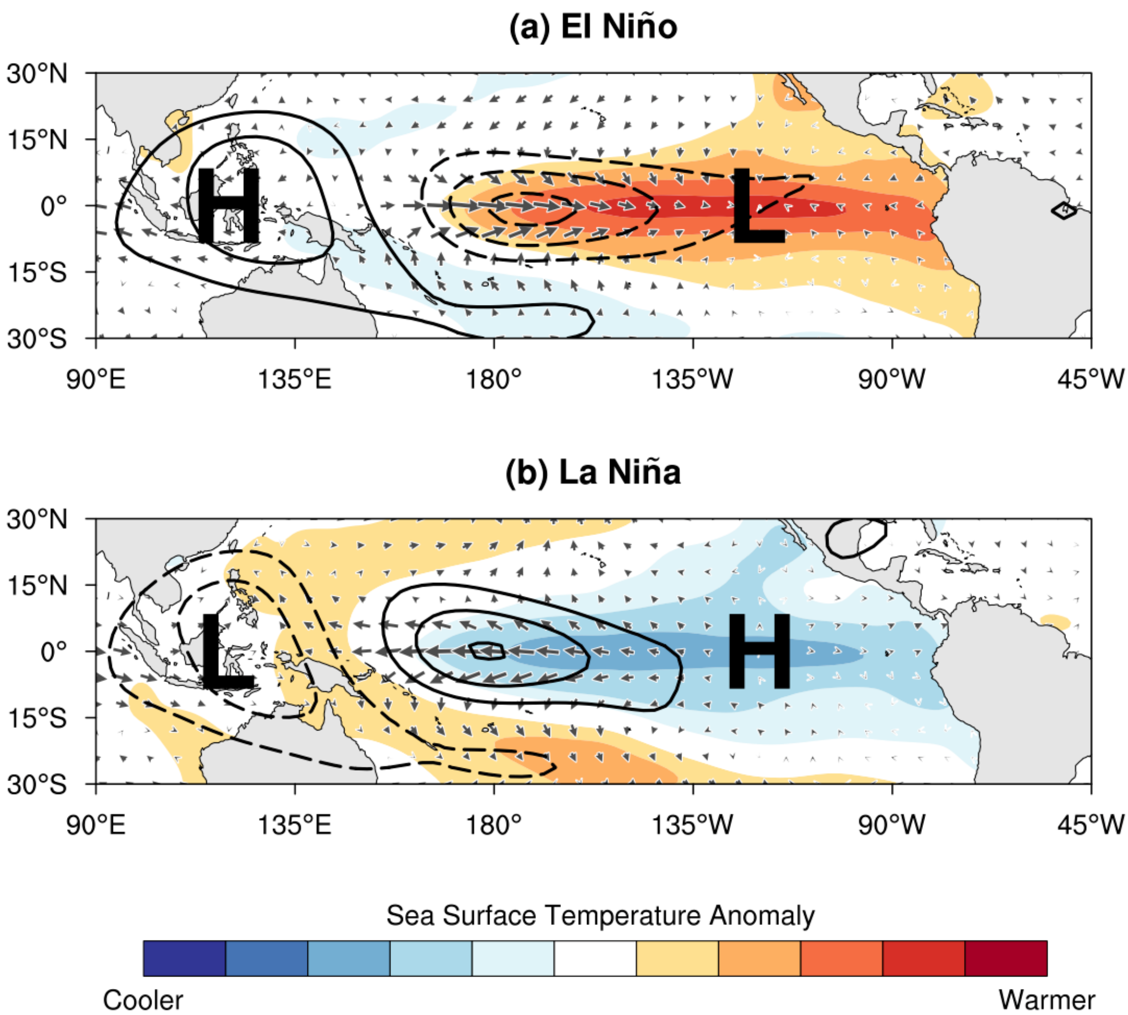
El Niño (warm temperatures near Latin America and cold temperatures near Indonesia) and La Niña (cold temperatures near Latin America and warm temperatures near Indonesia) cause significant differences in the average sea surface temperature, wind, air pressure, and rainfall throughout the Tropical Pacific Ocean.

Neutral indicates that conditions are close to the long-term average. ENSO is the most influential climatic pattern phenomenon on Earth. A period of weaker and stronger winds to the average trade wind, initiating El Niño and La Niña that swings back and forth every 3-7 years on average.

The ENSO anomaly disrupts atmospheric circulation in Earth's largest ocean basin, El Niño shifting the average location and strength of jet streams at middle latitudes, resulting in "side effects" on weather around the world.

In Sumatra, a strong El Niño initiates lower than average rainfall and therefore lower flows, whereas a strong La Niña initiates higher than average rainfall and therefore higher flows.

FIGURE 6–2 ENSO OSCILLATION



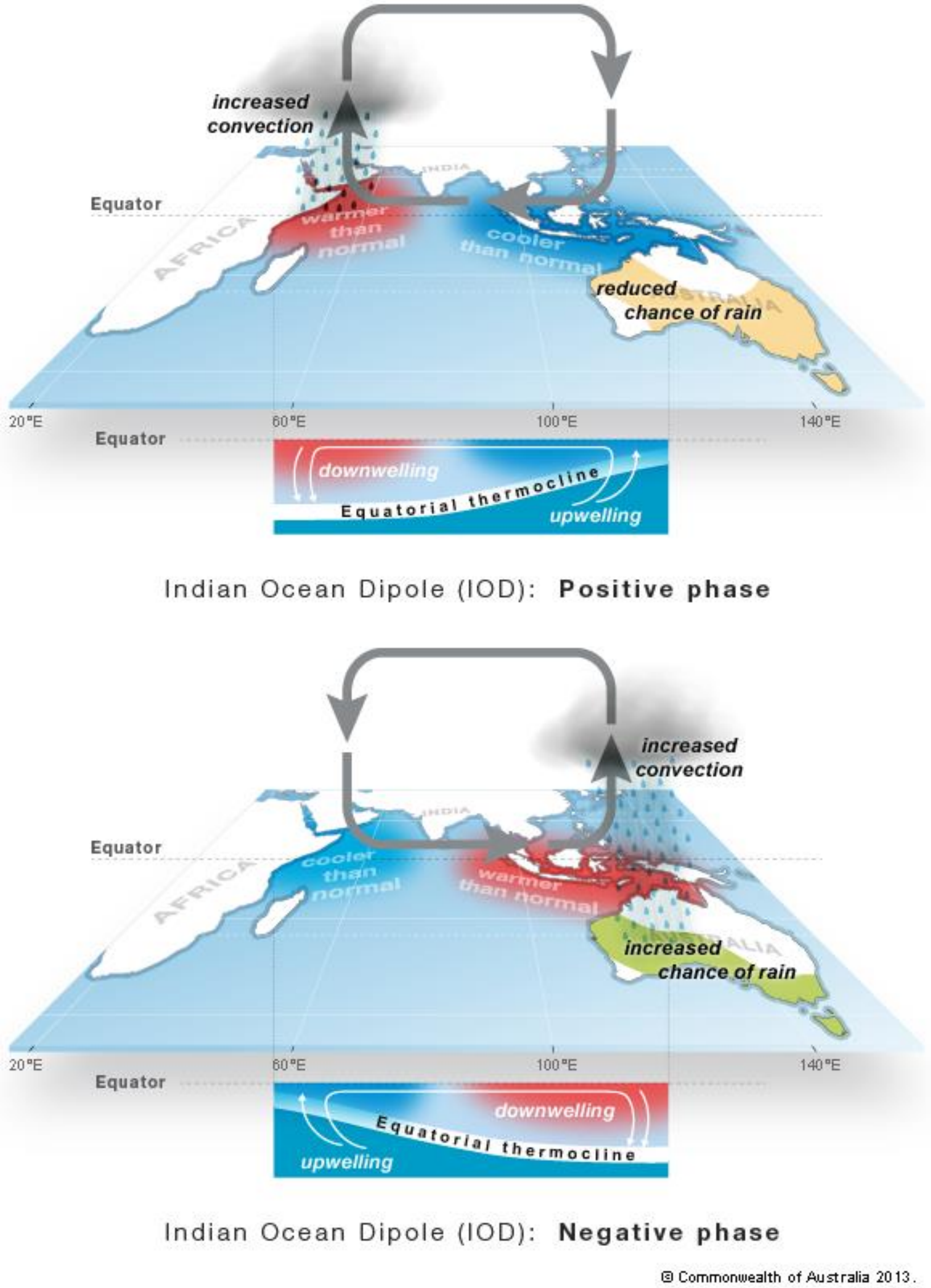
Source: *https://esrl.noaa.gov/psd/enso/mei/*

In areas with warmer temperatures, there is an increase in convection (vapor rises to the clouds) and hence an increase in rainfall. For Indonesia, this means that during La Niña there is an increased probability of flooding and, during El Niño, an increase in drought is expected (see Figure 6–2).

6.3 - Indian Ocean Dipole (IOD)

The Indian Ocean Dipole (IOD) is an irregular sea surface temperature oscillation in which the western Indian Ocean becomes alternately warmer (positive phase) and then cooler (negative phase) than the eastern Indian Ocean.

FIGURE 6–3 DIPOL SAMUDERA HINDIA (IOD)



Source: http://www.bom.gov.au/climate/iod/#tabs=Indian-Ocean-climate-drivers

IOD is usually characterized by anomalous cooling of sea surface temperatures in the southeastern part of the Equatorial Indian Ocean and anomalous warming of sea surface temperatures in the western part of the Equatorial Indian Ocean. Related to this change, the normal convection that is located above the Eastern Indian Ocean shifts to the west and brings high rainfall in the East African continent and drought/wildfires in the Indonesian region.

Figure 6–3 shows the expectations for Australia regarding the IOD. For Sumatra, positive IOD brings higher than average rainfall, and therefore the inflow from the Batutegi watershed into the Batutegi reservoir is also higher than average. Negative IOD causes lower than average rainfall so that the inflow of the Batutegi reservoir is lower. The IOD is a combined atmospheric-oceanic phenomenon in the Indian Ocean.

6.4 - Multiple Regression of IOD and ENSO Indec with the Batutegi Reservoir Inflow

To test the suitability of using ENSO and IOD values to explain the observed natural variation in the inflow of the Batutegi reservoir, the ENSO and IOD indices were collected. There are many ENSO and IOD indices produced by several institutes around the world to track the state of the world's oceans and weather.

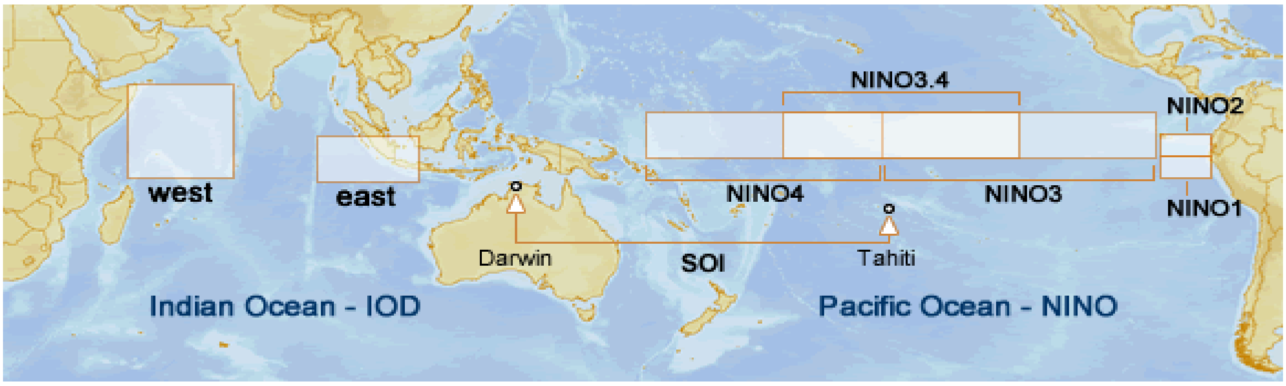
However, keep in mind that the goal is to get long-term forecasts, so the index that will be used in the regression must also be available in the forecast.

Forecasts are available from the Climate Prediction Center (CPC) of the National Oceanic and Atmospheric Administration (NOAA) in the United States (*https://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_advisory/ensodisc.shtml*), Australian Bureau of Meteorology (*http://www.bom.gov.au/climate/enso/*), Columbia University in Ohio (*https://iri.columbia.edu/our-expertise/climate/forecasts/enso/current/*), World Meteorological Organization (WMO) *https://public.wmo.int/en/our-mandate/climate/el-ni%C3%B1ola-ni%C3%B1a-update*), and Japan Agency for Marine-Earth Science and Technology (JAMSTEC) *http://www.jamstec.go.jp/aplinfo/sintexf/e/index.html*).

Given that the goal is to have long-term forecasts, it was discovered that only JAMSTEC provides an easily accessible long-term predictive index. The JAMSTEC index was generated using the SINTEX-F model. SINTEX-F, the combined Global Circulation Model (GCM) is one of the world's leading models that consistently predicts IOD and ENSO over the long term.

This model also helps to understand the mechanism of IOD, ENSO, and ENSO Modoki.

FIGURE 6–4 INDEX DEFINITION BY LOCATION



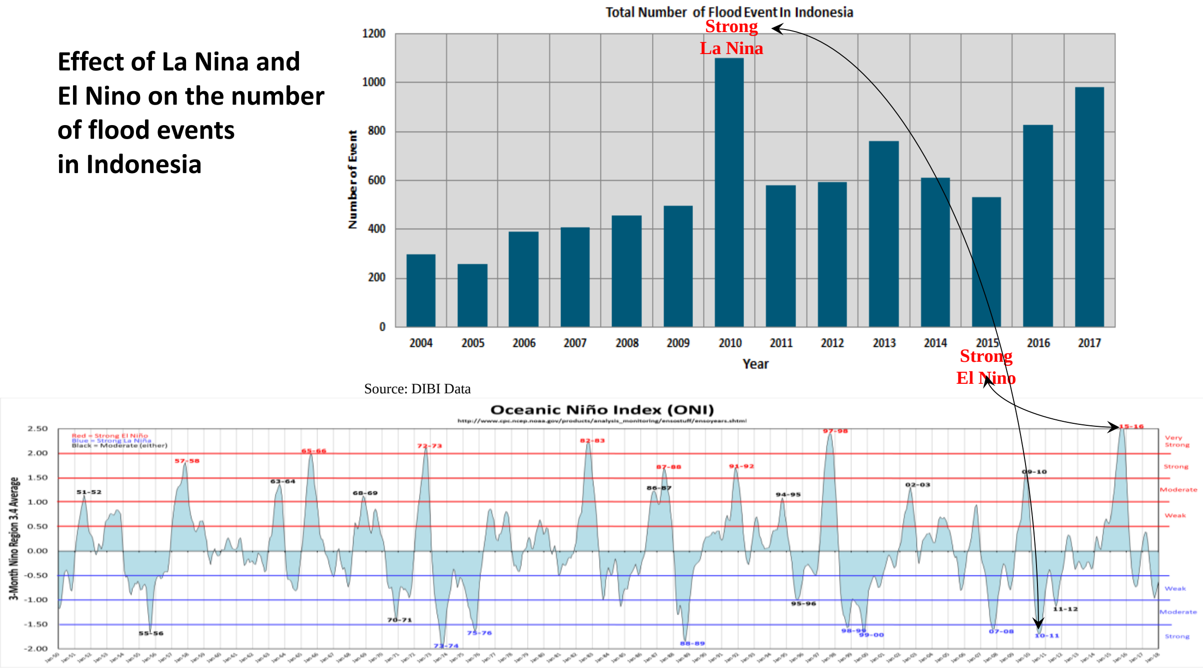
Source: *HTTP://WWW.BOM.GOV.AU/CLIMATE/INFLUENCES/IMAGES/MAP-INDICES.PNG*

From the regression analysis on the available ENSO indices, it is concluded that the forecasts for changes in rainfall are best based on the index located near the coast of America. For example, the indices NINO 1 and NINO 2 give better results than NINO 4, NINO 3.4, and NINO 3. (see Figure 6–4 andFigure 6–5, for location).

Since the availability of these indices is not all produced by JAMSTEC, the California Niño Index (CNI) was chosen because of its better results when compared to the NINO 3.4 index which is also available at JAMSTEC. The CNI index is generated from a location just off the California coast and is particularly well-suited for tracking strong ENSO anomalies.

As can be seen in Figure 5, the observed anomaly for ENSO causes changes in the occurrence of flood events.

FIGURE 6–5 OBSERVATIONS ON ENSO THAT CAUSED AN INCREASE (2010) AND A DECREASE (2015) IN THE NUMBER OF FLOOD EVENTS



Source: PPC of Way Sekampung

The IOD index at JAMSTEC is called the Indian Ocean Dipole Mode Index (DMI) and this DMI index is also used. Apparently, sometimes CNI and DMI work together to increase rainfall anomalies and sometimes contradict and cancel each other out. Together, however, they can predict the natural variation of Batutegi inflow with a high degree of accuracy.

6.5 - Monthly multiple regression gives the best result

Based on the literature, it appears that the actual weather in Sumatra can be influenced by IOD and ENSO anomalies in the past. Multiple regression is performed on historical data up to the previous 6 months. After testing using a simple time lag of 1 to 6 months, multiple regression was performed by using the data from an average time lag of 2, 3, 4, 5 to an average of 6 months. It was found that by using the average index value, the regression results were found to be better than when using the simple monthly lag time. Thus, the regression has 6 IOD indices (DMI) and 6 ENSO indices (CNI). The results of the monthly regression of each index depend on each month, thus the monthly average regression is carried out for the period January 2010 to September 2019. For each month, there are 9 or 10 data used.

With 12 variables and only 9 or 10 years of observations, the regression needs to be done in 3 stages:

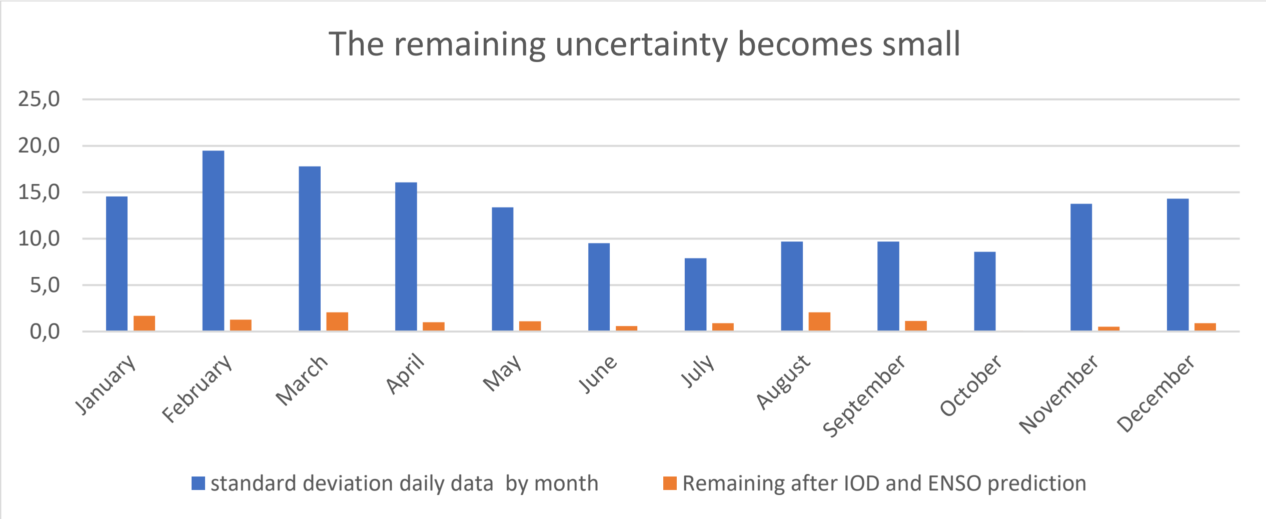
- The use of 6 IOD indices and selection of IOD with the best statistical analysis results
- The use of 6 ENSO indices and the selection of ENSO with the best statistical analysis results
- The selection of 6 indices with the best statistical analysis results to get a mixture of IOD and ENSO indices for the month
- Repeat the process for the next month

Batutegi's average monthly flows have a large variation with values ranging between 5 to 60 m^3/s. The standard deviation for all monthly flows is 16.1 m^3/s.

After accounting for seasonal variations, the monthly average standard deviation drops to 12.9 m^3/s (see Figure 6–6).

Multiple regression using the best mixture of IOD and ENSO for each month with observations of the Batutegi reservoir inflows resulted in a decrease in the standard deviation to 1.1 m^3/s (see Figure 6–6). The average decrease in the observed monthly standard deviation was 91%.

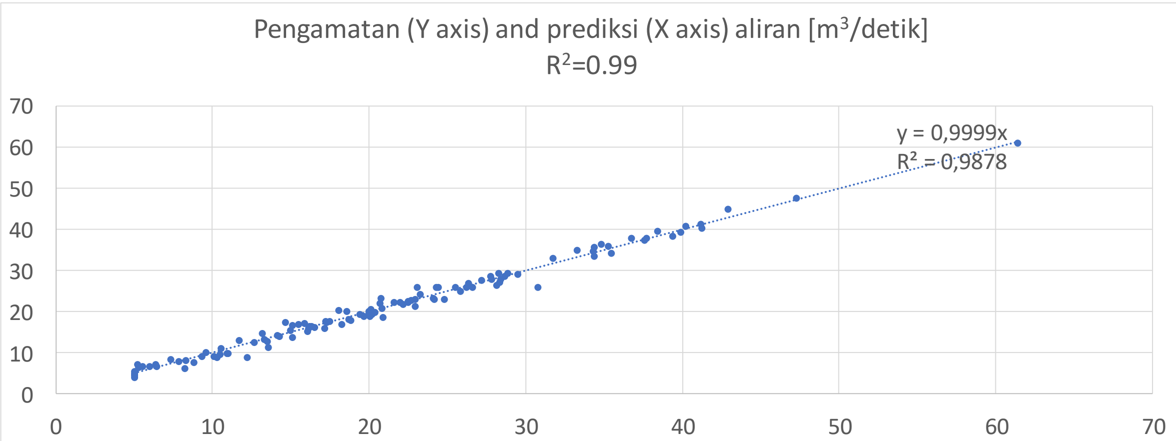
FIGURE 6–6 RESIDUAL STANDARD DEVIATION AFTER IOD AND ENSO CORRELATION



Source: PPC of Way Sekampung

Another way to analyze the results is to compare the observations of the inflow of the Batutegi reservoir with the results of the correlation index per month. This is done in two ways, first by using a "scatter diagram" (see Figure 6–6), second by drawing the data in a time-series fashion (see Figure 6–8**)**.

FIGURE 6–7 OBSERVATIONS ON THE BATUTEGI RESERVOIR INFLOW [M3/S] WITH FORECASTED FLOW MODELED USING IOD AND ENSO

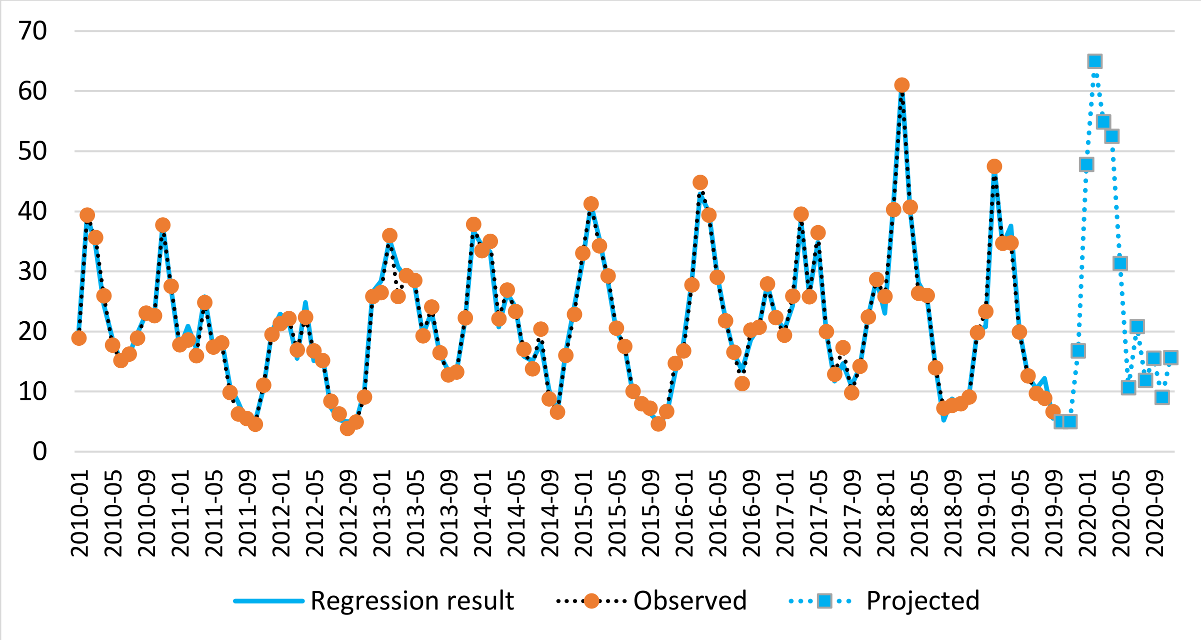


Source: PPC of Way Sekampung

6.6 - Forecast

Based on the prediction of IOD and ENSO index values from JAMSTEC until November 2020, forecasts using monthly regression results were made. These forecasts are shown in Figure 6–8. In recent months, there have been very high IOD index values and this is expected to lead to higher flows than usual in January, February, March, and April 2020.

