National Irrigation Commission
Ministry of Water and Irrigation
The United Republic of Tanzania

The Project on the Revision of National Irrigation Master Plan in the United Republic of Tanzania

Final Report

Volume-II

Appendixes

July 2018

Japan International Cooperation Agency (JICA)

Nippon Koei Co., Ltd.
International Development Center of Japan Inc.

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Appendix A

Hydrology and Water Resources Management

The Project on the Revision of National Irrigation Master Plan

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Appendix A: Hydrology and Water Resources Management

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Abbreviations

ADCP	Acoustic Doppler Current Profiler
AET	Actual Evapotranspiration
ASAL	Arid and Semi-Arid Lands
ASY	Annual Safe Yield
BBM	Building Block Methodology
BOD	Biochemical Oxygen Demand
BWB	Basin Water Boards
BWO	Basin Water Office
CA	Catchment Area
CD	Compact Disc
CGIAR	Consultative Group on International Agricultural Research
CHG	Climate Hazards Group
CHIRPS	Climate Hazards Group InfraRed Precipitation with Station data
CMB	Chloride Mass Balance
CSI	Consortium for Spatial Information
CWC	Catchment Water Committees
DEM	Digital Elevation Model
DJF	December - February
DRM	Desktop Reserve Model
DSS	Decision Support System
DVD	Digital Versatile Disc
DWRE	Department of Water Resources Engineering
EF	Environmental Flow
EFA	Environmental Flow Assessment
EFR	Environmental Flow Requirement
EWR	Environmental Water Requirement
FAO	Food and Agriculture Organization
FDC	Flow Duration Curve
GoT	Government of Tanzania
GRDC	Global Runoff Data Centre
GRU	Groundwater Resource Unit
GW	Groundwater
HPP	Hydropower Plant
IHA	Indicators of Hydrologic Alteration
ISBN	International Standard Book Number
IWMI	International Water Management Institute
IWRMDP	Integrated Water Resources Management and Development Plan
JICA	Japan International Cooperation Agency
LU	Livestock Unit
LVB	Lake Victoria Basin
LVBC	Lake Victoria Basin Commission
MAM	March - May
MCM	Million Cubic Meter
MoAFSC	Ministry of Agriculture, Flood Security and Cooperatives
MoWI	Ministry of Water and Irrigation

NAM	Nedboer Afstroemning Model
NAWAPO	National Water Policy
NBI	Nile Basin Initiative
NBS	National Bureau of Statistics
NERC	Natural Environment Research Council
NIMP2002	National Irrigation Master Plan 2002
NIMP2018	National Irrigation Master Plan 2018
NIRC	National Irrigation Commission
NRW	Non-revenue Water
NWB	National Water Board
NWSDS	National Water Sector Development Strategy
OECD	Organization for Economic Co-operation and Development
PET	Potential Evapotranspiration
RSCB	Ruvuma and Southern Coast Basin
SADCC	Southern African Development Coordination Conference
SCWC	Sub-catchment Water Committee
SMS	Short Message Service
SON	September - November
SW	Surface Water
TANESCO	Tanzania Electric Supply Company Limited
TAWIRI	Tanzania Wildlife Research Institute
TMA	Tanzania Meteorological Agency
TOR	Terms of Reference
TPC	Tanzania Planting Company
UDSM	University of Dar es Salaam
UNDP	United Nations Development Programme
USAID	United States Agency for International Development
WB	World Bank
WEI	Water Exploitation Index
WMO	World Meteorological Organization
WR	Water Resources
WRD	Water Resources Division
WRMA	Water Resources Management Act
WSDP	Water Sector Development Programme
WUA	Water User Associations
WWF	World Wide Fund for Nature
ZIO	Zonal Irrigation Office

Chapter 1 Introduction

1.1 Objectives of Study on Water Resources

(1) Overview

With a mean annual rainfall of around 950 mm, Tanzania is rather considered to be dry country. Besides, their uneven spatial and temporal distribution coupled with the ever increasing pressure on the water resources due to population growth and development of various sectors still remains a big challenges to the sustainable management and development of country's water resources. In fact, conflict over water between water users and/or areas have been reported.

Water resources is thought to be one of the possible bottlenecks in irrigation development in the Revision of National Irrigation Master Plan (NIMP2018). In order to appropriately evaluate irrigation potential, it will be essential to understand water resources availability spatially and seasonally.

Tanzania mainland is divided into nine basins and further divided into 71 sub-basins as presented in Figure 1.3.1. Water resources assessment in the NIMP2018 is to be done on a monthly and sub-basin basis. Since the Integrated Water Resources Management and Development Plans (IWRMDP) have been formulated as described later, the NIMP2018 project will fully utilize those information for making water resources assessment required for the NIMP2018.

(2) Objectives of Study on Water Resources

The principal objective of the study on hydrology and water resources management is to quantitatively assess water resources available for irrigation purpose. The major works will be done through the following steps:

- Understanding of present conditions of the water resources sector through reviewing basic information on natural conditions, relevant policies and strategies, the existing plans, and so forth
- Re-generation of internal renewable water resources data including both surface water and groundwater by using the existing reports and publicly available hydrological data
- Confirmation of various sectors' water demands that were projected in the previous relevant studies and their basis for calculation
- Estimation of available water resources for irrigation purpose through monthly water balance calculation by sub-basin

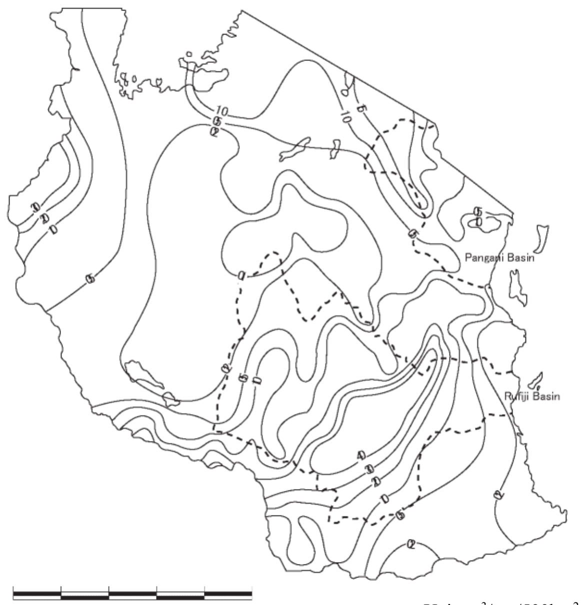
The details of work flow for assessing water resources is described in the section 3.1 "Method and Procedure" of this report.

1.2 Outline of the Water Resources Assessment in NIMP2002

(1) Major Terms of Assessment

The NIMP2002 study assessed water resources potential mainly from the following factors:

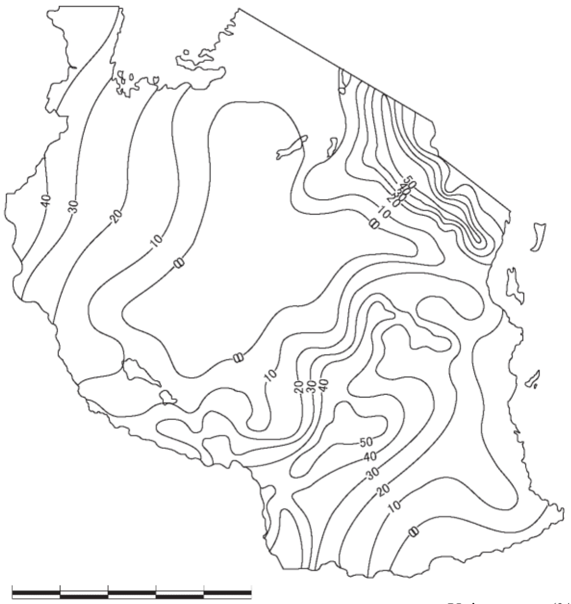
- Macroscopic water balance: the result showed sufficient water resources for water use at the time, which shares less than 1% of annual rainfall. However, seasonal fluctuation of water availability is a crucial factor.
- Specific runoff: specific runoff at gauging stations was calculated at annual mean level. The result identified a trend lower in central areas and southern part as presented in Figure 1.2.1.
- Flow regime: the flow duration curves were classified into three groups; (a) perennial river, (c) ephemeral river, and (b) intermittent river between (a) and (c). The regional distribution was formed with attention to the value of $Q_1(75)$ as presented in Figure 1.2.2.
- Groundwater: the general outline of groundwater potential was roughly estimated by using hydro-geological data at a national level.



Unit: m³/sec/500km²

Source: NIMP2002

Figure 1.2.1 Distribution of Specific Runoff



Unit: percent (%)

Source: NIMP2002

Figure 1.2.2 Distribution of $Q_1(75)$ in Flow Duration Curves

(2) Assessment Result

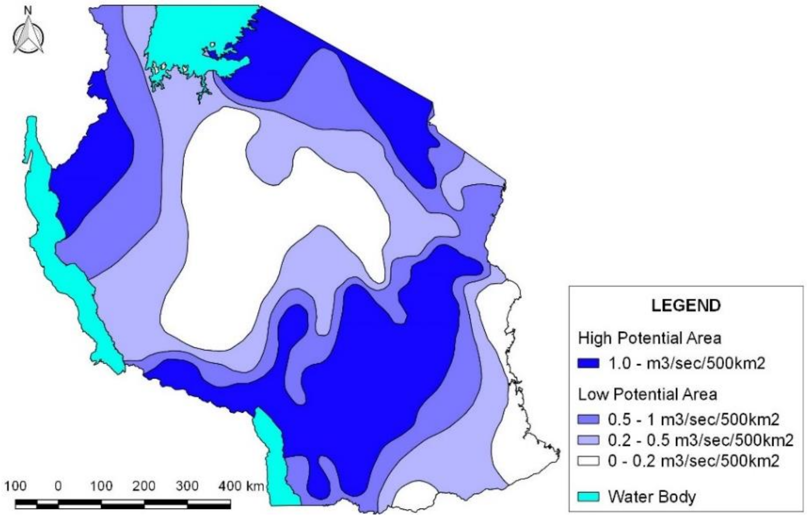
In the assessment of water resources potential, three points of view, namely, 1) quantitative potential of water in natural condition, 2) allowable water quantity under the artificial control and 3) seasonal steadiness of water availability, were taken into consideration. The assessment results are summarized in Table 1.2.1.

Table 1.2.1 Summary of Water Potential in Major Viewpoints

Viewpoints	Available Data	Identification of Water Potential	Status
1) Quantitative potential of water in natural condition	Map of Specific Runoff	Areas having the annual averaged specific discharge more than or equal 1.0 m³/sec/500km² could be identified as higher potential area.	To be considered largely
2) Allowable water under the artificial control	No information is available at the moment at the whole country basis.	It should be considered separately for scheme by scheme, by means of confirming individual water right.	To be referred if possible
3) Seasonal steadiness of water availability	Map of Distribution of $Q_1(75)$ in Flow Duration Curves	Areas having the value of $Q_1(75)$ more than or equal 10% could be identified as higher potential area for perennial irrigation.	To be considered supplementary

Source: NIMP2002

The water resources potential estimated in the NIMP2002 is presented in Figure 1.2.3.

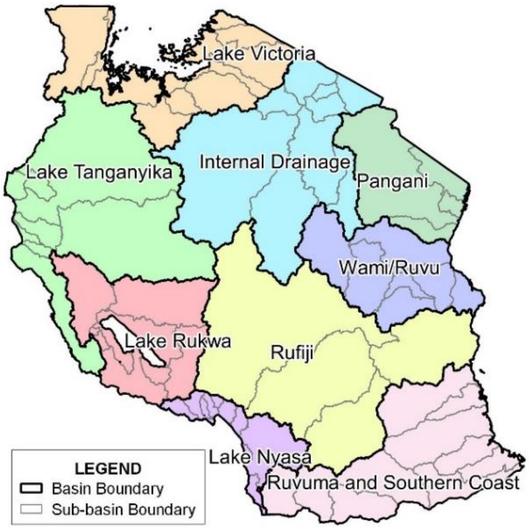


Source: Prepared by JICA Project Team based on NIMP2002

Figure 1.2.3 Water Resources Potential Estimated in NIMP2002

1.3 Basin and Sub-basin Boundary

The mainland of Tanzania is divided into nine basins and further divided into 71 sub-basins as presented in Figure 1.3.1. Basic information on the nine basins are summarized in Table 1.3.1. Since water resources management and development are undertaken on the basis of river basins, the study on water resources in the NIMP2018 is also made basin-wise and sub-basin-wise. The catchment areas of respective sub-basins to be used in this study are based on the previous study reports, which are described in the sub-section 2.3.1 in more detail.



Source: JICA Project Team based on Information by MoWI

Figure 1.3.1 Basin and Sub-basin Boundaries

Table 1.3.1 Basic Information of Nine Basins

No.	Basin Name	Basin Code*1	Catchment Area (km^2)*2	Nos. of Sub-basin	Drainage System
I	Pangani	PG	59,102	4	Indian Ocean
II	Wami / Ruvu	WR	66,295	7	Indian Ocean
III	Rufiji	RF	183,791	4	Indian Ocean
IV	Ruvuma and Southern Coast*3	RV	105,582	10	Indian Ocean
V	Lake Nyasa	LN	27,594	10	Indian Ocean
VI	Lake Rukwa	LR	74,965	7	Endorheic basin
VII	Lake Tanganyika	LT	149,500	7	Atlantic Ocean
VIII	Lake Victoria	LV	85,630	13	Mediterranean Sea
IX	Internal Drainage	ID	143,100	9	Endorheic basin
---	Total	---	895,559	71	---

*Notes: *1. Basin code used in this report is provided by the NIMP2018 study and it is not an official code.*
**2. Catchment areas are based on the respective IWRMDPs and LVBC reports described in the sub-section 2.3.1. It is noted that the total of catchment areas is different from the mainland area*
**3. The Ruvuma and Southern Coast basin is simply called as "Ruvuma basin" hereafter in this report.*
Source: Prepared by JICA Project Team based on Information provided by MoWI

1.4 Discussions with Relevant Organizations

In the course of formulating the NIMP2018, the JICA Project Team had a lot of discussions with the relevant organizations so as to avoid any discrepancies in the policies and strategies among different sectors. The major discussions on the water resources sector are summarized in Table 1.4.1 below.

Table 1.4.1 Major Discussions with Relevant Organizations

No.	Date	Organization	Main Points of Discussion
1	Oct 17, 2016	WRD, MoWI	・WRD will cooperate and is able to provide available data and information. ・WRD is willing to be involved in the NIMP2018 from a planning process stage. ・Water use in some parts is reliant on groundwater. WRD requested JICA Project Team to consider groundwater use even for large-scale irrigation.
2	Oct 20, 2016	WRD, MoWI	・Guideline on environmental flow requirement (EFR) is currently being prepared. ・Although there is no standard method before the approval of guideline, EFR has been considered 10% to 20% of minimum monthly discharge conventionally.
3	Oct 31, 2016	WRD, MoWI	・There is no large difference in the TORs for IWRMDP studies, while detail methods are different depending on the consultants. ・Discharge required for hydropower can be considered 100% return in water balance calculation. However, particular attention should be given to the New Pangani Falls HPP, which is located near river mouth.
4	Nov 7, 2016	WRD, MoWI	・The catchment areas (km^2) mentioned in the IWRMDP reports can be regarded as official figures.
5	Nov 18, 2016	DWRE, UDSM	・There is no clear methodology to determine the safe yield of groundwater. It's better to make assumption such as certain percent of groundwater recharge.
6	Mar 10, 2017	WRD, MoWI	・Findings from field visits were reported by JICA Project Team. WRD understood the situation and requested JICA Project Team to propose how to solve the issues related to water resources management at basin level.
7	Mar 28, 2017	All 9 BWOs and WRD, MoWI	・The IWRMDPs were formulated by reflecting opinions and information from irrigation-related offices including zone and district offices. ・MoWI consider that it is not desirable to present two different figures in terms of irrigation water between IWRMDP and NIMP2018. Therefore, NIMP2018 needs to comply with the water allocation determined in the IWRMDPs.
8	Apr 12, 2017	WRD, MoWI	・Available water resources for irrigation will be calculable by JICA Project Team. However, it would be difficult to change the determined water allocation because water resources should be utilized impartially between sectors. ・If there are plenty of available water resources in a basin, EFR could be reviewed and modified so as to utilize the water resources for other purposes. However, it is not easy to modify EFR in the NIMP2018 study considering that IWRMDPs made specific study for EFR in more details with enough time. Unless absolutely necessary, it will be better to keep the EFR unchanged.
9	May 17, 2017	NIRC	・NIRC requested JICA Project Team to positively include the effect of water storages into the water balance study. There are almost 120 reservoirs managed by NIRC. ・NIRC proposed an idea to utilize transboundary lake water for irrigation purpose, while NIRC understands the necessity of agreement among relevant countries.
10	May 18, 2017	WRD, MoWI	・Transboundary water use can be examined from a technical view point. It is not necessary to consider political issue in the NIMP2018 study.
11	Aug 16, 2017	WRD, MoWI	・MoWI understood that JICA Project Team estimated potential water for irrigation as well as allocated water for irrigation. ・MoWI understood and generally agreed to the recommendations related to water resource, which will be describe in the final chapter of Final Report.

Notes: WRD = Water Resources Division, DWRE = Department of Water Resources Engineering, UDSM = University of Dar es Salaam, BWO = Basin Water Office
Source: JICA Project Team

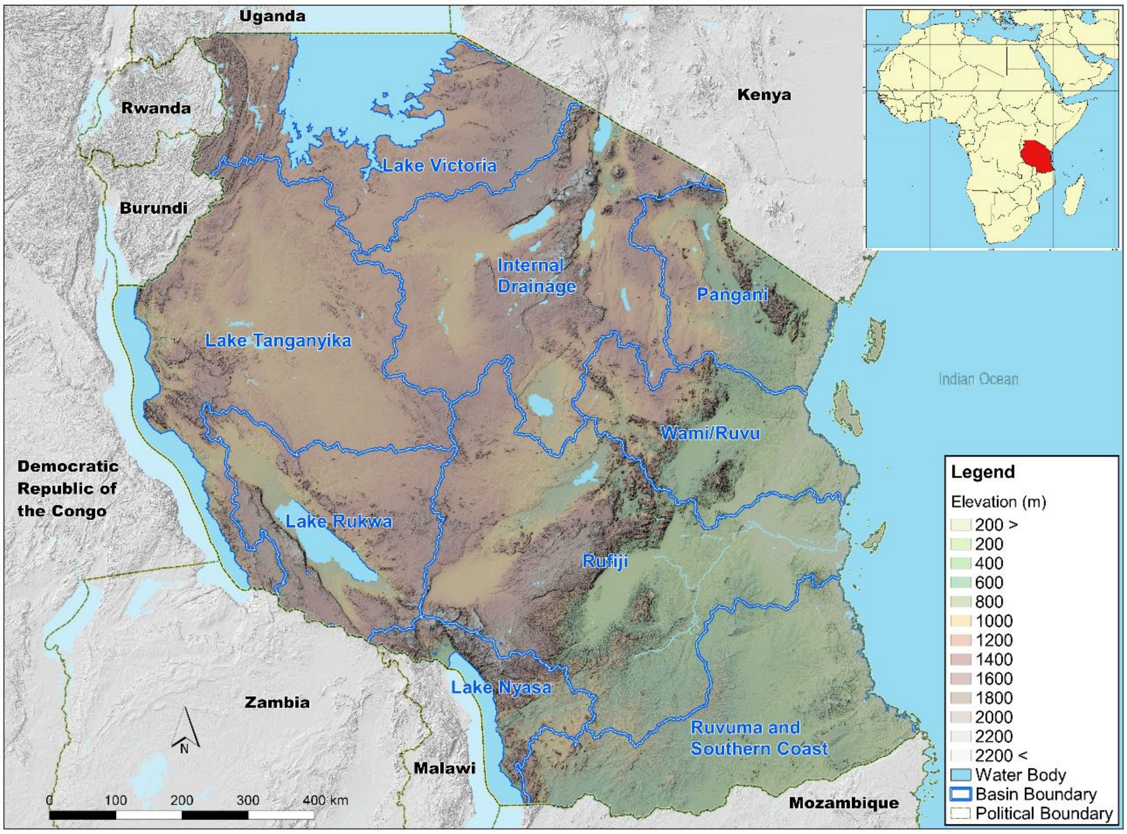
Chapter 2 Present Conditions of Water Resources Sector

2.1 Natural Conditions

2.1.1 Geographical Features

Tanzania is located just south of the Equator, lying mostly between latitudes 1° and 12°S, and longitudes 29° and 41°E. The area[1] of mainland Tanzania is 945,100 km^2. Its land area is 883,600 km^2 and an area of inland water bodies is 61,500 km^2. Tanzania shares borders with Kenya and Uganda in the north; Rwanda, Burundi and Democratic Republic of Congo in the west; Zambia and Malawi in the south-west, Mozambique in the South; and Indian Ocean in the East.

Tanzania has complex topographical features extending from a narrow coastal belt of the western Indian Ocean with sandy beaches to an extensive plateau with altitude ranging from 1,000 to 2,000 m above mean sea level. The plateau is fringed by narrow belts of highlands, including Mt. Kilimanjaro (5,895m), the highest mountain in Africa and other mountain ranges. Tanzania has several fresh water bodies, including Lake Victoria, the largest in Africa; Lake Tanganyika, the longest and deepest in Africa; and Lake Nyasa. Figure 2.1.1 below presents topographic map depicting the above features.



Source: JICA Project Team based on the SRTM data

Figure 2.1.1 Topographic Map with Basin Boundaries

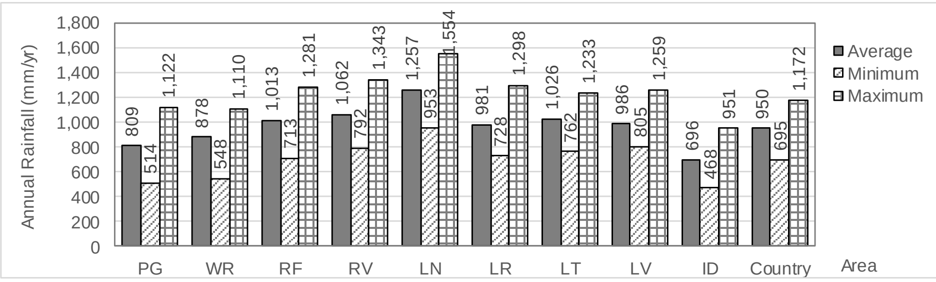
[1] Tanzania in Figures 2015 (National Bureau of Statistics, January 2016)

2.1.2 Hydrometeorological Features

(1) Rainfall

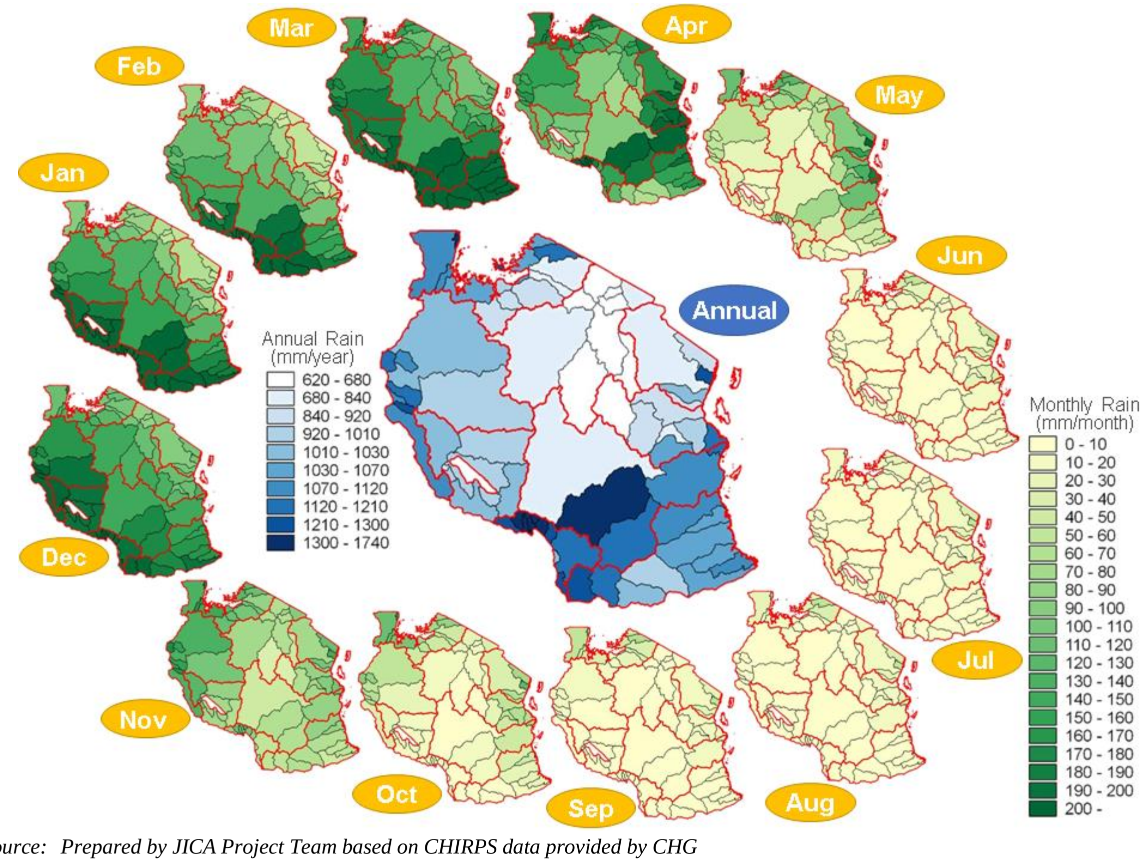
According to the Tanzania Meteorological Agency (TMA)[2], the climate of Tanzania is characterized by two main rain seasons, namely the long rains (*Masika*) that fall from mid-March to end-May and the short rains (*Vuli*) that begin in mid-October and continues to early December.

Figure 2.1.2 presents annual mean rainfall for 30 years from 1981 to 2010 by basin, while Figure 2.1.3 presents annual and monthly mean rainfall for the same period by sub-basin. The highest rainfall is observed in the month of March with the national average of 172 mm/month. In addition to the seasonal distribution, the both Figure 2.1.2 and Figure 2.1.3 show spatial unevenness. The Western Shore Streams sub-basin of Lake Victoria basin and the Kiwira, Rumakali, Lufirio and Mbala sub-basins of Lake Nyasa basin receive relatively high rainfall of more than 1,500 mm/yr, though national average is 950 mm/yr.



Source: Prepared by JICA Project Team based on CHIRPS data provided by CHG

Figure 2.1.2 Annual Rainfall Data by Basin (1981-2010)



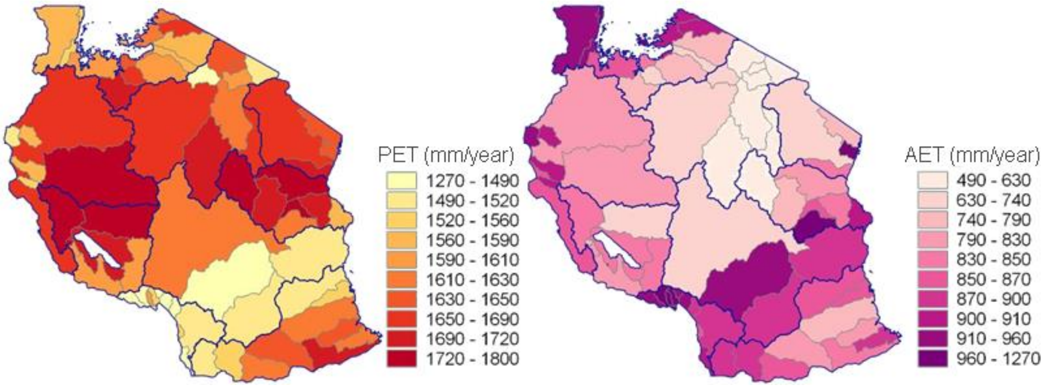
Source: Prepared by JICA Project Team based on CHIRPS data provided by CHG

Figure 2.1.3 Annual and Monthly Rainfall by Sub-basin (1981-2010)

[2] Climate Change Projection for Tanzania, ISBN 978-9987-9981-0-5. pp.2 (Tanzania Meteorological Agency)

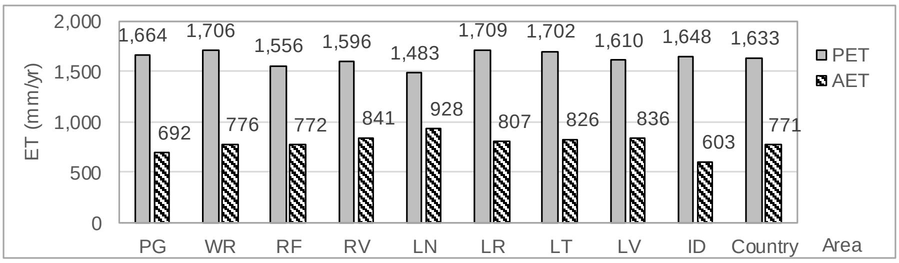
(2) Evapotranspiration

Figure 2.1.4 presents potential evapotranspiration (PET) and actual evapotranspiration (AET), which were analyzed by CGIAR[3]-CSI[4]. The national averages of PET and AET are 1,633 mm/yr and 771 mm/yr, respectively as summarized in Figure 2.1.5. Relatively high PET is observed in the Wami/Ruvu, Lake Rukwa and Lake Tanganyika basins, where air temperature is higher. On the other hand, higher AET is observed in the Rufiji, Lake Nyasa and Lake Victoria basins, where rainfall is higher.



Source: Prepared by JICA Project Team based on PET and AET data provided by CGIAR-CSI

Figure 2.1.4 Annual PET and AET by Sub-basin (1950-2000)



Source: Prepared by JICA Project Team based on PET and AET data provided by CGIAR-CSI

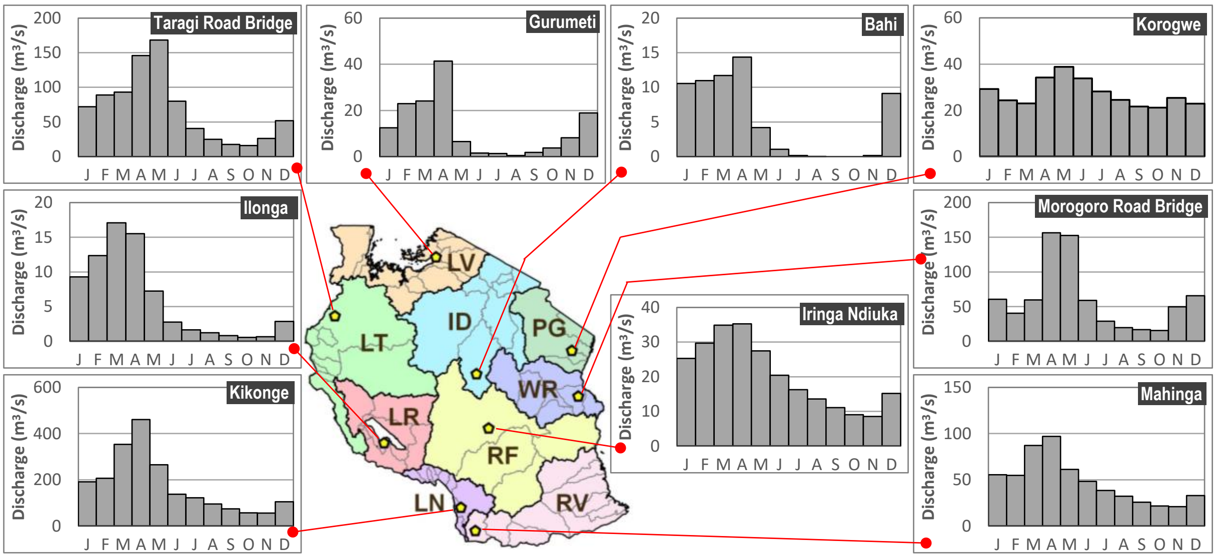
Figure 2.1.5 Annual PET and AET Data by Basin (1950-2000)

(3) Hydrology

Figure 2.1.6 presents mean monthly river discharge at some selected stations representing the respective nine basins. Basic information of the selected stations are summarized in Table 2.1.1. Although the data are a bit old and actual hydrological phenomena usually differ depending on the locations even in the same basin, the hydrographs below reasonably represent hydrological features.

In the areas where rainfall is small, rivers dry up over a few months in the dry season as shown in the graphs of Bahi and Gurumeti gauging stations. Although the Lake Rukwa basin receive moderate rainfall, the discharge at the Ilonga station rapidly decline in the dry season due to its small catchment area and steep slope. On the other hand, the Iringa Ndiuka station in Rufiji basin and Mahinga station in Ruvuma basin have rather small differences in river flows between the peak rainy season and dry season due to their gentle slopes of rivers and relatively longer rainy period. Discharge at the Korogwe station seem to be relatively steady throughout the year. This is thought to be due to the Nyumba ya Mungu hydropower plant located upstream, which is a reservoir type with a plant discharge of 42.5 m^3/s.

[3] Consultative Group on International Agricultural Research (CGIAR)
[4] Consortium for Spatial Information (CSI)



Source: *Prepared by JICA Project Team based on the discharge data provided by GRDC (Global Runoff Data Centre)*

Figure 2.1.6 Mean Monthly Discharge at Selected Stations

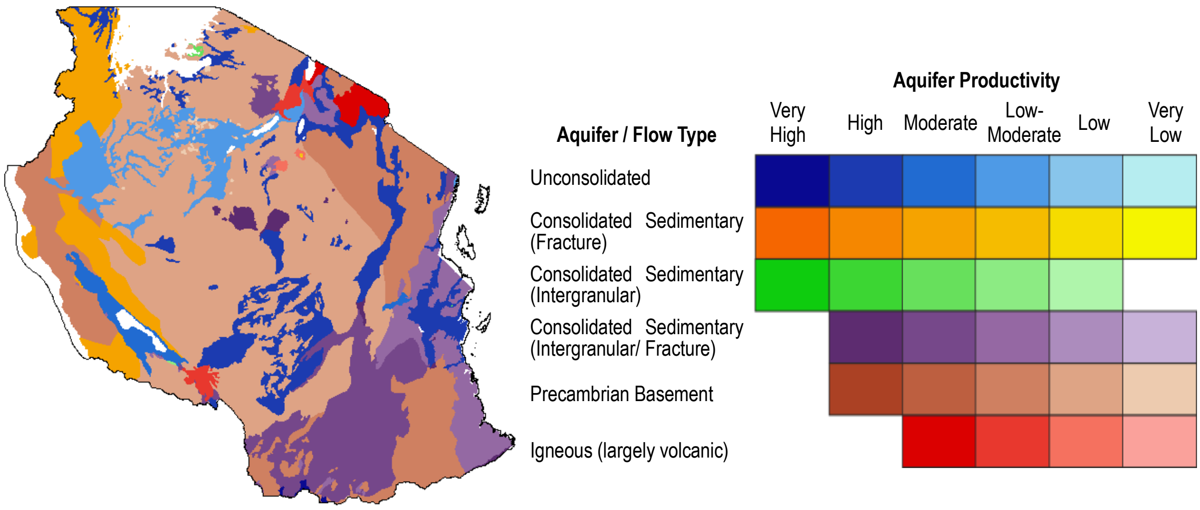
Table 2.1.1 Basic Information of the Selected Gauging Stations

No.	Basin	Sub-basin	Station Name	Catchment Area (km^2)	Mean Discharge (m^3/s)	Mean Discharge (mm/yr)	Period of Used Data
I	Pangani	Pangani	Korogwe	25,110	27.5	35	1959-1977
II	Wami / Ruvu	Lower Ruvu	Morogoro Road Bridge	15,916	57.9	115	1958-1989
III	Rufiji	Great Ruaha	Iringa Ndiuka	3,281	20.5	197	1954-1985
IV	Ruvuma	Upper Ruvuma	Mahinga	4,903	49.3	317	1971-1985
V	Lake Nyasa	Ruhuhu	Kikonge	14,161	179.1	399	1971-1978
VI	Lake Rukwa	Lake Shores	Ilonga	1,119	6.1	172	1956-1989
VII	Lake Tanganyika	Malagarasi	Taragi Road Bridge	8,525	68.0	252	1971-1979
VIII	Lake Victoria	Grumeti	Gurumeti	13,233	11.5	27	1970-1979
IX	Internal Drainage	Bahi Manyoni	Bahi	11,400	5.3	15	1960-1984

Source: *GRDC*

(4) Hydrogeology

Figure 2.1.7 presents the hydrogeology map showing a simplified overview of the type and productivity of the main aquifers in Tanzania.



Source: *Based upon mapping provided by British Geological Survey © NERC 2012. All rights reserved.*

Figure 2.1.7 Groundwater Productivity Map of Tanzania

2.1.3 Macroscopic Water Balance in the Country

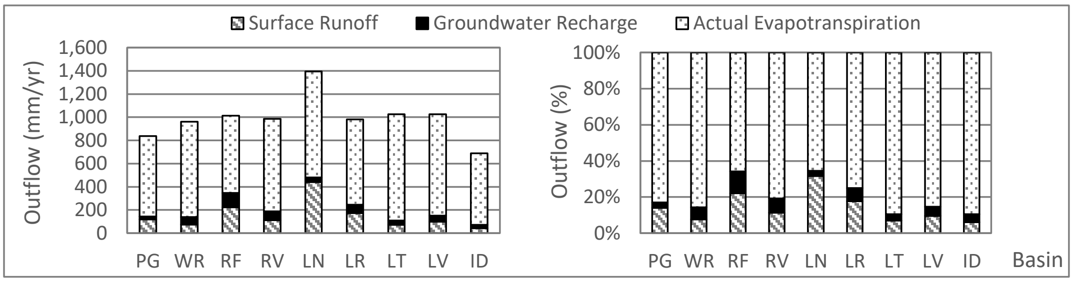
Prior to assessment of water resources potential, it is essential to understand a general feature of water balance in the entire Tanzania. In considering a hydrological cycle, inflow is defined as rainfall, while outflow is divided into surface runoff, groundwater recharge and actual evapotranspiration.

As introduced in the section 1.1 above, the IWRMDPs for the respective basins have already estimated surface runoff and groundwater recharge based on rainfall, though the details of estimation are discussed in the section 3.2 later. In this study, actual evapotranspiration was computed by deducting surface runoff and groundwater recharge from rainfall. The result is summarized in Table 2.1.2 and Figure 2.1.8.

Table 2.1.2 Macroscopic Water Balance by Basin

No.	Basin	Catchment Area (km^2)	Inflow (mm/yr)	Outflow (mm/yr)		
			Rainfall*1	Surface Runoff*2	Groundwater Recharge*3	Actual Evapo-transpiration*4
I	Pangani	59,102	838	118	25	695
II	Wami / Ruvu	66,295	961	73	64	823
III	Rufiji	183,791	1,013	223	123	667
IV	Ruvuma	105,582	987	111	79	797
V	Lake Nyasa	27,594	1,394	442	39	913
VI	Lake Rukwa	74,965	981	173	71	737
VII	Lake Tanganyika	149,500	1,026	71	37	918
VIII	Lake Victoria	85,630	1,027	99	52	877
IX	Internal Drainage	143,100	689	42	31	616
Total (km^2) / Ave. (mm/yr)		895,559	955	128	64	763

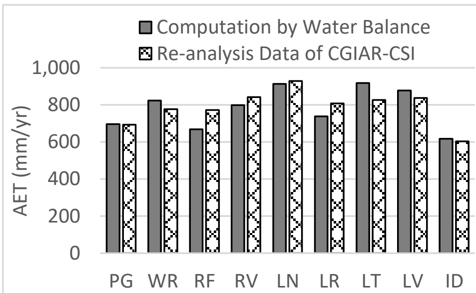
*Notes: *1. Rainfall is provided by the IWRMDP reports and LVBC report (or CHIRPS (CHG) data for No. III, VI and VII).*
**2. Surface runoff is 2015 data presented in the IWRMDP reports and LVBC report. Details are described in Sub-section 3.2.1.*
**3. Groundwater recharge is provided by the IWRMDP reports and LVBC report. Details are described in Sub-section 3.2.2.*
**4. AET is estimated by deducting surface runoff and groundwater recharge from rainfall.*
Source: JICA Project Team based on the above-mentioned data



Note: The left-side figure is shown in mm/yr and the right-side figure is shown in percentage (%).
Source: JICA Project Team based on the data mentioned in Table 2.1.2 above

Figure 2.1.8 Macroscopic Water Balance by Basin

The actual evapotranspiration estimated above was compared with the re-analysis data provided by different source for validation purpose. As seen in Figure 2.1.9, the differences between two sources are less than 10% except for the Rufiji basin, where the difference is 16%. Given the limitations of accuracy in estimating groundwater recharge and actual evapotranspiration, the result seems to fall within reasonable range.



Source: AET data presented in Figure 2.1.4

Figure 2.1.9 Comparison of AET

2.2 Relevant Policies and Strategy

(1) The Tanzania Development Vision 2025

The Tanzania Development Vision 2025 aims at achieving a high quality livelihood for its people, attaining good governance through the rule of law, and developing a strong and competitive economy.

Water is positioned as one of the most important agents to enable the country to achieve the objectives of both social and economic development, such as eradicating poverty, attaining water and food security, sustaining biodiversity and sensitive ecosystems.

(2) National Water Policy

The first National Water Policy was developed in 1991. In response to many changes in circumstances surrounding the water sector thereafter, the Government revised the Policy in 2002 with the main objective of developing a comprehensive framework for sustainable development and management of the Nation's water resources.

The National Water Policy 2002 (NAWAPO 2002) states the following key considerations, which will guide the NIMP2018 study, in terms of water use.

> In planning water uses, water for basic human needs in adequate quantity and acceptable quality will receive highest priority. Water for the environment to protect the eco- systems that underpin our water resources, now and in the future will attain second priority and will be reserved. Other uses will be subject to social and economic criteria, which will be reviewed from time to time. Utilization of trans-boundary water resources will be based on the principle of equity, right and rationality in accordance with agreements among the riparian state, and by respecting the principle of international obligations on trans- boundary water resource.

(3) National Water Sector Development Strategy 2006-2015

The National Water Sector Development Strategy 2006-2015 (NWSDS) sets out how the NAWAPO 2002 will be implemented to achieve targets.

NWSDS has been developed to support re-alignment of the water related aspects of other key sectoral policies (for example, energy, irrigation, industry, mining, and the environment) with NAWAPO, and to provide a focus on specific roles of the various actors through clearly defining roles and responsibilities and hence the removal of duplications and omissions. NWSDS contains 39 strategic statements covering the full range of issues arising from NAWAPO, and other policies and strategies of the Government.

The institutional framework set out by NWSDS provides effective and efficient integrated water resources management and development, and clearly identifies the roles and responsibilities of the relevant organizations and stakeholders at all levels, such as National Water Board (NWB), Basin Water Boards (BWB), Catchment Water Committees (CWC), and Water User Associations (WUA).

Although the NWSDS had expired in 2015, the preparation of NWSDS for the subsequent period has not been commenced as of May 2017, according to the MoWI.

(4) Water Sector Development Programme 2006-2025

The Water Sector Development Programme 2006-2025 (WSDP) follows a Sector Wide Approach to Planning (SWAP) with an overall objective of strengthening sector institutions for integrated water resources management and improve access to water supply and sanitation services.

Because of the long-term nature of the Programme, its implementation is done in phases of five years each. As a result of the component 1 (water resources management) during the phase I, the National Water Board and Basin Water Boards have been established and are operational in accordance to the Water Resources Management Act of 2009. Due to the extension of the phase I period, currently the phase II is being implemented for the period 2014/15-2018/19.

The WSDP phase II has five components, namely: 1) Water Resources Management; 2) Rural Water Supply and Sanitation; 3) Urban Water Supply and Sanitation; 4) Sanitation and Hygiene; and 5) Programme Delivery Support. As part of the component 1, the Integrated Water Resources Management and Development Plans (IWRMDPs) for the respective nine basins are to be formulated.

