# RESEARCH REPORT 2012-2013

C-09 PROJECT:

**Designing Local Framework for Integrated Water Resources Management**

Research Topic:

**Water Availability and Water Productivity in the Context of Climate, Landuse and Socio-economic Changes in Saba and Jeneberang Watershed, Indonesia**

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Bogor Agricultural University (IPB)
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2012/2013

## SUMMARY

**Designing Local Framework for Integrated Water Resources Management: "Water Availability and Water Productivity in the Context of Climate, Landuse and Socio-economic Changes".** Budi I. Setiawan, Satyanto K. Saptomo, I Wayan Budiasa, Liyantono and Sutoyo.

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Continuing increase in water use leads to growing concern over the availability and quality of water supplies. As water becomes scarcer, there is a growing need to find ways to produce sufficient food to feed the world's expanding population, while using less water, safeguarding fragile environmental services and without having much opportunity to open up new agricultural lands. Purpose of this research was to enhance stakeholders' capability on dealing with climate, landuse and socio-economic changes on managing water resources with special attentions to: 1) clarify significances of climate, landuse and socio-economic changes; 2) discover interrelations of climate, landuse and socio-economic changes with water resources; and 3) enhance water use efficiency and water productivity. In designing a local framework for integrated water resources management, involvement of stakeholders is very important. They should realize not only their demand on water but also a dynamic status of water resources. In these preliminary results, we found that there were indications that both Saba and Jeneberang Watershed have been experiencing climate and landuse changes. The main indicators were increase of daily minimum temperature and decrease of annual rainfall. Significant shrunk of water surface area of Bili-bili Dam could be detected. Land conversions from paddy fields to non-paddy fields were due to less irrigation water or available water to irrigate the paddy fields. In order to meet rice demand and the decreasing trend of available water resource, a proper method has been introduced to local farmers through SRI Paddy Field trainings. It is recommended to continue this research which gives more attention to deliver of research findings to the stakeholders, involving stakeholders to formulate mechanism to improve the existing water resources management especially in dealing with climate and landuse changes. Enhance capability of local farmers to produce agricultural product in more effective and water-efficient. Elaborate interrelationship among variables involved in determining water availability especially within the aspects of socio-economics. Specify driving forces behind landuse changes in example by using sensitivity analysis.

# FOREWORD

This report is submitted to RIHN associated with the implementation of a collaboration research between RIH and IPB signed in the fiscal year 2012/2013. The title of the collaboration research was Designing Local Frameworks for Integrated Water Resources Management, and the content of this report is on the topic of Water Availability and Water Productivity in the Context of Climate, Landuse and Socio-economic Changes in Saba and Jeneberang Watershed". This research topic involved associate scientists from Udayana University and Hasanuddin University.

In this report we present preliminary data and information based on secondary data collected from various institutions including through a workshops gathering scientists and relevant source persons. We also have installed necessary instruments for monitoring climate and soil environments in paddy fields that are becoming the main focus of our study. Some farmers were invited to attend training on SRI Paddy Fields with the purpose to get them acquainted with a new method on how to increase water productivity. Analysis results of climate and landuse changes based on limited data are presented here in this report, and will be elaborated in the next fiscal year. Elaboration will also be conducted in socio-economic aspects to know the driving forces behind landuse changes that occurring significantly especially in Jeneberang Watershed.

Finally, we convey our appreciation to RIHN for giving extraordinary opportunity to conduct this collaboration research, which we believe would gain extraordinary benefits for both institutions and also to the stakeholders in the studied areas, and also to the global community as valuable references for designing integrated water resources management that taking into account local knowledge and wisdom.

Bogor, March 31, 2013
Team Leader,

Prof.Dr. Budi I. Setiawan

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## DEFINITIONS

**Design** is an approach that engineering and some other disciplines use to specify how to create or do something. A successful design must satisfies a (perhaps informal) functional specification (do what it was designed to do); conforms to the limitations of the target medium (it is possible to implement); meets implicit or explicit requirements on performance and resource usage (it is efficient enough)[1].

**Framework** is an assemblage of structural elements or members fitted together to form a structure, as a multi-storey building, a rigid-frame shed, or a truss[2].

A design may also have to satisfy restrictions on the design process itself, such as its length or cost, or the tools available for doing the design.

**Water Resource** is sources of water that is useful or potentially useful for agricultural, industrial, household, recreational and environmental activities[3].

> Source of water are any of the entire range of natural waters (vapour, liquid, or solid) that occur on the Earth and that are of potential use to humans.
>
> These resources include the waters of the oceans, rivers, and lakes; groundwater and deep subsurface waters; and glaciers and permanent snowfields[4].

**Water Resource Management (WRM)** is the activity of planning, developing, distributing and managing the optimum use of water resources. It is a sub-set of water cycle management. In an ideal world, water resource management planning has regard to all the competing demands for water and seeks to allocate water on an equitable basis to satisfy all uses and demands. This is rarely possible in practice[5].

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[1] http://encyclopedia2.thefreedictionary.com/design

[2] http://encyclopedia2.thefreedictionary.com/framework

[3] http://en.wikipedia.org/wiki/Water_resources

[4] http://encyclopedia2.thefreedictionary.com/water+resource

[5] http://en.wikipedia.org/wiki/Water_management

**Integrated Water Resource Management (IWRM)** is a comprehensive, participatory planning and implementation tool for managing and developing water resources in a way that balances social and economic needs, and that ensures the protection of ecosystems for future generations.

Water's many different uses—for agriculture, for healthy ecosystems, for people and livelihoods—demands coordinated action.

IWRM approach is an open, flexible process, bringing together decision-makers across the various sectors that impact water resources, and bringing all stakeholders to the table to set policy and make sound, balanced decisions in response to specific water challenges faced.

In putting the IWRM principle into practice, many countries have adopted an approach where regulatory decisions such as water allocation and pollution licensing are implemented at the scale of the river basin or catchment.

This has been accompanied by the emergence of institutional arrangements for water resources management that based on hydrological boundaries.

While most of these institutions can be grouped as River Basin Organisations (RBOs) some are specifically mandated with managing groundwater water aquifers and lakes basins.

Cap-Net, a UNDP capacity development programme for sustainable water management developed a training manual on IWRM for River Basin Organisations and works with networks of local capacity builders around the world to assist water managers with the concept of using an IWRM approach on the ground[6].

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[6] http://en.wikipedia.org/wiki/Integrated_Water_Resources_Management

**Integrated Water Resource Management (**IWRM) is a coordinated, goal-directed process for controlling the development and use of river, lake, ocean, wetland, and other water assets[7].

**ToolBox of Integrated Water Resource Management (IWRM ToolBox)** launched by Global Water Partnership[8], is a free and open database with a library of background papers, policy briefs, technical briefs and perspective papers as well as huge sections of case studies and references in each tool. These are all available for use by anyone who is interested in implementing better approaches for the management of water or learning more about improving water management at a local, national, regional or global level[9].

**Water Availability (available water)** is a part of water resource that is readily available to use for supporting socio-economic activities.

**Water Utilization (use of water**) is a part of available water that is apparently use for socio-economic activities.

**Water Productivity** is a ratio of the net benefits gained or yielded from a socio-economic activity to the amount of water required to produce those benefits[10].

**Climate Change** is a significant change in the statistical distribution of weather patterns over periods ranging from decades to millions of years[11].

**Landuse Change** is a significant change in the statistical distribution of landuse patterns over a ranging of time.

**Watershed** is a basin-like landform defined by highpoints and ridgelines that descend into lower elevations and stream valleys[12].

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[7] http://en.wikipedia.org/wiki/Integrated_Water_Resources_Management

[8] http://www.gwp.org/

[9] http://www.gwptoolbox.org/

[10] http://en.wikipedia.org/wiki/Deficit_irrigation#Crop_water_productivity

[11] http://en.wikipedia.org/wiki/Climate_change

**Baseflow** is a portion of streamflow that comes from the sum of deep subsurface flow and delayed shallow subsurface flow. It is also called drought flow, groundwater recession flow, low flow, low-water flow, low-water discharge and sustained or fair-weather runoff[13].

**Environmental Flow** is a quantity, timing, and quality of water flows required to sustain freshwater and estuarine ecosystems and the human livelihoods and wellbeing that depend on these ecosystems.

**Socioeconomics** is a contemporary practice considers behavioural interactions of individuals and groups through social capital and social "markets" (not excluding for example, sorting by marriage) and the formation of social norms In the latter, it studies the relation of economics to social values[14].

**Human Development Index (HDI)[15]** is a summary composite index that measures a country's average achievements in three basic aspects of human development: longevity, knowledge, and a decent standard of living.

> **Longevity** is measured by life expectancy at birth; **knowledge** is measured by a combination of the adult literacy rate and the combined primary, secondary, and tertiary gross enrolment ratio; and **standard of living** is measured by GDP per capita. Human Development Report of the United Nations is an indication of where a country is development wise. The index can take value between 0 and 1. Countries with an index over 0.800 are part of the High Human Development group. Between 0.500 and 0.800, countries are part of the Medium Human Development group and below 0.500 they are part of the Low Human Development group.

**Regional Income** is annual income gained by regional administrative as its asset/capital to finance development program. Parts of the income come from the central government and another parts originally come from its own territory as **Pendapatan Asli Daerah** (**PAD**) or

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[12] http://en.wikipedia.org/wiki/Watershed_(image_processing)

[13] http://en.wikipedia.org/wiki/Baseflow

[14] http://en.wikipedia.org/wiki/Socioeconomics

[15] http://glossary.econguru.com/economic-term/Human+Development+Index

Original Regional Income, such as in form of taxes, royalty, retribution, etc that met by national and regional regulation.

**System Dynamics** (SD) is a computer-aided approach to policy analysis and design. It applies to dynamic problems arising in complex social, managerial, economic, or ecological systems -- literally any dynamic systems characterized by interdependence, mutual interaction, information feedback, and circular causality[16].

[16] http://www.systemdynamics.org/what_is_system_dynamics.html

# I. INTRODUCTION

## A. Background

In this recent time and in the coming decades, continuing increase in water use leads to growing concern over the availability and quality of water supplies. As water becomes scarcer, there is a growing need to find ways to produce sufficient food to feed the world's expanding population, while using less water, safeguarding fragile environmental services and without having much opportunity to open up new agricultural lands. It is then important to make improvement on how water and land resources are managed, with the aim of underpinning food security and reducing poverty while safeguarding vital environmental processes. Research is very vital focusing water availability and access, including adaptation to climate change; how water is used and how it can be used more productively; water quality and its relationship to health and the environment; and how societies govern their water resources.

The outcome of the research should be capable to improve agricultural water management, enhance food security, protect environmental health and alleviate poverty especially in developing countries. Problematic issues that need to be addressed among others are population and welfare increase, increase demand for food and other agricultural products, decrease of arable land due to land use competation, uncertainity of available water due to climate change, shifting of cultivation calendar, and decrease number of farmers.

Research outcome must have the answers to the following questions. Can traditional farmers produce more food and other agricultural products with less and less water? Can the stakeholders manage the available water wishly in order to increase water productivity? How to deliver research results to the stakeholders so that they use data and information to support their decision on dealing with water resources management?

This research selected 2 locations which are aba Watershed, in Bali Province, and Jeneberang Watershed in South-Sulawesi Province, the Republic of Indonesia. The two sites selected because they have contrasting socio-economic background but from preliminary study they have been facing similar problem of water availability in recent years that might be caused by the occurrences of climate changes. Water management in Saba Watershed has a long historical background which involved many aspects of nature and human life. On the other side, water management in Jeneberang Watershed applies a modern approach based on the establishment of a newly Bili-bili Dam.

Even though, stakeholders with their local wisdom have so far being capable in managing daily water resources it seems that difficulties have been arisen when dealing with the declining of available water due to climate and landuse changes. Data and information about these related matters including awareness and alert systems are not yet available. This research will elaborate to know how water resource and herewith water availability is related to, or determined by climate changes and landuse, and to know are main driving forces behind landuse changes, and to know consequences or future trends if these changes are not well addressed in managing water resources, and finally how to deliver research findings to the stakeholders so they become more capable in dealing with water scarcity and its consequences.

## B. Objectives

The main purpose of this research topic is to enhance stakeholders' capability on dealing with climate, landuse and socio-economic changes on managing water resources with special objectives to:

1. To clarify significances of climate, landuse and socio-economic changes.
2. To discover interrelations of climate, landuse and socio-economic changes with water resources, water availability and water utilization.
3. To enhance water use efficiency and water productivity.

## C. Scopes

The scope of this research topic is limited within a watershed with special focuses on elaborating interrelations among the following aspects, variables and units:

1. Climate focusing on temperature ($^oC$), rainfall (mm/d) and evapotranspiration (mm/d).
2. Landuse focusing on forest (ha), upland (ha) and paddy field (ha).
3. Socio-economics focusing on variables associated with human development index.
4. Water resources focusing on rainfall (mm/d) and river flows (m3/s).
5. Available water focusing on water intentionally collected or tapped for supporting socio-economic activity.
6. Water use focusing on water used in agricultures (mm).
7. Land productivity focusing on a quantity of agricultural product per hectare (kg/ha).
8. Water productivity focusing on a volume of water to produce a quantity of agricultural product per hectare ($kg/m^3$).
9. Labour productivity focusing on an equivalent number of workers to produce a quantity of agricultural product per hectare (kg/md).

## D. Hypothesis

1) In designing a local framework for integrated water resources management it is compulsory to involve stakeholders from the initiation of planning up to the final end of evaluation for further improvements.
2) The stakeholders should know not only their demand on water for their daily socio-economic activities but also status of water resources in their environment.
3) The status of water resources are very dynamic influenced naturally by climate and landuse.
4) Climate changes might be occurring in watershed.
5) Landuse conversions might be occurring in conjunction with socio-economic development in countryside.
6) Land conversion might be accelerated when the existing farmlands could not support basic needs to survive.
7) Without comprehensively knowing on climate and landuse changes and their severe impacts on water resources, stakeholders would do business as usual which in turn it would create uncertainty in the future.

8) In the other side, stakeholders should pay attention to enhance land and water as well as labour productivities by applying any appropriate means based on scientific findings.
9) Those interrelationships could be found by means of interdisciplinary and transdisciplinary analysis.
10) Those interrelationships would become important decision support knowledge to design a local framework for integrated water resource management.

## E. Expected Outputs

Expected of this research topic are:

1) Information of climate, landuse and water resource variabilities.
2) Validated hydrologic models and their simulation results.
3) Models to analyse interrelation of landuse, water resource and socio-economy.
4) Improved knowledge and capability to manage water resource properly.

## F. Expected Outcomes

The expected outcomes of this research topic are:

1) Papers presented in scientific conferences, and/or submitted to scientific journals.
2) Graduated Master and PhD students.
3) Enhanced young scientists.
4) Improved capacity of stakeholders.

## G. Expected Impacts

The expected impacts of this research topic are:

1) Trendsetting integrated water resource management plan and implementation.
2) Tightening mutual relationships among involving researchers, stakeholders and their institutions.

# II. RESEARCH CONCEPTION

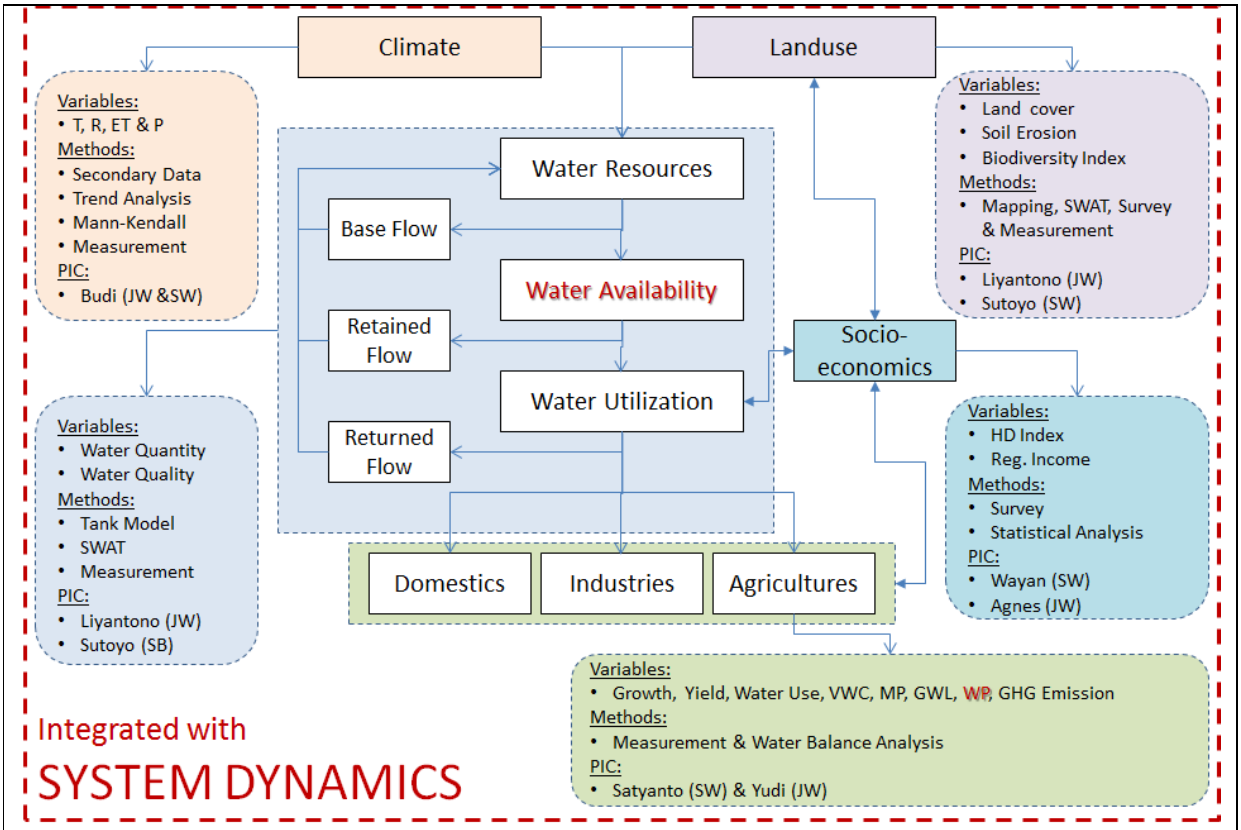


Figure II-1. A conceptual approach to on interaction among stakeholders

Figure II-1 shows a conceptual approach depicting an interrelationship of climate, landuse and socio-economics linked to water resource, water availability and water utilization. The concept might be explained in the following ways:

1. Climate and landuse altogether determine a quantity and quality of water resource. Any changes of climate and/or landuse to some extend would give a significant change on the water resource. These changes could be detected by looking into historical data using proper methods of analysis. From the results of analysis it would be possible to forecast what would happen to the water resource in the future.
2. Water availability or available water is a part of water resource that is available for supporting human activities. Another part of water resource is a baseflow that should be maintained in the water body for the sake of environmental healthy. In this sense, baseflow might be considered as environmental flow. The baseflow or

environmental flow ought to be determined in by looking to a historical data of minimum water discharge.

3. A part of the available water is used for domestics, industries and agricultures. Another part of the water might return to the water bodies and/or to the environment as seepage, deep percolation and/or drainage. Socio-economic conditions must play important roles in determining the proportion of water being used. In developing country like Indonesia, water used for agricultures is more than 80% which also implies a significant water loss or small efficiency in using the water. That is why water use in agricultures needs special attention. Increased water use efficiency means more water would be available for domestics and industries.
4. Socio-economic condition is very dynamic influenced by many aspects including externality. In developing country like Indonesia, socio-economic development which relays on resource or natural bases mostly results in land expansion, conversion of landuse, or landuse changes. It turns out these changes would give impacts on the water resource due to accelerated surface flow and less infiltration. It is then of interest to know if there any interrelations between socio-economic and landuse changes, and to find out what variables involved in socio-economic aspects?
5. Another important question is what variables representable to describe of socio-economic status? These variables should be easily understandable by the stakeholders as well as acceptable to the outside society. Herewith, we are determined to use Human Development Index and Regional Income as variables indicate socio-economic condition in the studied areas. These variables have been use by the Government of Indonesia as indicators in rating development plan and progress in all regions. Data of these variables are periodically measured by the National Statistics Agency and published every year in its website[17].
6. As being recognized elsewhere, agricultures consume incomparable amount of water than the two others, domestics and industries. In consequence, a deeper investigation on how the available water is being used? What is the merit of using the water? Is there any significant impact to the environment? Are there any possibilities to

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[17] http://www.bps.go.id/menutab.php?tabel=1&kat=1&id_subyek=26

improve the use of water to be more efficient? It is then necessary to apprehend water use associated with plant growth, yield, productivity as well as greenhouse gas emission.

7. By no means, the other two water users cannot be excluded in the analysed because even though they use less water but the economic productivity of using the water might be multiple higher that in the agriculture. To be recognized too that there is an elevating trend of water demand in these two sectors elsewhere.

Based on those descriptions it is now of interest to find an appropriate tool that can integrate all those variables into a system of analysis which is executable and can be used to forecast their trends in the future. Herewith, we are determined to apply System Dynamics. There are various tools (softwares) of System Dynamics available to use however there would be worthwhile to develop a simpler tool that is easily understood and implementable by the stakeholders. So, they can use it as a decision support system for developing locally integrated water resource management.

To carry out this research there are 6 focused studied on:

1. Climate Changes
2. Landuse Changes
3. Water Balance in Watershed Scale
4. Water Balance in Paddy Field
5. Allometric Growth of Paddy
6. Global Warming Potential.
7. Socio-economics
8. Integrated System Dynamics.

# III. METHODOLOGY

## A. Time and Locations

This research will be carried out in 5 years started from 2011/12 to 2015/16 in the period of 5 years in 2 watersheds, which are Saba Watershed in Bali Province and Jeneberang Watershed in South-Sulawesi Province.