FIGURE 6–8 OBSERVATIONS ON FLOW, REGRESSION RESULTS, AND FORECASTS



Source: PPC of Way Sekampung

TABLE 6-1 INFLOW PREDICTION (AVERAGE) [M3/S] IN BATUTEGI UNTIL NOVEMBER 2020

2019-10	2019-11	2019-12	2020-01	2020-02	2020-03	2020-04	2020-05	2020-06	2020-07	2020-08	2020-09	2020-10	2020-11
5	5	17	48	65	55	53	31	11	21	12	16	9	16

Source: PPC of Way Sekampung

6.7 - Comparison of Observed and Forecasted Flows

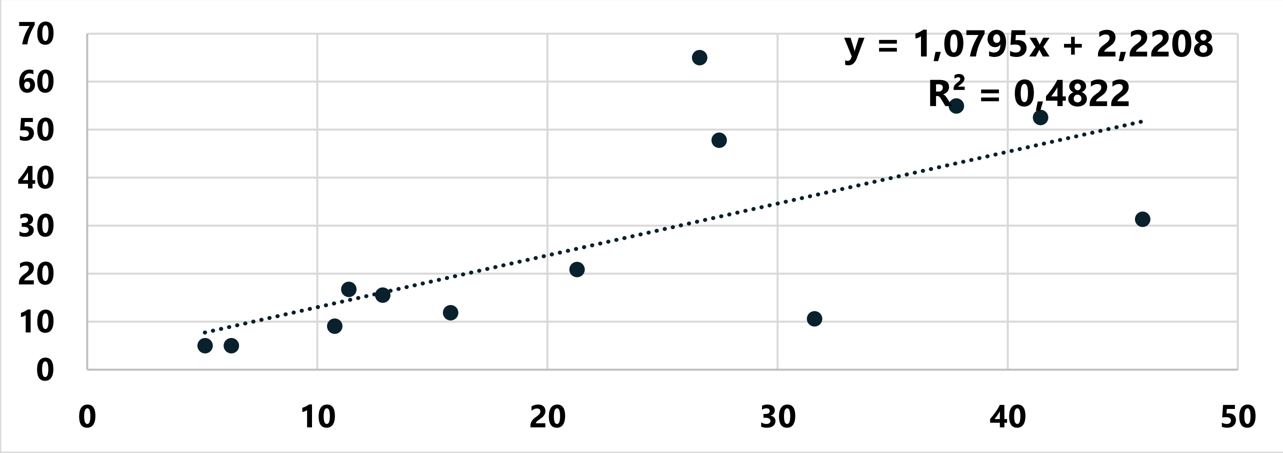
In November 2020, the data of the Batutegi reservoir inflow was collected from the Mesuji Sekampung BBWS and used until the end of the observation period (see Figure 6–9):

FIGURE 6–9 OBSERVATIONS ON FLOW UNTIL OCTOBER 2020 WITH REGRESSION RESULTS AND FORECASTS RESULTS IN 2019

Source: PPC of Way Sekampung

It is seen that this prediction is not optimal because the observed peak flow is lower and 3 months slower than expected. The prediction has an RMSE of 15 m^3/s, so the prediction is no better than for example using only the 10-year average monthly flow as a predictor.

FIGURE 6–10 SCATTER CHART OF FORECASTED FLOW (Y-AXIS) AND OBSERVATIONAL FLOW (X-AXIS) = LOW CORRELATION

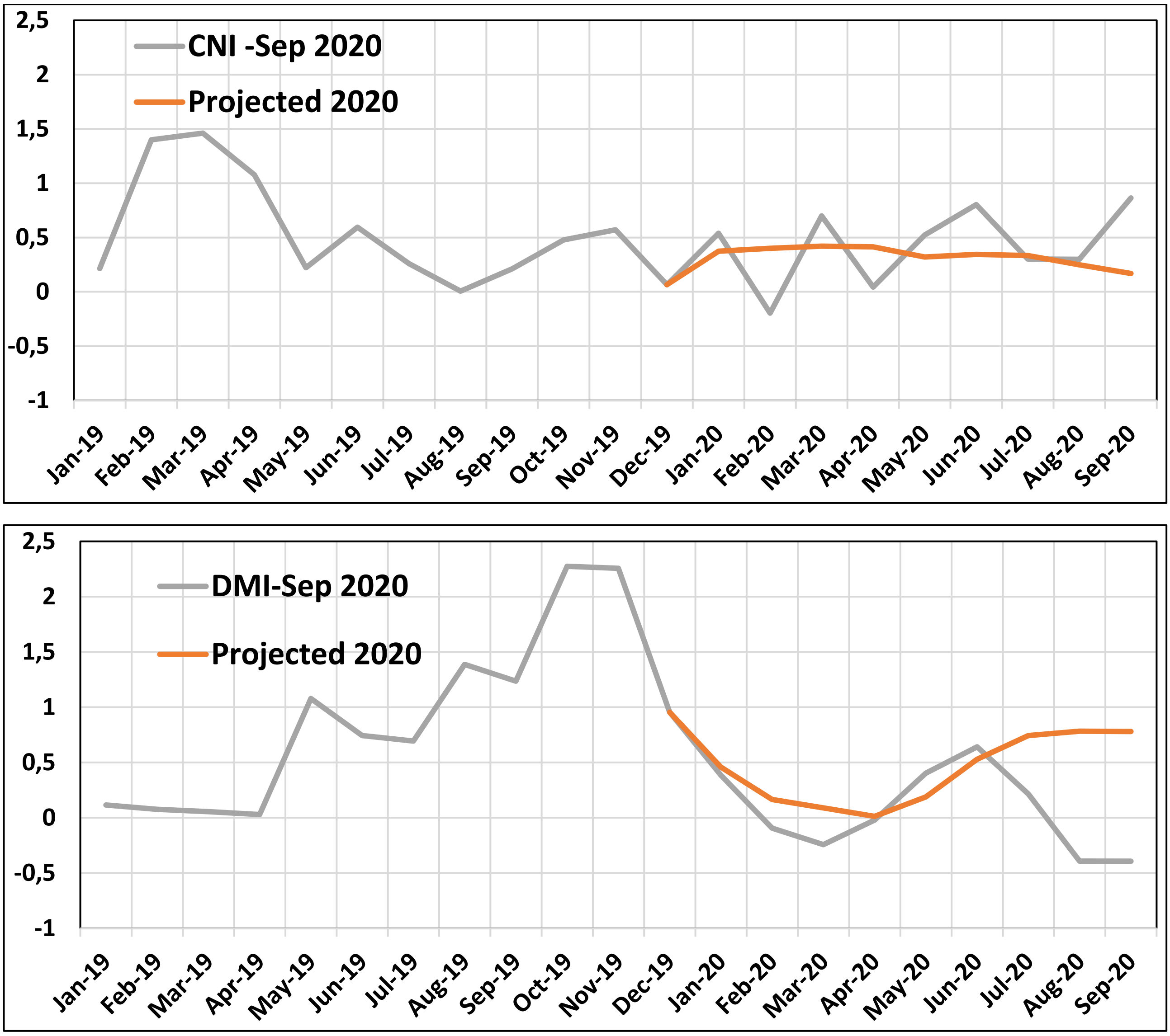


Source: PPC of Way Sekampung

6.8 - Comparison of observed and forecasted DMI and CNI index

The CNI (ENSO) and DMI (IOD) indices are downloaded to show the observed values and compare them with the forecasted index values.

FIGURE 6–11 OBSERVATIONS AND FORECASTS OF CNI AND DMI INDEX



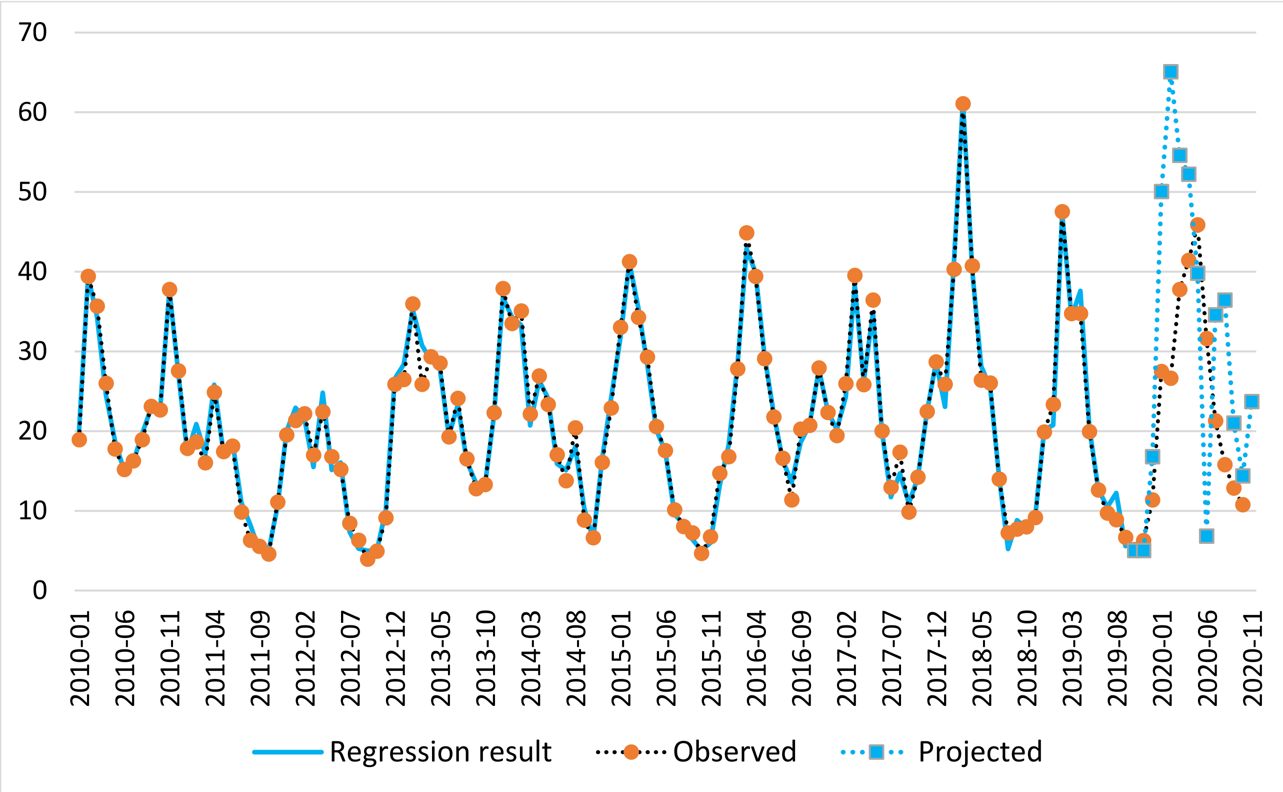
Source: PPC of Way Sekampung

It can be seen that the observed index is different from what was forecasted. The CNI index (ENSO) above shows a constant low value for forecast results and for observations it looks more varied and reaches a higher positive value (drier).

The DMI Index (IOD) shows a much lower observational value especially during the months of February, March, August, and September.

6.9 - Would the forecasts be better using the observed index?

FIGURE 6–12 APPLICATION OF OBSERVATION INDEX AND CORRELATION RESULTS



Source: PPC of Way Sekampung

If observational data for the ENSO index (CNI) and the IOD index (DMI) were available last year, would the prediction be better?

In

Figure 6–12 it is shown that the forecasts are not getting better. In other words, past regression results are not valid for the future.

6.10 - Conclusion

6.10.1 - Strong correlation between IOD, ENSO, and monthly flow of Batutegi reservoir

A strong correlation was found between IOD, ENSO, and flow in the Batutegi watershed area. The results of the strong correlation led to the concept that the regression can be used for long-term flow forecasts.

6.10.2 - Long-term flow forecasts are not reliable

Long-term flow forecasts have proven unreliable for two reasons. First, the forecasts of the IOD and ENSO indices are not reliable. Second, although these indices are reliable, the regression is not applicable to future flows.

6.10.3 - The direction of the anomaly can give an indication (wet/dry)

This means that to generate forecasts, a different approach is needed. When there is a strong forecast of an anomaly over several months, it is clear that this will have an impact on the flow, but knowing how big it is requires a different determination method.

6.10.4 - Further research is needed to improve reliability

Long-term flow forecasts as analyzed in this article are not reliable. Further research is needed to determine how the reliability of the predictions can be improved.

One of the research objections is to specifically analyze the occurrence of all very strong anomalies using a 3-month average because this average allows it to have the ability to show the direction of flow change compared to the “normal” situation using monthly averages.

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APPENDIX

APPENDIX 1

Example of timeseries data: column of runoff flow in Way Sekampung sub-watershed

Month	Year	Nr of Days	YYYY-MM	Selected column (m3/s)
				RainRunWSC
1	2	3	4	5
Month	Year	Nr.	YYYY-MM	RunoffWSC
1	2010	31	2010-01	28,3
2	2010	28	2010-02	32,9
3	2010	31	2010-03	27,6
4	2010	30	2010-04	19,4
5	2010	31	2010-05	15,9
6	2010	30	2010-06	15,9
7	2010	31	2010-07	15,3
8	2010	31	2010-08	16,3
9	2010	30	2010-09	16,1
10	2010	31	2010-10	14,4
11	2010	30	2010-11	16,3
12	2010	31	2010-12	15,3
1	2011	31	2011-01	16,9
2	2011	28	2011-02	20,2
3	2011	31	2011-03	16,8
4	2011	30	2011-04	18,7
5	2011	31	2011-05	12,8
6	2011	30	2011-06	9,9
7	2011	31	2011-07	7,7
8	2011	31	2011-08	6,3
9	2011	30	2011-09	5,6
10	2011	31	2011-10	5,0
11	2011	30	2011-11	4,6
12	2011	31	2011-12	4,5
1	2012	31	2012-01	12,9
2	2012	29	2012-02	17,9
3	2012	31	2012-03	14,1
4	2012	30	2012-04	18,1
5	2012	31	2012-05	12,4
6	2012	30	2012-06	12,5
7	2012	31	2012-07	9,1
8	2012	31	2012-08	7,3
9	2012	30	2012-09	6,2
10	2012	31	2012-10	5,4
11	2012	30	2012-11	23,3
12	2012	31	2012-12	30,9
1	2013	31	2013-01	36,5
2	2013	28	2013-02	29,3
3	2013	31	2013-03	25,9
4	2013	30	2013-04	22,2
5	2013	31	2013-05	20,7
6	2013	30	2013-06	15,9
7	2013	31	2013-07	18,9

Month	Year	Nr of Days	YYYY-MM	Selected column (m3/s)
				RainRunWSC
1	2	3	4	5
Month	Year	Nr.	YYYY-MM	RunoffWSC
8	2013	31	2013-08	13,1
9	2013	30	2013-09	10,1
10	2013	31	2013-10	7,8
11	2013	30	2013-11	9,1
12	2013	31	2013-12	15,8
1	2014	31	2014-01	18,3
2	2014	28	2014-02	19,9
3	2014	31	2014-03	20,5
4	2014	30	2014-04	16,3
5	2014	31	2014-05	14,8
6	2014	30	2014-06	11,0
7	2014	31	2014-07	9,6
8	2014	31	2014-08	10,5
9	2014	30	2014-09	8,1
10	2014	31	2014-10	6,6
11	2014	30	2014-11	10,7
12	2014	31	2014-12	21,3
1	2015	31	2015-01	24,7
2	2015	28	2015-02	28,6
3	2015	31	2015-03	24,5
4	2015	30	2015-04	20,2
5	2015	31	2015-05	19,8
6	2015	30	2015-06	15,4
7	2015	31	2015-07	11,0
8	2015	31	2015-08	8,5
9	2015	30	2015-09	7,0
10	2015	31	2015-10	5,9
11	2015	30	2015-11	5,2
12	2015	31	2015-12	4,8
1	2016	31	2016-01	9,1
2	2016	29	2016-02	16,4
3	2016	31	2016-03	22,2
4	2016	30	2016-04	26,4
5	2016	31	2016-05	28,9
6	2016	30	2016-06	21,9
7	2016	31	2016-07	17,6
8	2016	31	2016-08	16,6
9	2016	30	2016-09	19,0
10	2016	31	2016-10	18,6
11	2016	30	2016-11	23,7
12	2016	31	2016-12	17,2
1	2017	31	2017-01	13,5
2	2017	28	2017-02	24,7
3	2017	31	2017-03	21,2
4	2017	30	2017-04	23,4
5	2017	31	2017-05	16,9
6	2017	30	2017-06	19,7
7	2017	31	2017-07	13,4

Month	Year	Nr of Days	YYYY-MM	Selected column (m3/s)
				RainRunWSC
1	2	3	4	5
Month	Year	Nr.	YYYY-MM	RunoffWSC
8	2017	31	2017-08	10,0
9	2017	30	2017-09	8,0
10	2017	31	2017-10	6,5
11	2017	30	2017-11	8,3
12	2017	31	2017-12	13,7
1	2018	31	2018-01	13,5
2	2018	28	2018-02	19,4
3	2018	31	2018-03	22,9
4	2018	30	2018-04	21,2
5	2018	31	2018-05	19,8
6	2018	30	2018-06	14,2
7	2018	31	2018-07	10,4
8	2018	31	2018-08	8,1
9	2018	30	2018-09	6,7
10	2018	31	2018-10	5,7
11	2018	30	2018-11	5,1
12	2018	31	2018-12	5,9
1	2019	31	2019-01	13,2
2	2019	28	2019-02	21,0
3	2019	31	2019-03	20,1
4	2019	30	2019-04	18,9
5	2019	31	2019-05	13,0
6	2019	30	2019-06	10,0
7	2019	31	2019-07	7,7
8	2019	31	2019-08	6,4
9	2019	30	2019-09	5,6
10	2019	31	2019-10	5,0
11	2019	30	2019-11	4,7
12	2019	31	2019-12	4,4

APPENDIX 2

Parameter description of the hydraulic model

- **Scenario 0 Downstream Batutegi**
- **Scenario 1 (Current) setting with Batutegi**
- **Scenario 2 (2021 Way Sekampung) setting**
- **Scenario 3 (Climate Change 2040) setting**

Parameter description of the hydraulic model

Block	Description		Unit	Method	Nr	ID	Explanation of method/parameter
1. Date definition	Month				1	Month	Month value of the date, used for summaries and lookups where needed
	Year				2	Year	Year value of the date, used for summaries and lookups where needed
	Nr of Days				3	Nr.	Number of days within the corresponding month, used for summaries and lookups where needed
	YYYY-MM				4	YYYY-MM	Year-Month text of the date, used for summaries of monthly data by year
2. Batutegi catchment BTC	Rainfall		mm/month	Mean	1	RainBTC	Rainfall in the Batutegi Catchment - measured data, but only 1 station available in this catchment.
	Runoff		m3/s	RainRunBTC	2	RunoffBTC	Runoff generated by the rainfall. Comes from rainfall-runoff model
	DMI (net)		m3/s	Lookup	3	DMIBTC	Domestic, municipal, industrial water consumption. As nett (demand minus the return flow). Based on Cipta Karya guidelines and population data from the spatial model. Constant during the year
	Irrigation (nnetett)		m3/s	Fixed flow	4	IrrBTC	Irrigation water consumption. As net (diversion demand minus the return flow). Based on rice field maps, and unit water demands by month with assumed cropping pattern. Uncertainty remains on the % of the rice fields that are irrigated from the river
	Outflow catchment = inflow BTR		m3/s	Calc	5	OutBTC	Calculated as OutBTC = RunoffBTC - DMIBTC - IrrBTC
	NET CATCHMENT	NET BTC	m3/s	Calc	6	NetBTC	Calculated as NetBTC = RunoffBTC – DMIBTC – IrrBTC - EvaporationBTR
		NET BTC	MCM	Calc	7	NetBTCMCM	NetBTCMCM is a conversion NetBTC from m3/s into Million Cubic Meter [MCM]
3. Batutegi reservoir	Demand for BTR		m3/s	Calc	8	Demand for BTR	Demand for BTR is the amount of water needs to be released from BTR. Calculated as DemandforBTR = MAX(0;NetWSC+NetAGC-Otherdemand-WSIrrigationdemand)
	Expected net inflow		m3/s	Calc	9	NetInfBTR	Calculated as NetInfBTR = NetBTC – Deman for BTR
	Delta volume without spill check		MCM	Calc	10	ExpDeltaVBTR	ExpDeltaVBTR is a conversion of NetInfBR from m3/s into Million Cubic Meter [MCM]
	Volume without spill check		MCM	Calc	11	VolwithoutSpillcheckBTR	Is the potential total volume of water inside the reservoir without spillcheck or released. Calculated as VolwithoutSpillcheckBTR = MAX(Volmin;ExpDeltaVBTR(t)+VolumeBTR(t-1)
	Spillway limit volume		MCM	Lookup	12	SpillLimVolBTR	Lookup function on the volume at spillway elevation 274m
	flow needs to be released to get to the upper limit		m3/s	Calc	13	ActualExtraRelBTR	Calculated as AcutalExtraRelBTR=VolwithoutSpillcheckBTR-SpillLimVolBTR Then the result is converted into m3/s
	Volume after spill check		MCM	Calc	14	VASpillBTR	Calculated as VASpillBTR = VolumeBTR + (NetInfBTR- ActualExtraRelBTR*86400*Nr/10^6)
	Allocation		%	Calc	15	AllocationBTR	Lookup of the Batutegi reservoir rule curves ROR of the result: VASpillBTR(t)+VolumeBTR(t-1)/2
	Flow released after spill check		m3/s	Calc	16	FlowRelBTR	Condition: Formula works if ElevationBTR > 226 Calculated as FlowRelBTR = Demand for BTR* AllocationBTR+ ActualExtraRelBTR
	Firm hydro power		m3/s	Calc	17	FirmHydroBTR	Condition: Formula works if ElevationBTR > 226

						Calculated as FirmHydroBTR = MIN(BTR_Firm; FlowRelBTR) BTR_Firm is a table in optimization sheet
	Energy Produced	MILLION kWh	Calc	18	BTR_Energy	Is a conversion of FirmHydroBTR into Million kwh
	Irrigation valve	m3/s	Calc	19	RORIrrBTR	Calculated as RORIrrBTR = FlowRelBTR- FirmHydroBTR
	Possible flow through irrigation gate according to elevation	m3/s	Lookup	20	Irr_gate_max_flow	Lookup up function into the elevation inside the Batutegi reservoir according to design information of irrigation valve elevation. To verify if the released through irrigation gate is possible.
	Spillway	m3/s	Calc	21	RORSpillBTR	The amount of spillway
	Outflow	m3/s	Calc	22	ROROutflowBTRflow	Calculated as ROROutflowBTRflow= FirmHydroBTR+ RORIrrBTR+ RORSpillBTR
	Ouflow MCM	MCM	Cacl	23	ROROutflowBTRMCM	Conversion of ROROutflowBTRflow from m3/s into Million cubic meter[MCM]
	WATER BALANCE CHECK	MCM	Calc	24	WBcheckBTC	Water balance check inside the Batutegi catchment and Batutegi reservoir. Calculated as WBcheckBTC= RORDeltaBTR+ ROROutflowBTRMCM- NetBTCMCM. IF WBcheckBTC = 0, then water balance is correct.
	BTR Elevation with ROR	m	Lookup	25	EleationBTR	Lookup function on VolumeBTR Looking at the elevation depending on the volume
	Delta volume **with sediment** with ROR	MCM	Calc	26	RORDeltaBTR	Calculated as RORDeltaBTR= NetBTC- ROROutflowBTRflow The result is then converted into million cubic meter [MCM]
	Area **with Sediment** with ROR	km2	Lookup	27	AreaBTR	Lookup function on VolumeBTR Looking at the area depending on the volume
	Volume **with sediment** with ROR	MCM	Calc	28	VolumeBTR	Calculated as VolumeBTR(t)= VolumeBTR(t-1)+ RORDeltaBTR
	Evaporation	mm/day	Lookup	29	EvapBTR	Evaporation data
4. Way Sekampung catchment WSC	Rainfall	mm/month	Mean	30	RainWSC	Rainfall in the Way Sekampung Catchment - measured data, but only 1 station available in this catchment.
	Runoff	m3/s	RainRunWSC	31	RunoffWSC	Runoff generated by the rainfall. Comes from rainfall-runoff model
	DMI (nett)	m3/s	Lookup	32	DMIWSC	Domestic, municipal, industrial water consumption. As net (demand minus the return flow). Based on Cipta Karya drinking water guidelines and population data from the spatial model. Constant during the year.
	Irrigation (nett)	m3/s	Fixed flow	33	IrrWSC	Irrigation water consumption. As net (diversion demand minus the return flow). Based on rice field maps, and unit water demands by month with assumed cropping pattern. Uncertainty remains on the % of the rice fields that are irrigated from the river
	NET CATCHMENT – NET WSC	m3/s	Calc	34	NetWSC	Calculated as NetWSC = RunoffWSC – DMIWSC – IrrWSC - EvaporationWSR
	NET CATCHMENT – NET WSC	MCM	Calc	35	NetWSCMCM	NetWSCMCM is a conversion NetWSC from m3/s into Million Cubic Meter [MCM]