(5) The Water Resources Management Act, 2009

In order to provide the enabling legislative framework for implementing NAWAPO and NWSDS, the Water Resources Management Act No.11 of 2009 (WRMA) was enacted in 2009. The water sector in the mainland of Tanzania is presently governed by the WRMA and the Water Supply and Sanitation Act No.12 of 2009.

The WRMA provides new legislative framework in order to realize the integrated water resources management and development with the initiative of administratively and financially autonomous BWBs and participation of water users through WUAs and CWCs/SCWCs. The WRMA gives powers to BWB to regulate water use and pollution control, to set the Integrated Water Resources Management and Development Plan, to collect water user fees, to promote establishment of lower level organizations for water resources management at Catchment/ Sub-Catchment and community levels, and to manage conflict resolutions over water use.

2.3 Existing Plans and Studies

2.3.1 IWRMDP

(1) Basic Information on IWRMDP Formulation

As part of the Water Sector Development Programme (WSDP) for the period 2006-2025, the Ministry of Water and Irrigation (MoWI) has been formulating the Integrated Water Resources Management and Development Plans (IWRMDP) for the respective nine basins with a planning horizon of 2035.

Although consultancy services for the IWRMDP formulation are executed separately for the respective basins, the common objective of the services is to develop a basin-wide IWRMDP by:

i) assessing water resources (both surface and groundwater) with climate change effect and identifying current and future water demands of different sectors,
ii) identifying gaps between the water resources and future water demands,

iii) formulating/evaluating alternatives that will meet those demands,
iv) recommending specific water resources development and management options to meet the specific identified demands,
v) developing a sound and environmentally sustainable IWRMDP,
vi) preparing an implementation strategy including financing options, and action plan,
vii) building capacity of the Basin Water Board in preparing an IWRMDP, and in undertaking periodic reviews and updating of the plan, and
viii) enabling the stakeholders to participate fully in the planning and management processes.

As seen above, the IWRMDP is considered the latest and comprehensive water resources management and development plan. Therefore, the respective IWRMDPs are expected to provide quantitatively and qualitatively significant inputs to the NIMP2018. Prior to incorporating the IWRMDPs into the NIMP2018, the result of IWRMDP studies will be reviewed and adjusted as needed.

(2) Status of IWRMDP Formulation

As summarized in Table 2.3.1, water resources assessment and/or formulation of IWRMDP for three basins have not yet been completed. Consultancy services for formulating IWRMDP for the Wami/Ruvu basin commenced in July 2017 and is scheduled to be completed in 16 months. In case of the Lake Victoria basin, even assessment study has not commenced yet. However, the Lake Victoria Basin Commission (LVBC) conducted a study for Lake Victoria Basin Water Resources Management Plan - Phase 1 in 2014 (hereinafter called the LVBC study). The study assessed available water resources and projected future water demand by sub-basin for the entire catchment area covering the Lake Victoria basin. The NIMP2018 utilizes the LVBC study instead of IWRMDP for the Lake Victoria basin.

Table 2.3.1 Status of IWRMDP Formulation in Nine Basins

No.		I	II	III	IV	V	VI	VII	VIII	IX
Basin Name (Basin Code)		Pangani (PG)	Wami/ Ruvu (WR)	Rufiji (RF)	Ruvuma (RV)	Lake Nyasa (LN)	Lake Rukwa (LR)	Lake Tan-ganyika (LT)	Lake Victoria (LV)	Internal Drainage (ID)
Status (Fund Source*)	WR Assessment	Complete (WB)	Complete (JICA)	Complete (WB)	Complete (WB)	Complete (WB)	Complete (WB)	Complete (WB)	Not yet (GoT)	Complete (WB)
	Formulation of IWRMDP	Not yet (TBD)	On-going (WB)	Complete (WB)	Complete (WB)	Complete (WB)	Complete (WB)	Complete (WB)	Not yet (GoT)	Complete (WB)

Notes: WR: Water Resources, WB: World Bank, JICA: Japan International Cooperation Agency, GoT: Government of Tanzania, TBD: To be determined
Source: JICA Project Team based on interview with MoWI

The available reports for the NIMP2018 study as of August 2017 are summarized in Table 2.3.2. Although the table presents only the latest stage of reports, the other previous stages including some inception and interim reports are also available.

Table 2.3.2 Status of Available Reports for NIMP2018

No.	Basin	Title of Report	Published in
I	PG	Interim Report 2 on IWRMDP for Pangani Basin	Dec 2013
II	WR	Final Report on Water Resources Management and Development in Wami/Ruvu Basin[*1]	Nov 2013
III	RF	Final Report on IWRMDP for Rufiji Basin	Dec 2015
IV	RV	Final Report on IWRMDP for Ruvuma and Southern Coast Basin	Jan 2015
V	LN	Final Report on IWRMDP for Lake Nyasa Basin	Jun 2015

No.	Basin	Title of Report	Published in
VI	LR	Final Report on IWRMDP for Lake Rukwa Basin	May 2016
VII	LT	Final Report on IWRMDP for Lake Tanganyika Basin	Jun 2015
VIII	LV	Final Report on Lake Victoria Basin Water Resources Management Plan Phase 1*2	May 2014
IX	ID	Final Report on IWRMDP for Internal Drainage Basin	Mar 2015

Note: **1. The tile of report is "Final Report", however the MoWI regards it as only an assessment report because the study did not assess water resources with future climate change.*
**2. This report is not IWRMDP to be prepared under WSDP, however included in the list as an available study report.*
Source: *JICA Project Team based on interview with MoWI*

(3) Assessment of Climate Change Impact

The impact of climate change on hydrometeorological environment have been assessed in the IWRMDP studies except for the Wami/Ruvu and Lake Victoria basins. Assessment for these two basins will be made in formulating the basin IWRMDPs, which have not yet been prepared. The results of assessment are mentioned in the sub-section 3.2.1 later.

(4) Water Balance Method by Basin

The IWRMDPs for the nine basins have been/ will be prepared by different consultant firms after much discussion with the respective Basin Water Offices (BWO). Although the TORs for their consulting services are similar among the basins, the respective firms adopted different methodologies. There has been no document that compares or summarizes the differences in their methods. It is necessary to look over the study results horizontally in the NIMP2018 considering its target area of entire Tanzania mainland, while due consideration of regional characteristics is also important in water resources planning. The basic conditions in terms of input for water balance calculation are summarized in Table 2.3.3.

Table 2.3.3 Basic Conditions of Water Balance Calculation

(No.) Basin Code	Water Balance Calculation Basis	Supply Side						Demand Side (sectors considered in balance calculation)								
		Surface Runoff					Ground-water									
		Estimation*1			Reliability of Water Utilization	Period of Used Hydro Data	Consi-dered in Water Balance	Domestic & Institute	Industry & Mining	Irrigation	Livestock	Wildlife	Tourism	Fisheries & Aquaculture	Hydropower	Environment Flow
		2015	2025	2035												
(I) PG	Monthly long-term*2	O	O	O	Mean runoff	1952-2011	Yes	✓	✓	✓	✓	✓	✓	---	---	✓
(II) WR	Monthly (selected year)	O	X	X	1/10 drought year runoff	1951-1980	Yes	✓	✓	✓	✓	---	---	✓	---	✓
(III) RF	Monthly long-term	O	Gr	Gr	Mean runoff	1950-2011	Yes	✓	✓	✓	✓	---	---	---	✓*3	✓
(IV) RV	Monthly long-term*2	O	O	O	Mean runoff / 80% dependable	1959-1994	Yes	✓	---	✓	✓	✓	---	---	---	✓
(V) LN	Monthly (mean value)	O	O	O	Mean runoff	1950-2012	Yes	✓	✓	✓	✓	---	---	---	✓*3	✓
(VI) LR	Monthly long-term	O	Gr	Gr	Mean runoff	1956-2013	No	✓	✓	✓	✓	---	---	---	---	✓
(VII) LT	Annual	O	O	O	Mean runoff	1974-2002	Yes	✓	✓	✓	✓	✓	✓	---	✓	✓

(No.) Basin Code	Water Balance Calculation Basis	Supply Side							Demand Side (sectors considered in balance calculation)								
		Surface Runoff					Groundwater										
		Estimation*1			Reliability of Water Utilization	Period of Used Hydro Data	Consi-dered in Water Balance	Domestic & Institute	Industry & Mining	Irrigation	Livestock	Wildlife	Tourism	Fisheries & Aquaculture	Hydropower	Environment Flow
		2015	2025	2035												
(VIII) LV	Annual	O	X	X	Mean runoff	1967-2013	No	✓	✓	✓	✓	---	---	✓	---	---
(IX) ID	Monthly long-term	O	O	O	Mean runoff	1953-1999	Yes	✓	✓	✓	✓	✓	✓	✓	✓*3	✓

Notes: **1. The symbols "O" / "X" / "Gr" denote "estimated" / "not estimated" / "presented in a form of hydrograph", respectively.*
**2. Although the reports do not clearly mention, it is presumably long-term basis computation.*
**3. Although hydropower water demand is estimated, it is treated as non-consumptive water in water balance calculation.*
Source: *Summarized by JICA Project Team based on the LVBC study and IWRMDPs reports*

Besides, methods of water balance calculation by each basin particularly in terms of how to incorporate groundwater use into the entire water use are briefed as below:

i) <u>Pangani Basin</u>:
MIKE BASIN model directly computed surface flow leaving catchment/ sub-basin after all demands have been catered for and after taking into account sustainable groundwater availability as part of supply side factors. Then, the estimated mean monthly surface flow was checked whether or not the flow satisfy the environmental flow requirement (EFR).

ii) <u>Wami/Ruvu Basin</u>:
Although a runoff simulation model was developed in the study, it was concluded that the model doesn't have enough accuracy to formulate the concrete plan. Therefore, the actual observed discharge in a past dry year was used for formulating the plan.
Water source (surface water or groundwater) was classified and assigned to each water use in estimating water demand. When water deficit was found in monthly balance calculation of surface water, additional groundwater development was considered as part of measures.

iii) <u>Rufiji Basin</u>:
The rainfall-runoff simulation was made by a Sacramento type model. The water balance simulation supplied only by surface water indicated that the surface water may be inadequate to meet future demands. Then, more detailed assessments showed that a balanced groundwater - surface water resources management strategy is viable.

iv) <u>Ruvuma Basin</u>:
The RSCB-BWB-DSS (Ruvuma and Southern Coast Basin Water Board decision support system) model comprises of two fundamental components - water resources assessment and water demand assessment. The model produced the output including surface water resources availability, surface water demand, groundwater use and percentage to groundwater availability, hydropower generation, surface water deficit or surplus, and groundwater stress.

v) <u>Lake Nyasa Basin</u>:
The NAM (Nedboer Afstroemning Model) model, which is part of the MIKE BASIN software package, was adopted as the rainfall-runoff model.
The assessment by comparing monthly water demand and 0.2 percentile mean monthly runoff

(80% exceedance) revealed that the monthly demand will exceed the available surface water for the year 2035 particularly in the dry season in three sub-basins. Accordingly, groundwater was supplementally allocated up to a ceiling of ASY (annual safe yield).

vi) Lake Rukwa Basin:
The rainfall-runoff simulation was made by a Sacramento type model. On the other hand, groundwater resources was not considered in the water balance study. According to the study report (Interim Report II, volume II, chapter 4), since there are no information on surface-groundwater interactions, monthly water balance was computed as the difference between the river flow and estimated water demand.

vii) Lake Tanganyika Basin:
MIKE BASIN model was developed for the major four sub-basins. None of the other three sub-basins were modelled due to the limitation of flow data or their small catchment areas.
Water balance calculation was made by comparing annual water demand and annual available surface water and groundwater resources. Considering the uncertainties in ground water availability, allocation of groundwater and surface water was simply determined as 20% from groundwater and 80% from surface water.

viii) Lake Victoria Basin:
The rainfall-runoff model used in the study was basically the GR2M model, which is a monthly time step conceptual model. When the results are inaccurate, NAM model was also used.
Groundwater recharge estimates are provided in the study report to a limited extent. Water balance calculation was made by comparing annual water demand and annual surface runoff.

ix) Internal Drainage Basin:
MIKE HYDRO model with 41-year monthly time step runoff data was used. The model also incorporated abstraction from groundwater resources. After a series of scenario evaluation, water allocation was determined as almost 79% demand coverage.

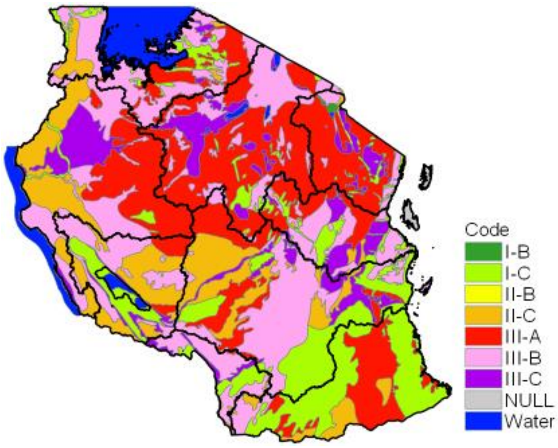
2.3.2 Other Studies related to Water Resources

(1) Groundwater

Aside from the groundwater assessment made by the respective IWRMDP studies, some information on country-wise groundwater assessments were obtained from the previous studies as follows:

(a) Groundwater Productivity Map, Sub-saharan Africa Hydrological Assessment

Figure 2.3.1 shows distribution of productive aquifer in the mainland of Tanzania. Most of northern parts are low to fairly productive formations. On the other hand, highly and moderately productive aquifers are distributed mainly in southern part of the country.



Code	Aquifer Productivity	Amount
I-B	Highly productive aquifer	10-50 l/s
I-C	Moderately productive aquifer	0.1-15 l/s
II-B	Moderately productive aquifer	5-20 l/s
II-C	Locally productive aquifer	0.1-10 l/s
III-A	Low to fairly productive aquifer	> 1 l/s and < 4 l/s
III-B	Low yielding formations	0-1 l/s
III-C	Unproductive aquifer	0 l/s
Null	No data	---
Water	Water body	---

Source: Sub-saharan Africa Hydrological Assessment (SADCC Countries), World Bank and UNDP
Note: The original map provided in a Tiff format was digitized and colored by JICA Project Team.

Figure 2.3.1 Groundwater Productivity Map

(b) Assessment of Groundwater Availability and Its Current and Potential Use and Impacts

IWMI (2010)[5] assesses groundwater availability, potential use and impacts in Tanzania by reviewing existing reports and data. According to the report, groundwater has not been extensively used for irrigation largely due to the following reasons:

- Detailed analysis on groundwater irrigation potential nation-wide has not been thoroughly explored. Most of the estimates are based on surface water information.
- Tanzania still has enough areas potential for irrigation using surface water resources.
- There is scant information on the potential of aquifers and yields of individual boreholes.
- Limited groundwater resources management plans
- The majority of people in the community have an inadequate understanding of groundwater resources and this has led to inappropriate development of groundwater.

(2) Environmental Flow Requirement

(a) Draft Guideline on Environmental Flow Assessment

MoWI is currently preparing a draft guideline on environmental flow assessment (EFA). The draft guideline introduces a general review of methodologies in four major groups: i) hydrology-based methodologies; ii) hydraulic rating methodologies; iii) habitat simulation methodologies; and iv) holistic methodologies. Among the hydrology-based methodologies, the draft guideline states that the Indicators of Hydrologic Alteration (IHA) method is the most recommended followed by the Flow Duration Curve (FDC)-Median Value method. These two methods shall therefore be adopted for hydrology-based environmental water requirement assessment in Tanzania.

(b) Practical Example of Environmental Flow Assessment

Comprehensive EFA are only available in the Ruvu River basin[6] and the Kilombero River basin[7] so far done by collaborative body with technical and financial assistance from USAID. The both assessments

[5] IWMI (International Water Management Institute), 2010, Assessment of Groundwater Availability and Its Current and Potential Use and Impacts in Tanzania
[6] Environmental Flow Recommendations for the Ruvu River Basin, Tanzania (USAID, 2014)
[7] Environmental Flows in the Rufiji River basin Assessed from the Perspective of Planned Development in the Kilombero and Lower Rufiji Sub-basins (USAID, 2016)

were made after the completion of IWRMDPs for Wami/Ruvu and Rufiji basins, respectively. In general, a detailed EFA study covers only a particular river basin. For this reason, the said assessments do not cover the entire basin areas of Wami/Ruvu and Rufiji.

In the assessment study for the Ruvu River basin, environmental flow (EF) was set for five sites in the basin on a monthly basis for maintenance year (year of normal rainfall) and dry year (driest year). The approach employed by the Ruvu EFA was a hybrid of holistic methodologies, notably the Savannah Process (Richter et al. 2006) and the Building Block Methodology (BBM; King et al., 2008).

On the other hand, the assessment study for Kilombero and Lower Rufiji sub-basins in the Rufiji basin recommended monthly EF by using BBM for five sites in the Kilombelo River Valley for maintenance year and dry year.

(3) Climate Change

TMA reports[8] climate change projections for Tanzania. The conclusions are summarized as follows:

- The country is projected to experience consistent and sustained warming from 2025 to 2100, with the warming being more pronounced over the south-western highland and over the western parts, where a warming of up to 3.8°C is projected by 2100.
- Though less confidence can be placed in model output for rainfall changes, most of the models suggest an increase in mean annual rainfall of up to 11% in 2100, particularly over the north-eastern highland.
- For the March - May (MAM) rainfall season, rainfall is projected to decrease by up to 12%, particularly over the north-eastern highland. During September - November (SON) period rainfall is projected to increase progressively from the year 2025 to 2100 over the central and northern parts of the country. The increase will be more pronounced over the Lake Victoria Basin and some parts of north-eastern highland, where an increase of up 22% is projected. However, areas around south-western highland and southern areas are projected to experience rainfall reduction. The decrease in percentage rainfall during MAM and SON season seem to be compensated by significant increase in December - February (DJF) rainfall.

2.4 Water Resources Structures

(1) Existing Dams

A list of both man-made and natural existing reservoirs was collected from MoWI for the purpose of referring in water balance calculation. The list contains 694 dams with their basic information including coordinates, dam height, reservoir capacity and so forth. However, the purposes of dams are not mentioned in the list because the list was prepared with the view of dam safety study. The total capacity excluding hydropower plant (HPP) dams is 425.9 MCM as summarized in Table 2.4.1.

[8] Climate Change Projection for Tanzania, ISBN 978-9987-9981-0-5. pp.37 (Tanzania Meteorological Agency (TMA), Ministry of Transport, United Republic of Tanzania)

Table 2.4.1 Numbers and Reservoir Capacity of Existing Dams

Basin[*1]	Nos. of Dams				Reservoir Capacity (MCM)
	All Dams in the List				
		Dams with Positional Information[*2]			
			Dams with Capacity Data		
				Excluding HPP[*3]	Excluding HPP
Pangani	131	120	118	117	49.1
Wami Ruvu	157	136	134	134	40.9
Rufiji	67	67	67	65	79.8
Ruvuma	62	59	58	58	19.1
Lake Tanganyika	35	34	34	34	50.3
Lake Victoria	139	129	127	127	78.5
Internal Drainage	103	87	84	84	108.2
Total	694	632	622	619	425.9

*Note: *1. Although the Lake Nyasa and Lake Rukwa basins have storage dams, an inventory survey has not been conducted in the basins.*
**2. The dams with questionable coordinates data that indicate different position from the basin or district mentioned in the list were excluded in the second column and later because the coordinates data are not able to correctly identify sub-basin.*
**3. There are only three reservoir type hydropower plants (HPP), namely Nyumba ya Mungu Dam (600 MCM) in Pangani Basin, Mtera Dam (3,200 MCM) and Kidatu Dam (125 MCM) in Rufiji Basin. All of them are single purpose dams for hydropower.*
Source: 1. List of existing dams (As of Nov 2016, MoWI)
2. Power System Master Plan 2016 Update (Dec 2016, Ministry of Energy and Minerals)

(2) Planned Dams

The IWRMDP studies for the respective basins proposed 69 dams in total except for hydropower single purpose dams. These proposals include new construction and heightening of existing dykes. Among these, the MoWI has completed the construction designs of three major dams, namely Kidunda, Farkwa, and Ndembera (Lugoda) dams.

On the other hand, TANESCO[9] has the 23 projects for large and medium scale HPP according to the Power System Master Plan 2016 Update. Out of these, 10 to 13 projects will adopt reservoir type power generation. The Kikonge HPP is the only multi-purpose dam for hydropower and irrigation purposes. The project is in collaboration between NIRC and TANESCO.

The total reservoir capacity of the above planned 70 dams is 8,723 MCM, although the allocation for each sector is not mentioned in the reports. The list of planned dams is presented in Attachment 1.

2.5 Water Resources Management at Basin Level

2.5.1 Field Survey

JICA Project Team conducted field visit in the course of study for the principal purpose of data collection from Basin Water Offices (BWOs). Along with the interviews with the BWOs for data collection, field survey was also done for understanding the status of water resources management at basin level.

Since the purpose of visit is collection of data that are hardly obtainable through the existing reports, the visit areas were limited to four out of the nine basins. Table 2.5.1 summarizes the surveyed facilities.

Table 2.5.1 Facilities Surveyed during Field Visit

Basin	Facilities related to Water Resources Management			
	Gauging Station	Weather Station	Intake for Water Abstraction	Dam
Pangani	1DD1, 1DC1	Nyumba ya Mungu Dam	TPC (sugarcane), Lower Moshi Irrigation Scheme, Lemkuna Irrigation Scheme	Nyumba ya Mungu Dam
Wami/Ruvu	1G1	---	Mlali Irrigation Scheme	Mindu Dam

[9] Tanzania Electric Supply Company Limited (TANESCO) is a parastatal organization under the Ministry of Energy and Minerals.

Basin	Facilities related to Water Resources Management			
	Gauging Station	Weather Station	Intake for Water Abstraction	Dam
Rufiji	1KA2A, 1KA31	Rufiji BWO	Mlenge & Itunudu Irrigation Scheme, Mgambalenga Irrigation Scheme	Mtera Dam
Lake Victoria	5D3, 5E2, 5F3	---	Grumeti Irrigation Scheme, Mwanza Urban Water Supply and Sewerage Authority	---

Source: JICA Project Team

2.5.2 Findings from BWOs and Field Survey

The major findings obtained though the interviews with BWOs and the field survey are listed as below.

(1) Hydrological Monitoring

- Hydrological monitoring is made by manual observation and/or automatic observation with field data logger or direct transmission via SMS.
- It was found in the Pangani, Rufiji and Lake Victoria basins that some malfunctioning devices are left unrepaired.
- Pangani BWO has current meters and Q-liner, which is a type of Acoustic Doppler Current Profiler (ADCP), and conducts discharge measurement regularly. However, rating curves have not been updated since the initial development in 1994.
- Flood flow caused change of riverbed and sediment deposition in the Lake Victoria basin. The BWO intends to shift the gauging station to other section. However, there is no suitable site with good accessibility.

(2) Data Management in BWO

- Each BWO uses either HYDATA[10] or DSS[11] as database for hydrological data. The data are stored in different database and format depending on the BWO.
- Groundwater data, such as list of boreholes, are not well prepared and updated by BWOs. Besides, each BWO uses a different format and has so many missing data.
- Basin Water Register is not properly updated by BWOs.
- BWOs are basically supposed to manage hydrological data at basin level. Therefore such data are not always shared with the headquarters of MoWI.
- The output data used for water balance study in the IWRMDPs have not been transferred from consultant firms to BWOs, through the study reports were compiled into CD or DVD.

(3) Water Use Management

- Neither BWO nor water users monitor the actual amounts of water abstraction. In addition, BWO is not able to verify water abstraction applied by water users due to lack of data, such as available amount of water at an intake point, actual water abstraction, etc.
- Although water use permit needs to be granted on a seasonal basis, the Pangani and Lake Victoria BWOs grant the permits throughout the year.
- BWOs recognize many non-approved water users in their basin. Consequently, appropriate water fee is not collected from those users.

[10] HYDATA is a database and analysis system for processing the hydrometeorological data, including river water levels and flows, reservoir, lake and tank levels and storages, rainfall and so forth.
[11] Decision Support System (DSS) is a comprehensive information, modeling, and decision support software for basin management.

- Water conflict issues among upstream water users, downstream water users and TANESCO, which is hydropower operator, have been reported in the Pangani River basin.
- Water loss along the unlined canals is one of the issues in the Wami-Ruvu basin. Sediment deposition in the canals is another issue.

2.6 Challenges in Water Sector

The following challenges were identified through reviewing the IWRMDP reports as well as discussing with the MoWI.

(1) Water Demand Management

The biggest challenge in water sector is the localized seasonal water shortages especially during peak irrigation periods. The situation surrounding water resources has become more difficult due to climate change effect as well as increase in water demands for various sectors. It is important to consider managing the water demands to ensure sustainability of water resources. The principal measures for water demand management in terms of irrigation sector may include more efficient irrigation technologies and awareness activities for farmers, etc.

(2) Limited Availability of Long-term Hydrological Data

As summarized in Table 2.3.3, the IWRMDPs for some basins were formulated by using non-latest hydrological data due to the limited availability of long-term data. In the Wami/Ruvu case, water level and discharge data at most of the gauging stations are missing from the late 1980s to the mid-2000s.

This issue could be attributed to the above-mentioned insufficient hydrological monitoring activities as well as non-systematic data management at basin level.

(3) Undefined Reliability of Water Utilization in IWRMDPs

In general, reliability of water utilization is considered in water resources planning. In many cases, the reliabilities of 1/10-yr for domestic & other sectors and 1/5-yr for irrigation sector are adopted. However, in preparing the IWRMDPs, long-term mean runoff was utilized as water resources potential in all the basins except for the Wami/Ruvu basin, which adopted 1/10-yr for all the sectors including irrigation. The reason why the mean runoff was utilized is not clearly mentioned in the reports. Adopting the long-term mean runoff in water resources development plans means that water shortage may happen once in every one to two years.

It is not always necessary to consider the reliability in the form of 1/5-yr or 1/10-yr. However, in the case where the reliability of 1/5-yr is considered in the future, it is desirable to settle this issue before implementation stage.

(4) Careful Consideration on Transboundary Water Use

Tanzania has five transboundary lakes, namely, the Victoria, Tanganyika, Nyasa, Jipe and Chala Lakes. Abstraction of water from those transboundary lakes is not explicitly mentioned in the IWRMDP reports. However, NIRC expect water use particularly in the Victoria Lake.

Considering the fact that the lake water is derived partially from rainfall onto the territory of Tanzania, the water may be used for irrigation in Tanzania even after the water flow into the lake. In this regard, water use from transboundary lakes may be one of the conceivable measures subject to agreements among the concerned countries.

Chapter 3 Water Resources Assessment

3.1 Method and Procedure

(1) Principle

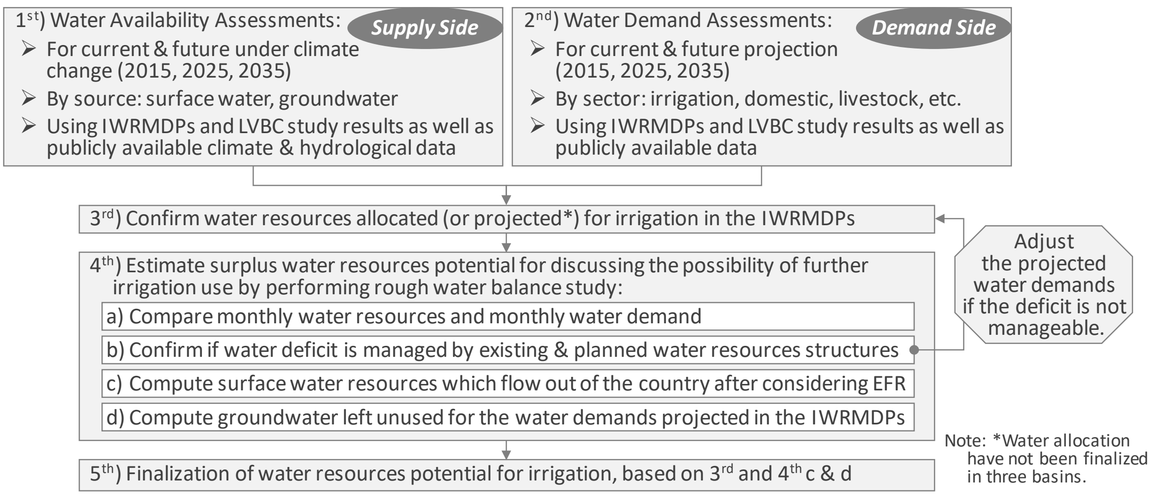
According to the National Water Policy (NAWAPO), water uses other than basic human needs and environment purposes will be subject to social and economic criteria, which will be reviewed from time to time. Water is a finite and vulnerable resource which is under pressure and growing scarce as a result of increasing multi-sectoral demands due to the rapidly growing population. Under such difficult circumstances, water resources shall be utilized based on the principle of equity, right and rationality.

The aforementioned IWRMDPs have been formulated in accordance with NAWAPO including the said principle. From the standpoint of impartial utilization between sectors, even water resources left unused are not freely allocable for a specific sector. Consequently, the balanced IWRMDPs will be fundamentals in preparing the NIMP2018. This means that the NIMP2018 have to basically harmonize with the water allocation determined in the IWRMDPs. On that basis, water resources remained unallocated to any sector is estimated as surplus water for reference in discussing the possibility of further irrigation use.

(2) Procedure

Figure 3.1.1 presents the key procedure of water resources assessment. First of all, the IWRMDP reports and the LVBC study report were carefully reviewed for understanding the methodologies applied to the respective basins as well as compiling the study outputs in terms of surface water, groundwater, water demand for each sector and environmental flow, on a monthly and sub-basin basis.

After gathering the study outputs as well as confirming the water allocation to be used for the irrigation development plan of NIMP2018, surplus water resources potential was separately estimated for the purpose of discussing the possibility of further irrigation use. The estimation was made by performing a rough water balance study as listed in the 4th step of Figure 3.1.1.



Source: JICA Project Team

Figure 3.1.1 Procedure of Water Resources Assessment

3.2 Estimation of Water Resources

3.2.1 Surface Water Resources

(1) Approach for Utilizing the Previous Study Results

Many of the IWRMDP and LVBC study reports do not present numerical data of the estimated monthly surface runoff. Some reports present only annual basis data, but others present monthly basis data in a form of hydrograph, which is hardly referable in the NIMP2018 study. Thus, there was a need to re-generate monthly surface runoff data by using available information clearly mentioned in the reports as well as supplementally applying public hydrological data.

(2) Method of Re-generation of Mean Monthly Surface Runoff

The methods are classified into the following three patterns according to the availability of data.

1) Direct Utilization

Only the IWRMDP report for the Lake Nyasa basin expressly provides numerical monthly runoff data by sub-basin for the years 2015, 2025 and 2035 with climate change effect. Thus, there was no need to re-generate runoff data.

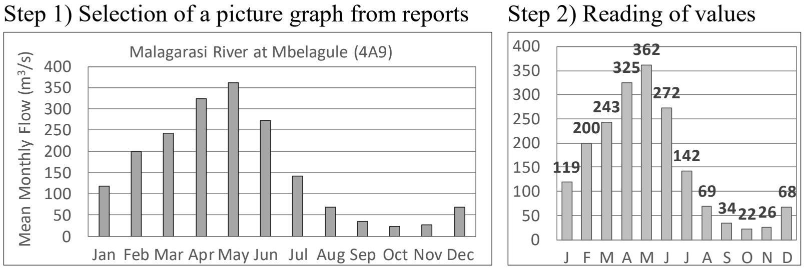
2) Annual Runoff Data and Monthly Runoff Bar Chart

This method was applied for the case that annual runoff data is clearly mentioned and monthly runoff bar chart graph are presented in the report. The bar chart graphs indicated monthly runoff at a specific gauging station in some cases or monthly runoff for sub-basin average in other cases. If a sub-basin does not have such graph, the nearest one was applied from the hydrological viewpoint. Monthly runoff was calculated by multiplying the annual runoff by the monthly proportion estimated based on the graph.

The image of estimation is illustrated in Figure 3.2.1. This is an example of the Malararasi sub-basin of Tanganyika basin. In this case, the annual runoff of 2,818 MCM/yr was clearly provided in the report. On the other hand, monthly runoff graph at the Mberagule station, where is located in the Malararasi sub-basin, was presented in the report.

Step 1) Selection of a picture graph from reports

Step 2) Reading of values



In this example, the station "Mberagule" was selected for estimating monthly runoff of the Malagarasi sub-basin.

The values of the selected bar chart graph were roughly read by using Excel.

Step 3) Multiplication of proportion

Month	Reading	Proportion	Annual	Monthly
Jan	119	6%	2,818	178
Feb	200	11%		299
Mar	243	13%		364
Apr	325	17%		487
May	362	19%		542
Jun	272	14%		407
Jul	142	8%		213
Aug	69	4%		103
Sep	34	2%		51
Oct	22	1%		33
Nov	26	1%		39
Dec	68	4%		102
Total	1,882	100%	----	2,818

Source: *JICA Project Team*

Figure 3.2.1 Image of Estimating Monthly Runoff by Using Graph

This method was applied for the Pangani, Ruvuma, Tanganyika, Lake Victoria and Internal Drainage basins. The bar chart graphs of Pangani and Ruvuma indicate the monthly runoff estimated for the years 2015, 2025 and 2035 with climate change effect, while the graphs of the other basins indicate the monthly runoff of past records as summarized in Table 3.2.1. Strictly speaking, monthly runoff proportion will be also affected by climate change. In some cases, runoff increase in the rainy season and decrease in the dry season compared to the current condition. However, considering the uncertainty of climate change as well as data availability, the re-generated monthly runoff for the Tanganyika and Internal Drainage basins could be regarded as runoff with climate change effect.

Table 3.2.1 Consideration of Climate Change in the Re-generated Runoff Data

Basin	Annual Runoff Volume	Monthly Runoff Proportion
Pangani	With climate change	With climate change
Ruvuma	With climate change	With climate change
Tanganyika	With climate change	Without climate change
Lake Victoria	Without climate change	Without climate change
Internal Drainage	With climate change	Without climate change

Source: JICA Project Team based on the IWRMDP reports for the above basins

Besides, in case no monthly runoff information is available, mean monthly rainfall data by sub-basin was applied instead of monthly runoff graph. This is limited to some sub-basins surrounding the Victoria Lake because their catchment areas are relatively small and runoff is expected to fluctuate directly according to rainfall.

3) Monthly Runoff at a Specific Station and Catchment Area Ratio

This method was applied for the case that monthly runoff data at a specific gauging station are presented in the report. The Wami/Ruvu basin report provides numerical data at some gauging stations. On the other hand, the Rufiji and Lake Rukwa reports present monthly runoff bar chart graphs at some gauging stations and therefore numerical data for these two basins were generated with the method shown in Figure 3.2.1 by using the graph and mean annual runoff at the station. Finally, monthly runoff for each sub-basin was generated after multiplying the monthly runoff at a specific gauging station by a catchment area ratio of sub-basin and the gauging station.

It must be noted that all the runoff data re-generated as explained above are only mean runoff in the past period, which have no climate change effect. Although the IWRMDP studies for the Rufiji and Lake Rukwa assessed climate change effect with sophisticated models, the results are presented only in a form of hydrograph. The original data of the graphs were obtainable from neither the headquarters of MoWI nor the Basin Water Offices.

(3) Result of Re-generating Mean Monthly Surface Runoff

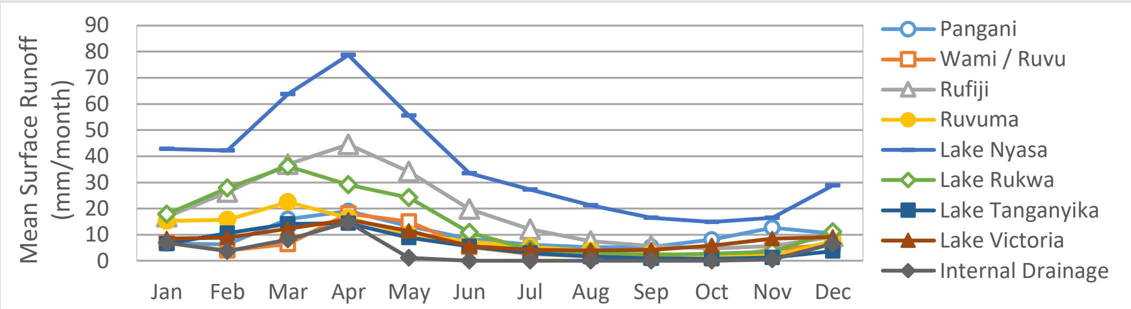
Table 3.2.2 and Figure 3.2.2 present the summary of mean monthly surface runoff by basin for 2015. Monthly data by sub-basin for 2035 is presented in Attachment 2. The data for 2015 is also used for 2035 when data with climate change effect is not obtainable from reports, as stated in the following clause.

Table 3.2.2 Mean Monthly Surface Runoff by Basin for 2015

Basin	Area (km^2)	Surface Runoff (mm/month for each month and mm/yr for total)													Rain (mm/yr)	RC*1
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total		
Pangani	59,102	6.7	6.3	16.0	19.0	13.3	8.3	6.2	5.3	5.4	8.2	12.7	10.4	117.8	809	0.15
Wami / Ruvu	66,295	6.9	4.0	6.5	18.1	15.0	5.3	2.6	1.7	1.3	1.2	4.3	6.5	73.4	878	0.08
Rufiji	183,791	16.8	26.3	36.9	44.5	34.1	19.8	12.1	7.6	5.8	4.7	5.6	9.2	223.3	1,013	0.22
Ruvuma	105,582	15.2	15.7	22.5	16.5	10.2	7.4	5.3	3.9	2.7	2.0	1.9	7.6	110.8	1,062	0.10

Basin	Area (km^2)	Surface Runoff (mm/month for each month and mm/yr for total)													Rain (mm/yr)	RC*1
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total		
Lake Nyasa	27,594	42.7	42.2	63.7	78.7	55.5	33.5	27.2	21.3	16.5	14.9	16.4	28.9	441.7	1,257	0.35
Lake Rukwa	74,965	17.8	27.9	36.2	29.1	24.2	10.8	4.3	3.1	2.3	2.7	3.5	11.1	173.2	981	0.18
Lake Tanganyika	149,500	6.5	10.6	14.2	14.3	8.9	5.5	3.0	1.6	0.9	0.7	1.2	3.7	71.2	1,026	0.07
Lake Victoria	85,630	8.5	8.9	12.3	15.8	11.4	5.7	4.2	4.0	4.3	5.8	8.6	9.1	98.6	986	0.10
Internal Drainage	143,100	6.9	3.8	8.1	14.8	1.2	0.0	0.0	0.0	0.0	0.0	0.5	6.6	41.8	696	0.06
Average	---	12.0	14.8	21.6	24.8	16.7	9.3	5.8	4.1	3.2	3.2	4.4	8.3	128.2	950	0.13

*Note: *1. Since rainfall data is average for 30 years from 1981 to 2010, the above runoff coefficients (RC) are only reference.*
Source: Re-generated by JICA Project Team based on the IWRMDP reports and the LVBC study report



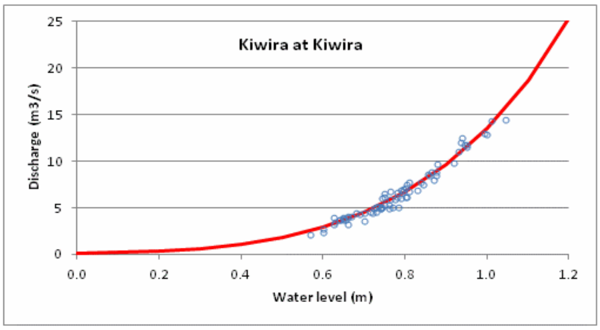
Source: Re-generated by JICA Project Team based on the IWRMDP reports and the LVBC study report

Figure 3.2.2 Mean Monthly Surface Runoff by Basin for 2015

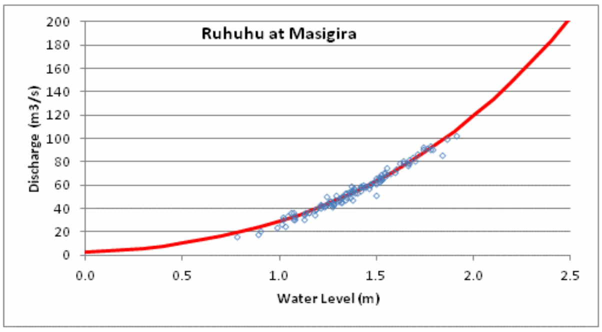
As seen in the table and figure, the runoff in the Lake Nyasa basin is remarkably large compared to the others. The annual runoff coefficient of the entire Nyasa basin is estimated at 0.35, while the national average of coefficient covering the nine basins is only 0.13. After considering that basin is high rainfall area, there is a need to confirm the background.

Fortunately the Lake Nyasa basin IWRMDP report presents various basic hydrological data. Figure 3.2.3 shows rating curves at two gauging stations. Since discharge data plotted on the rating curve is direct result of measurement data, it is quite reliable. The two figures indicate that discharge ranges from 2 to 9 m^3/s at the Kiwira station and from 20 to 80 m^3/s at the Masigira station. Considering the respective catchment areas (CA) of 187 km^2 and 1,979 km^2, the average annual runoff height can be roughly calculated at 928 mm/yr for Kiwira and 797 mm/yr for Masigira. Although the actual timing of each discharge measurement is not clear, even the minimum runoff height that can be estimated from the rating curves exceed 300 mm/yr. From the viewpoint of these raw discharge data as well as the topographic feature that the basin is generally hilly and mountainous up to almost 3,000 m above sea level, the relatively high runoff of 441.7 mm/yr seem reasonable.

Kiwira River at Kiwira Station (CA=187 km^2)



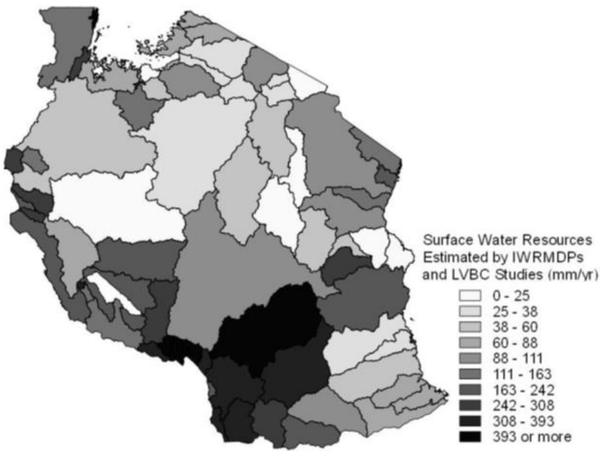
Ruhuhu River at Masigira Station (CA=1,979 km^2)



Source: Hydrology Report for the Nyasa IWRMDP

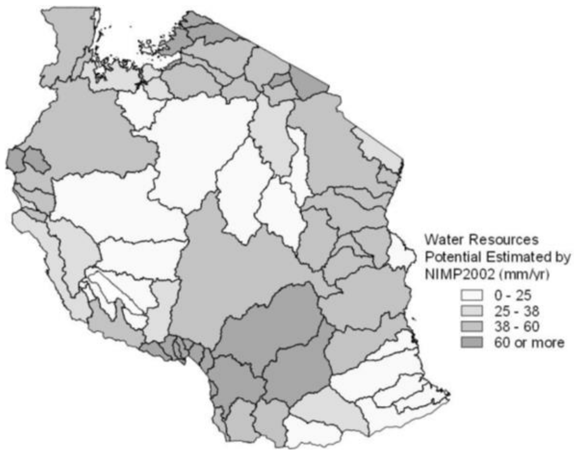
Figure 3.2.3 Rating Curves at Selected Stations in Lake Nyasa Basin

The annual surface water for 2015 by sub-basin is presented in Figure 3.2.4. Besides, water resources potential estimated by NIMP2002, which is presented with the unit of $m^3/sec/500km^2$ in Figure 1.2.3 in the section 1.2, is converted to the unit of mm/yr and presented in Figure 3.2.5 by sub-basin. Since the maximum potential value of NIMP2002 is given as 1.0 $m^3/sec/500km^2$, which is equivalent to 63 mm/yr, Figure 3.2.5 is able to show only up to 63 mm/yr. Although there is such a difference, the both maps indicate relatively high water potential in the Rufiji, Lake Nyasa, and Lake Tanganyika basins compared to the others from a broader perspective.