## B. Climate Changes

Climate changes will be analysed using parametric and non-parametric model, such as linear trend and Mann-Kendall method[18]. A series of climate data will be collected from closer climate stations starting several before the great El-Nino in 1997. Seasonal climate change will also be analysed to know whether there is a significant shifting of dry and wet seasons. From this analysis, we to know how climate variables change with time and what it would be in the future. The main variables are Air Temperature (Ta), Solar Radiation (Rs), Potential Evapotranspiration (ETp) and Precipitation (P).

## C. Landuse Changes

Landuse changes will be analysed using Remote Sensing data (Landsat and MODIS) and Geographic Information System. From this analysis, we to know how landuse distributions change with time what it would be in the future. The main variables are the Area of Forest (Af), Upland (Au), Paddy Field (Ap) and Settlement (As).

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[18] http://www.esdat.net/TrendAnalysis.aspx

### D. Water Balance in Watershed

Water balance in watershed scale will be analysed using Lumped Hydrologic Tank Model (HTM)[19] and Distributed Hydrologic Soil and Water Assessment Tools (SWAT)[20]. From this analysis, we to know how available water changes with time what it would be in the future. The main variables are River Flow (Qr) and Available Water (Qa). Available water considered here is the water which is flowing through the main canal from a weir or reservoir for irrigation.

### E. Water Balance in Paddy Field

Water use by domestics and industries will be assessed by means of secondary data collection and interviews. Water use by agricultures will be measured and analysed using water balance model in field scale. Automatic weather station (AWS) will be installed in three different locations, which are upstream, midstream and downstream. Soil and groundwater will also be measured. From this analysis, we to know how available water changes with time what it would be in the future. The main variables are the component of water balance, such as Precipitation (P), Groundwater ($Q_G$), Irrigation Water ($Q_I$), Runoff (RO), Deep Percolation (DP) Drainage Water ($Q_D$), Crop Evapotranspiration, (ETc) and Volumetric Water Content (VWC).

### F. Allometric Growth

The allometric growth of paddy will be measured with main variables are Land Productivity ($Y_L$), Water Productivity ($Y_P$), accumulation of Above and Below Ground Biomass/Carbon. Growth of paddy will be observed too using a static camera in the field.

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[19] http://academic.research.microsoft.com/Publication/6321613/developing-procedures-for-optimization-of-tank-model-s-parameters

[20] http://swat.tamu.edu/

## G. Global Warming Potential

Global Warming Potential will be measured consisting of $CO_2$, $CH_4$ and $N_2O$ by means of Closed Chamber method in the interval of once a week. A model will be developed to estimate GWP from TS and VWC using an Artificial Neural Network (ANN).

## H. Socio-economics

Human Development Index will be obtained through secondary data and field survey focusing to farmers' households. Interview and stakeholders meeting will be carried out whether through formal gathering and while conducting field works. Other related data of socio-economics will be collected from statistical data such as population, education, regional income, agricultures, rice consumption, etc.

## I. System Dynamics

In the initial stage, available tools of SD will be used but in the following stages a locally specific SD will be developed.

## J. Field Data and Information System

Three sets of field monitoring system were installed in paddy fields (Figure III-1). Climate was measured using Davis instrument and soil environment was measured using Decagon instrument (Figure III-2). Measured soil variables were volumetric water content, soil temperature and electric conductivity in three different depths, soil matric potential in one depth, and groundwater level, electric conductivity and temperature. A camera was installed to take picture of paddy. Measured data was stored in Field Router and one in a day was transmitted to a server that could be accessed through internet.

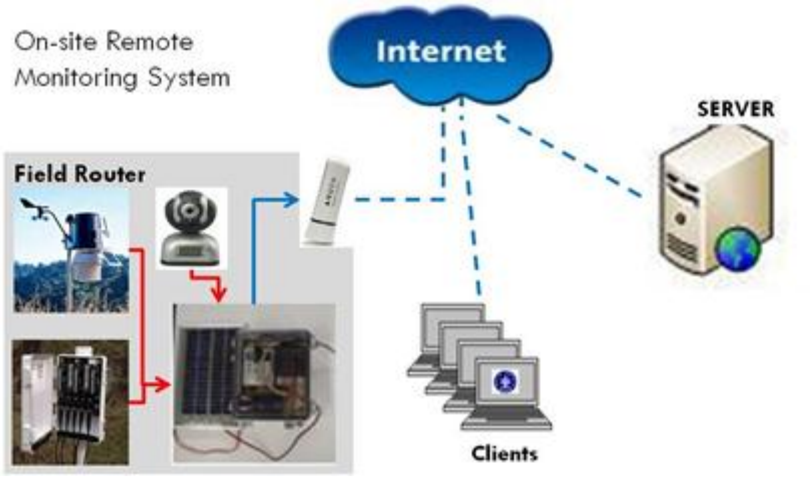


Figure III-1. Field Monitoring System

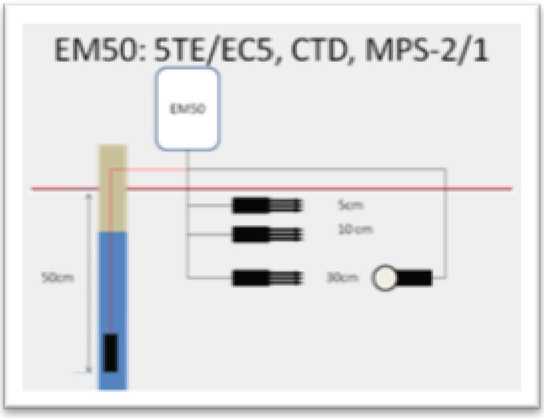


Figure III-2. Sensors to measure soil environments

## K. Research Roadmap

Table III-1. Research Roadmap, topics and Persons in Charges

| No | SUBJETCS | STAGE/YEAR | | | | | PIC |
|---|---|---|---|---|---|---|---|
| | | I | II | III | IV | V | |
| 1 | Climate Changes | | | | | | BIS |
| | Landuse Changes | | | | | | LYT, STY |
| 2 | WB in Watershed | | | | | | LYT, STY |
| 3 | WB in Paddy Field | | | | | | SKS |
| 4 | Allometric Growth | | | | | | SKS |
| 5 | GW Potential | | | | | | YCH |
| 6 | Socio-economics | | | | | | IWB |
| 7 | System Dynamics | | | | | | BIS |
| 8 | Instrumentation | | | | | | SKS, CHA |
| 9 | DBI System | | | | | | SKS, CHA |

BIS : Budi Indra Setiawan

LYT : Liyantono

STY : Sutoyo

SKS : Satyanto Krido Saptomo

YCH : Yudi Chadirin

IWB : I Wayan Budiasa

CHA : Chusnul Arif.

# IV. SABA WATERSHED

## A. Location

As shown in Figure IV-1, Saba Watershed (WS) is located in the Northern part of Bali Province within the geographical coordinates of 114° 55' 13.08" East to 115° 7' 7.68" East and from 8° 10' 50.16" South to 8° 20' 5.64" South. The Area of the watershed has is 140.2 km$^2$. Its highest altitude is about 5000 m from the mean sea level.


Figure IV-1. Bali Island/Province and the Location of Saba Watershed

There are two regencies (Figure IV-2) inside the watershed, which are Buleleng Regency occupying 78% and Tabanan Regency occupying 22% of the total area. From these two regencies, there 5 districts (Figure IV-3), which are Banjar, Busungbiu, Seririt, and Sukasada Districts of Buleleng Regency, and Pupuan District of Tabanan Regency. There are 30 villages inside the watershed (Figure IV-4), where their areas can be seen in Table IV-1.

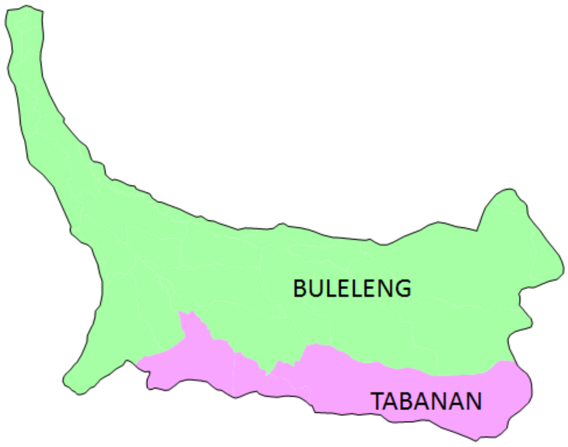


Figure IV-2. Parts of Buleleng and Tabanan Regencies inside Saba Watershed.

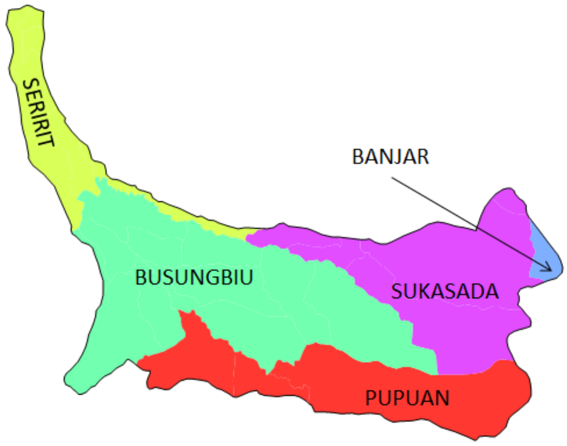


Figure IV-3. Parts of 5 districts inside Saba Watershed.

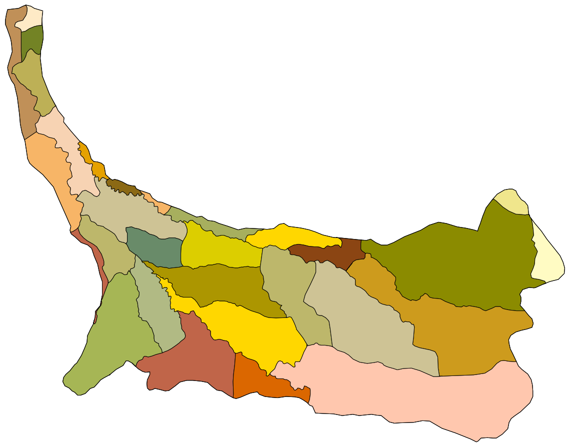

Figure IV-4. Parts of 30 Villages inside Saba Watershed

Table IV-1. Regencies, Districts and Villages inside Saba Watershed

| Regency | District | Village | Area(ha) |
|---|---|---|---|
| Buleleng | Banjar | Munduk | 1,812 |
| | | Gesing | 1,276 |
| | | Banyuatis | 226 |
| | | Kayuputih | 199 |
| | | Gobleg | 84 |
| | | | 3,597 (26%) |
| | Busungbiu | Umejero | 1,100 |
| | | Puncaksari | 842 |
| | | Tinggarsari | 761 |
| | | Kedis | 602 |
| | | Bengkel | 566 |
| | | Busungbiu | 523 |
| | | Pelapuan | 381 |
| | | Subuk | 379 |
| | | Titab | 253 |
| | | Kekeran | 233 |
| | | Telaga | 68 |
| | | | 5,709 (41%) |
| | Seririt | Ularan | 351 |
| | | Ringdikit | 299 |
| | | Kalopaksa | 254 |
| | | Patemon | 197 |
| | | Gunungsari | 137 |
| | | Seririt | 83 |
| | | Pengastulan | 62 |
| | | Rangdu | 55 |
| | | Mayong | 46 |
| | | Bestala | 34 |
| | | | 1,517(11%) |
| | Sukasada | Pancasari | 176 (1%) |
| Tabanan | Pupuan | Pujungan | 2,072 |
| | | Bantiran | 672 |
| | | Pupuan | 277 |
| | | | 3,021 (22%) |
| TOTAL | | | 14,019 (100%) |

Badan Informasi Geospasial 2000

## B. Lands

Figure IV-5, Figure IV-6, Figure IV-7 and Figure IV-8 show maps of landuse in Saba watershed in 2000, 2002, 2005 and 2008, respectively, and Table IV-2 lists comparisons between each other.

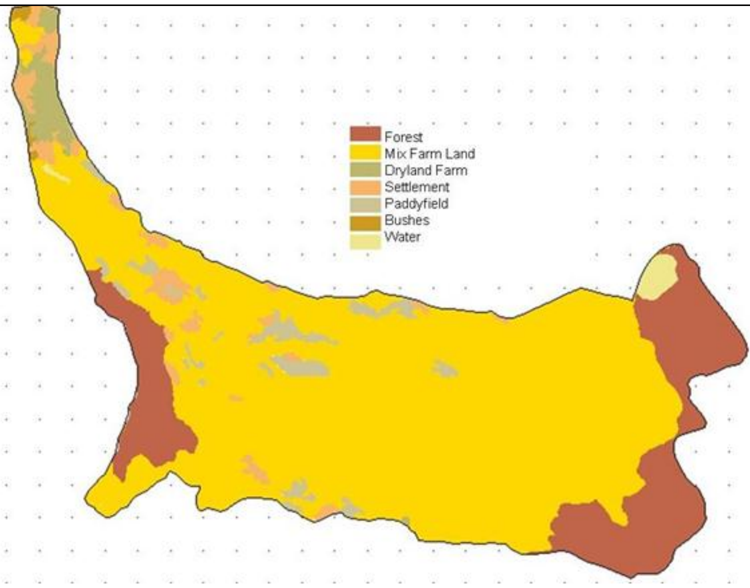


Figure IV-5. Landuse in Saba Watershed (2000)

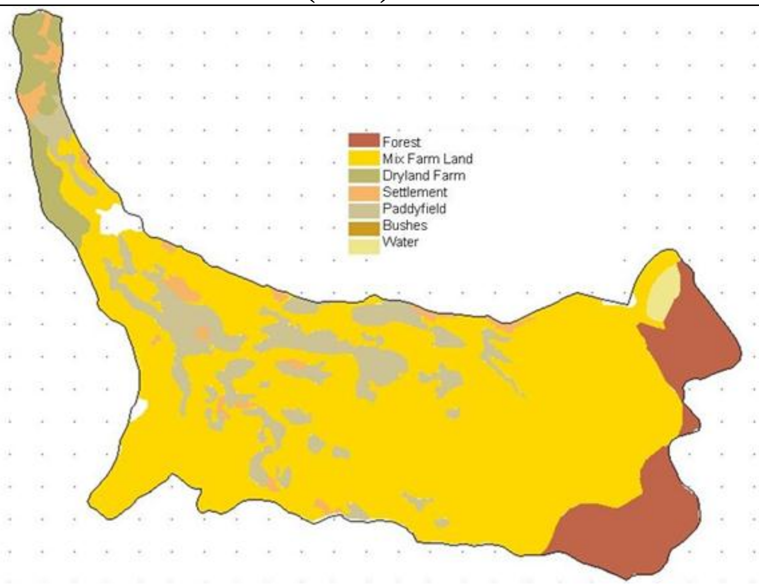


Figure IV-6. Landuse in Saba Watershed (2002)

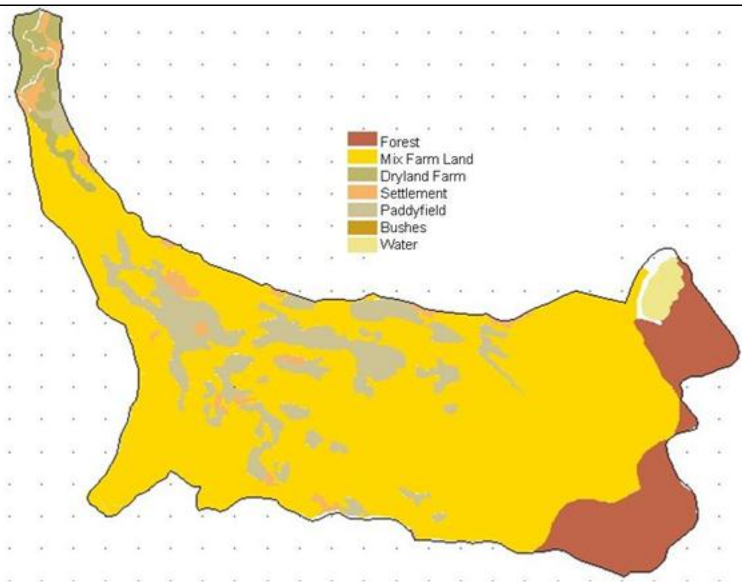


Figure IV-7. Landuse in Saba Watershed (2005)

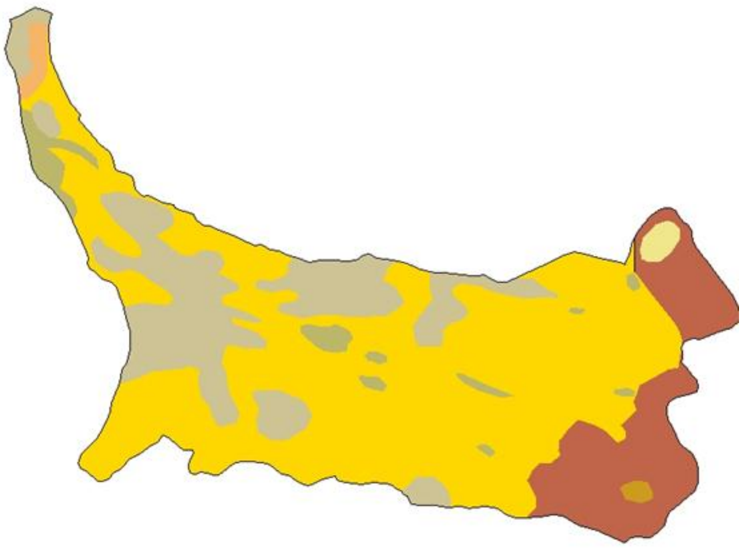

Figure IV-8. Landuse in Saba Watershed (2008)

Mix farmland occupied the highest area followed by Forest area, Paddy Field, Dryland and Settlement, and other minor landuses. Changes of landuse are clearly seen. There was increasing area of Paddy Fields whereas decreasing area of Mix Farmland and Forest. New paddy fields might take land area from mix farmland and forest. It was so then more water may be needed to irrigate the increasing number of paddy field.

Table IV-2. Landuse and its change from 2000-2008

| Landuse | 2000 (ha) | 2002 (ha) | 2005 (ha) | 2008 (ha) | 2000-2008 (ha) | Percent (ha) |
|---|---|---|---|---|---|---|
| Mix farmland | 10,135 | 9,549 | 9,827 | 8,290 | -1845 | -13.2% |
| Forest | 2,491 | 1,546 | 1,569 | 2,018 | -473 | -3.4% |
| Paddy Field | 439 | 1,788 | 1,694 | 2,828 | 2389 | 17.0% |
| Dryland | 296 | 525 | 330 | 435 | 139 | 1.0% |
| Settlement | 300 | 333 | 315 | 121 | -179 | -1.3% |
| Water | 127 | 112 | 155 | 102 | -25 | -0.2% |
| Cloud | - | 121 | 39 | - | 0 | 0.0% |
| Bushes | 43 | - | - | 49 | 6 | 0.0% |
| Sec.Dryland Forest | - | 45 | 28 | - | 0 | 0.0% |
| No Data Avalable | 188 | - | 62 | 176 | -12 | -0.1% |
| Total | 14,019 | 14,019 | 14,019 | 14,019 | | |

## C. Soils

Figure IV-9 and Table IV-3 shows soil type and its distribution in the watershed. There are 5 soil types, which are Greyish Brown Andosol occupying 29%, Reddish Brown Latosol 23%, Yellowish Brown Latosol 20%, Brown Latosol 19% and Grey Regosol 9% of the watershed area.

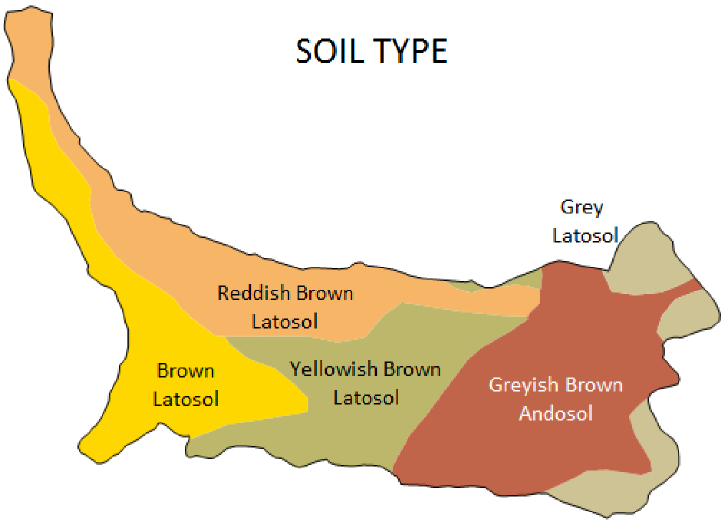


Figure IV-9. Five Soil Types inside Saba Watershed

Table IV-3. Soil Types in Saba Watershed.

| Soil Types | Area (ha) | Percent |
|---|---|---|
| Greyish Brown Andosol | 4,114 | 29% |
| Reddish Brown Latosol | 3,186 | 23% |
| Yellowish Brown Latosol | 2,789 | 20% |
| Brown Latosol | 2,721 | 19% |
| Greyish Regosol | 1,210 | 9% |
| Total | 14,019 | 100% |

## D. Rivers

Figure IV-10 and Table IV-4 show river network and sub-watershed in Saba watershed. There are 9 sub-watersheds, which are Panas occupying 32%, Dati 19%, Upstream Saba 11%, Titab 11%, Downstream Saba 9%, Pangkung 5%, Bakah 4%, Yehpenes 4% and Getes 4% of the watershed area.