Way Sekampung reservoir	remaining Demand for WSR	m3/s	Calc	36	DemandWSR	Calculated as the sum of all downstream Way Sekampung reservoir water demand including Argoguruh weir water demand (Way Sekampung irrigation system, Metro city and Lampung city water demand)
	Expected net inflow	m3/s	Calc	37	ExpInWSR	Calculated as ExpInWSR = NetWSC – DemandWSR
	Expected delta volume without spill check	MCM	Calc	38	ExpDeltaVWSR	ExpDeltaVBTR is a conversion of ExpInWSR from m3/s into Million Cubic Meter [MCM]
	Volume without spill check	MCM	Calc	39	ChkVolWSR	Is the potential total volume of water inside the reservoir without spill check or released. Calculated as ChkVolWSR = MAX(Volmin; ExpDeltaVWSR (t)+ WSRVolume (t-1)
	volume at spillway elevation	MCM	Lookup	40	LimitSpillWSR	Lookup function on the volume at spillway elevation
	flow needs to be released to get to the upper limit	m3/s	Calc	41	ExtraRelWSR	Calculated as ExtraRelWSR = ChkVolWSR - LimitSpillWSR Then the result is converted into m3/s
	Volume after spillcheck	MCM	Calc	42	VASpillWSR	Calculated as VASpillWSR = WSRVolume + (ExpInWSR - ExtraRelWSR *86400*Nr/10^6)
	MAXIMUM FLOW POSSIBLE	m3/s	Calc	43	MaxFlowWSR	Check of a maximum flow possible due to elevation and ROR rule curves
	Allocation	%	Cacl	44	AllocationWSR	Lookup of the Way Sekampung reservoir rule curves ROR of the result: VASpillWSR (t)+ WSRVolume (t-1)/2
	Flow released after spill + % allocation	m3/s	Calc	45	FlowReleaWSR	The actual flow that will be released. Calculated as FlowReleaWSR=IF(ExpInWSR>0; DemandWSR+ ExtraRelWSR;(MIN(MaxFlowWSR; NetWSC+ DemandWSR- ExpInWSR* AllocationWSR+ ExtraRelWSR))
	Firm hydro power	m3/s	Calc	46	FirmHdroWSR	Condition: Formula works if WSRelev > 113 Calculated as FirmHdroWSR = MIN(WSR_Firm; FlowReleaWSR) WSR _Firm is a table in optimization sheet
	Energy produced from hydropower	MILLION kWh	Calc	47	FirmEnergy	It is a conversion of FirmHdroWSR into Million kwh
	Irrigation vavle	m3/s	Calc	48	IrrValveRORWSR	Calculated as IrrValveRORWSR = FlowReleaWSR - FirmHdroWSR
	Spillway	m3/s	Calc	49	SpillRORWSr	The amount of spillway
	Outflow	m3/s	Calc	50	OutflowrorWSRflow	Calculated as OutflowrorWSRflow= FirmHdroWSR+ IrrValveRORWSR+ SpillRORWSr
	Outflow	MCM	Calc	51	OuflowWSRMCM	Conversion of OutflowrorWSRflow from [m3/s] into million cubic meter [MCM]
	WATER BALANCE CHECK WSC	MCM	Calc	52	WBcheckWSC	Water balance check inside the Way Sekampung catchment and Way Sekampung reservoir. Calculated as WBcheckWSC = DeltaVol + OuflowWSRMCM - NetWSCMCM . IF WBcheckWSC = 0, then water balance is correct.
	WSR Elevation with ROR	m	Lookup	53	WSRelev	Lookup function on WSRVolume Looking at the elevation depending on the volume

	Delta volume	MCM	Calc	54	DeltaVol	Calculated as DeltaVol = NetWSC - OutflowrorWSRflow The result is then converted into million cubic meter [MCM]
	Area	km2	Lookup	55	WSRArea	Lookup function on WSRVolume Looking at the area depending on the volume
	Volume **with sediment** with ROR	MCM	Calc	56	WSRVolume	Calculated as WSRVolume (t)= WSRVolume (t-1)+ DeltaVol
	Evaporation	mm/day	Lookup	57	EvapWSR	Evaporation data. Same as EvapBTR
6. Argoguruh catchment AGC	Rainfall	mm/month	Mean	58	RainAGC	Rainfall of the Argoguruh Catchment - measured data, but only 1 station available in this catchment.
	Runoff	m3/s	RainRunAGC	59	RunoffAGC	Runoff generated by the rainfall. Comes from rainfall-runoff model
	DMI (nett)	m3/s	Lookup	60	DMIAGC	Domestic, municipal, industrial water consumption. As net (demand minus the return flow). Based on Cipta Karya guidelines and population data from the spatial model. Constant during the year.
	Irrigation (nett)	m3/s	Lookup	61	IrrAGC	Irrigation water consumption. As net (diversion demand minus the return flow). Based on rice field maps, and unit water demands by month with assumed cropping pattern. Uncertainty remains on the % of the rice fields that are irrigated from the river
	NET CATCHMENT – NET AGC	m3/s	Calc	62	NetAGC	Calculated as NetAGC = RunoffAGC – DMIAGC – IrrAGC
	NET CATCHMENT – NET AGC	MCM	Cacl	63	NetAGCMCM	NetWSCMCM is a conversion NetAGC from m3/s into Million cubic meter [MCM]
Argoguruh weir	Bandar Lampung DMI	m3/s	Lookup	64	DMIBandarLampung	Domestic, municipal, mndustrial water consumption for Bandar Lampung. Values vary between scenario. In scenario 1 DMIBL = 0, in scenario 2 DMIBL = 2 m3/s, in scenario 3 DMIBL = 3,5 m3/s
	Metro city DMI	m3/s	Lookup	65	DMIMetro	Domestic, municipal, industrial water consumption for Metro city. Values vary between scenario. In scenario 1 DMIMetro = 0.24 m3/s, in scenario 2 = 0.25 m3/s, in scenario 3 = 0.28 m3/s
	Ecological flow downstream Argoguruh weir	m3/s	Lookup	66	EcoFlow	Outflow of the weir to the Way Sekampung river. In theory this should consider downstream demand and ecological flow, but of course it cannot be negative, meaning that if needed the Feeder canals receive less water than requested. Ecological flow is calculated by taking 5% of the minimum average monthly flow during the 10-year time step. Ecological flow = 1.8 m3/s
	TOTAL OTHER DEMAND a	m3/s	Calc	67	Otherdemand	Calculated as Otherdemand= DMIBandarLampung + DMIMetro+ EcoFlow
	TOTAL OTHER DEMAND Volume a	MCM	Calc	68	OtherdemandMCM	Conversion of Otherdemand from [m3/s] into million cubic meter [MCM]

	Water available for irrigation at Argoguruh weir	m3/s	Calc	69	WaterForWSIrri	Water available after fulfilling DMI (Bandar Lampung and Metro) and ecological flow water demand.
	Outflow over weir C	m3/s	Calc	70	Weir outflow	Calculated as Weir outflow = WaterForWSIrri- Irrigation allocated
	Outflow over weir Volume C	MCM	Calc	71	AGW_Outflow	Conversion of Weir outflow from [m3/s] into million cubic meter [MCM]
	irrigation allocated Demand B	m3/s	Calc	72	Irrigation allocated	Calculated as Irrigation allocated= WaterForWSIrri* % irrigation met
	irrigation allocated VOLUME Demand B	MCM	Calc	73	Irr_Alloc_MCM	Conversion of Irrigation allocated from [m3/s] into million cubic meter [MCM]
	Allocation BTR	Fraction	Calc	74	Allocation BTR	Allocation BTR = AllocationBTR in Batutegi reservoir side (Nr 15)
	Allocation WTR	Fraction	Calc	75	Allocation WTR	Allocation WTR = AllocationWTR in Way Sekampung reservoir side (Nr 44)
	% irrigation met	%	Calc	76	% irrigation met	Calculated as a ratio between water available (column 55) with Way Sekampung Irrigation water demand. If water available > water demand = 100% If water available < water demand = less than 100% (potential simulated value depends on the ratio)
8. Way Sekampung Irrigation system	**Way Sekampung irrigation water demand**	m3/s	Lookup	77	WS Irrigation demand	Lookup function looking at the irrigation water demand of Way Sekampung Irrigation System on the "Crop Calender" sheet.
	Water balance check	m3/s	Calc	78	Water_Balance_Check	Water balance check inside the Argoguruh catchment and Argoguruh weir. Calculated as Water_Balance_Check = Irr_Alloc_MCM + AGW_Outflow + OtherdemandMCM - NetAGCMCM - OuflowWSRMCM . IF Water_Balance_Check = 0, then water balance is correct.
	Way Sekampung irrigation water demand - updated calculation	m3/s	Lookup	79	WS Irrigation demand new	Lookup function looking at the irrigation water demand of Way Sekampung Irrigation System on the "Crop Calender" sheet.
	Areal Rainfall WSIS	mm/month	Lookup	80	Areal Rainfall WSIS	Areal rainfall data in the Way Sekampung Irrigation System

Worksheet list in the Excel file:

1. Scenario tab depending on the scenario

This tab contains all columns described above with colors (from column 1 to 80).

THE SCENARIO SETTING (REFER TO FIGURE BELOW) CAN BE FOUND ON THE SCENARIO TAB.

SCENARIO 1 (CURRENT) SETTING

Scenario settings												
Item												
Scenario	1	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	300%
MT1 Way Sekampung	per year-->	78%	78%	78%	78%	78%	78%	78%	78%	78%	78%	
MT2 Way Sekampung	per year-->	72%	72%	72%	72%	72%	72%	72%	72%	72%	72%	230%
MT3 Way Sekampung	per year-->	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	
MT1 Argoguruh Irrigation	34%	43191	43191	43191	43191	43191	43191	43191	43191	43191	43191	
MT2 Argoguruh Irrigation	32%	39869	39869	39869	39869	39869	39869	39869	39869	39869	39869	
MT3 Argoguruh Irrigation	35%	44298	44298	44298	44298	44298	44298	44298	44298	44298	44298	
MT 1 average % water available	per year-->	100%	100%	100%	100%	100%	83%	100%	100%	100%	100%	98%
MT 2 average % water available	per year-->	100%	100%	97%	99%	100%	100%	100%	100%	100%	97%	99%
MT 3 average % water available	per year-->	100%	93%	36%	93%	83%	83%	98%	98%	97%	73%	85%
		230%	224%	176%	224%	217%	203%	229%	228%	228%	206%	**216%**
	CI	300%	293%	230%	292%	283%	264%	298%	298%	297%	269%	**282%**

Rumbia extension	0
Starting date [-1 to 4] to Nov-I	4
Time between cropping season 1 and 2 (1-24)	0
Scenario	1
Year	2019
Way Sekampung Reservoir	No
DMI Bandar Lampung	No
Future rainfall	No
Percolation (1-10)	5
Canal efficiency	**70%**
Actual to Effective rainfall	70%

SCENARIO 2 (2021 WAY SEKAMPUNG) SETTINGS

Scenario settings												
Item												
Scenario	2	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	300%
MT1 Way Sekampung	per year-->	78%	78%	78%	78%	78%	78%	78%	78%	78%	78%	
MT2 Way Sekampung	per year-->	72%	72%	72%	72%	72%	72%	72%	72%	72%	72%	230%
MT3 Way Sekampung	per year-->	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	
MT1 Argoguruh Irrigation	34%	43191	43191	43191	43191	43191	43191	43191	43191	43191	43191	
MT2 Argoguruh Irrigation	32%	39869	39869	39869	39869	39869	39869	39869	39869	39869	39869	
MT3 Argoguruh Irrigation	35%	44298	44298	44298	44298	44298	44298	44298	44298	44298	44298	
MT 1 average % water available	per year-->	100%	100%	100%	100%	100%	100%	100%	100%	100%	99%	100%
MT 2 average % water available	per year-->	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
MT 3 average % water available	per year-->	100%	100%	48%	100%	100%	100%	100%	100%	100%	78%	93%
		230%	230%	189%	230%	230%	230%	230%	230%	230%	212%	**224%**
	CI	300%	300%	246%	300%	300%	300%	300%	300%	300%	276%	**292%**

Rumbia extension	0
Starting date [-1 to 4] to Nov-I	4

Time between cropping season 1 and 2 (1-24)	0
Scenario	2
Year	2021
Way Sekampung Reservoir	Yes
DMI Bandar Lampung	Yes
Future rainfall	Yes

Percolation (1-10)	5
Canal efficiency	**76%**
Actual to Effective rainfall	70%

SCENARIO 3 (2040 CLIMATE CHANGE) SETTINGS

Scenario settings												
Item												
Scenario	3	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	300%
MT1 Way Sekampung	per year-->	78%	78%	78%	78%	78%	78%	78%	78%	78%	78%	
MT2 Way Sekampung	per year-->	72%	72%	72%	72%	72%	72%	72%	72%	72%	72%	230%
MT3 Way Sekampung	per year-->	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	
MT1 Argoguruh Irrigation	34%	43191	43191	43191	43191	43191	43191	43191	43191	43191	43191	
MT2 Argoguruh Irrigation	32%	39869	39869	39869	39869	39869	39869	39869	39869	39869	39869	
MT3 Argoguruh Irrigation	35%	44298	44298	44298	44298	44298	44298	44298	44298	44298	44298	
MT 1 average % water available	per year-->	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
MT 2 average % water available	per year-->	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
MT 3 average % water available	per year-->	100%	100%	43%	100%	100%	100%	100%	100%	100%	90%	93%
		230%	230%	185%	230%	230%	230%	230%	230%	230%	222%	**225%**
	CI	300%	300%	241%	300%	300%	300%	300%	300%	300%	289%	**293%**

Rumbia extension	0
Starting date [-1 to 4] to Nov-I	4

Time between cropping season 1 and 2 (1-24)	0
Scenario	3
Year	2040
Way Sekampung Reservoir	Yes
DMI Bandar Lampung	Yes
Future rainfall	Yes

Percolation (1-10)	5
Canal efficiency	**83%**
Actual to Effective rainfall	70%

Corrections	
BTC	1
WSC	1
AGC	1

The scenario settings let the user to change initial parameter and see how the potential water availability, calculated by the model, varies depending on the parameters chosen. Changing parameters in the scenario setting will automatically change the data taken account inside the model.

2. Single variable analysis (as described in Chapter 2.1.1 in this report)
3. Optimization
4. Analysis water demand met (%)
5. Batutegi elevation analysis; This tab contains 1 graph with an overview of Batutegi reservoir elevation during the 10 years timeseries
6. Way Sekampung elevation analysis; This tab contains 1 graph with an overview of Way Sekampung reservoir elevation during the 10 years timeseries
7. WSIS water demand vs availability; This tab contains 1 graph with and overview of Way Sekampung Irrigation System water demand and availability at Argoguruh weir
8. Cropping calendar; This tab contains all the calculations of irrigation water demand using KP formulation

This tab contains irrigation water demand calculations located at:

- Batutegi sub-watershed
- Way Sekampung sub-watershed
- Argoguruh sub-watershed
- Way Sekampung irrigation System (Batanghari Utara, Raman Utara, Bekri, Sekampung Bunut, Sekampung Batanghari, Punggur Utara, Rumbia Barat).

9. Batutegi reservoir data tab

This tab contains data for:

- Batutegi reservoir Area-Capacity Relationship using the updated Bathymetry study (Dehas, Ltd., 2016)
- Batutegi Reservoir Operating Guidelines (ROR).

10. Way Sekampung reservoir data tab
11. Allocation check; This tab contains 1 graph showing an overview of restrictions on the releases of both reservoirs depending on their elevation and respective curve rules according to the Reservoir Operating Guidelines
12. Sensitivity analysis
13. Flow to KWmonth cal base; this tab contains the basic calculation to determine how much energy [kWmonth] can be obtained from flow rate [m3/s] with its economic value
14. DMI + ecological flow tab
15. Evaporation + Re tab; this tab contains data on the evaporation and effective rainfall dataset.

APPENDIX 3

Table of discharge design of each Bekri Way Sekampung irrigation system

Secondary	Canal	Total Area	Discharge	UPTD
Bekri Irrigation Area	BKH.0-BBK.0	32425.6	70.14	BEKRI
Bekri Irrigation Area	BBK.0-BBK.1	4626.4	10.01	BEKRI
Bekri Irrigation Area	BBK.1-BBK.2	4611.8	9.98	BEKRI
Bekri Irrigation Area	BBK.2-BBK.3	4588.3	9.93	BEKRI
Bekri Irrigation Area	BBK.4-BBK.5	3700.2	8.00	BEKRI
Bekri Irrigation Area	BBK.5-BBK.6	3655.9	7.91	BEKRI
Bekri Irrigation Area	BBK.6-BBK.7	2565.9	5.55	BEKRI
Bekri Irrigation Area	BBK.7-BBK.8	2530.4	5.47	BEKRI
Bekri Irrigation Area	BBK.8-BBK.9	2420.9	5.24	BEKRI
Bekri Irrigation Area	BBK.9-BBK.10	2409.3	5.21	BEKRI
Bekri Irrigation Area	BBK.10-BBK.11	2350.5	5.08	BEKRI
Bekri Irrigation Area	BBK.11-BBK.12	2316.0	5.01	BEKRI
Bekri Irrigation Area	BBK.12-BBK.13	1694.0	3.66	BEKRI
Bekri Irrigation Area	BBK.13-BBK.14	1664.7	3.60	BEKRI
Bekri Irrigation Area	BSK.1-BSK.2	166.4	0.36	BEKRI
Bekri Irrigation Area	BSK.2-BSK.3	109.4	0.24	BEKRI
Bekri Irrigation Area	BSK.3-BSK.4	65.0	0.14	BEKRI
Bekri Irrigation Area	BSK.1-BSM.1	96.2	0.21	BEKRI
Bekri Irrigation Area	BBK.6-BBA.1	1088.4	2.35	BEKRI
Bekri Irrigation Area	BBA.1-BBA.2	967.8	2.09	BEKRI
Bekri Irrigation Area	BBA.2-BBA.3	875.5	1.89	BEKRI
Bekri Irrigation Area	BBA.3-BBA.4	792.0	1.71	BEKRI
Bekri Irrigation Area	BBA.4-BBA.5	766.8	1.66	BEKRI
Bekri Irrigation Area	BBA.5-BBA.6	716.2	1.55	BEKRI
Bekri Irrigation Area	BBA.6-BBA.7	652.2	1.41	BEKRI
Bekri Irrigation Area	BBA.7-BBA.8	566.6	1.23	BEKRI
Bekri Irrigation Area	BBA.8-BBA.9	523.9	1.13	BEKRI
Bekri Irrigation Area	BBA.9-BBA.10	474.9	1.03	BEKRI
Bekri Irrigation Area	BBA.10-BBA.11	403.6	0.87	BEKRI
Bekri Irrigation Area	BBA.11-BBA.12	356.8	0.77	BEKRI
Bekri Irrigation Area	BBA.12-BBA.13	249.3	0.54	BEKRI
Bekri Irrigation Area	BBA.14-BBA.15	219.1	0.47	BEKRI
Bekri Irrigation Area	BBA.15-BBA.16	150.7	0.33	BEKRI
Bekri Irrigation Area	BBA.16-BBA.17	83.1	0.18	BEKRI
Bekri Irrigation Area	BBA.17-BBA.18	23.6	0.05	BEKRI
Bekri Irrigation Area	BBA.2-BSJ.1	37.6	0.08	BEKRI
Bekri Irrigation Area	BBA.9-BKB.1	24.8	0.05	BEKRI
Bekri Irrigation Area	BBK.8-BWT.1	95.0	0.21	BEKRI
Bekri Irrigation Area	BWT.1-BWT.2	43.8	0.09	BEKRI
Bekri Irrigation Area	BWT.2-BWT.3	32.4	0.07	BEKRI
Bekri Irrigation Area	BWT.1-BTR.1	29.1	0.06	BEKRI
Bekri Irrigation Area	BTR.1-BTR.2	19.5	0.04	BEKRI
Bekri Irrigation Area	BBK.10-BAM.1	45.6	0.10	BEKRI
Bekri Irrigation Area	BAM.1-BAM.2	17.4	0.04	BEKRI
Bekri Irrigation Area	BBA.14-BSW.1	10.7	0.02	BEKRI
Bekri Irrigation Area	BBK.12-BSR.1	555.9	1.20	BEKRI
Bekri Irrigation Area	BSR.1-BSR.2	534.7	1.16	BEKRI
Bekri Irrigation Area	BSR.2-BSR.3	501.6	1.09	BEKRI