Source: JICA Project Team based on the IWRMDP & LVBC reports

Figure 3.2.4 Surface Water Resources for 2015 Compiled by NIMP2018



Source: NIMP2002

Figure 3.2.5 Water Resources Potential Compiled by NIMP2002

(4) Impact of Climate Change

As stated in the clause (2) of sub-section 3.2.1, runoff data with climate change effect is not available for the Wami/Ruvu, Rufiji, Lake Rukwa and Lake Victoria basins. The monthly runoff data for the other basins for the year 2025 and 2035 are shown in Table 3.2.3 and Table 3.2.4, respectively.

Table 3.2.3 Mean Monthly Surface Runoff by Basin for 2025

Basin	Area (km^2)	Surface Runoff (mm/month for each month and mm/yr for annual)												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Pangani	59,102	5.6	5.4	13.4	16.2	11.3	7.1	5.2	4.6	4.6	6.8	10.5	8.7	99.5
Ruvuma	105,582	15.6	16.1	22.7	16.5	10.1	7.3	5.3	3.8	2.7	2.0	1.8	7.4	111.3
Lake Nyasa	27,594	42.2	41.7	63.0	77.8	54.9	33.1	26.9	21.0	16.3	14.7	16.2	28.5	436.4
Lake Tanganyika	149,500	6.6	10.7	14.4	14.5	9.0	5.5	3.0	1.6	0.9	0.7	1.2	3.8	71.9
Internal Drainage	143,100	6.5	3.6	7.7	14.0	1.1	0.0	0.0	0.0	0.0	0.0	0.5	6.2	39.5

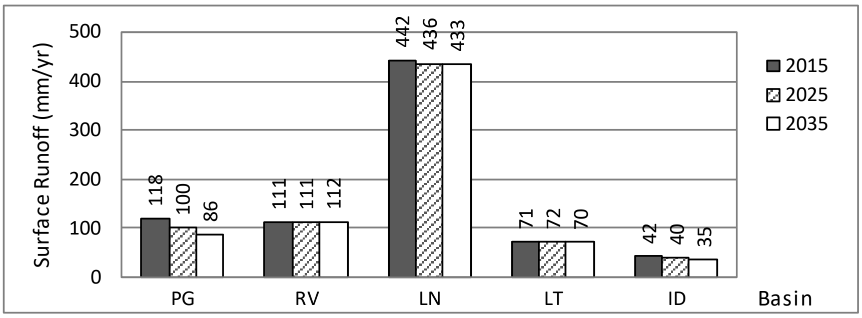
Source: Re-generated by JICA Project Team based on the IWRMDP reports

Table 3.2.4 Mean Monthly Surface Runoff by Basin for 2035

Basin	Area (km^2)	Surface Runoff (mm/month for each month and mm/yr for annual)												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Pangani	59,102	4.7	4.7	11.7	14.0	9.9	6.1	4.6	3.8	4.1	6.0	9.1	7.6	86.3
Ruvuma	105,582	15.7	16.3	22.8	16.5	10.1	7.3	5.3	3.8	2.7	2.0	1.8	7.4	111.7
Lake Nyasa	27,594	42.0	41.4	62.5	77.3	54.5	32.9	26.7	20.9	16.2	14.7	16.1	28.3	433.4
Lake Tanganyika	149,500	6.4	10.5	14.0	14.2	8.7	5.4	2.9	1.6	0.9	0.7	1.2	3.7	70.1
Internal Drainage	143,100	5.8	3.1	6.8	12.2	0.9	0.0	0.0	0.0	0.0	0.0	0.4	5.5	34.8

Source: Re-generated by JICA Project Team based on the IWRMDP reports

The annual surface runoff for the above five basins are presented in Figure 3.6.1. It was found that the rates of increase or decrease from 2015 to 2035 in the Ruvuma (RV), Lake Nyasa (LN) and Lake Tanganyika (LT) basins fall within 2%. On the other hand, the decrease rates are relatively large in the Pangani (PG) and Internal Drainage (ID) basins with the rates of 27% and 17%, respectively. In the Lake Tanganyika basin, the runoff for 2025 is higher than 2015 and 2035. This is because rainfall is increasing towards 2030 and thereafter rainfall is more or less similar to the one in the base period, which is assumed to be around 2012.



Source: Prepared by JICA Project Team based on the IWRMDP reports

Figure 3.2.6 Surface Runoff with Climate Change by Basin

In view of uncertainty of climate change phenomena as well as the relatively small change rates obtained from the above five basins, it would be acceptable for the NIMP2018 study to apply the 2015 surface runoff data for the years 2025 and 2035 in the remaining four basins, namely the Wami/Ruvu, Rufiji, Lake Rukwa and Lake Victoria basins.

3.2.2 Groundwater Resources

(1) Assessment of Groundwater Recharge in the Existing Studies

The IWRMDPs studies for the respective basins and the LVBC study have assessed groundwater resources potential. Prior to determining sustainable yield of groundwater resources, firstly annual groundwater recharge was estimated in all the basins with different methods. The basic methods of recharge estimation by each basin are briefed as below:

i) Pangani Basin:
Chloride mass balance (CMB) method was used to estimate groundwater recharge in the basin. The chloride concentration in groundwater within the basin was obtained from the basin water office water quality analysis results, and other reports on borehole completion.

ii) Wami/Ruvu Basin:
The recharge amount to groundwater is calculated as the infiltration in the water balance analysis. The infiltration is the amount subtracting both evapotranspiration and surface runoff from the rainfall. The recharge amount was assessed in accordance with the existing water level monitoring data and rainfall data.

iii) Rufiji Basin:
Mean annual effective recharge from rainfall to the basin aquifers was assessed using the Maxey-Eakin empirical method and the chloride mass balance (CMB) method. However, no values of chloride concentration in rainwater are available for coastal aquifers. Therefore, calculation of recharge using the CMB method was only used for the limited areas.

iv) Ruvuma Basin:

Due to insufficient availability of data, groundwater recharge cannot be calculated by water balance. Instead, recharge rates were calculated by assigning a percentage to each outcrop geology type, representing the proportion of rainfall estimated to become recharge. These factors are based on information from previous hydrogeological studies in Southern Africa.

v) Lake Nyasa Basin:

As there is no long-term groundwater level monitoring data within the basin, groundwater recharge was assumed to be a percentage of the total annual rainfall. Rainfall infiltration rates in the order of 5% to 15% were estimated during the model calibration. Recharge zoning was made based on the geology and rainfall isohyet maps.

vi) Lake Rukwa Basin:

Mean annual effective recharge from rainfall to the basin aquifers was assessed using the Maxey-Eakin empirical method and the chloride mass balance (CMB) method. The CMB technique was used in the study as an independent check on the recharge estimates of the empirical Maxey-Eakin model.

vii) Lake Tanganyika Basin:

Chloride mass balance (CMB) method was used to estimate groundwater recharge in the basin. The chloride concentration in groundwater within the basin was obtained from the basin water office water quality analysis results, and other reports on borehole completion.

viii) Lake Victoria Basin:

Groundwater recharge was estimated for some sub-basins by using the Meyboom baseflow recession method and Smakhtin baseflow separation method. The results of Meyboom method were on average about half of the recharge estimated by the Smakhtin method.

ix) Internal Drainage:

Annual groundwater recharge in fractures and rocks aquifers was estimated assuming an infiltration coefficient to annual rainfall. Besides, recharge in river bed aquifers was estimated as the amount of available storage in river alluvial beds by each single flood. Since the number of flood events per year is not predictable, the recharge is considered the minimum recharge potential for each year.

(2) Re-assessment of Groundwater Recharge in NIMP2018

As mentioned above, various methods were adopted in estimating annual groundwater recharge. As a result, there was considerable difference in recharge by basin. The minimum recharge height is 6 mm/yr in the Internal Drainage basin and the maximum one is 257 mm/yr in the Rufiji basin. After considering the difference in regional characteristics, there seems to be effects caused by the difference in estimate method. Accordingly, groundwater recharge in the following four basins were further reviewed.

(a) Rufiji and Lake Rukwa Basins

In the Rufiji and Lake Rukwa basins, firstly mean annual groundwater recharge is simply computed based on mean annual rainfall by using the Maxey-Eakin method. After that, annual groundwater potential is estimated at approximately three to six times of the annual recharge. Although this numerical computation process is not explained in the report, it is inferable that aquifer storage volume of groundwater, which have been stored over a long-period of more than several decades, was added to the initial recharge volume.

On the other hand, the above study has made many assumptions due to lack of aquifer survey data and mentioned that potential will require much further work to reduce uncertainties. There are presumably sufficient groundwater resources in the aquifer within the basins. However, it is better to regard the potential in the aquifer as reference information at this moment in order to avoid misunderstanding that this potential is realistically exploitable for irrigation development. Therefore, the NIMP2018 adopted the mean annual recharge directly estimated by the Maxey-Eakin method. Sustainable yield of groundwater was then estimated at 40% of annual recharge, considering the percentages used in the original computation for the two basins.

(b) Lake Victoria Basin

Annual groundwater recharge was estimated in the LVBC study report only for the Biharamulo and Simiyu sub-basins out of 13 sub-basins. Therefore, based on the recharge estimates by the Mayboom method of 50 mm/yr for Biharamulo and 51 mm/yr for Simiyu, the NIMP2018 Project Team computed recharge ratios to annual rainfall at 4.5% and 5.9%, respectively. Then, annual recharge for the other sub-basins were computed by applying the average recharge ratio of 5.2% and annual rainfall of each sub-basin. Sustainable yield of groundwater was then estimated at 30% of annual recharge.

(c) Internal Drainage Basin

The groundwater potential estimated in the IWRMDP for the Internal Drainage basin ranges from 0.5 to 46 mm/yr by sub-basin with a basin average of 6.2 mm/yr. If these figures were annual recharge, these are considerably small compared with the other basins. One of the possible reasons is difference in the recharge estimation method from the other basins. Annual groundwater recharge in the surrounding areas are estimated at 25 mm/yr in Pangani, 64 mm/yr in Wami-Ruvu, 37 mm/yr in Tanganyika, 52 mm/yr in Lake Victoria and reported at 37 mm/yr[12] in the whole of Kenya, where almost 80% of whole area is classified as arid and semi-arid lands (ASAL).

With due consideration of relative comparison with the surrounding areas, the figure of 6.2 mm/yr may be equivalent to sustainable yield of groundwater resources rather than groundwater recharge. Thus, the NIMP2018 Project Team has determined to treat the potential as sustainable yield of groundwater resources.

(3) Sustainable Yield of Groundwater Resources

The estimated annual groundwater recharges are not fully usable. It is quite difficult to estimate the sustainable yield of groundwater. The respective basin IWRMDPs differently adopted 10% to 50% of groundwater recharge as sustainable yield. By respecting the elaborate IWRMDP studies, those percentages were left unchanged except for the above four basins that recharges were re-assessed, as summarized in Table 3.2.5.

[12] Annual groundwater recharge data for the year 2010 (Final Report on the Development of the National Water Master Plan 2030, JICA)

Table 3.2.5 Calculation Basis for Sustainable Yield

Basin	Original Basis in IWRMDP	Basis Modified by NIMP2018
Pangani	40% of annual recharge	(no change)
Wami / Ruvu	8% to 59% of annual recharge by sub-basin	(no change)
Rufiji	40% to 70% of annual recharge by GRU	40% of annual recharge
Ruvuma	40% of annual recharge	(no change)
Lake Nyasa	10% of annual recharge	(no change)
Lake Rukwa	40% to 70% of annual recharge by GRU	40% of annual recharge
Lake Tanganyika	50% of annual recharge	(no change)
Lake Victoria	No estimation	30% of annual recharge
Internal Drainage	No estimation	20% of annual recharge

Note: GRU = Groundwater resource unit
Source: Prepared by JICA Project Team based on the IWRMDP and LVBC study reports

(4) Result of Data Processing

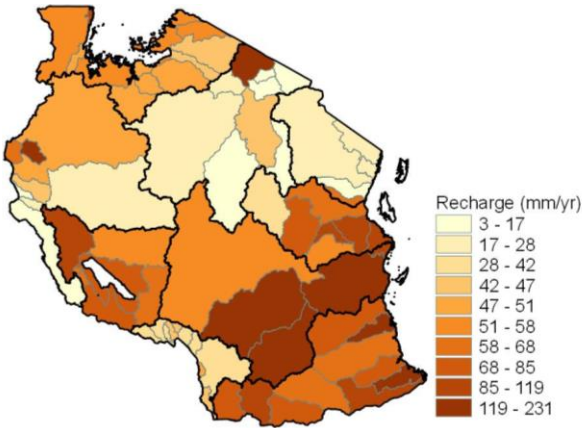
As a result of compiling and re-assessing groundwater (GW) data as above, finally annual groundwater recharge and sustainable yield of groundwater resources are obtained as given in Table 3.2.6. Also, the sustainable yield data by sub-basin is presented in Attachment 2.

Table 3.2.6 Annual Recharge and Sustainable Yield

Basin	Area (km^2)	Annual GW Recharge		Sustainable Yield of GW Resources	
		(MCM/yr)	(mm/yr)	(MCM/yr)	(mm/yr)
Pangani	59,102	1,466	25	587	10
Wami / Ruvu	66,295	4,273	64	1,139	17
Rufiji	183,791	22,533	123	9,021	49
Ruvuma	105,582	8,307	79	3,238	31
Lake Nyasa	27,594	1,070	39	107	4
Lake Rukwa	74,965	5,341	71	2,136	28
Lake Tanganyika	149,500	5,511	37	2,755	18
Lake Victoria	85,630	4,424	52	1,327	15
Internal Drainage	143,100	4,421	31	884	6
Total	895,559	84,322	94	21,195	24

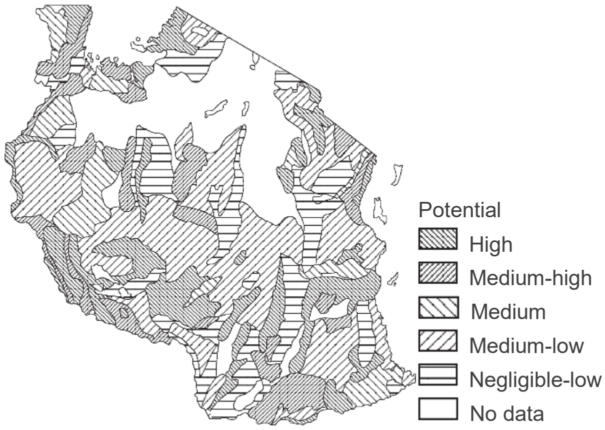
Source: Prepared by JICA Project Team based on the IWRMDP and LVBC study reports

The annual groundwater recharge by sub-basin is presented in Figure 3.2.7. On the other hand, the NIMP2002 qualitatively assessed groundwater from the viewpoint of hydro-geological features and presents only the general outline of groundwater potential as presented in Figure 3.2.8. Comparing the two maps, almost similar tendency can be seen. The both maps indicate that groundwater potential in the Rufiji, Ruvuma and Lake Rukwa basins is higher than one in the other basins.



Source: JICA Project Team based on IWRMDPs & LVBC reports

Figure 3.2.7 Annual Groundwater Recharge Complied by NIMP2018



Source: NIMP2002

Figure 3.2.8 Groundwater Potential Compiled by NIMP2002

3.3 Estimation of Water Demand

3.3.1 Consumptive Water Use

(1) Calculation Basis by Basin

Water demand with different time horizon have been projected in the IWRMDP and LVBC studies. The sectors considered in the respective basins are different depending on the natural and social conditions of the basin. The projected sectors by basin are summarized in Table 2.3.3 of the sub-section 2.3.1.

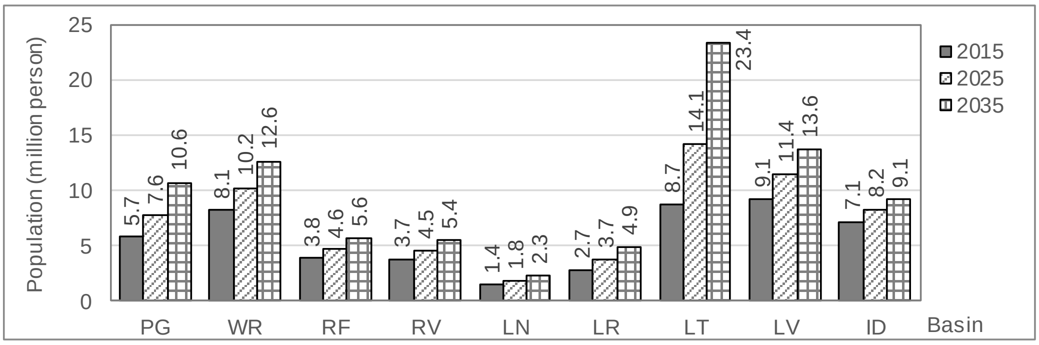
Since the estimates were made by different consultant firms with due consideration of characteristics of the basin as well as their experiences, in some cases different methods have been adopted. This clause will brief the major differences in calculation basis between basins if any in addition to the key points of general calculation basis for estimating water demand by each sector. The estimated water demand data is presented collectively in the subsequent clause (2) for easy comparison between sectors.

There are seven sectors, namely 1) domestic and institute, 2) industry and mining, 3) irrigation, 4) livestock, 5) wildlife, 6) tourism, and 7) fisheries and aquaculture. Although different sector name is used in some reports, all the sector names are standardized into the said seven sectors. In general, hydropower generation is a non-consumptive use of water and thus normally is it not used in water balance calculation. The following descriptions focus on consumptive water uses.

1) Domestic and Institutional Water Demand

Domestic water demand has been estimated using the population projected based on the National Census 2002 and the unit water requirement by the area and income level classification, which are guided in the design manual[13] of MoWI. Future population was estimated based on the growth rate projected by National Bureau of Statistics (NBS) or Malthusian growth model that is also used by the NBS depending on the basin. Figure 3.3.1 shows the projected population by basin. NRW (non-revenue water) rates of 20% to 40% of gross demand were adopted depending on basins and target years. Institutional and commercial water demand were integrated with domestic water demand in the NIMP2018 study.

[13] Tanzania Design Manual for Water Supply and Waste Water Disposal (3rd edition, March 2009)



Source: Prepared by JICA Project Team based on the IWRMDP and LVBC study reports

Figure 3.3.1 Projected Population by Basin for 2015, 2025 and 2035

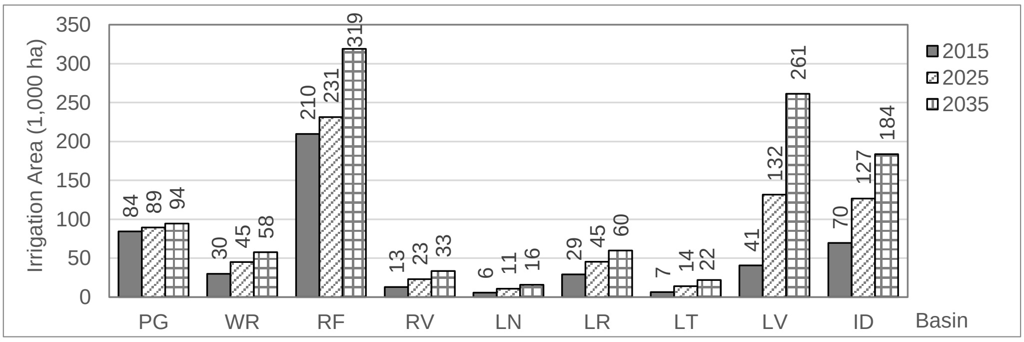
2) Industry and Mining Water Demand

There are broadly two types of estimation method. In some basins, industrial and mining water demand was estimated simply using a certain percentage of net domestic water demand. The percentages range from 10% to 15%. In the other basins, water demand was estimated based on the actual industry types that exist in the basins by using production volume (in ton), unit water requirement (in m^3/ton) and growth rate (in %). Some growth rates were determined based on the national industrial sector development target.

3) Irrigation Water Demand

Irrigation water demand has been estimated with the participation of Zonal Irrigation Offices (ZIO) and concerned district and regional engineers to the respective basins in the course of studies. Basic information on the current irrigation practices as well as future plans was provided by those offices. The projected irrigation areas for the time horizon are summarized in Figure 3.3.2. The total areas for 2015, 2025 and 2035 are 488,268 ha, 717,054 ha and 1,046,422 ha, respectively.

In most of basins, irrigation water requirement has been estimated based on the methodology[14] of the Ministry of Agriculture, Flood Security and Cooperatives (MoAFSC). In some cases, the FAO method (CROPWAT[15] & CLIMWAT[16]) adopted in the previous study conducted in the basin were used. Irrigation efficiency applied to the estimation ranges from 25% to 50% depending on basins and condition of canal lining, though some basins provided no clear information in the reports.



Source: Prepared by JICA Project Team based on the IWRMDP and LVBC study reports

Figure 3.3.2 Projected Irrigation Area by Basin for 2015, 2025 and 2035

[14] Comprehensive Guidelines for formulation of irrigation Schemes under District Agricultural Development Projects
[15] CROPWAT is a decision support tool developed by the Land and Water Development Division of FAO.
[16] CLIMWAT is a climatic database to be used in combination with the computer program CROPWAT.

4) Livestock Water Demand

Estimation of livestock water requirements is basically made based on livestock population and daily per capita water consumption. The design manual[17] of MoWI provides specific guidelines on recommended per capita livestock water requirements of 25 liters per Livestock Unit (LU) per day. On the other hand, the number of base livestock population was collected from the survey in 2007/08 conducted by MoAFSC or collected from various districts based on social surveys. The design manual also recommends specific annual growth rates for respective species.

5) Wildlife Water Demand

Wildlife water demand was estimated in the four basins. Since the number of wildlife in Tanzania has been surveyed by TAWIRI[18] in particular areas such as national park, game reserve, Ramsar site, etc., the estimation was also made for the surveyed areas. Unit water requirement is estimated as equivalent to 4% of the body weight (Bothma, 2002).

The increase rate of estimated wildlife water demand from 2015 to 2035 is relatively large compared to the other sectors. This is attributed to the considerable increase in two basins, namely the Ruvuma and Lake Tanganyika basins. In the Ruvuma basin, although the number of wildlife is not expected to increase, water demand is assumed to increase at the rate of 25% per decade considering the plan to construct ponds in strategic areas within the game reserves to provide water in drought periods. In the Lake Tanganyika basin, the number of wildlife is expected to increase according to the projection using a basic population growth model.

6) Tourism Water Demand

Tourism water demand was estimated in the three basins. The report for the Internal Drainage basin provided no explanation in terms of calculation basis. In the Pangani and Lake Tanganyika basins, the demand was estimated for the national parks located in the basins. The number of visitors is predicted based on visitor numbers from recent years. The unit water requirement was set at 300 liters per tourist per day based on the information in South Africa.

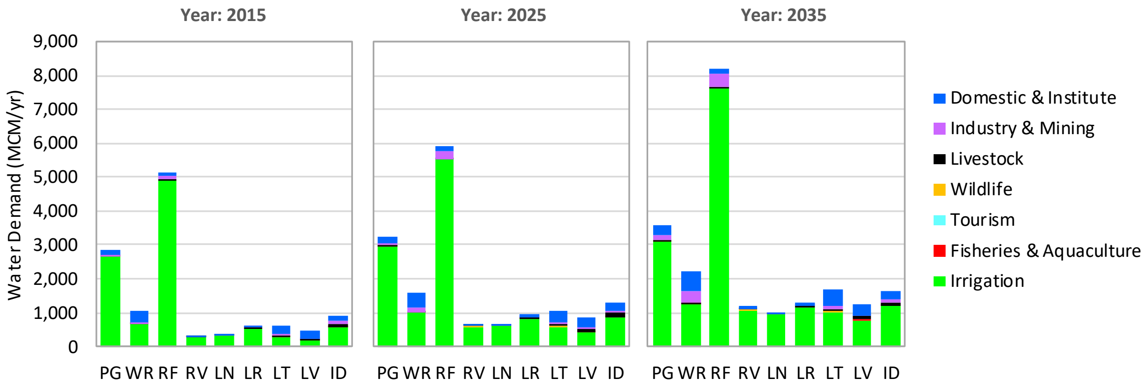
7) Fisheries and Aquaculture Water Demand

Fisheries and aquaculture water demand was estimated in the three basins. The reports for the Internal Drainage basin provided no explanation in terms of calculation basis. In the Wami/Ruvu and Lake Victoria basins, water demand was estimated as water requirement to compensate water loss due to evaporation and seepage in fish ponds based on the number and assumed area of fish pond.

(2) Summary of Water Demand by Basin

The water demand by sector by basin for the years 2015, 2025 and 2035 are summarized in Figure 3.3.3. The bar chart graphs offer an indication of the differences between basins and between sectors. As seen in the figure, the irrigation sector accounts for more than 80% of the total water demand, while the wildlife, tourism and fisheries & aquaculture sectors account for quite small percentages.

[17] Tanzania Design Manual for Water Supply and Waste Water Disposal (3rd edition, March 2009)
[18] Tanzania Wildlife Research Institute



Source: Prepared by JICA Project Team based on the IWRMDP and LVBC study reports

Figure 3.3.3 Annual Water Demand by Basin for 2015, 2025 and 2035

The numerical figures for the years 2015, 2025 and 2035 corresponding to Figure 3.3.3 are presented in Table 3.4.1, Table 3.4.2, and Table 3.4.3, respectively, in the sub-section 3.4.2. Besides, the water demand data by sub-basin for 2035 is presented in Attachment 3. However, the irrigation water demands for the Pangani and Lake Nyasa basins were adjusted in the NIMP2018 as explained in the sub-section 3.5.1. Therefore, the data presented in Attachment 3 indicate allocated water for each sector.

3.3.2 Environmental Flow Requirement

(1) Background

Environmental flow requirement (EFR) is non-consumptive requirement of water. However, it should be considered as part of water resources management in order to preserve normal functions of river flow. In formulating the NIMP2002, no regard was given to EFR possibly because the concept of EFR has not become general yet at that time particularly in developing countries.

As stated in the sub-section 2.3.2, currently the Environmental Water Requirements Assessment Guidelines (hereinafter called the EWR Guidelines) is being prepared by the MoWI. Since the existing IWRMDPs have been formulated before the finalization of EWR Guidelines, the EFR studies carried out in the IWRMDPs are not always fully compliant with the EWR Guidelines. In some basins, detailed EFR studies had been conducted before the IWRMDPs and in that cases the results of previous EFR studies were reflected to the IWRMDPs. In the other cases, EFR was assessed with possible methods.

(2) Assessment of EFR by Basin

The basic methods of assessing EFR by each basin are briefed as below:

i) <u>Pangani Basin</u>:

Lack of biodata in the basin forces the adoption of the Texas method which uses percentile of median monthly flow in any given flow regime and time mimicking the natural flows in the river. Using this method a 40-60% of the median monthly flow is recommended for adequate health of the rivers in the basin.

ii) Wami/Ruvu Basin:

Prior to the IWRMDP study, EFR was calculated based on the result of environmental flow assessment. However, as a result of comparison between the EFR and the observed discharge at the representative stations, it was confirmed that the EFR set at some points are considered excessive compared to the actual river flow conditions. Therefore, more reasonable and realistic EFR were alternatively set in the IWRMDP study.

iii) Rufiji Basin:

EFR obtained through the previous assessment, which was carried out partially in the basin by WWF in the late 2000s, were incorporated in the scenario assessments carried out under the IWRMDP study. In addition to those areas, a rapid desktop approach based on the Building Block Methodology (BBM) was used to estimate EFR at three other critical locations.

iv) Ruvuma Basin:

The Desktop Reserve Model incorporating the concepts of the Building Block Methodology was used in the study to estimate EFR. The study classified most catchments into the Category B or B/C and as a result the ratios of EFR to runoff range from 31% to 53%. The study emphasized that the estimated EFR should be reviewed in a detailed manner when any developmental activities are considered in future.

v) Lake Nyasa Basin:

The study recommended that in the absence of adequate biological data, a hydrological method that specifies percentages of the mean annual flow that provide different quality habitats should be used to estimate environmental flows. Although the report provides no clear description, it is assumed that the study adopted the Tenant Method.

vi) Lake Rukwa Basin:

Two methods were employed in the study. The Building Block Methodology (BBM) was applied to two of the most critical sub-basins with respect to water use and water resources management issues. The Desktop Reserve Model (DRM) method was applied to four sub-basins, which include the two basins for BBM. The rapid assessment with DRM was intended to supplement the detailed assessment conducted only for the critical two sub-basins.

vii) Lake Tanganyika Basin:

The Texas method was applied for determination of EFR. An environmental flow target of 40% of median monthly flows was finally recommended, as this is a commonly accepted value to maintain river health.

viii) Lake Victoria Basin:

EFR has not been assessed in the basin. The LVBC study estimated sanitation water demand instead of EFR. It is defined in the report as water flow required in order to dilute the pollution loads to a certain level. The study has estimated the sanitation water demand using BOD5[19] by sub-basin under various population and access to sanitation scenarios.

[19] The BOD value is most commonly expressed in milligrams of oxygen consumed per litre of sample during 5 days of incubation at 20 °C.

ix) Internal Drainage Basin:

Most of rivers in the basin are ephemeral or seasonal. EFR of the perennial rivers was estimated using the Texas method. Regarding the seasonal and major ephemeral rivers, the customized Texas method was employed, in which a percentage of the natural water potential (considered as 30% to maintain a good condition in the stream) in each catchment is allocated to the environment.

(3) Re-assessment of EFR in NIMP2018

(a) Rufiji Basin

EFR was estimated in the Rufiji IWRMDP only for three sub-basins. Therefore, EFR for the remaining one sub-basin was additionally estimated based on the EFR for the neighboring sub-basin by multiplying ratios of monthly surface runoff.

(b) Lake Rukwa

BBM was primarily applied to the two sub-basins. The EFR estimated with this method was not for the entire sub-basin but for a particular reference point. After converting the EFR at the point to the entire sub-basin with their catchment area ratios, it was found that the monthly EFR exceed monthly surface runoff in some months particularly in the rainy season. Therefore, the NIMP2018 selected the results of DRM. Since the estimation with this method is limited to four sub-basin, the EFR for the remaining sub-basins was additionally estimated based on the EFR for the neighboring sub-basin by multiplying ratios of monthly surface runoff.

(c) Lake Victoria Basin

In the Lake Victoria basin, sanitation demand for the year 2040[20] was estimated for the following three scenarios. The NIMP2018 will employ the third one because it would be the most realistic scenario and the sanitation demands estimated with the first and second scenarios are considerably large compared with available water resources.

- in 2040 with constant population growth and constant access to improved sanitation facilities
- in 2040 with linearly decreasing population growth (down to 0% in 2040) and constant access to improved sanitation facilities
- in 2040 with linearly decreasing population growth (down to 0% in 2040) and higher access to improved sanitation facilities (85% everywhere in the LVB)

The selected sanitation demand was still larger than surface runoff on in some months because the adopted BOD5 method does not take into account hydrological condition. Therefore, the monthly sanitation demand was adjusted up to a ceiling of each monthly surface runoff.

(d) Internal Drainage Basin

As with the case of the Lake Victoria basin, the monthly EFR was adjusted up to a ceiling of monthly surface runoff.

[20] Time horizon for the LVBC study is 2020 and 2040 and therefore all the estimates are made for the years 2020 and 2040. The estimates are interpolated to 2025 and 2035 in the NIMP2018.

(4) Summary of Estimated EFR by Basin

The respective IWRMDPs have estimated EFR on a monthly basis. On the other hand, the LVBC study has estimated sanitation water demand on an annual basis because the demand is strongly related to human activities and therefore it is almost constant through the year.

In some assessment methods, EFR is estimated based on natural surface runoff. In that case, the future EFR may be changed in accordance with the change of surface runoff due to climate change. However, the EFR for the years 2025 and 2035 was estimated only in the Pangani, Lake Nyasa and Lake Victoria basins. The NIMP2018 will use the 2015 EFR for the years 2025 and 2035 if unobtainable from the reports.

The monthly EFR estimates for 2015 are summarized into annual basis as presented in Table 3.3.1. The ratio of EFR to surface runoff water ranges from 0.23 to 0.53 except for the Wami/Ruvu basin, where the theoretically desirable EFR that was estimated in the previous study was downwardly adjusted in the IWRMDP study from the viewpoint of actual hydrological conditions. The monthly EFR by sub-basin for 2035 is presented in Attachment 4.

Table 3.3.1 Annual Environmental Flow Requirement by Basin for 2015

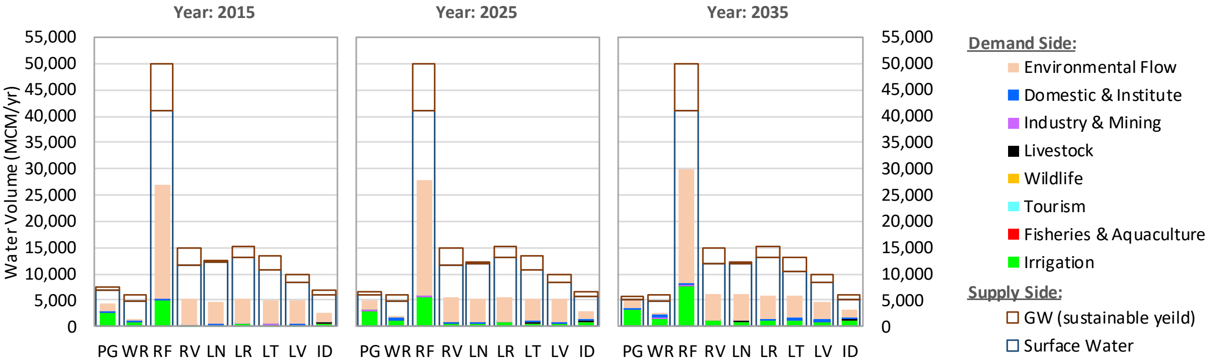
Basin	Catchment Area	Surface Water (SW)		Environmental Flow Requirement (EFR)		Ratio EFR / SW
	km^2	MCM/yr	mm/yr	MCM/yr	mm/yr	
Pangani	59,102	6,963	118	1,622	27	0.23
Wami / Ruvu	66,295	4,865	73	298	4	0.06
Rufiji	183,791	41,049	223	21,850	119	0.53
Ruvuma	105,582	11,700	111	4,801	45	0.41
Lake Nyasa	27,594	12,188	442	4,161	151	0.34
Lake Rukwa	74,965	12,982	173	4,674	62	0.36
Lake Tanganyika	149,500	10,641	71	4,271	29	0.40
Lake Victoria	85,630	8,439	99	4,400	51	0.52
Internal Drainage	143,100	5,985	42	1,599	11	0.27
Total	895,559	114,812	128	47,676	53	0.42

Source: Prepared by JICA Project Team based on the IWRMDP and LVBC study reports

3.4 Assessment of Water Stress

3.4.1 Summary of Annual Estimates

The monthly water resources, the monthly environmental flow requirement, and the monthly water demand estimated in the previous sections 3.2 and 3.3 are summarized on an annual basis in Figure 3.4.1. The numerical figures for the years 2015, 2025 and 2035 corresponding to Figure 3.4.1 are presented in the following Table 3.4.1, Table 3.4.2, and Table 3.4.3, respectively, in the sub-section 3.4.2.



Note: *Groundwater in the graph indicate sustainable yield of groundwater resources.*
Source: *Prepared by JICA Project Team based on the IWRMDP and LVBC study reports*

Figure 3.4.1 Summary of Annual Water Resource and Water Demand by Basin

3.4.2 Assessment based on Water Exploitation Index

For the purpose of understanding the severity of water stress by basin, WEI (water exploitation index) was calculated as percentage of total consumptive water demand to internal renewable water resources, which consist of surface runoff and annual groundwater recharge. The result is presented in the following tables as well as Figure 3.4.2. The figures in the tables are rounded to an integer. Several international organizations including OECD (Organization for Economic Co-operation and Development) define the situation as "under severe water stress" in case the annual WEI exceeds 40%. It was found from the tables and the figure that the Pangani basin is almost under severe water stress even in the current condition and the water stresses of all the basins will progressively increase towards 2035.

Table 3.4.1 Summary of Annual Water Resource and Water Demand by Basin for 2015

Basin	Water Resources (MCM/yr)			EFR (MCM/yr)	Water Demand (MCM/yr)								Annual WEI (%)
	SW	GW-S	GW-R		Dom	Ind	Irr	Liv	Wil	Tou	Fis	Total	
PG	6,963	587	1,466	1,622	157	36	2,657	12	0	0	0	2,862	34%
WR	4,865	1,139	4,273	298	345	61	656	15	0	0	0	1,076	12%
RF	41,049	9,021	22,533	21,850	69	131	4,905	19	0	0	0	5,124	8%
RV	11,700	3,238	8,307	4,801	50	0	254	7	25	0	0	335	2%
LN	12,188	107	1,070	4,161	34	11	309	11	0	0	0	365	3%
LR	12,982	2,136	5,341	4,674	54	2	532	13	0	0	0	600	3%
LT	10,641	2,755	5,511	4,271	215	63	273	25	16	1	0	592	4%
LV	8,439	1,327	4,424	4,400	206	15	163	73	0	0	0	456	4%
ID	5,985	884	4,421	1,599	176	89	561	87	4	0	0	917	9%
Total	114,812	21,195	57,345	47,676	1,306	407	10,309	261	45	1	1	12,329	7%

Note-1: *SW = Surface Water, GW-S = Groundwater (sustainable yield), GW-R = Groundwater (recharge), EFR = Environmental Flow Requirement, Dom = Domestic & Institute, Ind = Industry & Mining, Irr = Irrigation, Liv = Livestock, Wil = Wildlife, Tou = Tourism, Fis = Fisheries & Aquaculture*
Note-2: *WEI (water exploitation index) here is calculated as percentage of total water demand to internal renewable water resources, which consist of surface runoff and groundwater recharge.*
Source: *Prepared by JICA Project Team based on the IWRMDP and LVBC study reports*

Table 3.4.2 Summary of Annual Water Resource and Water Demand by Basin for 2025

Basin	Water Resources (MCM/yr)			EFR (MCM/yr)	Water Demand (MCM/yr)								Annual WEI (%)
	SW	GW-S	GW-R		Dom	Ind	Irr	Liv	Wil	Tou	Fis	Total	
PG	5,881	587	1,466	1,655	204	56	2,959	14	1	0	0	3,234	44%
WR	4,865	1,139	4,273	298	441	142	993	19	0	0	0	1,595	17%
RF	41,049	9,021	22,533	21,850	110	245	5,504	33	0	0	0	5,891	9%
RV	11,755	3,238	8,307	4,801	61	0	568	8	36	0	0	673	3%
LN	12,041	102	1,070	4,545	39	11	606	11	0	0	0	668	5%
LR	12,982	2,136	5,341	4,674	83	3	832	16	0	0	0	934	5%

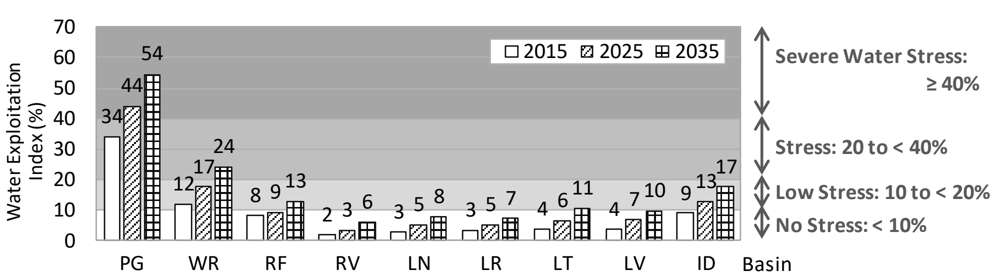
Basin	Water Resources (MCM/yr)			EFR (MCM/yr)	Water Demand (MCM/yr)								Annual WEI (%)
	SW	GW-S	GW-R		Dom	Ind	Irr	Liv	Wil	Tou	Fis	Total	
LT	10,750	2,755	5,511	4,271	318	67	578	30	29	13	0	1,037	6%
LV	8,439	1,327	4,424	4,466	322	23	430	84	0	0	6	865	7%
ID	5,654	884	4,421	1,599	206	95	869	107	4	0	0	1,282	13%
Total	113,417	21,189	57,345	48,159	1,784	642	13,338	323	70	13	7	16,179	9%

Note: Same as Table 3.4.1
Source: Prepared by JICA Project Team based on the IWRMDP and LVBC study reports

Table 3.4.3 Summary of Annual Water Resource and Water Demand by Basin for 2035

Basin	Water Resources (MCM/yr)			EFR (MCM/yr)	Water Demand (MCM/yr)								Annual WEI (%)
	SW	GW-S	GW-R		Dom	Ind	Irr	Liv	Wil	Tou	Fis	Total	
PG	5,099	587	1,466	1,667	294	155	3,110	16	1	0	0	3,577	54%
WR	4,865	1,139	4,273	298	552	355	1,268	25	0	0	0	2,201	24%
RF	41,049	9,021	22,533	21,850	149	363	7,619	58	0	0	0	8,188	13%
RV	11,794	3,238	8,307	4,801	76	0	1,056	12	47	0	0	1,191	6%
LN	11,959	96	1,070	5,019	50	12	938	12	0	0	0	1,012	8%
LR	12,982	2,136	5,341	4,674	110	4	1,164	21	0	0	0	1,298	7%
LT	10,474	2,755	5,511	4,271	520	75	986	37	52	27	0	1,699	11%
LV	8,439	1,327	4,424	3,514	335	24	772	96	0	0	17	1,245	10%
ID	4,981	884	4,421	1,599	229	102	1,177	131	4	0	0	1,644	17%
Total	111,641	21,184	57,345	47,693	2,315	1,090	18,091	408	104	27	18	22,056	13%

Note: Same as Table 3.4.1
Source: Prepared by JICA Project Team based on the IWRMDP and LVBC study reports



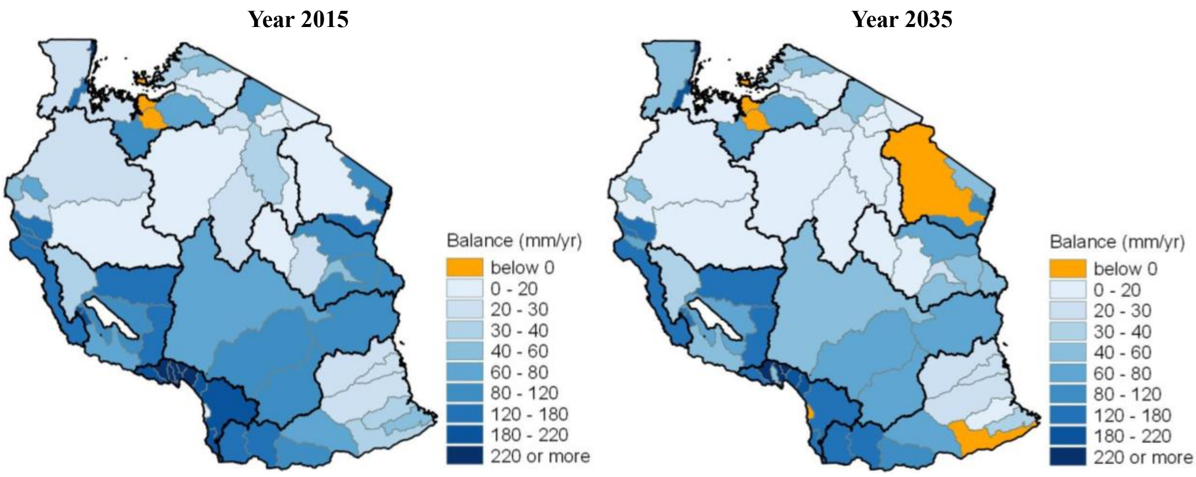
Source: Prepared by JICA Project Team based on the IWRMDP and LVBC study reports

Figure 3.4.2 Water Exploitation Index by Basin

3.4.3 Assessment based on Annual Water Balance Calculation

Prior to monthly water balance calculation to be made in the following section 3.5, annual water balance by sub-basin was preliminarily calculated under the limited assumption. Considering the fact that groundwater use is still supplementary supply side factor, in this section water balance was calculated by deducting EFR and all water demand from surface water by sub-basin. Surface flow from upstream sub-basin to downstream sub-basin was simply considered in the Wami/Ruvu and Rufiji basins, where downstream demand largely depend on upstream surface water. The computation result of annual water balance is summarized by sub-basin as presented in Figure 3.4.3.