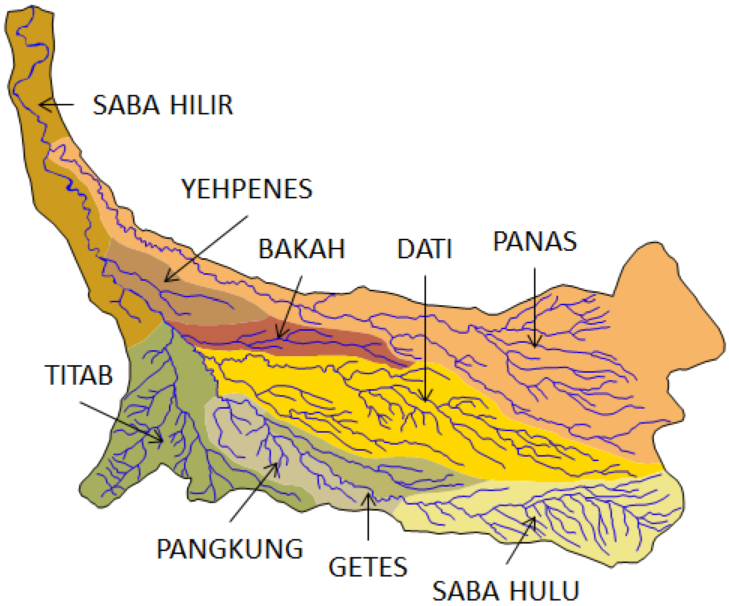


Figure IV-10. River Network and Sub-watershed in Saba Watershed

Table IV-4. Sub-watershed in Saba Watershed

| Sub-watershed | Area (ha) | Percentage |
|---|---|---|
| Panas | 4,529 | 32% |
| Dati | 2,665 | 19% |
| Upstream Saba | 1,570 | 11% |
| Titab | 1,566 | 11% |
| Downstream Saba | 1,298 | 9% |
| Pangkung | 720 | 5% |
| Bakah | 567 | 4% |
| Yehpenes | 562 | 4% |
| Getes | 541 | 4% |
| Total Luas | 14,019 | 100% |

In Saba River there is Titab Dam that used to supply irrigation water through a main canal. There are 3 measurement points of water level; one is to measure the river discharge, another one to measure return flow/overflow form the crest of the weir and the last one is to measure water discharge flowing to the irrigation canal. Measurements were done by reading the water level meter two times a day, which was in the morning about 080:00AM and in the afternoon about 17:00PM. Water discharge was then calculated using the corresponding rating curve. Those rating curves are shown in Figure IV-11, Figure IV-12 and Figure IV-13.

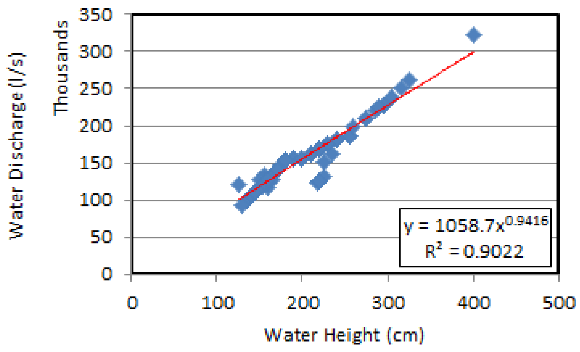


Figure IV-11. Rating Curve for Saba River

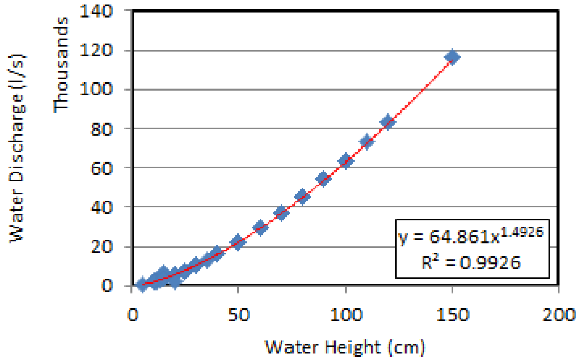


Figure IV-12. Rating Curve for Return Flow

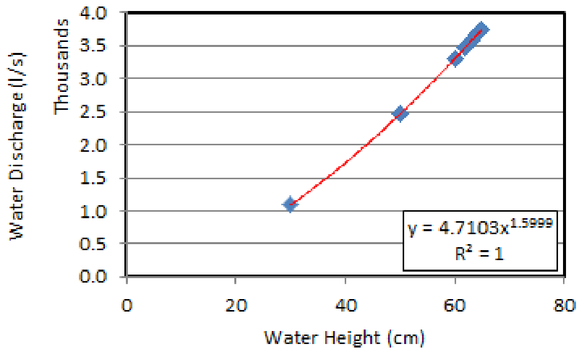


Figure IV-13. Rating Curve for Available Flow

Secondary data of River Flow is still limited in the parts of the year of 2012 and other data is being collected. Secondary data of Return Flow and Available Flow have been collected. Some of the data were missing or could not be measured because was too small. The accuracy of the measurement was questionable since it was conducted manually that might generate systematic and random errors altogether. It is then of necessary to measure these flows by means of automatic water sensors equipped with data loggers. Indeed, the sensors have been installed in the early 2013.

As show in the Figures, those daily flows are fluctuated with time. Table IV-5 shows a recapitulation of those flows in every year and as a whole in those periods. The Return Flows (Min, Ave and Max) were not much different except in the last two years. The Available Flows (Min, Ave and Max) were much or less similar in each year.

Table IV-5. Daily Water Discharges of Saba River, Return Flow and Available Flow.

| Year | River Flow | | | Return Flow | | | Available Flow | | |
|---|---|---|---|---|---|---|---|---|---|
| | Min (m3/s) | Ave (m3/s) | Max (m3/s) | Min (m3/s) | Ave (m3/s) | Max (m3/s) | Min (m3/s) | Ave (m3/s) | Max (m3/s) |
| 2006 | | | | 0.18 | 2.71 | 36.81 | 2.23 | 2.58 | 3.47 |
| 2007 | | | | 0.18 | 2.72 | 69.79 | 2.15 | 2.38 | 4.82 |
| 2008 | | | | 0.18 | 3.29 | 82.06 | 2.15 | 2.55 | 4.61 |
| 2009 | | | | 0.18 | 4.31 | 63.57 | 2.23 | 3.44 | 5.43 |
| 2010 | | | | 0.18 | 6.63 | 62.69 | 2.38 | 3.72 | 5.54 |
| 2011 | | | | 0.51 | 15.49 | 98.56 | 1.09 | 3.33 | 4.91 |
| 2012 | 96.51 | 139.09 | 221.84 | 0.71 | 16.82 | 69.30 | 2.42 | 3.56 | 3.75 |
| Min | | | | 0.18 | 2.71 | 36.81 | 1.09 | 2.38 | 3.47 |
| Ave | | | | 0.30 | 7.42 | 68.97 | 2.09 | 3.08 | 4.65 |
| Max | | | | 0.71 | 16.82 | 98.56 | 2.42 | 3.72 | 5.54 |

In the whole periods (2006-2012), the minimum, averaged and maximum Available Flow were 2.38m3/s, 3.08m3/s and 3.72m3/s. However, there was a chance that the minimum flow would be around 1m3/s and the maximum flow would be more than 5m3/s. The maximum value was limited by the dimension of the main irrigation canal, which was around 6m3/s.

Looking to the values of the Return Flow that was ultimately higher than the Available Flow, Saba River has a plenty of water quantity that can be tapped for further water resource development. However, it would need a large investment and it seems difficult to get feasible level for paddy field extension since in the other side there has been a trend of land conversion from paddy field to other landuses.

The available Flow now and in the future would be shared too by other socio-economic activities, such as domestics and industries. It is the imperative to study water demands in three sectors: agricultures, domestics and industries.

## E. Climates

Figure IV-14 shows annual rainfall from 1995 to 2004. During these periods, annual rainfall tended to decrease with time. Before the great El-Nino in 1997 rainfall have reached 2500 mm in 1995 but later on decreased significantly and reached below 1500 mm.

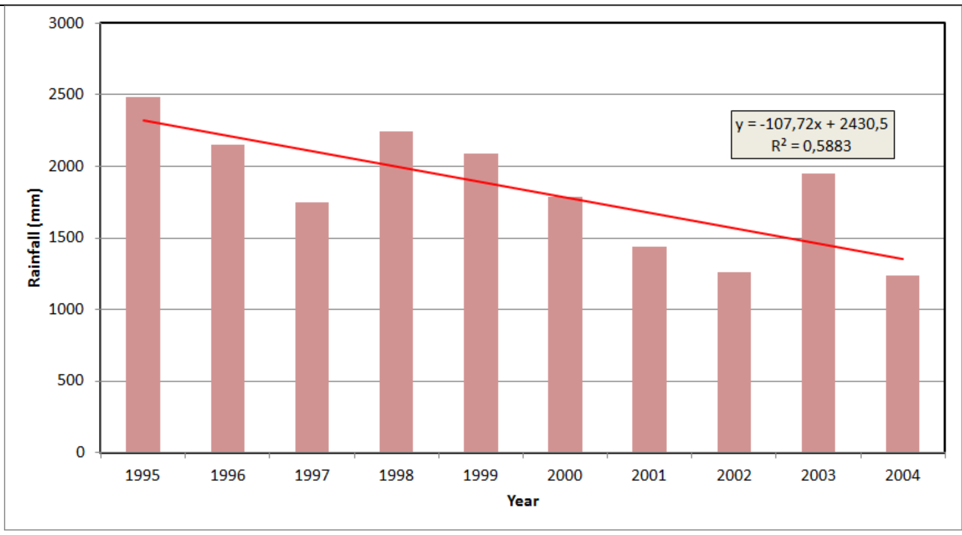


Figure IV-14. Annual Rainfall and Its Trend from 1995 to 2004

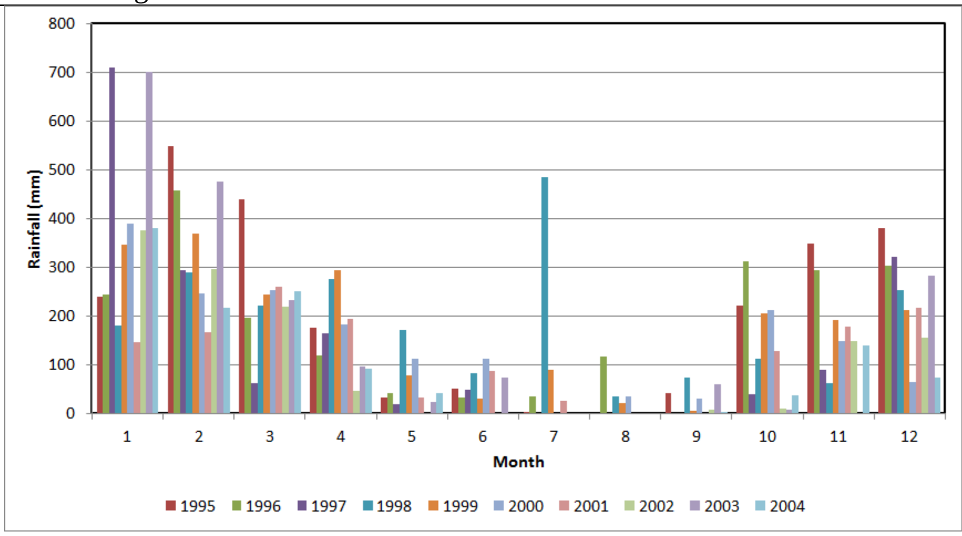


Figure IV-15. Monthly Rainfall from 1995-2004

Figure IV-15 shows monthly rainfall during 1995-2004. It can be seen that generally dry season starts from Mei up to September. Table IV-6 shows start and length of dry and wet seasons in the periods of 1989-2012. Since 1997, length of dry season have reached more than 200 days which was not common previously.

Table IV-6. Annual Dry and Wet Season from 1989 to 2012 in Julian Calendar.

**RESULT**

| Year | Early dry season | Early wet season | Length of dry season | Peak of dry season | Annual rainfall (mm) | Maximum rainfall (mm) |
|---|---|---|---|---|---|---|
| 1989 | 139 | 306 | 167 | 214 | 982 | 80 |
| 1990 | 163 | 313 | 150 | 260 | 1308 | 80 |
| 1991 | 132 | 321 | 189 | 232 | 944 | 51 |
| 1992 | 140 | 307 | 167 | 228 | 1468 | 110 |
| 1993 | 146 | 318 | 172 | 243 | 905 | 75 |
| 1994 | 139 | 302 | 163 | 220 | 1597 | 105 |
| 1995 | 133 | 295 | 162 | 213 | 1476 | 109 |
| 1996 | 119 | 287 | 168 | 203 | 1117 | 73 |
| 1997 | 105 | 315 | 210 | 264 | 1018 | 96 |
| 1998 | 142 | 367 | 225 | 216 | 1197 | 81 |
| 1999 | 133 | 290 | 157 | 208 | 1549 | 105 |
| 2000 | 132 | 299 | 167 | 209 | 1218 | 105 |
| 2001 | 144 | 304 | 160 | 240 | 886 | 76 |
| 2002 | 108 | 315 | 207 | 240 | 1238 | 374 |
| 2003 | 116 | 313 | 197 | 212 | 1310 | 132 |
| 2004 | 122 | 308 | 186 | 202 | 1098 | 242 |
| 2005 | 139 | 298 | 159 | 226 | 1148 | 93 |
| 2006 | 125 | 323 | 198 | 217 | 1014 | 109 |
| 2007 | 161 | 367 | 206 | 233 | 824 | 77 |
| 2008 | 138 | 290 | 152 | 215 | 949 | 76 |
| 2009 | 139 | 354 | 215 | 271 | 876 | 97 |
| 2010 | 134 | 291 | 157 | 216 | 2010 | 72 |
| 2011 | 151 | 367 | 216 | 235 | 1224 | 64 |
| 2012 | 135 | 367 | 232 | 209 | 950 | 79 |
| Average | 135 | 317 | 183 | 226 | 1179 | 107 |

## F. Irrigation Systems

Figure IV-16 shows irrigation network in Saba Watershed. There are 8 main rivers as water resource for irrigation which are Saba River, Getas River, Jehe River, Selat River, Titab River, Bakah River, Panas River and Ling River along with 28 dams and/or weirs.

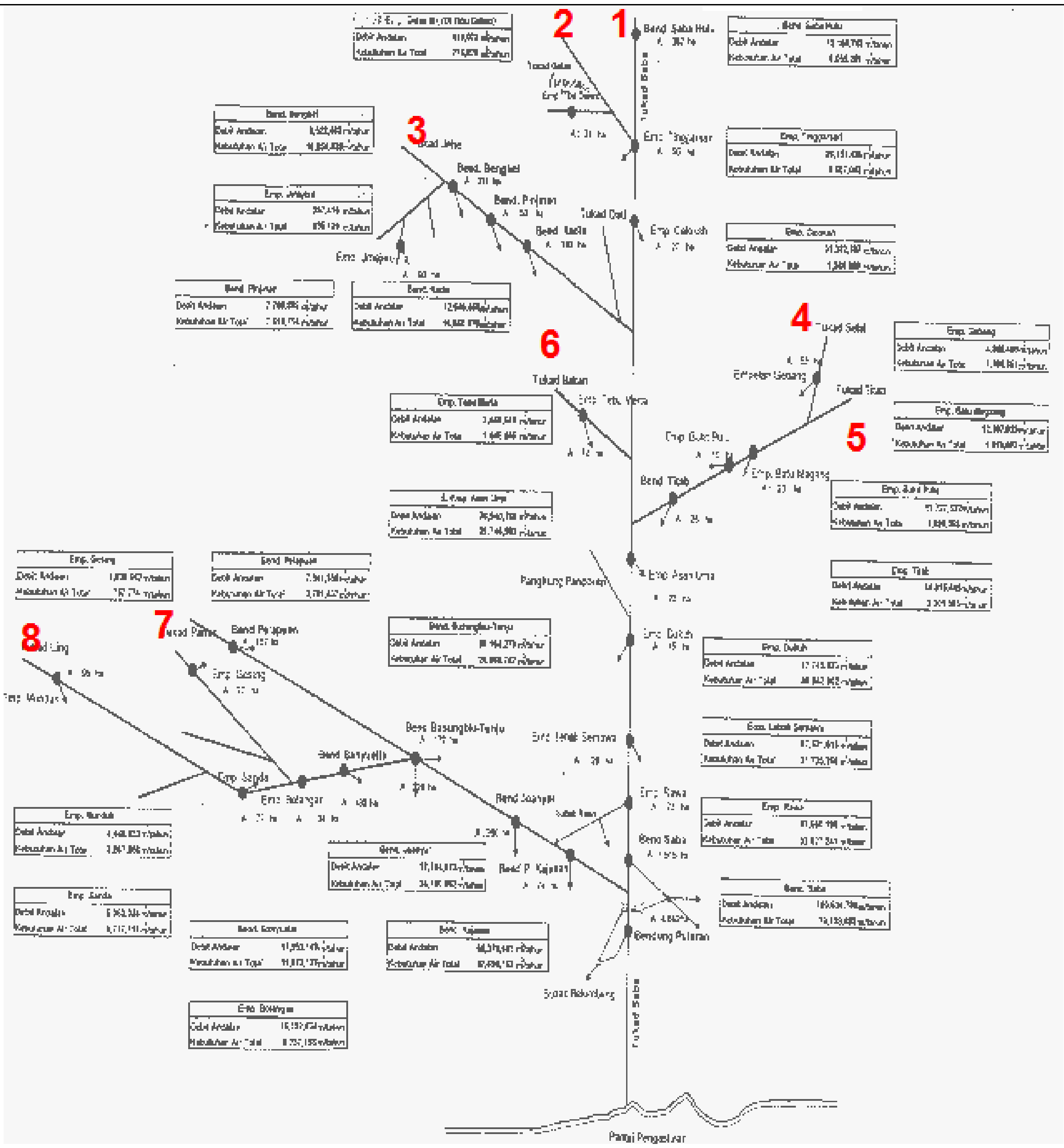


Figure IV-16. Irrigation Network form Saba Dam

This irrigation network has a potential to irrigate 9,124 ha of paddy fields (Table IV-7) which is distributed into 55 subaks in 27 irrigation unit area including a new development area of Saba irrigation area. Saba irrigation unit area under Saba dam is about 1,915 ha including 10 subaks (5 old subaks & 5 new subaks), supported by 25.25 km long of secondary canals.

Table IV-7. Rivers, Dams and Irrigation Areas in Saba Wateshed

| Regency | District | River | Dam/Weir | Area (ha) | Area (%) |
|---|---|---|---|---|---|
| Buleleng | Seririt | Saba | Puluran | 4562 | |
| Buleleng | Seririt & Gerokgak | Saba | Saba | 1915 | |
| Buleleng | Busungbiu | Jehe | Bengkel | 311 | |
| Buleleng | Seririt | Ling-Panas | Joanyar | 260 | |
| Buleleng | Busungbiu | Jehe | Kedis | 180 | |
| Buleleng | Banjar | Ling | Banyuatis | 180 | |
| Buleleng | Busungbiu | Panas | Busungbiu | 172 | |
| Buleleng | Busungbiu | Panas | Pelapuan | 157 | |
| Buleleng | Banjar | Ling | Tunju | 128 | |
| Buleleng | Busungbiu | Saba | Tinggarsari | 96 | |
| Buleleng | Banjar | Ling | Munduk | 96 | |
| Buleleng | Busungbiu | Jehe | Umejero | 90 | |
| Buleleng | Banjar | Ling | Sanda | 77 | |
| Buleleng | Seririt | Ling-Panas | P. Kajanan | 74 | 95.5% |
| Buleleng | Busungbiu | Bakah | Tebu Merta | 72 | |
| Buleleng | Busungbiu | Selat | Gebang | 55 | |
| Buleleng | Busungbiu | Jehe | Pinjinan | 50 | |
| Buleleng | Banjar | Ling | Bolangan | 34 | |
| Buleleng | Busungbiu | Saba | Lebah Semawa | 28 | |
| Buleleng | Busungbiu | Saba | Celokah | 27 | |
| Buleleng | Banjar | Ling | Gesing | 27 | |
| Buleleng | Busungbiu | Titab | Titab | 26 | |
| Buleleng | Busungbiu | Titab | Batu Megaag | 23 | |
| Buleleng | Busungbiu | Saba | Asah Uma | 23 | |
| Buleleng | Busungbiu | Saba | Rawa | 23 | |
| Buleleng | Busungbiu | Saba | Dukuh | 15 | |
| Buleleng | Busungbiu | Titab | Bukit Pulu | 10 | |
| Tabanan | Pupuan | Saba | Saba Hulu | 382 | 4.5% |
| Tabanan | Pupuan | Getas | Tibu Dalem | 31 | |
| Total | | | | 9124 | 100.0% |

Not a whole potential area under the Saba dam could be irrigated due to the following reasons:

1. Local people barricading the main canal → water level being go up → some water is use to fulfill domestic water demand
2. Many small bridges with very low position are used by local people to connect one from another side of the main canal
3. Division structure – continuous system to (a) new subaks and (b) old subaks area under Saba irrigation area
4. Limited water arrives on subak Tukad Sumaga in Gerokgak district at more then KM10
5. The water has arrived on Subak Berombong but it couldn't continue, due to the broken of secondary canal in Berombong village at KM17 after the irrigation tunnel (6)

Irrigation system in Saba watershed is managed by a number of subaks. As shown in Table IV-8, there are 55 subaks in Saba Watershed.