Secondary	Canal	Total Area	Discharge	UPTD
Bekri Irrigation Area	BSR.3-BSR.4	484.2	1.05	BEKRI
Bekri Irrigation Area	BSR.4-BSR.5	373.3	0.81	BEKRI
Bekri Irrigation Area	BSR.5-BSR.6	324.3	0.70	BEKRI
Bekri Irrigation Area	BSR.6-BSR.7	288.3	0.62	BEKRI
Bekri Irrigation Area	BSR.7-BSR.8	262.0	0.57	BEKRI
Bekri Irrigation Area	BSR.8-BSR.9	203.8	0.44	BEKRI
Bekri Irrigation Area	BSR.9-BSR.10	185.4	0.40	BEKRI
Bekri Irrigation Area	BSR.10-BSR.11	131.9	0.29	BEKRI
Bekri Irrigation Area	BSR.11-BSR.12	88.0	0.19	BEKRI
Bekri Irrigation Area	BSR.12-BSR.13	59.6	0.13	BEKRI
Bekri Irrigation Area	BSR.4-BBU.1	62.3	0.13	BEKRI
Bekri Irrigation Area	BBU.1-BBU.2	38.5	0.08	BEKRI
Bekri Irrigation Area	BBU.2-BBU.3	27.2	0.06	BEKRI
Bekri Irrigation Area	BBK.4-BBW.1	602.9	1.30	BEKRI
Bekri Irrigation Area	BBW.1-BBW.2	594.3	1.29	BEKRI
Bekri Irrigation Area	BBW.2-BBW.3	585.7	1.27	BEKRI
Bekri Irrigation Area	BBW.4-BBW.5	424.6	0.92	BEKRI
Bekri Irrigation Area	BBW.5-BBW.6	400.3	0.87	BEKRI
Bekri Irrigation Area	BBW.6-BBW.7	389.7	0.84	BEKRI
Bekri Irrigation Area	BBW.7-BBW.8	382.1	0.83	BEKRI
Bekri Irrigation Area	BBW.8-BBW.9	170.0	0.37	BEKRI
Bekri Irrigation Area	BBW.9-BBW.10	126.8	0.27	BEKRI
Bekri Irrigation Area	BBW.10-BBW.11	89.5	0.19	BEKRI
Bekri Irrigation Area	BBW.11-BBW.12	57.0	0.12	BEKRI
Bekri Irrigation Area	BBW.12-BBW.13	53.8	0.12	BEKRI
Bekri Irrigation Area	BBW.8-BMD.1	183.3	0.40	BEKRI
Bekri Irrigation Area	BMD.1-BMD.2	177.7	0.38	BEKRI
Bekri Irrigation Area	BMD.2-BMD.3	133.6	0.29	BEKRI
Bekri Irrigation Area	BMD.3-BMD.4A	104.1	0.23	BEKRI
Bekri Irrigation Area	BMD.4A-BMD.4B	92.5	0.20	BEKRI
Bekri Irrigation Area	BMD.4B-BMD.4	81.1	0.18	BEKRI
Bekri Irrigation Area	BMD.4-BMD.5	48.0	0.10	BEKRI
Bekri Irrigation Area	BMD.5-BMD.6A	22.9	0.05	BEKRI
Bekri Irrigation Area	BMD.6A-BMD.6A	14.3	0.03	BEKRI
Bekri Irrigation Area	BBW.4-BSS.1	140.5	0.30	BEKRI
Bekri Irrigation Area	BSS.1-BSS.2	70.5	0.15	BEKRI
Bekri Irrigation Area	BBK.14-BGR.1	431.5	0.93	BEKRI
Bekri Irrigation Area	BGR.1-BGR.2	314.9	0.68	BEKRI
Bekri Irrigation Area	BGR.2-BGR.3	236.2	0.51	BEKRI
Bekri Irrigation Area	BGR.3-BGR.4	192.4	0.42	BEKRI
Bekri Irrigation Area	BGR.4-BGR.5	128.5	0.28	BEKRI
Bekri Irrigation Area	BGR.5-BGR.6	29.7	0.06	BEKRI
Bekri Irrigation Area	BGR.6-BGR.7	17.1	0.04	BEKRI
Bekri Irrigation Area	BGR.1-BBR.1	102.1	0.22	BEKRI
Bekri Irrigation Area	BGR.2-BBM.1	65.8	0.14	BEKRI
Bekri Irrigation Area	BBM.1-BBM.2	29.7	0.06	BEKRI
Bekri Irrigation Area	BBK.14-BBS.1	1173.2	2.54	BEKRI
Bekri Irrigation Area	BBS.1-BBS.2	1095.1	2.37	BEKRI
Bekri Irrigation Area	BBS.2-BBS.3	1048.3	2.27	BEKRI
Bekri Irrigation Area	BBS.3-BBS.4	980.1	2.12	BEKRI
Bekri Irrigation Area	BBS.4-BBS.5	973.5	2.11	BEKRI

Secondary	Canal	Total Area	Discharge	UPTD
Bekri Irrigation Area	BBS.5-BBS.6	882.3	1.91	BEKRI
Bekri Irrigation Area	BBS.6-BBS.7	852.2	1.84	BEKRI
Bekri Irrigation Area	BBS.7-BBS.8	815.1	1.76	BEKRI
Bekri Irrigation Area	BBS.8-BBS.9	750.2	1.62	BEKRI
Bekri Irrigation Area	BBS.9-BBS.10	597.6	1.29	BEKRI
Bekri Irrigation Area	BBS.10-BBS.11	583.1	1.26	BEKRI
Bekri Irrigation Area	BBS.11-BBS.12	548.6	1.19	BEKRI
Bekri Irrigation Area	BBS.12-BBS.13	538.0	1.16	BEKRI
Bekri Irrigation Area	BBS.13-BBS.14	399.5	0.86	BEKRI
Bekri Irrigation Area	BBS.14-BBS.15	303.7	0.66	BEKRI
Bekri Irrigation Area	BBS.15-BBS.16	285.6	0.62	BEKRI
Bekri Irrigation Area	BBS.16-BBS.17	207.8	0.45	BEKRI
Bekri Irrigation Area	BBS.17-BBS.18	181.6	0.39	BEKRI
Bekri Irrigation Area	BBS.18-BBS.19	167.1	0.36	BEKRI
Bekri Irrigation Area	BBS.19-BBS.20	157.6	0.34	BEKRI
Bekri Irrigation Area	BBS.20-BBS.21	148.0	0.32	BEKRI
Bekri Irrigation Area	BBS.21-BBS.22	109.0	0.24	BEKRI
Bekri Irrigation Area	BBS.22-BBS.23	34.1	0.07	BEKRI
Bekri Irrigation Area	BBS.23-BBS.24	24.5	0.05	BEKRI
Bekri Irrigation Area	BBS.24-BBS.25	15.2	0.03	BEKRI
Bekri Irrigation Area	BBS.5-BWR.1	33.2	0.07	BEKRI
Bekri Irrigation Area	BWR.1-BWR.2	27.5	0.06	BEKRI
Bekri Irrigation Area	BBS.8-BBO.1	57.9	0.13	BEKRI
Bekri Irrigation Area	BWS.1-BTM.1	42.1	0.09	BEKRI
Bekri Irrigation Area	BBS.9-BWS.1	148.9	0.32	BEKRI
Bekri Irrigation Area	BWS.1-BWS.2	101.2	0.22	BEKRI
Bekri Irrigation Area	BWS.2-BWS.3	66.7	0.14	BEKRI
Bekri Irrigation Area	BWS.3-BWS.4	27.6	0.06	BEKRI
Bekri Irrigation Area	BWS.4-BWS.5	16.4	0.04	BEKRI
Bekri Irrigation Area	BBS.13-BTP.1	60.0	0.13	BEKRI
Bekri Irrigation Area	BBS.22-BTW.1	55.6	0.12	BEKRI
Bekri Irrigation Area	BTW.1-BTW.2	37.0	0.08	BEKRI

Table of discharge design of each Punggur Utara irrigation system

Secondary	Canal	Total Area	Discharge	UPTD
Punggur Utara Irrigation Area	BBk.0 - BPU 1	27799	60.14	Trimurjo
Punggur Utara Irrigation Area	BPU 1 - BPU 2	27747	60.02	Trimurjo
Punggur Utara Irrigation Area	BPU 2 - BPU 3	27599	59.70	Trimurjo
Punggur Utara Irrigation Area	BPU 3 - BPU 4	27521	59.54	Trimurjo
Punggur Utara Irrigation Area	BPU 4 - BPU 5	27121	58.67	Trimurjo
Punggur Utara Irrigation Area	BPU 5 - BPU 6	26713	57.79	Trimurjo
Punggur Utara Irrigation Area	BPU 6 - BPU 7	26166	56.60	Trimurjo
Punggur Utara Irrigation Area	BPU 7 - BPU 8	25906	56.04	Trimurjo
Punggur Utara Irrigation Area	BPU 8 - BPU 9	23144	50.07	Punggur
Punggur Utara Irrigation Area	BPU 9 - BPU 10	22985	49.72	Punggur
Punggur Utara Irrigation Area	BPU 10 - BPU 11	22783	49.29	Punggur
Punggur Utara Irrigation Area	BPU 11 - BPU 12	20808	45.01	Punggur

Secondary	Canal	Total Area	Discharge	UPTD
Punggur Utara Irrigation Area	BPU 12 - BPU 13	20615	44.60	Punggur
Punggur Utara Irrigation Area	BPU 13 - BPU 14	20013	43.29	Punggur
Punggur Utara Irrigation Area	BPU 14 - BPU 15	19740	42.70	Punggur
Punggur Utara Irrigation Area	BPU 15 - BPU 16	18837	40.75	Kota Gajah
Punggur Utara Irrigation Area	BPU 16 - BPU 17	17210	37.23	Kota Gajah
Punggur Utara Irrigation Area	BPU 17 - BPU 18	15934	34.47	Kota Gajah
Punggur Utara Irrigation Area	BPU 18 - BPU 19	15892	34.38	Kota Gajah
Punggur Utara Irrigation Area	BPU 19 - BPU 20	15233	32.95	Kota Gajah
Punggur Utara Irrigation Area	BPU 20 - BPU 21	14798	32.01	Kota Gajah
Punggur Utara Irrigation Area	BPU 21 - BPU 22	14537	31.45	Rukti Endah
Punggur Utara Irrigation Area	BPU 22 - BPU 23	4251	9.20	Seputih Raman
Punggur Utara Irrigation Area	BPU 23 - BPU 23A	1664	3.60	Seputih Raman
Punggur Utara Irrigation Area	BPU 23 - BPU 24	2564	5.55	Seputih Raman
Punggur Utara Irrigation Area	BPU 24 - BPU 25	2234	4.83	Seputih Raman
Punggur Utara Irrigation Area	BPU 25 - BPU 25A	500	1.08	Seputih Raman
Punggur Utara Irrigation Area	BPU 25 - BPU 26	1348	2.92	Seputih Raman
Punggur Utara Irrigation Area	BPU 4 - BA 1A	148	0.32	Trimurjo
Punggur Utara Irrigation Area	BA 1A - BA 1	130	0.28	Trimurjo
Punggur Utara Irrigation Area	BPU 6 - BB 1	238	0.52	Trimurjo
Punggur Utara Irrigation Area	BB 1 - BB 2	209	0.45	Trimurjo
Punggur Utara Irrigation Area	BB 2 - BB 3	188	0.41	Trimurjo
Punggur Utara Irrigation Area	BB 3 - BB 4A	166	0.36	Trimurjo
Punggur Utara Irrigation Area	BB 4A - BB 4	135	0.29	Trimurjo
Punggur Utara Irrigation Area	BPU 8 - BC 1	2481	5.37	Trimurjo
Punggur Utara Irrigation Area	BC 1 - BC 2	2415	5.22	Trimurjo
Punggur Utara Irrigation Area	BC 2 - BC 3	2111	4.57	Trimurjo
Punggur Utara Irrigation Area	BC 3 - BC 4A	1682	3.64	Trimurjo
Punggur Utara Irrigation Area	BC 4A - BC 4	1655	3.58	Trimurjo
Punggur Utara Irrigation Area	BC 4 - BC 5	1419	3.07	Trimurjo
Punggur Utara Irrigation Area	BC 5 - BC 6	1094	2.37	Trimurjo
Punggur Utara Irrigation Area	BC 6 - BC 7	1065	2.30	Trimurjo
Punggur Utara Irrigation Area	BC 7 - BC 8	443	0.96	Trimurjo
Punggur Utara Irrigation Area	BC 8 - BC 9	194	0.42	Trimurjo
Punggur Utara Irrigation Area	BC 9 - BC 10	12	0.03	Trimurjo
Punggur Utara Irrigation Area	BPU 11 - BD 1	1911	4.13	Punggur
Punggur Utara Irrigation Area	BD 1 - BD 2	1699	3.68	Punggur
Punggur Utara Irrigation Area	BD 2 - BD 3	1630	3.53	Punggur
Punggur Utara Irrigation Area	BD 3 - BD 4	1176	2.54	Punggur
Punggur Utara Irrigation Area	BD 4 - BD 5	1117	2.42	Punggur
Punggur Utara Irrigation Area	BD 5 - BD 6	1040	2.25	Punggur
Punggur Utara Irrigation Area	BD 6 - BD 7	756	1.64	Punggur
Punggur Utara Irrigation Area	BD 7 - BD 8	693	1.50	Punggur
Punggur Utara Irrigation Area	BD 8 - BD 9	509	1.10	Punggur
Punggur Utara Irrigation Area	BD 9 - BD 10	368	0.80	Punggur

Secondary	Canal	Total Area	Discharge	UPTD
Punggur Utara Irrigation Area	BD 10 - BD 11A	305	0.66	Punggur
Punggur Utara Irrigation Area	BD 11A - BD 11	235	0.51	Rantau Fajar
Punggur Utara Irrigation Area	BD 11 - BD 12	121	0.26	Rantau Fajar
Punggur Utara Irrigation Area	BD 12 - BD 13	90	0.20	Rantau Fajar
Punggur Utara Irrigation Area	BPU 13 - BE 1	467	1.01	Punggur
Punggur Utara Irrigation Area	BE 1 - BE 2	213	0.46	Punggur
Punggur Utara Irrigation Area	BE 2 - BE 3	111	0.24	Punggur
Punggur Utara Irrigation Area	BE 3 - BE 4	28	0.06	Punggur
Punggur Utara Irrigation Area	BPU 15 - BF 1	790	1.71	Punggur
Punggur Utara Irrigation Area	BF 1 - BF 2	644	1.39	Punggur
Punggur Utara Irrigation Area	BF 2 - BF 3	540	1.17	Punggur
Punggur Utara Irrigation Area	BF 3 - BF 4	356	0.77	Punggur
Punggur Utara Irrigation Area	BF 4 - BF 5	269	0.58	Punggur
Punggur Utara Irrigation Area	BF 5 - BF 6	160	0.35	Punggur
Punggur Utara Irrigation Area	BF 6 - BF 7	95	0.21	Punggur
Punggur Utara Irrigation Area	BPU 14 - BG 1	255	0.55	Punggur
Punggur Utara Irrigation Area	BG 1 - BG 2	140	0.30	Punggur
Punggur Utara Irrigation Area	BG 2 - BG 3	106	0.23	Punggur
Punggur Utara Irrigation Area	BG 3 - BG 4	71	0.15	Punggur
Punggur Utara Irrigation Area	BG 4 - BG 5	18	0.04	Rantau Fajar
Punggur Utara Irrigation Area	BPU 16 - BH 1	1365	2.95	Kota Gajah
Punggur Utara Irrigation Area	BH 1 - BH 2	1274	2.76	Rantau Fajar
Punggur Utara Irrigation Area	BH 2 - BH 3	1215	2.63	Rantau Fajar
Punggur Utara Irrigation Area	BH 3 - BH 4	984	2.13	Rantau Fajar
Punggur Utara Irrigation Area	BH 4 - BH 5	916	1.98	Rantau Fajar
Punggur Utara Irrigation Area	BH 5 - BH 6	679	1.47	Rantau Fajar
Punggur Utara Irrigation Area	BH 6 - BH 7	555	1.20	Rantau Fajar
Punggur Utara Irrigation Area	BH 7 - BH 8	433	0.94	Rantau Fajar
Punggur Utara Irrigation Area	BH 8 - BH 9	374	0.81	Rantau Fajar
Punggur Utara Irrigation Area	BH 9 - BH 10	300	0.65	Rantau Fajar
Punggur Utara Irrigation Area	BH 10 - BH 11	183	0.40	Rantau Fajar
Punggur Utara Irrigation Area	BPU 17 - BI 1	1139	2.46	Kota Gajah
Punggur Utara Irrigation Area	BI 1 - BI 2	1064	2.30	Kota Gajah
Punggur Utara Irrigation Area	BI 2 - BI 3	957	2.07	Kota Gajah
Punggur Utara Irrigation Area	BI 3 - BI 4	722	1.56	Kota Gajah
Punggur Utara Irrigation Area	BI 4 - BI 5	626	1.35	Kota Gajah
Punggur Utara Irrigation Area	BI 5 - BI 6	470	1.02	Kota Gajah
Punggur Utara Irrigation Area	BI 6 - BI 7	218	0.47	Kota Gajah
Punggur Utara Irrigation Area	BI 7 - BI 8	107	0.23	Kota Gajah
Punggur Utara Irrigation Area	BI 8 - BI 9	67	0.14	Kota Gajah
Punggur Utara Irrigation Area	BPU 17 - BJ 1	133	0.29	Rantau Fajar
Punggur Utara Irrigation Area	BJ 1 - BJ 2	108	0.23	Rantau Fajar
Punggur Utara Irrigation Area	BPU 19 - BK 1	476	1.03	Kota Gajah
Punggur Utara Irrigation Area	BK 1 - BK 2	319	0.69	Kota Gajah

Secondary	Canal	Total Area	Discharge	UPTD
Punggur Utara Irrigation Area	BK 2 - BK 3	148	0.32	Kota Gajah
Punggur Utara Irrigation Area	BK 3 - BK 4	84	0.18	Kota Gajah
Punggur Utara Irrigation Area	BPU 20 - BL 1	241	0.52	Kota Gajah
Punggur Utara Irrigation Area	BL 1 - BL 2	184	0.40	Kota Gajah
Punggur Utara Irrigation Area	BL 2 - BL 3	130	0.28	Kota Gajah
Punggur Utara Irrigation Area	BPU 22 - BM 1	4347	9.40	Rukti Endah
Punggur Utara Irrigation Area	BM 1 - BM 2	4244	9.18	Rukti Endah
Punggur Utara Irrigation Area	BM 2 - BM 3	3882	8.40	Rukti Endah
Punggur Utara Irrigation Area	BM 3 - BM 4	3648	7.89	Rukti Endah
Punggur Utara Irrigation Area	BM 4 - BM 5	3221	6.97	Rukti Endah
Punggur Utara Irrigation Area	BM 5 - BM 6	2290	4.95	Rantau Fajar
Punggur Utara Irrigation Area	BM 6 - BM 7	1733	3.75	Rantau Fajar
Punggur Utara Irrigation Area	BM 7 - BM 8	1013	2.19	Rantau Fajar
Punggur Utara Irrigation Area	BM 8 - BM 9	813	1.76	Rantau Fajar
Punggur Utara Irrigation Area	BM 9 - BM 10	667	1.44	Rantau Fajar
Punggur Utara Irrigation Area	BM 10 - BM 11	357	0.77	Rantau Fajar
Punggur Utara Irrigation Area	BM 11 - BM 12	93	0.20	Rantau Fajar
Punggur Utara Irrigation Area	BM 12 - BM 13	29	0.06	Rantau Fajar
Punggur Utara Irrigation Area	BPU 23 - BN 1	238	0.51	Seputih Raman
Punggur Utara Irrigation Area	BN 1 - BN 2	121	0.26	Seputih Raman
Punggur Utara Irrigation Area	BPU 23 - BO 1	1238	2.68	Seputih Raman
Punggur Utara Irrigation Area	BO 1 - BO 2	745	1.61	Seputih Raman
Punggur Utara Irrigation Area	BO 2 - BO 3	497	1.08	Seputih Raman
Punggur Utara Irrigation Area	BO 3 - BO 4	391	0.84	Seputih Raman
Punggur Utara Irrigation Area	BO 4 - BO 5	225	0.49	Seputih Raman
Punggur Utara Irrigation Area	BO 5 - BO 6	147	0.32	Seputih Raman
Punggur Utara Irrigation Area	BO 1 - BP 1	460	1.00	Seputih Raman
Punggur Utara Irrigation Area	BP 1 - BP 2	445	0.96	Seputih Raman
Punggur Utara Irrigation Area	BP 2 - BP 3	355	0.77	Seputih Raman
Punggur Utara Irrigation Area	BP 3 - BP 4	134	0.29	Seputih Raman
Punggur Utara Irrigation Area	BP 4 - BP 5	100	0.22	Seputih Raman
Punggur Utara Irrigation Area	BPU 26 - BQO	1029	2.23	Seputih Raman
Punggur Utara Irrigation Area	BQO - BQ 1	898	1.94	Seputih Raman
Punggur Utara Irrigation Area	BQ 1 - BQ 2	669	1.45	Seputih Raman
Punggur Utara Irrigation Area	BQ 2 - BQ 3	413	0.89	Seputih Raman
Punggur Utara Irrigation Area	BQ 3 - BQ 4	224	0.48	Seputih Raman
Punggur Utara Irrigation Area	BQ 4 - BQ 5	124	0.27	Seputih Raman
Punggur Utara Irrigation Area	BPU 24 - BR 1	220	0.48	Seputih Raman
Punggur Utara Irrigation Area	BR 1 - BR 2	121	0.26	Seputih Raman
Punggur Utara Irrigation Area	BD 3 - BS 1	293	0.63	Punggur
Punggur Utara Irrigation Area	BD 6 - BT 1	211	0.46	Punggur
Punggur Utara Irrigation Area	BT 1 - BT 2	104	0.22	Punggur
Punggur Utara Irrigation Area	BD 8 - BU 1	94	0.20	Punggur
Punggur Utara Irrigation Area	BU 1 - BU 2	80	0.17	Rantau Fajar

Secondary	Canal	Total Area	Discharge	UPTD
Punggur Utara Irrigation Area	BPU 26 - BV	141	0.30	Seputih Raman
Punggur Utara Irrigation Area	BM 1 - BMW 0	44	0.09	Rukti Endah
Punggur Utara Irrigation Area	BMW 1 - BMW 2	44	0.09	Rukti Endah
Punggur Utara Irrigation Area	BMW 2 - BMW 3	44	0.09	Rukti Endah
Punggur Utara Irrigation Area	BF 3 - BX 1	156	0.34	Punggur
Punggur Utara Irrigation Area	BX 1 - BX 2	103	0.22	Punggur
Punggur Utara Irrigation Area	BQ 2 - BY 1	217	0.47	Seputih Raman
Punggur Utara Irrigation Area	BY 1 - BY 2	89	0.19	Seputih Raman
Punggur Utara Irrigation Area	BC 7 - BZ 1A	235	0.51	Trimurjo
Punggur Utara Irrigation Area	BZ 1A - BZ 1B	210	0.45	Trimurjo
Punggur Utara Irrigation Area	BZ 1B - BZ 1	50	0.11	Trimurjo
Punggur Utara Irrigation Area	BM 4 - BMA 1	216	0.47	Rukti Endah
Punggur Utara Irrigation Area	BMA 1 - BMA 2	141	0.31	Rukti Endah
Punggur Utara Irrigation Area	BM 5 - BMB 1	230	0.50	Rukti Endah
Punggur Utara Irrigation Area	BM 5 - BMC 1	224	0.48	Rantau Fajar
Punggur Utara Irrigation Area	BMC 1 - BMC 2	84	0.18	Rantau Fajar
Punggur Utara Irrigation Area	BM 6 - BMD 1	310	0.67	Rantau Fajar
Punggur Utara Irrigation Area	BM 7 - BME 1	545	1.18	Rantau Fajar
Punggur Utara Irrigation Area	BME 1 - BME 2	180	0.39	Rantau Fajar
Punggur Utara Irrigation Area	BME 1 - BMF 1	221	0.48	Rantau Fajar
Punggur Utara Irrigation Area	BMF 1 - BMF 2	113	0.24	Rantau Fajar
Punggur Utara Irrigation Area	BM 10 - BMG 1	147	0.32	Rantau Fajar
Punggur Utara Irrigation Area	BM 11 - BMH 1	150	0.33	Rantau Fajar
Punggur Utara Irrigation Area	BM 2 - BMI 1	283	0.61	Rukti Endah
Punggur Utara Irrigation Area	BMI 1 - BMI 2	248	0.54	Rukti Endah
Punggur Utara Irrigation Area	BPU 25 - BUA 1	302	0.65	Seputih Raman
Punggur Utara Irrigation Area	BUA 1 - BUA 2	217	0.47	Seputih Raman
Punggur Utara Irrigation Area	BUA 2 - BUA 3	125	0.27	Seputih Raman
Punggur Utara Irrigation Area	BQ 3 - BQA 1	83	0.18	Seputih Raman
Punggur Utara Irrigation Area	BQA 1 - BQA 2	50	0.11	Seputih Raman
Punggur Utara Irrigation Area	BPU 21 - UB.1	134	0.29	Kota Gajah
Punggur Utara Irrigation Area	BPU 26 - BUD	141	0.30	Seputih Raman
Punggur Utara Irrigation Area	BPU 25 - BUE 1	288	0.62	Seputih Raman
Punggur Utara Irrigation Area	BC 7 - BGS 1	361	0.78	Trimurjo
Punggur Utara Irrigation Area	BGS 1 - BGS 2	202	0.44	Trimurjo
Punggur Utara Irrigation Area	BGS 2 - BGS 3	155	0.33	Trimurjo
Punggur Utara Irrigation Area	BGS 3 - BGS 4	119	0.26	Trimurjo
Punggur Utara Irrigation Area	BGS 4 - BGS 5	9	0.02	Trimurjo
Punggur Utara Irrigation Area	BPU 22 - BUF 1	219	0.47	Rukti Endah
Punggur Utara Irrigation Area	BUF 1 - BUF 2	143	0.31	Rukti Endah
Punggur Utara Irrigation Area	BUF 2 - BUF 3	75	0.16	Rukti Endah