The legend of below 0 (zero) in the figure means that the EFR and/or water demand are not satisfied by surface water even in annual calculation. Out of the six sub-basins with the balance below zero, the four sub-basins are not recoverable with groundwater supply. In that case, EFR and/or water demand need to be reviewed and adjusted unless inter-boundary transfer of water is considered.



Note: Groundwater use has not been considered in this calculation.
Source: Prepared by JICA Project Team based on the IWRMDP and LVBC study reports

Figure 3.4.3 Annual Water Balance by Sub-basin

3.5 Water Resources for Irrigation Sector

As illustrated in Figure 3.1.1 above, water resources for irrigation were considered with a two-step process, namely 3rd) allocated water and 4th) potential water, which are explained in the following sub-sections 3.5.1 and 3.5.2, respectively. The allocated water is basically to be used for the NIMP2018, while the potential water is presented as reference.

3.5.1 Allocated Water for Irrigation

(1) Approach for Determining Water for Irrigation

Water resources allocated for irrigation in the respective IWRMDPs can be basically considered secured and fully available for irrigation use by 2035. Irrigation areas to be proposed in the NIMP2018 will be elaborated within these water allocations, though some improvement of irrigation system may be assumed in terms of cropping pattern, irrigation efficiency, etc.

However, the problem is that the IWRMDPs have not yet been formulated in the three basins, namely Pangani, Wami/Ruvu and Lake Victoria basins. This means that the projected irrigation water demands have neither been officially allocated nor secured. Therefore, it is necessary to review whether or not the water demands projected in the existing studies are realistically manageable for the three basins.

In addition, the annual water balance calculation made in sub-section 3.4.3 indicated that the projected water demands for 2035 are not met in four sub-basins, which are included in the Pangani, Lake Nyasa and Lake Victoria basins. Therefore, irrigation demand for the Lake Nyasa basin need to be additionally reviewed below.

(2) Review of Irrigation Water Demands for Four Basins

(a) Pangani Basin

The result of annual water balance calculation by sub-basin is summarized in Table 3.5.1. As seen in the table, the water demand in the Pangani River sub-basin will not be satisfied in 2025 and 2035 if EFR (environmental flow requirement) is deducted from SW (surface water). Even if GW (groundwater) is fully used, the deficit remains.

The deficit in annual calculation means that any water storage facilities are not able to overcome the water shortage within the sub-basin unless water is supplied from the other sub-basins. However, from the topographic viewpoint, water transfer from the surrounding sub-basins is not realistic.

Table 3.5.1 Annual Water Balance by Sub-basin for Pangani Basin

Sub-basin Name	Area (km^2)	SW (MCM/yr)			GW (MCM/yr)			Demand (MCM/yr)			EFR (MCM/yr)			SW - EFR - Dem (MCM/yr)		
		2015	2025	2035	2015	2025	2035	2015	2025	2035	2015	2025	2035	2015	2025	2035
Pangani River	43,652	4,832	4,096	3,524	466	466	466	2,685	2,976	3,209	1,511	1,544	1,557	636	**-424**	**-1,242**
Umba	8,205	934	733	611	71	71	71	133	154	190	19	19	19	782	559	401
Msangazi	5,085	687	601	543	31	31	31	12	54	102	1	1	1	674	546	440
Zigi-Mkulumuzi	2,159	510	452	422	18	18	18	33	49	76	91	90	90	387	312	256

Source: Prepared by JICA Project Team based on the Pangani IWRMDP study report

On the other hand, the percentage of EFR to SW in the Pangani River sub-basin for 2035 is 44%. This is quite large compared to the other three sub-basins. However, the EFR of Pangani River sub-basin almost correspond to the plant discharge required for hydropower generation at the existing New Pangani Falls HPP. Thus, the EFR is hardly able to be reduced.

It is particularly worth noting that one of the key features in the Pangani basin assessment is largely decreasing surface water by 27% from 2015 to 2035 due to climate change. The surface water might be reviewed at the planning stage, however, this is still unclear factor at present. Even if irrigation area is not further developed, the projected water demand for 2035 will not be satisfied. The envisaged future water deficit need to be managed by more effective utilization of water resources in various sectors and/or alternative power generation means. If the deficit is managed only by the irrigation sector, water resources allocated for irrigation sector in 2035 will be less than 78% of 2015-based irrigation water demand, according to the monthly calculation made in the following sub-section 3.5.2.

Considering the severe situation of the Pangani River sub-basin, irrigation water use in the sub-basin cannot be increased from 2015 to 2025 and need to be reduced by 22% from 2015 to 2035 by improving irrigation system or reducing irrigation area. The NIMP2018 study will adopt the above-adjusted irrigation water in planning irrigation development for 2025 and 2035 for the sub-basin.

(b) Wami/Ruvu Basin

Although the IWRMDP for the Wami/Ruvu basin has not been formulated, a comprehensive water resources management and development plan was prepared in 2013 with technical assistance of JICA. The MoWI has positioned the plan as an assessment part of IWRMDP because climate change impacts have not been taken into account the said plan.

The plan also proposed appropriate water resources development measures including new construction of 16 reservoirs and heightening of the existing 5 dykes, with careful consideration of the reliability of water utilization of 1/10-yr drought.

There is still possibility of monthly water deficit if climate change impacts are considered. However, from the viewpoint of annual water balance presented in Table 3.5.2, water deficit will be manageable[21]

[21] This is a view by JICA Study Team, not agreed with the MoWI.

within the basin. Therefore, the NIMP2018 study will adopt the projected water demands without changes.

Table 3.5.2 Annual Water Balance by Sub-basin for Wami/Ruvu Basin

Sub-basin Name	Area (km^2)	SW (MCM/yr)			GW (MCM/yr)			Demand (MCM/yr)			EFR (MCM/yr)			SW - EFR - Dem (MCM/yr)		
		2015	2025	2035	2015	2025	2035	2015	2025	2035	2015	2025	2035	2015	2025	2035
Kinyasungwe	16,509	289	289	289	129	129	129	118	182	279	0	0	0	171	107	9
Mkondoa	12,964	671	671	671	179	179	179	290	422	502	3	3	3	378	246	166
Wami	14,270	1,408	1,408	1,408	169	169	169	141	209	247	91	91	91	1,176	1,108	1,070
Upper Ruvu	7,623	2,252	2,252	2,252	102	102	102	79	108	127	116	93	93	1,766	1,511	1,121
Ngerengere	2,913	156	156	156	27	27	27	33	50	82	0	0	0			
Lower Ruvu	7,253	54	54	54	283	283	283	62	100	119	70	85	85			
Coast	4,763	35	35	35	250	250	250	353	525	845	17	26	26			

Note: *The balance for the Upper Ruvu, Ngerengere, Lower Ruvu and Coast sub-basins are shown together because water demand in the lower sub-basins (Lower Ruvu and Coast) highly depend on the water supply from the upper sub-basins.*
Source: *Prepared by JICA Project Team based on the Wami/Ruvu IWRMDP study report*

(c) Lake Victoria Basin

As seen in the result of annual water balance presented in Table 3.5.3, three sub-basins will have annual deficit. However, the situation is considered still manageable within the basin by adjusting EFR and/or by water transfer between sub-basins. Since EFR has not been estimated for the Lake Victoria basin, sanitation water demand using BOD5 is provided instead in the water balance calculation. As a result, the percentages of EFR to SW exceed 90% in some sub-basins. The basin has enough leeway to review the EFR. Therefore, the NIMP2018 study will adopt the projected water demands without changes.

Table 3.5.3 Annual Water Balance by Sub-basin for Lake Victoria Basin

Sub-basin Name	Area (km^2)	SW (MCM/yr)			GW (MCM/yr)			Demand (MCM/yr)			EFR (MCM/yr)			SW - EFR - Dem (MCM/yr)		
		2015	2025	2035	2015	2025	2035	2015	2025	2035	2015	2025	2035	2015	2025	2035
Biharamulo	1,876	534	534	534	28	28	28	10	18	20	194	190	126	331	326	388
Eastern shore	6,677	587	587	587	107	107	107	49	74	78	300	318	294	238	196	214
Grumeti	12,856	323	323	323	166	166	166	24	58	116	207	212	187	92	53	20
Isanga	7,081	854	854	854	100	100	100	28	73	133	238	248	217	588	533	504
L.V. Islands	1,407	124	124	124	28	28	28	15	23	24	116	119	115	**-8**	**-19**	**-15**
Lower Kagera	19,341	2,436	2,436	2,436	327	327	327	80	157	222	1,830	1,829	1,228	527	450	986
Magogo-Moame	5,401	284	284	284	77	77	77	73	122	136	272	271	235	**-61**	**-109**	**-87**
Mara	5,277	463	463	463	92	92	92	14	35	68	133	139	114	316	289	281
Mbalageti	3,537	136	136	136	46	46	46	8	18	36	95	94	79	33	23	21
Nyashishi	1,689	41	41	41	26	26	26	43	67	68	41	41	41	**-43**	**-67**	**-68**
Simiyu	11,095	1,234	1,234	1,234	170	170	170	38	81	146	453	445	359	743	707	729
Southern shore	8,749	722	722	722	143	143	143	75	135	195	459	500	482	188	87	46
Western shore	644	701	701	701	17	17	17	1	2	3	63	61	37	637	638	661

Source: *Prepared by JICA Project Team based on the LVBC study report*

(d) Lake Nyasa Basin

As seen in the result of annual water balance presented in Table 3.5.4, the Muchuchuma sub-basin will have annual deficit in 2025 and 2035. Although the Lake Nyasa IWRMDP study report also points out this situation, it does not clearly mention any interventions. According to the inventory survey conducted in the NIMP2018 for the purpose of updating the irrigation database, there is no existing scheme in the sub-basin. Irrigation development is less expected even in the future. Therefore, as with the case of the above Pangani River sub-basin, it is recommended to reduce the irrigation water use for 2025 and 2035 to 96% and 89% of 2015-based irrigation water demand, respectively, based on the monthly calculation in the following sub-section 3.5.2.

Table 3.5.4 Annual Water Balance by Sub-basin for Lake Nyasa Basin

Sub-basin Name	Area (km^2)	SW (MCM/yr)			GW (MCM/yr)			Demand (MCM/yr)			EFR (MCM/yr)			SW - EFR - Dem (MCM/yr)		
		2015	2025	2035	2015	2025	2035	2015	2025	2035	2015	2025	2035	2015	2025	2035
Songwe	2,479	975	954	938	10	10	9	51	68	91	430	454	473	494	431	374
Kiwira	1,887	1,659	1,635	1,613	8	7	7	16	21	27	409	463	517	1,234	1,150	1,069
Mbaka	746	909	899	890	3	3	3	75	275	500	271	310	348	563	315	42
Lufilyo	1,012	1,033	1,022	1,010	5	4	4	54	77	102	357	353	395	622	592	513
Rumakali	684	758	752	743	3	3	3	1	1	1	228	261	293	530	490	449
Lumbira	2,153	928	917	909	9	8	8	2	2	3	452	446	442	474	468	464
Nkiwe	1,880	656	651	645	7	7	7	2	2	2	256	254	283	399	395	360
Ruhuhu	14,210	4,516	4,467	4,465	51	48	46	52	101	155	1,512	1,723	1,951	2,952	2,644	2,359
Muchuchuma	670	143	141	141	3	3	3	93	100	107	47	53	59	3	**-12**	**-26**
Mbawa	1,873	611	603	605	8	8	7	20	22	24	201	227	257	390	354	325

Source: Prepared by JICA Project Team based on the Lake Nyasa IWRMDP study report

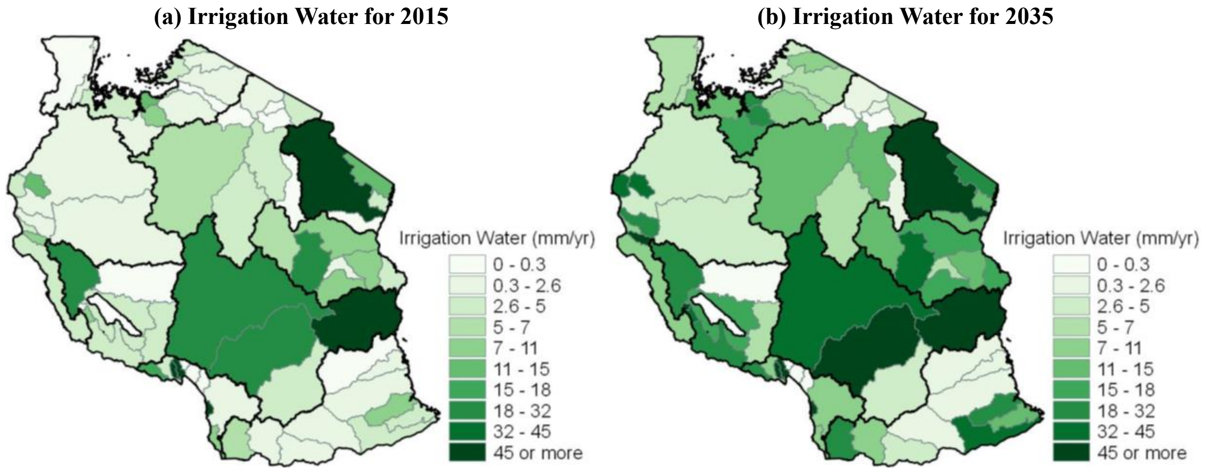
(3) Determined Water Allocation for Irrigation

As a result of the 3rd step process of Figure 3.1.1, monthly water resources for irrigation use by sub-basin have been determined. The allocated irrigation water is summarized in Table 3.5.5 by basin and Figure 3.5.1 by sub-basin. The NIMP2018 will utilize these figures for planning irrigation development.

Table 3.5.5 Annual Irrigation Water by Basin by Target Year

Basin	Original Irrigation Water Demand (MCM/yr)			Determined Water for Irrigation [To be used for NIMP2018] (MCM/yr)			Remarks
	2015	2025	2035	2015	2025	2035	
Pangani	2,657	2,959	3,110	2,657	**2,724**	**2,234**	Changed from IWRMDP
Wami / Ruvu	656	993	1,268	656	993	1,268	
Rufiji	4,905	5,504	7,619	4,905	5,504	7,619	
Ruvuma	254	568	1,056	254	568	1,056	
Lake Nyasa	309	606	938	309	**595**	**913**	Changed from IWRMDP
Lake Rukwa	532	832	1,164	532	832	1,164	
Lake Tanganyika	273	578	986	273	578	986	
Lake Victoria	163	430	772	163	430	772	
Internal Drainage	561	869	1,177	561	869	1,177	
Total	10,309	13,338	18,091	10,309	**13,092**	**17,190**	

Source: Prepared by JICA Project Team based on the IWRMDP and LVBC study reports



Source: Prepared by JICA Project Team based on the IWRMDP and LVBC study reports

Figure 3.5.1 Allocated Water for Irrigation by Sub-basin

The monthly data by sub-basin is presented in Attachment 3. Monthly allocation of irrigation water for the Ruvuma and Lake Victoria basins are determined based on cropping patterns proposed by the NIMP2018 because only annual irrigation water is presented in the previous study reports for those basins.

3.5.2 Potential Water for Irrigation

(1) Purpose of Estimating Potential Water for Irrigation

The above-mentioned allocated water on a monthly and sub-basin basis for the target year of 2035 is to be used in formulating an irrigation development plan in the NIMP2018. On the other hand, the NIMP2018 Project Team is requested to present the potential of further irrigation development under the assumption that surplus water resources are fully used for irrigation. Thus, the purpose of estimating potential water for irrigation is to grasp the irrigation potential areas from the perspective of limitation of water resources.

(2) Handling of Potential Water for Irrigation

The potential water to be estimated in this sub-section shall be basically treated as reference in the NIMP2018 for understanding the future potential of further irrigation development that will be incorporated into the plan after 2035. The potential water is defined as water resources remained unused in the existing water resources plans by 2035. The potential water comprises two forms, namely i) water exceeding environmental flow requirement among unused surface water flowing into sea or transboundary lakes, and ii) groundwater remained unused. It can be used not only for irrigation but also for the other sectors. Although the potential water is not basically used for irrigation development plan to be proposed in the NIMP2018, it may be partially used if the necessity of additional water use exceeding the allocated water arises.

(3) Approach for Estimating Potential Water for Irrigation

(a) Basic Data to be Used for Calculation

The following data that were compiled and/or estimated based on the IWRMDP and LVBC reports as well as provided by the MoWI are used in water balance calculation. All the data here are 2035 basis.

- Monthly water resources (surface water and groundwater) by sub-basin
- Monthly water demand and monthly environmental flow requirement (EFR) by sub-basin
- Storage capacities of the existing reservoirs and planned reservoirs proposed by IWRMDPs

(b) Key Considerations in Calculating Water Balance

Basic rules of how to supply water to each demand sector are considered as follows:

- The EFR needs to be secured only by surface water. This means that the potential water is not computed from a simple addition and subtraction method by sub-basin such as "surface water + groundwater – water demand – environmental flow".
- The water demand is divided into "irrigation" demand and "the other" demands in advance. Groundwater is used only for "the other" demands in the calculation. The "irrigation" here indicates the allocated water for irrigation, which was determined in the sub-section 3.5.1.
- Although balance calculation is made basically by sub-basin, the surface water resources generated but unused in upper sub-basins can be used in lower sub-basins. Among all the 71 sub-basins, only 8 sub-basins have flow to downstream sub-basins.

(c) Procedure of Water Balance Calculation

Step-wise procedures of calculation are listed as follows:

- At first, all water demands including EFR are deducted from surface water.
- If the demands are not satisfied only with the surface water, groundwater is added up to a ceiling of "the other" demands or sustainable yield of groundwater, whichever is smaller.
- If monthly water balance in a lower sub-basin is below zero and the deficit is recoverable by the remaining surface water of upper sub-basin, the surface water is properly accommodated.
- If monthly deficits still remain, water resources management and development using appropriate storage facilities must have been proposed in the IWRMDPs. Therefore, the thing to do here is to confirm whether the deficit volume is roughly covered by the existing and planned reservoir capacities.
- If the annual balance in a certain sub-basin is below zero, potential water for further irrigation development in the sub-basin is set at zero through the year. If the monthly balance in a certain sub-basin is below zero, potential water in the sub-basin is set at zero in the month.
- Finally, surplus water resources that are remained as plus in the balance calculation are estimated dividing into surface water and groundwater.

(d) Output to be Yielded from the Calculation

From the above computation, the following water resources are regarded as potential water available for further irrigation development:

- Monthly water exceeding EFR among unused surface water flowing into sea or transboundary lakes
- Monthly groundwater remained unused for "the other" demands

(4) Monthly Water Deficit to be Managed

The water deficits computed on a monthly and sub-basin basis are summarized into an annual and basin basis as presented in Table 3.5.6 together with the reservoir capacity of existing and planned dams.

Obviously, this is a rough computation at both demand and supply sides. The estimated deficit may not include the localized short-term water shortages especially during peak irrigation periods. On the other hand, some of small reservoirs or water pans may not be counted in the reservoir capacity. Although the computation has such accuracy limitation, this clause gives comparison of the both sides for the purpose of confirming whether the monthly water deficit is managed by water supply from the reservoirs.

As seen in the table, the total of monthly water deficit for 2035 is not manageable in the Pangani, Rufiji and Lake Victoria basins. The reasons for the Pangani and Lake Victoria basins are because future storage facilities have not been proposed. The situation of Rufiji basin would be improved if EFR is reviewed and appropriately modified particularly for the Kilombero sub-basin where the percentage of EFR to surface water account for 57% in the current IWRMDP. The MoWI also consider there is room for further review in terms of EFR for the Rufiji basin.

Table 3.5.6 Comparison of Monthly Water Deficit and Reservoir Capacity

Basin Code	Total of Monthly Sub-basin Deficit (MCM/yr)			Reservoir Capacity (MCM)			Result of Comparison for 2035	Remarks
	2015	2025	2035	Total	Existing	Planned		
PG	357	607	497	49	49	0	Insufficient	IWRMDP has not been formulated.
WR	18	163	398	539	41	498	Sufficient	
RF	25	95	1,113	290	80	210	Insufficient	EFR need to be reviewed.
RV	17	82	226	377	19	358	Sufficient	
LN	19	60	177	6,200	0	6,200	Sufficient	Kikonge dam will be used for HPP as well.
LR	67	87	150	762	0	762	Sufficient	
LT	0	0	5	50	50	0	Sufficient	
LV	81	174	208	78	78	0	Insufficient	IWRMDP has not been formulated.
ID	163	280	477	802	108	694	Sufficient	

Source: Prepared by JICA Project Team based on the IWRMDP and LVBC study reports

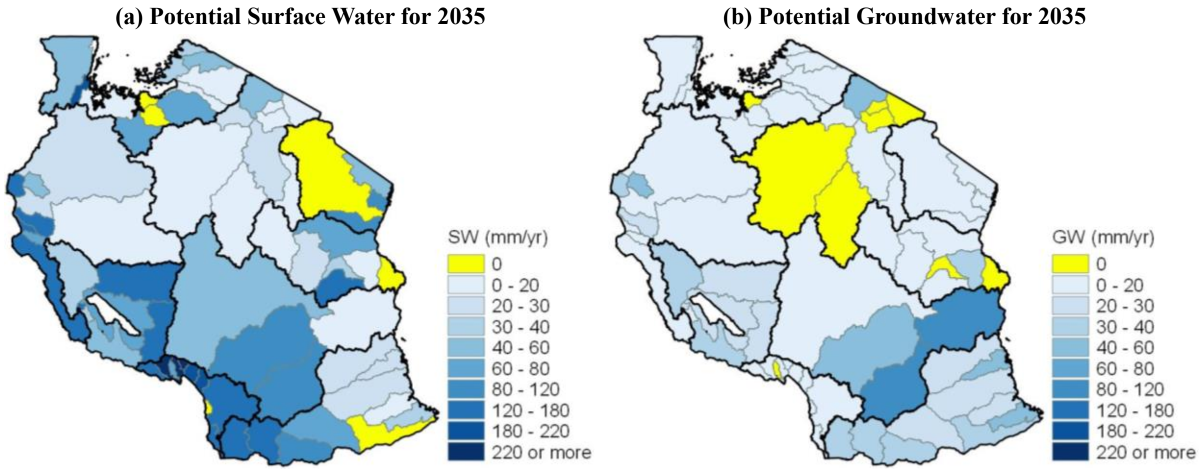
(5) Estimated Potential Water for Irrigation

The computation was made on a monthly and sub-basin basis. The result of estimating the potential water for irrigation is summarized into annual data and presented in Table 3.5.7 by basin and Figure 3.5.2 by sub-basin. The monthly data by sub-basin is presented in Attachment 5.

Table 3.5.7 Estimated Potential Water for Irrigation by Basin for 2035

Basin	Catchment Area	Potential Surface Water		Potential Groundwater		Potential SW+GW	
	(km^2)	(MCM/yr)	(mm/yr)	(MCM/yr)	(mm/yr)	(MCM/yr)	(mm/yr)
Pangani	59,102	1,097	19	220	4	1,317	22
Wami / Ruvu	66,295	2,731	41	775	12	3,505	53
Rufiji	183,791	11,485	62	8,548	47	20,032	109
Ruvuma	105,582	5,866	56	3,173	30	9,039	86
Lake Nyasa	27,594	5,957	216	103	4	6,060	220
Lake Rukwa	74,965	7,063	94	2,083	28	9,146	122
Lake Tanganyika	149,500	5,168	35	2,091	14	7,259	49
Lake Victoria	85,630	3,998	47	1,009	12	5,007	58
Internal Drainage	143,100	2,112	15	510	4	2,622	18
Total	895,559	45,477	51	18,511	21	63,988	71

Source: Prepared by JICA Project Team based on the IWRMDP and LVBC study reports



Source: Prepared by JICA Project Team based on the IWRMDP and LVBC study reports

Figure 3.5.2 Estimated Potential Water for Irrigation by Sub-basin for 2035

(6) Consideration for Utilizing the Potential Water

Due to the limitation of computation accuracy as well as extreme calculation conditions, it must be noted that the estimated potential water is not completely utilized for irrigation purpose realistically. Besides, careful attentions should be paid particularly to the following matters in incorporating the potential water into irrigation development plan.

- Assuming that the water storage facilities proposed in the IWRMDPs can cover only the water demand projected for the year 2035, additional irrigation areas shall be examined based on monthly water resources without storage effect. If favorable dam site for additional water storage is found in the future, storage effect will be able to be considered.
- Increase in water demands for the sectors other than irrigation after 2035 have not been considered in estimating the above potential water. If the estimated potential water is used for irrigation water use planning after 2035, it is necessary to take into account the increase in water demands for the other sectors as well.
- When the potential surface water flows from upper sub-basin to lower sub-basin, the surface water resources can be withdrawn at either sub-basin.
- Groundwater was used only for the sectors other than irrigation in the above computation. On the other hand, the estimated potential groundwater could be fully used for irrigation, in theory. It is necessary to study whether the groundwater use for irrigation purpose is feasible or not.

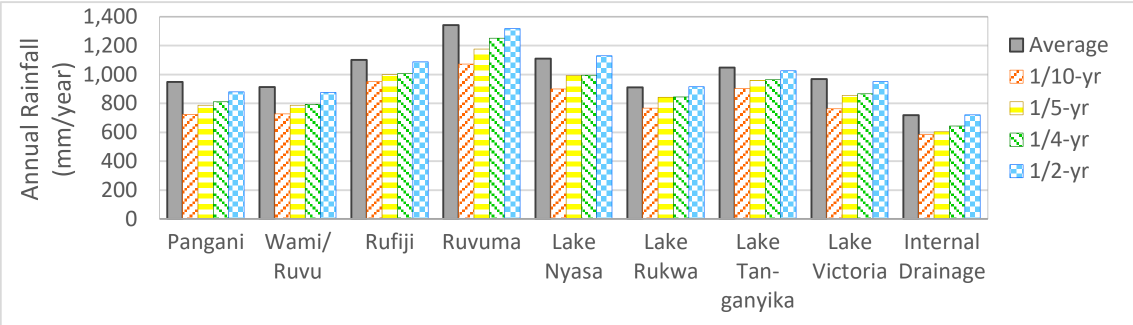
3.6 Supplemental Study on Reliability of Water Utilization

(1) Purpose and Characterization of the Study

As mentioned in the section 2.6 above, the water resources plans of most basins were formulated without adequate attention to reliability of water utilization, while not necessarily incorrect. In this regard, the purpose of this supplemental study it to assess how the mean values of long-term runoff data are different from drought runoff data with various return periods. This section will provide an example of quick hydrological assessment from the viewpoints of rainfall and river discharge. In that sense, this supplemental study is characterized only as a reference.

(2) Long-term Rainfall Analysis for Considering Return Periods

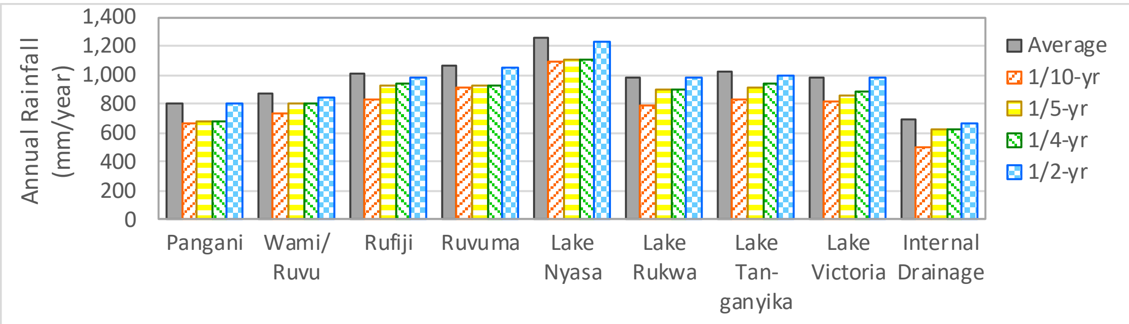
In order to assess water resources in probable drought year, long-term rainfall analysis was made by using reanalysis dataset of 30 years. After comparing several dataset of historical rainfall in terms of usability and applicability to Tanzania, the CGIAR-CSI[22] dataset[23] was initially analyzed. The results are summarized in Figure 3.6.1 below. It was found that annual rainfall of 1/5-yr drought is almost 83% to 92% of mean annual rainfall (average of 30 years).



Source: JICA Project Team based on CRU-TS v3.10.01 Historic Climate Database (1980-2009) provided by CGIAR-CSI

Figure 3.6.1 Annual Rainfall of Each Probable Drought Year by Basin (CGIAR-CSI)

In addition, the CHIRPS-CHG[24] dataset[25] was also analyzed in the same way. The results are summarized in Figure 3.6.2 below. It was found that annual rainfall of 1/5-yr drought is almost 84% to 91% of mean annual rainfall (average of 30 years).



Source: JICA Project Team based on CHIRPS data (1981-2010) provided by CHG

Figure 3.6.2 Annual Rainfall of Each Probable Drought Year by Basin (CHIRPS-CHG)

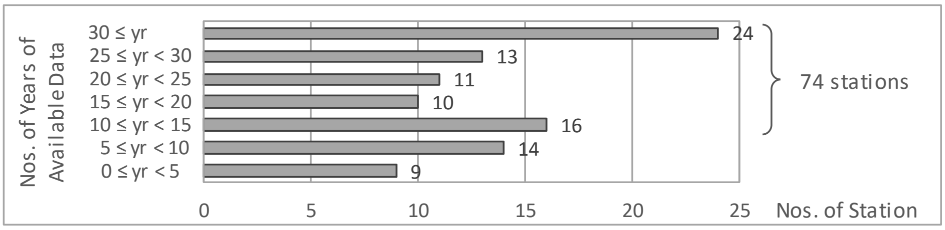
From the both above analyses, it may be said that annual rainfall of 1/5-yr probable drought correspond to almost 80% of long-term mean rainfall even though regional distribution of rainfall height is different depending on the dataset.

(3) Long-term Discharge Analysis for Considering Return Periods

In order to more appropriately assess water resources, long-term discharge analysis is better than rainfall analysis. The problem is that discharge data is less accessible than rainfall data. JICA Project Team decided to utilize well-organized discharge data, which is provided by an international institution in the form of mean monthly discharge.

[22] Consultative Group on International Agricultural Research (CGIAR) - Consortium for Spatial Information (CSI)
[23] University of East Anglia (UEA)'s CRU-TS is one of the most widely used historical climate database. To help facilitate the use of this database, CGIAR-CSI have converted the raw data into the ESRI ASCII raster format.
[24] Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) - Climate Hazards Group (CHG)
[25] CHIRPS is a 30+ year quasi-global rainfall dataset. CHIRPS incorporates 0.05° resolution satellite imagery with in-situ station data to create gridded rainfall time series for trend analysis and seasonal drought monitoring.

The database of GRDC[26] provides river discharge data at 97 monitoring stations covering all the nine basins in the mainland of Tanzania. The data of 97 stations cover a little bit old years between 1940 and 1991. The number of years of available data is summarized in Figure 3.6.3. As seen in the figure, 74 stations have relatively long-term data of 10 years or more.



Source: JICA Project Team based on discharge data provided by GRDC

Figure 3.6.3 Numbers of Years of Available Discharge Data

Out of the obtained 97 stations, anomalous or inappropriate data need to be excluded from the analysis. Thus, stations that fail to fulfill the following three conditions were removed.

i) There are mean annual discharge data for 10 years or more.

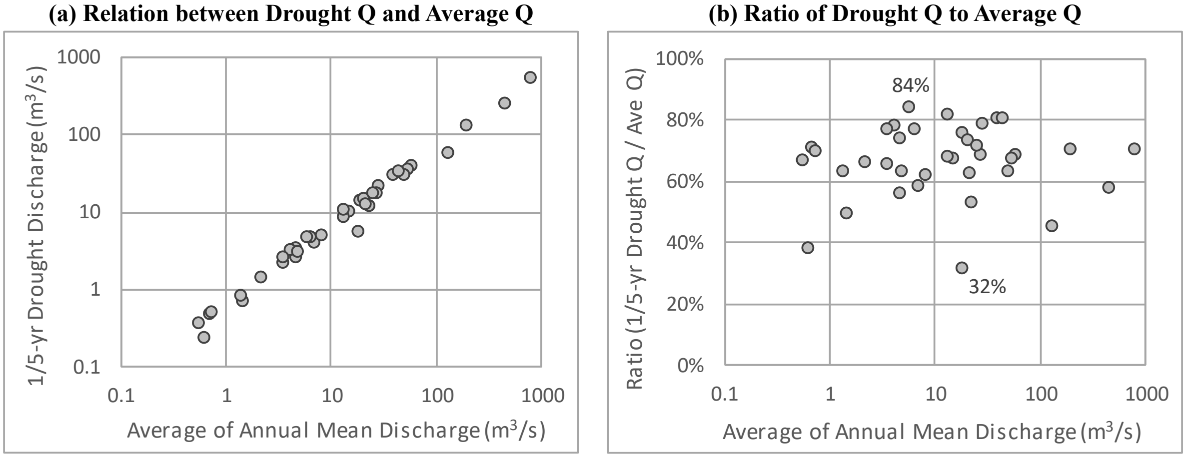
ii) The minimum mean monthly discharge in the past is more than zero[27].

iii) Long-term average runoff height does not exceed long-term average rainfall height.

As a result, only 37 stations were used for the analysis. Based on the long-term annual mean discharge at the selected 37 stations, annual mean discharge of 1/5-yr probable drought were computed. The relation between the 1/5-yr drought discharge and long-term average discharge is presented in Figure 3.6.4 (a). Besides, the ratios of the 1/5-yr drought discharge to the long-term average discharge at the respective 37 stations were calculated from Figure 3.6.4 (a) as shown in Figure 3.6.4 (b).

As seen in Figure 3.6.4 (b), the ratios range from 32% to 84% with an average of 67%. In other words, annual mean discharge of 1/5-yr probable drought may correspond to almost 67% of long-term average of annual mean discharge. This result is considered reasonable because decrease ratio of discharge is generally larger than that of rainfall when comparing normal year and drought year.

(a) Relation between Drought Q and Average Q **(b) Ratio of Drought Q to Average Q**



Source: Prepared by JICA Project Team based on discharge data provided by GRDC

Figure 3.6.4 Result of Long-term Discharge Analysis

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[26] The Global Runoff Data Centre (GRDC) is an international data centre operating under the auspices of the World Meteorological Organization (WMO).

[27] In a river that dry up for one month or more, it often happens that river water level and/or discharge is not accurately measured.

However, it must be noted that runoff characteristics, which are generally influenced by topography, hydrometeorology, hydrogeology, land use, etc., are different depending on the river basin, although neighboring basins have a similar trend. For this reason, the ratio of drought discharge to average discharge must be essentially different by river basin. Therefore, the above-calculated ratio is not able to be used simply for multiplication in assessing water resources. It is only a reference value.

Chapter 4 Recommendations to MoWI

4.1 Recommendations toward Implementing the NIMP2018

(1) Steady Implementation of IWRMDPs

The NIMP2018 is formulated on the premise that the IWRMDPs are fully implemented by 2035. Therefore, in order to implement the irrigation development plan proposed by the NIMP2018, the MoWI is supposed to implement the water resources management and development plans as scheduled.

(2) Early Formulation of the Remaining IWRMDPs

In parallel with the implementation of the previously formulated IWRMDPs, early formulation of IWRMDPs for the Pangani, Wami/Ruvu and Lake Victoria basins is required. If water resources to be allocated for irrigation within these basins are largely changed from that of the NIMP2018, the MoWI needs to discuss with NIRC based on technical justification. Furthermore, development plans of water storage facilities need to be appropriately incorporated into the IWRMDPs for the Pangani and Lake Victoria basins in order to ensure irrigation water to be supplied to the irrigation areas proposed by the NIMP2018.

(3) Review of EFR for Rufiji Basin

Although the Rufiji basin has plenty of surface water, monthly water deficit may not be covered by storage facilities in the dry season if the environmental flow requirement (EFR) estimated in the basin's IWRMDP is fully secured particularly for the Kilombero sub-basin.

NAWAPO 2002 provides the second priority in water allocation to EFR followed by basic human needs. However, it is less-than-reasonable to construct water storage facilities for the purpose of securing the EFR from the perspective that practical and feasible water resources development plan need to be formulated. In this regards, it is recommended to allocate appropriate water resources to EFR considering the actual river flow.

(4) Necessary Actions for Transboundary Water Use

The NIMP2018 include some irrigation schemes that may require water use from transboundary lakes. And there is a possibility of implementing these schemes depending on the result of F/S. Accordingly, the MoWI will be required to take necessary actions for coordinating with surrounding countries directly and/or through NBI's[28] facilitation.

4.2 Recommendations for Better Water Resources Management

(1) Accumulation of Hydrological Data

Reliable and long-term hydrological data is essential for formulating appropriate water resources management and development plans. It is strongly recommended to accumulate hydrological data for

[28] The Nile Basin Initiative (NBI) is an intergovernmental partnership of 10 Nile Basin countries. NBI provides the first and only all-inclusive platform for the Basin States to discuss how to collectively take care of and jointly use the shared Nile Basin water and related resources.

conducting more precise studies at subsequent implementation stages as well as updating the IWRMDPs in the future.

Although data management can be practiced at a basin level by the respective BWOs, it is desirable to standardize a monitoring system, a data quality checking method, a database format, etc. among all the nine basins.

(2) Consideration of Reliability of Water Utilization

Understanding the reliability of water utilization is quite important in considering the necessity of newly developing water resources. If an occasion to improve the reliability of water utilization arises, it is recommended to incorporate the concept of reliability of water utilization into the water resources development plans in the course of updating the IWRMDPs in the future.

(3) Collection of Water Fee

There are many non-approved water uses and therefore the water used in that manner is not properly billed. In order for BWOs to secure the funds required for performing their functions, BWOs should collect water fee from those water users as well. It will be important to increase income for enhancing financial autonomy of BWOs by 2025.