Table IV-8. Irrigation Areas and Number of Subak in Saba Watershed

| No | Irrigation Area | Name of Subak | No | Irrigation Area | Name of Subak | No | Irrigation Area | Name of Subak |
|---|---|---|---|---|---|---|---|---|
| 1 | Asah Uma | Asah Uma | 21 | Munduk | Munduk | 41 | Saba | Tegal Intaran |
| 2 | Banyuatis | Banyuatis | 22 | Munduk | Tegallinggah G | 42 | Saba | Tegallenga |
| 3 | Banyuatis | Bebau | 23 | P.Kajanan | Patemon Kajanan | 43 | Saba | Tukad Sumaga |
| 4 | Bengkel | Bengkel | 24 | Pelapuan | Pelapuan | 44 | Saba | Umedesa |
| 5 | Bengkel | Kekeran | 25 | Pinjinan | Pinjinan | 45 | Saba | Yeh Anakan |
| 6 | Bengkel | Timbul | 26 | Puluran | Babakan | 46 | Sanda | Sanda |
| 7 | Bolangan | Bolangan | 27 | Puluran | Batan Bekul | 47 | Tebu Merta | Tebu Merta |
| 8 | Bukit Pulu | Bukit Pulu | 28 | Puluran | Belumbang | 48 | Tibu Dalem | Tibu Dalem |
| 9 | Busungbiu-Tunju | Busungbiu | 29 | Puluran | Kapal | 49 | Tinggarsari | Tinggarsari |
| 10 | Busungbiu-Tunju | Tunju | 30 | Puluran | Karangsari | 50 | Titab | Batu Megaang |
| 11 | Celokah | Celokah | 31 | Puluran | Puluran | 51 | Titab | Titab |
| 12 | Dukuh | Dukuh | 32 | Pupuan | Pupuan | 52 | Umejero | Celagi |
| 13 | Gebang | Gebang | 33 | Pupuan | Sai | 53 | Umejero | Lebah |
| 14 | Gesing | Gesing | 34 | Pupuan | Yeh Saba | 54 | Umejero | Tanah Pegat |
| 15 | Joanyar | Anyar Patemon | 35 | Rawa | Rawa | 55 | Umejero | Umejero |
| 16 | Joanyar | Joanyar | 36 | Saba | Banjar Munduk | | | |
| 17 | Joanyar | M. Pengulkulan | 37 | Saba | Banyumati | | | |
| 18 | Joanyar | Mayong | 38 | Saba | Berongbong | | | |
| 19 | Kedis | Kedis | 39 | Saba | Pangkung Kunyit | | | |
| 20 | Lebah Semawa | Lebah Semawa | 40 | Saba | Ponjokcukli | | | |

Subak is a customary law with socio-agrarian-religious nature which was established since long time ago and developed continuously as landholding organizations in the sphere of water distribution and other for rice fields in one irrigation area (Bali Provincial Decree No. 02/PD/DPRD/1972).

Subak functions as operating irrigation network (distributing irrigation water), conducting irrigation facilities maintenance, managing conflicts, mobilizing/managing resources (land, water, human, and money) and conducting ceremonials activities.

Daily activities of subak are based on the philosophy of Tri Hita Karana (THK), which the meaning harmonization among following three relationships:

1. Between human beings and God, as the creator of the world
2. Among human beings themselves
3. Between human beings and the environment

Subak has a regulation which is called Awig-awig that governs relationships among the members of the same society, who are aware of the sanctions to which they can subjected, in case of transgression of such regulation. It includes both written and unwritten rules (“pararem”), that are all accepted by the subak members. Awig-awig generally starts with information about the name, location & area of subak, the scope of the society and the membership composition; listed all aspects of subak activities (from the work in the rice fields to the water sharing and management, crop dieses control, communal work and ceremonies; and sanction for the transgressors. Awig-awig is hand-written on “lontar” (a kind of palm tree) dry leaves, by using the old Balinese language and/or writing (typing). A ritual ceremony, called “pasupati” is sometimes performed by all the subak members asking a God a magic-religious strength and rightness onto the “awig-awig”. A written “awig-awig” could be signed by the subak board, then registered at the local government officer (head of customary village, head of administrative village, head of district, and head of regency)

Cropping pattern varies according to the locations. In the downstream where has lost of irrigation, 3 times paddy cultivations are possible. In the middle and upstream, the most possible cropping pattern is Paddy, Paddy/Palawija and Paddy/Palawija/Fallow.

In the middle and upstream, some enterprises of farming are held by farmer into diversified and/or mixed farming system. While in the downstream, some enterprises of farming are held by farmer into diversified and/or mixed farming system (rice, corn, grape, tobacco, chili, long bean, black bean, green bean, ground nut, cattle).

## G. Paddy Fields

Figure IV-17 shows climate and soil observation stations in paddy fields in 3 locations, which are Umejero in the upstream, Titab in the midstream and Lokapaksa in the downstream of Saba Watershed.

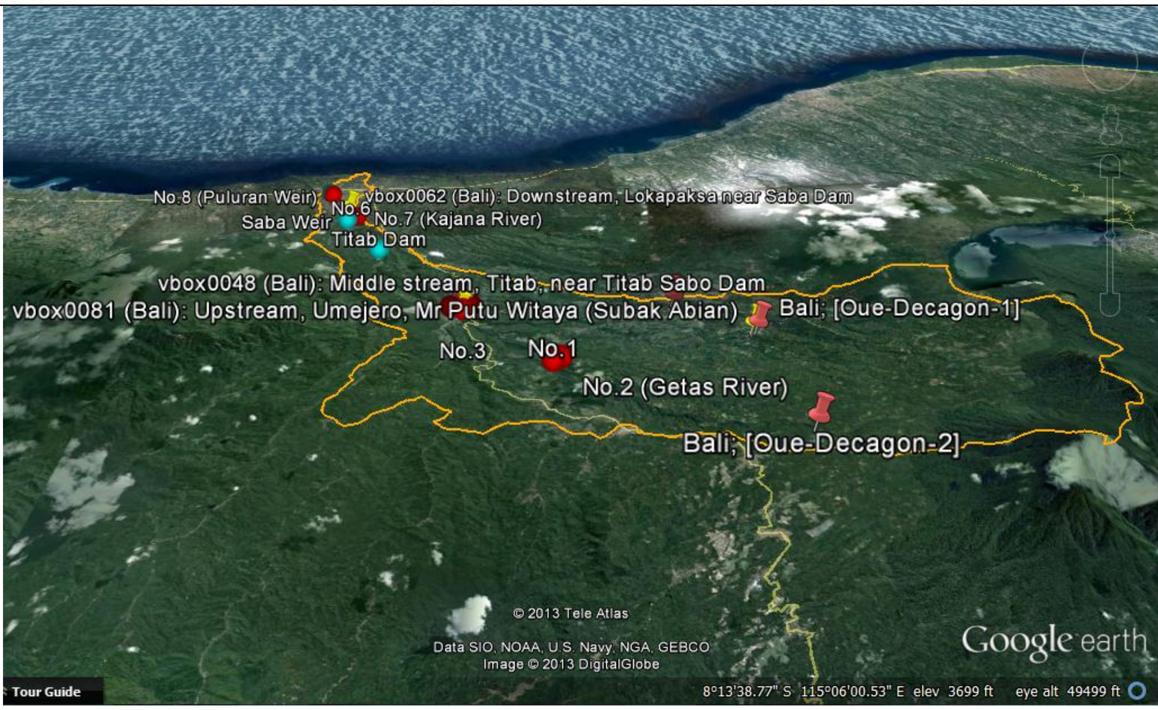


Figure IV-17. Climate and Soil Observation Stations in Saba Watershed

As previously shown in Table IV-2, paddy field in Saba Watershed expanded form 439 ha in 2000 up to 2389 ha in 2008 with the rate of about 17% per year. The soil properties of the soil in 3 observed plots are shown Figure IV-18 for soil physical and hydraulic properties and soilwater retention curves. Most of the soils belong to silty clay and loam. Even though, they have different soil properties. The soil in Lokapaksa for example was more permeable than the two other locations.

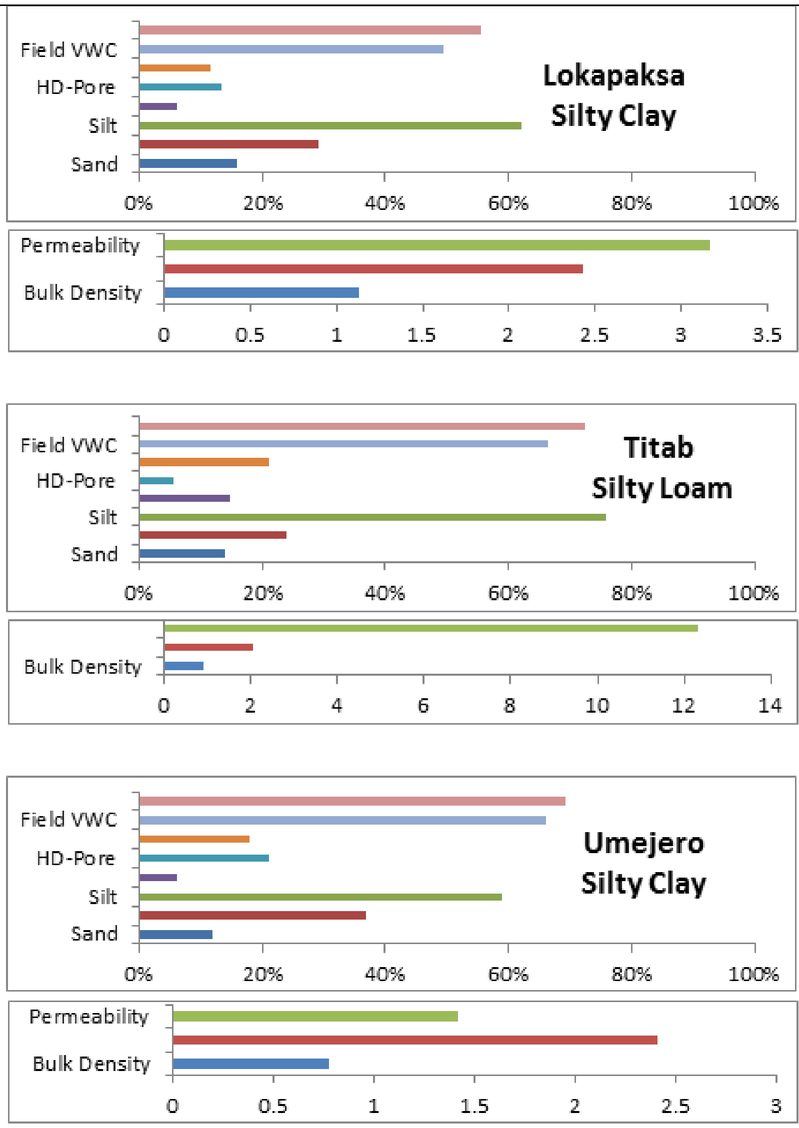


Figure IV-18. Soil Physical Properties in Paddy Fields

Figure IV-19 shows water balance in paddy field in Umejero which is the upstream of Saba Watershed. The paddy field received rainfall in about similar amount of evapotranspiration. Climatic water balance (rainfall-evapotranspiration) was negative but the paddy field received sufficient irrigation. Soil moisture in the surface soil was always higher than field capacity. In this sense, the paddy field more or less had sufficient water.

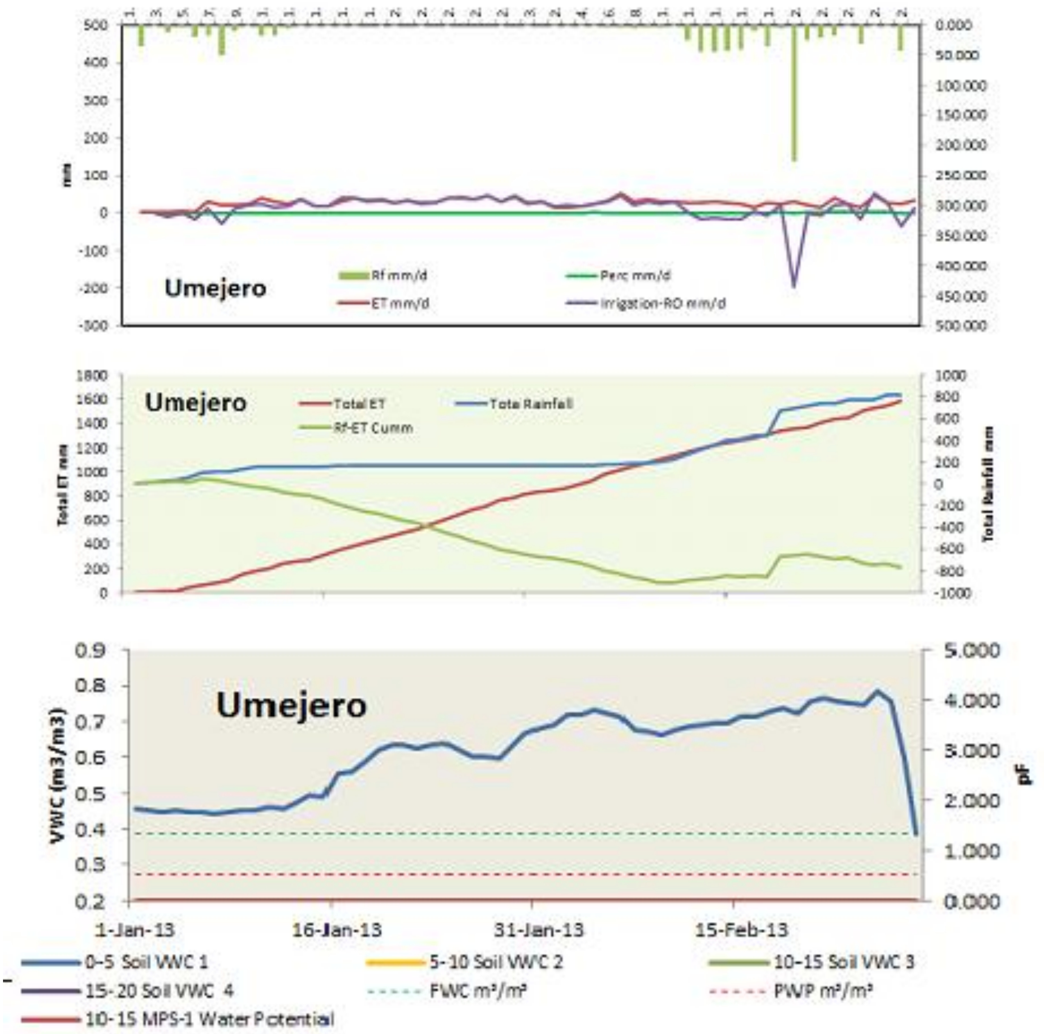


Figure IV-19. Daily Water Balance in Umejero Paddy Field

Figure IV-20 shows water balance in paddy field in Titab which is in the middle part of Saba Watershed. Climatic water balance was always negative however the paddy field received sufficient irrigation water. Accordingly, soil moisture was always higher than field capacity. In this sense, the paddy fields had no problem with water.

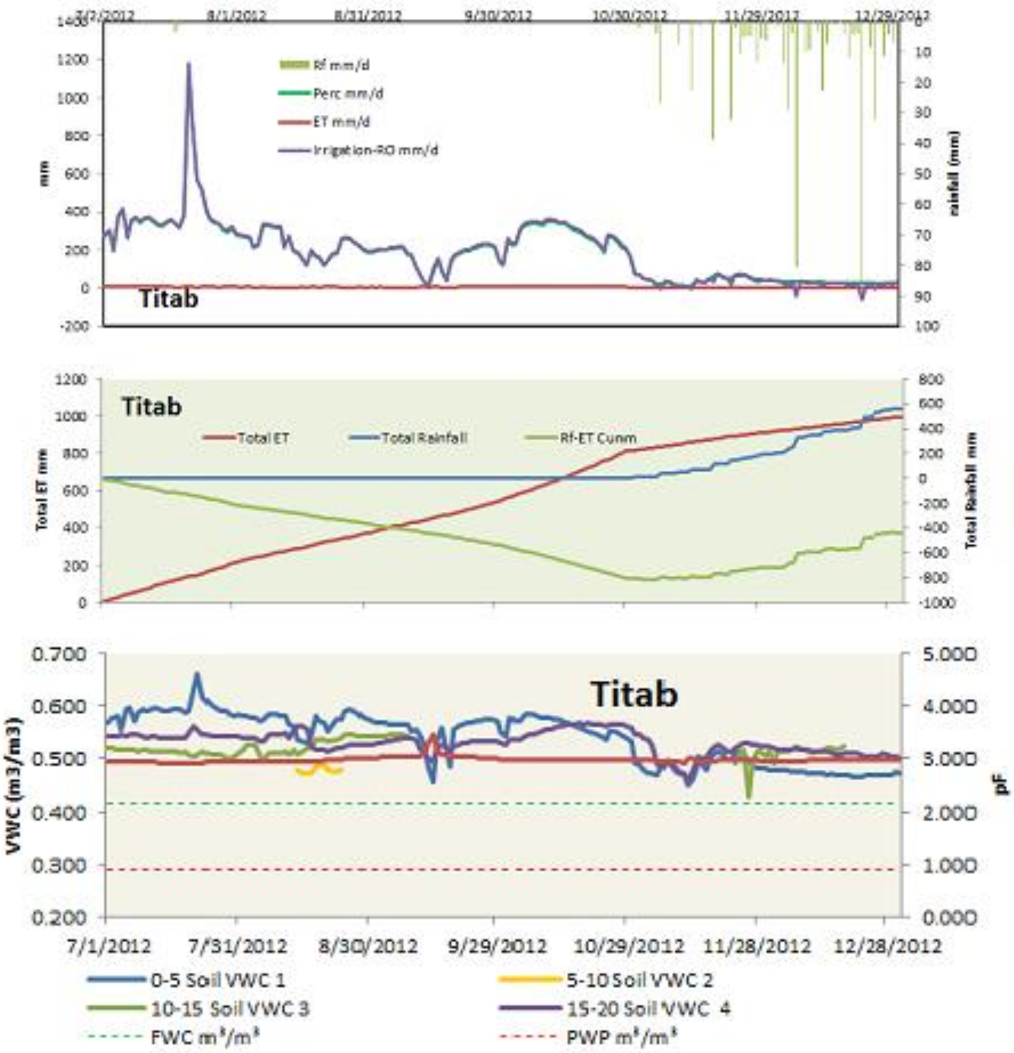


Figure IV-20. Daily Water Balance in Titab Paddy Field

Figure IV-21 shows water balance in paddy field in Lokapaksa which is located the downstream of Saba Watershed. Climatic water balance was always negative but the paddy field received sufficient irrigation water. Accordingly, soil moisture was always above field capacity. In this sense, the paddy field had no problem with water.

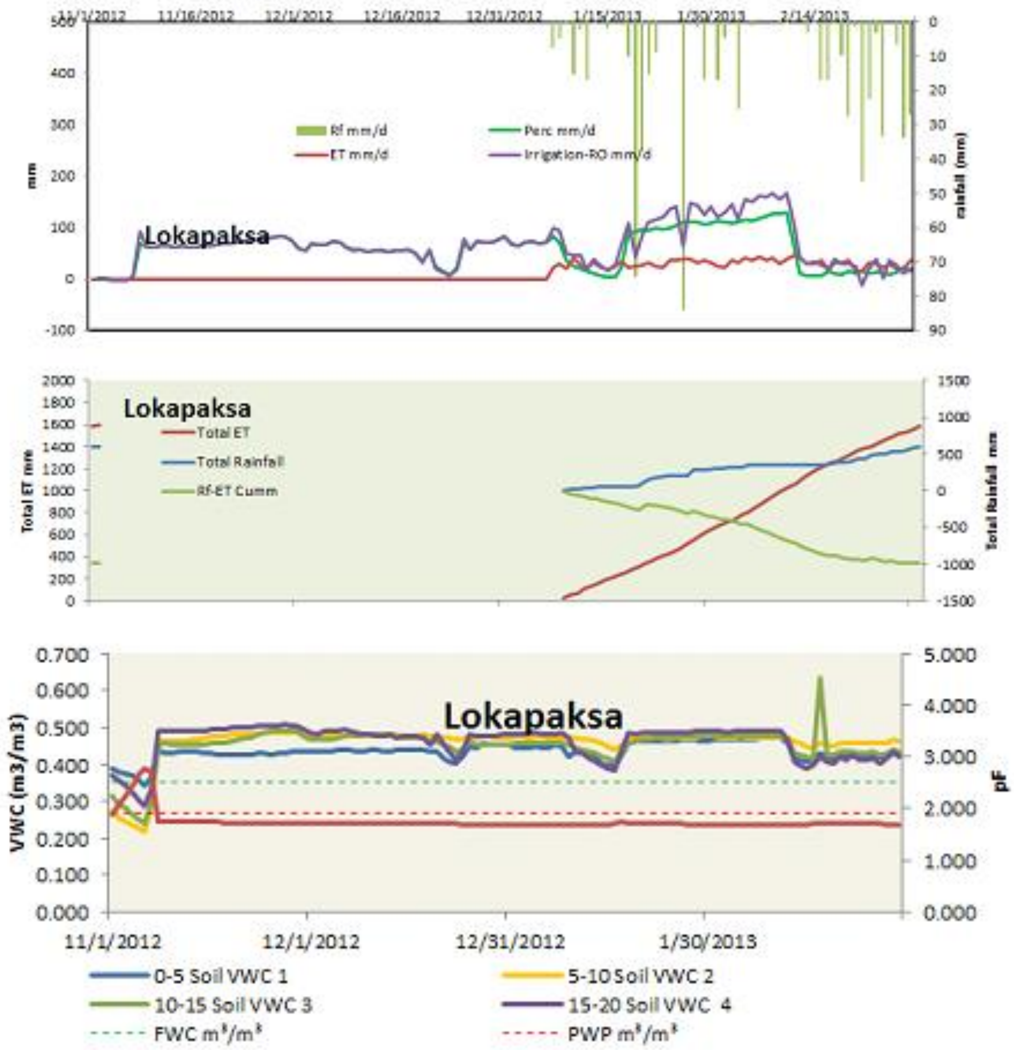


Figure IV-21. Daily Water Balance in Lokapaksa Paddy Field

## H. Socio-economics

Table IV-9 shows population and its density in 5 districts and those estimated in Saba Watershed in 2011. Seririt District was the highest number in population amounted to 78.8 thousand persons, or occupying 26% with the density was 705 persons per km$^2$. Based on the densities and area of these districts in the watershed, Banjar District was the most populated area amounted to 14 thousand persons occupying 31% of the total population in the watershed, which were about 45.3 thousand persons.