Table of discharge design of each Raman Utara Way Sekampung irrigation system

Secondary	Canal	Total Area	Discharge	UPTD
Raman Utara Irrigation Area	BRU 0 - BRU 1A	4339.3	9.39	RAMAN
Raman Utara Irrigation Area	BRU 1A - BRU 1B	4302.8	9.31	RAMAN
Raman Utara Irrigation Area	BRU 1B - BRU 1	4261.4	9.22	RAMAN
Raman Utara Irrigation Area	BRU 1 - BRU 2	4151.0	8.98	RAMAN
Raman Utara Irrigation Area	BRU 2 - BRU 3	4120.3	8.91	RAMAN
Raman Utara Irrigation Area	BRU 4 - BRU 5	3033.8	6.56	RAMAN
Raman Utara Irrigation Area	BRU 5 - BRU 6	2989.2	6.47	RAMAN
Raman Utara Irrigation Area	BRU 6 - BRU 7	2941.0	6.36	RAMAN
Raman Utara Irrigation Area	BRU 7 - BRU 8	2777.4	6.01	RAMAN
Raman Utara Irrigation Area	BRU 8 - BRU 9	2701.8	5.84	RAMAN
Raman Utara Irrigation Area	BRU 9 - BRU 10	2040.2	4.41	RAMAN
Raman Utara Irrigation Area	BRU 10 - BRU 11	1955.6	4.23	RAMAN
Raman Utara Irrigation Area	BRU 11 - BRU 12A	1544.7	3.34	RAMAN
Raman Utara Irrigation Area	BRU 12 - BRU 13	977.0	2.11	RAMAN
Raman Utara Irrigation Area	BRU 13 - BRU 14A	781.1	1.69	RAMAN
Raman Utara Irrigation Area	BRU 14A - BRU 14	693.4	1.50	RAMAN
Raman Utara Irrigation Area	BRU 14 - BRU 15	620.7	1.34	RAMAN
Raman Utara Irrigation Area	BRU 15 - BRU 16	424.5	0.92	RAMAN
Raman Utara Irrigation Area	BRU 16 - BRU 17	388.4	0.84	RAMAN
Raman Utara Irrigation Area	BRU 17 - BRU 18	303.5	0.66	RAMAN
Raman Utara Irrigation Area	BRU 18 - BRU 19A	156.3	0.34	RAMAN
Raman Utara Irrigation Area	BRU 19A - BRU 19	137.9	0.30	RAMAN
Raman Utara Irrigation Area	BRU 4 - BC 1	161.0	0.35	RAMAN
Raman Utara Irrigation Area	BC.1- BC.2	88.8	0.19	RAMAN
Raman Utara Irrigation Area	BRU 4 - BA 1	840.2	1.82	RAMAN
Raman Utara Irrigation Area	BA 1 - BA 2	795.9	1.72	RAMAN
Raman Utara Irrigation Area	BA 2 - BA 3	407.2	0.88	RAMAN
Raman Utara Irrigation Area	BA 3 - BA 4	350.3	0.76	RAMAN
Raman Utara Irrigation Area	BA 4 - BA 5	313.6	0.68	RAMAN
Raman Utara Irrigation Area	BA 5 - BA 6	225.7	0.49	RAMAN
Raman Utara Irrigation Area	BA 2 - BB 1	310.8	0.67	RAMAN
Raman Utara Irrigation Area	BB.1 - BB.2	227.6	0.49	RAMAN
Raman Utara Irrigation Area	BRU 9 - BD 1	447.4	0.97	RAMAN
Raman Utara Irrigation Area	BD.1 - BD.2	175.5	0.38	RAMAN
Raman Utara Irrigation Area	BD.2 - BD.3	134.1	0.29	RAMAN
Raman Utara Irrigation Area	BRU 9 - BE 1	117.6	0.25	RAMAN
Raman Utara Irrigation Area	BRU 11 - BF 1	276.6	0.60	RAMAN
Raman Utara Irrigation Area	BF.1 - BF.2	100.1	0.22	RAMAN
Raman Utara Irrigation Area	BRU 12 - BG 1	366.5	0.79	RAMAN
Raman Utara Irrigation Area	BG.1 - BG.2	296.8	0.64	RAMAN
Raman Utara Irrigation Area	BG.2 - BG.3	185.9	0.40	RAMAN
Raman Utara Irrigation Area	BRU 15 - BH 1	149.7	0.32	RAMAN

Table of discharge design of each Rumbia Barat Sekampung irrigation system

Secondary	Canal	Total Area	Discharge	UPTD
Rumbia Barat Irrigation Area	BRB 1 - BRB 2	4999.4	10.8	
Rumbia Barat Irrigation Area	BRB 3 - BRB 4	2717.2	5.9	
Rumbia Barat Irrigation Area	BRB 1 - BHG 1	839.2	1.8	
Rumbia Barat Irrigation Area	BHG 1 - BHG 2	311.5	0.7	
Rumbia Barat Irrigation Area	BHG 2 - BHG 3	224.6	0.5	
Rumbia Barat Irrigation Area	BHG 3 - BHG 4	112.0	0.2	
Rumbia Barat Irrigation Area	BHG 4 - BHG 5	42.4	0.1	
Rumbia Barat Irrigation Area	BHG 1 - BHS 1	422.2	0.9	
Rumbia Barat Irrigation Area	BHS 1 - BHS 2	262.0	0.6	
Rumbia Barat Irrigation Area	BHS 2 - BHS 3	154.6	0.3	
Rumbia Barat Irrigation Area	BRB 3 - BTH 1.1	248.3	0.5	
Rumbia Barat Irrigation Area	BTH 1.1 - BTH 1.2	201.8	0.4	
Rumbia Barat Irrigation Area	BTH 1.2 - BTH 1.3	134.9	0.3	
Rumbia Barat Irrigation Area	BTH 1.3 - BTH 1.4	88.0	0.2	
Rumbia Barat Irrigation Area	BRB 5 - BSKB 1	226.1	0.5	
Rumbia Barat Irrigation Area	BSKB 1 - BSKB 2	76.2	0.2	
Rumbia Barat Irrigation Area	BRB 6 - BSKA 1	184.6	0.4	
Rumbia Barat Irrigation Area	BSKA 1 - BSKA 2	148.7	0.3	
Rumbia Barat Irrigation Area	BSKA 2 - BSKA 3	90.8	0.2	
Rumbia Barat Irrigation Area	BRB 7 - BKB 1	976.0	2.1	
Rumbia Barat Irrigation Area	BKB 1 - BKB 2	902.4	2.0	
Rumbia Barat Irrigation Area	BKB 2 - BKB 3	860.0	1.9	
Rumbia Barat Irrigation Area	BKB 3 - BKB 4	815.8	1.8	
Rumbia Barat Irrigation Area	BKB 5 - BKB 6	358.0	0.8	
Rumbia Barat Irrigation Area	BKB 6 - BKB 7	294.5	0.6	
Rumbia Barat Irrigation Area	BKB 7 - BKB 8	195.0	0.4	
Rumbia Barat Irrigation Area	BKB 5 - BSN 1	338.6	0.7	
Rumbia Barat Irrigation Area	BSN 1 - BSN 2	211.6	0.5	
Rumbia Barat Irrigation Area	BSN 2 - BSN 3	159.0	0.3	
Rumbia Barat Irrigation Area	BSN 3 - BSN 4	135.9	0.3	
Rumbia Barat Irrigation Area	BKB 9 - BSB 1	167.8	0.4	
Rumbia Barat Irrigation Area	BSB 1 - BSB 2	86.4	0.2	
Rumbia Barat Irrigation Area	BSB 2 - BSB 3	70.4	0.2	
Rumbia Barat Irrigation Area	BRB 8 - BTH 2.1	193.2	0.4	
Rumbia Barat Irrigation Area	BTH 2.1 - BTH 2.2	142.0	0.3	
Rumbia Barat Irrigation Area	BTH 2.2 - BTH 2.3	116.5	0.3	
Rumbia Barat Irrigation Area	BTH 2.3 - BTH 2.4	93.2	0.2	
Rumbia Barat Irrigation Area	BTH 2.4 - BTH 2.5	55.9	0.1	
Rumbia Barat Irrigation Area	BRB 9 - BBR 1	1093.1	2.4	
Rumbia Barat Irrigation Area	BBR 1 - BBR 2	1031.3	2.2	
Rumbia Barat Irrigation Area	BBR 2 - BBR 3	999.1	2.2	
Rumbia Barat Irrigation Area	BBR 3 - BBR 4	867.1	1.9	
Rumbia Barat Irrigation Area	BBR 4 - BBR 5	793.0	1.7	

Secondary	Canal	Total Area	Discharge	UPTD
Rumbia Barat Irrigation Area	BBR 5 - BBR 6	595.9	1.3	
Rumbia Barat Irrigation Area	BBR 6 - BBR 7	566.1	1.2	
Rumbia Barat Irrigation Area	BBR 7 - BBR 8	518.5	1.1	
Rumbia Barat Irrigation Area	BBR 8 - BBR 9	220.0	0.5	
Rumbia Barat Irrigation Area	BBR 9 - BBR 10	183.5	0.4	
Rumbia Barat Irrigation Area	BBR 5 - BBM 1.1	197.1	0.4	
Rumbia Barat Irrigation Area	BBM 1.1 - BBM 1.2	89.7	0.2	
Rumbia Barat Irrigation Area	BRB 3 - BDY 1	1956.7	4.2	
Rumbia Barat Irrigation Area	BDY 1 - BDY 2	1692.0	3.7	
Rumbia Barat Irrigation Area	BDY 2 - BDY 3	1591.4	3.4	
Rumbia Barat Irrigation Area	BDY 4 - BDY 5	1097.0	2.4	
Rumbia Barat Irrigation Area	BDY 5 - BDY 6	1035.1	2.2	
Rumbia Barat Irrigation Area	BDY 7 - BDY 8	295.2	0.6	
Rumbia Barat Irrigation Area	BDY 8 - BDY 9	224.0	0.5	
Rumbia Barat Irrigation Area	BDY 9 - BDY 10	133.4	0.3	
Rumbia Barat Irrigation Area	BDY 1 - BBT 1	175.6	0.4	
Rumbia Barat Irrigation Area	BBT 1 - BBT 2	96.7	0.2	
Rumbia Barat Irrigation Area	BDY 4 - BWN 1.1	429.8	0.9	
Rumbia Barat Irrigation Area	BWN 1.1 - BWN 1.2	268.4	0.6	
Rumbia Barat Irrigation Area	BWN 1.2 - BWN 1.3	229.7	0.5	
Rumbia Barat Irrigation Area	BDY 6 - BWN 2.1	521.3	1.1	
Rumbia Barat Irrigation Area	BWN 2.1 - BWN 2.2	477.3	1.0	
Rumbia Barat Irrigation Area	BWN 2.2 - BWN 2.3	426.4	0.9	
Rumbia Barat Irrigation Area	BWN 2.3 - BWN 2.4	348.6	0.8	
Rumbia Barat Irrigation Area	BDY 7 - BDY 1.1	152.2	0.3	
Rumbia Barat Irrigation Area	BDY 1.1 - BDY 1.2	89.0	0.2	
Rumbia Barat Irrigation Area	BDY 1.2 - BDY 1.3	54.6	0.1	
Rumbia Barat Irrigation Area	BWN 2.3 - BSKC 1	202.5	0.4	
Rumbia Barat Irrigation Area	BSKC 1 - BSKC 2	162.0	0.4	
Rumbia Barat Irrigation Area	BSKC 2 - BSKC 3	41.3	0.1	
Rumbia Barat Irrigation Area	BBR 8 - BBM 2.1	241.7	0.5	
Rumbia Barat Irrigation Area	BBM 2.1 - BBM 2.2	174.3	0.4	
Rumbia Barat Irrigation Area	BBM 2.2 - BBM 2.3	147.5	0.3	

Table of discharge design of each Sekampung Batanghari Way Sekampung irrigation system

Secondary	Canal	Total Area	Discharge	UPTD
Sekampung Batanghari Irrigation Area	KH 2-BKBH.1	9193.4	19.89	ADIPURO
Sekampung Batanghari Irrigation Area	BKBH.1-BKBH.2	9180.9	19.86	ADIPURO
Sekampung Batanghari Irrigation Area	BKBH.2-BKBH.3	8843.2	19.13	ADIPURO
Sekampung Batanghari Irrigation Area	BKBH.3-BKBH.4 A	8697.8	18.82	ADIPURO
Sekampung Batanghari Irrigation Area	BKBH.4 A-BKBH.4	8668.3	18.75	ADIPURO
Sekampung Batanghari Irrigation Area	BKBH.5 A-BKBH.5	8420.3	18.22	Metro
Sekampung Batanghari Irrigation Area	BKBH.5-BKBH.6 A	7878.9	17.04	Metro

Secondary	Canal	Total Area	Discharge	UPTD
Sekampung Batanghari Irrigation Area	BKBH.6 A-BKBH.6	7819.3	16.92	Metro
Sekampung Batanghari Irrigation Area	BKBH.6-BKBH.7 A	7552.8	16.34	Metro
Sekampung Batanghari Irrigation Area	BKBH.7 A-BKBH.7	7484.3	16.19	Metro
Sekampung Batanghari Irrigation Area	BKBH.7-BKBH.8 A	7084.5	15.33	Metro
Sekampung Batanghari Irrigation Area	BKBH.8 A-BKBH.8 B	7029.8	15.21	Metro
Sekampung Batanghari Irrigation Area	BKBH.8 B-BKBH.8 C	7004.2	15.15	Metro
Sekampung Batanghari Irrigation Area	BKBH.8 C-BKBH.8 D	6977.3	15.09	KPD BATANGHARI
Sekampung Batanghari Irrigation Area	BKBH.8 D-BKBH.8	6909.1	14.95	KPD BATANGHARI
Sekampung Batanghari Irrigation Area	BKBH.8-BKBH.9	5401.2	11.68	KPD BATANGHARI
Sekampung Batanghari Irrigation Area	BKBH.9-BKBH.10 A	5110.7	11.06	KPD BATANGHARI
Sekampung Batanghari Irrigation Area	BKBH.10 A-BKBH.10	4810.1	10.41	KPD BATANGHARI
Sekampung Batanghari Irrigation Area	BKBH.10-BKBH.11 A	4637.5	10.03	KPD BATANGHARI
Sekampung Batanghari Irrigation Area	BKBH.11 A-BKBH.11	4513.1	9.76	KPD BATANGHARI
Sekampung Batanghari Irrigation Area	BKBH.11-BKBH.12	4248.1	9.19	KPD BATANGHARI
Sekampung Batanghari Irrigation Area	BKBH.12-BKBH.13	3587.3	7.76	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKBH.14 A'-BKBH.14 A	2624.0	5.68	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKBH.14 A-BKBH.14 B	2512.3	5.43	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKBH.14 B-BKBH.14 C	2408.3	5.21	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKBH.14 C-BKBH.14	2408.3	5.21	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKBH.14-BKBH.15 A	600.3	1.30	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKBH.15 A-BKBH.15 B	537.7	1.16	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKBH.15 B-BKBH.15 C	527.0	1.14	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKBH.15 D-BKBH.15	473.5	1.02	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKBH.15-BKBH.16 A	360.1	0.78	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKBH.16 A-BKBH.16 B	340.8	0.74	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKBH.16 B-BKBH.16	317.2	0.69	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKBH.16-BSN.1	72.2	0.16	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BSn.1-BSn.2	49.6	0.11	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BSN.3 A-BSN.3	21.9	0.05	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BSN.3-BSN.4	7.4	0.02	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKBH.16-BTM.1	150.8	0.33	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BTM.1-BTM.2	54.3	0.12	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKBH.14-BKMI.1 A	1483.8	3.21	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKMI.1 A-BKMI.1 B	1448.0	3.13	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKMI.1 B-BKMI.1	1448.0	3.13	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKMI.1-BKMI.2 A	842.2	1.82	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKMI.2 A-BKMI.2 B	832.7	1.80	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKMI.2 C-BKMI.2 D	632.9	1.37	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKMI.2-BKMI.3 A	363.8	0.79	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKMI.3 A-BKMI.3 B'	357.8	0.77	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKMI.3 B'-BKMI.3 B	338.2	0.73	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKMI.3 B-BKMI.3	338.2	0.73	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKMI.3-BKMI.4	306.4	0.66	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKMI.4-BKMI.5	69.2	0.15	KPD SEKAMPUNG

Secondary	Canal	Total Area	Discharge	UPTD
Sekampung Batanghari Irrigation Area	BKBH.14-BSH.1	152.3	0.33	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKMI.1-BWK.1	120.4	0.26	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKMI.1-BGK.1	321.6	0.70	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BGK.1-BGK.2	279.4	0.60	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BDM.2-BDM.3 A	156.1	0.34	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BGK.3 B-BGK.3	108.8	0.24	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKMI.2 C-BHG.1	148.1	0.32	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BHG.1-BHG.2	120.7	0.26	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BHG.3 A-BHG.3	84.4	0.18	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BHG.3-BHG.4	68.9	0.15	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKMI.2-BSB.1	164.5	0.36	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BSB.1-BSB.2	123.4	0.27	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKMI.5-BBP.1	37.7	0.08	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKMI.2-BKS.1	92.5	0.20	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKS.2 B-BKS.2	41.7	0.09	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKMI.4-BDM.1	190.7	0.41	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BDM.2 B-BDM.2	114.8	0.25	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BDM.3 A-BDM.3	90.3	0.20	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKBH.8-BKDJ.1 A	1065.4	2.30	KPD BATANGHARI
Sekampung Batanghari Irrigation Area	BKDJ.1 A-BKDJ.1	1045.1	2.26	KPD BATANGHARI
Sekampung Batanghari Irrigation Area	BKDJ.1-BKDJ.2 A	711.6	1.54	KPD BATANGHARI
Sekampung Batanghari Irrigation Area	BKDJ.2 A-BKDJ.2 B	677.3	1.47	KPD BATANGHARI
Sekampung Batanghari Irrigation Area	BKDJ.2 B-BKDJ.2	648.9	1.40	KPD BATANGHARI
Sekampung Batanghari Irrigation Area	BKDJ.2-BKDJ.3 A	544.1	1.18	KPD BATANGHARI
Sekampung Batanghari Irrigation Area	BKDJ.3 A-BKDJ.3 B	525.3	1.14	KPD BATANGHARI
Sekampung Batanghari Irrigation Area	BKDJ.3 B-BKDJ.3	515.7	1.12	KPD BATANGHARI
Sekampung Batanghari Irrigation Area	BKDJ.3-BKDJ.4	458.2	0.99	KPD BATANGHARI
Sekampung Batanghari Irrigation Area	BKDJ.5-BKDJ.6 A	269.6	0.58	KPD BATANGHARI
Sekampung Batanghari Irrigation Area	BKDJ.6 A-BKDJ.6	254.3	0.55	KPD BATANGHARI
Sekampung Batanghari Irrigation Area	BKDJ.6-BKDJ.7	110.5	0.24	KPD BATANGHARI
Sekampung Batanghari Irrigation Area	BKDJ.7-BKDJ.8	25.4	0.06	KPD BATANGHARI
Sekampung Batanghari Irrigation Area	BKDJ.6-BNR.1	93.9	0.20	KPD BATANGHARI
Sekampung Batanghari Irrigation Area	BKBH.12-BBMI.1 A	597.5	1.29	KPD BATANGHARI
Sekampung Batanghari Irrigation Area	BBMI.1 A-BBMI.1 B	561.8	1.22	KPD BATANGHARI
Sekampung Batanghari Irrigation Area	BBMI.1 B-BBMI.1	529.0	1.14	KPD BATANGHARI
Sekampung Batanghari Irrigation Area	BBMI.1-BBSA.1	179.5	0.39	KPD BATANGHARI
Sekampung Batanghari Irrigation Area	BBSA.1-BBSA.2	164.2	0.36	KPD BATANGHARI
Sekampung Batanghari Irrigation Area	BBSA.3 A-BBSA.3	93.2	0.20	KPD BATANGHARI
Sekampung Batanghari Irrigation Area	BBSA.3-BBSA.4	35.0	0.08	KPD BATANGHARI
Sekampung Batanghari Irrigation Area	BBMI.1-BSR.1	128.7	0.28	KPD BATANGHARI
Sekampung Batanghari Irrigation Area	BKBH.13-BKSI.1 A	865.5	1.87	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKSI.1 A-BKSI.1 B	826.0	1.79	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKSI.1 B-BKSI.1	795.4	1.72	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKSI.1-BKSI.2 A	669.6	1.45	KPD SEKAMPUNG

Secondary	Canal	Total Area	Discharge	UPTD
Sekampung Batanghari Irrigation Area	BKSI.2 A-BKSI.2 B	665.0	1.44	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKSI.2 B-BKSI.2 C	638.3	1.38	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKSI.2 D-BKSI.2	616.3	1.33	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKSI.2-BKSI.3	295.3	0.64	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKSI.3-BKSI.4	216.1	0.47	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKSI.4-BKSI.5	143.6	0.31	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKSI.5-BKSI.6 A	67.9	0.15	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKSI.6 A-BKSI.6	43.2	0.09	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKSI.2-BSM.1	223.8	0.48	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BSM.1-BSM.2	182.7	0.40	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BKBH.13-BSG.1A	65.11	0.14	KPD SEKAMPUNG
Sekampung Batanghari Irrigation Area	BSG.1A-BSG.1	46.3	0.10	KPD SEKAMPUNG

Table of discharge design of each Sekampung Bunut Way Sekampung irrigation system

Secondary	Canal	Total Area	Discharge	UPTD
Sekampung Bunut Irrigation Area	BKH.0-BKH.1	23646.5	51.15	ADIPURO
Sekampung Bunut Irrigation Area	BKH.1-BKH.2	23567.0	50.98	ADIPURO
Sekampung Bunut Irrigation Area	BKH.2-BKH.3	5074.1	10.98	ADIPURO
Sekampung Bunut Irrigation Area	BKH.3-BKB.1 A	2964.2	6.41	ADIPURO
Sekampung Bunut Irrigation Area	BKB.1 A-BKB.1	2919.8	6.32	Metro
Sekampung Bunut Irrigation Area	BKB.1-BKB.2 A	2782.7	6.02	Metro
Sekampung Bunut Irrigation Area	BKB.2 A-BKB.2 B	2746.1	5.94	Metro
Sekampung Bunut Irrigation Area	BKB.2 B-BKB.2 C	2713.5	5.87	Metro
Sekampung Bunut Irrigation Area	BKB.2 C-BKB.2	2684.2	5.81	Metro
Sekampung Bunut Irrigation Area	BKB.2-BKB.3 A	2676.2	5.79	Metro
Sekampung Bunut Irrigation Area	BKB.3 A-BKB.3 B	2655.8	5.75	Metro
Sekampung Bunut Irrigation Area	BKB.3 B-BKB.3	2594.5	5.61	Metro
Sekampung Bunut Irrigation Area	BKB.3-BKB.4	2137.0	4.62	Metro
Sekampung Bunut Irrigation Area	BKB.4-BKB.5 A	2066.1	4.47	Metro
Sekampung Bunut Irrigation Area	BKB.5 A-BKB.5	1990.0	4.30	PEKALONGAN
Sekampung Bunut Irrigation Area	BKB.5-BKB.6	1928.7	4.17	PEKALONGAN
Sekampung Bunut Irrigation Area	BKb.6-BKB.7	1301.9	2.82	PEKALONGAN
Sekampung Bunut Irrigation Area	BKB.7 -BKB.8 A	895.1	1.94	PEKALONGAN
Sekampung Bunut Irrigation Area	BKB.8 A-BKB.8 B	862.3	1.87	PEKALONGAN
Sekampung Bunut Irrigation Area	BKB.8 B-BKB.8 C	856.4	1.85	PEKALONGAN
Sekampung Bunut Irrigation Area	BKB.8 C-BKB.8 D	847.3	1.83	PEKALONGAN
Sekampung Bunut Irrigation Area	BKB.8 D-BKB.8	826.9	1.79	PEKALONGAN
Sekampung Bunut Irrigation Area	BKb.8-BKb.9	640.8	1.39	PEKALONGAN
Sekampung Bunut Irrigation Area	BKb.9-BKb.10A	306.1	0.66	PEKALONGAN
Sekampung Bunut Irrigation Area	BKB.10A-BKB.10	271.7	0.59	PEKALONGAN
Sekampung Bunut Irrigation Area	BKB.10-BKB.11 A	173.1	0.37	PEKALONGAN
Sekampung Bunut Irrigation Area	BKB.11 A-BKB.11	85.3	0.18	PEKALONGAN
Sekampung Bunut Irrigation Area	BKB.11-BKB.12	37.8	0.08	PEKALONGAN
Sekampung Bunut Irrigation Area	BKH.3-BKR.1	1643.0	3.55	ADIPURO
Sekampung Bunut Irrigation Area	BKR.1-BKR.2 A	1279.1	2.77	ADIPURO