Attachment 1: List of Planned Dams

No.	Basin Code	Sub-basin Name	Dam Name	Reservoir Capacity (MCM)	Source	Remarks
1	WR	Kinyasungwe	Dabalo	0.91	Final Report, Summary, Table 4.3	
2			Hombolo	5.7		Heightening of Existing Dyke
3			Buigili	0.15		
4			Ikowa	0.7		
5			Msagali	6.31		New Construction
6			Ngipa	2.03		
7			Ngomai	1.02		
8			Farkwa	34.39		
9		Mkondoa	Ilonga	1.07		
10			Wami	42		
11			Kisangata	52		
12			Tami	32		
13		Wami	Mvomelo	4.46		
14			Dihinda	3.75		
15		Upper Ruvu	Ruvu Kibungo	28		
16			Mvuha	30		
17			Mungazi	23		
18			Mgeta	28		
19			Kidunda	191		
20		Ngerengere	Mindu	4		Heightening
21			Morogoro	8		New Construction
22	RF	Great Ruaha	Lukosi	-	Final Report, Vol.I, Appendix 1	
23			Ndembera / Lugoda	210		
24			Little Ruaha	-		
25	RV	Lower Middle Ruvuma	Malombe Hills	6.5	Final Report, Comp.4, Table 6.13	
26			Ruanda	33		
27		Lower Ruvuma	Chingulun- gulu	14		
28			Mahinyo Hills	42		
29			Makanyama	4.5		
30			Sindano	3.8		
31		Lukuledi	Mtua	15.2		
32		Mbwemkuru	Nanjirinji	16.7		
33			Mitonono	76.5		
34			Singira	16		
35			Mbondo	27.5		
36		Mavuji	Mbiliwia	24		
37		Matandu	Miguruwe	5.4		
38			Muhinje	44		
39			Mtumbei	6		
40			Liwale 1	7.2		
41			Liwale 2	16		
42	LN	Ruhuhu	Kikonge	6200	PSMP2016, Table 3-5 (1)	
43	LR	Katuma	Sitalike watershed	18	FR, Vol.I, Section 7.3	
44			Usevya watershed (site 23, option 3)	44.3	FR, Vol.II(a), Table 4.4	
45			Katuma Northern watershed	25.1	FR, Vol.I, Section 7.3	
46		Songwe River	Galula watershed (site 31, option 5)	103	FR, Vol.II(b), Table 4.5	
47			Lupa watershed	36.9	FR, Vol.I, Section 7.3	
48			Songwe Eastern watershed (site 2)	31.3	FR, Vol.I, Section 7.3	
49		Momba	Within Momba Sub-basin	2.3	FR, Vol.I, Section 7.3	
50			Out of Momba Sub-basin	454.3	FR, Vol.II(c), Table 4.3	
51		Luiche River	Option 3	39.9	FR, Vol.II(d), Section 4.2.1	
52		Muze	Option 2	7.3	FR, Vol.II(e), Section 4.2.1	
53	ID	Bahi Swamp	Farkwa	195	Final Report, Vol.6, Table 5.4	For Dodoma
54			Mbwasa	8		For Bahi
55			Mianji	7		
56			Mponde	25		
57			Dams in south of Bahi Swamp	5		
58		Lake Manyara	Dudumera	225.4	Final Report, Vol.6, Table 5.8	For Lake Manyara, Monduli A, Monduli B, and Masai Steppe
59			Kolo	18		
60			Makuyuni	25.4		
61			Small dams in Monduli	7		
62		Lake Natron	Pinyini	6.5	Final Report, Vol.6, Table 5.12	For Lake Natron and Namanga
63			Munik	6.8		
64		Namanga	Namanga	0.358		
65			Namanga small dams	7		
66		Lake Eyasi	Igunga Dams	31	Final Report, Vol.6, Table 5.16	For Lake Eyasi and Olduvai
67			Nzega Dams	7.4		
68			Shinyanga Dams	38.8		
69			Manonga 1 Dam	30		
70			Manonga 2 Dam	50		

Note: Proposed dams are not found from the IWRMDP reports for the Pangani, Tanganyika and Lake Nyasa basins.
Source: IWRMDP reports, Power Supply Master Plan (PSMP) 2016

Attachment 2: Surface Water (MCM/month) and Sustainable Yield of Groundwater (MCM/yr) by Sub-basin in 2035

Basin Code	Sub-basin Name	Area (km²)	SW													GW
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	
PG	Pangani River	43,652	206	175	430	612	462	284	212	176	150	195	311	310	3,524	466
	Umba	8,205	19	40	62	48	25	21	19	19	29	93	164	73	611	71
	Msangazi	5,085	39	47	142	80	37	22	14	10	37	35	36	44	543	31
	Zigi-Mkulumuzi	2,159	15	15	59	89	59	33	26	23	25	32	27	20	422	18
WR	Kinyasungwe	16,509	37	27	36	49	35	17	14	12	10	10	16	26	289	129
	Mkondoa	12,964	50	48	65	175	150	64	35	22	14	9	6	34	671	179
	Wami	14,270	119	92	130	428	293	74	34	28	22	24	63	101	1,408	169
	Upper Ruvu	7,623	156	146	234	525	432	155	92	67	68	62	111	203	2,252	102
	Ngerengere	2,913	13	12	11	35	39	12	5	3	2	2	10	12	156	27
	Lower Ruvu	7,253	50	-36	-28	-8	28	18	-4	-9	-21	-15	47	32	54	283
	Coast	4,763	33	-24	-18	-6	18	12	-3	-6	-13	-10	31	21	35	250
RF	Great Ruaha	85,554	925	1,361	1,540	1,506	887	392	263	183	160	149	259	494	8,118	1,795
	Kilombero	40,330	1,054	1,678	2,401	3,075	2,569	1,586	1,033	658	492	395	391	603	15,935	2,359
	Luwegu	25,288	557	936	1,645	2,151	1,696	1,012	531	304	218	165	202	294	9,711	2,079
	Lower Rufiji	32,619	547	858	1,205	1,452	1,112	645	394	247	188	153	184	300	7,285	2,789
RV	Upper Ruvuma	8,328	323	320	450	390	280	215	165	130	105	83	75	140	2,678	259
	Likonde	8,782	369	329	648	438	229	159	120	95	70	55	50	149	2,710	294
	Upper Middle Ruvuma	9,550	280	307	325	172	100	79	64	49	36	26	28	128	1,594	298
	Lower Middle Ruvuma	15,155	364	395	377	149	53	44	35	26	18	13	18	149	1,640	356
	Lower Ruvuma	10,737	91	91	127	86	56	46	30	20	10	7	5	66	635	349
	Mambi	5,258	35	39	86	82	46	30	19	11	7	4	3	29	391	273
	Lukuledi	6,848	52	58	99	91	66	41	25	15	8	4	3	20	483	219
	Mbwemkuru	18,636	95	109	173	166	115	75	47	27	14	6	5	48	880	472
	Mavuji	4,928	10	12	27	42	30	18	12	7	4	2	2	12	177	246
	Matandu	17,360	42	57	91	126	97	65	41	24	13	7	6	39	606	472
LN	Songwe	2,479	100	104	130	130	98	68	62	49	43	38	43	72	938	10
	Kiwira	1,887	133	128	197	355	217	119	95	79	66	62	64	98	1,613	8
	Mbaka	746	56	44	99	205	194	105	57	31	22	20	22	36	890	3
	Lufilyo	1,012	86	96	148	190	164	91	61	42	28	27	28	47	1,010	5
	Rumakali	684	90	90	139	145	94	43	28	18	12	12	18	53	743	3
	Lumbira	2,153	107	103	109	97	88	72	64	54	44	40	46	84	909	9
	Nkiwe	1,880	71	68	75	68	63	52	46	39	32	30	39	61	645	7
	Ruhuhu	14,210	433	433	742	866	514	298	271	217	162	135	135	257	4,465	51
	Muchuchuma	670	16	15	17	15	14	12	10	9	7	6	8	13	141	3
	Mbawa	1,873	67	62	69	62	56	48	42	37	30	32	42	60	605	8
LR	Katuma	15,802	137	148	224	339	289	111	23	6	1	3	10	63	1,353	581
	Momba	11,284	168	219	395	351	136	165	34	20	10	7	11	58	1,575	370
	Lake Shores	14,247	254	387	507	398	312	149	63	43	31	35	47	153	2,380	407
	Songwe River	10,800	330	605	703	402	418	153	93	76	64	78	93	249	3,265	261
	Luiche River	838	13	15	20	17	10	5	3	2	1	1	1	7	95	22
	Muze	354	8	7	10	42	35	1	1	1	1	0	3	8	116	9
	Rungwa	21,640	424	707	858	635	617	230	109	81	65	80	100	293	4,198	487
LT	Malagarasi	67,100	171	287	348	466	519	390	204	99	49	32	37	97	2,698	1,717
	Ugalla	54,000	65	109	132	177	197	148	77	38	19	12	14	37	1,026	496
	Ruchugi	3,200	32	54	65	87	97	73	38	19	9	6	7	18	506	203
	Luiche	2,600	74	77	95	125	86	40	28	23	20	25	48	76	718	88
	Lugufu	4,500	122	150	202	211	121	64	39	28	19	17	39	93	1,107	98
	Luegele	1,400	40	49	66	69	40	21	13	9	6	6	13	30	361	12
	Other Rivers	16,700	456	840	1,190	980	240	68	30	20	10	10	20	195	4,058	141
LV	Biharamulo	1,876	49	45	76	92	43	3	2	8	22	54	81	58	534	28
	Eastern shore streams	6,677	44	39	84	106	68	18	8	14	25	46	74	62	587	107
	Grumeti	12,856	25	27	33	50	40	23	14	14	15	17	34	29	323	166
	Isanga	7,081	88	105	133	180	114	48	24	15	12	11	43	81	854	100
	Lake Victoria Islands	1,407	9	8	18	22	14	4	2	3	5	10	16	13	124	28
	Lower Kagera	19,341	182	182	213	235	261	240	229	203	176	171	167	176	2,436	327
	Magogo-Moame	5,401	29	35	44	60	38	16	8	5	4	4	14	27	284	77
	Mara	5,277	36	39	48	72	58	33	19	20	22	24	49	42	463	92
	Mbalageti	3,537	14	17	21	29	18	8	4	2	2	2	7	13	136	46
	Nyashishi	1,689	5	4	6	7	3	0	0	0	1	3	6	6	41	26
	Simiyu	11,095	127	151	192	259	165	70	35	22	17	16	62	117	1,234	170
	Southern shore streams	8,749	74	63	102	121	49	4	1	12	27	75	103	91	722	143
	Western shore streams	644	49	46	83	117	105	21	15	23	35	62	76	69	701	17
ID	Lake Eyasi	64,545	308	165	366	792	5	0	0	0	0	1	40	340	2,017	224
	Monduli - A	4,115	14	6	15	28	0	0	0	0	0	0	5	16	85	6
	Monduli - B	1,385	2	4	9	12	4	0	0	0	0	0	0	2	33	1
	Lake Manyara	18,491	135	30	204	417	9	0	0	0	0	0	0	149	944	169
	Lake Natron	8,658	58	72	109	236	98	0	0	0	0	0	9	27	609	400
	Olduvai	4,577	14	5	23	30	4	0	0	0	0	0	0	27	104	23
	Bahi Swamp	26,445	278	132	214	97	0	0	0	0	0	0	3	220	944	35
	Masai Steppe	9,313	15	36	9	79	0	0	0	0	0	0	0	11	149	18
	Namanga	5,570	3	0	22	59	13	0	0	0	0	0	0	0	96	9

Source: Prepared by JICA Project Team based on the IWRMDP and LVBC study reports

Attachment 3: Water Allocation for Irrigation (MCM/month) and the Other Sectors (MCM/yr) by Sub-basin in 2035

Basin Code	Sub-basin Name	Area (km^2)	Irrigation													Other Sectors
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	
PG	Pangani River	43,652	51	72	198	166	210	210	103	54	145	300	230	228	1,966	366
	Umba	8,205	14	18	27	18	17	17	7	2	8	14	13	10	165	25
	Msangazi	5,085	7	10	13	8	7	7	3	1	4	6	6	4	76	26
	Zigi-Mkulumuzi	2,159	3	4	5	3	3	3	1	0	1	2	2	1	27	50
WR	Kinyasungwe	16,509	20	43	61	52	39	0	4	5	8	8	0	0	240	39
	Mkondoa	12,964	126	116	105	47	72	0	3	4	6	6	1	0	487	15
	Wami	14,270	36	32	28	12	20	0	14	16	25	25	19	0	227	20
	Upper Ruvu	7,623	31	27	23	10	16	0	3	3	4	4	0	0	121	6
	Ngerengere	2,913	4	4	3	1	2	0	0	0	0	0	0	0	15	67
	Lower Ruvu	7,253	22	17	12	5	9	0	11	9	11	10	0	0	105	13
	Coast	4,763	14	13	8	4	5	1	7	6	8	6	1	0	72	773
RF	Great Ruaha	85,554	443	399	371	356	348	115	162	162	156	168	388	433	3,502	187
	Kilombero	40,330	7	4	6	5	353	343	355	355	343	354	343	6	2,475	196
	Luwegu	25,288	11	9	11	10	11	10	11	0	0	0	0	11	85	96
	Lower Rufiji	32,619	81	73	2	2	109	199	218	221	207	208	157	81	1,558	91
RV	Upper Ruvuma	8,328	45	40	11	26	6	2	2	4	2	8	6	7	160	25
	Likonde	8,782	9	8	2	5	2	3	3	5	3	9	7	8	63	10
	Upper Middle Ruvuma	9,550	6	5	1	4	2	2	3	4	2	6	5	5	44	13
	Lower Middle Ruvuma	15,155	2	2	3	1	0	0	0	1	2	2	3	2	19	8
	Lower Ruvuma	10,737	35	38	44	46	20	16	15	23	31	41	61	41	409	18
	Mambi	5,258	6	6	7	9	4	3	2	3	5	8	11	8	74	15
	Lukuledi	6,848	20	20	17	18	16	11	7	11	16	23	34	23	216	12
	Mbwemkuru	18,636	1	0	0	2	7	5	4	5	8	8	7	1	48	16
	Mavuji	4,928	1	1	2	1	1	1	0	0	1	1	2	1	12	4
	Matandu	17,360	1	1	2	1	1	1	0	0	1	1	2	1	12	15
LN	Songwe	2,479	6	9	9	9	11	6	1	4	8	8	7	0	78	13
	Kiwira	1,887	1	2	2	2	2	1	0	1	2	2	1	0	15	13
	Mbaka	746	36	56	53	59	74	41	6	25	53	49	44	0	494	6
	Lufilyo	1,012	7	12	11	12	14	8	1	5	10	9	9	0	96	6
	Rumakali	684	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Lumbira	2,153	0	0	0	0	0	0	0	0	0	0	0	0	0	3
	Nkiwe	1,880	0	0	0	0	0	0	0	0	0	0	0	0	0	2
	Ruhuhu	14,210	9	18	13	15	18	10	2	6	14	14	12	0	131	25
	Muchuchuma	670	8	13	10	11	14	7	0	2	6	5	5	0	81	1
	Mbawa	1,873	2	3	2	2	3	1	0	1	2	2	2	0	19	5
LR	Katuma	15,802	88	105	88	53	0	2	2	4	4	0	53	105	504	21
	Momba	11,284	52	62	52	31	0	1	1	2	2	0	31	62	299	18
	Lake Shores	14,247	43	51	43	26	0	1	1	2	2	0	26	51	246	13
	Songwe River	10,800	2	2	1	0	6	15	15	11	4	1	2	3	63	64
	Luiche River	838	6	7	6	4	0	0	0	0	0	0	4	7	35	14
	Muze	354	3	4	3	2	0	0	0	0	0	0	2	4	17	1
	Rungwa	21,640	0	0	0	0	0	0	0	0	0	0	0	0	0	3
LT	Malagarasi	67,100	20	28	39	37	39	39	14	1	4	6	6	4	235	472
	Ugalla	54,000	14	18	26	27	25	25	10	1	3	4	4	3	159	104
	Ruchugi	3,200	11	15	21	20	21	21	8	1	2	3	3	2	126	46
	Luiche	2,600	9	11	16	17	18	18	6	0	2	3	3	2	104	40
	Lugufu	4,500	9	11	16	17	18	18	6	0	2	3	3	2	104	8
	Luegele	1,400	9	11	16	19	17	17	6	0	2	3	3	2	104	4
	Other Rivers	16,700	14	17	23	28	25	25	8	1	3	4	4	3	153	39
LV	Biharamulo	1,876	1	2	1	1	1	1	1	0	0	0	1	1	10	10
	Eastern shore streams	6,677	4	7	5	3	3	3	2	0	0	0	3	2	31	47
	Grumeti	12,856	9	12	10	8	8	8	7	3	5	6	8	5	89	28
	Isanga	7,081	14	19	14	12	16	14	5	1	1	0	8	5	110	23
	Lake Victoria Islands	1,407	0	0	0	0	0	0	0	0	0	0	0	0	0	24
	Lower Kagera	19,341	10	21	15	10	11	12	6	1	0	0	7	6	98	123
	Magogo-Moame	5,401	15	19	15	11	14	10	2	1	0	0	7	5	99	36
	Mara	5,277	14	3	2	1	1	1	1	0	4	5	10	8	51	17
	Mbalageti	3,537	7	1	1	1	1	1	1	0	2	3	4	3	23	12
	Nyashishi	1,689	5	6	5	4	4	3	1	0	0	0	2	2	30	38
	Simiyu	11,095	17	21	17	12	13	10	2	1	0	0	8	6	108	38
	Southern shore streams	8,749	17	23	17	12	17	13	6	2	0	0	5	8	121	74
	Western shore streams	644	0	0	0	0	0	0	0	0	0	0	0	0	1	2
ID	Lake Eyasi	64,545	127	155	147	115	13	15	16	13	0	0	4	82	686	289
	Monduli - A	4,115	0	0	0	0	0	0	0	0	0	0	0	0	1	6
	Monduli - B	1,385	0	0	0	0	0	0	0	0	0	0	0	0	1	1
	Lake Manyara	18,491	16	28	16	11	46	73	0	0	0	0	62	20	271	74
	Lake Natron	8,658	2	2	2	2	2	4	0	0	0	0	4	2	18	10
	Olduvai	4,577	0	0	0	0	0	0	0	0	0	0	0	0	1	7
	Bahi Swamp	26,445	13	16	16	18	26	9	8	7	7	6	28	9	164	62
	Masai Steppe	9,313	0	1	0	0	1	2	0	0	0	0	2	1	8	10
	Namanga	5,570	3	2	3	2	3	6	0	0	0	0	6	3	28	7

Source: Prepared by JICA Project Team based on the IWRMDP and LVBC study reports

Attachment 4: Environmental Flow Requirement (MCM/month) by Sub-basin in 2035

Basin Code	Sub-basin Name	Area (km²)	EFR												
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
PG	Pangani River	43,652	106	98	142	177	169	147	138	127	114	116	111	113	1,557
	Umba	8,205	0	0	0	1	0	0	0	0	1	8	6	4	19
	Msangazi	5,085	0	0	0	0	0	0	0	0	0	0	0	0	1
	Zigi-Mkulumuzi	2,159	5	4	9	9	7	7	12	9	7	6	8	6	90
WR	Kinyasungwe	16,509	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mkondoa	12,964	0	0	0	0	0	0	0	0	0	0	0	0	3
	Wami	14,270	8	7	8	7	8	7	8	8	7	8	7	8	91
	Upper Ruvu	7,623	5	5	6	4	7	7	12	14	11	8	6	5	93
	Ngerengere	2,913	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lower Ruvu	7,253	4	5	6	4	7	7	11	13	10	8	6	5	85
	Coast	4,763	1	1	2	1	2	2	3	4	3	2	2	1	26
RF	Great Ruaha	85,554	16	21	36	52	47	39	34	28	19	13	8	12	324
	Kilombero	40,330	592	841	1,665	1,473	1,200	904	734	506	355	278	256	328	9,130
	Luwegu	25,288	312	470	1,141	1,031	792	577	377	233	157	116	132	160	5,498
	Lower Rufiji	32,619	516	728	1,105	2,195	1,624	529	0	0	0	0	7	194	6,898
RV	Upper Ruvuma	8,328	131	130	188	163	117	90	69	54	44	35	31	58	1,109
	Likonde	8,782	172	150	310	210	110	76	57	45	33	26	24	71	1,284
	Upper Middle Ruvuma	9,550	117	128	141	75	43	34	28	21	16	11	12	55	681
	Lower Middle Ruvuma	15,155	131	144	137	58	23	19	15	11	8	6	8	64	623
	Lower Ruvuma	10,737	32	32	45	31	20	16	11	7	4	3	2	23	226
	Mambi	5,258	12	14	30	30	16	11	7	4	2	1	1	11	140
	Lukuledi	6,848	19	20	35	33	23	15	9	5	3	2	1	7	172
	Mbwemkuru	18,636	31	36	58	57	41	27	17	10	5	2	2	17	303
	Mavuji	4,928	3	4	9	14	10	6	4	3	1	1	1	4	60
	Matandu	17,360	13	19	30	42	33	23	15	9	5	2	2	12	205
LN	Songwe	2,479	46	48	60	60	45	31	29	34	30	27	30	33	473
	Kiwira	1,887	39	38	58	105	64	35	28	35	29	28	28	29	517
	Mbaka	746	21	16	37	76	72	39	21	17	12	11	12	13	348
	Lufilyo	1,012	32	35	55	70	60	34	23	23	16	15	16	17	395
	Rumakali	684	34	34	53	55	36	16	11	10	7	7	10	20	293
	Lumbira	2,153	47	45	48	43	39	32	28	36	29	27	31	37	442
	Nkiwe	1,880	28	27	30	27	25	21	18	23	19	18	23	24	283
	Ruhuhu	14,210	176	176	303	353	209	121	110	132	99	83	83	105	1,951
	Muchuchuma	670	6	6	6	6	5	5	4	5	4	4	4	5	59
	Mbawa	1,873	25	23	26	23	21	18	16	21	17	18	24	23	257
LR	Katuma	15,802	28	41	93	102	50	16	5	2	1	1	1	6	347
	Momba	11,284	73	94	178	143	61	30	13	8	4	3	4	21	630
	Lake Shores	14,247	112	141	249	267	108	84	34	16	11	10	14	27	1,071
	Songwe River	10,800	145	221	345	269	145	86	50	28	22	22	27	45	1,404
	Luiche River	838	4	5	9	7	4	2	1	0	0	0	0	1	35
	Muze	354	2	2	4	16	14	0	0	0	0	0	1	2	43
	Rungwa	21,640	86	196	355	191	107	34	24	27	60	26	10	29	1,146
LT	Malagarasi	67,100	63	106	129	172	192	144	75	37	18	12	14	36	997
	Ugalla	54,000	44	75	91	122	135	102	53	26	13	8	10	25	704
	Ruchugi	3,200	13	21	26	35	39	29	15	7	4	2	3	7	202
	Luiche	2,600	23	24	30	39	27	12	9	7	6	8	15	24	224
	Lugufu	4,500	36	44	59	61	35	19	11	8	6	5	11	27	322
	Luegele	1,400	16	20	26	28	16	8	5	4	3	2	5	12	145
	Other Rivers	16,700	188	347	492	405	99	28	12	8	4	4	8	81	1,678
LV	Biharamulo	1,876	12	12	12	12	12	3	2	8	12	12	12	12	126
	Eastern shore streams	6,677	29	29	29	29	29	18	8	14	25	29	29	29	294
	Grumeti	12,856	16	16	16	16	16	16	14	14	15	16	16	16	187
	Isanga	7,081	20	20	20	20	20	20	20	15	12	11	20	20	217
	Lake Victoria Islands	1,407	9	8	16	16	14	4	2	3	5	10	16	13	115
	Lower Kagera	19,341	102	102	102	102	102	102	102	102	102	102	102	102	1,228
	Magogo-Moame	5,401	29	32	32	32	32	16	8	5	4	4	14	27	235
	Mara	5,277	10	10	10	10	10	10	10	10	10	10	10	10	114
	Mbalageti	3,537	9	9	9	9	9	8	4	2	2	2	7	9	79
	Nyashishi	1,689	5	4	6	7	3	0	0	0	1	3	6	6	41
	Simiyu	11,095	34	34	34	34	34	34	34	22	17	16	34	34	359
	Southern shore streams	8,749	55	55	55	55	49	4	1	12	27	55	55	55	482
	Western shore streams	644	3	3	3	3	3	3	3	3	3	3	3	3	37
ID	Lake Eyasi	64,545	113	74	147	214	2	0	0	0	0	0	19	142	712
	Monduli - A	4,115	5	2	5	9	0	0	0	0	0	0	2	5	28
	Monduli - B	1,385	1	1	3	4	2	0	0	0	0	0	0	1	12
	Lake Manyara	18,491	48	14	58	71	4	0	0	0	0	0	0	54	249
	Lake Natron	8,658	30	37	57	60	27	0	0	0	0	0	5	14	229
	Olduvai	4,577	0	0	0	0	0	0	0	0	0	0	0	0	0
	Bahi Swamp	26,445	68	56	68	45	0	0	0	0	0	0	1	43	281
	Masai Steppe	9,313	6	13	3	29	0	0	0	0	0	0	0	4	55
	Namanga	5,570	1	0	8	20	5	0	0	0	0	0	0	0	34

Source: *Prepared by JICA Project Team based on the IWRMDP and LVBC study reports*

Attachment 5: Unused Surface Water (MCM/month) and Sustainable Yield of Groundwater (MCM/yr) by Sub-basin in 2035

Basin Code	Sub-basin Name	Area (km^2)	SW													GW
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	
PG	Pangani River	43,652	0	0	0	0	0	0	0	0	0	0	0	0	0	99
	Umba	8,205	3	19	33	26	7	2	10	15	17	70	143	57	401	71
	Msangazi	5,085	30	35	127	69	28	13	8	7	31	27	28	37	440	31
	Zigi-Mkulumuzi	2,159	4	3	41	74	45	20	9	9	12	20	13	8	256	18
WR	Kinyasungwe	16,509	0	0	0	0	0	15	8	6	0	0	13	22	64	90
	Mkondoa	12,964	0	0	0	110	66	54	27	15	0	0	4	29	305	164
	Wami	14,270	64	45	81	350	228	57	10	4	0	0	31	80	950	149
	Upper Ruvu	7,623	104	0	77	390	345	110	0	0	0	0	92	175	1,294	102
	Ngerengere	2,913	5	4	4	27	30	7	2	0	0	0	6	7	93	0
	Lower Ruvu	7,253	0	0	0	0	0	0	0	0	0	0	23	2	25	269
	Coast	4,763	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RF	Great Ruaha	85,554	425	858	1,033	1,000	448	217	61	0	0	0	0	44	4,087	1,609
	Kilombero	40,330	416	758	665	1,455	926	310	0	0	0	0	0	245	4,775	2,162
	Luwegu	25,288	161	410	443	326	241	305	123	56	30	0	56	105	2,257	2,079
	Lower Rufiji	32,619	0	51	90	0	0	0	161	24	0	0	18	22	366	2,698
RV	Upper Ruvuma	8,328	145	148	249	200	155	121	92	70	57	38	35	72	1,385	259
	Likonde	8,782	188	170	335	223	117	80	59	43	33	19	18	69	1,353	294
	Upper Middle Ruvuma	9,550	156	173	182	93	54	42	33	23	18	8	10	66	856	298
	Lower Middle Ruvuma	15,155	230	247	237	89	29	24	19	13	8	5	6	82	990	356
	Lower Ruvuma	10,737	0	0	0	0	0	0	0	0	0	0	0	0	0	331
	Mambi	5,258	15	17	45	40	23	15	9	3	0	0	0	10	178	258
	Lukuledi	6,848	8	10	27	22	15	9	6	0	0	0	0	0	96	207
	Mbwemkuru	18,636	62	71	113	106	66	43	26	12	1	0	0	29	528	456
	Mavuji	4,928	6	7	16	27	18	11	7	4	2	0	0	7	105	243
	Matandu	17,360	26	36	58	81	61	40	24	14	6	2	1	24	374	472
LN	Songwe	2,479	47	46	60	60	41	29	31	10	4	3	5	38	374	10
	Kiwira	1,887	91	87	136	248	150	82	66	42	34	32	33	68	1,069	8
	Mbaka	746	0	0	2	16	11	6	7	0	0	0	0	5	45	0
	Lufilyo	1,012	46	49	82	108	89	50	37	14	2	2	4	29	513	5
	Rumakali	684	56	56	86	90	58	27	17	8	5	5	8	33	449	3
	Lumbira	2,153	59	57	60	54	49	40	36	18	15	13	15	47	464	9
	Nkiwe	1,880	43	41	45	41	38	31	28	16	13	12	16	37	360	7
	Ruhuhu	14,210	246	237	425	496	285	164	157	76	47	37	38	150	2,359	51
	Muchuchuma	670	0	0	0	0	0	0	0	0	0	0	0	0	0	2
	Mbawa	1,873	39	35	40	36	32	28	26	15	11	11	16	37	325	8
LR	Katuma	15,802	18	1	36	154	201	77	13	1	0	1	0	0	502	560
	Momba	11,284	40	59	153	165	69	124	18	9	4	5	0	0	646	352
	Lake Shores	14,247	99	193	214	105	203	63	27	25	18	24	7	74	1,051	407
	Songwe River	10,800	178	376	352	127	262	47	23	32	33	49	59	197	1,734	261
	Luiche River	838	3	2	5	6	5	2	2	1	0	0	0	0	26	7
	Muze	354	2	1	3	24	21	0	0	0	0	0	0	3	55	9
	Rungwa	21,640	338	512	502	444	509	195	84	54	5	54	90	263	3,049	487
LT	Malagarasi	67,100	87	153	181	257	289	207	114	61	27	14	18	58	1,466	1,245
	Ugalla	54,000	7	16	15	29	37	22	15	11	3	0	0	9	163	392
	Ruchugi	3,200	8	17	18	32	38	23	15	11	3	0	1	9	177	157
	Luiche	2,600	39	39	46	66	38	6	10	12	9	11	27	47	350	88
	Lugufu	4,500	78	94	126	132	67	27	21	19	11	9	25	63	673	98
	Luegele	1,400	14	17	23	22	7	0	2	5	2	0	5	16	112	8
	Other Rivers	16,700	254	476	675	547	116	15	9	11	3	1	7	111	2,227	102
LV	Biharamulo	1,876	35	30	62	78	29	0	0	0	10	41	68	45	398	18
	Eastern shore streams	6,677	11	3	50	72	35	0	0	0	0	17	42	31	261	60
	Grumeti	12,856	0	0	5	19	11	0	0	0	0	0	7	5	48	138
	Isanga	7,081	49	60	89	133	70	13	0	0	0	0	13	50	477	77
	Lake Victoria Islands	1,407	0	0	2	6	0	0	0	0	0	0	0	0	8	5
	Lower Kagera	19,341	60	48	85	113	137	115	111	90	64	58	48	58	986	327
	Magogo-Moame	5,401	0	0	0	0	0	0	0	0	0	0	0	0	0	40
	Mara	5,277	11	26	35	60	46	21	7	9	7	9	28	23	281	92
	Mbalageti	3,537	0	5	8	14	6	0	0	0	0	0	0	1	33	34
	Nyashishi	1,689	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Simiyu	11,095	71	91	134	201	112	24	0	0	0	0	19	73	724	132
	Southern shore streams	8,749	1	0	20	37	0	0	0	0	0	13	29	19	120	69
	Western shore streams	644	45	42	80	114	102	17	12	20	32	59	73	66	661	17
ID	Lake Eyasi	64,545	49	0	52	358	0	0	0	0	0	0	9	86	554	0
	Monduli - A	4,115	9	4	10	19	0	0	0	0	0	0	3	11	56	0
	Monduli - B	1,385	1	3	6	7	2	0	0	0	0	0	0	1	20	0
	Lake Manyara	18,491	50	0	90	233	0	0	0	0	0	0	0	52	424	95
	Lake Natron	8,658	26	32	50	173	68	0	0	0	0	0	1	11	361	389
	Olduvai	4,577	14	5	23	30	4	0	0	0	0	0	0	27	103	16
	Bahi Swamp	26,445	159	48	104	26	0	0	0	0	0	0	0	136	473	0
	Masai Steppe	9,313	8	21	5	46	0	0	0	0	0	0	0	6	86	8
	Namanga	5,570	0	0	7	24	3	0	0	0	0	0	0	0	34	1

Source: Prepared by JICA Project Team based on the IWRMDP and LVBC study reports

Appendix B

Site Investigation Report

The Project on the Revision of National Irrigation Master Plan

in the United Republic of Tanzania

Final Report

Appendix B: Site Investigation Report

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Site Investigation Sheet

Chapter 1 Introduction

1.1 General

This document reports the results of site visits from a technical view point. Site visits were carried out from January 2017 to March 2017.

1.1.1 Purposes of Site Visit

The JICA Project team for the Project on the Revision of National Irrigation Master Plan (hereinafter referred to as NIMP2018) visited 6 out of 7 zonal irrigation offices, several districts, institutions concerned and irrigation schemes for the following purposes.

- To explain the NIMP2018 project and discuss the irrigation development with officials concerned
- To understand the present status of the existing irrigation schemes at site
- To understand the present status of SSIDP schemes
- To understand the activities of irrigators' organizations
- To collect information on existing and potential (plan) irrigation schemes
- To understand the present status of capacity building in irrigation field
- To collect data and information on present agricultural practices

1.1.2 Itinerary

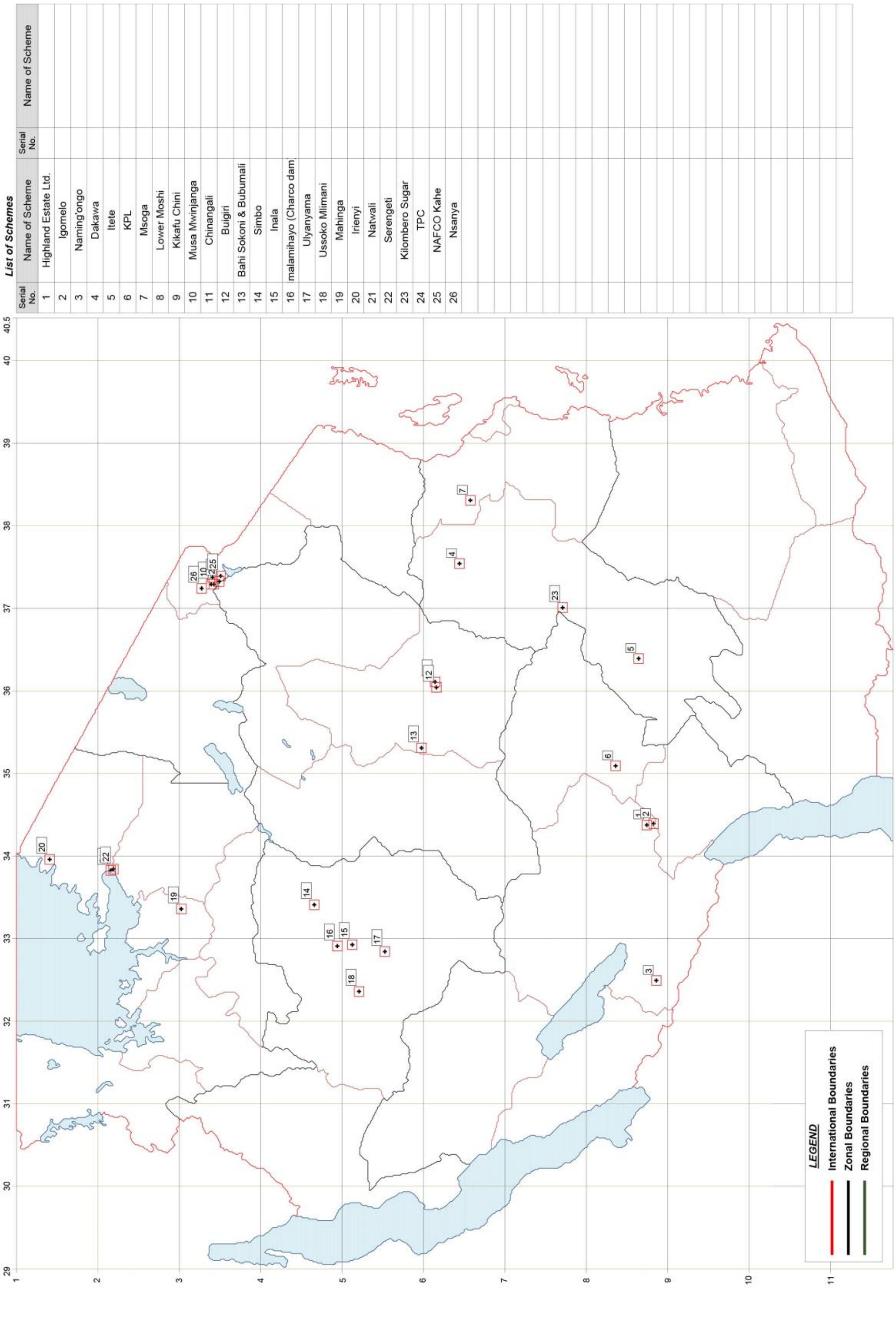
Name of offices and irrigation schemes visited are tabulated as shown below.

Table 1.1.1 Itinerary of Site Visits in 2017

Date	Offices and Institutes Visited	Irrigation Scheme Visited	Date	Offices and Institutes Visited	Irrigation Scheme Visited
30 Jan.	Mbeya Zonal Office MATI - Igurusi		16 Feb.	Hai DC	Nsanya, Kikafu chini, Musa Mwinjanga
31 Jan.	Mbarali DC	Highland Estate Igomelo (SSIDP)	17 Feb.	Holili OSBP Moshi CU ICCE	
01 Feb.	Momba DC RAS office	Namingo'ngo (SSIDP)	20 Feb.	Dodoma Zonal Office Chamwino DC	Chinangali grape farm Buigiri dam
02 Feb.	Tunduma border market PMW construction Ltd.		21 Feb.	Bahi DC	Bahi Sokoni
06 Feb.	Morogoro Zonal Office Mvomero DC Chollima Research Centre	Proposed NIRTC site	27 Feb.	Tabora Zonal Office	
07 Feb.	UWAWAKUDA IO office	Dakawa Rice Farm	28 Feb.	Simbo Ward Office	Simbo Traditional
08 Feb.	Sokoine University	Experimental Farm	01 Mar.	Tabora MC	Inala (SSIDP) Imalamihayo Charco
09 Feb.	Kilombero DC	Itete KPL	02 Mar.	Sikoge DC	Ulayanyama
10 Feb.		Msoga dam (SSIDP)	03 Mar.	Urambo DC	Ussoke Mlimani (SSIDP)
14 Feb.	ATC		06 Mar.	Mwanza Zonal Office Kwimba DC	Mahiga
15 Feb.	Kilimanjaro Zonal Office Moshi DC KATC	Lower Moshi	07 Mar.	Rorya DC	Irienyi (SSIDP)
			08 Mar.	Bunda DC	Nyatwali (SSIDP)
					Serengeti

Sources: JICA Project Team

Locations of irrigation schemes visited are shown on the following map.



Source: JICA Project Team

Figure 1.1.1 Location Map of Irrigation Schemes

1.2 Site Investigation of SSIDP Schemes

Among the 22 irrigation schemes visited by the JICA Project Team, nine schemes are covered with SSIDP. List of these SSIDP schemes with minimal information are tabulated in the following table.

Table 1.2.1 List of SSDIP Schemes Visited by the JICA Project Team

Serial No.	Name of Scheme	Zone	District	Irrigation Area (ha)	Present Status
1.	Igomelo	Mbeya	Mbarali	320	Main canal lining work is on-going. (Site Investigation Sheet: page A-5)
2.	Naming'ongo	Mbeya	Momba	1,600	Main canal lining was completed. (Site Investigation Sheet: page A-8)
3.	Msoga	Morogoro	Chalinze	100	Dam construction is suspended. (Site Investigation Sheet: page A-23)
4.	Kikafu Chini	Kilimanjaro	Hai	640	Rehabilitation work is on-going. (Site Investigation Sheet: page A-32)
5.	Musa Mwinjanga	Kilimanjaro	Hai	656	Secondary lining work is on-going (Site Investigation Sheet: page A-35)
6.	Inala	Tabora	Tabora MC	500	Scheme construction was completed. (Site Investigation Sheet: page A-51)
7.	Ussoke Mlimani	Tabora	Urambo	500	Secondary lining work is on-going. Rehabilitation of dam has not yet finished. (Site Investigation Sheet: page A-61)
8.	Irienyi	Mwanza	Rorya	250	Main canal lining was completed. (Site Investigation Sheet: page A-69)
9.	Nyatwali	Mwanza	Bunda TC	140	Secondary lining work was completed. (Site Investigation Sheet: page A-72)

Sources: JICA Project team

1.3 Records of Irrigation Schemes

Records of irrigation schemes are summarized in a "Site Investigation Sheet" together with a Scheme Map and Photos, and the sheets are attached at the end of this report. Since "Scheme Maps" are created on the "Google Earth Pro", electronic files are also available.

Chapter 2 Findings During the Site Visit

JICA Project Team made many findings during the site visits and through discussions with government officials and IO members.

These findings are categorised into the following four items.

- Findings related to Existing irrigation schemes
- Findings related to Future Potential for Irrigation Development
- Findings related to Irrigation Technology
- others

2.1 Findings Related to Existing Irrigation Schemes

(1) Project Formulation and Design Stage

(a) Design Standards and Criteria

There aren't unified design standards and criteria for irrigation scheme design works. Introduction of unified international criteria would be necessary.

(b) Documents and Back up Data Keeping

Documents and data are not properly kept at zonal and district offices. Proper documents and data keeping system would be useful for a future rehabilitation work. Common understanding of terms related to irrigation areas would be important for scheme development and the NIRC database.

(c) Definition of Technical Terms

LGA staff and IO members understand the meaning of "Potential Irrigation Area" is the area where there is a possibility to conduct irrigation.

(d) Inadequate Evaluation of Water Source

Through discussion with a zonal engineer, we found that evaluation of water source is not always properly conducted. In one scheme, design was conducted without data and technical calculation method.

(e) Lack of Drainage Canals

In many schemes, drainage canals are made of little account in design and implementation stages.

The main reason may be farmers refuse to give their land for drainage canals not to reduce cultivation areas. However, drainage canal system is crucial for sustainable irrigation system.

For example, the team observed the water flow from a paddy field to the main farm road because of absence of a drainage canal in the Itete scheme. This water flow could easily give damages to the main farm road.

(f) Sedimentation is a Serious Problem especially in Reservoirs and Canals.

In general, sediment load is decided without actual measurement in a river. Usually, engineers estimate sediment load by applying an empirical equation which is described in a textbook. Or they don't take it into account. Estimate of sedimentation needs to be conducted carefully to avoid abandonment of an irrigation scheme.

For example, the following Joglekar's empirical equation is applied to estimate of silting rate in the Dodoma Zone.

Qs = 0.597 / A ^0.24

Where: Qs = the annual silting rate (MCM/100 sq. km)

A = the Catchment area (sq. km)

This equation may be applicable to rather small catchments. However, sediment load usually varies from river to river. Actual measurements of sediment volume in several reservoirs in a river basin would be useful to estimate sediment load in the basin.

(g) Difference between Developed Area and Irrigated Area

This cause of the discrepancy might be insufficient water or uncompleted facilities. As a result, farmers might be discouraged in operation and maintenance activities.

(2) Project Implementation

(a) Poor Performance of Contractors

Many defects were observed especially in reinforced concrete work and in compaction of embankment. For example, protective covering for reinforcement bars is not enough, and reinforcement bars are exposed from concrete. Several pieces of wooden form are remaining in concrete. Water leakage from the wooden form remains was reported at intake structure under the Inala embankment.

Many gullies were found in some embankments of dams. The cause of the problem would be loose compaction of embankment material.

In relation to the poor performance, supervision by zonal or district office would be a problem. It seems that supervisor was not in place where concrete was placed.

(b) Project Committee

According to the roles of the Project Committee described in CGL (See Reference page 1), Project committee needs to take a part of supervision work. However, committee members do not have technical background to supervise the scheme construction. Stationing of skilful engineer from Zonal or District office would be necessary.

(c) Completion of Scheme

In many cases, an irrigation scheme used to be constructed partially. Consequently, irrigation area was reduced from the original plan. This reduction of farm land discourages farmers very much. Each scheme need to be completed.

(3) Project O&M and Water Management

(a) High Electricity Charge for Irrigation and Drainage Pumps

Among schemes the team visited, three schemes receive electricity for pump operation form TANESCO.

Two schemes, namely Chinangari and Nyatwali, are in operation. However, pumps were not fully utilized because of high electricity charges. This issue is further discussed in section 3.3 of the Chapter 3

(b) Utilization of Solar Power System

Related to the electric pump, the team observed two solar pump systems. First one is operating in the lower Moshi upland area of Rau ya Kati system. Another scheme is Serengeti in Bunda District. Both solar pumps are working properly without trouble. Solar pump system would be useful for small horticulture schemes.

(c) Lack of O&M Fee

The following table calculates the ratio between the total O&M fee and assumed construction cost.

Table 2.1.1 O&M Fee

Name of Scheme	Name of IO	No. of Member	Irrigation Area (acre)	O&M Fee (acre/year)	O&M Total (TZS)	O&M ration in Const. cost
Igomelo	Igomelo Irrigators Org.	382	800	25,000	20 million	0.95 %
Dakawa	UWAWAKUDA	850	5,000	74,000	370 million	2.80 %
Kikafu Chini	UWAKICHI	759 (farmer 1500)	1,125	17,470 (average)	19.7 million	0.66 %
Chinangali	CHABUMA	296	300	360,000	22.2 million	2.80 %
Irienyi	UWAIRO	170	300	50,000	8.5 million	1.07 %

Note: In this estimate, construction cost is assumed to be 3,000 US$/ha. IO data are the result of interview survey.
Sources: JICA Project Team based on interview survey

Dakawa and Chinangali schemes use electric pump. Therefore, O&M fee is higher than the other schemes.

It is commonly said that minimum annual O&M cost would be 2 – 3 % of the total construction cost. If so, O&M fee would not be able to cover the necessary O&M cost.

(d) O&M by IOs

In operation of the modern irrigation system, gate will be closed not to intake a flood flow which contains considerable sand, silt, and clay. However, most of the irrigation systems in Tanzania use flood flow as a water source. Consequently, sedimentation is inevitable.

IOs should remove deposited material from canal sections. As for a canal design, designers should pay attention to a sand trap structures for easy removal of deposited material.

(e) Lack of Water Management Tools and Water Management

In order to save water and to get good product, water management is one of the key technology. For the water management, measuring devices or staves would be necessary. However, no devices and staves were in all the schemes the team visited except Dakawa Scheme (under rehabilitation).

In the case of Buigiri dam scheme, intake water from the reservoir was drained directly from a spillway of the main canal without using it because of absence of water management. Water saving through proper water management is essential especially for the reservoir schemes to secure agricultural production.

(4) Irrigators' Organization (IO)

(a) Registration of IO

There are three forms of farmers' group.

- Groups registered to NIRC
- Groups registered to MoHA as Associations
- Groups registered as Cooperatives

Under the Irrigation Act 2013 Article 28 (b), "all farmers owning land in an irrigation scheme are members of the irrigators' organization". And, irrigators' organizations shall register to NIRC with necessary fees.

According to the Operation and Support Services division of NIRC, 458 IOs were registered as Associations or as Cooperative Societies by 2015.

Table 2.1.2 Registration of IOs

Zone	Association	Cooperative	Unknown	Total
Dodoma	8	4	23	35
Kilimanjaro	42	25	0	67
Mbeya	77	50	1	128
Morogoro	57	14	0	71
Mtwara	80	6	1	87
Mwanza	37	0	0	37
Tabora	21	9	3	33
Total	322	108	28	458

Sources: Operation and Support Services division of NIRC

The number of registration as Irrigators' Organization under Irrigation Act is reported as only eight (8).

The reasons for the small number of registrations might be:

- Irrigation Act 2013 and its regulations are not yet well known,
- Irrigators' Organization shall go to NIRC Dar es Salaam to submit registration application, and
- Irrigators' Organization shall pay registration fee, annual fee, and so on.
- In order to increase the number of IOs registered to NIRC, the following measures might be possible solutions.
- Dissemination of Irrigation Act 2013
- Additional location (Zonal office) for registration
- Review of registration fees for existing registered IOs

(b) Capacity Building of IO

During the site visits, LGA staff pointed out necessity of capacity building of IO management members. Especially financial accounting is poor in IO management.