Table IV-9. Population and its Density in Districts and those estimated in Saba Watershed in 2011

| District Names | District | | | | Saba Watershed | | |
|---|---|---|---|---|---|---|---|
| | Area (km$^2$) | Population (p) | Percent | Density (p/km$^2$) | Area (km$^2$) | Population (p/km$^2$) | Percent |
| Seririt | 111.78 | 78,809 | 26% | 705.0 | 15.2 | 10,695 | 24% |
| Sukasada | 172.93 | 71,769 | 24% | 415.0 | 1.8 | 730 | 2% |
| Banjar | 172.60 | 67,762 | 22% | 392.6 | 36.0 | 14,122 | 31% |
| Busungbiu | 196.62 | 44,765 | 15% | 227.7 | 57.1 | 12,998 | 29% |
| Pupuan | 179.02 | 40,451 | 13% | 226.0 | 30.2 | 6,826 | 15% |
| Total | 832.95 | 303,556 | | 364 | 140.20 | 45,372 | |

Based on the UU 7/2004, Central Government is responsible for the O&M of primary and secondary irrigation systems of size more than 3,000 ha, provinces for systems of sizes between 1,000 and 3,000 ha, and regency for irrigation systems of up to 1,000 ha. Subaks in Bali however remained fully responsible for village and the tertiary level irrigation systems. But, farmers may also request assistance from the government to upgrade tertiary irrigation and drainages facilities.

In 2007, the wetland area in Bali includes 80,701 ha of irrigated paddy field and 443 ha of non-irrigated paddy field distributed in 1,559 subaks. Based on cropping pattern and calendar, there are 6 cropping patterns associated with paddy and 1 pattern for other crops such as palawija/vegetables. The typical and present cropping pattern and calendar in 2003 was used for projection of irrigation water demand.

Irrigation water management in Bali is held by subak. A subak consists of the three main elements, strictly interconnected and indivisible, (a) *Parhyangan*, (b) *Pawongan*, and (c) *Palemahan*. Daily life in the subak societies is based on the philosophy of the *Tri Hita Karana* (three happiness causes). General and detailed rules for implementing it are included in the subak *awig-awig* and *perarem* (bylaws). A subak system can be broadly subdivided into four mayor components: (a) the main structure (weir/inlet structure); (b) the main canal, with the function of conveying the irrigation water from the main structure upstream to the last rice field downstream; (c) the irrigation canals, with the function of distributing the irrigation water to the rice fields; and (d) the drainage facilities, including the small on-farm drains up to the big drains and rivers, serving several subak irrigation systems.

The partition of irrigation water among the subak members is based on the principle of *ayahan.* A portion of irrigation water called *tektek*. *Tektek* is amount of water necessary for one-season irrigation of paddy field with an area up to about one hectare; other terms with the same meaning are *kecoran* or *tanding.*

Based on the *subak* characteristics, also on the Presidential Decree No. 3/1999 as well as the Water Law No 7/2004 that is called as Participative Irrigation Management (PIM), the *subak* is very potential to play the double roles, i.e. to manage an irrigation system and a legal business unit in the farm level. The successful of subak to play the important roles are useful to support sustainable irrigated agriculture in Bali.

Based on the population and national rice consumption rate, annual rice demand in Saba Watershed is shown in Figure IV-22, where Banjar District had higher rice demand than the others. While rice productivity is shown in Figure IV-23, where Busungbio District has higher rice productivity than the others. Rice productivity here is larger than national rice productivity which was less than 5 ton/ha. From this viewpoint, it can be said that rice production is not a major problem in Saba Watershed.

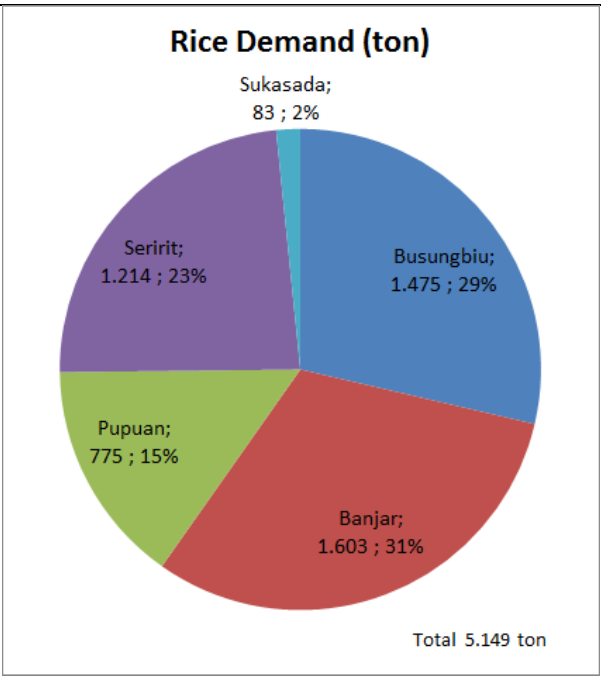


Figure IV-22. Estimated Rice Demand in Saba Watershed

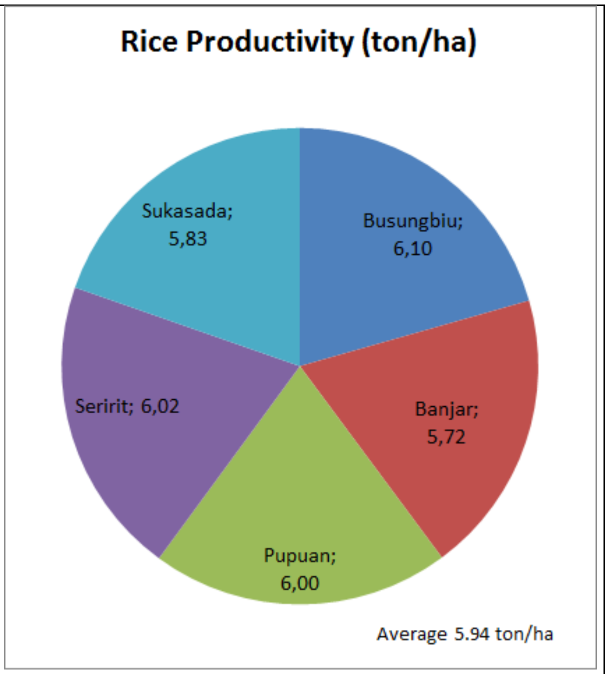


Figure IV-23. Estimated Rice Productivity in Saba Watershed

# V. JENEBERANG WATERSHED

## A. Location

Jeneberang Watershed (Figure V-1) is located in South Sulawesi Province with its geographic position lays on 119°22'47.42" – 119°56'42.67" East and 5°11'8.40" – 5°25'46.52"S South. The Area of Jeneberang Watershed is 755 880 km$^2$ in the inside of Kabupaten Gowa (97.11%) and Kabupaten Takalar (1.16%) and Kotamadya Makassar (1.73%). Kabupaten Gowa has 18 kecamatan, Kabupaten Takalar has 9 kecamatan and Kotamadya Makassar has 14 kecamantan.

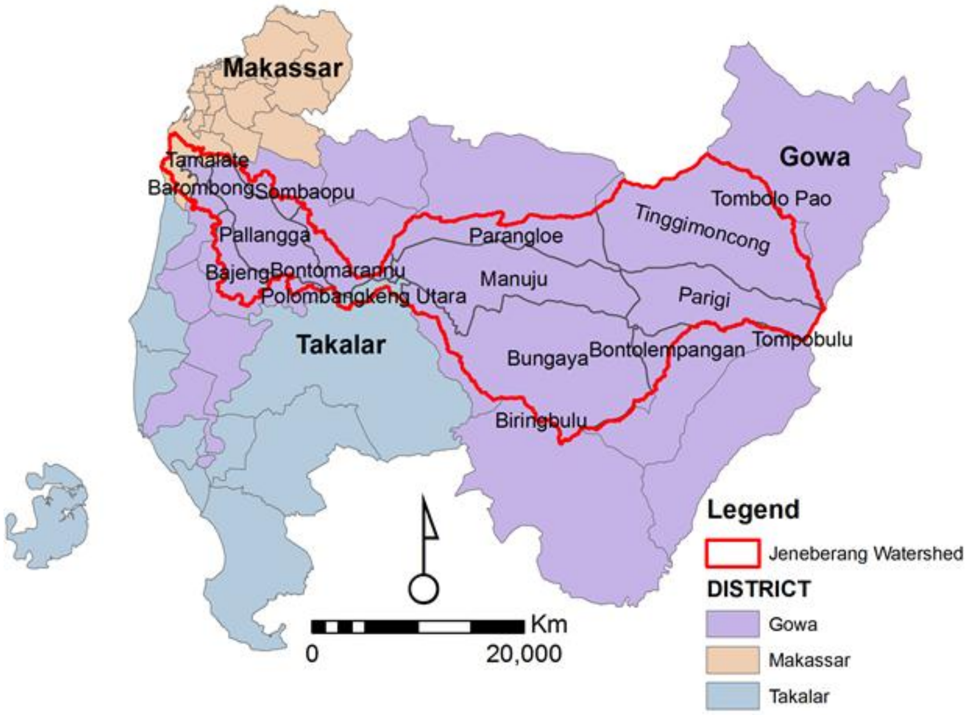


Figure V-1. Jeneberang Watershed

## B. Land

Figure V-2, Figure V-3 and Figure V-4 show land topography, land slope and contour of land elevation, respectively in Jeneberang Watershed. The highest elevation on the eastern part is up to 2000 m above sea level (asl). Bili-bili Dam is located in the bottleneck area which has elevation 50-100 msl, and supplying irrigation water to paddy fields in the plateau in the western part which has elevation lower than 50 m asl and land slope lower than 3 m asl.

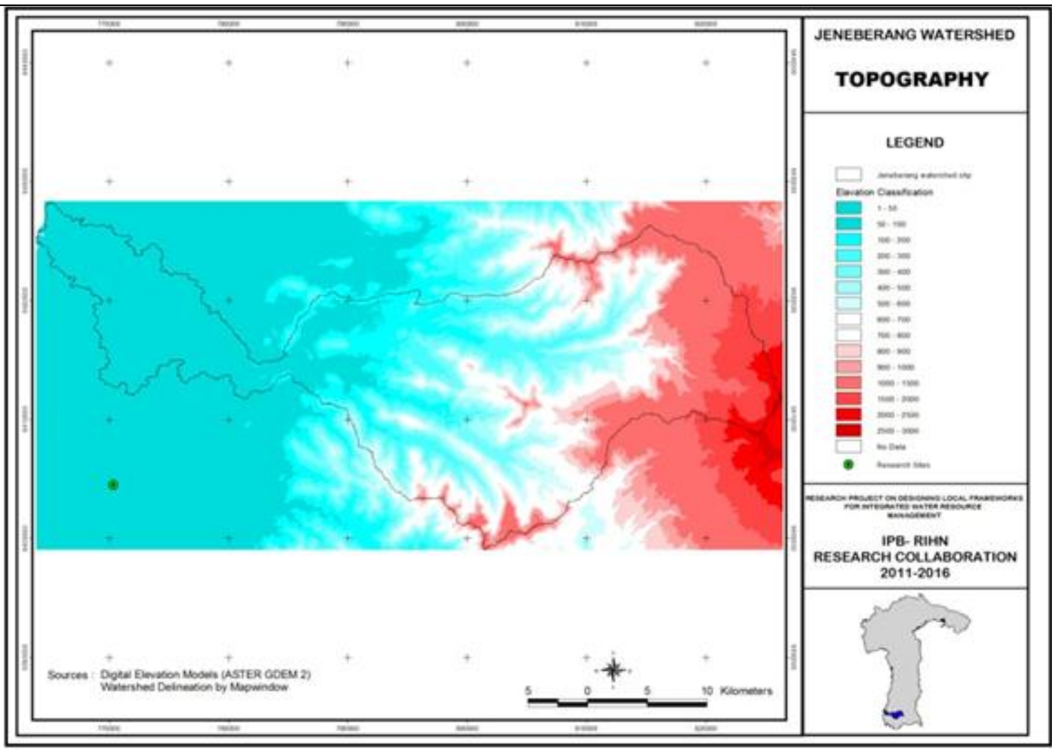


Figure V-2. Land Topography in Jeneberang Watershed

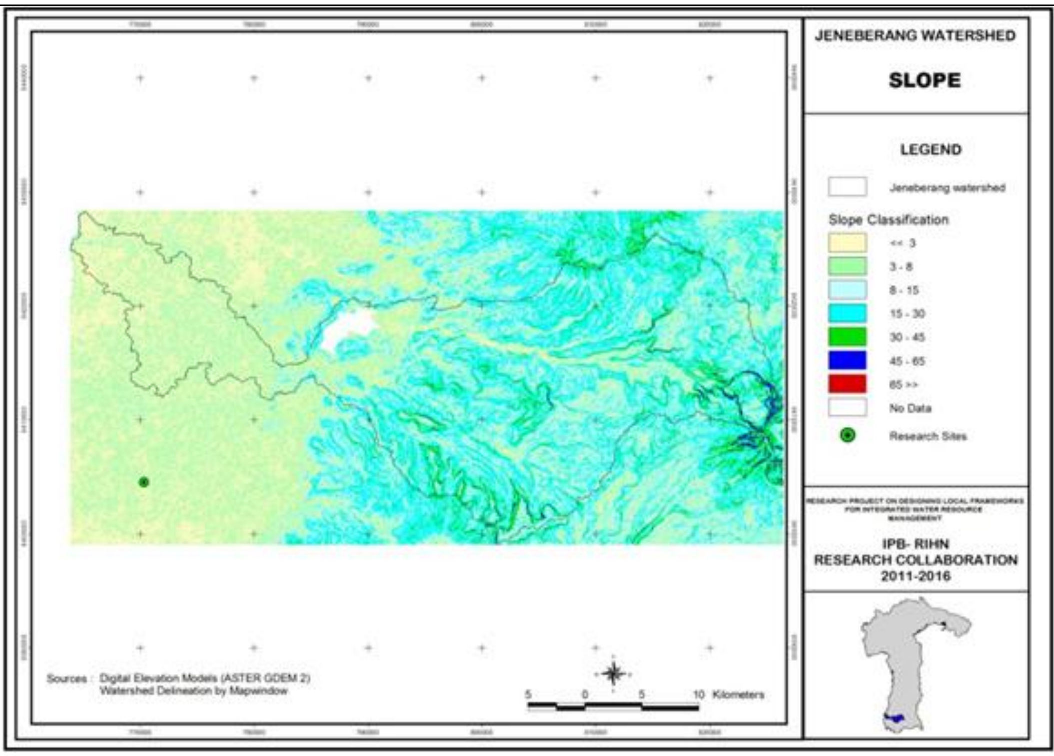


Figure V-3. Land Slope in Jeneberang Watershed

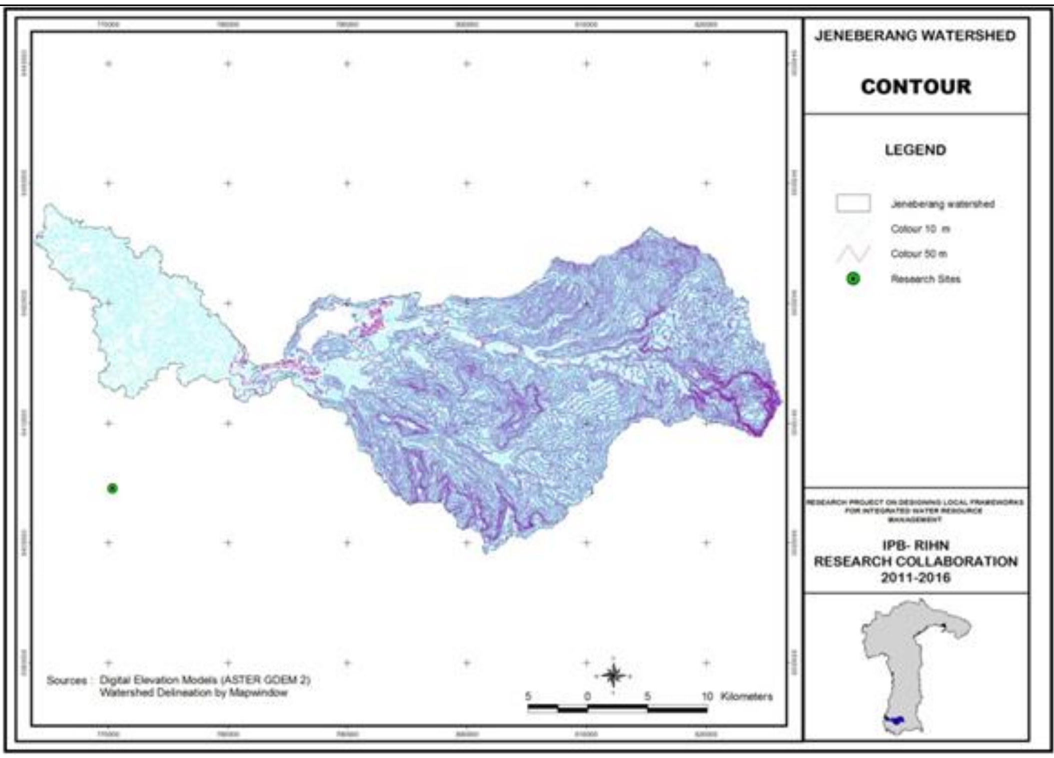


Figure V-4. Contour of Land Elevation in Jeneberang Watershed

Figure V-5 shows maps of landuse in 5 different years. It can be seen that during this time period, the downstream of Jeneberang Watershed has experienced landuse changes compared with that in the upstream. Notes should also be focused on the Bili-bili Dam, which was not yet exist in 1994. The water body of the Bili-bili Dam has shrunk to some extent.

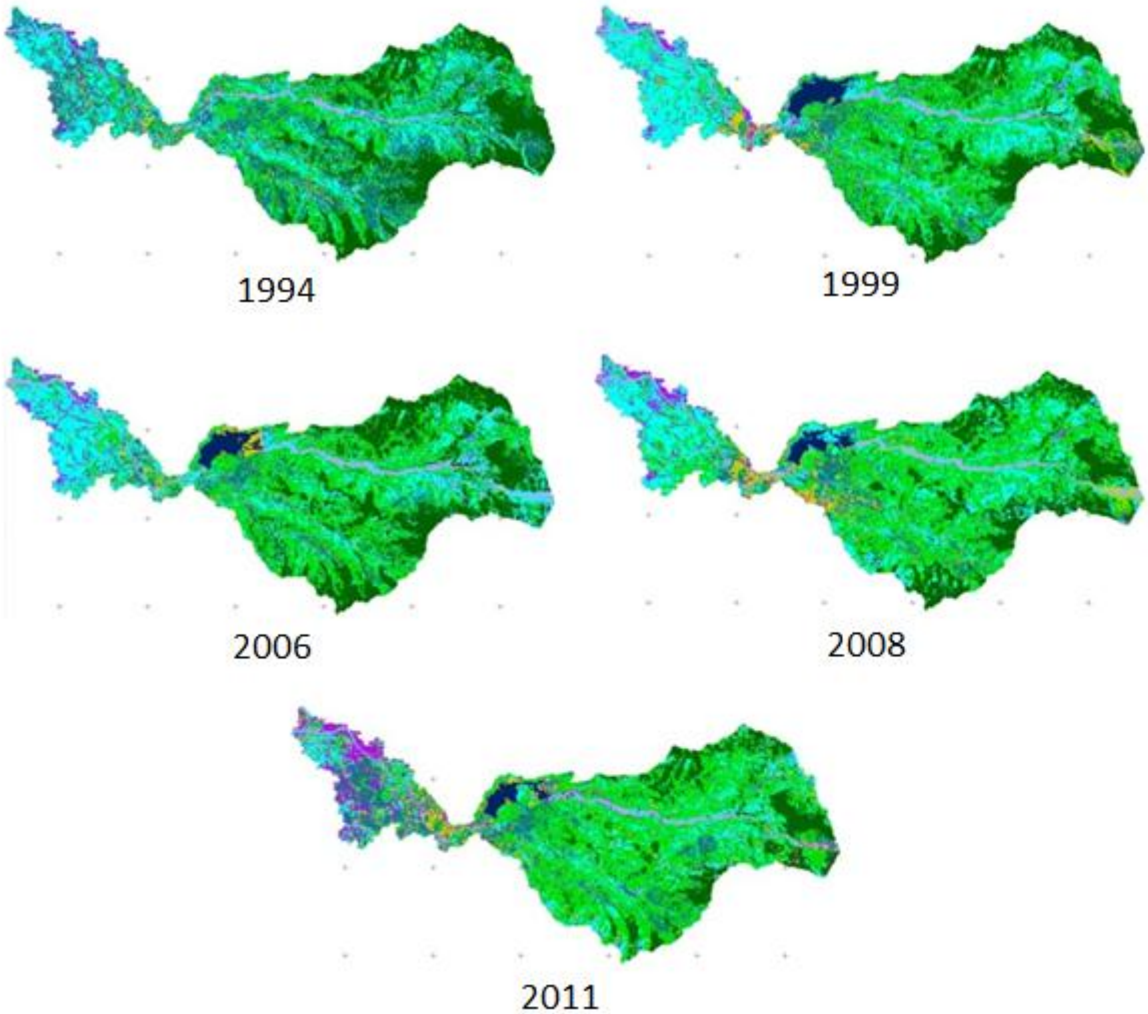


Figure V-5. Maps of Landuse in 1994, 1999, 2006, 2008 and 2011

As shown in Table V-1 and Figure V-6, paddy field expanded form 1994-1999 but then decreased with the speed 24% per year until it reached 16.6 thousand hectare. Forest area was also experience significant changes. These changes were clearly seen due to expansion of cropland other than paddy fields.  It is also important to know that water body in Bili-bili Dam has shrunk gradually with the rate of 36% per year. The decrease of paddy field area might also due to the decrease of available water from Bili-bili Dam.