Secondary	Canal	Total Area	Discharge	UPTD
Sekampung Bunut Irrigation Area	BKR.2 A-BKR.2 B	1213.3	2.62	ADIPURO
Sekampung Bunut Irrigation Area	BKR.2 B-BKR.2 C	1166.5	2.52	ADIPURO
Sekampung Bunut Irrigation Area	BKR.2 C-BKR.2 D	1140.0	2.47	ADIPURO
Sekampung Bunut Irrigation Area	BKR.2 D-BKR.2 E	1119.4	2.42	ADIPURO
Sekampung Bunut Irrigation Area	BKR.2 E-BKR.2	1107.3	2.40	Metro
Sekampung Bunut Irrigation Area	BKR.2-BKR.3 A	970.0	2.10	Metro
Sekampung Bunut Irrigation Area	BKR.3 A-BKR.3 B	963.3	2.08	Metro
Sekampung Bunut Irrigation Area	BKR.3 B-BKR.3	906.0	1.96	Metro
Sekampung Bunut Irrigation Area	BKR.3-BKR.4 A	742.0	1.61	Metro
Sekampung Bunut Irrigation Area	BKR.4 A-BKR.4 B	735.7	1.59	Metro
Sekampung Bunut Irrigation Area	BKR.4 B-BKR.4 C	700.3	1.51	Metro
Sekampung Bunut Irrigation Area	BKR.4 C-BKR.4 D	581.1	1.26	PEKALONGAN
Sekampung Bunut Irrigation Area	BKR.4 D-BKR.4	505.0	1.09	PEKALONGAN
Sekampung Bunut Irrigation Area	BKR.4-BKR.5 A	272.9	0.59	PEKALONGAN
Sekampung Bunut Irrigation Area	BKR.5 A-BKR.5 B	206.9	0.45	PEKALONGAN
Sekampung Bunut Irrigation Area	BKR.5 B-BKR.5	192.2	0.42	PEKALONGAN
Sekampung Bunut Irrigation Area	BKR.3-BPS.1	134.1	0.29	Metro
Sekampung Bunut Irrigation Area	BKR.4-BWS.1	113.3	0.25	Metro
Sekampung Bunut Irrigation Area	BKR.5-BGW.1	130.6	0.28	PEKALONGAN
Sekampung Bunut Irrigation Area	BGW.1-BGW.2	100.1	0.22	PEKALONGAN
Sekampung Bunut Irrigation Area	BGW.2-BGW.3	64.9	0.14	PEKALONGAN
Sekampung Bunut Irrigation Area	BKB.3-BKBW.1 A	389.8	0.84	Metro
Sekampung Bunut Irrigation Area	BKBW.1 A-BKBW.1 B	348.2	0.75	Metro
Sekampung Bunut Irrigation Area	BKBW.1 B-BKBW.1	305.2	0.66	Metro
Sekampung Bunut Irrigation Area	BKBW.1-BKBW.2 A	197.8	0.43	Metro
Sekampung Bunut Irrigation Area	BKBW.2 A-BKBW.2 B	186.3	0.40	Metro
Sekampung Bunut Irrigation Area	BKBW.2 B-BKBW.2	175.8	0.38	Metro
Sekampung Bunut Irrigation Area	BKBW.2-BKBW.3 A	113.1	0.24	Metro
Sekampung Bunut Irrigation Area	BKBW.3 A-BKBW.3 B	86.0	0.19	Metro
Sekampung Bunut Irrigation Area	BKBW.3 B-BKBW.3 C	70.3	0.15	Metro
Sekampung Bunut Irrigation Area	BKBW.3 C-BKBW.3	55.4	0.12	Metro
Sekampung Bunut Irrigation Area	BKB.6-BKBZ.1 A	510.5	1.10	PEKALONGAN
Sekampung Bunut Irrigation Area	BKBZ.1 A-BKBZ.1 B	484.7	1.05	PEKALONGAN
Sekampung Bunut Irrigation Area	BKBZ.1 B-BKBZ.1	395.6	0.86	PEKALONGAN
Sekampung Bunut Irrigation Area	BKBZ.1-BKBZ.2	266.4	0.58	PEKALONGAN
Sekampung Bunut Irrigation Area	BKBZ.2-BKBZ.3 A	246.1	0.53	PEKALONGAN
Sekampung Bunut Irrigation Area	BKBZ.3 A-BKBZ.3	188.6	0.41	PEKALONGAN
Sekampung Bunut Irrigation Area	BKB.7-BKBM.1 A	341.4	0.74	PEKALONGAN
Sekampung Bunut Irrigation Area	BKBM.1 A-BKBM.1	257.7	0.56	PEKALONGAN
Sekampung Bunut Irrigation Area	BKBM.1-BKBM.2	185.7	0.40	PEKALONGAN
Sekampung Bunut Irrigation Area	BKBM.2-BKBM.3	117.4	0.25	PEKALONGAN
Sekampung Bunut Irrigation Area	BKB.9-BKBO.1	198.9	0.43	PEKALONGAN
Sekampung Bunut Irrigation Area	BKBO.1-BKBO.2	93.9	0.20	PEKALONGAN
Sekampung Bunut Irrigation Area	BKBO.1-BKBS.1	63.0	0.14	PEKALONGAN
Sekampung Bunut Irrigation Area	BKBZ.3-BG.1	118.6	0.26	PEKALONGAN

APPENDIX 4

Arrival time of irrigation flow at Way Sekampung Irrigation Area

Irrigation Sub-system	Canal	Service Capacity (Ha)	Discharge Capacity (m^3/s)	Canal Length (m)	Flowing time		
					Minutes	Cumulative minute	Hours
Feeder Canal 2	BKH.0-BBK.0	32,481	70.3	3,567	45	45	0.7
Bekri	BBK.0-BBK.1	4,682	10.1	1,304	22	67	1.1
Bekri	BBK.1-BBK.2	4,668	10.1	2,408	78	145	2.4
Bekri	BBK.2-BBK.3	4,644	10.0	1,139	23	167	2.8
Bekri	BBK.3-BBK.4	4,359	9.4	622	9	176	2.9
Bekri	BBK.4-BBK.5	3,756	8.1	376	6	182	3.0
Bekri	BBK.5-BBK.6	3,712	8.0	959	29	212	3.5
Bekri	BBK.6-BBK.7	2,569	5.6	1,389	18	230	3.8
Bekri	BBK.7-BBK.8	2,534	5.5	441	4	234	3.9
Bekri	BBK.8-BBK.9	2,429	5.3	555	5	239	4.0
Bekri	BBK.9-BBK.10	2,417	5.2	437	11	250	4.2
Bekri	BBK.10-BBK.11	2,353	5.1	304	7	257	4.3
Bekri	BBK.11-BBK.12	2,318	5.0	1,073	179	436	7.3
Bekri	BBK.12-BBK.13	1,699	3.7	799	12	449	7.5
Bekri	BBK.13-BBK.14	1,670	3.6	754	28	477	7.9
Bekri	BBK.3-BSK.1	263	0.6	560	10	178	3.0
Bekri	BSK.1-BSK.2	166	0.4	664	27	205	3.4
Bekri	BSK.2-BSK.3	109	0.2	866	28	233	3.9
Bekri	BSK.3-BSK.4	65	0.1	333	7	240	4.0
Bekri	BSK.1-BSM.1	96	0.2	444	4	182	3.0
Bekri	BBK.6-BBA.1	1,141	2.5	631	9	221	3.7
Bekri	BBA.1-BBA.2	992	2.1	1,384	16	237	3.9
Bekri	BBA.2-BBA.3	860	1.9	953	12	249	4.1
Bekri	BBA.3-BBA.4	776	1.7	1,723	50	298	5.0
Bekri	BBA.4-BBA.5	751	1.6	619	19	317	5.3
Bekri	BBA.5-BBA.6	700	1.5	469	13	329	5.5
Bekri	BBA.6-BBA.7	636	1.4	685	34	364	6.1
Bekri	BBA.7-BBA.8	550	1.2	535	11	374	6.2
Bekri	BBA.8-BBA.9	507	1.1	597	40	414	6.9
Bekri	BBA.9-BBA.10	458	1.0	1,191	37	451	7.5
Bekri	BBA.10-BBA.11	387	0.8	1,063	24	475	7.9
Bekri	BBA.11-BBA.12	340	0.7	838	24	499	8.3
Bekri	BBA.12-BBA.13	234	0.5	550	18	516	8.6
Bekri	BBA.13-BBA.14	215	0.5	966	12	528	8.8
Bekri	BBA.14-BBA.15	204	0.4	317	18	546	9.1
Bekri	BBA.15-BBA.16	136	0.3	1,628	40	587	9.8
Bekri	BBA.16-BBA.17	70	0.2	599	11	597	10.0
Bekri	BBA.17-BBA.18	24	0.1	1,656	15	613	10.2
Bekri	BBA.2-BSJ.1	63	0.1	1,134	16	253	4.2
Bekri	BBA.9-BKB.1	25	0.1	1,423	37	451	7.5
Bekri	BBK.8-BWT.1	90	0.2	199	5	240	4.0
Bekri	BWT.1-BWT.2	34	0.1	271	28	268	4.5
Bekri	BWT.2-BWT.3	23	0.0	1,184	13	280	4.7
Bekri	BWT.1-BTR.1	33	0.1	436	9	249	4.1
Bekri	BTR.1-BTR.2	27	0.1	836	12	261	4.3

Irrigation Sub-system	Canal	Service Capacity (Ha)	Discharge Capacity (m^3/s)	Canal Length (m)	Flowing time		
					Minutes	Cumulative minute	Hours
Bekri	BBK.10-BAM.1	51	0.1	889	16	267	4.4
Bekri	BAM.1-BAM.2	13	0.0	790	7	274	4.6
Bekri	BBA.14-BSW.1	11	0.0	477	10	538	9.0
Bekri	BBK.12-BSR.1	553	1.2	1,057	52	488	8.1
Bekri	BSR.1-BSR.2	532	1.1	1,362	37	525	8.7
Bekri	BSR.2-BSR.3	498	1.1	1,263	34	558	9.3
Bekri	BSR.3-BSR.4	481	1.0	590	23	581	9.7
Bekri	BSR.4-BSR.5	370	0.8	680	28	609	10.2
Bekri	BSR.5-BSR.6	320	0.7	722	109	718	12.0
Bekri	BSR.6-BSR.7	288	0.6	1,214	32	749	12.5
Bekri	BSR.7-BSR.8	262	0.6	844	18	767	12.8
Bekri	BSR.8-BSR.9	204	0.4	833	11	779	13.0
Bekri	BSR.9-BSR.10	185	0.4	856	10	788	13.1
Bekri	BSR.10-BSR.11	132	0.3	1,065	22	810	13.5
Bekri	BSR.11-BSR.12	88	0.2	696	20	830	13.8
Bekri	BSR.12-BSR.13	60	0.1	282	4	833	13.9
Bekri	BSR.4-BBU.1	62	0.1	1,444	33	614	10.2
Bekri	BBU.1-BBU.2	39	0.1	834	31	645	10.8
Bekri	BBU.2-BBU.3	27	0.1	531	16	661	11.0
Bekri	BBK.4-BBW.1	603	1.3	368	2	178	3.0
Bekri	BBW.1-BBW.2	594	1.3	873	18	196	3.3
Bekri	BBW.2-BBW.3	586	1.3	463	21	217	3.6
Bekri	BBW.3-BBW.4	565	1.2	408	12	229	3.8
Bekri	BBW.4-BBW.5	425	0.9	583	14	244	4.1
Bekri	BBW.5-BBW.6	400	0.9	564	19	262	4.4
Bekri	BBW.6-BBW.7	390	0.8	365	12	274	4.6
Bekri	BBW.7-BBW.8	382	0.8	887	21	295	4.9
Bekri	BBW.8-BBW.9	170	0.4	1,140	49	344	5.7
Bekri	BBW.9-BBW.10	127	0.3	1,414	18	362	6.0
Bekri	BBW.10-BBW.11	90	0.2	1,011	25	387	6.5
Bekri	BBW.11-BBW.12	57	0.1	258	3	390	6.5
Bekri	BBW.12-BBW.13	54	0.1	389	8	398	6.6
Bekri	BBW.8-BMD.1	183	0.4	498.2	38	333	5.6
Bekri	BMD.1-BMD.2	178	0.4	387	10	343	5.7
Bekri	BMD.2-BMD.3	134	0.3	710	40	383	6.4
Bekri	BMD.3-BMD.4A	104	0.2	449.7	58	441	7.3
Bekri	BMD.4A-BMD.4B	93	0.2	662.8	23	464	7.7
Bekri	BMD.4B-BMD.4	81	0.2	369.1	12	476	7.9
Bekri	BMD.4-BMD.5	48	0.1	403	51	528	8.8
Bekri	BMD.5-BMD.6A	23	0.0	73.6	1	529	8.8
Bekri	BMD.6A-BMD.6	14	0.0	802	35	564	9.4
Bekri	BBW.4-BSS.1	141	0.3	627	6	235	3.9
Bekri	BSS.1-BSS.2	71	0.2	896	16	251	4.2
Bekri	BBK.14-BGR.1	432	0.9	462	5	481	8.0
Bekri	BGR.1-BGR.2	315	0.7	219	7	488	8.1
Bekri	BGR.2-BGR.3	236	0.5	243	2	490	8.2
Bekri	BGR.3-BGR.4	192	0.4	939	22	512	8.5
Bekri	BGR.4-BGR.5	129	0.3	1895	40	552	9.2

Irrigation Sub-system	Canal	Service Capacity (Ha)	Discharge Capacity (m^3/s)	Canal Length (m)	Flowing time		
					Minutes	Cumulative minute	Hours
Bekri	BGR.5-BGR.6	30	0.1	1,531	30	582	9.7
Bekri	BGR.6-BGR.7	17	0.0	532	11	593	9.9
Bekri	BGR.1-BBR.1	102	0.2	627	6	487	8.1
Bekri	BGR.2-BBM.1	66	0.1	1,145	76	564	9.4
Bekri	BBM.1-BBM.2	30	0.1	794	18	582	9.7
Bekri	BBK.14-BBS.1	1,179	2.5	711	14	491	8.2
Bekri	BBS.1-BBS.2	1,100	2.4	730	17	508	8.5
Bekri	BBS.2-BBS.3	1,054	2.3	744	15	523	8.7
Bekri	BBS.3-BBS.4	985	2.1	942	25	548	9.1
Bekri	BBS.4-BBS.5	979	2.1	982	161	709	11.8
Bekri	BBS.5-BBS.6	888	1.9	1,088	25	734	12.2
Bekri	BBS.6-BBS.7	858	1.9	396	9	743	12.4
Bekri	BBS.7-BBS.8	820	1.8	250	7	749	12.5
Bekri	BBS.8-BBS.9	756	1.6	463	18	768	12.8
Bekri	BBS.9-BBS.10	603	1.3	986	26	793	13.2
Bekri	BBS.10-BBS.11	589	1.3	435	8	801	13.4
Bekri	BBS.11-BBS.12	554	1.2	499	9	810	13.5
Bekri	BBS.12-BBS.13	543	1.2	785	25	835	13.9
Bekri	BBS.13-BBS.14	405	0.9	911	67	901	15.0
Bekri	BBS.14-BBS.15	309	0.7	415	12	914	15.2
Bekri	BBS.15-BBS.16	291	0.6	1,634	47	961	16.0
Bekri	BBS.16-BBS.17	213	0.5	941	26	987	16.4
Bekri	BBS.17-BBS.18	187	0.4	832	13	999	16.7
Bekri	BBS.18-BBS.19	173	0.4	2,197	38	1037	17.3
Bekri	BBS.19-BBS.20	163	0.4	817	35	1072	17.9
Bekri	BBS.20-BBS.21	153	0.3	646	15	1087	18.1
Bekri	BBS.21-BBS.22	114	0.2	1,156	11	1099	18.3
Bekri	BBS.22-BBS.23	39	0.1	436	11	1109	18.5
Bekri	BBS.23-BBS.24	30	0.1	394	6	1115	18.6
Bekri	BBS.24-BBS.25	21	0.0	827	15	1130	18.8
Bekri	BBS.5-BWR.1	33	0.1	364	5	714	11.9
Bekri	BWR.1-BWR.2	28	0.1	561	8	722	12.0
Bekri	BBS.8-BBO.1	58	0.1	1,011	17	766	12.8
Bekri	**BWS.1-BTM.1**	42	0.1	**988**	24	801	13.4
Bekri	BBS.9-BWS.1	149	0.3	448	9	777	12.9
Bekri	BWS.1-BWS.2	101	0.2	450	6	782	13.0
Bekri	BWS.2-BWS.3	67	0.1	349	12	795	13.2
Bekri	BWS.3-BWS.4	28	0.1	508	19	814	13.6
Bekri	BWS.4-BWS.5	16	0.0	194	1	815	13.6
Bekri	BBS.13-BTP.1	60	0.1	1,443	10	845	14.1
Bekri	BBS.22-BTW.1	56	0.1	896	10	1108	18.5
Bekri	BTW.1-BTW.2	37	0.1	1,072	13	1122	18.7
Punggur Utara	BBk.0 - BPU 1	27,799	60.1	4,604.41	215	260	4.3
Punggur Utara	BPU 1 - BPU 2	27,747	60.0	1,512	51	311	5.2
Punggur Utara	BPU 2 - BPU 3	27,599	59.7	2,020	27	338	5.6
Punggur Utara	BPU 3 - BPU 4	27,521	59.5	504	3	341	5.7
Punggur Utara	BPU 4 - BPU 5	27,121	58.7	2,560	42	383	6.4
Punggur Utara	BPU 5 - BPU 6	26,713	57.8	1,500	18	401	6.7

Irrigation Sub-system	Canal	Service Capacity (Ha)	Discharge Capacity (m^3/s)	Canal Length (m)	Flowing time		
					Minutes	Cumulative minute	Hours
Punggur Utara	BPU 6 - BPU 7	26,166	56.6	1,399	24	425	7.1
Punggur Utara	BPU 7 - BPU 8	25,906	56.0	2,049	121	546	9.1
Punggur Utara	BPU 8 - BPU 9	23,144	50.1	813	14	560	9.3
Punggur Utara	BPU 9 - BPU 10	22,985	49.7	1,085	17	577	9.6
Punggur Utara	BPU 10 - BPU 11	22,783	49.3	771	22	599	10.0
Punggur Utara	BPU 11 - BPU 12	20,808	45.0	1,773	43	641	10.7
Punggur Utara	BPU 12 - BPU 13	20,615	44.6	924	18	659	11.0
Punggur Utara	BPU 13 - BPU 14	20,013	43.3	2,389	40	699	11.6
Punggur Utara	BPU 14 - BPU 15	19,740	42.7	907	9	708	11.8
Punggur Utara	BPU 15 - BPU 16	18,837	40.7	1,071	15	723	12.0
Punggur Utara	BPU 16 - BPU 17	17,210	37.2	1,814	23	746	12.4
Punggur Utara	BPU 17 - BPU 18	15,934	34.5	1,035	17	763	12.7
Punggur Utara	BPU 18 - BPU 19	15,892	34.4	1,622	28	791	13.2
Punggur Utara	BPU 19 - BPU 20	15,233	33.0	490	4	795	13.2
Punggur Utara	BPU 20 - BPU 21	14,798	32.0	993	9	803	13.4
Punggur Utara	BPU 21 - BPU 22	14,537	31.4	1,500	100	903	15.1
Punggur Utara	BPU 22 - BPU 23	4,251	9.2	1,706	37	940	15.7
Punggur Utara	BPU 23 - BPU 23A	1,664	3.6	391.65	7	947	15.8
Punggur Utara	BPU 23 - BPU 24	2,564	5.5	1,147	23	970	16.2
Punggur Utara	BPU 24 - BPU 25	2,234	4.8	2,221	72	1042	17.4
Punggur Utara	BPU 25 - BPU 25A	500	1.1	75	1	1043	17.4
Punggur Utara	BPU 25 - BPU 26	1,348	2.9	2,476	50	1093	18.2
Punggur Utara	BPU 4 - BA 1A	148	0.3	1,045	16	357	6.0
Punggur Utara	BA 1A - BA 1	130	0.3	388.5	6	363	6.0
Punggur Utara	BPU 6 - BB 1	238	0.5	2,115	48	449	7.5
Punggur Utara	BB 1 - BB 2	209	0.5	411	7	455	7.6
Punggur Utara	BB 2 - BB 3	188	0.4	615	23	478	8.0
Punggur Utara	BB 3 - BB 4A	166	0.4	188	4	483	8.0
Punggur Utara	BB 4A - BB 4	135	0.3	178	2	484	8.1
Punggur Utara	BPU 8 - BC 1	2,481	5.4	2,175	118	663	11.1
Punggur Utara	BC 1 - BC 2	2,415	5.2	1,129	35	699	11.6
Punggur Utara	BC 2 - BC 3	2,111	4.6	1,342	55	753	12.6
Punggur Utara	BC 3 - BC 4A	1,682	3.6	1480	40	794	13.2
Punggur Utara	BC 4A - BC 4	1,655	3.6	1,279	50	844	14.1
Punggur Utara	BC 4 - BC 5	1,419	3.1	1,335	79	922	15.4
Punggur Utara	BC 5 - BC 6	1,094	2.4	1,100	46	968	16.1
Punggur Utara	BC 6 - BC 7	1,065	2.3	658	11	979	16.3
Punggur Utara	BC 7 - BC 8	443	1.0	2,054	60	1039	17.3
Punggur Utara	BC 8 - BC 9	194	0.4	1,698	26	1065	17.7
Punggur Utara	BC 9 - BC 10	12	0.0	1,869.31	17	1082	18.0
Punggur Utara	BPU 11 - BD 1	1,911	4.1	701	8	607	10.1
Punggur Utara	BD 1 - BD 2	1,699	3.7	921	20	626	10.4
Punggur Utara	BD 2 - BD 3	1,630	3.5	947	28	654	10.9
Punggur Utara	BD 3 - BD 4	1,176	2.5	1,155	23	678	11.3
Punggur Utara	BD 4 - BD 5	1,117	2.4	804	14	692	11.5
Punggur Utara	BD 5 - BD 6	1,040	2.2	869	10	702	11.7
Punggur Utara	BD 6 - BD 7	756	1.6	2,042	49	751	12.5
Punggur Utara	BD 7 - BD 8	693	1.5	625	5	756	12.6