(c) Strengthening of By-law

In the case that land ownership belongs to farmers, IO management staff encounters difficulty in controlling farmers. For example, in Uyanyama case, three farmers took land issue to court. (Recently, IO won the case.) Many IOs plan to strengthen their Constitutions and by-laws.

2.2 Findings Related to Future Irrigation Development

(1) Potential Irrigation Scheme

Tabora Zonal Office have identified many potential irrigation schemes which have not yet been made public. NIMP2018 needs to include these identified potential schemes into the scheme list.

The Team recognizes that data collection on potential schemes, which have been identified but not made public, would be necessary in other Zonal Offices.

(2) Study by Nile Basin Initiative

Under Nile Basin Initiative programme (NELSAP) have conducted feasibility studies on Mara and Ngono valley basins. Development of large irrigation schemes was studied. Water demand of aforesaid schemes would be necessary to take into account in a future development plan.

(3) Water Harvesting Technology

There are many small earth dams especially in the jurisdiction of Tabora and Mwanza Zonal Offices, where water is scarce. Small earth dams as a water harvesting facility would be a useful tool to secure agricultural production.

By the way, DANIDA defined the type of small earth dam in the report of "Water from Small Dam, 2006" as follows.

- Charco Dam
- Hillside Dam
- Valley Dam

Some of LGA staff consider a small earth dam to be the Charco dam from its purpose of water use. However, dams which the Team observed would be categorised into the Valley Dam if the team follows DANIDA definition.

By the way, the international commission on large dam defines a dam with more than 15m in height as "a Large Dam. Other water storage facilities are not clearly defined.

In this context, JICA Project Team proposes the name of a small earth dam with less than 15 m in height for irrigation purpose as "a Water Harvesting Pond".

(4) Lake Water Use

Lake water use is one of key strategies in Mwanza Zonal Office. Chapter 3 of this paper discusses in detail about the lake water use.

(5) Traditional Irrigation Scheme as a Potential Area

There are many traditional irrigation schemes with vast areas. If water sources could be found, these schemes would become promising potential schemes.

2.3 Other Findings

(1) Definition of Traditional Irrigation Scheme

Traditional irrigation scheme is defined in the National Irrigation Policy 2010 as follows:

"Traditional irrigation scheme is an irrigation scheme with irrigation system comprising of temporary infrastructures and / or facilities that are not technically constructed/installed."

The team visited one of the traditional irrigation system in Simbo village. The system uses rain water which flows down from upstream area by forming so-called a "sheet flow". There is no canal and division structure. Water flows from a farm plot to a farm plot. Judging from the manner of water use, it seems to be a "Rain-fed Scheme".

In this connection, traditional irrigation scheme should not be categorised into irrigation scheme.

(2) Basin Water Board Member

ZIE is not a board member of the Basin Water Board, although the irrigation sector is the major water user. ZIE should be a member of Basin Water Board as a representative of giant water users.

Chapter 3 Use of Lake Water

3.1 Lakes in Tanzania

The following table shows major lakes in Tanzania. There are two types of lakes i. The first type of lakes is the transboundary lakes, namely Lake Victoria, Lake Tanganyika, Lake Nyasa (Malawi), Lake Jipe and Lake Chala. Another type is interior lakes.

As shown in Table 3.1.1, many interior lakes seem to have several limitations such as salinity or alkaline problems and existence of protected areas. It is also reported that some interior lakes are reducing their water surface area year by year due to climate change. As for transboundary lakes, Lake Nyasa has a border issue with Malawi. Lake Tanganyika would have environmental issues.

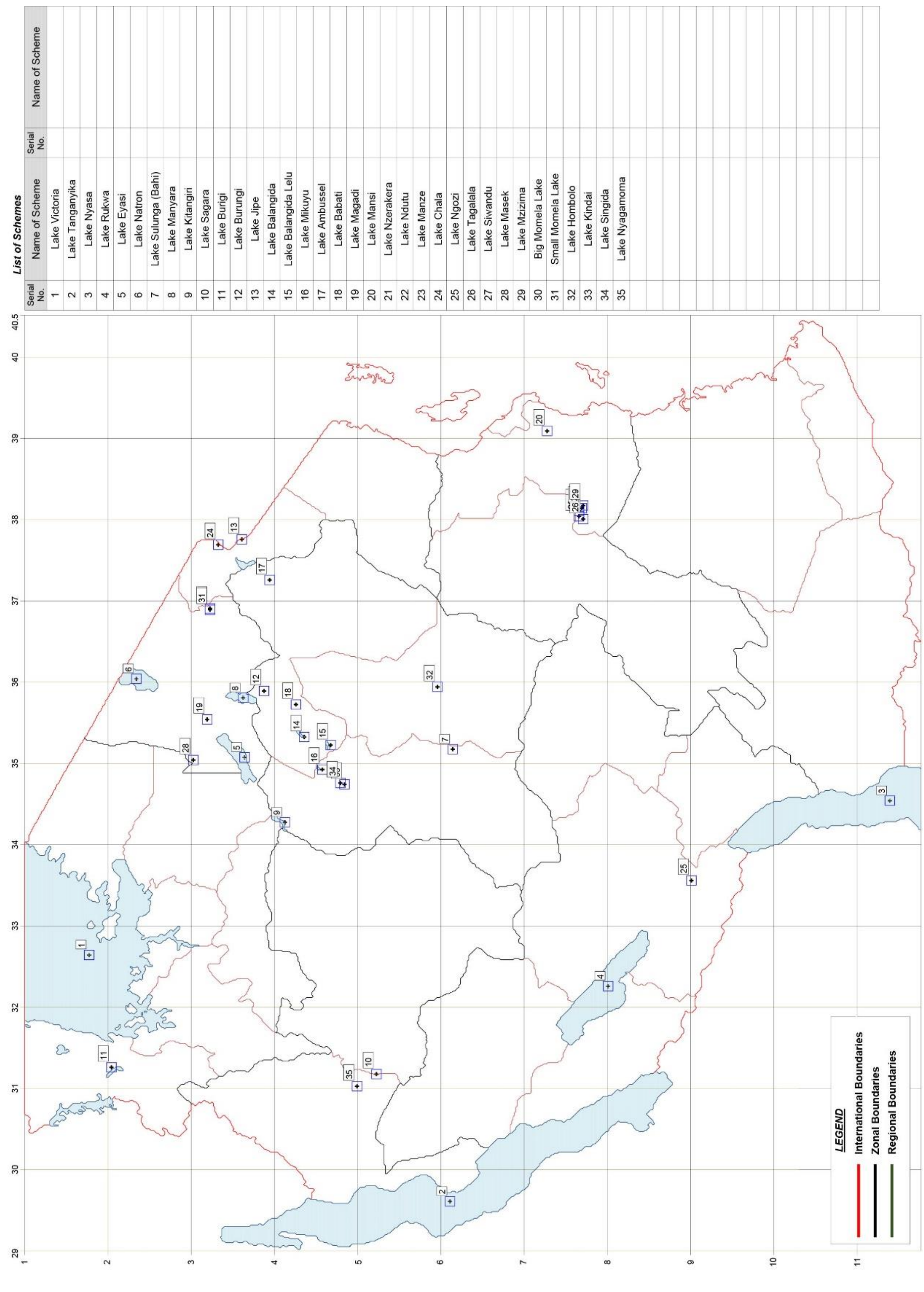
In consideration of the present status of lakes and the sizes of lake as a water Source, Lake Victoria would be a possible water source for irrigation development.

Table 3.1.1 List of Major Lakes in Tanzania

Name of Lake	Surface Area (km^2)	Zonal Office Concerned	Remarks
Lake Victoria	66,700	Mwanza, Tabora	Transboundary Lake
Lake Tanganyika	32,900	Katavi	Transboundary Lake
Lake Nyasa	29,700	Mbeya, Mtwara	Transboundary Lake
Lake Rukwa	5,580	Katavi, Mbeya	Alkaline Lake
Lake Eyasi	1,130	Kilimanjaro, Tabora	Seasonal Lake, Salt water
Lake Natron	660	Kilimanjaro	Salt and Soda Lake
Lake Sulunga (Bahi)	360	Dodoma	High saline Lake
Lake Manyara	231	Kilimanjaro, Tabora	Lake Manyara National Park Shallow Alkaline Lake
Lake Kitangiri	160	Tabora, Dodoma	
Lake Sagara	75	Katavi, Tabora	In the protected area
Lake Burigi	70	Mwanza	Burugi game reserve
Lake Burungi	46	Dodoma	Farmland on the south-west shore
Lake Jipe	30	Kilimanjaro	Transboundary Lake Protected on the Kenyan side
Lake Balangida	26	Dodoma	Alkaline Lake
Lake Mikuyu	26	Dodoma	
Lake Ambussel	23	Kilimanjaro	Pangani Basin
Lake Babati	17	Dodoma	Large hippo population
Lake Magadi	15	Kilimanjaro	Alkaline Lake (ph 10 over)
Lake Mansi	11	Morogoro	Marshes
Lake Nzerakera	8.2	Morogoro	Slouce Game Reserve
Lake Ndutu	5.3	Kilimanjaro	Ngorongoro National Park
Lake Manze	4.8	Morogoro	Slouce Game Reserve
Lake Chala	4.2	Kilimanjaro	Transboundary Lake
Lake Ngozi	3.3	Mbeya	Crater Lake, Volcano
Lake Tagalala	2.7	Morogoro	Slouce Game Reserve
Lake Siwandu	2.7	Morogoro	Slouce Game Reserve
Lake Masek	1.9	Tabora, Kilimanjaro	Ngorongoro National Park
Lake Mzizima	1.3	Morogoro	Slouce Game Reserve
Big Momela Lake	0.9	Kilimanjaro	Arusha National Park
Small Momela Lake	0.8	Kilimanjaro	Arusha National Park

Note: Surface areas are measured on the Google Earth Pro except the Lake Victoria. Surface area data of the Lake Victoria is abstracted form the NBI, "Nile Basin Water Resources Atlas", July 2016
Sources: Wikipedia "List of Lakes of Tanzania", Google Map and Google Earth Pro.

The location Map of these lake are shown in Figure 3.1.1.



Sources: JICA Project Team

Figure 3.1.1 Location Map of Lakes

3.2 Use of Lake Victoria

Lake Victoria is one of the transboundary lakes. Therefore, international rules of water use should be taking into account in its utilization.

Table 3.2.1 Information on Lake Victoria

Surface Area (km^2)	Countries Concerned	Remarks
66,700 *L1*	Tanzania* Kenya* Uganda* Rwanda Burundi DRC Egypt Ethiopia Sudan South Sudan	Management Institute: Nile Basin Initiative Countries' name with the asterisk mark are bordering countries.

Note: Surface area data: NBI, "Nile Basin Water Resources Atlas", July 2016
Sources: JICA Project Team

(1) International Agreements

In 1999, Nile Basin Initiative (NBI) was established with 10 Nile riparian countries' participation.

The Nile riparian countries are Burundi, the Democratic Republic of Congo, Egypt, Ethiopia, Kenya, Rwanda, South Sudan, The Sudan, Tanzania, and Uganda. Eritrea participated as an observer.

The objectives of the Initiative are stipulated as follows.

"The initiative seeks to develop the River Nile in a cooperative manner, share the socio-economic benefits arising from utilization of the water resources of the Nile, and promote regional peace and security to achieve its shared vision of: sustainable socio-economic development through the equitable utilization of, and benefit from, the common Nile Basin water resources." (Source: The State of the River Nile Basin 2012)

As for water allocation of the Nile River water including Lake Victoria, the Initiative has not discussed.

In 2003, for the purpose of equitable water sharing of Nile water, negotiation was launched for the "Cooperative Framework Agreement (CFA)". In 2008, CFA was drafted up.

General principals stipulated in Article 3 of CFA are as follows.

i) Cooperation
ii) Sustainable Development
iii) Subsidiarity
iv) Equitable and reasonable utilization
v) Prevention of the causing significant harm
vi) The right of Nile Basin States to use water within their territories
vii) Protection and conservation
viii) Information concerning planned measures
ix) Community interest
x) Exchange of data and information
xi) Peaceful resolution of disputes
xii) Water as a finite and Vulnerable resource
xiii) Water has social and economic value

xiv) Water security

In 2010, CFA was officially opened for signature. By the end of 2011, six countries of Tanzania, Kenya, Uganda, Rwanda, Burundi and Ethiopia singed. CFA requires six nations to ratify the agreement. Only three countries including Tanzania ratified by the end of 2015. It might take time to ratify the agreement.

After ratifying the agreement, Nile River Basin Commission will be established as a permanent institutional structure under the article 15 of CFA.

The issue of water allocation of the Nile River Basin might be discussed in the institution.

(2) Present Water Use of the Nile River Basin

NBI studied water use in the Nile River Basin. Dominant users of the Nile River are Egypt and Sudan as shown in Table 3.2.2.

According to the study, in 2002, there were 64 irrigation schemes in the lake basin of Tanzania including not only schemes which directly withdrew water from Lake Victoria but also schemes which utilised river water in the basin. Tanzania utilises only 0.1 % of available water source for irrigation. (Data on irrigation would need to be updated.)

This fact shows that Tanzania might have a right to use more water from the Lake Victoria Basin including the lake from the viewpoint of “equitable and reasonable utilization”.

Table 3.2.2 Estimated Equipped, Crop Areas, Withdrawal Requirement and Actual Withdrawal

Country	Equipped Area		Cropped Area		Withdrawal Requirement		Actual Withdrawal	
	(1,000 ha)	%	(1,000 ha)	%	(MCM)	%	(MCM)	%
Burundi	15.3	0.3%	8.7	0.1%	28.9	0.0%	28.7	0.0%
DR Congo	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%
Egypt	3,447.0	63.8%	5,021.0	79.0%	66,551.5	79.8%	66,054.0	80.4%
Ethiopia	91.0	1.7%	134.0	2.1%	2,018.2	2.4%	1,500.9	1.8%
Kenya	47.8	0.9%	20.0	0.3%	367.4	0.4%	307.5	0.4%
Rwanda	7.0	0.1%	7.0	0.1%	3.4	0.0%	3.2	0.0%
South Sudan	0.5	0%	0.2	0.0%	58.6	0.1%	57.4	0.0%
Sudan	1,764.6	32.7%	1,146.7	18.0%	13,959.8	16.7%	13,921.6	16.9%
Tanzania	19.7	0.4%	6.5	0.1%	102.2	0.1%	63.4	0.1%
Uganda	9.7	0.2%	9.7	0.2%	260.4	0.3%	260.3	0.3%
Total	5,402.6	100.0%	6,353.8	100.0%	83,350.4	100.0%	82,197.0	100.0%

Sources: NBI, “Nile Basin Water Resources Atlas”, July 2016

(3) Proposed Lake Water Use

As the JICA Project Team reviewed the present status of international agreement, no agreement on water allocation exists. However, as a result of continuous efforts of riparian countries, there is CFA. Therefore, the team decided to follow the basic principle of CFA for the estimation of available water amount.

One of the principle of CFA is the “Equitable and Reasonable Utilization” of the Nile Basin water. In Article 4 -2 of CFA stipulate the “Equitable and Reasonable Utilization”. (See Table 3.2.3)

In the Article, the part (d) "population dependent" would be a clear and quantitative indicator to estimate equitable and reasonable amount of water for irrigation. Then, the team used the population data for estimate.

Table 3.2.3 Article 4 of CFA

2 In ensuring that their utilization of Nile River System water resources is equitable and reasonable, Nile Basin States shall take into account all relevant factors and circumstances, including but not limited to the following: (a) Geographic, hydrographic, hydrological, climatic, ecological and other factors of a natural character; (b) The social and economic needs of the Basin States concerned; (c) The population dependent on the water resources in each Basin State; (d) The effects of the use or uses of the water resources in one Basin State on other Basin States; (e) Existing and potential uses of the water resources; (f) Conservation, protection, development and economy of use of the water resources and the costs of measures taken to that effect; (g) The availability of alternatives, of comparable value, to a particular planned or existing use; (h) The contribution of each Basin State to the waters of the Nile River system; (i) The extent and proportion of the drainage area in the territory of each Basin State.

Sources: Agreement on the Nile River Basin Cooperative Framework

The following table summarises the estimated population and its ratio in the Nile River Basin.

Table 3.2.4 Population Living in the Nile River Basin, 2015

Country	Population (million)	Ratio (%)	Country	Population (million)	Ratio (%)
Burundi	5.7	2.3 %	Rwanda	8.7	3.5 %
CR Congo	2.9	1.2 %	South Sudan	11.9	4.8 %
Egypt	85.8	34.6 %	Sudan	31.4	12.6 %
Ethiopia	37.6	15.1 %	Tanzania	11.3	4.6 %
Eritrea	2.2	0.9 %	Uganda	33.6	13.5 %
Kenya	17.2	6.9 %			
Total				248.3	100.0 %

Sources: NBI, "Nile Basin Water Resources Atlas", July 2016

(a) Scenario 1:

If the team assumes the total withdrawal requirement shown in the Table 3.2.2 is the maximum amount, Tanzania would receive 4.6% of the total on the basis of population ratio at maximum.

4.6 % of the total withdrawal requirement = 83,350.4 million m^3 x 4.6 %

= 3,834.1 million m^3

Available irrigation area would be calculated dividing available water amount by unit water requirement.

Unit water requirement = 63.4 million m^3 / 6,500 ha = 9,754 m^3/ha

Estimated irrigable area = 3,834.1 million m^3 / 9,754 m^3 = 393,000 ha

(b) Scenario 2:

If the team assumes a basis of calculation is the withdrawal requirement of Egypt, Tanzania would receive 8,764.9 million m^3 of withdrawal requirement.

Unit Withdrawal requirement (UWr) = Withdrawal requirement / Population

= 66,551.5 million m^3 / 85.8 million

= 775.7 m^3/person

Total amount of requiremen t = UWr x Tanzanian Population

= 8,764.9 million m^3

Available irrigation area would be calculated dividing available water amount by unit water requirement.

Estimated irrigable area = 8,764.9 million m^3 / 9,754 m^3 = 898,600 ha

As a conclusion, Tanzania would not need to consider the limitation of irrigation development in terms of water in the Lake Victoria Basin.

3.3 Electric Charge for Pump Irrigation

As the team learnt during site visit, introduction of solar power generation system would be useful for a small scaled horticulture irrigation system. However, irrigation for paddy with a certain scale would require power supply from TANESCO as more reliable and continuous source of power supply.

Unfortunately, many electric pumps were not in operation because of high electricity charge for irrigation. In Tanzania, farmers need to pay the same electricity charge as an industrial use. The following table shows the customer groups for tariff setting. No customer group for agriculture use is prepared.

Table 3.3.1 Customer Groups in TANESCO's Tariff

Existing Customer Group		Proposed Customer Group (2017)	
D1:	Domestic Low Usage, for low consumption users	D1:	Domestic Low Usage, for low consumption users
T1:	General Usage, for general use of electricity including residential, small industries, commercial and public lighting;	T1a:	General Usage, for general use of electricity including residential, small commercial and public lighting
T2:	Low Voltage Maximum Demand Usage, for general use at 400 Volts with average consumption greater than 7500 kWh per meter reading period	T1b:	General Usage for light industrial use, Billboards and Communication towers
T3MV:	Medium Voltage Maximum Demand Usage, for general use where power is metered at 11/33 kV;	T2:	Low Voltage Maximum Demand Usage, for general use at 400 Volts with average consumption greater than 7500 kWh per meter reading period
T3HV:	High Voltage for general use where power is metered at 132kV and above (including bulk supply to Zanzibar)	T3MV:	Medium Voltage Maximum Demand Usage, for general use where power is metered at 11/33 kV
		T3HV:	High Voltage for general use where power is metered at 132kV and above (including bulk supply to Zanzibar)

Sources: TANESCO, "Tariff Adjustment Application for year 2017"

As shown in the table above, there is no category of irrigation and agriculture. In Japan, electric power companies supply low price electricity to irrigation and drainage purpose from the view point of food security as shown in the following table.

Table 3.3.2 Monthly Tariff in Japan (in Ratio)

Category of Contract	Basic Charge	Demand Charge		
		Normal	High Season (Summer)	Other Seasons
Residential Use B	25 – 153 %	114 – 176 %	-	-
Residential Use C (Large Family, Shops)	25 %	114 – 176 %	-	-
Low Voltage (Small industry and business)	100 %	100 %	100 %	100 %
High Voltage (Big Industry)	153 %	-	101 %	104 %
Irrigation and Drainage	39 %	-	76 %	76 %

Note: This table is prepared assuming the charge for "Low Voltage" as 100%.
Sources: Home page of Tokyo Electric Power Company (TEPCO)

In order to promote lake water as a stable water source, a special consideration of electricity charge for agricultural purposes would be necessary.

Chapter 4 National Irrigation Research and Training Centre

4.1 Review of Application Form for Grant Aid from Japan

(1) Proposed Location

NIRC plans to establish NIRTC in Dakawa Village, Mvomero district, Morogoro. The following table summarises the location plan of NIRC and the result of site visits by the team.

Table 4.1.1 Site Conditions and Findings

	Explanation by NIRC	Findings by JICA Project Team
Land	Flat land with minimum slope	Small trees exist. Land clearing would be necessary
Site condition	Electricity, telephone services are available	Extension would be necessary from existing research centres
	Water supply system is at final stage of construction	Water supply system is constructed for Chollima and Chinese research centres. NIRTC requires new water supply system including pump house and Water Permit. Water source will be the Wami River.
Access		From Morogoro-Dodoma road: 7.0 km Existing road: 5.3 km Access road:1.7 km New construction of the access road would be necessary.

Sources: Application Form for Grant Aid from Japan, 2014

(2) Site Plan: Laboratories

NIRTC has a plan to establish 6 laboratories as shown below.

i) Laboratory No.1 - Hydrology & Water Resources
ii) Laboratory No.2 - Soil Mechanics
iii) Laboratory No.3 - Irrigation & Water Management
iv) Laboratory No.4 - Material Testing (Strength of materials)
v) Laboratory No.5 - Remote Sensing & GIS
vi) Laboratory No.6 - Technology Transfer

Proposed NIRTC site

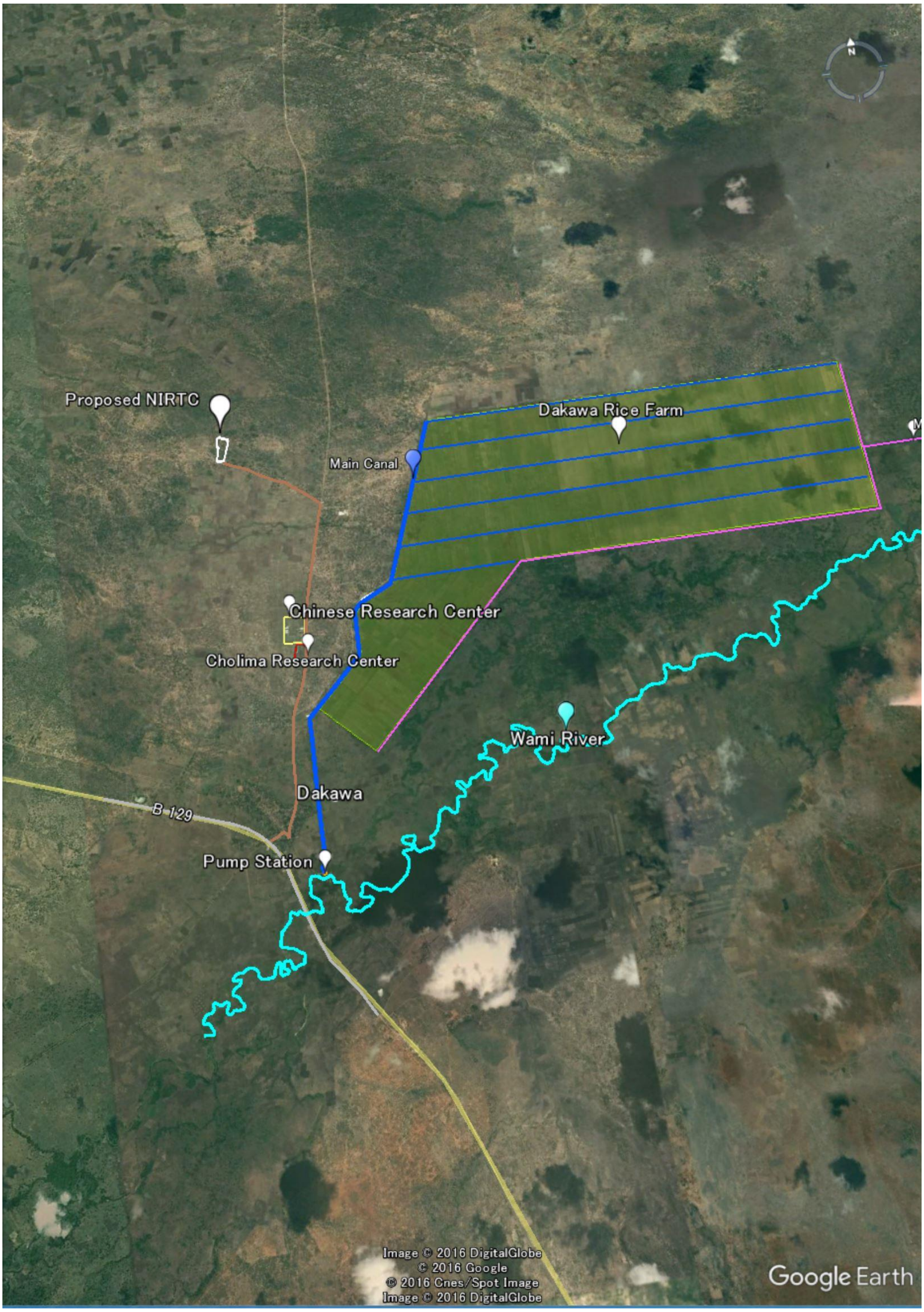
NIRTC plans to provide various in-service trainings for both public and private personnel in the irrigation sector.

If the meaning of "in-service" is to get order from outside institution for training purpose, each laboratory would require 3-4 skilful technicians and 1-2 engineers.

(3) Cost Estimate

The application includes 135,000 US$/year for project staff salaries. Assumed that salary of staff is 750 US$/month, the amount could employ 15 staff in total.

As for budget of international experts is 365,000 US$ year. With this amount, NIRTC would be able to employ one expert.



Source: JICA Project Team

Figure 4.1.1 NIRTC Location Map

4.2 Comments on the plan of NIRTC

(1) NIRTC Construction

Construction of NIRTC would be possible with enough budget including the following facilities.

- New pump house would be necessary.
- New water supply system would be necessary.
- Access road improvement would be necessary.

If NIRTC would plan to conduct hydraulic model test, considerable amount of water may be required additionally.

(2) Staff Recruitment

If NIRTC will plan to get order from outside, recruitment of skilful technicians and engineers will be indispensable.

Total number of necessary technical staff will be 30.

It will be difficult to cover salary of 30 staff with contract works from outside. Therefore, annual expense might be much higher than the estimate.

The most difficult problem will be employment of skilful technical staff.

(3) Cooperation with Other Institutions

As a solution to find skilful technical staff, it would be necessary to seek cooperation with other technical institutions. In consideration of the location, one of possibilities would be cooperation with the Sokoine University in Morogoro.

The Sokoine University has a department of agricultural engineering including irrigation. In addition, the University has laboratories, and an experimental farm with water harvesting pond.

Experimental Farm

Water Harvesting Pond

4.3 Reference Material:

(1) The Roles of the Project Committee

CGL Volume 2 – Implementation describes the role of the project committee as follows.

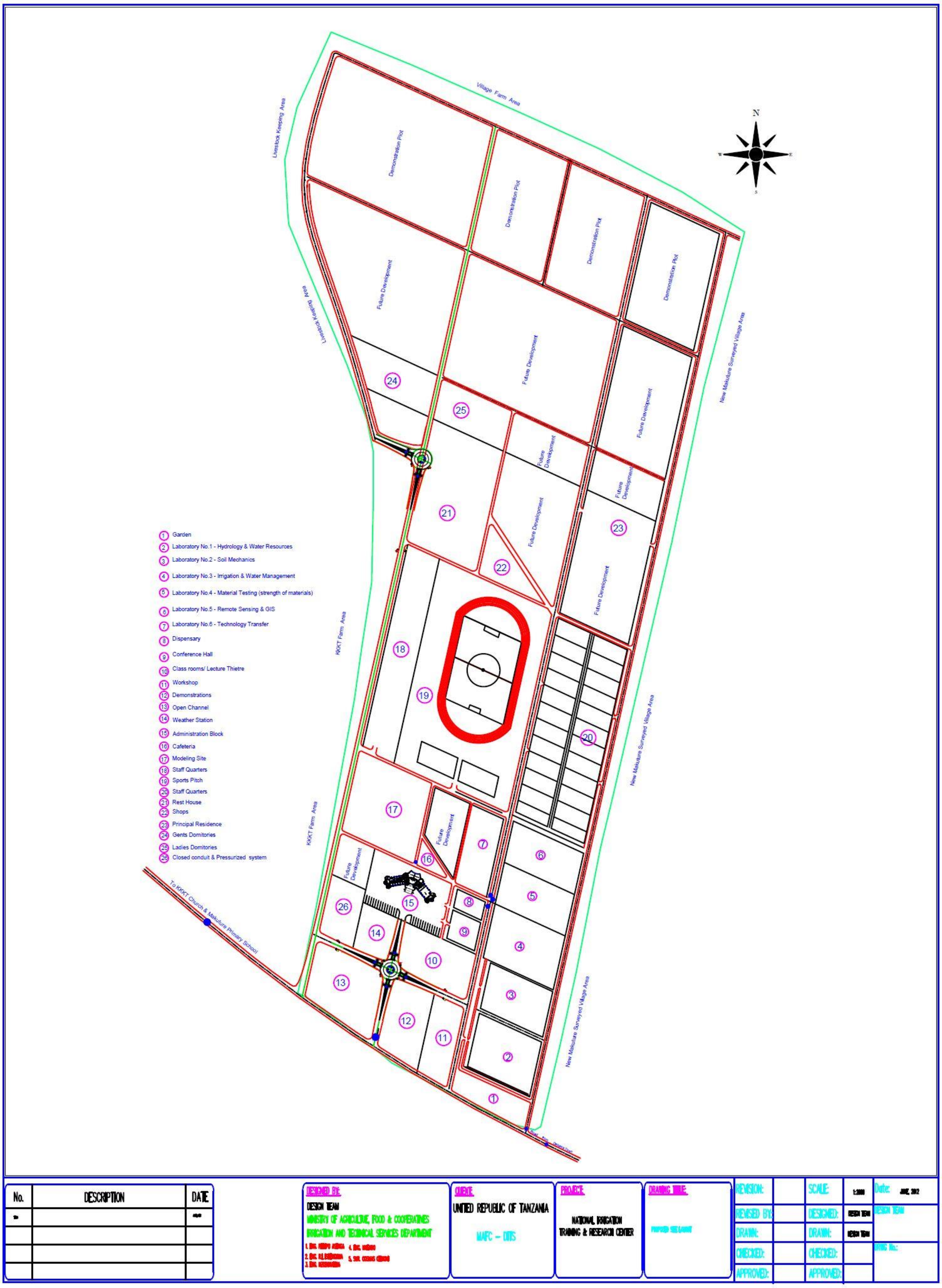
The DIDT will brief the roles of the project committee, to be elected from the beneficiaries, to the community, and instruct the community to make arrangements for the meeting to elect project committee members.
The roles of the project committee shall be:

a) Project implementation.
b) Maintain a bank account under the supervision and the guidance of the Village Council.
c) Provide information on implementation progress.
d) Mobilize contributions from the community members.
e) Handle the procurement of goods and services.
f) Seek technical support and other services from extension workers, DIDT, ZIO/RIO, private consultants, NGOs and development agencies.
g) Prepare and submit monthly, quarterly and annually physical and financial reports to the Village Council, following the PO-RALG reporting format.

Source: NIRC, "Guidelines for Irrigation Scheme Development Volume 2 – Implementation", Revised Edition 2016

(2) Site Plan of NIRTC

The site plan of NIRTC originally proposed by NIRC is as shown in Figure 4.3.1.



Sources: JICA Project Team

Figure 4.3.1 Site Plan of NIRTC

Site investigation Sheet (1)

Name of Scheme	**Highland Estate Ltd.** **(Head Office: Dar es Salaam)**
Date of Investigation	31/Jan/ 2017
Name of Site Visitor	NIMP2018 team : Sibuta Leader、Shiga、Amano、Masaki、Majo、Mashafi、Samson, Mbeya Zonal Office: Muendo, Faraja
Name /Position of Guide	Mbarali DC Irrigation Engineer: Highland Estate Manager: Sadiki Nigira
Findings	
Location	Zone : Mbeya District : Mbarali Intake Site: Latitude S 8.73556 Longitude E 34.37462 Farmland: Latitude S 8.65773 Longitude E 34.28548
Outline of the Scheme	This scheme was constructed in 1970's with assistance of China. Private farm of Highland Estate Ltd. has taken over the irrigation systems from NAFCO since 2004/5.
Scheme Area	Potential Area (ha) : unknown Developed Area (ha) : 3,600 Irrigation Area (ha) : 300 direct management 3,300 contract to farmers
Present Status of Scheme	・ Estate has two irrigation systems. The system 2 area is located at north of the system 1. (See the Scheme Map) Major crop is paddy with single planting per year. Land preparation: September Transplantation of rice: December - January Harvesting: June - July ・ O&M Cost: 6 million Tzs / year ・ Farming and Post harvesting:
Water Source	Mbarali River （Perennial River）
Irrigation Method	Gravity Irrigation (Headworks, and Open channel)
Irrigation Facilities	Headworks : Dimensions are unknown. Main canal : System 1 Main 13.5 km * System 2 Main 7.0 km * Irrigation Area of System 1 : Gross 2,270 ha* Irrigation Area of System 2 : Gross 2,110 ha*
Findings	・ Maintenance activities, such as lubricants on gate spindles, coating of gate covers and weeding of canals, are seems to be well conducted. ・ Canal slope collapse of major canals was not observed in the field. ・ The company spend small amount of 6 million Tzs annually for maintenance of facilities. This amount might cover material cost only, and might not include manpower and machinery costs.

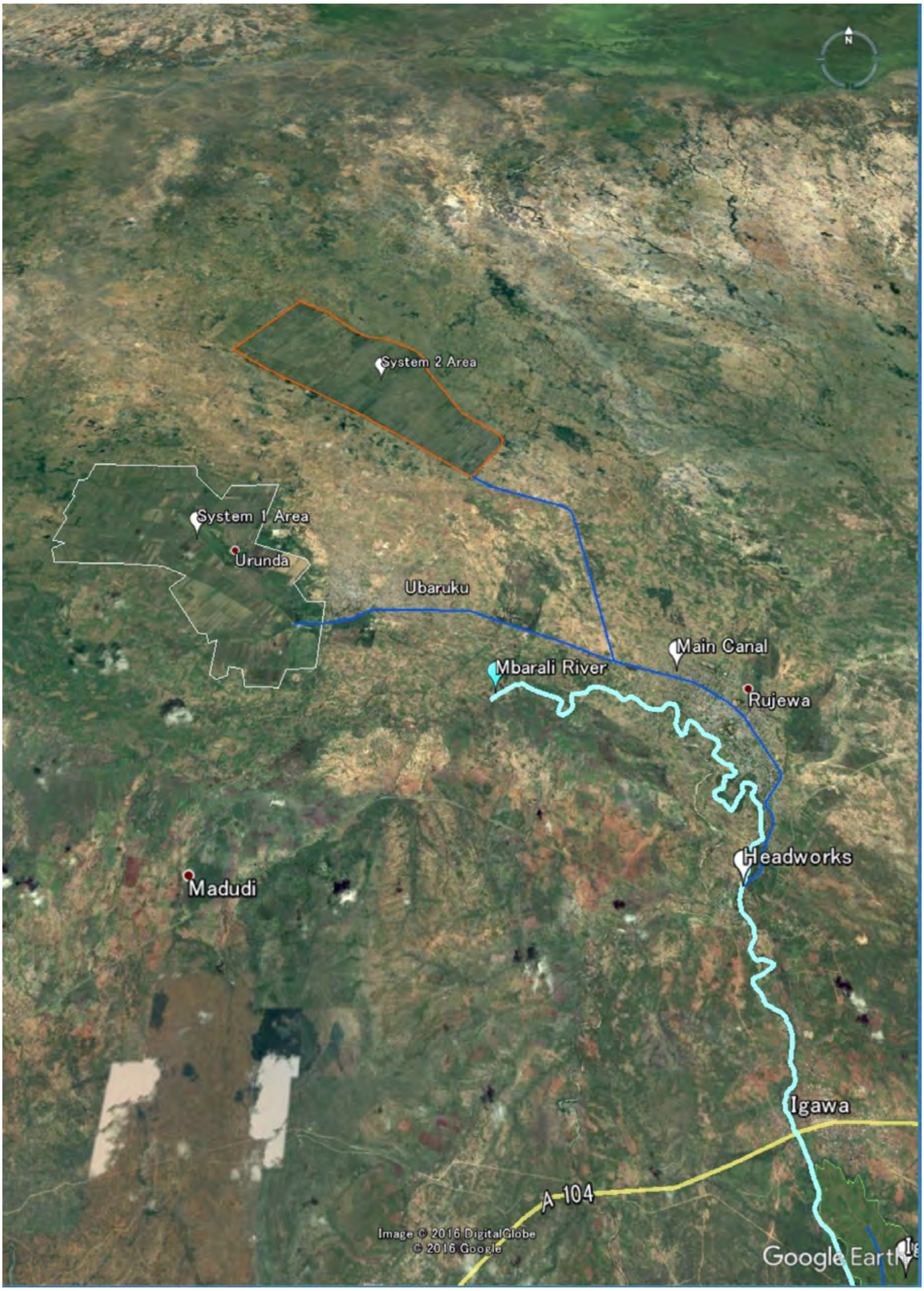
Photos 1/2

Location	Photo	Comments
Headworks Weir		A low height concrete wall structure, that is not commonly constructed, can be seen at downstream apron.
Sand Sluiceway		Three gated sand sluiceway is provided in the left bank of the Mbarali River.
Intake Structure		Well maintained irrigation intake structure
Main Canal		Beginning point of the Main Canal paved with concrete (13.5 ㎞).

Photos 2/2

Location	Photo	Observation
Trunk canal in Scheme 1 Area		Canal problem such as collapse of canal slope, is not observed.
Gated check structure		Water level control is conducted by gates in the canal. System is old, but it seems operational without problem.

Scheme Map


System 2 Area
System 1 Area
Urunda
Ubaruku
Main Canal
Mbarali River
Rujewa
Headworks
Madudi
Igawa
A-104
Image © 2016 DigitalGlobe
© 2016 Google
Google Earth

Site investigation Sheet (2)

Name of Scheme	**Igomelo Scheme (SSIDP Scheme)**
Date of Investigation	31/Jan/ 2017
Name of Site Visitor	NIMP2018 team : Sibuta Leader、Shiga、Amano、Masaki、Majo、Mashafi、Samson Mbeya Zonal Office: Mwendo, Faraja
Name /Position of Guide	Mbarali DC Irrigation Engineer: IO : IOs : Chairman, Vice Chairman, Accountant (Attend Interview), Board member 1, Member 1
Findings	
Location	Zone : Mbeya District : Mbarali Intake Site: Latitude S 8.81741 Longitude E 34.39184 Farmland: Latitude S 8.81537 Longitude E 34.39229
Outline of the Scheme	This site started as a Traditional irrigation scheme in 1950's. Improvement works were carried out with WB assistance in 2001/2002 fiscal year. As a result, irrigation area expanded from 100 ha to 312, and unit yield of crops also increased drastically. At present, canal lining work (1.3km) is going on under SSIDP.
Scheme Area	Potential Area (ha) : 312 ha Developed Area (ha) : 312 ha Irrigation Area (ha) : 312 ha
Water Source	Mbarali River （Perennial River）
Irrigation Method	Gravity Irrigation (Headworks, and Open channel)
Irrigation Facilities	Headworks : Dimensions are unknown. Canal : Main 5.0 km * Secondary 2.8 km *
Irrigators Organization	Name of IO: Igomelo irrigators Organization Registration: 1998 with 195 members as a cooperative Membership: 303 (Male 202, Female 101), non-member 79 Member Fee: 75,000/acre/year (O&M uses 25,000 out of 75,000) Non-member fee 115,000/acre/year
Findings	・ Canal lining with wet stone masonry is going on under SSIDP. ・ The work manner using finishing rulers, observed in the field, is proper, and good result will be expected. ・ Intake site seems to be stable because of rock foundation. ・ IO seems to be active enough to maintain the scheme.

*Note ; The asterisk mark " * " means that the data is approximated value measured on the google earth pro.*

Photos

Location	Photo	Comments
Intake Weir		Rocks are exposed. Foundation of the weir would be steady.
Intake Structure		A gate for sand sluiceway can be seen just downstream part of the intake without guide wall.
Main Canal		Beginning point of the main canal ・In the left side of a gate located in front, there is a spillway structure to eliminate excessive water from the main canal, and return it to the river.

Scheme Map


Igawa
Igomero Irrigation Area
Main Canal
Igomero Scheme HWs
© 2016 Google
Image © 2016 DigitalGlobe
Google Earth

Site investigation Sheet (3)

Name of Scheme	**Namingo'ngo (SSIDP scheme)**
Date of Investigation	2/Feb/ 2017
Name of Site Visitor	NIMP2018 team : Sibuta Leader、Shiga、Amano、Masaki、Majo、Mashafi、Samson Mbeya Zonal Office: Muendo, Faraja
Name /Position of Guide	Momba DC DAICO: Momba DC Irrigation Technician:
Findings	
Location	Zone : Mbeya District : Momba Intake Site: Latitude S 8.85397 Longitude E 32.48743 Farmland: Latitude S 8.85174 Longitude E 32.47636
Outline of the Scheme	A headworks was constructed at old river course, however, the headworks were flushed away together with bridge due to flood in 2005. New headworks construction has been implemented in excavated artificial river course utilising NIDF since 2009, and is scheduled to complete in July, 2017.
Scheme Area	Potential Area (ha) : 5,000 ha Designed Area (ha): 3,000 ha Developed Area (ha): 1,500 ha Irrigation Area (ha) ha
Water Source	River （Perennial River）
Irrigation Method	Gravity Irrigation (Headworks, and Open channel)
Irrigation Facilities	Headworks : Dimensions are unknown. Canal : Main 2.5 km Canal lining under SSIDP 550 m
Findings	・ Serious sedimentation is observed in front of intake facility. ・ According to district technician, the foundation of the headworks is covered with 10 meters' thick layer of deposited sand and clay. Therefore, this foundation, which shows a weak bearing capacity, makes construction work difficult. ・ No measuring devices are found. Consequently, suitable water distribution would be difficult. ・ Poor construction manners can be observed in many sections. · Grooves are not straight · Vibration at the time of concrete placing might be insufficient. · Reinforcement bars are exposed without cut.

Photos (1/2)

Location	Photo	Comments
Intake Weir		・An intake facility is constructed in the left bank of the river. ・A concrete bridge is constructed just downstream reach of the headworks.
Intake Structure		・Serious sedimentation can be seen in the back of gates of sand sluiceway.
Bridge and Debris		・A pier of bridge located in front of sand sluiceway has debris stay. This will cause negative effect to the sand sluiceway.
Sand Sluiceway		・Gate spindle and frame are seemed to be lack of necessary strength. ・A frame that can be seen in the back has already changed its shape because of lack of strength.

Photos (2/2)

Location	Photo	Comments
Stop log		Careless supervision of concrete work ・Grooves should be made straight. ・Reinforcement bar should be cut to an appropriate length.
Beginning point of Main canal		・No water volume measuring device or facility exists. ・Unnecessary projections are found.
Intake and Regulator		・No water volume measuring device or facility exists.
Design of Stop Log		・Unnecessary sudden contraction of a canal section would cause much loss of energy of water.