Table V-1. Landuse in Jeneberang Watershed in 1994, 1999, 2006, 2008 and 2011

| Land use | Area (ha) | | | | | Changes |
| --- | --- | --- | --- | --- | --- | --- |
| | 1994 | 1999 | 2006 | 2008 | 2011 | 1994-2011 |
| Cropland/Woodland Mosaic | 17,003 | 25,500 | 23,398 | 29,304 | 31,336 | 84% |
| Paddy Field | 16,706 | 20,070 | 18,355 | 18,392 | 12,674 | -24% |
| Forest | 17,649 | 14,212 | 18,861 | 13,560 | 11,177 | -37% |
| Agricultural Land Generic | 19,056 | 7,097 | 7,146 | 5,560 | 9,193 | -52% |
| Residential | 1,357 | 2,418 | 1,513 | 2,318 | 4,169 | 207% |
| Grassland | 1,974 | 2,249 | 1,744 | 2,717 | 3,706 | 88% |
| River/stream | 1,674 | 1,664 | 1,811 | 1,640 | 1,640 | -2% |
| Bili-bili DAM | | 1,638 | 1,464 | 1,149 | 1,047 | -36% |
| Water Body | 173 | 696 | 1,278 | 853 | 615 | 255% |
| Wetland/Water Body | | 49 | 22 | 99 | 35 | |
| Total | 75,592 | 75,593 | 75,592 | 75,592 | 75,592 | |

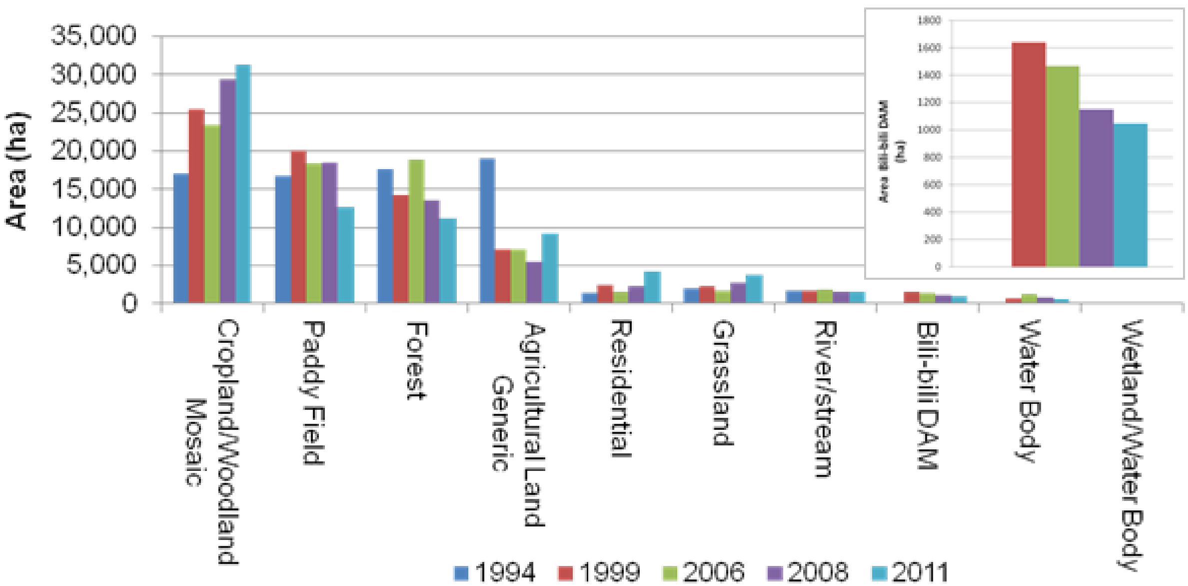


Figure V-6. Areas of Landuse in Jeneberang Watershed 1994-2011.

## C. Soils

Figure V-7 shows distribution of soil types in Jeneberang Watershed which was obtained from Pusat Penelitian dan Pengembangan Tanah dan Agroklimat (P3TA) or R/D Center on Soil and Agroclimate. As also shown in Table V-2, there are 13 land systems with soil classification based on USDA Soil Taxonomy in 1975.

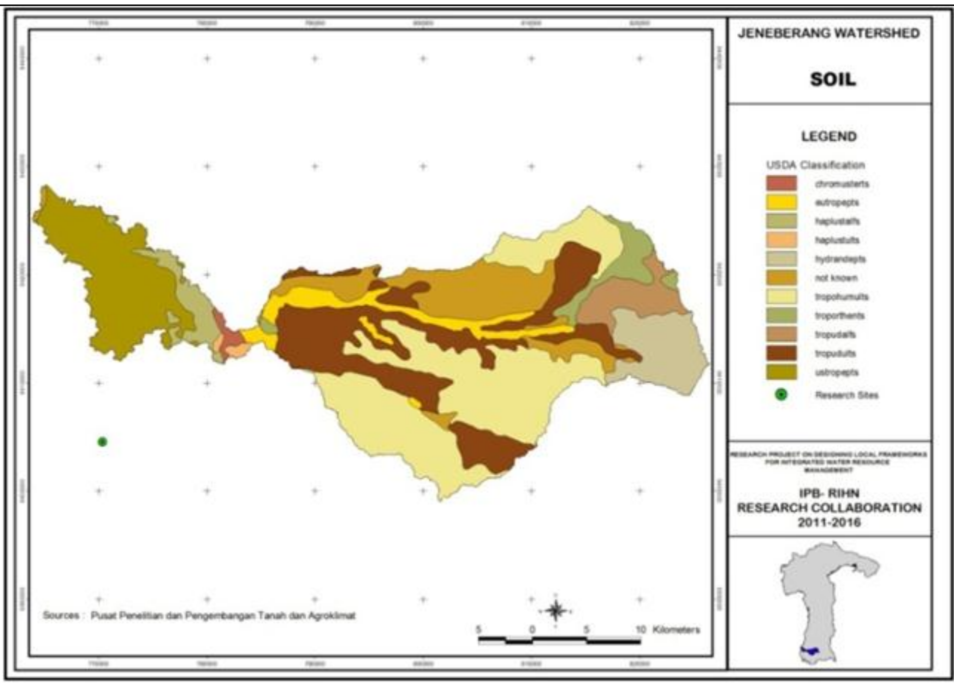


Figure V-7. Distribution of Soil Types in Jeneberang Watershed

Table V-2. Soil Types and their Areas in Jeneberang Watershed

| No | Land System | Area (ha) | Area (%) | Soil Taxonomy USDA 1975 | | |
|---|---|---|---|---|---|---|
| 1 | Bukit Balang | 22,481 | 30% | Dystropepts | Humitropepts | Tropohumults |
| 2 | Air Hitam-Kanan | 15,384 | 20% | Dystropepts | Haplorthox | Tropudults |
| 3 | Makasar | 10,526 | 14% | Tropaquepts | Fluvaquents | Ustropepts |
| 4 | Bukit Ayun | 7,385 | 10% | Dystropepts | Tropohumults | Not Known |
| 5 | Tanggamus | 5,076 | 7% | Dystrandepts | Humitropepts | Hydrandepts |
| 6 | Bakunan | 4,058 | 5% | Tropaquepts | Tropofluvents | Eutropepts |
| 7 | Barong Tongkok | 3,206 | 4% | Dystropepts | Eutropepts | Tropudalfs |
| 8 | Bukit Masung | 2,538 | 3% | Dystropepts | Tropudults | Troporthents |
| 9 | Bontosapiri | 2,291 | 3% | Ustropepts | Haplustults | Haplustalfs |
| 10 | Sungai Mimpi | 1,691 | 2% | Dystropepts | Tropudults | Not Known |
| 11 | Buludowang | 472 | 1% | Haplustults | Dystropepts | Chromusterts |
| 12 | Lantang | 344 | 0% | Dystropepts | Paleustults | Haplustults |
| 13 | Ujung Petang | 136 | 0% | Ustipsamments | Tropaquents | Not Known |
| Total | | 75,589 | 100% | | | |

## D. Rivers

Figure V-8. River network in Jeneberang Watershed. The watershed has 4 sub-watersheds (Table V-3), which are Jeneberang (41%), Jenelata (30%), Lengkese (17%) and Malino (11%). As shown in Table V-3, there 4 rivers meet into Jeneberang River, which are Jeneberang, Malino, Lengkese and Jenelata Rivers. Table V-4 lists names of rivers in Jeneberang Watershed.

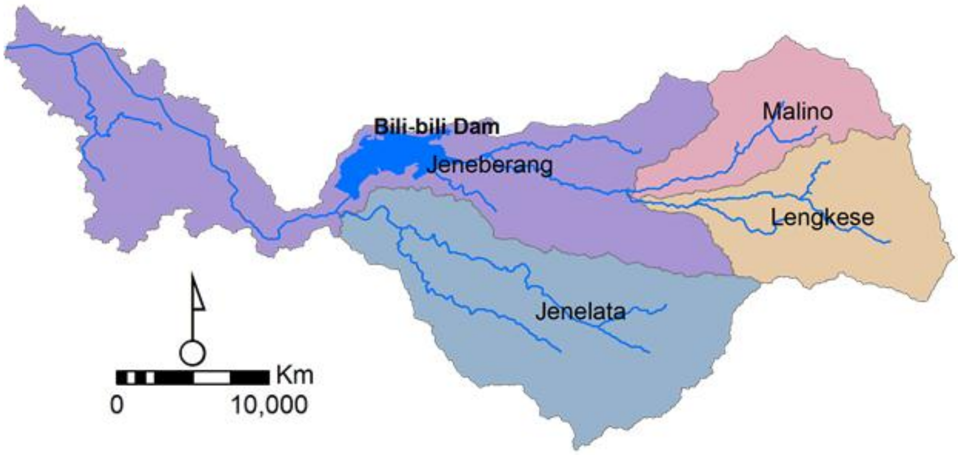


Figure V-8. River network in Jeneberang Watershed

Table V-3. Sub-watershed in Jeneberang Watershed

| Sub-watershed | Area (ha) | Percent |
|---|---|---|
| Jeneberang | 31,091 | 41% |
| Jenelata | 22,952 | 30% |
| Lengkese | 12,915 | 17% |
| Malino | 8,634 | 11% |
| Total | 75,591 | 100% |

Table V-4. Names of rivers in Jeneberang Watershed

| No | River Name | Length | Slope |
|---|---|---|---|
| 1 | Jene Berang | 85,035 | 0.0189 |
| 2 | Salo Bontorea | 19,765 | 0.0011 |
| 3 | Binanga Sapaya | 19,737 | 0.0147 |
| 4 | Binanga Tokka | 18,471 | 0.0139 |
| 5 | Salo Malino | 14,541 | 0.0263 |
| 6 | Jene Rakikang | 13,349 | 0.0166 |
| 7 | Salo Kaisisi | 8,568 | 0.0446 |
| 8 | Binanga Jajang | 8,056 | 0.0156 |
| 9 | Binanga Kampala | 5,688 | 0.0364 |
| 10 | Jene Dotara | 5,472 | 0.0029 |
| 11 | Salo Pambola | 4,589 | 0.1327 |
| 12 | Binanga Patteteang | 4,296 | 0.0319 |
| 13 | Salo Takapala | 4,266 | 0.0915 |
| 14 | Salo Ahuwa | 1,025 | 0.0419 |
| 15 | Salo Manapa | 405 | 0.0791 |

As shown in Figure V-9, the maximum and averaged daily discharge of Jeneberang River in the period of 1999 to 2007 was relatively constant in between 99.39 - 100.01 $m^3/s$; while the the minimum daily discharge was decreasing with time and attained the lowest level in 2006, which was 75.22 $m^3/s$.

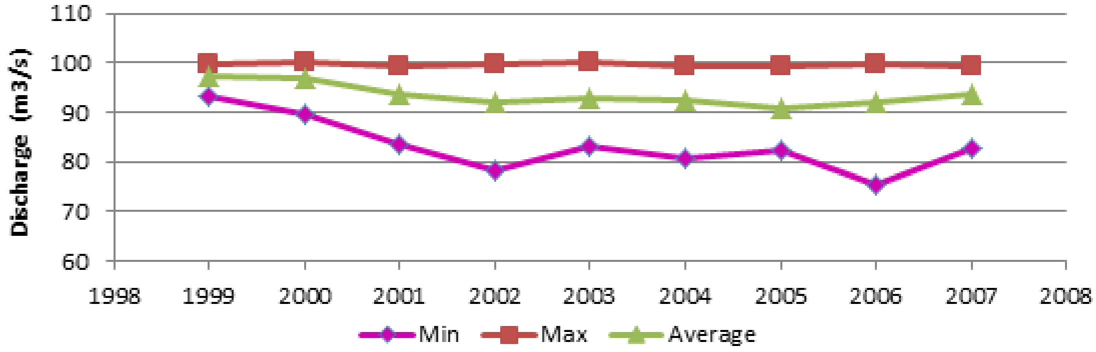


Figure V-9. The discharge of Jeneberang River

## E. Climates

Figure V-10 shows annual rainfall in Jeneberang Watershed from 1999 to 2006. The annual rainfall decreased with time significantly from 4000 mm in 1999 up to lower than 1500 mm in 2006. As shown in Figure V-11, the dry season commonly started from 190 up to 290 Julian calendar.

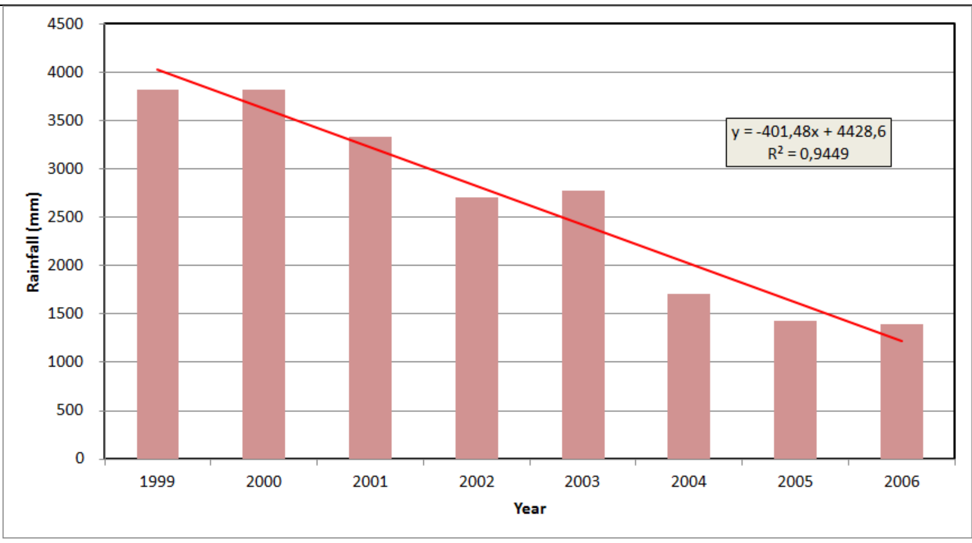


Figure V-10. Annual Rainfall in Jeneberang Watershed from 1999-2006

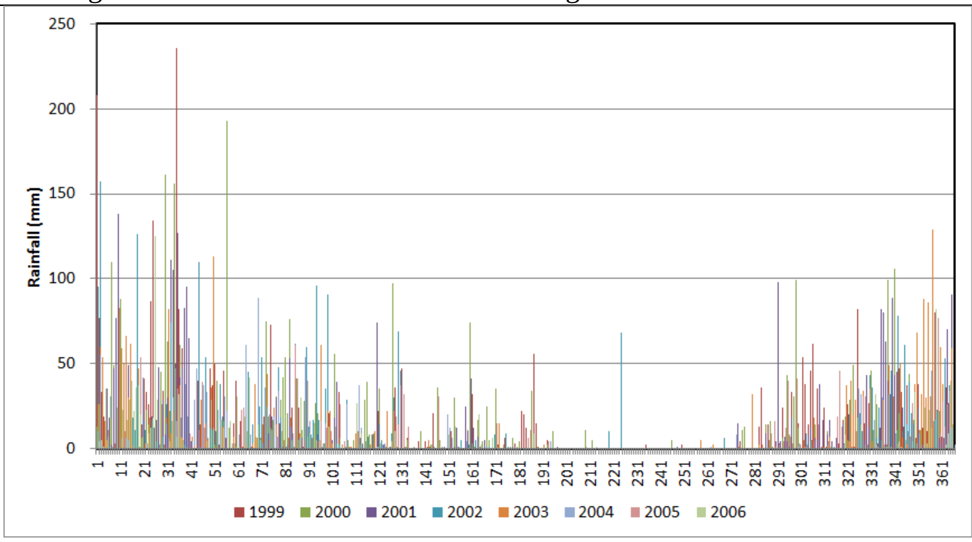


Figure V-11. Daily Rainfall in Jeneberang Watershed from 1999-2006

Trends of climate in Jeneberang (Stasiun Bonto Bili, Parangloe Sub-district, Gowa) can be seen in Figure V-12 for air temperature, Figure V-13 for air relative humidity, Figure V-14 for solar radiation, Figure V-15 for evaporation and Figure V-16 for rainfall.

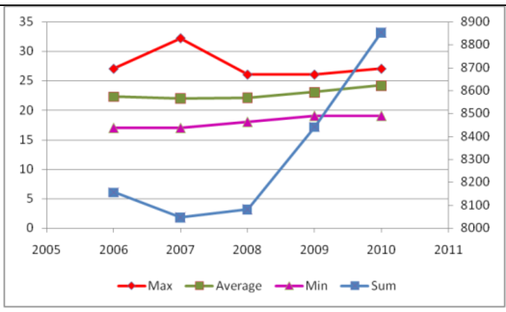


Figure V-12. Air Temperature

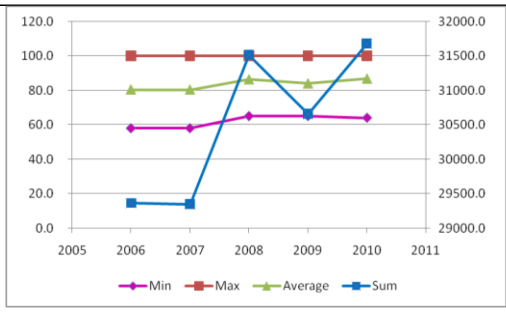


Figure V-13. Air Relative Humidity

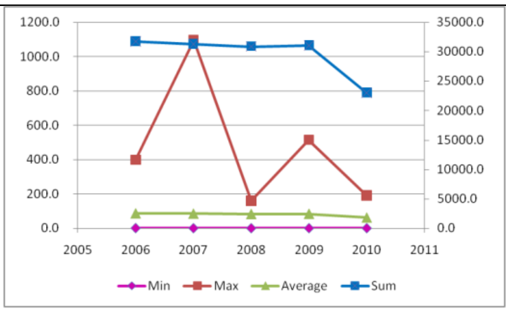


Figure V-14. Solar Radiation

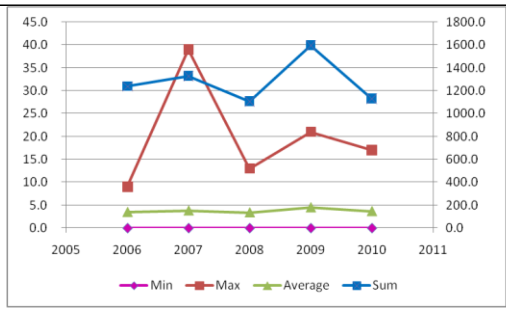


Figure V-15. Evaporation

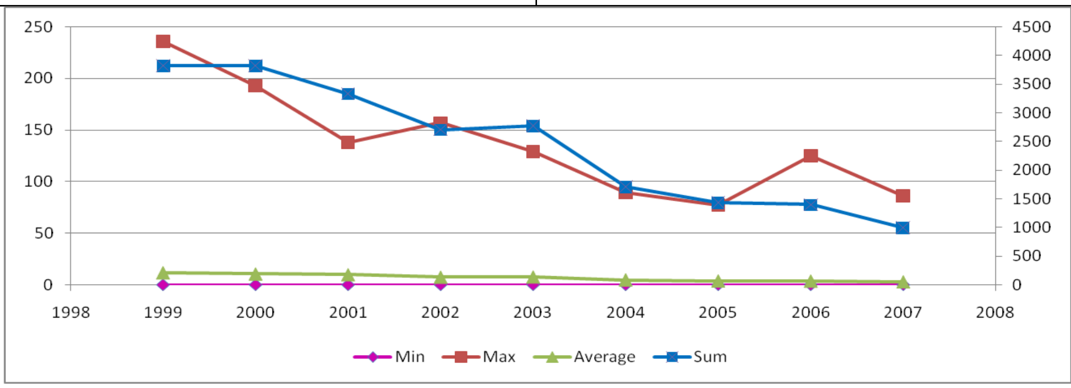


Figure V-16. Rainfall

Table V-5 shows the results of Mann-Kendall Analysis to see whether there was a climate change phenomenon Jeneberang Watershed. Based on limited time span, we can see that the averaged, maximum and cumulative rainfall decreased significantly with time. Even though, we could not see if there were significant changes of dry and wet seasons during these time period.