Irrigation Sub-system	Canal	Service Capacity (Ha)	Discharge Capacity (m^3/s)	Canal Length (m)	Flowing time		
					Minutes	Cumulative minute	Hours
Punggur Utara	BD 8 - BD 9	509	1.1	1,655	34	790	13.2
Punggur Utara	BD 9 - BD 10	368	0.8	1,050	28	818	13.6
Punggur Utara	BD 10 - BD 11A	305	0.7	86.78	1	818	13.6
Punggur Utara	BD 11A - BD 11	235	0.5	1,213.441	18	836	13.9
Punggur Utara	BD 11 - BD 12	121	0.3	1,994	32	868	14.5
Punggur Utara	BD 12 - BD 13	90	0.2	163	5	873	14.6
Punggur Utara	BPU 13 - BE 1	467	1.0	586	8	668	11.1
Punggur Utara	BE 1 - BE 2	213	0.5	675	8	676	11.3
Punggur Utara	BE 2 - BE 3	111	0.2	1,220.1	29	704	11.7
Punggur Utara	BE 3 - BE 4	28	0.1	1,059	62	766	12.8
Punggur Utara	BPU 15 - BF 1	790	1.7	1,481	24	732	12.2
Punggur Utara	BF 1 - BF 2	644	1.4	1,530	30	763	12.7
Punggur Utara	BF 2 - BF 3	540	1.2	753	17	780	13.0
Punggur Utara	BF 3 - BF 4	356	0.8	512	8	787	13.1
Punggur Utara	BF 4 - BF 5	269	0.6	1,229	15	802	13.4
Punggur Utara	BF 5 - BF 6	160	0.3	1,230	25	826	13.8
Punggur Utara	BF 6 - BF 7	95	0.2	1,093	16	842	14.0
Punggur Utara	BPU 14 - BG 1	255	0.6	142	1	700	11.7
Punggur Utara	BG 1 - BG 2	140	0.3	958	24	724	12.1
Punggur Utara	BG 2 - BG 3	106	0.2	599	14	739	12.3
Punggur Utara	BG 3 - BG 4	71	0.2	534	19	758	12.6
Punggur Utara	BG 4 - BG 5	18	0.0	926	15	774	12.9
Punggur Utara	BPU 16 - BH 1	1,365	3.0	196	8	730	12.2
Punggur Utara	BH 1 - BH 2	1,274	2.8	930	19	749	12.5
Punggur Utara	BH 2 - BH 3	1,215	2.6	1,371	53	802	13.4
Punggur Utara	BH 3 - BH 4	984	2.1	1,667	33	835	13.9
Punggur Utara	BH 4 - BH 5	916	2.0	662	32	867	14.4
Punggur Utara	BH 5 - BH 6	679	1.5	1,403	20	886	14.8
Punggur Utara	BH 6 - BH 7	555	1.2	1,631	35	921	15.3
Punggur Utara	BH 7 - BH 8	433	0.9	1,215	26	947	15.8
Punggur Utara	BH 8 - BH 9	374	0.8	204.4	2	948	15.8
Punggur Utara	BH 9 - BH 10	300	0.6	499	16	964	16.1
Punggur Utara	BH 10 - BH 11	183	0.4	485	10	974	16.2
Punggur Utara	BPU 17 - BI 1	1,139	2.5	800	17	762	12.7
Punggur Utara	BI 1 - BI 2	1,064	2.3	1,023	15	778	13.0
Punggur Utara	BI 2 - BI 3	957	2.1	1,745	29	807	13.4
Punggur Utara	BI 3 - BI 4	722	1.6	2,502	23	830	13.8
Punggur Utara	BI 4 - BI 5	626	1.4	730	9	839	14.0
Punggur Utara	BI 5 - BI 6	470	1.0	2,330	76	915	15.3
Punggur Utara	BI 6 - BI 7	218	0.5	1,191	30	945	15.7
Punggur Utara	BI 7 - BI 8	107	0.2	2,014	30	975	16.2
Punggur Utara	BI 8 - BI 9	67	0.1	1,451	28	1002	16.7
Punggur Utara	BPU 17 - BJ 1	133	0.3	2,245	66	812	13.5
Punggur Utara	BJ 1 - BJ 2	108	0.2	1,119	20	832	13.9
Punggur Utara	BPU 19 - BK 1	476	1.0	1,832	36	827	13.8
Punggur Utara	BK 1 - BK 2	319	0.7	1,328	72	898	15.0
Punggur Utara	BK 2 - BK 3	148	0.3	1,185	48	947	15.8
Punggur Utara	BK 3 - BK 4	84	0.2	490	20	967	16.1

Irrigation Sub-system	Canal	Service Capacity (Ha)	Discharge Capacity (m^3/s)	Canal Length (m)	Flowing time		
					Minutes	Cumulative minute	Hours
Punggur Utara	BPU 20 - BL 1	241	0.5	1,470.2	24	819	13.7
Punggur Utara	BL 1 - BL 2	184	0.4	636.3	30	849	14.2
Punggur Utara	BL 2 - BL 3	130	0.3	833.3	17	866	14.4
Punggur Utara	BPU 22 - BM 1	4,347	9.4	1,471	24	927	15.4
Punggur Utara	BM 1 - BM 2	4,244	9.2	914	14	941	15.7
Punggur Utara	BM 2 - BM 3	3,882	8.4	1,590	28	968	16.1
Punggur Utara	BM 3 - BM 4	3,648	7.9	1,475	17	985	16.4
Punggur Utara	BM 4 - BM 5	3,221	7.0	1,621	37	1023	17.0
Punggur Utara	BM 5 - BM 6	2,290	5.0	1,991	38	1061	17.7
Punggur Utara	BM 6 - BM 7	1,733	3.7	2192.4	38	1099	18.3
Punggur Utara	BM 7 - BM 8	1,013	2.2	1,316	19	1118	18.6
Punggur Utara	BM 8 - BM 9	813	1.8	2,115	28	1146	19.1
Punggur Utara	BM 9 - BM 10	667	1.4	1,223.6	29	1175	19.6
Punggur Utara	BM 10 - BM 11	357	0.8	1,451	24	1199	20.0
Punggur Utara	BM 11 - BM 12	93	0.2	2,078	44	1243	20.7
Punggur Utara	BM 12 - BM 13	29	0.1	1,292	50	1293	21.6
Punggur Utara	BPU 23 - BN 1	238	0.5	2,514	86	1026	17.1
Punggur Utara	BN 1 - BN 2	121	0.3	950	14	1040	17.3
Punggur Utara	BPU 23 - BO 1	1,238	2.7	698	11	951	15.8
Punggur Utara	BO 1 - BO 2	745	1.6	1,601	48	999	16.6
Punggur Utara	BO 2 - BO 3	497	1.1	1,939	44	1043	17.4
Punggur Utara	BO 3 - BO 4	391	0.8	1,295	27	1070	17.8
Punggur Utara	BO 4 - BO 5	225	0.5	1,024	20	1090	18.2
Punggur Utara	BO 5 - BO 6	147	0.3	1,206	12	1102	18.4
Punggur Utara	BO 1 - BP 1	460	1.0	1,300	18	968	16.1
Punggur Utara	BP 1 - BP 2	445	1.0	994	37	1005	16.8
Punggur Utara	BP 2 - BP 3	355	0.8	983	12	1018	17.0
Punggur Utara	BP 3 - BP 4	134	0.3	732	13	1030	17.2
Punggur Utara	BP 4 - BP 5	100	0.2	1,446	20	1050	17.5
Punggur Utara	BPU 26 - BQO	1,029	2.2	750	19	1112	18.5
Punggur Utara	BQO - BQ 1	898	1.9	1,300	19	1131	18.8
Punggur Utara	BQ 1 - BQ 2	669	1.4	940	17	1148	19.1
Punggur Utara	BQ 2 - BQ 3	413	0.9	1,484	40	1187	19.8
Punggur Utara	BQ 3 - BQ 4	224	0.5	1,650	19	1207	20.1
Punggur Utara	BQ 4 - BQ 5	124	0.3	1,561	30	1237	20.6
Punggur Utara	BPU 24 - BR 1	220	0.5	1,450	68	1037	17.3
Punggur Utara	BR 1 - BR 2	121	0.3	1,475	26	1064	17.7
Punggur Utara	BD 3 - BS 1	293	0.6	2,326	56	711	11.8
Punggur Utara	BD 6 - BT 1	211	0.5	1,320	73	775	12.9
Punggur Utara	BT 1 - BT 2	104	0.2	1,051	19	794	13.2
Punggur Utara	BD 8 - BU 1	94	0.2	1,233	14	770	12.8
Punggur Utara	BU 1 - BU 2	80	0.2	1,364	41	812	13.5
Punggur Utara	BPU 26 - BV	141	0.3	2,160	50	1143	19.1
Punggur Utara	BM 1 - BMW 0	44	0.1	850	12	939	15.6
Punggur Utara	BMW 1 - BMW 2	44	0.1	287.98	7	946	15.8
Punggur Utara	BMW 2 - BMW 3	44	0.1	1,033.02	36	982	16.4
Punggur Utara	BF 3 - BX 1	156	0.3	1,059	102	881	14.7
Punggur Utara	BX 1 - BX 2	103	0.2	1,196	34	916	15.3

Irrigation Sub-system	Canal	Service Capacity (Ha)	Discharge Capacity (m^3/s)	Canal Length (m)	Flowing time		
					Minutes	Cumulative minute	Hours
Punggur Utara	BQ 2 - BY 1	217	0.5	956	28	1175	19.6
Punggur Utara	BY 1 - BY 2	89	0.2	2,231	90	1265	21.1
Punggur Utara	BC 7 - BZ 1A	235	0.5	1,114	38	1017	16.9
Punggur Utara	BZ 1A - BZ 1B	210	0.5	228	2	1019	17.0
Punggur Utara	BZ 1B - BZ 1	50	0.1	379	37	1057	17.6
Punggur Utara	BM 4 - BMA 1	216	0.5	2,355	120	1105	18.4
Punggur Utara	BMA 1 - BMA 2	141	0.3	1,279	16	1121	18.7
Punggur Utara	BM 5 - BMB 1	230	0.5	1,933	72	1095	18.2
Punggur Utara	BM 5 - BMC 1	224	0.5	1,633	41	1136	18.9
Punggur Utara	BMC 1 - BMC 2	84	0.2	2,129	44	1180	19.7
Punggur Utara	BM 6 - BMD 1	310	0.7	2,108	573	1634	27.2
Punggur Utara	BM 7 - BME 1	545	1.2	1,102	18	1117	18.6
Punggur Utara	BME 1 - BME 2	180	0.4	2,009	27	1144	19.1
Punggur Utara	BME 1 - BMF 1	221	0.5	1,640	22	1139	19.0
Punggur Utara	BMF 1 - BMF 2	113	0.2	1,995	43	1182	19.7
Punggur Utara	BM 10 - BMG 1	147	0.3	1,133	17	1192	19.9
Punggur Utara	BM 11 - BMH 1	150	0.3	385	5	1204	20.1
Punggur Utara	BM 2 - BMI 1	283	0.6	425	48	989	16.5
Punggur Utara	BMI 1 - BMI 2	248	0.5	100	1	990	16.5
Punggur Utara	BPU 25 - BUA 1	302	0.7	2,351	31	1073	17.9
Punggur Utara	BUA 1 - BUA 2	217	0.5	1,552	26	1099	18.3
Punggur Utara	BUA 2 - BUA 3	125	0.3	884	31	1130	18.8
Punggur Utara	BQ 3 - BQA 1	83	0.2	1,150	25	1212	20.2
Punggur Utara	BQA 1 - BQA 2	50	0.1	1,028.3	13	1225	20.4
Punggur Utara	BPU 21 - UB.1	134	0.3	640.3	8	811	13.5
Punggur Utara	BPU 26 - BUD	141	0.3	125	2	1095	18.2
Punggur Utara	BPU 25 - BUE 1	288	0.6	762	11	1053	17.6
Punggur Utara	BC 7 - BGS 1	361	0.8	1,580	48	1027	17.1
Punggur Utara	BGS 1 - BGS 2	202	0.4	603	2	1030	17.2
Punggur Utara	BGS 2 - BGS 3	155	0.3	679	18	1048	17.5
Punggur Utara	BGS 3 - BGS 4	119	0.3	786	20	1068	17.8
Punggur Utara	BGS 4 - BGS 5	9	0.0	896	30	1098	18.3
Punggur Utara	BPU 22 - BUF 1	219	0.5	110	1	904	15.1
Punggur Utara	BUF 1 - BUF 2	143	0.3	1,708	48	952	15.9
Punggur Utara	BUF 2 - BUF 3	75	0.2	932	31	983	16.4
Rumbia Barat	BPU 22 - BRB 1	5,839	12.6	11,637	215	1118	18.6
Rumbia Barat	BRB 1 - BRB 2	4,999	10.8	1,956	50	1168	19.5
Rumbia Barat	BRB 2 - BRB 3	4,922	10.6	459	10	1178	19.6
Rumbia Barat	BRB 3 - BRB 4	2,717	5.9	1,801	52	1229	20.5
Rumbia Barat	BRB 4 - BRB 5	2,673	5.8	1,181	70	1299	21.7
Rumbia Barat	BRB 5 - BRB 6	2,447	5.3	2,550	44	1343	22.4
Rumbia Barat	BRB 6 - BRB 7	2,262	4.9	686	44	1386	23.1
Rumbia Barat	BRB 7 - BRB 8	1,286	2.8	87	2	1388	23.1
Rumbia Barat	BRB 8 - BRB 9	1,093	2.4	1,553	88	1476	24.6
Rumbia Barat	BRB 1 - BHG 1	839	1.8	189	8	1126	18.8
Rumbia Barat	BHG 1 - BHG 2	312	0.7	982	67	1193	19.9
Rumbia Barat	BHG 2 - BHG 3	225	0.5	1,216	33	1226	20.4
Rumbia Barat	BHG 3 - BHG 4	112	0.2	405	7	1233	20.6

Irrigation Sub-system	Canal	Service Capacity (Ha)	Discharge Capacity (m^3/s)	Canal Length (m)	Flowing time		
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Rumbia Barat	BHG 4 - BHG 5	42	0.1	1,391	129	1362	22.7
Rumbia Barat	BHG 1 - BHS 1	422	0.9	882	15	1140	19.0
Rumbia Barat	BHS 1 - BHS 2	262	0.6	1,836	39	1179	19.6
Rumbia Barat	BHS 2 - BHS 3	155	0.3	1,558	51	1230	20.5
Rumbia Barat	BRB 3 - BTH 1.1	248	0.5	207	12	1190	19.8
Rumbia Barat	BTH 1.1 - BTH 1.2	202	0.4	801	19	1209	20.2
Rumbia Barat	BTH 1.2 - BTH 1.3	135	0.3	595	14	1223	20.4
Rumbia Barat	BTH 1.3 - BTH 1.4	88	0.2	912	12	1235	20.6
Rumbia Barat	BRB 5 - BSKB 1	226	0.5	188	6	1305	21.7
Rumbia Barat	BSKB 1 - BSKB 2	76	0.2	991	16	1320	22.0
Rumbia Barat	BRB 6 - BSKA 1	185	0.4	277	9	1352	22.5
Rumbia Barat	BSKA 1 - BSKA 2	149	0.3	747	21	1373	22.9
Rumbia Barat	BSKA 2 - BSKA 3	91	0.2	851	9	1383	23.0
Rumbia Barat	BRB 7 - BKB 1	976	2.1	138	8	1394	23.2
Rumbia Barat	BKB 1 - BKB 2	902	2.0	308	6	1400	23.3
Rumbia Barat	BKB 2 - BKB 3	860	1.9	599	21	1421	23.7
Rumbia Barat	BKB 3 - BKB 4	816	1.8	413	9	1431	23.8
Rumbia Barat	BKB 4 - BKB 5	697	1.5	945	61	1491	24.9
Rumbia Barat	BKB 5 - BKB 6	358	0.8	746	18	1509	25.2
Rumbia Barat	BKB 6 - BKB 7	294	0.6	2,236	42	1551	25.8
Rumbia Barat	BKB 7 - BKB 8	195	0.4	545	22	1572	26.2
Rumbia Barat	BKB 8 - BKB 9	168	0.4	429	34	1607	26.8
Rumbia Barat	BKB 5 - BSN 1	339	0.7	207	3	1494	24.9
Rumbia Barat	BSN 1 - BSN 2	212	0.5	1,042	14	1508	25.1
Rumbia Barat	BSN 2 - BSN 3	159	0.3	1,209	35	1543	25.7
Rumbia Barat	BSN 3 - BSN 4	136	0.3	101	0	1543	25.7
Rumbia Barat	BKB 9 - BSB 1	168	0.4	285	5	1612	26.9
Rumbia Barat	BSB 1 - BSB 2	86	0.2	475	13	1625	27.1
Rumbia Barat	BSB 2 - BSB 3	70	0.2	1,399	37	1662	27.7
Rumbia Barat	BRB 8 - BTH 2.1	193	0.4	143	2	1574	26.2
Rumbia Barat	BTH 2.1 - BTH 2.2	142	0.3	1,005	31	1604	26.7
Rumbia Barat	BTH 2.2 - BTH 2.3	117	0.3	889	119	1724	28.7
Rumbia Barat	BTH 2.3 - BTH 2.4	93	0.2	1,093	29	1753	29.2
Rumbia Barat	BTH 2.4 - BTH 2.5	56	0.1	486	22	1774	29.6
Rumbia Barat	BRB 9 - BBR 1	1,093	2.4	610	14	1490	24.8
Rumbia Barat	BBR 1 - BBR 2	1,031	2.2	832	26	1516	25.3
Rumbia Barat	BBR 2 - BBR 3	999	2.2	950	36	1552	25.9
Rumbia Barat	BBR 3 - BBR 4	867	1.9	300	14	1566	26.1
Rumbia Barat	BBR 4 - BBR 5	793	1.7	654	41	1607	26.8
Rumbia Barat	BBR 5 - BBR 6	596	1.3	360	19	1627	27.1
Rumbia Barat	BBR 6 - BBR 7	566	1.2	712	48	1675	27.9
Rumbia Barat	BBR 7 - BBR 8	518	1.1	616	29	1704	28.4
Rumbia Barat	BBR 8 - BBR 9	220	0.5	626	23	1727	28.8
Rumbia Barat	BBR 9 - BBR 10	184	0.4	955	23	1750	29.2
Rumbia Barat	BBR 5 - BBM 1.1	197	0.4	162	1	1608	26.8
Rumbia Barat	BBM 1.1 - BBM 1.2	90	0.2	472	33	1642	27.4
Rumbia Barat	BRB 3 - BDY 1	1,957	4.2	275	23	1200	20.0
Rumbia Barat	BDY 1 - BDY 2	1,692	3.7	549	38	1238	20.6

Irrigation Sub-system	Canal	Service Capacity (Ha)	Discharge Capacity (m^3/s)	Canal Length (m)	Flowing time		
					Minutes	Cumulative minute	Hours
Rumbia Barat	BDY 2 - BDY 3	1,591	3.4	125	2	1239	20.7
Rumbia Barat	BDY 3 - BDY 4	1,527	3.4	1,259	44	1283	21.4
Rumbia Barat	BDY 4 - BDY 5	1,097	2.4	479	7	1290	21.5
Rumbia Barat	BDY 5 - BDY 6	1,035	2.2	561	78	1368	22.8
Rumbia Barat	BDY 6 - BDY 7	447	2.2	1,250	35	1403	23.4
Rumbia Barat	BDY 7 - BDY 8	295	0.6	160	2	1405	23.4
Rumbia Barat	BDY 8 - BDY 9	224	0.5	1,471	65	1471	24.5
Rumbia Barat	BDY 9 - BDY 10	133	0.3	1,398	64	1535	25.6
Rumbia Barat	BDY 1 - BBT 1	176	0.4	1,744	302	1502	25.0
Rumbia Barat	BBT 1 - BBT 2	97	0.2	594	9	1511	25.2
Rumbia Barat	BDY 4 - BWN 1.1	430	0.9	592	81	1365	22.7
Rumbia Barat	BWN 1.1 - BWN 1.2	268	0.6	629	92	1457	24.3
Rumbia Barat	BWN 1.2 - BWN 1.3	230	0.5	787	11	1467	24.5
Rumbia Barat	BDY 6 - BWN 2.1	521	1.1	856	16	1483	24.7
Rumbia Barat	BWN 2.1 - BWN 2.2	477	1.0	918	50	1533	25.5
Rumbia Barat	BWN 2.2 - BWN 2.3	426	0.9	413	15	1548	25.8
Rumbia Barat	BWN 2.3 - BWN 2.4	349	0.8	1,761	63	1611	26.8
Rumbia Barat	BDY 7 - BDY 1.1	152	0.3	278	3	1406	23.4
Rumbia Barat	BDY 1.1 - BDY 1.2	89	0.2	1,061	15	1421	23.7
Rumbia Barat	BDY 1.2 - BDY 1.3	55	0.1	727	10	1431	23.9
Rumbia Barat	BWN 2.3 - BSKC 1	203	0.4	130	3	1551	25.9
Rumbia Barat	BSKC 1 - BSKC 2	162	0.4	612	16	1567	26.1
Rumbia Barat	BSKC 2 - BSKC 3	41	0.1	1,003	18	1585	26.4
Rumbia Barat	BBR 8 - BBM 2.1	242	0.5	395	5	1709	28.5
Rumbia Barat	BBM 2.1 - BBM 2.2	174	0.4	710	11	1720	28.7
Rumbia Barat	BBM 2.2 - BBM 2.3	148	0.3	715	6	1726	28.8
Batanghari Utara	BG.0-BG.1 A	4,723	10.2	914	33	33	0.6
Batanghari Utara	BG.1 A-BG.1 B	4,700	10.2	434	4	37	0.6
Batanghari Utara	BG.1 B-BG.1 C	4,688	10.1	9,252	684	722	12.0
Batanghari Utara	BG.1 C-BG.1	4,640	10.0	332	6	728	12.1
Batanghari Utara	BG.1-BG. 2	4,478	9.7	1,282	129	857	14.3
Batanghari Utara	BG.2-BG.3 A	4,143	9.0	362	5	862	14.4
Batanghari Utara	BG.3 A-BG.3	4,140	9.0	352	9	871	14.5
Batanghari Utara	BG.3-BG.4 A	4,100	8.9	602	9	880	14.7
Batanghari Utara	BG.4-BG. 5	3,582	7.7	176	2	882	14.7
Batanghari Utara	BG.5-BG. 6	3,524	7.6	1,889	71	953	15.9
Batanghari Utara	BG.6-BG.7	3,202	6.9	1,155	19	973	16.2
Batanghari Utara	BG.7-BG.8	2,897	6.3	1,024	43	1015	16.9
Batanghari Utara	BG.8-BG.9 A	2,282	4.9	352	9	1024	17.1
Batanghari Utara	BG.9 A-BG.9	2,224	4.8	1,211	58	1082	18.0
Batanghari Utara	BG.9-BG.10 A	2,008	4.3	689	36	1118	18.6
Batanghari Utara	BG.10 A-BG.10 B	1,978	4.3	116	2	1120	18.7
Batanghari Utara	BG.10 B-BG.10	1,873	4.1	1,157	26	1146	19.1
Batanghari Utara	BG.10-BG.11	1,667	3.6	1,398	44	1190	19.8
Batanghari Utara	BG.11-BG.12	1,548	3.3	823	23	1213	20.2
Batanghari Utara	BG.12-BG.13	856	1.9	1,197	116	1329	22.1
Batanghari Utara	BG.13-BG.14 A	705	1.5	356	13	1342	22.4
Batanghari Utara	BG.14 A-BG.14	676	1.5	508	25	1367	22.8

Irrigation Sub-system	Canal	Service Capacity (Ha)	Discharge Capacity (m^3/s)	Canal Length (m)	Flowing time		
					Minutes	Cumulative minute	Hours
Batanghari Utara	BG.14-BG.15 A	575	1.2	869	41	1408	23.5
Batanghari Utara	BG.15 A-BG.15	533	1.2	1,310	26	1433	23.9
Batanghari Utara	BG.16 A-BG.16	254	0.5	564	3	1437	23.9
Batanghari Utara	BG.15-BG.16 A	231	0.5	1,730	38	1475	24.6
Batanghari Utara	BG.16-BG.17	181	0.4	1,019	19	1494	24.9
Batanghari Utara	BG.17-BG.18	95	0.2	740	6	1499	25.0
Batanghari Utara	BG.2-BTB.1	128	0.3	642	12	869	14.5
Batanghari Utara	BG.7-BTP.1	289	0.6	1,519	35	904	15.1
Batanghari Utara	BTP.1-BTP.2	145	0.3	1,525	22	926	15.4
Batanghari Utara	BG.8-BTK.1	573	1.2	696	17	1033	17.2
Batanghari Utara	BTK.1-BTK.2 A	490	1.1	592	8	1040	17.3
Batanghari Utara	BTK.2 A-BTK.2	412	0.9	1,584	40	1081	18.0
Batanghari Utara	BTK.2-BTK.3	191	0.4	2,136	25	1106	18.4
Batanghari Utara	BG.9-BPU.1 A	91	0.2	1,114	19	1101	18.4
Batanghari Utara	BPU.1 A-BPU. 1	61	0.1	816	13	1114	18.6
Batanghari Utara	BPU.1-BPU. 2	57	0.1	695	17	1131	18.8
Batanghari Utara	BPU.2-BPU. 3	39	0.1	630	14	1145	19.1
Batanghari Utara	BPU.3-BPU. 4	16	0.0	625	14	1159	19.3
Batanghari Utara	BG.4-BTE.1	423	0.9	1,438	35	915	15.3
Batanghari Utara	BTE.1-BTE.2	366	0.8	1,876	75	990	16.5
Batanghari Utara	BTE.3 A-BTE.3	254	0.5	829	17	1007	16.8
Batanghari Utara	BTE.2-BTE.3 A	139	0.3	2,198	202	1209	20.2
Batanghari Utara	BG.12-BP.1 A	515	1.1	1,970	48	1261	21.0
Batanghari Utara	BP.1-BP.2 Ka.1 A	178	0.4	1,340	58	1319	22.0
Batanghari Utara	BP.2 Ka.1 A-BP.2 Ka.1 B	159	0.3	433	6	1325	22.1
Batanghari Utara	BP.2 Ka.1 B-BP.2 Ka.1	82	0.2	1,871	70	1395	23.2
Batanghari Utara	BP.1-BP.2 Kr.1	303	0.7	1,157	30	1425	23.7
Batanghari Utara	BP.2 Kr.1-BP.2 Kr.2	96	0.2	978	81	1505	25.1
Batanghari Utara	BP.2 Kr.2-BP.2 Kr.3	26	0.1	956	14	1520	25.3
Raman Utara	BRU 0 - BRU 1A	4,339	9.4	566	5	632	10.5
Raman Utara	BRU 1A - BRU 1B	4,303	9.3	2,774	52	684	11.4
Raman Utara	BRU 1B - BRU 1	4,261	9.2	988	34	717	12.0
Raman Utara	BRU 1 - BRU 2	4,151	9.0	3,742	133	851	14.2
Raman Utara	BRU 2 - BRU 3	4,120	8.9	990	19	870	14.5
Raman Utara	BRU 3 - BRU 4	4,035	8.7	1,374	56	926	15.4
Raman Utara	BRU 4 - BRU 5	3,034	6.6	649	19	945	15.7
Raman Utara	BRU 5 - BRU 6	2,989	6.5	901	25	970	16.2
Raman Utara	BRU 6 - BRU 7	2,941	6.4	1,087	40	1009	16.8
Raman Utara	BRU 7 - BRU 8	2,777	6.0	964	14	1023	17.1
Raman Utara	BRU 8 - BRU 9	2,702	5.8	1,132	20	1044	17.4
Raman Utara	BRU 9 - BRU 10	2,040	4.4	1,410	66	1110	18.5
Raman Utara	BRU 10 - BRU 11	1,956	4.2	1,392	16	1126	18.8
Raman Utara	BRU 11 - BRU 12A	1,545	3.3	1,193	20	1145	19.1
Raman Utara	BRU 12 - BRU 13	977	2.1	1,246	16	1161	19.4
Raman Utara	BRU 13 - BRU 14A	781	1.7	491	4	1165	19.4
Raman Utara	BRU 14A - BRU 14	693	1.5	1,253	23	1187	19.8
Raman Utara	BRU 14 - BRU 15	621	1.3	969	19	1206	20.1
Raman Utara	BRU 15 - BRU 16	425	0.9	1,358	90	1296	21.6