Scheme Map


Kasawe
Momba DC office
Namingo'ngo Irrigation Area
Ngongo
Main Canal
Namingo'ngo Headworks
© 2016 Google
Image © 2016 CNES / Astrium
Google Earth

Site investigation Sheet (4)

Name of Scheme	**Dakawa Rice Farm**
Date of Investigation	7/Feb/ 2017
Name of Site Visitor	NIMP2018 team : Sibuta Leader, Eng. Majo, Mr. Arai, Mr. Shiga, Mr. Amano, Mr. Masaki, Eng. Mashafi, Mr. Samson
Name /Position of Guide	Morogoro Zonal Office: Eng. Towa, Eng. Mtui
Findings	
Location	Zone : Morogoro District : Mvomero Pump Station: Latitude S 6.443639 Longitude E 37.53640 Farmland: Latitude S 6.423108 Longitude E 37.53812
Outlie of the Scheme	The scheme was constructed by GoT through NAFCO between 1979 and 1982 with technical assistance by North Korea. In 2003, the farm was handed over to farmers group. As a part of IRRIP of USAID, CDM smith prepared the up-dating feasibility study report based on 1996 F/S in 2012. At present, rehabilitation of the scheme is on-going under IRRIP.
Scheme Area	Potential Area (ha) : 5,000 ha Designed Area (ha): 3,000 ha Developed Area (ha): 2,000 ha Irrigation Area (ha) 2,000 ha
Water Source	Wami River （Perennial River）
Irrigation Method	Pump Irrigation (Headworks, and Open channel)
Irrigation Facilities	Pump Station : 6 pumps 600mm dia. 3,600 m^3/hr x 4 Canal : Main 1 no. 7.4 km Secondary 8 nos. 26.2 km Drainage 34.3 km Farm road 37.4 km
Irrigators Organization	Name of IO: UWAWAKUDA Year of Establishment: 2006 Year of Registration: 2006 as Cooperative Membership: 840 (male = 516, female = 324) Entrance fee: 100,000 Tzs, Irrigation fee: 74,000 Tzs
Findings	・Lining concrete of Main Canal is reinforced by iron bar. This reinforced lining would resist water pressure caused by high ground water level. ・Water measuring facilities such as Parshall measuring flume have been constructed at the head of secondary canal. Proper water management using measuring facilities would bring cost saving of electricity charge of pumps.

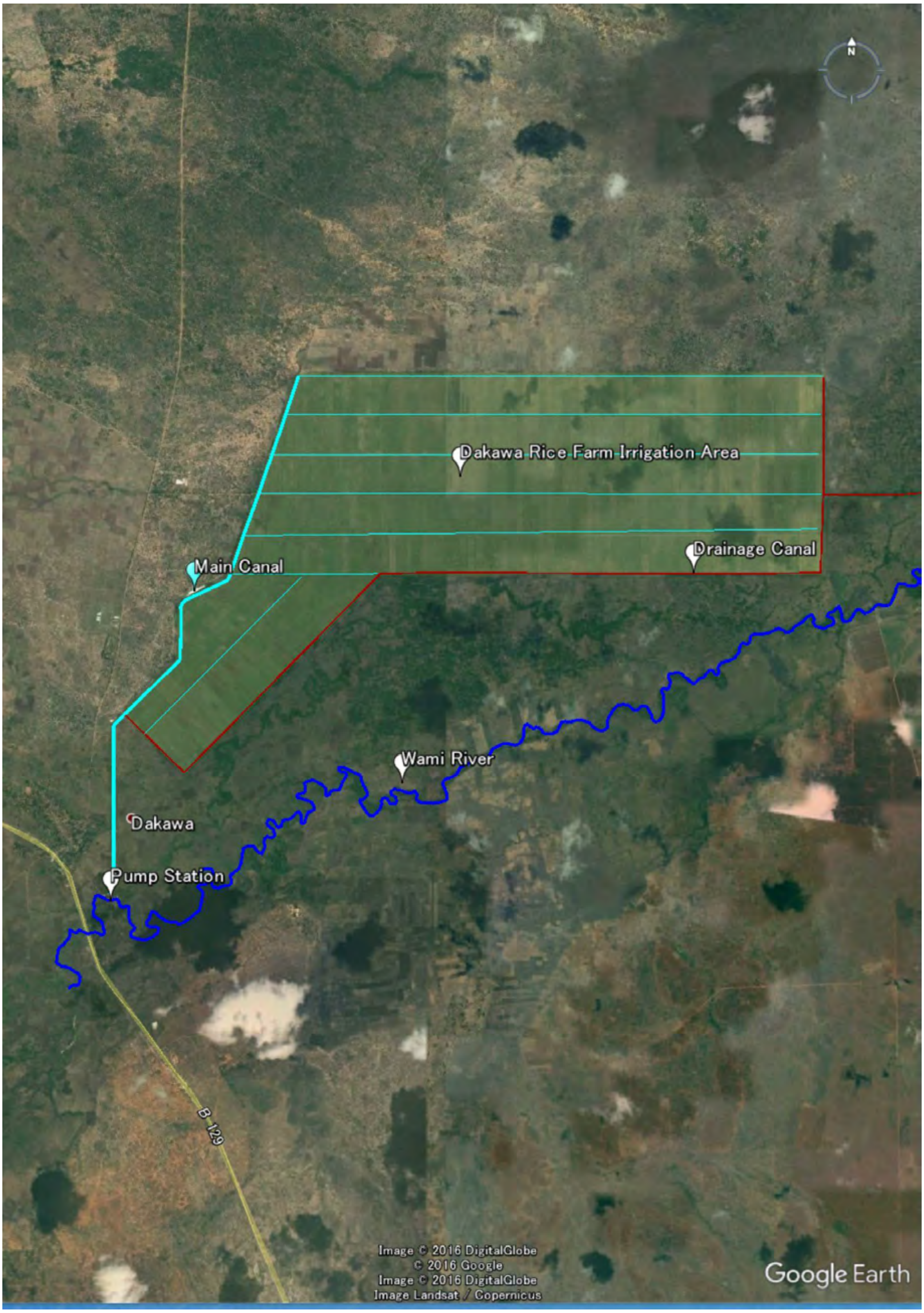
Photos (1/2)

Location	Photo	Comments
Pump Station		GoT constructed pump station in 1982.
Pump		Pumps installed were made in Germany.
Concrete Lining for Main Canal		Completed section of the Main canal.
Concrete Lining under Construction		Main canals and 500m section of each secondary canals are scheduled to be lined. As for secondary lining, concrete panels are used.

Photos (2/2)

Location	Photo	Comments
Check structure under Construction		Typical type of check gate structure under construction.
Farmland		For the farm practice machines such as tractor, combine are utilised.

Scheme Map


Dakawa Rice Farm Irrigation Area
Drainage Canal
Main Canal
Wami River
Dakawa
Pump Station
B 129
Image © 2016 DigitalGlobe
© 2016 Google
Image © 2016 DigitalGlobe
Image Landsat / Copernicus
Google Earth

Site investigation Sheet (5)

Name of Scheme	**Itete Irrigation Scheme**
Date of Investigation	9/Feb/ 2017
Name of Site Visitor	NIMP2018 team : Sibuta Leade, Eng. Majo, Mr. Amano, Mr. Masaki, Eng. Mashafi, Mr. Samson
Name /Position of Guide	Malinyi District:
Findings	
Location	Zone : Morogoro District: Malinyi Headworks: Latitude S 8.648297 Longitude E 36.39573 Left Main Canal: Latitude S 8.648844 Longitude E 36.39216 Right Main Canal: Latitude S 8.641767 Longitude E 36.39483
Outline of the Scheme	Itete Scheme was constructed between 2013 and 2015 by support from SAGOT with an amount of 6.09 billion Tzs.
Scheme Area	Potential Area (ha) : 8,000 ha Designed Area (ha): 1,000 ha Developed Area (ha): 1,000 ha Irrigation Area (ha) ha
Water Source	Mchilipa River （Perennial River）
Irrigation Method	Gravity Irrigation (Headworks, and Open channel)
Irrigation Facilities	Headworks : no data Canal : Left Main 4.7 km (covers 600 ha) Right Main 2.4 km (covers 400 ha) Secondary 22 canals Farm road : 6.6 km
Irrigators Organization	Name of IO: Itete Irrigators Organization Establishment: 2007 Registration: 2011 as Association Membership: 417 (male = 320, female = 97), non-member = 230
Findings	・Some intake structures are located at just upstream of the drop structure which does not equipped with water level control facilities. These intakes would face difficulty in receiving water during low-water-demand period. (See Photo 3) ・Drainage canals were not found at the field. A farmer drained our excess water from paddy field to the edge of the main farm road. (See Photo 8) The road would be easily damaged by water ponded along the road. ・Water level control of gated-type check structure would require careful water management. Otherwise, canal would be easily damaged by overflow water from upstream. (See Photo 7) ・The right main canal construction was suspended. (See Photo 4) ・A drainage system in the scheme and a catch drain network surrounding the scheme area would be necessary.

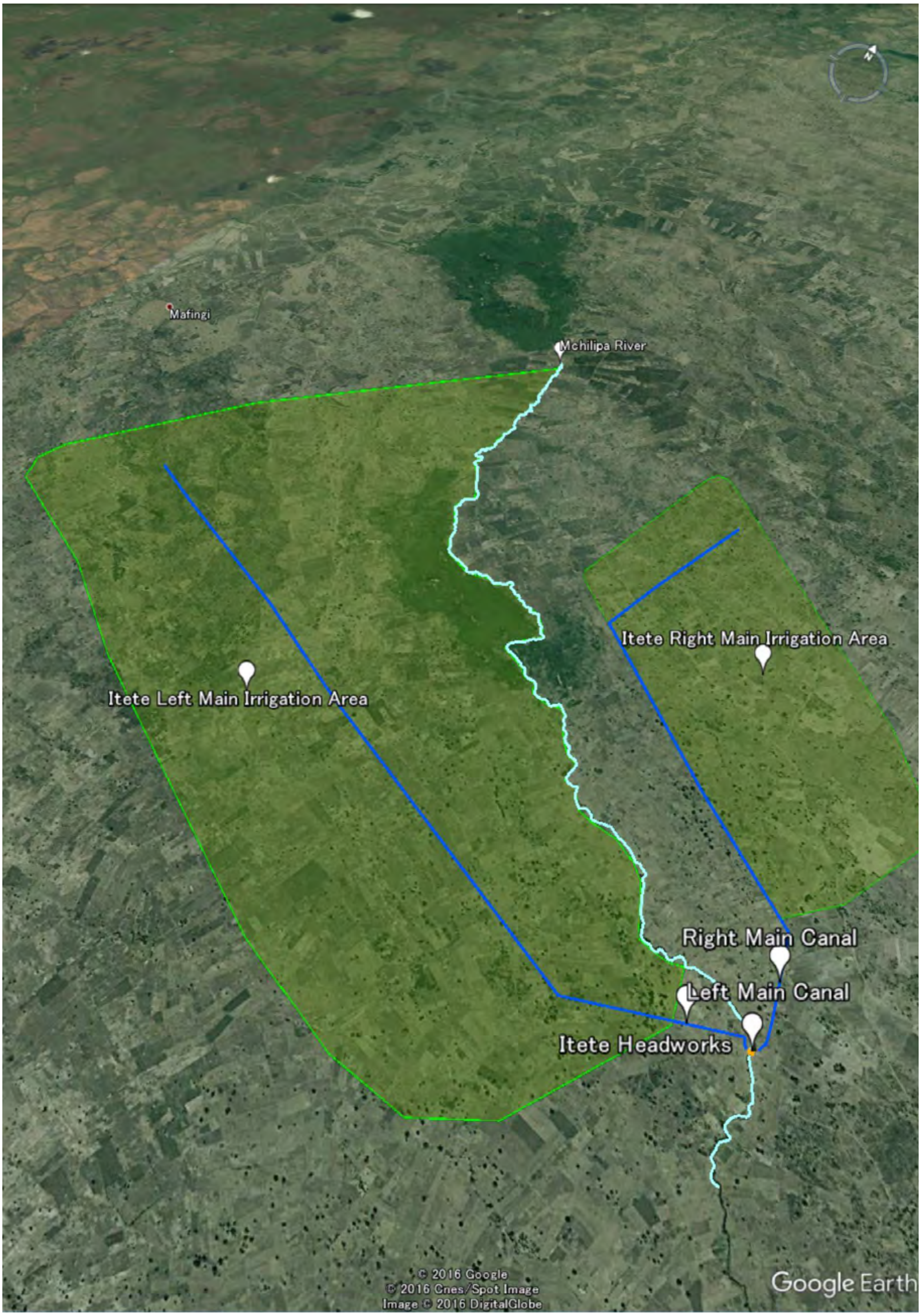
Photos (1/2)

Location	Photo	Comments
Photo 1 Headworks		This headworks has both left and right intake structures.
Photo 2 Beginning point of Right Main Canal		Excess water will return to the river through spillway of the main canal.
Photo 3 Turnout with drop structure		In addition to this small drop structure, another drop structure is placed a few meters downstream. For the stable intake of water, it is not recommendable to place a drop-structure without a check function at just downstream portion of a turnout.
Photo 4 Existing end point of the Right Main Canal		The right main canal construction was suspended due to unexpected ponding water and a wadi flow in rainy season.

Photos (2/2)

Location	Photo	Comments
Photo 5 Damaged Right Main Canal		Drainage water, came from outside of the scheme area, damaged a canal section.
Photo 6 Left Main Canal		Spillway constructed at the beginning of the Left Main Canal.
Photo 7 Turnouts with Gated Check Structure		A check structure equipped with only gates would be difficult in control when unexpected water flows into canal. Downstream portion of this Check structure was damaged by overflow.
Photo 8 Paddy field		Excess water runs beside the farm road because no drainage canal was constructed.

Scheme Map


Mafingi
Mchilipa River
Itete Right Main Irrigation Area
Itete Left Main Irrigation Area
Right Main Canal
Left Main Canal
Itete Headworks
© 2016 Google
© 2016 Cnes/Spot Image
Image © 2016 DigitalGlobe
Google Earth

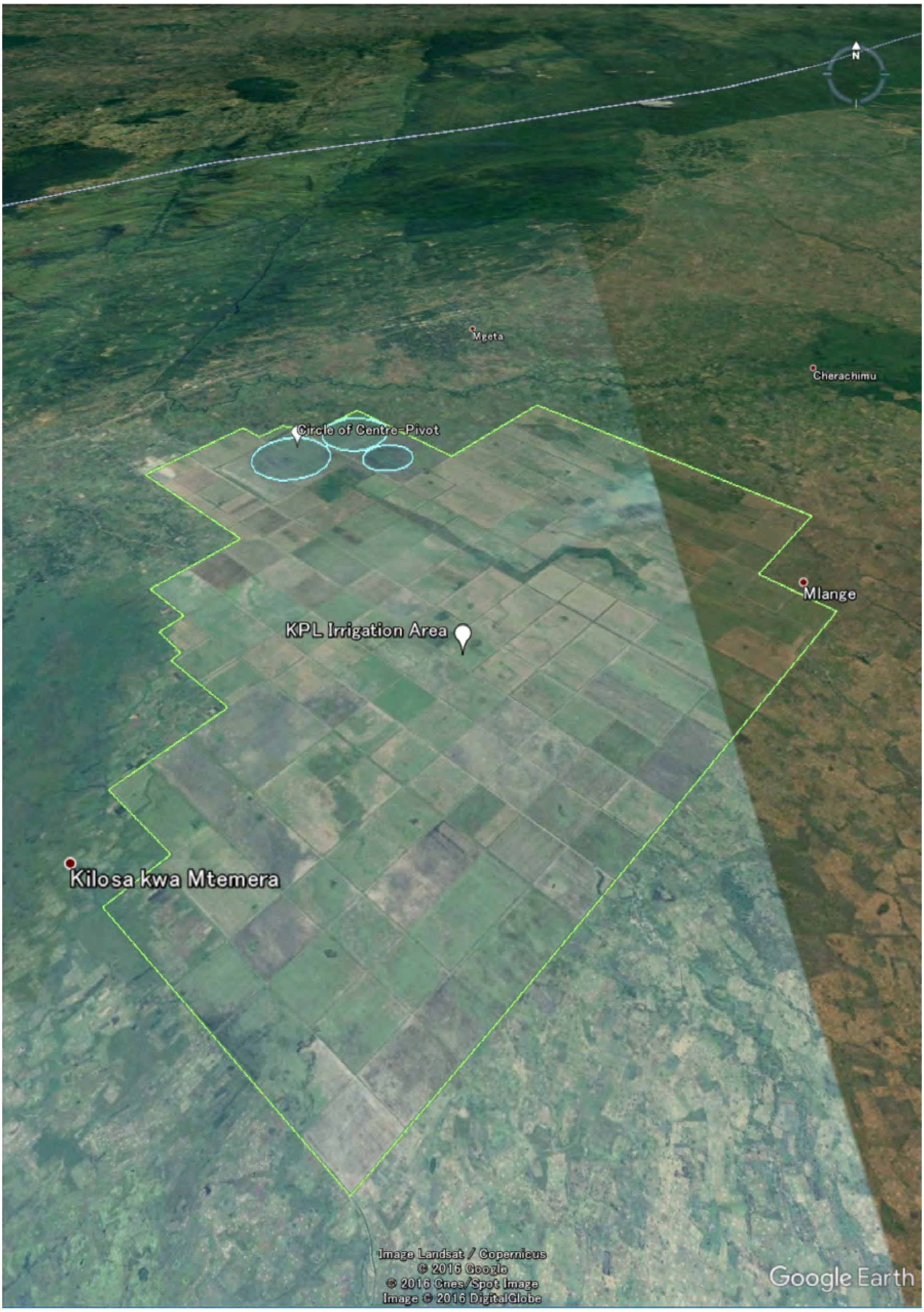
Site investigation Sheet (6)

Name of Scheme	**Kilombero Plantations Limited (KPL)**
Date of Investigation	9/Feb/ 2017
Name of Site Visitor	NIMP2018 team : Mr. Arai, Eng. Majo, Mr. Siga, Mr. Samson
Name /Position of Interviewee	Mr. David Arnott (Deputy Managing Director), Mr. Ivan Hayes (Crop Production Manager), Mr. Fredrik Jailos (Smallholder Dept.)
Findings	
Location	Zone : Morogoro District: Kilombero Field Office: Latitude S 8.358161 Longitude E 35.09121
Outline of the Scheme	・The scheme was initially developed in 1980s with support from North Korea and then handed over to GoT (RUBADA). During the privatization time, the scheme was transferred to KPL. ・KPL started operation in 2009 with an area of 500 ha. The irrigation area has been gradually increased to1,500 ha by 2015 December. ・Current irrigation area is 3,030 ha. KPL grows paddy in wet season, and maize in dry season.
Scheme Area	Potential Area (ha) : - ha Designed Area (ha): 5,500 ha Developed Area (ha): 3,030 ha Irrigation Area (ha) 3,030 ha
Water Source	River (Perennial River)
Irrigation Method	Centre-Pivot Irrigation
Irrigation Facilities	Pump system: 3 sets 12 pumps for water supply to Pivot system Size of Centre-Pivot Main System: 77 ha / system Size of Other Centre-Pivot Systems: 38 ha/system, 17 ha/system
Findings	・ Irrigation method is a large-scale centre-pivot which covers 77ha. ・ Operation and maintenance of centre pivot system is easy. ・ SRI cultivation is practiced. ・ KPL has no immediate expansion plan of irrigation area.

Photos

Location	Photo	Comments
Pump Site at the river		Submersible pumps
Main canal which connects pumps at the river and the pump house located at the field		Main canal is line with " Dam Liner".
Pump House at the Field		Pump house to add pressure for the centre pivot irrigation system
Centre Pivot System		One system covers 77 ha

Scheme Map


Mgeta
Cherachimu
Circle of Centre-Pivot
Mlange
KPL Irrigation Area
Kilosa kwa Mtemera
Image Landsat / Copernicus
© 2016 Google
© 2016 Cnes/Spot Image
Image © 2016 DigitalGlobe
Google Earth

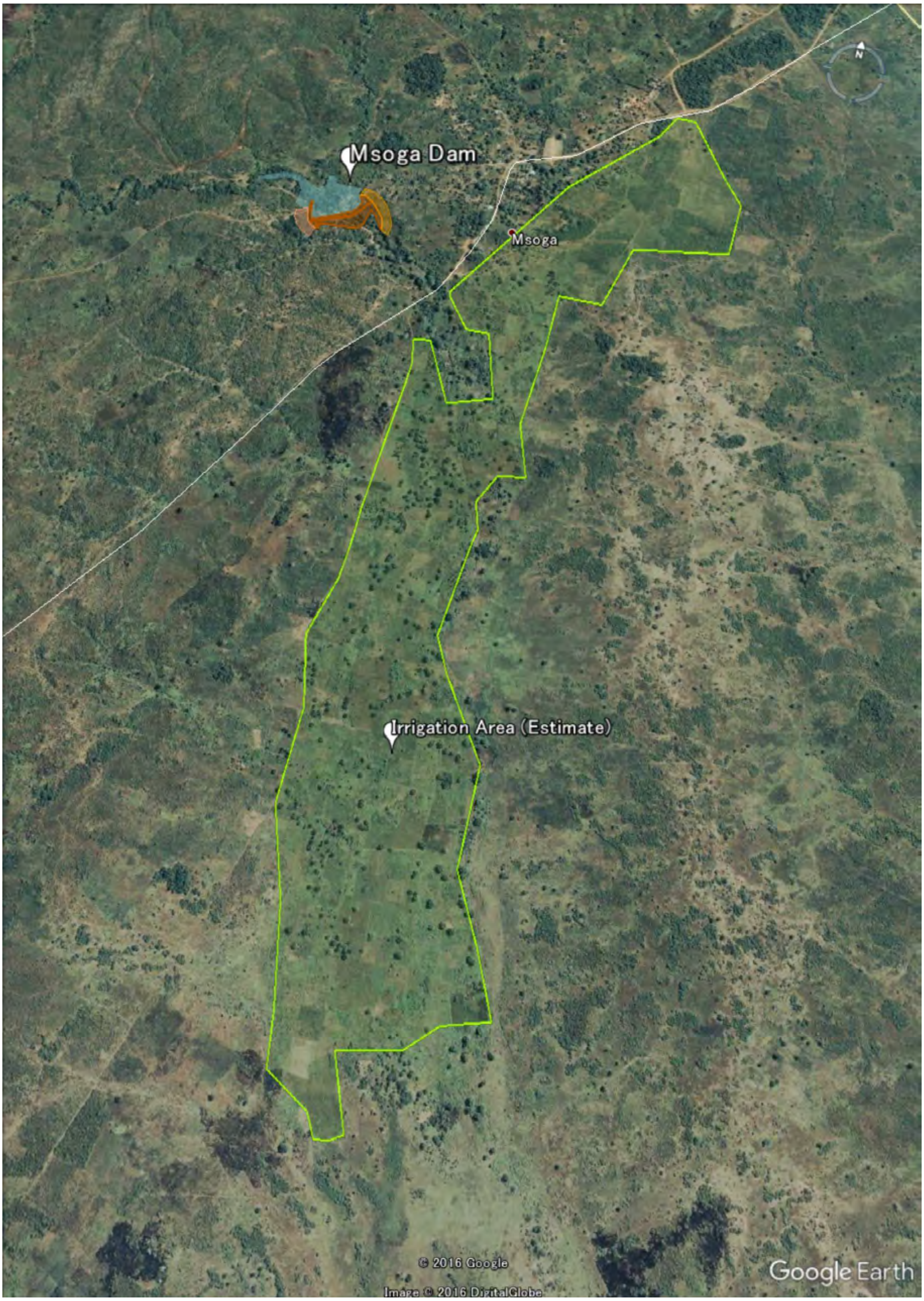
Site investigation Sheet (7)

Name of Scheme	**Msoga Irrigation Scheme (SSIDP Scheme)**	
Date of Investigation	10 /Feb/ 2017	
Name of Site Visitor	NIMP2018 team : Sibuta Leader, Eng. Majo, Mr. Arai, Mr. Siga, Mr. Amano. Mr. Masaki, Eng. Mashafi, Mr. Samson	
Name /Position of Guide	Chalinze District:	
Findings		
Location	Zone : Morogoro Region : Pwani District : Chalinze Village : Msoga Coordinates: Centre of Dam Crest Latitude S 6.56928 Longitude E 38.30365	
Outline of the Scheme	・This dam was constructed to irrigate 50 ha of farmland in 2010. ・Remaining 100 ha was initially planned to be irrigated by deep well. ・After formulation of scheme plan, it turned out that there is no source of groundwater. In this connection, the plan was modified to cover entire irrigation area by reservoir in 2015. ・The bund was decided to be heightened by 2.25m. ・Improvement works are on- going.	
Scheme Area	Potential Area (ha) : 200 ha Designed Area (ha): 150 ha Developed Area (ha): 150 ha Irrigation Area (ha) 0 ha	
Water Source	（Seasonal River）	
Irrigation Method	Gravity Irrigation (Headworks, and Open channel)	
Dimension of Dam	Existing Dam: Homogeneous Earth Fill Dam Dam Height : 12.45 m Crest Length : 289 m Crest Width : 4.5 m Crest Elevation: 219.35 m Full Supply Level : 217.0 m Gross Capacity : 427,600 m^3 Dead Capacity : 0 m^3 Catchment Area: 26 km^2 Spillway: Left bank	After Improvement: Homogeneous Earth Fill Dam Dam Height : 14.70 m Crest Length : 289 m Crest Width : 6.0 m Crest Elevation: 221.0 m Full Supply Level : 219.0 m High Flood Level : 220.0 m Gross Capacity : 970,480 m^3 Dead Capacity: 0 m^3 Catchment Area: 26 km^2 Spillway: Right bank (W=40m) Emergency Spillway: Use of Existing Spillway
Findings	・Improvement works are suspended due to an administrative reason. ・Dead water volume for sedimentation was not considered in design. ・Protection of Spillway has not yet conducted satisfactorily.	

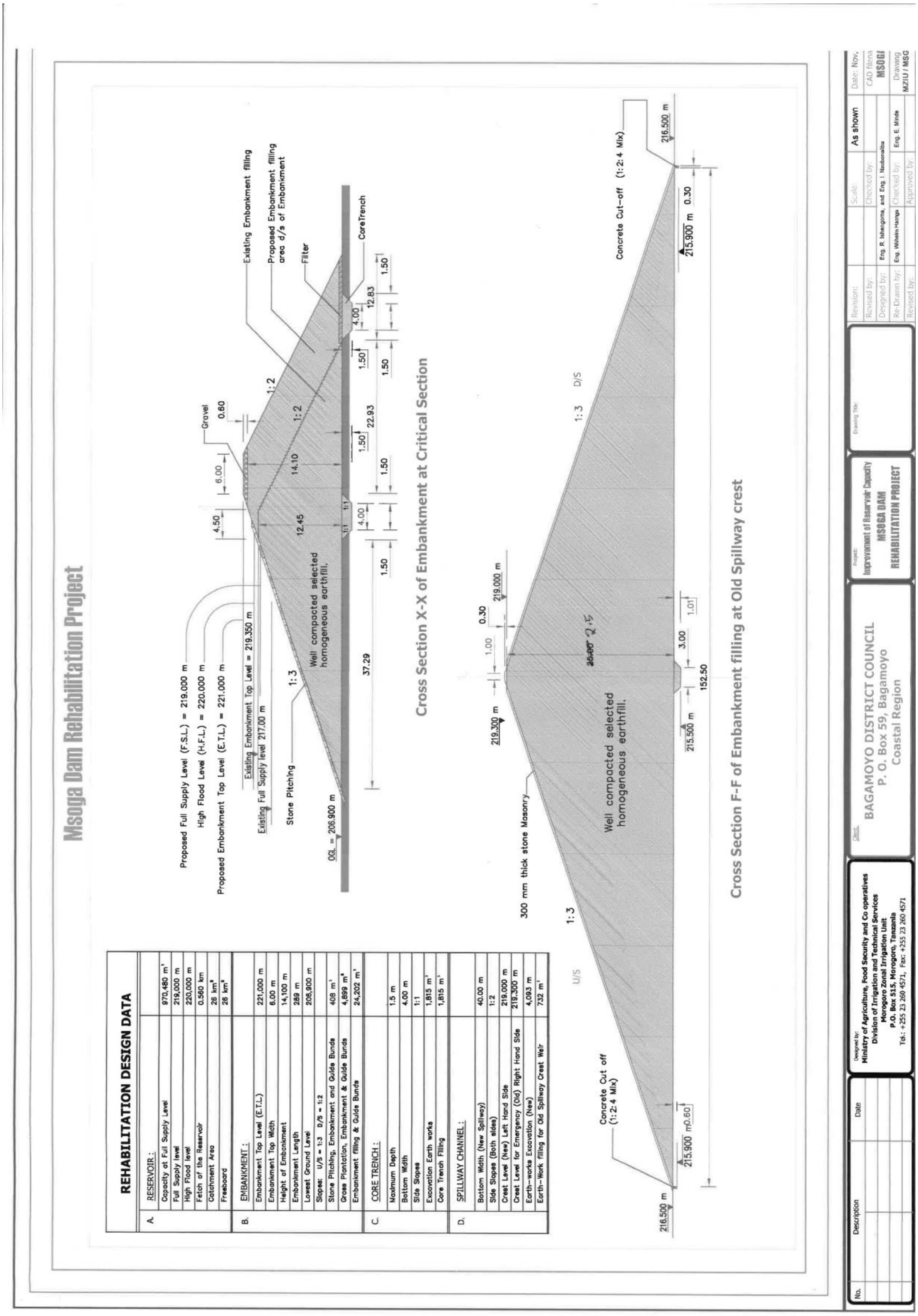
Photos

Location	Photo	Comments
Overview of Dam		Embank materials were dumped on the bund.
Suspension of Bund Embankment		Embank materials were dumped on the bund. No construction work was carried out.
Downstream view from Existing Spillway		A portion of spillway left bank was damaged when excess water was drained out through spillway channel.
Upstream view of new Spillway		For a time being, there is no protection in the new spillway.

Scheme Map


Msoga Dam
Msoga
Irrigation Area (Estimate)
© 2016 Google
Image © 2016 DigitalGlobe
Google Earth

Drawing


Msoga Dam Rehabilitation Project
REHABILITATION DESIGN DATA
A. RESERVOIR :
Capacity at Full Supply Level 970,480 m³
Full Supply level 219,000 m
High Flood level 220,000 m
Fetch of the Reservoir 0.560 km
Catchment Area 26 km²
Freeboard 26 km²
B. EMBANKMENT :
Embankment Top Level (E.T.L.) 221,000 m
Embankment Top Width 6.00 m
Height of Embankment 14,100 m
Embankment Length 289 m
Lowest Ground Level 206,900 m
Slopes: U/S = 1:3 D/S = 1:2
Stone Pitching, Embankment and Guide Bunds 408 m³
Grass Plantation, Embankment & Guide Bunds 4,899 m²
Embankment filling & Guide Bunds 24,202 m³
C. CORE TRENCH :
Maximum Depth 1.5 m
Bottom Width 4.00 m
Side Slopes 1:1
Excavation Earth works 1,815 m³
Core Trench Filling 1,815 m³
D. SPILLWAY CHANNEL :
Bottom Width (New Spillway) 40.00 m
Side Slopes (Both sides) 1:2
Crest Level (New) Left Hand Side 219.000 m
Crest Level for Emergency (Old) Right Hand Side 219.300 m
Earth-works Excavation (New) 4,093 m
Earth-Work filling for Old Spillway Crest Weir 732 m³
Proposed Full Supply Level (F.S.L.) = 219.000 m
High Flood Level (H.F.L.) = 220.000 m
Proposed Embankment Top Level (E.T.L.) = 221.000 m
Existing Embankment Top Level = 219.350 m
Existing Full Supply level 217.00 m
Stone Pitching
OGL = 206.900 m
Gravel
Existing Embankment filling
Proposed Embankment filling area d/s of Embankment
Filter
CoreTrench
Well compacted selected homogeneous earthfill.
Cross Section X-X of Embankment at Critical Section
300 mm thick stone Masonry
Concrete Cut off (1:2:4 Mix)
Concrete Cut-off (1:2:4 Mix)
Well compacted selected homogeneous earthfill.
Cross Section F-F of Embankment filling at Old Spillway crest
Designed by:
Ministry of Agriculture, Food Security and Co operatives
Division of Irrigation and Technical Services
Morogoro Zonal Irrigation Unit
P.O. Box 515, Morogoro, Tanzania
Tel.: +255 23 260 4571, Fax: +255 23 260 4571
BAGAMOYO DISTRICT COUNCIL
P. O. Box 59, Bagamoyo
Coastal Region
Improvement of Reservoir Capacity
MSOGA DAM
REHABILITATION PROJECT
As shown
Eng. R. Ishengoma, and Eng. I. Nsobonaliba
Eng. Wilhelm Hanga
Eng. E. Minde

Site investigation Sheet (8)

Name of Scheme	**Lower Moshi Scheme**
Date of Investigation	15/Feb/ 2017
Name of Site Visitor	NIMP2018 team : Sibuta Leader、Amano、Masaki、Majo、Mashafi、Samson
Name /Position of Guide and Interviewee	Kilimanjaro ZIO: Eng. Tegamaisho LMS Coordinator: Mr. Fredrick S. Mawolle
Findings	
Location	Zone : Kilimanjaro District : Moshi Rural Mabogini System Intake Site: Latitude S 3.384158 Longitude E 37.35811 Farmland: Latitude S 3.385911 Longitude E 37.35873 Rau ya Kati System Intake Site: Latitude S 3.413589 Longitude E 37.38042 Farmland: Latitude S 3.416472 Longitude E 37.38219
Outline of the Scheme	Construction works were completed in 1987 applying Japanese Loan. Secondary and tertiary canals were rehabilitated with NIDF under ASDP I three years ago (2013/14?).
Scheme Area	Potential Area (ha): - ha Designed Area (ha): 2,300 ha Developed Area (ha): 1,100 ha for Paddy 1,200 ha for Upland Crop Irrigation Area (ha) 1,100 ha
Water Source	Rau river for Rau ya Kati system & Njoro river for Mabogini system
Irrigation Method	Gravity Irrigation (Headworks and Open channels)
Irrigation Facilities	Headworks : Mabogini (Intake amount = 840 litre/sec) Rau ya Kati (Intake amount = 1,135 litre/sec) Irrigation Canal : Total 35 km Drainage Canal : Total 49 km Farm Road : Total 70 km Flood Protection Dyke: Total 16 km Land levelling : 1,100 ha
Irrigators Organization	Name of IO : Lower Moshi Irrigators Association (LOMIA) Registration : 2007 as Association Fees : 38,000 /Tzs /plot/season Others : Sub-LOMIAs were set up at four villages under Central-LOMIA
Findings	・ The scheme consists of two systems, namely Mabogini and Rau ya Kati. ・ The scheme has been working since 1987. ・ Water shortage problem is reported at the upland crop area of Rau ya Kati system. To add water, ground water is utilized by solar pump system.

Photos (1/3)

Location	Photo	Comments
Mabogini Headworks (Mbogini HWs)		Headworks is in good condition.
Mabogini HWs: Sand Trap		
Mabogini HWs: Sluice Gate		Gates are in good condition.
Rau ya Kati Weir and Intake		Headworks is in good condition.

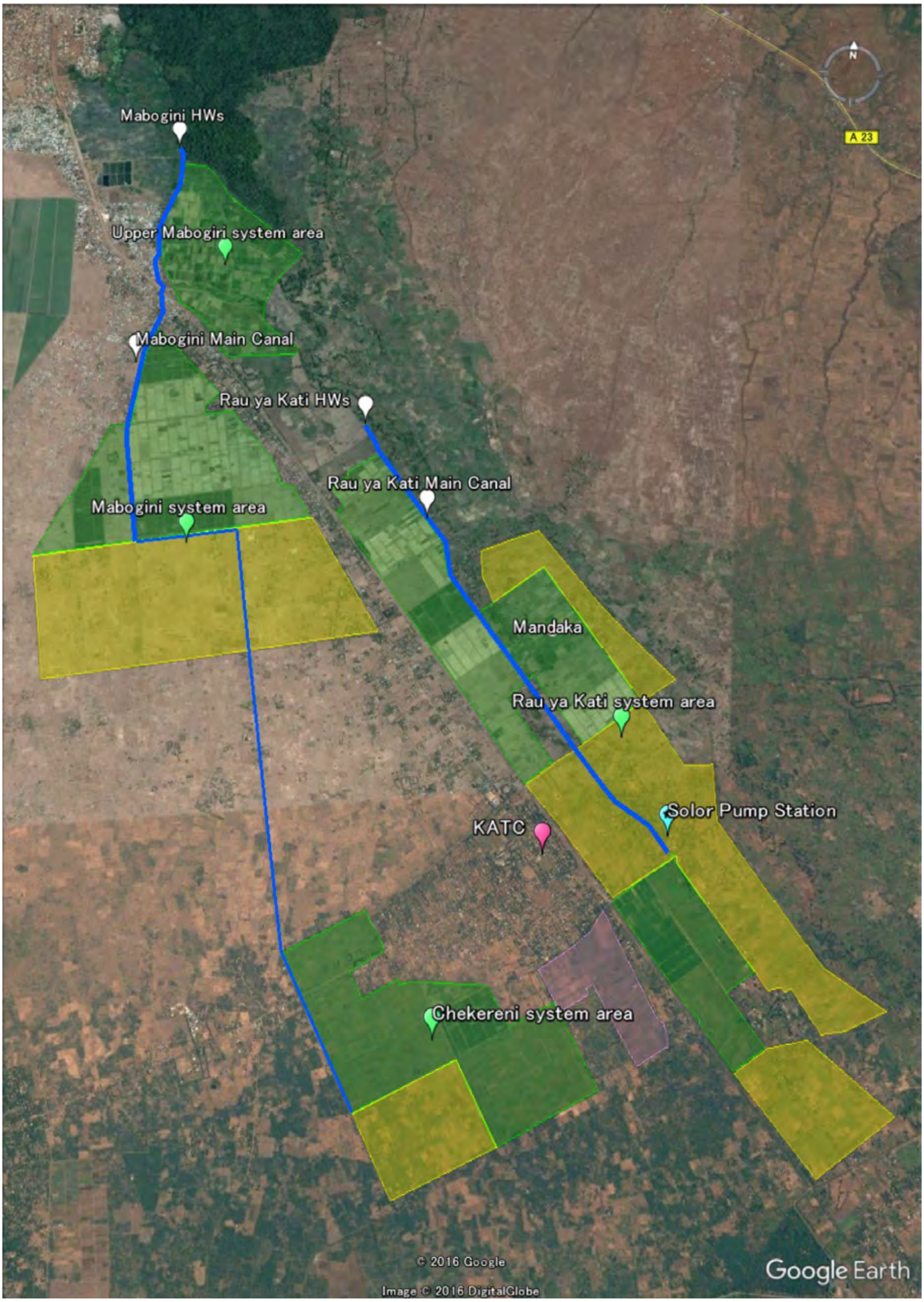
Photos (2/3)

Location	Photo	Comments
Rau ya Kati: Main Canal		Canal is in good condition.
Rau ya Kati: Secondary Canal and Paddy Field		
Rau ya Kati: Division Box on Secondary Canal		
Rau ya Kati: Tertiary Canal		Tertiary canals were rehabilitated in 2013/14.

Photos (3/3)

Location	Photo	Comments
Solar Panels for Pump		The solar pump system was found in the Rau ya Kati upland crop area.
Secondary canal in the Rau ya Kati upland crop area		Water is supplied from the solar pump system.

Scheme Map


Mabogini HWs
Upper Mabogiri system area
Mabogini Main Canal
Rau ya Kati HWs
Rau ya Kati Main Canal
Mabogini system area
Mandaka
Rau ya Kati system area
Solor Pump Station
KATC
Chekereni system area
A 23
N
© 2016 Google
Image © 2016 DigitalGlobe
Google Earth

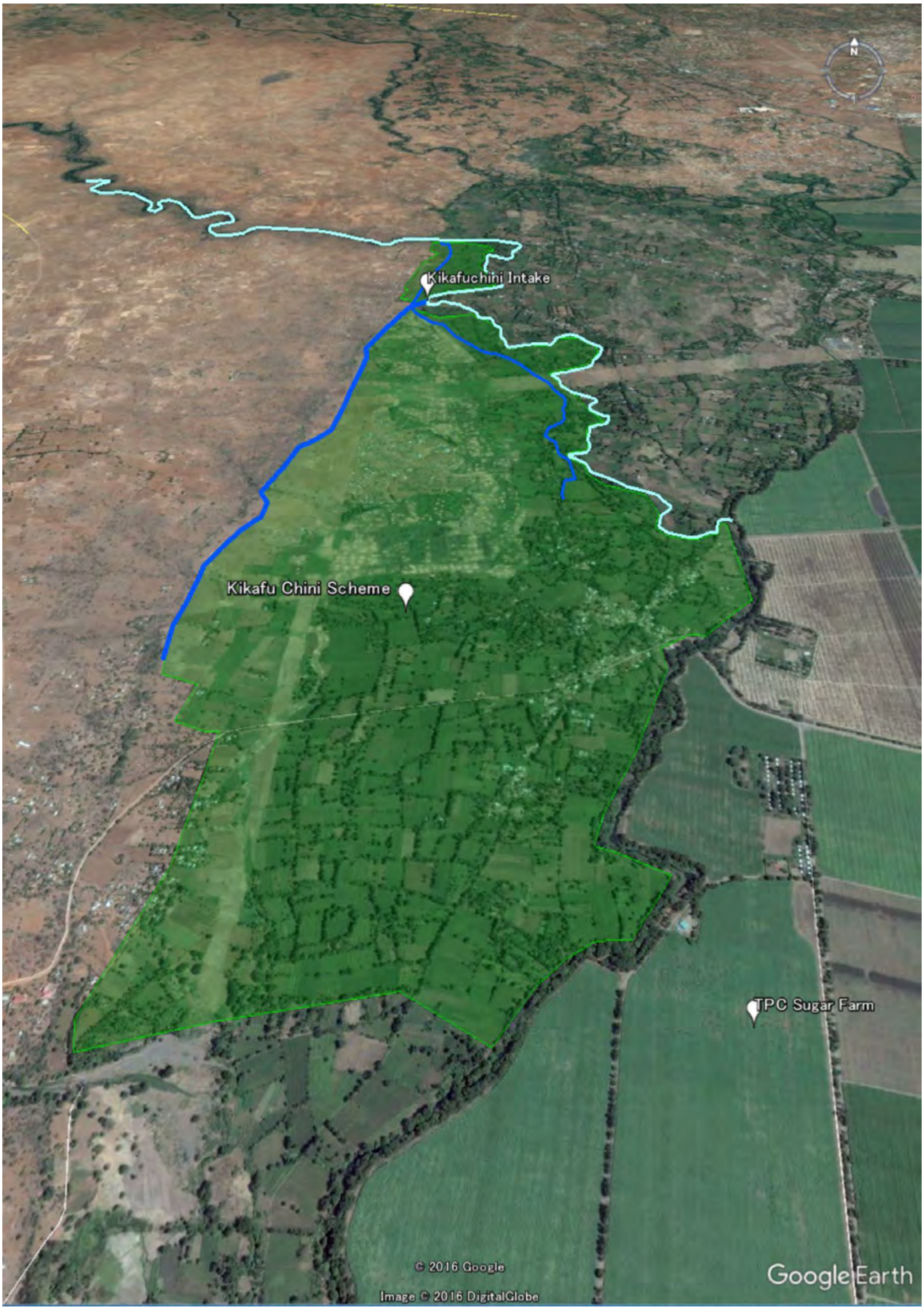
Site investigation Sheet (9)

Name of Scheme	**Kikafu Chini (SSIDP Scheme)**
Date of Investigation	16/Feb/ 2017
Name of Site Visitor	NIMP2018 team : Sibuta Leader, Eng. Majo, Mr. Shiga, Mr. Masaki
Name /Position of Guide and Interviewee	ZIO: Eng. Tegamaisho (ZIO), Hai DC: Mr. Silo IO: Village chairman, Project Committee (5), IO (4), District Councilor, VAEO
Findings	
Location	Zone : Kilimanjaro District: Hai Coordinates: Intake Site Latitude S 3.416869 Longitude E 37.29269 Farmland Latitude S 3.417492 Longitude E 37.29178
Outline of the Scheme	Government improved the traditional furrow irrigation area, and expanded the irrigation area from 150 to 450ha in 1999.
Scheme Area	Potential Area (ha) : 641 ha Designed Area (ha): 541 ha Developed Area (ha): 541 ha Irrigation Area (ha): 180 ha (Wet) 80 ha (Dry)
Water Source	Kikafu River
Irrigation Method	Gravity Irrigation (Headworks and Open channel)
Irrigation Facilities	Weir : Dimensions are unknown Canal : Total 4 km, Kikafu area = 1 km, Upareni area = 3 km
Irrigators Organization	Name of IO : UWAKICHI cooperative Registration : 1999 Membership : Cooperative member 187 Land owner 759, beneficiaries = 1,500 Fees : Member fee = 15,000/acre/season for paddy = 10,000/acre/season for maize Rental fee of land = 200,000/acre/season for paddy = 100,000/acre/season for maize
Findings	· IO lends farm land to non-member villagers and farmer from outside of the village. · IO hires labors to conduct canal maintenance works. · Rehabilitation is going on.