Table V-5. Result of Mann Kendall Analysis

| T (°C) | Start | End | n | S | $\sigma_s$ | Z | α | Zα | Trend |
|---|---|---|---|---|---|---|---|---|---|
| Max | 2006 | 2010 | 5 | -1 | 16.667 | -0.245 | 0.05 | 1.65 | NEG NS |
| Average | 2006 | 2010 | 5 | 5 | 16.667 | 1.2247 | 0.05 | 1.65 | POS NS |
| Min | 2006 | 2010 | 5 | 7 | 16.667 | 1.7146 | 0.05 | 1.65 | **POS S** |
| Sum | 2006 | 2010 | 5 | 5 | 16.667 | 1.2247 | 0.05 | 1.65 | POS NS |
| Monthly Rainfall (mm) | Start | End | n | S | $\sigma_s$ | Z | α | Zα | Trend |
| Min | Jan-99 | 7-Oct | 106 | 1 | 134178 | 0.0027 | 0.05 | 1.55 | POS NS |
| Max | Jan-99 | 7-Oct | 106 | -1401 | 134178 | -3.825 | 0.05 | 1.55 | **NEG S** |
| Ave | Jan-99 | 7-Oct | 106 | -1331 | 134178 | -3.634 | 0.05 | 1.55 | **NEG S** |
| Sum | Jan-99 | 7-Oct | 106 | -1263 | 134178 | -3.448 | 0.05 | 1.55 | **NEG S** |
| Dry Day | Start | End | n | S | $\sigma_s$ | Z | α | Zα | Trend |
| Start of dry day | 1999 | 2007 | 9 | 6 | 92 | 0.6255 | 0.05 | 1.65 | POS NS |
| Start of wet day | 1999 | 2007 | 9 | 9 | 92 | 0.9383 | 0.05 | 1.65 | POS NS |
| Period of dry days | 1999 | 2007 | 9 | -3 | 92 | -0.313 | 0.05 | 1.65 | NEG NS |
| Peak of dry day | 1999 | 2007 | 9 | 1 | 92 | 0.1043 | 0.05 | 1.65 | POS NS |

## F. Irrigation Systems

Irrigation water for paddy fields was originally flowing from Bili-bili Dam. As previously described, the water body (Figure V-17) was decreasing since 1996

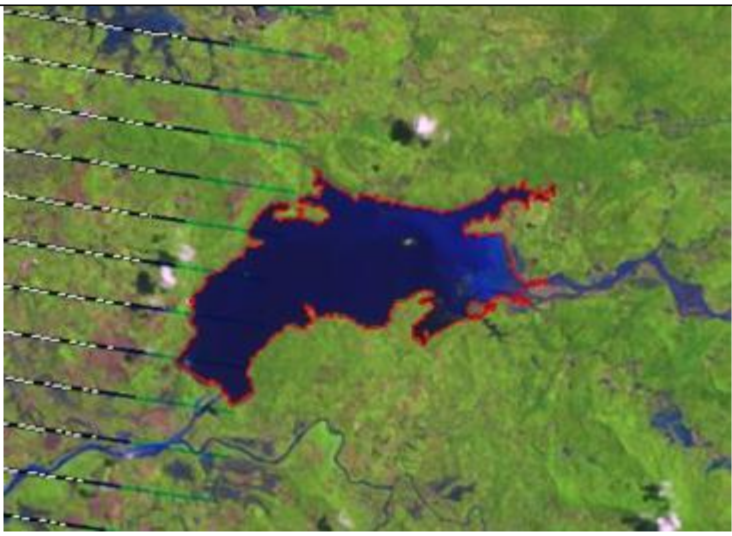

Figure V-17. Water Body of Bili-bili Dam in 2012

The outlet of Bili-bili Dam is at coordinate S:5$^o$16' 34.2" and E:119$^o$34' 45.6"with longitudinal length was about 844 m. First priority of the Dam was for electricity then for irrigation and clean water.

There are 3 irrigation unit irrigation zones, which are:

1. Bili-bili Irrigation Zone which has command area of 2,360 ha with planned water discharge was about 3.909 $m^3$/s. There exists Bili-bili Weir at the coordinate of S: 05$^o$16'34.2" and E: 119$^o$34'45.6".
2. Bisua Irrigation Zone which has command area of 10,785 ha with planned discharge of 3.909 $m^3$/s. There exists Bisua Weir at the coordinate of S: 05$^o$18'14.1" and E: 119$^o$31'58.7".
3. Kampili Irrigation Zone which has command area of 10,547 ha with a planned water discharge of 17.403 $m^3$/s. There exists Kampili Weir at the coordinate of S: 05$^o$16'39.1" and E:LS dan 119$^o$30'47.7".

## G. Paddy Fields

Figure IV-17 shows climate and soil observation stations in paddy fields in 3 locations, which are Malino in the upstream, Bissue in the midstream and Kampili in the downstream of Jeneberang Watershed.

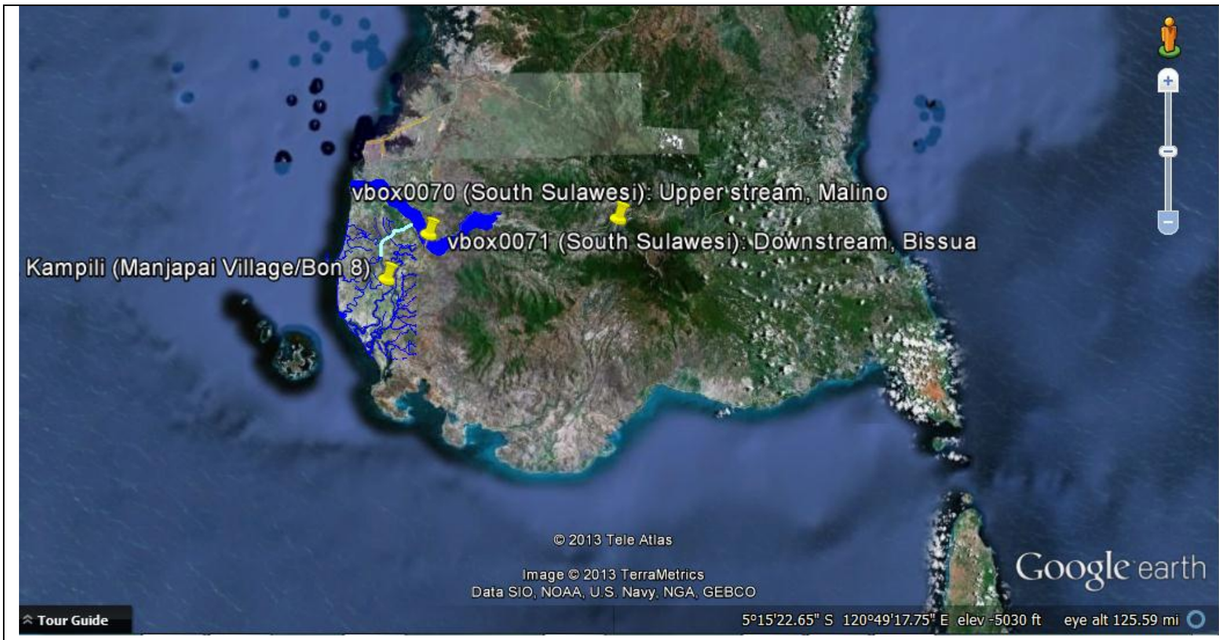


Figure V-18. Climate and Soil Observation Stations in Jeneberang Watershed

As previously shown in Table V-1. Landuse in Jeneberang Watershed in 1994, 1999, 2006, 2008 and 2011the area of paddy field in Jeneberang Watershed has being decreasing since 1999 with the rate of about 24% per year up to 2011. Water availability for paddy fields might also decrease which can be seen from the decreasing of the area of water surface in Bili-bili Dam. It means that the existing paddy fields would have experienced water shortage in some period of cultivation time.  Soil types in the paddy fields were mostly similar belong to Silty Clay Loam, which their properties are shown in Figure V-19.

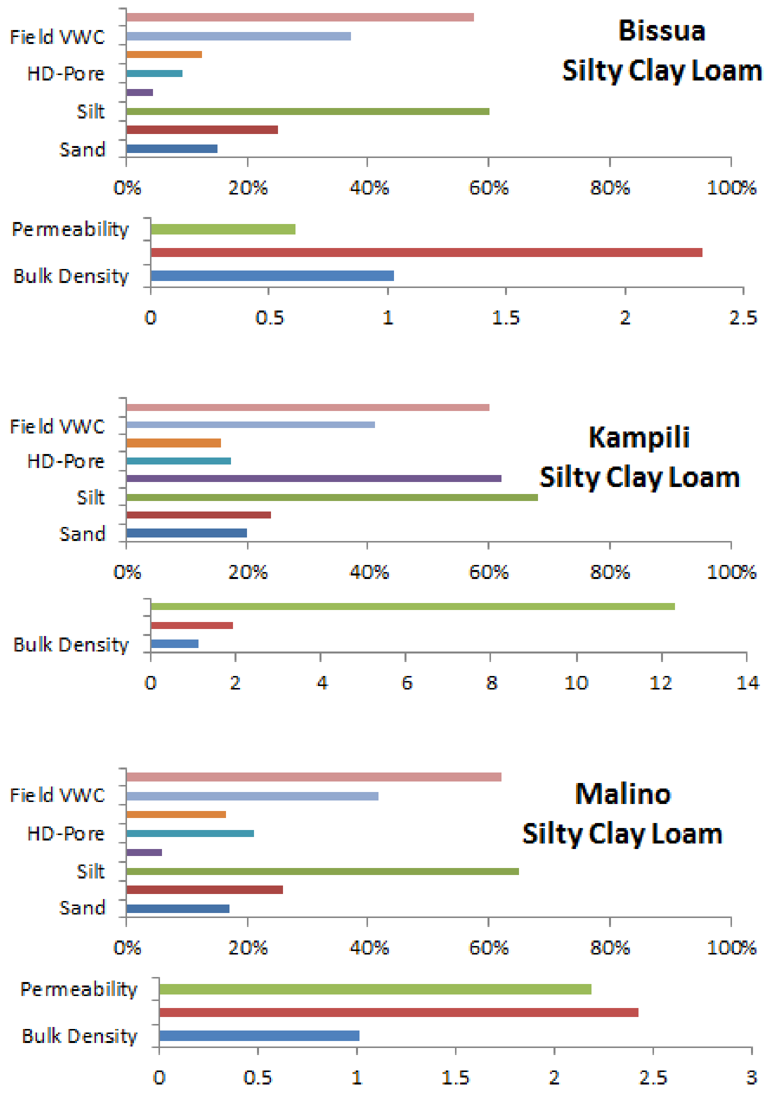


Figure V-19. Soil Properties in the observed 3 paddy fields in Jeneberang Watershed

As shown in Figure V-20, the observed paddy field in Malino received rainfall at the same amount of evapotranspiration. Water balance is mostly positive and all soil layers were above Field Capacity. In some occasion, there was ponded water in the soil surface. In this sense, paddy fields in Malino which is in the upstream had no water shortage experiences.

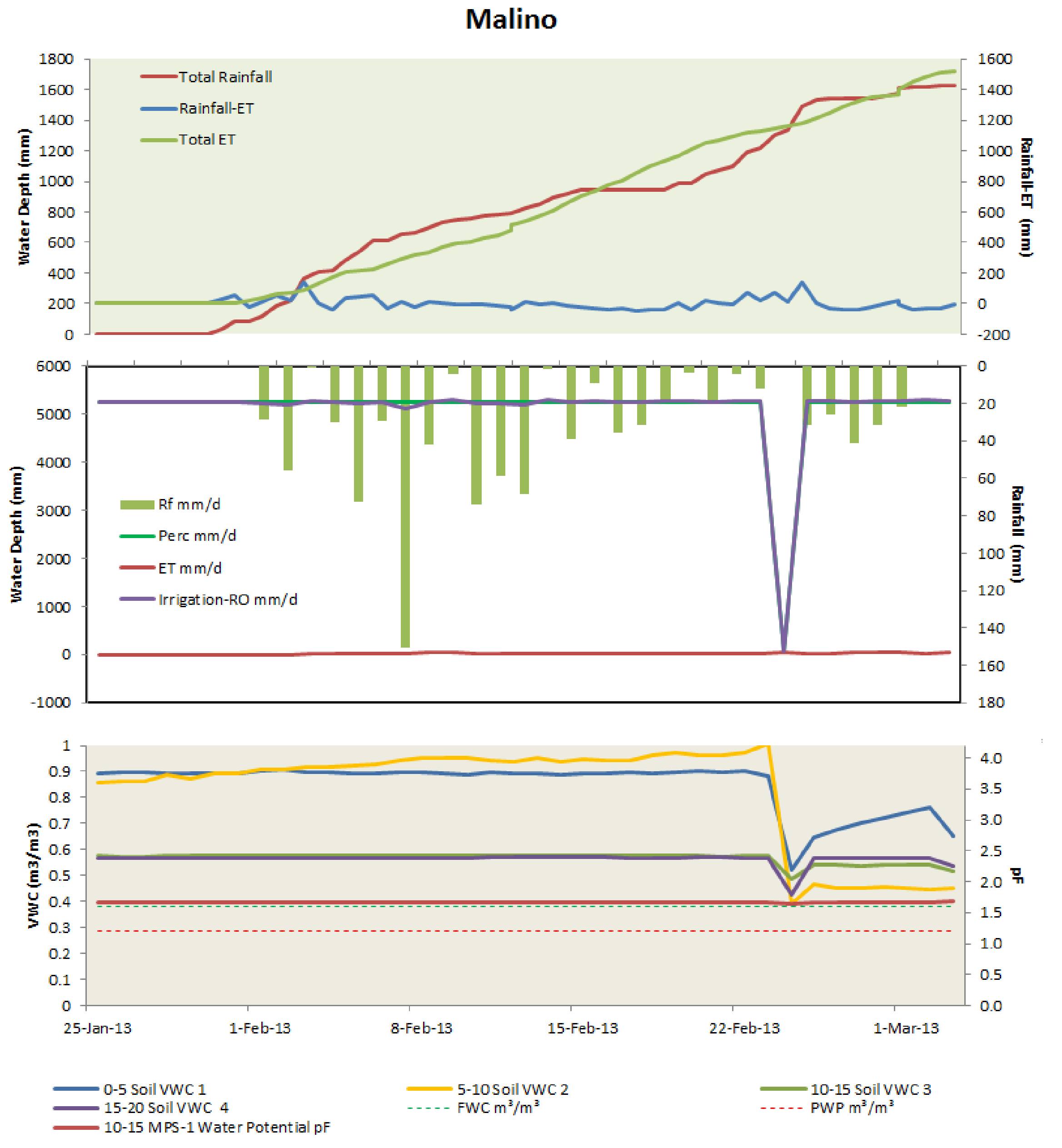


Figure V-20. Climate and Soil Conditions in 3 Observed Paddy Fields in Malino

As shown in Figure V-21, the observed paddy field in Bissua received rainfall at the same amount of evapotranspiration. Water balance is mostly positive even though at some moment soil moisture in the surface soil felt below field capacity and closer to Permanent Wilting Point. However, at deeper layers the soil was constantly saturated with water. This situation indicated that irrigation water was not functioning well.

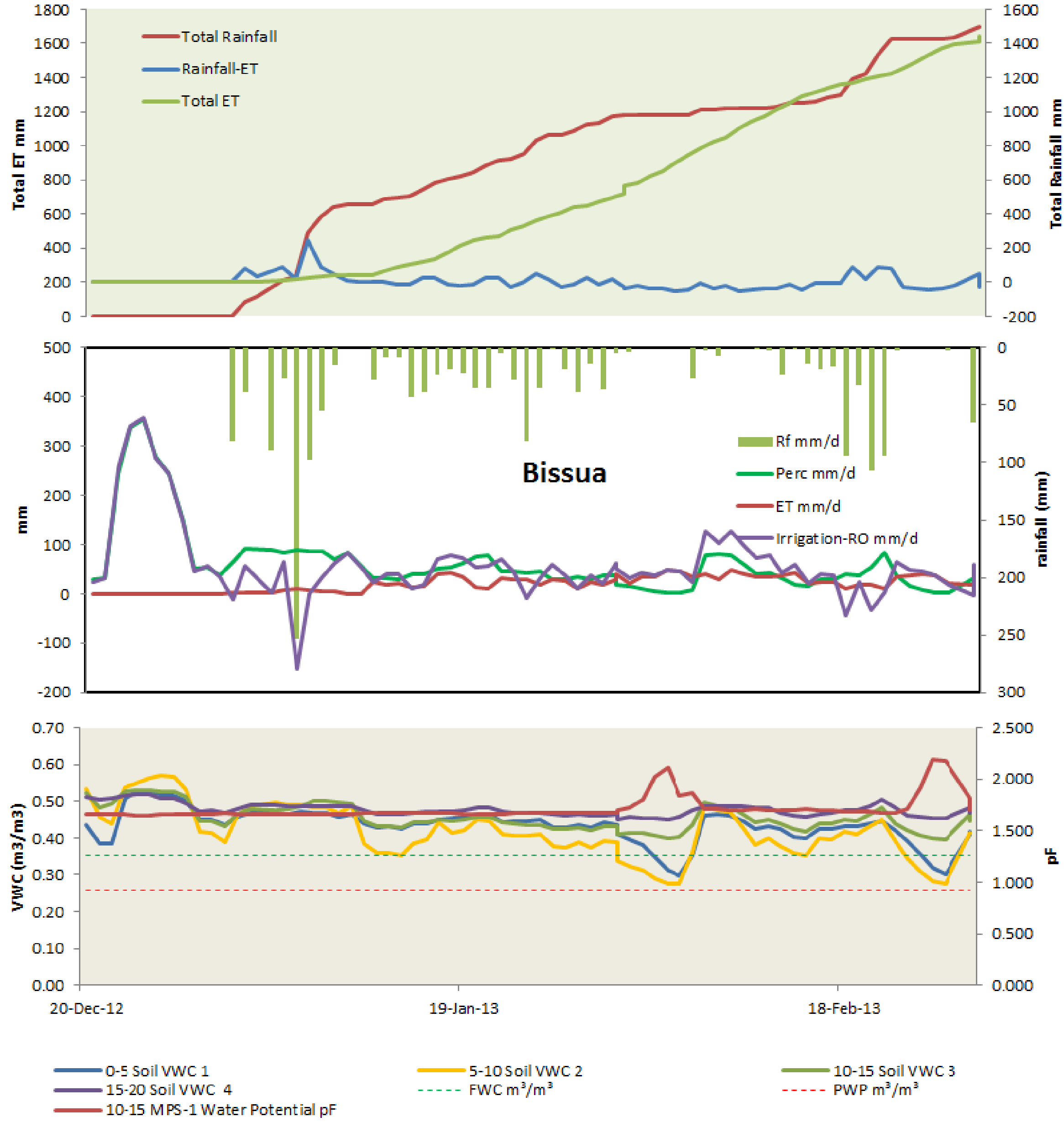


Figure V-21. Climate and Soil Conditions in 3 Observed Paddy Fields in Bissua

As shown in Figure V-22, the observed paddy field in Kampili received less rainfall. Water balance is negative all the time. This caused soil moisture not only in the surface but also in the deeper dropped below Permanent Wilting Point. This situation indicated that irrigation water was not sufficiently given to the paddy fields or irrigation water might not reach the paddy fields.

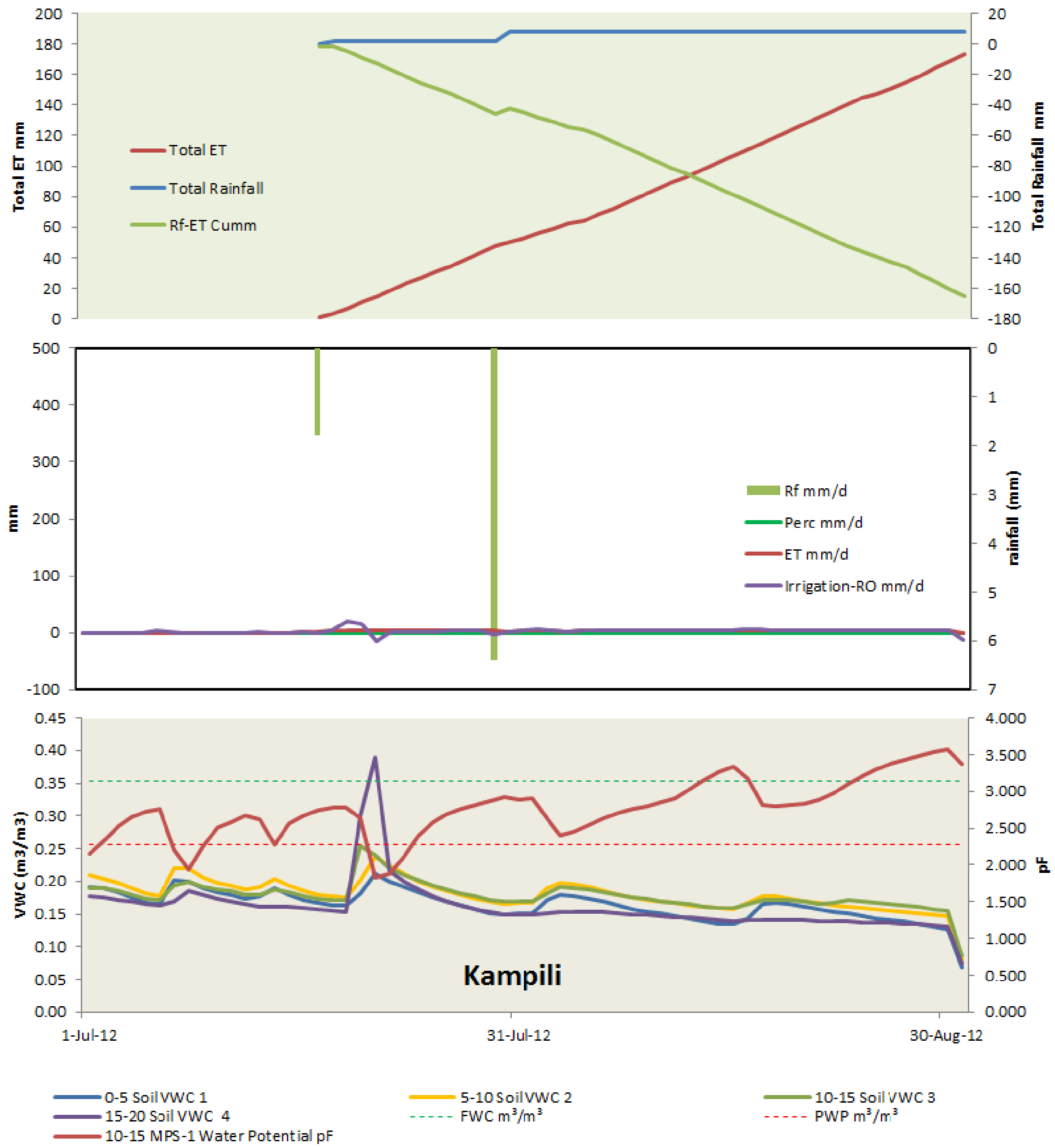


Figure V-22. Climate and Soil Conditions in 3 Observed Paddy Fields in Kampili

## H. Socio-economics

Table V-6 shows population in Jeneberang Watershed which was estimated based on population density, and area in each kecamatan inside Jeneberang. Total population was about 351.300 people, where 71.01% out of it is Kabupaten Gowa, 28.47% in Kota Makassar and 0.51% in Kabupaten Takalar.