Irrigation Sub-system	Canal	Service Capacity (Ha)	Discharge Capacity (m^3/s)	Canal Length (m)	Flowing time		
					Minutes	Cumulative minute	Hours
Raman Utara	BRU 16 - BRU 17	388	0.8	1,039	20	1316	21.9
Raman Utara	BRU 17 - BRU 18	304	0.7	721	14	1330	22.2
Raman Utara	BRU 18 - BRU 19A	156	0.3	164	1	1331	22.2
Raman Utara	BRU 19A - BRU 19	138	0.3	1,299	28	1359	22.6
Raman Utara	BRU 4 - BC 1	161	0.3	404	6	932	15.5
Raman Utara	BC.1- BC.2	89	0.2	1,421	26	958	16.0
Raman Utara	BRU 4 - BA 1	840	1.8	1,662	61	987	16.5
Raman Utara	BA 1 - BA 2	796	1.7	964	28	1016	16.9
Raman Utara	BA 2 - BA 3	407	0.9	1,132	23	1038	17.3
Raman Utara	BA 3 - BA 4	350	0.8	946	13	1051	17.5
Raman Utara	BA 4 - BA 5	314	0.7	1,449	25	1076	17.9
Raman Utara	BA 5 - BA 6	226	0.5	1,609	60	1136	18.9
Raman Utara	BA 2 - BB 1	311	0.7	879	20	1035	17.3
Raman Utara	BB.1 - BB.2	228	0.5	380	3	1038	17.3
Raman Utara	BRU 9 - BD 1	447	1.0	1,177	61	1105	18.4
Raman Utara	BD.1 - BD.2	176	0.4	912	8	1114	18.6
Raman Utara	BD.2 - BD.3	134	0.3	948	20	1133	18.9
Raman Utara	BRU 9 - BE 1	118	0.3	912	25	1069	17.8
Raman Utara	BRU 11 - BF 1	277	0.6	596	21	1147	19.1
Raman Utara	BF.1 - BF.2	100	0.2	1,277	17	1163	19.4
Raman Utara	BRU 12 - BG 1	367	0.8	566	9	1154	19.2
Raman Utara	BG.1 - BG.2A	297	0.8	788	24	1179	19.6
Raman Utara	BG.2A - BG.2	276	0.8	795	13	1192	19.9
Raman Utara	BG.2 - BG.3	186	0.4	1,152	23	1214	20.2
Raman Utara	BRU 15 - BH 1	150	0.3	240	5	1212	20.2
Feeder Canal 1	BKH.0-BKH.1	23,647	51.2	8,000	237	237	3.9
Sekampung Bunut	BKH.1-BKH.2	23,567	51.0	9,250	488	725	12.1
Sekampung Bunut	BKH.2-BKH.3	5,074	11.0	3,148	38	763	12.7
Sekampung Bunut	BKH.3-BKB.1 A	2,964	6.4	3,580	113	876	14.6
Sekampung Bunut	BKB.1 A-BKB.1	2,920	6.3	1,199	44	920	15.3
Sekampung Bunut	BKB.1-BKB.2 A	2,783	6.0	1,145	42	962	16.0
Sekampung Bunut	BKB.2 A-BKB.2 B	2,746	5.9	561	26	987	16.5
Sekampung Bunut	BKB.2 B-BKB.2 C	2,713	5.9	965	92	1079	18.0
Sekampung Bunut	BKB.2 C-BKB.2	2,684	5.8	241	16	1095	18.3
Sekampung Bunut	BKB.2-BKB.3 A	2,676	5.8	1,522	34	1129	18.8
Sekampung Bunut	BKB.3 A-BKB.3 B	2,656	5.7	618	13	1142	19.0
Sekampung Bunut	BKB.3 B-BKB.3	2,594	5.6	400	7	1149	19.2
Sekampung Bunut	BKB.3-BKB.4	2,137	4.6	1,417	30	1179	19.7
Sekampung Bunut	BKB.4-BKB.5 A	2,066	4.5	1,752	28	1207	20.1
Sekampung Bunut	BKB.5 A-BKB.5	1,990	4.3	667	21	1229	20.5
Sekampung Bunut	BKB.5-BKB.6	1,929	4.2	1,727	35	1264	21.1
Sekampung Bunut	BKb.6-BKB.7	1,302	2.8	1,800	77	1341	22.3
Sekampung Bunut	BKB.7 -BKB.8 A	895	1.9	551	0	1341	22.3
Sekampung Bunut	BKB.8 A-BKB.8 B	862	1.9	100	2	1342	22.4
Sekampung Bunut	BKB.8 B-BKB.8 C	856	1.9	1,113	77	1419	23.7
Sekampung Bunut	BKB.8 C-BKB.8 D	847	1.8	714	23	1443	24.0
Sekampung Bunut	BKB.8 D-BKB.8	827	1.8	672	12	1455	24.3
Sekampung Bunut	BKb.8-BKb.9	641	1.4	1,504	37	1492	24.9

Irrigation Sub-system	Canal	Service Capacity (Ha)	Discharge Capacity (m^3/s)	Canal Length (m)	Flowing time		
					Minutes	Cumulative minute	Hours
Sekampung Bunut	BKb.9-BKb.10A	306	0.7	1,100	19	1512	25.2
Sekampung Bunut	BKB.10 A-BKB.10	272	0.6	412	8	1519	25.3
Sekampung Bunut	BKB.10-BKB.11 A	173	0.4	604	11	1530	25.5
Sekampung Bunut	BKB.11 A-BKB.11	85	0.2	870	8	1539	25.6
Sekampung Bunut	BKB.11-BKB.12	38	0.1	1,662	40	1579	26.3
Sekampung Bunut	BKH.3-BKR.1	1,643	3.6	1,676	73	836	13.9
Sekampung Bunut	BKR.1-BKR.2 A	1,279	2.8	1,964	34	871	14.5
Sekampung Bunut	BKR.2 A-BKR.2 B	1,213	2.6	446	9	880	14.7
Sekampung Bunut	BKR.2 B-BKR.2 C	1,166	2.5	600	35	915	15.2
Sekampung Bunut	BKR.2 C-BKR.2 D	1,140	2.5	704	12	927	15.4
Sekampung Bunut	BKR.2 D-BKR.2 E	1,119	2.4	82	2	929	15.5
Sekampung Bunut	BKR.2 E-BKR.2	1,107	2.4	300	9	939	15.6
Sekampung Bunut	BKR.2-BKR.3 A	970	2.1	288	4	942	15.7
Sekampung Bunut	BKR.3 A-BKR.3 B	963	2.1	2,035	115	1057	17.6
Sekampung Bunut	BKR.3 B-BKR.3	906	2.0	508	5	1062	17.7
Sekampung Bunut	BKR.3-BKR.4 A	742	1.6	959	14	1076	17.9
Sekampung Bunut	BKR.4 A-BKR.4 B	736	1.6	601	9	1085	18.1
Sekampung Bunut	BKR.4 B-BKR.4 C	700	1.5	381	9	1094	18.2
Sekampung Bunut	BKR.4 C-BKR.4 D	581	1.3	1,813	64	1158	19.3
Sekampung Bunut	BKR.4 D-BKR.4	505	1.1	1,068	19	1177	19.6
Sekampung Bunut	BKR.4-BKR.5 A	273	0.6	926	22	1198	20.0
Sekampung Bunut	BKR.5 A-BKR.5 B	207	0.4	1,081	66	1265	21.1
Sekampung Bunut	BKR.5 B-BKR.5	192	0.4	1,030	38	1303	21.7
Sekampung Bunut	BKR.3-BPS.1	134	0.3	351	7	1069	17.8
Sekampung Bunut	BKR.4-BWS.1	113	0.2	361	6	1182	19.7
Sekampung Bunut	BKR.5-BGW.1	131	0.3	240	9	1311	21.9
Sekampung Bunut	BGW.1-BGW.2	100	0.2	171	3	1315	21.9
Sekampung Bunut	BGW.2-BGW.3	65	0.1	33	1	1315	21.9
Sekampung Bunut	BKB.3-BKBW.1 A	390	0.8	1,748	41	1190	19.8
Sekampung Bunut	BKBW.1 A-BKBW.1 B	348	0.8	592	8	1198	20.0
Sekampung Bunut	BKBW.1 B-BKBW.1	305	0.7	587	5	1203	20.1
Sekampung Bunut	BKBW.1-BKBW.2 A	198	0.4	631	5	1208	20.1
Sekampung Bunut	BKBW.2 A-BKBW.2 B	186	0.4	187	1	1209	20.2
Sekampung Bunut	BKBW.2 B-BKBW.2	176	0.4	321	5	1214	20.2
Sekampung Bunut	BKBW.2-BKBW.3 A	113	0.2	585	6	1221	20.3
Sekampung Bunut	BKBW.3 A-BKBW.3 B	86	0.2	415	16	1236	20.6
Sekampung Bunut	BKBW.3 B-BKBW.3 C	70	0.2	895	16	1252	20.9
Sekampung Bunut	BKBW.3 C-BKBW.3	55	0.1	541	8	1260	21.0
Sekampung Bunut	BKB.6-BKBZ.1 A	510	1.1	850	14	1277	21.3
Sekampung Bunut	BKBZ.1 A-BKBZ.1 B	485	1.0	550	18	1295	21.6
Sekampung Bunut	BKBZ.1 B-BKBZ.1	396	0.9	1,220	15	1310	21.8
Sekampung Bunut	BKBZ.1-BKBZ.2	266	0.6	330	8	1318	22.0
Sekampung Bunut	BKBZ.2-BKBZ.3 A	246	0.5	1,050	143	1461	24.3
Sekampung Bunut	BKBZ.3 A-BKBZ.3	189	0.4	150	3	1464	24.4
Sekampung Bunut	BKB.7-BKBM.1 A	341	0.7	1,100	30	1370	22.8
Sekampung Bunut	BKBM.1 A-BKBM.1	258	0.6	931	13	1383	23.1
Sekampung Bunut	BKBM.1-BKBM.2	186	0.4	964	32	1415	23.6
Sekampung Bunut	BKBM.2-BKBM.3	117	0.3	705	17	1432	23.9

Irrigation Sub-system	Canal	Service Capacity (Ha)	Discharge Capacity (m^3/s)	Canal Length (m)	Flowing time		
					Minutes	Cumulative minute	Hours
Sekampung Bunut	BKB.9-BKBO.1	199	0.4	2,850	71	1563	26.1
Sekampung Bunut	BKBO.1-BKBO.2	94	0.2	984	17	1580	26.3
Sekampung Bunut	BKBO.1-BKBS.1	63	0.1	856	30	1593	26.5
Sekampung Bunut	BKBZ.3-BG.1	119	0.3	152	3	1467	24.4
Sekampung Batanghari	KH 2-BKBH.1	9,193	19.9	686	24	749	12.5
Sekampung Batanghari	BKBH.1-BKBH.2	9,181	19.9	819	18	767	12.8
Sekampung Batanghari	BKBH.2-BKBH.3	8,843	19.1	1,069	16	783	13.0
Sekampung Batanghari	BKBH.3-BKBH.4 A	8,698	18.8	1,897	31	814	13.6
Sekampung Batanghari	BKBH.4 A-BKBH.4	8,668	18.8	424	9	823	13.7
Sekampung Batanghari	BKBH.5 A-BKBH.5	8,420	18.2	166	1	823	13.7
Sekampung Batanghari	BKBH.5-BKBH.6 A	7,879	17.0	1,330	28	851	14.2
Sekampung Batanghari	BKBH.6 A-BKBH.6	7,819	16.9	732	17	868	14.5
Sekampung Batanghari	BKBH.6-BKBH.7 A	7,553	16.3	1,862	51	919	15.3
Sekampung Batanghari	BKBH.7 A-BKBH.7	7,484	16.2	714	9	928	15.5
Sekampung Batanghari	BKBH.7-BKBH.8 A	7,084	15.3	1,596	43	971	16.2
Sekampung Batanghari	BKBH.8 A-BKBH.8 B	7,030	15.2	256	3	974	16.2
Sekampung Batanghari	BKBH.8 B-BKBH.8 C	7,004	15.2	628	14	988	16.5
Sekampung Batanghari	BKBH.8 C-BKBH.8 D	6,977	15.1	623	18	1006	16.8
Sekampung Batanghari	BKBH.8 D-BKBH.8	6,909	14.9	603	8	1014	16.9
Sekampung Batanghari	BKBH.8-BKBH.9	5,401	11.7	2,913	137	1151	19.2
Sekampung Batanghari	BKBH.9-BKBH.10 A	5,111	11.1	1,799	70	1221	20.4
Sekampung Batanghari	BKBH.10 A-BKBH.10	4,810	10.4	134	1	1222	20.4
Sekampung Batanghari	BKBH.10-BKBH.11 A	4,637	10.0	678	18	1241	20.7
Sekampung Batanghari	BKBH.11 A-BKBH.11	4,513	9.8	1,186	12	1253	20.9
Sekampung Batanghari	BKBH.11-BKBH.12	4,248	9.2	1,723	141	1394	23.2
Sekampung Batanghari	BKBH.12-BKBH.13	3,587	7.8	598	32	1426	23.8
Sekampung Batanghari	BKBH.14 A'-BKBH.14 A	2,624	5.7	240	3	1429	23.8
Sekampung Batanghari	BKBH.14 A-BKBH.14 B	2,512	5.4	534	54	1484	24.7
Sekampung Batanghari	BKBH.14 B-BKBH.14 C	2,408	5.2	266	14	1497	25.0
Sekampung Batanghari	BKBH.14 C-BKBH.14	2,408	5.2	775	13	1511	25.2
Sekampung Batanghari	BKBH.14-BKBH.15 A	600	1.3	933	12	1523	25.4
Sekampung Batanghari	BKBH.15 A-BKBH.15 B	538	1.2	132	1	1523	25.4
Sekampung Batanghari	BKBH.15 B-BKBH.15 C	527	1.1	617	17	1541	25.7
Sekampung Batanghari	BKBH.15 D-BKBH.15	474	1.0	600	16	1556	25.9
Sekampung Batanghari	BKBH.15-BKBH.16 A	360	0.8	1,202	16	1572	26.2
Sekampung Batanghari	BKBH.16 A-BKBH.16 B	341	0.7	89	1	1573	26.2
Sekampung Batanghari	BKBH.16 B-BKBH.16	317	0.7	368	9	1582	26.4
Sekampung Batanghari	BKBH.16-BSN.1	72	0.2	1,535	44	1626	27.1
Sekampung Batanghari	BSn.1-BSn.2	50	0.1	398	15	1641	27.4
Sekampung Batanghari	BSN.3 A-BSN.3	22	0.0	601	14	1656	27.6
Sekampung Batanghari	BSN.3-BSN.4	7	0.0	322	5	1661	27.7
Sekampung Batanghari	BKBH.16-BTM.1	151	0.3	430	8	1591	26.5
Sekampung Batanghari	BTM.1-BTM.2	54	0.1	1,042	17	1607	26.8
Sekampung Batanghari	BKBH.14-BKMI.1 A	1,484	3.2	1,306	21	1532	25.5
Sekampung Batanghari	BKMI.1 A-BKMI.1 B	1,448	3.1	575	22	1553	25.9
Sekampung Batanghari	BKMI.1 B-BKMI.1	1,448	3.1	516	18	1572	26.2
Sekampung Batanghari	BKMI.1-BKMI.2 A	842	1.8	1,167	36	1608	26.8
Sekampung Batanghari	BKMI.2 A-BKMI.2 B	833	1.8	151	4	1611	26.9

Irrigation Sub-system	Canal	Service Capacity (Ha)	Discharge Capacity (m^3/s)	Canal Length (m)	Flowing time		
					Minutes	Cumulative minute	Hours
Sekampung Batanghari	BKMI.2 C-BKMI.2 D	633	1.4	89	1	1613	26.9
Sekampung Batanghari	BKMI.2-BKMI.3 A	364	0.8	803	18	1631	27.2
Sekampung Batanghari	BKMI.3 A-BKMI.3 B'	358	0.8	90	1	1631	27.2
Sekampung Batanghari	BKMI.3 B'-BKMI.3 B	338	0.7	492	9	1640	27.3
Sekampung Batanghari	BKMI.3 B-BKMI.3	338	0.7	1,011	40	1680	28.0
Sekampung Batanghari	BKMI.3-BKMI.4	306	0.7	278	3	1682	28.0
Sekampung Batanghari	BKMI.4-BKMI.5	69	0.1	963	34	1716	28.6
Sekampung Batanghari	BKBH.14-BSH.1	152	0.3	1,150	30	1541	25.7
Sekampung Batanghari	BKMI.1-BWK.1	120	0.3	435	8	1580	26.3
Sekampung Batanghari	BKMI.1-BGK.1	322	0.7	1,503	28	1600	26.7
Sekampung Batanghari	BGK.1-BGK.2	279	0.6	1,590	22	1622	27.0
Sekampung Batanghari	BDM.2-BDM.3 A	156	0.3	123	1	1750	29.2
Sekampung Batanghari	BGK.3 B-BGK.3	109	0.2	112	4	1626	27.1
Sekampung Batanghari	BKMI.2 C-BHG.1	148	0.3	1,342	33	1645	27.4
Sekampung Batanghari	BHG.1-BHG.2	121	0.3	540	17	1663	27.7
Sekampung Batanghari	BHG.3 A-BHG.3	84	0.2	108	3	1666	27.8
Sekampung Batanghari	BHG.3-BHG.4	69	0.1	334	3	1669	27.8
Sekampung Batanghari	BKMI.2-BSB.1	165	0.4	71	0	1631	27.2
Sekampung Batanghari	BSB.1-BSB.2	123	0.3	938	34	1665	27.8
Sekampung Batanghari	BKMI.5-BBP.1	38	0.1	384	12	1729	28.8
Sekampung Batanghari	BKMI.2-BKS.1	93	0.2	90	1	1632	27.2
Sekampung Batanghari	BKS.2 B-BKS.2	42	0.1	102	0	1632	27.2
Sekampung Batanghari	BKMI.4-BDM.1	191	0.4	1,266	50	1733	28.9
Sekampung Batanghari	BDM.2 B-BDM.2	115	0.2	211	16	1749	29.2
Sekampung Batanghari	BDM.3 A-BDM.3	90	0.2	326	4	1753	29.2
Sekampung Batanghari	BKBH.8-BKDJ.1 A	1,065	2.3	1,748	25	1039	17.3
Sekampung Batanghari	BKDJ.1 A-BKDJ.1	1,045	2.3	225	4	1044	17.4
Sekampung Batanghari	BKDJ.1-BKDJ.2 A	712	1.5	969	26	1069	17.8
Sekampung Batanghari	BKDJ.2 A-BKDJ.2 B	677	1.5	830	16	1085	18.1
Sekampung Batanghari	BKDJ.2 B-BKDJ.2	649	1.4	385	9	1095	18.2
Sekampung Batanghari	BKDJ.2-BKDJ.3 A	544	1.2	691	13	1108	18.5
Sekampung Batanghari	BKDJ.3 A-BKDJ.3 B	525	1.1	744	19	1127	18.8
Sekampung Batanghari	BKDJ.3 B-BKDJ.3	516	1.1	211	2	1129	18.8
Sekampung Batanghari	BKDJ.3-BKDJ.4	458	1.0	305	4	1133	18.9
Sekampung Batanghari	BKDJ.4-BKDJ.5	270	0.6	437	4	1138	19.0
Sekampung Batanghari	BKDJ.5-BKDJ.6 A	270	0.6	447	5	1143	19.0
Sekampung Batanghari	BKDJ.6 A-BKDJ.6	254	0.6	183	1	1144	19.1
Sekampung Batanghari	BKDJ.6-BKDJ.7	111	0.2	850	15	1159	19.3
Sekampung Batanghari	BKDJ.7-BKDJ.8	25	0.1	656	10	1169	19.5
Sekampung Batanghari	BKDJ.6-BNR.1	94	0.2	179	1	1145	19.1
Sekampung Batanghari	BKBH.12-BBMI.1 A	598	1.3	810	23	1417	23.6
Sekampung Batanghari	BBMI.1 A-BBMI.1 B	562	1.2	390	14	1431	23.9
Sekampung Batanghari	BBMI.1 B-BBMI.1	529	1.1	310	2	1433	23.9
Sekampung Batanghari	BBMI.1-BBSA.1	179	0.4	396	6	1439	24.0
Sekampung Batanghari	BBSA.1-BBSA.2	164	0.4	682	10	1449	24.2
Sekampung Batanghari	BBSA.3 A-BBSA.3	93	0.2	81	1	1450	24.2
Sekampung Batanghari	BBSA.3-BBSA.4	35	0.1	371	9	1459	24.3
Sekampung Batanghari	BBMI.1-BSR.1	129	0.3	254	2	1435	23.9

Irrigation Sub-system	Canal	Service Capacity (Ha)	Discharge Capacity (m^3/s)	Canal Length (m)	Flowing time		
					Minutes	Cumulative minute	Hours
Sekampung Batanghari	BKBH.13-BKSI.1 A	865	1.9	1,008	51	1477	24.6
Sekampung Batanghari	BKSI.1 A-BKSI.1 B	826	1.8	419	14	1490	24.8
Sekampung Batanghari	BKSI.1 B-BKSI.1	795	1.7	706	31	1521	25.4
Sekampung Batanghari	BKSI.1-BKSI.2 A	670	1.4	366	10	1532	25.5
Sekampung Batanghari	BKSI.2 A-BKSI.2 B	665	1.4	895	46	1577	26.3
Sekampung Batanghari	BKSI.2 B-BKSI.2 C	638	1.4	502	11	1588	26.5
Sekampung Batanghari	BKSI.2 D-BKSI.2	616	1.3	115	4	1593	26.5
Sekampung Batanghari	BKSI.2-BKSI.3	295	0.6	1,990	107	1700	28.3
Sekampung Batanghari	BKSI.3-BKSI.4	216	0.5	1,280	29	1729	28.8
Sekampung Batanghari	BKSI.4-BKSI.5	144	0.3	1,144	14	1742	29.0
Sekampung Batanghari	BKSI.5-BKSI.6 A	68	0.1	756	19	1761	29.4
Sekampung Batanghari	BKSI.6 A-BKSI.6	43	0.1	237	4	1765	29.4
Sekampung Batanghari	BKSI.2-BSM.1	224	0.5	395	16	1609	26.8
Sekampung Batanghari	BSM.1-BSM.2	183	0.4	402	8	1617	27.0
Sekampung Batanghari	BKBH.13-BSG.1A	65	0.1	1,031	30	1456	24.3
Sekampung Batanghari	BSG.1A-BSG.1	46	0.1	491	12	1468	24.5

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