Table V-6. Population and its Density in Jeneberang Watershed

| No | Regency | District | Population Density per | Sub-district Area in Watershed (km2) | Population in Watershed |
|---|---|---|---|---|---|
| 1 | Gowa | Pallangga | 1,775 | 56.51 | 100,303 |
| 2 | Makassar | Tamalate | 7,643 | 13.09 | 100,039 |
| 3 | Gowa | Sombaopu | 3,517 | 9.85 | 34,653 |
| 4 | Gowa | Tinggimoncong | 147 | 169.27 | 24,882 |
| 5 | Gowa | Bajeng | 989 | 24.65 | 24,378 |
| 6 | Gowa | Bungaya | 111 | 174.50 | 19,370 |
| 7 | Gowa | Manuju | 162 | 111.61 | 18,081 |
| 8 | Gowa | Bontomarannu | 544 | 20.63 | 11,221 |
| 9 | Gowa | Parigi | 105 | 77.76 | 8,165 |
| 10 | Gowa | Parangloe | 74 | 59.41 | 4,397 |
| 11 | Gowa | Bontolempangan | 122 | 17.12 | 2,088 |
| 12 | Takalar | Polombangkeng Utara | 206 | 8.75 | 1,802 |
| 13 | Gowa | Barombong | 160 | 11.17 | 1,787 |
| 14 | Gowa | Tombolo Pao | 111 | 1.37 | 152 |
| 15 | Gowa | Biringbulu | 166 | 0.16 | 27 |
| 16 | Gowa | Tompobulu | 246 | 0.04 | 9 |
| | | | Total | 755.88 | 351,354 |

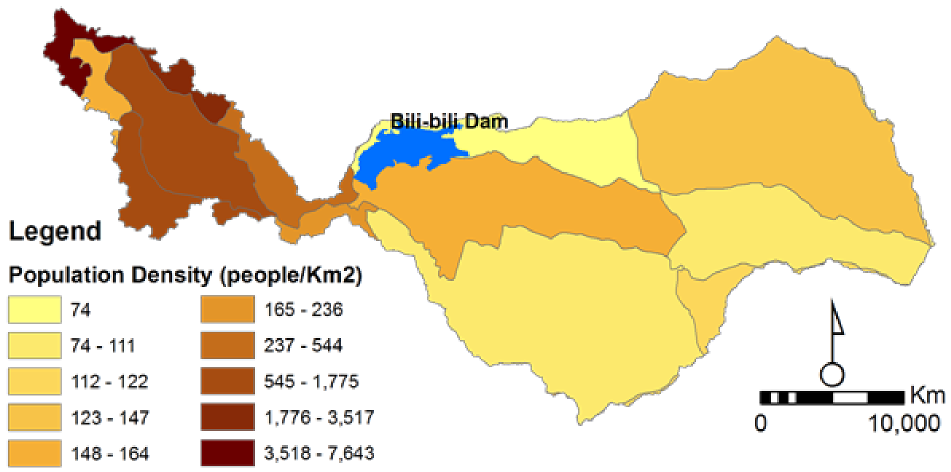


Figure V-23. Distribution of Population Density in Sub-watershed

Table V-7 shows harvested area and rice production in 2010 and estimated rice demand based on population in Jeneberang Watershed. Polombangken Utara has larger area and higher rice production than the other districts. But, the rice demand was Bontomarannu followed by Tinggi Moncong District. Rice productivity ranged from 4.9 to 6.4 ton/ha with the averaged value was 5.6 ton/ha which was higher than the averaged national value of 5 ton/ha for wetland paddy field. Form this viewpoint, it can be said that rice production is not a problem in Jeneberang Watershed.

Table V-7. Rice Production and Demand in Jeneberang Watershed

| Kecamatan (District) | Harvested paddy area (ha) | Rice Production (ton) | Productivity (ton/ha) | Rice Demand (ton/year) |
|---|---|---|---|---|
| Polombangkeng Utara | 6038 | 38475 | 6.4 | 172 |
| Palangga | 5078 | 31442 | 6.2 | 1381 |
| Bajeng | 4959 | 29913 | 6.0 | 313 |
| Tompobulu | 3168 | 18774 | 5.9 | 2 |
| Tombolo Pao | 3044 | 15074 | 5.0 | 5 |
| Barombong | 2922 | 17249 | 5.9 | 205 |
| Pattallassang | 2867 | 15057 | 5.3 | 27 |
| Manuju | 2852 | 14182 | 5.0 | 825 |
| Bontolempangan | 2563 | 13141 | 5.1 | 4787 |
| Tinggi Moncong | 2415 | 12232 | 5.1 | 15021 |
| Bungaya | 2350 | 12274 | 5.2 | 3366 |
| Somba Opu | 2135 | 12646 | 5.9 | 123 |
| Parangloe | 2006 | 9926 | 4.9 | 7397 |
| Biringbulu | 1774 | 9464 | 5.3 | 1 |
| Galesong Utara | 1720 | 10956 | 6.4 | 45 |
| Bontomarannu | 1626 | 9830 | 6.0 | 17609 |
| Tamalate | 700 | 3986 | 5.7 | 1683 |

# VI. CONCLUSIONS AND RECOMMENDATIONS

From this preliminary research, it can be concluded that:

1. There were high indications that in both Saba and Jeneberang Watershed might have been experiencing climate changes.
2. The main indicators were increasing of daily minimum air temperature and decreasing annual rainfall.
3. Impact on these climate changes on water resources could not be detected clearly in Saba Watershed but it was real in Jeneberang Watershed where there was a significant shrunk of water surface area of Bili-bili Dam.
4. Due to this condition, paddy field in the downstream of Jeneberang Watershed received less or might not get irrigation water compared with that in the upper streams.
5. To make matters worse, Jeneberang Watershed has been experiencing landuse changes in which the area of paddy fields in the downstream decreased significantly.
6. There might be interrelations, which are needed to be explored, that these land conversions from paddy fields to non-paddy fields were due to less irrigation water or available water to irrigate the paddy fields.
7. Since these land conversions occurred in the downstream where most of people live there with the highest rice demand, it is a high risk that more new areas for agricultures would be opened in the upper stream.
8. In order to meet rice demand and dealing with the decreasing trend of available water resource, it is important to find proper methods on using the available water resources effectively or more productive.
9. It is also imperative to find effective water resource management involving stakeholders in both Saba and Jeneberang Watershed based on these preliminary research results.

It is recommended to continue this research activity which gives more attention to:

1. Deliver of the research findings to the stakeholders to get their awareness and to be used as decision supporting system.

2. Involve stakeholders to formulate mechanism on how to improve the existing water resources management especially in dealing with climate and landuse changes.
3. Enhance capability of local farmers to produce agricultural product in more effective and water-efficient.
4. Elaborate interrelationship among variables involved in determining water availability especially within the aspects of socio-economics.
5. Specify driving forces behind landuse changes in example by using sensitivity analysis.

## ANNEX 1: FIELD MONITORING SYSTEM

### A. Instrumentation

Generally two measurement systems were used in each set which are soil measurements and weather measurements (weather stations) system (Figure 0-1). Soil measurements systems used 5 sensors, which one of them measure soil water potential (suction/pF) which will show the soil water retention. Each of the other 4 sensors measure 3 parameters at once soil volumetric water content ($m^3/m^3$), temperature ($^oC$) and Electro-conductivity (µS). These sensors measure at different level of depth beneath the soil surface.

Weather station is used to acquire weather parameters at the site, and for some extent can be used as weather primary data for the watershed. The parameter directly measured by sensors attached to the station are air temperature ($^oC$), air relative humidity (%), solar radiation ($Wm^{-2}$), ultraviolet index (), rainfall (mm), barometric pressure (kPa), wind speed (m/s) and wind direction ($^o$). Additionally, a few derived parameters can also automatically calculated by the station like evapotranspiration (mm). Using these systems the analysis of water balance can be done as well as more detailed analysis of soil water.

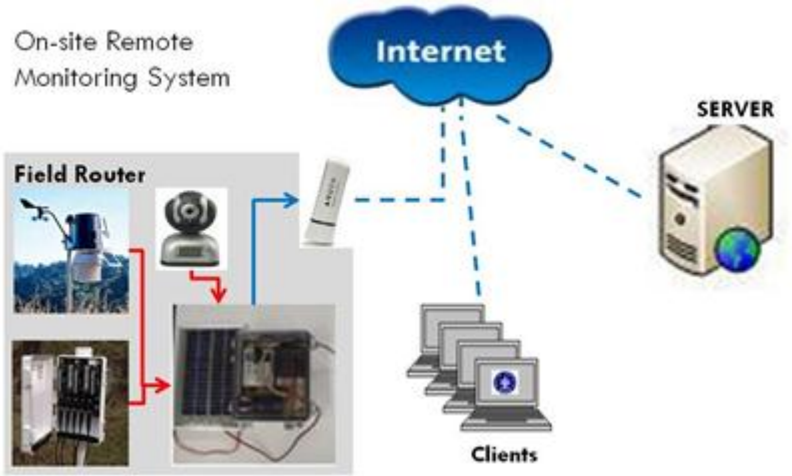


Figure 0-1. Field Monitoring System

The two measurements systems are connected to data server through internet connection. This is made possible by using remote monitoring system named Field Router (FR). Soil measurements and Weather station data loggers are connected to FR which will regularly download data from the loggers and upload them to the server. Additionally FR takes pictures from the site which enabled the visualization of the situation at the site, for example: plant growth and farming stages. Using the remote monitoring system data acquisition can be done and problems with the instrumentations can be known without visiting the site.

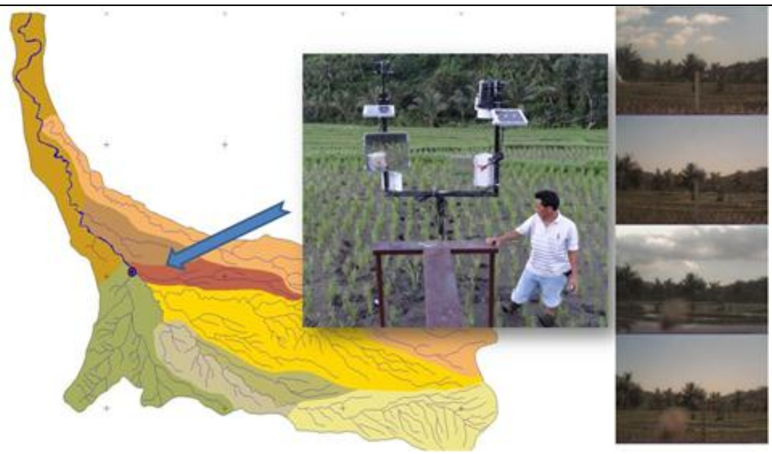

Figure 0-2. Field Station in Saba Watershed

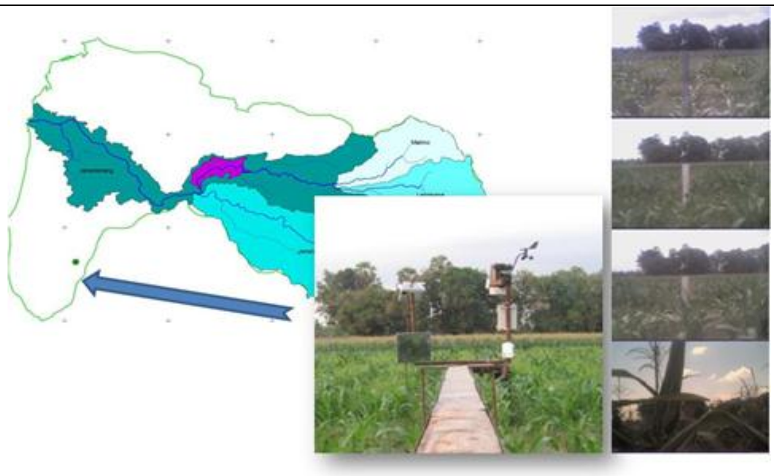

Figure 0-3. Field Station in Jeneberang Watershed

Two sets of on-site monitoring system had been set up at paddy field in Saba Watershed, Buleleng, Bali (Figure 0-2) and Kampili Irrigation Area which takes water from Bili-bili Reservoir System, Jeneberang Watershed, Gowa, South- Sulawesi (Figure 0-3).

The on-site field monitoring system is powered by solar energy and battery and can be placed in remote location far from electricity line. The installation were planned to be integrated, easy to maintain but minimize unnatural changes to the field and minimize disturbance to plant growth and farming activities. Fork-like installation pole is used, which all of the measurement systems and FR are attached to. A maintenance bridge shaping “T” (T-bridge) is used for personnel walk and work place in the maintenance of the instruments.

### B. Data Acquisitions

The data acquired can be downloaded by accessing the server website for each location.

Figure 0-4. and

Figure 0-5. show the websites of the installed monitoring system at the both locations. The data can be used for further process and analysis such as water balance.

Figure 0-4. Wedatabase for Saba Watershed

Figure 0-5. Webdatabase for Jeneberang Watershed

### C. Data Storage

Data measured and collected was stored in DropBox that can be accessed by all research members. Figure 0-6 shows structures of DropFiles which under the main folder RIHN.

There is also list of research members containing their activities and progress report. There are also lists of references that can be shared by all research members.

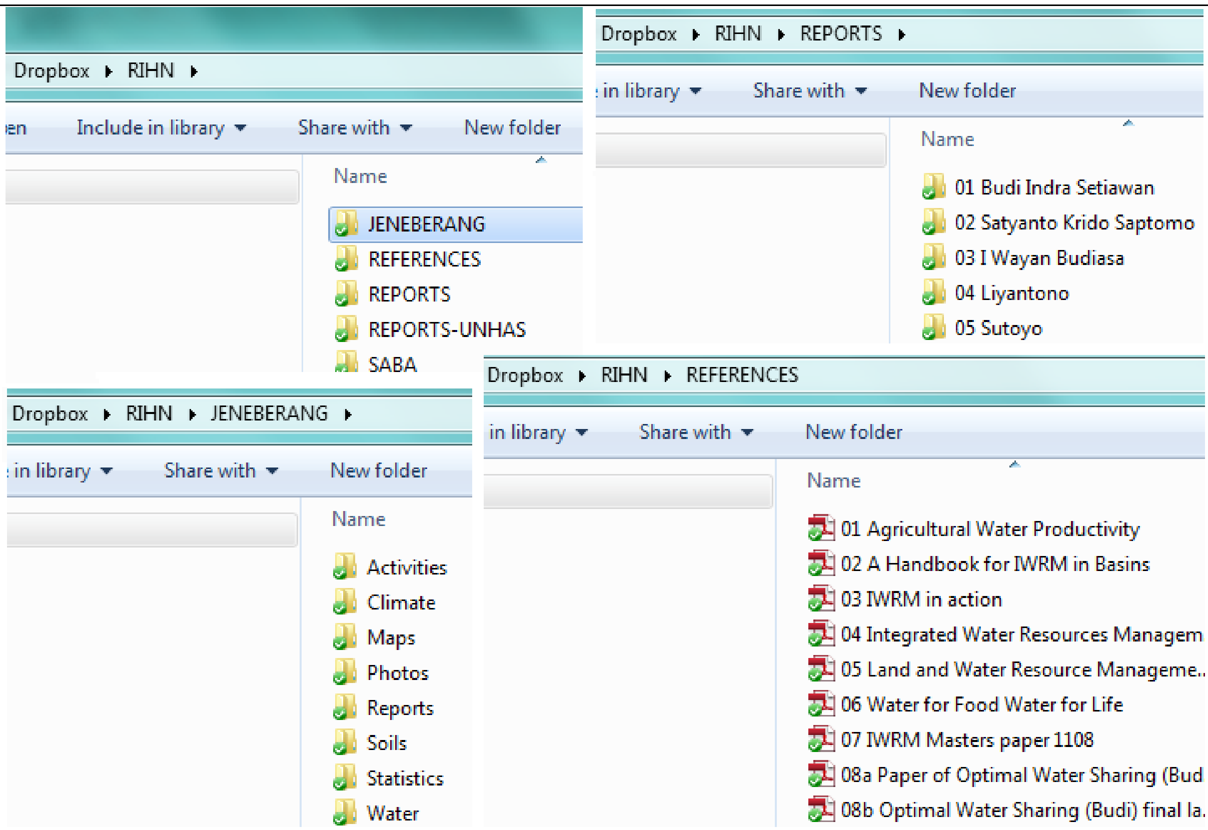


Figure 0-6. DropBox files to stored data and information

## ANNEX 2: TRAINING ON SRI ORGANIC RICE CULTIVATION

### NOSC, Nagrak-Sukabumi, May28-31, 2012

### A. Introduction

Organic rice cultivation with SRI (*System of Rice Intensification*) is currently more and more applied in various parts of Indonesia. This is because this method proven to have many advantages compared to the conventional one. The organic rice farming with SRI method would also be applied on the experimental plots of the IWRM (*Integrated Water Resource Management*) research project located at Saba Watershed in Bali and at Jeneberang Watershed in South Sulawesi. In connection with that, RIHN-IPB as the implementing institution of the IWRM research project sent some personnel to participate in the training on organic rice farming with SRI method at NOSC (*Nusantara Organic SRI Center*) located in Nagrak, District of Sukabumi, West Java Province. The training was held for four days, May 28 – 31, 2012.

### B. Training Participants

RIHN-IPB sent 9 (nine) persons for the training consisted of farmers from Saba (3), Jeneberang (3) and research members from IPB (3). A special participant, Dr. Wilfredo from the Philippines, also attended the training, as well as two participants of CSR (*Corporate Social Responsibility*) program of PT H.M. Sampoerna in East Java. Therefore, the $81^{st}$ NOSC Training Program was taken by a total of 12 participants.

### C. Training Organizer

NOSC is a non-profit organization that is very concerned about rice organic farming with SRI in Indonesia. This foundation type of organization was founded in 2004 on the basis of encouragement to participate in overcoming various agricultural and environmental problems. This foundation is expected to be the ‘center of excellent’ in overcoming national agricultural problems where every program and activity of this organization are agricultural oriented which can give holistic and integrated solutions in increasing agricultural production, protecting environment from chemical utilization, independency of farmers since they are able to produce by themselves organic fertilizers and biological pesticides, providing healthy organic food and eventually improving farmers' welfare. To achieve the goals, one of the activities of NOSC is to provide training on rice organic farming with SRI routinely in order to develop agricultural human resources.

## D. Training Implementation

This activity was a full-day training started from 8.00 AM through 4.00 PM. Method used in this training was adult learning method emphasizing on activities of discussion, critical review and active participation. Participants were not over-restricted with strict rules but still attended the training seriously. Aside from obtaining presentation of materials from the trainers in class, the participants also conducted simulation and direct field or lab works. The training materials were delivered by some very experienced trainers with attractive communication technique, so that they were not boring and easily understood by the participants.

## E. Training Materials

The training materials were organized and systematically delivered, started from global comprehension about agricultural and environmental problems through technical aspects of rice organic farming with SRI. More detail information about the daily training materials are as follows:

Day-1:

- Introduction to NOSC and SRI
- Agricultural and environmental problems
- Systems of soil ecology

Day-2:

- Soil physics, soil biology and soil chemistry
- Organic materials and compost
- Practical works on the determination of soil properties and effects of organic materials

Day-3:

- Pesticides and bio-fertilizer (*Mikroorganisme local*/MOL)
- MOL production practice
- Compost production practice

Day-4:

- Organic rice cultivation with SRI
- Practical work on organic rice cultivation with SRI

**F. Photos of Training Activity**

| | |
|---|---|
| <br>Figure 0-1. NOSC, training venue | <br>Figure 0-2. Opening of training by the General Manager of NOSC, Mr Iwan Setiaji |
| <br>Figure 0-3. Participants were listening seriously to the material delivered on Day-1 class | <br>Figure 0-4. Mr. Misnan Mulyadi, NOSC Training Manager, was explaining about soil ecology with simulation |

Figure 0-5. Explanation of the introduction to practical work on soil properties and organic materials

Figure 0-6. Practical work to determine soil properties and organic materials

Figure 0-7. Discussion on the results of the practical work

Figure 0-8. Simulation on compost production

Figure 0-9. Practical work on MOL production

Figure 0-10. Practical work on compost production