Photos

Location	Photo	Comments
Diversion Point		Rehabilitation is on-going
Rehabilitation of Canal		
Paddy Field in the Scheme		
Interview with Irrigators Organization		

Scheme Map


Kikafuchini Intake
Kikafu Chini Scheme
TPC Sugar Farm
© 2016 Google
Image © 2016 DigitalGlobe
Google Earth

Site investigation Sheet (10)

Name of Scheme	**Musa Mwinjanga (SSIDP Scheme)**
Date of Investigation	16/Feb/ 2017
Name of Site Visitor	NIMP2018 team : Sibuta Leader, Eng. Majo, Mr. Shiga, Mr. Masaki
Name /Position of Guide	ZIO: Eng. Tegamaisho (ZIO), Hai DC: Mr. Silo IO: Village chairperson, VAEO, Village council member, Project committee, IO (4)
Findings	
Location	Zone : Kilimanjaro District: Hai Coordinates: Intake Site Latitude S 3.395358 Longitude E 37.29513 Farmland Latitude S 3.397817 Longitude E 37.29635
Outline of the Scheme	Main canal was improved in 1990s. In 2009, the canal was rehabilitated under DADP fund.
Scheme Area	Potential Area (ha) : 676 ha Designed Area (ha): 506 ha Developed Area (ha): 506 ha Irrigation Area (ha): 485 ha (Wet) 220 ha (Dry)
Water Source	Weruweru River (water permit: 320 litre/sec)
Irrigation Method	Gravity Irrigation (Headworks and Open channel)
Irrigation Facilities	Weir : Dimensions are unknown Canal : Main Canal 3 km Secondary Lebulu 450 m under improvement Secondary Kondo 300 m under improvement
Irrigators Organization	Name of IO : UWAMI Registration : 2003 as a cooperative Membership : Cooperative member = 770, non-member = 20 Fees : Member fee = 10,000/acre/season member = 20,000/acre/season non-member villager = 40,000/acre/season non-villager O&M budget : 2 million Tzs/ year
Findings	· Irrigation canal system consists of 1main and 2 secondary canals. · Concrete block lining work of secondary canal is going on.

Photos

Location	Photo	Comments
Division structure of existing secondary canal		
Secondary canal		Kondo secondary canal is formed with precast concrete blocks.
Interview Survey with IO		

Scheme Map


Musamwinjanga Intake
Main Canal
Lebulu Secondary Canal
Kondo Seconfary Canal
Musamwinjanga Scheme
TPC Sugar Farm
© 2016 Google
Image © 2016 DigitalGlobe
Google Earth

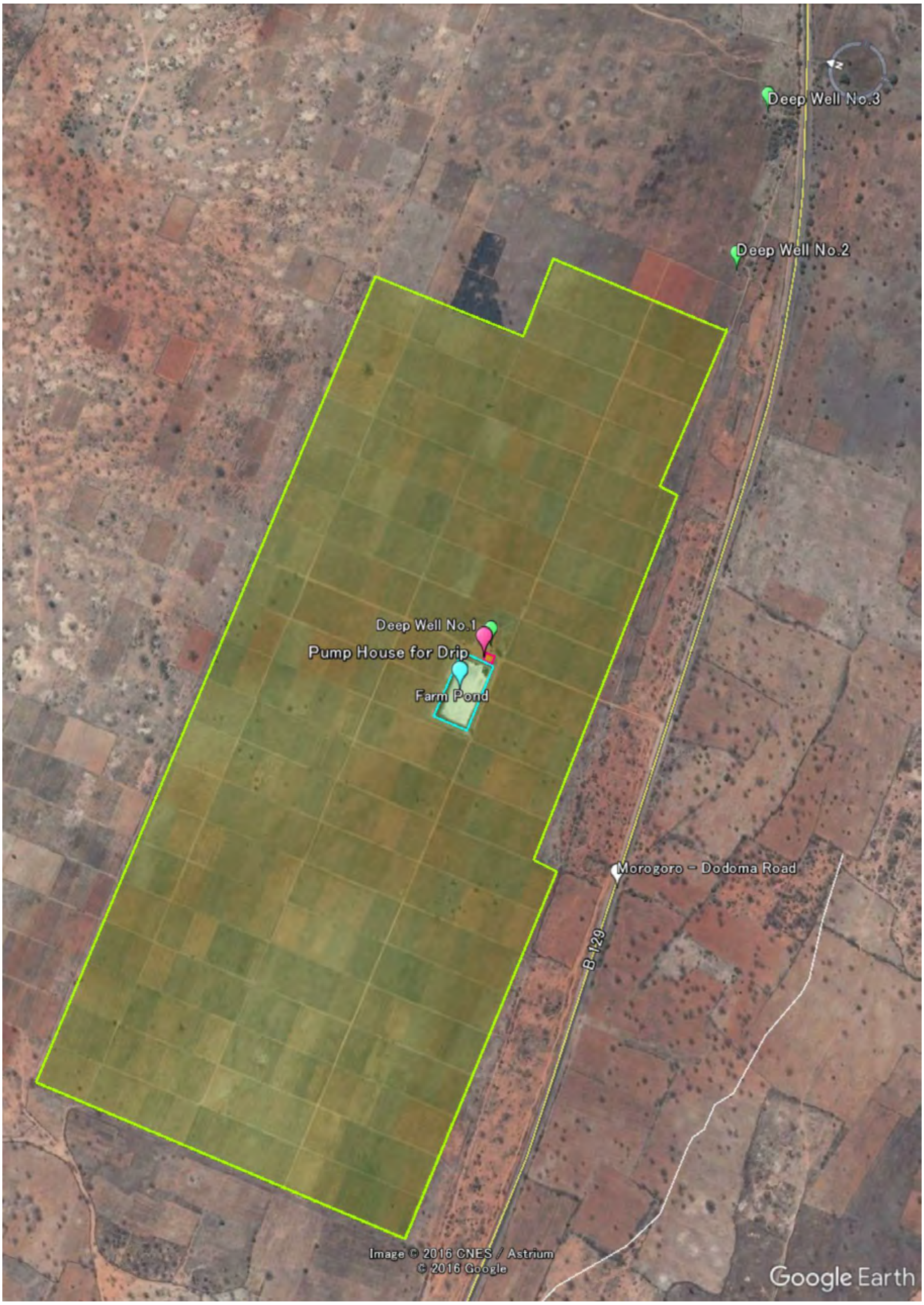
Site investigation Sheet (11)

Name of Scheme	**Chinangali II Grape Farm**
Date of Investigation	21/Feb/ 2017
Name of Site Visitor	NIMP2018 team : Sibuta Leader, Eng. Majo, Mr. Masaki,
Name /Position of Guide	Dodoma Zone: Eng. Lucia Lema (ZIE-Dodoma)
Findings	
Location	Zone : Dodoma District: Chamwino Coordinates: Well No.1 Latitude S 6.143022 Longitude E 36.11381
Outline of the Scheme	The grape farm was constructed in 2008 by receiving a loan from the CRDB bank with support from Chamwino DC. The loan amount was 1.5 billion Tzs.
Scheme Area	Potential Area (ha) : 280 ha Designed Area (ha): 120 ha Developed Area (ha): 160 ha Irrigation Area (ha) 120 ha (wet season) 120 ha (dry season)
Water Source	Groundwater
Irrigation Method	Drip irrigation
Irrigation Facilities	Deep well : 3 locations with submersible electric pump Farm pond : 1
Irrigators Organization	Name of IO : CHABUMA - AMCOS Registration : 2008 as a cooperative society Membership : 296 (male = 183, female = 113) Fees : Member fee = 360,000/acre/season + 30 Tzs/kg + 10% of production
Findings	・ There are 3 deep wells. Among 3 wells, the well located at near the farm pond has a salinity problem. The other wells supply fresh water. ・ Grape production has dropped year by year because of poor production technic, high electric charge, and damage of trees by white ants. ・ Usually, IO operates one pump to save electricity charge. ・ Farmers receive a loan from a bank to install pipeline system. ・ Low farm gate price of grapes and lack of market are challenges.

Photos

Location	Photo	Comments
Borehole Pump House No.1 near the pump house for drip irrigation		The No.1 well has a salinity water problem.
Farm pond		Farm pond is covered with rubber sheets to prevent percolation loss of storage water.
Grape Farm		Height of grape tree is low.
Grape Farm		Many trees are damaged by white ants.

Scheme Map


Deep Well No.3
Deep Well No.2
Deep Well No.1
Pump House for Drip
Farm Pond
Morogoro - Dodoma Road
B-129
Image © 2016 CNES / Astrium
© 2016 Google
Google Earth

Site investigation Sheet (12)

Name of Scheme	**Buigiri Scheme**
Date of Investigation	20/Feb/ 2017
Name of Site Visitor	NIMP2018 team : Sibuta Leader, Eng. Majo, Mr. Masaki,
Name /Position of Guide	Dodoma Zone: Eng. Lucia Lema (ZIE-Dodoma)
Findings	
Location	Zone : Dodoma District: Chamwino Coordinates: Intake Site Latitude S 6.153922 Longitude E 36.03538 Farmland Latitude S 6.152544 Longitude E 36.03624
Outline of the Scheme	Bund was constructed between 1957 and 1959 for the purpose of domestic and cattle water supply. Since 2005, farmers group consisting of 24 members has started to use the reservoir for irrigation. Farmers grow vegetables and maize twice a year.
Scheme Area	Potential Area (ha) : 24 ha (60 acre) Designed Area (ha): ha Developed Area (ha): 18 ha (45 acre) Irrigation Area (ha): 16 ha (40 acre)
Water Source	Reservoir
Irrigation Method	Gravity Irrigation (Reservoir and Open channel)
Irrigation Facilities	Dam : Crest length = 820 m*, Bund height = 8 m** Canal : 900 m*
Irrigators Organization	Name of IO : UWAMABBU Registration : As an association Membership : 79 non-member 100
Findings	・ Sedimentation in the reservoir area is serious problem. ・ End sill elevation of the intake for watering place is lower than that for irrigation. Watering place has a priority to take water. ・ River flow as a source of water tends to decrease.

Note: The asterisk mark " * " means that the data is approximated value measured on the google earth pro.
The double asterisk mark " ** " means that the data is approximated value measured by a GPS device.

Photos (1/2)

Location	Photo	Comments
Reservoir		
Bund		The bund has no gully and eroded portion.
Main Canal		
Spillway of Main canal		Lack of water management wastes water through spillway of the main canal.

Photos (2/2)

Location	Photo	Comments
Division Structure		Condition of canal facilities is good.
Vegetable Farm		Farmers irrigate vegetables and maize.

Scheme Map


Main Canal
Spillway
Buigiri Scheme Area
Buigiri Bund
Image © 2016 CNES / Astrium
© 2016 Google
Google Earth

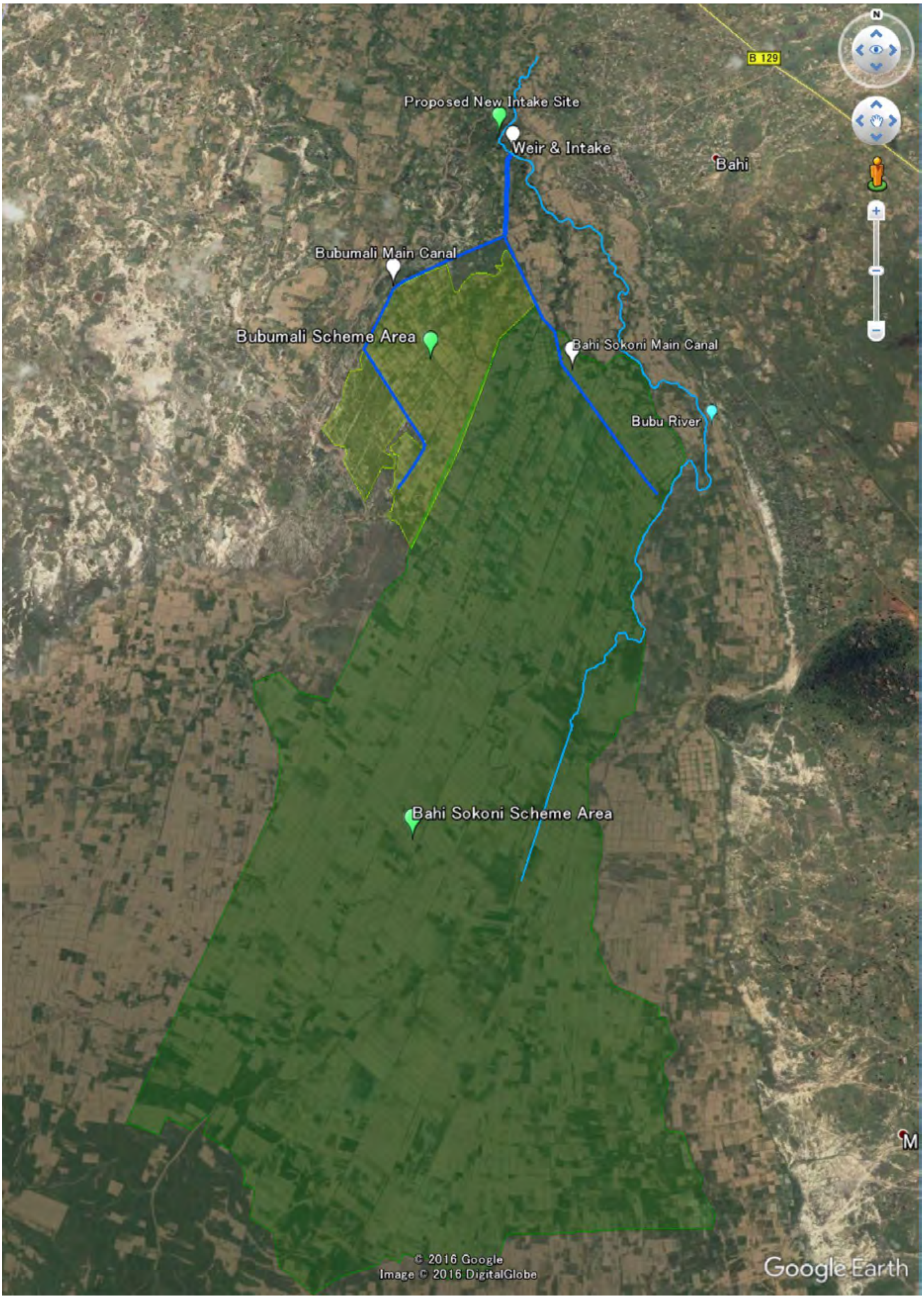
Site investigation Sheet (13)

Name of Scheme	**Bahi Sokoni Scheme**
Date of Investigation	20/Feb/ 2017
Name of Site Visitor	NIMP2018 team : Sibuta Leader, Eng. Majo, Mr. Masaki,
Name /Position of Guide and Interviewee	Zoneal Office: Eng. Lucia Lema (ZIE) IO : Chairman, Secretary, and members
Findings	
Location	Zone : Dodoma District: Bahi Coordinates: Intake Site Latitude S 5.973017 Longitude E 35.30582 Farmland Latitude S 5.983258 Longitude E 35.30601
Outline of the Scheme	・The former weir made of gabion was constructed at 2 km downstream portion from the existing weir with a support of FAO in 1984 for the Bahi sokoni scheme. ・In 1993, the existing weir and main canal were constructed for the Bhai sokoni and the adjacent scheme of Nguvumali.
Scheme Area	Bahi sokoni / Nguvuma Potential Area (ha) : 2,000 ha / 500 ha Developed Area (ha): 780 ha / 360 ha Irrigation Area (ha): 110 ha / 100 ha
Water Source	Bubu River （Perennial River）
Irrigation Method	Gravity Irrigation (Headworks, and Open channel)
Irrigation Facilities	Weir : Length 16.5 m* with 10 gates Main Canal : Headrace 0.85 km
Irrigators Organization	Name of IO : UWAMABBU Registration : As an association Membership : Bahi sokoni 2,000 Nguvumali 360
Findings	・Because of serious sedimentation in the main canal, the scheme is not able to irrigate the area sufficiently. ・Debris at weir site obstruct the river flow. Consequently, the weir creates flood in the upstream area and it is said that flood affects the railway operation. ・For the sustainable water supply, farmers have a plan of new intake site that would be located at 100 meters upstream of the existing site. ・Irrigators organization hires day laborers to maintain the canal system. Members don't maintain by themselves.

Photos

Location	Photo	Comments
Weir and Intake gates		Debris close the weir gates.
Main Canal		Canal bed height is too high to convey irrigation water taken at intake site.
Submersible Bridge		In the rainy season this bridge would be submersed.

Scheme Map


Proposed New Intake Site
Weir & Intake
Bahi
B 129
Bubumali Main Canal
Bubumali Scheme Area
Bahi Sokoni Main Canal
Bubu River
Bahi Sokoni Scheme Area
© 2016 Google
Image © 2016 DigitalGlobe
Google Earth

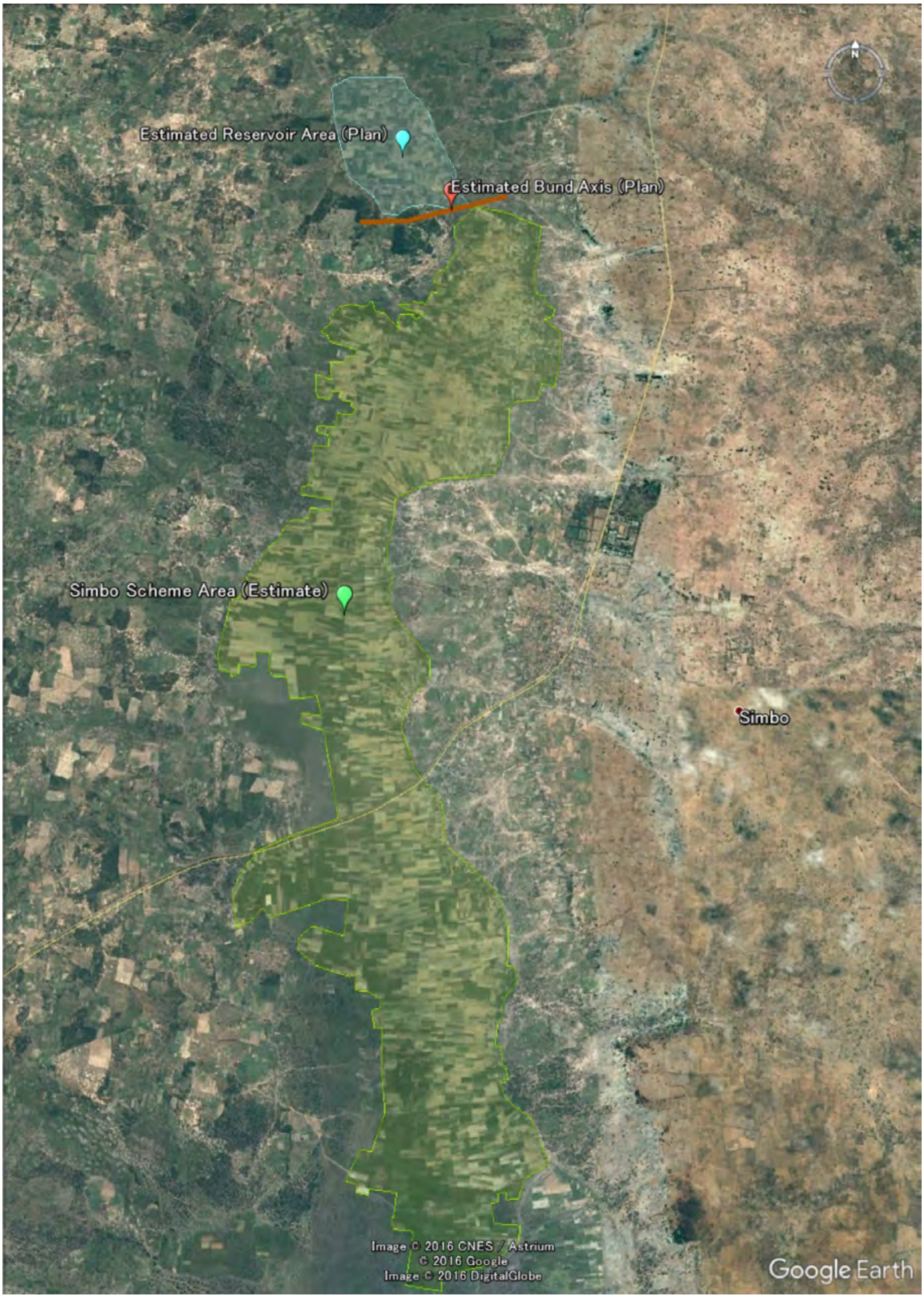
Site investigation Sheet (14)

Name of Scheme	**Simbo Traditional Irrigation Scheme**
Date of Investigation	28/Feb/ 2017
Name of Site Visitor	NIMP2018 team : TL Sibuta, Eng. Majo, Eng. Mashafi, Mr. Amano, Mr. Masaki
Name /Position of Guide	Tabora ZIO: Eng. Eliafie W. Mwanga (ZIE) Simbo DC: Ms. Martha Teveli Ward Councilor: Mr. Hamis Athman Village Chairman: Mr. Yousuf Ifinyongola
Findings	
Location	Zone : Tabora District: Igunga Coordinates: Proposed Bund: Latitude S 4.603683 Longitude E 33.42039 Farmland: Latitude S 4.651528 Longitude E 33.40859
Outline of the Scheme	This is a traditional scheme which use sheet flow from upstream. Recently, Tabora Zone office identified a possible reservoir site.
Scheme Area	Potential Area (ha) : 1,500 ha Designed Area (ha): 0 ha Developed Area (ha): 0 ha Irrigation Area (ha) 1,500 ha
Water Source	Rain
Irrigation Method	Traditional Irrigation at present Gravity (plan)
Irrigation Facilities	No facility exists.
Findings	Boundary between traditional irrigation scheme and Rain-fed scheme is not clear. ZIO calls a scheme, which utilize "sheet flow" for irrigation without canals, as a traditional irrigation scheme.

Photos

Location	Photo	Comments
Existing paddy field		Sheet flow from the upstream area is the source of this traditional irrigation scheme
Existing paddy field		Existing paddy field
Existing paddy field along the road		Existing paddy field
Proposed Bund Axis		Left bank of the proposed bund

Scheme Map


Estimated Reservoir Area (Plan)
Estimated Bund Axis (Plan)
Simbo Scheme Area (Estimate)
Simbo
Image © 2016 CNES / Astrium
© 2016 Google
Image © 2016 DigitalGlobe
Google Earth

Site investigation Sheet (15)

Name of Scheme	**Inala Irrigation Scheme (SSIDP Scheme)**
Date of Investigation	01/Mar/ 2017
Name of Site Visitor	NIMP2018 team : Sibuta Leader, Eng. Majo, Masaki,
Name /Position of Guide	
Findings	
Location	Zone : Tabora District: Tabora Municipal Coordinates: Intake Site Latitude S 5.116722 Longitude E 32.91800 Farmland Latitude S 5.117356 Longitude E 32.91795
Outline of the Scheme	New irrigation scheme of Inala was completed in 2016. Scheme operation is scheduled to start in this year 2017 after fixing the problem of the leakage from outlet conduit.
Scheme Area	Potential Area (ha) : 400 ha Developed Area (ha): 130 ha Irrigation Area (ha) - ha
Water Source	Reservoir
Irrigation Method	Gravity Irrigation (Reservoir and Open channel)
Irrigation Facilities	Dam : Crest length 1,340 m*, Bund height 5 m* Canal : Right Main Canal 1.6 km* Left Main Canal 3.2 km*
Irrigators Organization	Name of IO : Registration : As an association (registered at MoHA)
Findings	The team noticed many defects in concrete works. · Lack of protective covering of concrete · Separation of concrete milk and aggregates · Several pieces of wooden formwork in the inlet concrete structure. The scheme has not yet started to store water due to leakage water from the inlet culvert.

*Note: The asterisk mark " * " means that the data is approximated value measured on the google earth pro.*

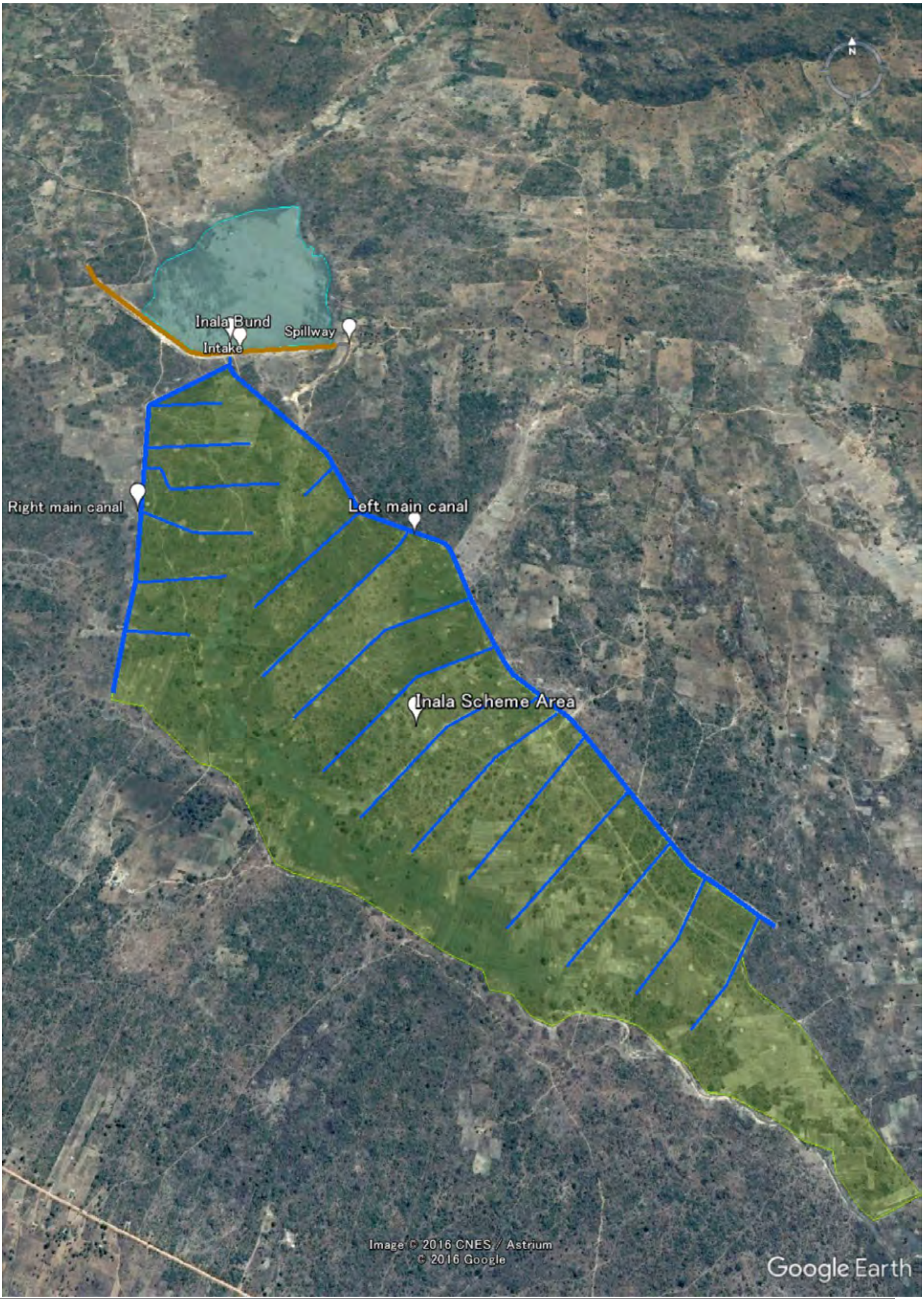
Photos (1/2)

Location	Photo	Comments
Bund		Both bund slopes were covered with grasses.
Reservoir Area (Upstream slope of the bund)		Rocks were placed on the upstream slope of the bund.
Spillway		Common type of spillway in Tanzania
Intake Structure		Some of the wooden floor panels have already lost.

Photos (2/2)

Location	Photo	Comments
Inlet structure		Leakage of water problem from the inlet culvert was reported.
Inlet Structure: pier		Reinforcement bar was exposed from the concrete surface.
Irrigation Area		The area newly developped

Scheme Map


Inala Bund
Intake
Spillway
Right main canal
Left main canal
Inala Scheme Area
Image © 2016 CNES / Astrium
© 2016 Google
Google Earth

Site investigation Sheet (16)

Name of Scheme	**Imalamihayo Charco Dam**
Date of Investigation	01/Mar/ 2017
Name of Site Visitor	NIMP2018 team : TL Sibuta, Eng. Majo, Mr. Masaki
Name /Position of Guide and Interviewee	Mr. Ditrick Mwinuka, Acting MAICO, Tabora MC Mr. Mohamed Mnally, District Agriculture Engineer, Tabora MC Eng. Edward Magembe, Tabora ZIO
Findings	
Location	Zone : Tabora District: Tabora MC Coordinates: Charco Bund: Latitude S 4.934025 Longitude E 32.90396 Farmland: Latitude S 4.930653 Longitude E 32.90387
Outline of the Scheme	Old Imalamihayo charco dam for cattle water supply to was rehabilitated in 2008. The local leader has a plan to use storage water for existing farmland located at downstream area.
Scheme Area	Potential Area (ha) : 140 ha Designed Area (ha): 0 ha Developed Area (ha): 0 ha Irrigation Area (ha) 0 ha
Water Source	Not available
Irrigation Method	Gravity Irrigation (Proposal)
Irrigation Facilities	Bund : Length of Bund 285 m* with Concrete Spillway Bund height 4 m* Canal : Not yet constructed
Irrigators Organization	Not available
Findings	· Originally, "Charco" is a name given to a construction method. However, local people uses the term for a dam constructed to supply water to cattle. · Judging from the size of the reservoir, water amount would be insufficient to cover the whole potential area. · Careful assessment of water availability would be necessary to proceed to next step.

Note: The asterisk mark " * " means that the data is approximated value measured on the google earth pro.

Photos

Location	Photo	Comments
Charco bund and reservoir area from left bank		Reservoir stores few water in March 1, 2017.
Existing Spillway		There is no protection at downstream portion of the spillway.
Bund		Some portions of the bund are eroded seriously.
Watering place		No sign of use

Scheme Map


Existing Farmland
Watering Place for Cattle
Imalamihayo Charco Dam
Spillway
Image © 2016 CNES / Astrium
© 2016 Google
Google Earth

Site investigation Sheet (17)

Name of Scheme	**Ulyanyama Irrigation Scheme**
Date of Investigation	02/Mar/ 2017
Name of Site Visitor	NIMP2018 team : TL Sibuta, Eng. Majo, Mr. Masaki
Name /Position of Guide	Tabora ZIO : Eng. Edward Magembe, IO: Mr. Dickson Simbila, Chairman, Mr. Simon Kalossa, Secretary, Mr. Marko Bukwimba, Deputy Chairman and other two members
Findings	
Location	Zone : Tabora District: Sikonge Coordinates: Bund: Latitude S 5.522731 Longitude E 32.83604 Farmland: Latitude S 5.523064 Longitude E 32.83496
Outline of the Scheme	
Scheme Area	Potential Area (ha) : 500 ha Surveyed Designed Area (ha): ha Developed Area (ha): 170 ha Irrigation Area (ha) 122 ha
Water Source	Perennial River
Irrigation Method	Gravity Irrigation (Reservoir and Open channels)
Irrigation Facilities	Bund : Dimensions are unknown. Canal : Main - km
Irrigators Organization	Name of IO : Ulyanyama Association Society Registration : Under registration with NIRC Membership : 300
Findings	· Developed area of 52 ha had been under dispute over land allocation with 3 farmers. · Recently, IO won the case in court and the land dispute has been settled.

Note: The asterisk mark " * " means that the data is approximated value measured on the google earth pro.

Photos

Location	Photo	Comments
Reservoir and spillway		Long and well protected spillway
Bund and bund slope		Bund slop is covered with grasses. It is necessary to remove small trees from the bund slope not to create problems such as leakage of water through long roots.
Irrigation area		
Main Canal		Canal lining by Wet-Masonry

Scheme Map


Ulyanyama Irrigation Area
Main canal
Intake
Ulyanyama Bund
Spillway
Image © 2016 DigitalGlobe
© 2016 Google
Image © 2016 DigitalGlobe
Google Earth

Site investigation Sheet (18)

Name of Scheme	**Ussoko Mlimani (SSIDP scheme)**
Date of Investigation	03/Mar/ 2017
Name of Site Visitor	NIMP2018 team : TL Sibuta, Eng. Majo, Mr. Masaki,
Name /Position of Guide and Interviewee	Tabora Zone: Eng. Edward Magembe Urambo DC : Mr. Absalama A. Kajuna, DAICO, Mr. Frednick Ndeweso, Agriculture Officer, Mr. Kilawe Living, Agriculture Officer
Findings	
Location	Zone : Tabora District: Urambo Coordinates: Bund: Latitude S 5.207583 Longitude E 32.35106 Farmland: Latitude S 5.206667 Longitude E 32.34938
Outline of the Scheme	Original dam was constructed in 2011. The scheme has been improved with SSIDP funds since Nov. 2016, and is scheduled to complete in April 2017. Total developed area would be 122 ha.
Scheme Area	Potential Area (ha): 554 ha Designed Area (ha): ha Developed Area (ha): 122 ha existing 30 Irrigation Area (ha) 122 ha
Water Source	Seasonal River
Irrigation Method	Gravity Irrigation (Reservoir and Open channel)
Irrigation Facilities	Bund : Bund length 680 m, Bund height 9 m Reservoir : Gross Storage volume 846,890 m^3 Dead water volume 13,000 m^3
Irrigators Organization	Name of IO : UMWAMUYE Registration : Membership : 239 (male = 117, female =112)
Findings	・ Project committee members and ZIO engineer supervises the scheme at the site. ・ Erosion and small-scale land slide are observed at downstream slope of the existing bund. The cause of this problem would be unsuitable embankment materials and lack of compaction. Rehabilitation of this defect is included in SSIDP component.

Photos (1/2)

Location	Photo	Comments
Reservoir		Reservoir can't store enough water because of insufficient water source.
Bund: Downstream Slope		Gullies and small-scale land slide area observed. This defect will be rehabilitated by SSIDP
Irrigation Area		Between the bund and the main canal, a catch drain channel is constructed not to damage main canal by flood from hilly area.
Spillway		Spillway with wide space.

Photos (2/2)

Location	Photo	Comments
Secondary Canal: Existing Lining		Quality of mortar plastering work is not good.
Secondary Canal: New lining		Surface of stones are covered with mortar.
Tertiary Canal		Tertiary canals are unlined.

Scheme Map


Ussoko Mlimani Irrigation Area
Spillway
Ussoko Mlimani Bund
Intake
Image © 2016 DigitalGlobe
© 2016 Google
Google Earth

Site investigation Sheet (19)

Name of Scheme	**Mahiga Irrigation Scheme**
Date of Investigation	06/Mar/ 2017
Name of Site Visitor	NIMP2018 team : TL Sibuta, Eng. Majo, Mr. Masaki
Name /Position of Guide and Interviewee	Eng. Mtemi M. Simeon, District Commissioner Mr. Andrea I. Ng'hwani, Administrative Secretary Mr. Pancras Lugaimukya, Ag DAICO Other District Staff
Findings	
Location	Zone : Tabora District: Kwinba Coordinates: Bund: Latitude S 3.020761 Longitude E 33.36532 Farmland: Latitude S 3.010511 Longitude E 33.36302
Outline of the Scheme	The dam was constructed between 2012 and 2013/2014.
Scheme Area	Potential Area (ha) : 300 ha Designed Area (ha): ha Developed Area (ha): ha Irrigation Area (ha) 242 ha
Water Source	Reservoir
Irrigation Method	Gravity Irrigation (Reservoir and Open channel)
Irrigation Facilities	Bund : Bund length 1,090 m*, Bund height 8 m** Canal : 2 Main Canals
Irrigators Organization	Name of IO : UWAMA (Umoja wa Wamwagiliaji Mahiga) Registration : 2012 as Association Membership :
Findings	The scheme requires lining of secondary canals and construction of tertiary canals. The bund seems to be stable by covering with grasses.

Note: The asterisk mark " * " means that the data is approximated value measured on the google earth pro.
The asterisk mark " ** " means that the data is approximated value measured by a GPS device.

Photos (1/2)

Location	Photo	Comments
Reservoir area		Last year, reservoir stored water at full capacity level.
Bund		The bund seems to be stable by covering with grasses.
Spillway		Spillway with wide space
Main Canal		Main canal is made of wet-stone-masonry walls and bottom.

Photos (2/2)

Location	Photo	Comments
Intake Structure		Inlet elevation is higher than the reservoir bottom. Dead storage volume seems to be considered.
Outlet Valve		There is no valve box to protect.

Scheme Map


Main Canal No.2
Mahinga Irrigation Area
Main Canal No.1
Intake No.2
Spillway
Mahinga Bund
Intake No.1
Image © 2016 CNES / Astrium
© 2016 Google
Google Earth

Site investigation Sheet (20)

Name of Scheme	**Irienyi Irrigation Scheme (SSIDP Scheme)**
Date of Investigation	07/Mar/ 2017
Name of Site Visitor	NIMP2018 team : TL Sibuta, Eng. Majo, Mr. Masaki
Name /Position of Guide	Rorya DC : Mr. Dominick Ndyetabura, DAICO, Mr. Emmanuel Lutego, ASMS
Findings	
Location	Zone : Mwanza District: Rorya Coordinates: Bund: Latitude S 1.416511 Longitude E 33.95818 Farmland: Latitude S 1.415992 Longitude E 33.95848
Outline of the Scheme	The scheme was constructed in 2005 as a dam project. Main crop is paddy.
Scheme Area	Potential Area (ha) : ha Designed Area (ha): 320 ha Developed Area (ha): 120 ha Irrigation Area (ha) - ha
Water Source	Reservoir
Irrigation Method	Gravity (Reservoir and Channels)
Irrigation Facilities	Bund : Bund length 460 m*, Bund height 4 m** Canal : Main 2.5 km
Irrigators Organization	Name of IO : UWAIRO (UMOJA wa Wakulima Iruenyi Rorya) Registration : As an Association Membership : 170 (male=100, female70) Fees : Member fee 10,000 Tzs/year O&M fee 50,000 Tzs/person or 1 bag of paddy (1 bag = 100kg)
Findings	· Sedimentation in the reservoir area is a serious problem. Aquatic plants were flourishing up to near the intake. · The bund slopes are covered with grasses, and seem to have no problem.

Note: The asterisk mark “ * “ means that the data is approximated value measured on the google earth pro.
The asterisk mark “ ** “ means that the data is approximated value measured by a GPS device.

Photos

Location	Photo	Comments
Bund		Aquatic plants near the intake
Spillway		There is no structure such as guide walls.
Irrigation Area and Main canal		
Lining of Main Canal		Main canal is lined with wet-stone-masonry.

Scheme Map


Irienyi Irrigation Area
Main Canal
Intake
Spillway
Irienyi Bund
© 2016 Google
Image © 2016 DigitalGlobe
Google Earth

Site investigation Sheet (21)

Name of Scheme	**Nyatwali Irrigation Scheme (SSIDP scheme)**
Date of Investigation	08/Mar/ 2017
Name of Site Visitor	NIMP2018 team : TL Sibuta, Eng. Majo, Mr. Masaki
Name /Position of Guide	Bunda DC: Bunda TC:
Findings	
Location	Zone : Mwanza District: Bunda TC Coordinates: Bund: Latitude S 2.157664 Longitude E 33.83256 Farmland: Latitude S 2.150442 Longitude E 33.83997
Outline of the Scheme	The old pump house was built in 1964, and pumps were deteriorated seriously and they are not in use. The existing scheme has started cultivation of paddy since 2009/10. In 2013, 600 m of main canal was lined with concrete panels. This scheme was selected by SSDIP.
Scheme Area	Potential Area (ha) : 210 ha Designed Area (ha): ha Developed Area (ha): 160 ha Irrigation Area (ha) 24 ha (Wet) 16 ha (Dray)
Water Source	Lake Victoria
Irrigation Method	Pump and Surface irrigation
Irrigation Facilities	Pump : Electric Submersible pump 3 sets Canal : Main 1.3 km Secondary 5 canals 2.1 km
Irrigators Organization	Name of IO : Umoja wa Wakulina Nyatwali Registration : Membership : 156
Findings	・For irrigation water supply, farmers need to pay 80,000 Tzs/acre in advance to buy pre-paid electricity from TANESCO. ・Unlike other countries, there are no discounts on electricity charges for irrigation and drainage use. ・The tariff is the same as that of industrial use.

Photos (1/2)

Location	Photo	Comments
Submersible 3 pumps installed in the Lake		Three submersible pump were installed in the Lake Victoria. Two of them were not operational at present.
Control Valve		The pipe line system equip with a control valve and a check valve.
Old Pump House		This house was built in 1964.
Switchboard		The switchboard is installed in the old pump house.

Photos (2/2)

Location	Photo	Comments
Secondary Canal		Secondary canals are lined with concrete panels.
Division Box on the Secondary Canal		A stoplog type of division box is constructed.

Scheme Map


On Going Development area
Existing Nyatwali Irrigation Area
Potential Area?
Nyatwali Scheme Pump Station
Image © 2016 CNES / Astrium
© 2016 Google
Google Earth

Site investigation Sheet (22)

Name of Scheme	**Serengeti Scheme**
Date of Investigation	08/Mar/ 2017
Name of Site Visitor	NIMP2018 team : TL Sibuta, Eng. Majo, Mr. Masaki
Name /Position of Guide	Bunda DC:
Findings	
Location	Zone : Mwanza District: Bunda TC Coordinates: Bund: Latitude S 2.194558 Longitude E 33.84116 Farmland: Latitude S 2.185197 Longitude E 33.84626
Outline of the Scheme	This scheme is a solar pump project for horticulture.
Scheme Area	Potential Area (ha) : ha Designed Area (ha): ha Developed Area (ha): 20 ha Irrigation Area (ha) ha
Water Source	Lake Victoria
Irrigation Method	Pump Irrigation (Pump, Pipeline and Open channel)
Irrigation Facilities	Pump : Solar pump 1 set Solar Panel: 22 panels Farm Storage Tank Capacity: 120 m^3
Irrigators Organization	Name of IO : Registration : Membership :
Findings	・ For power supply to a small-scale scheme, solar panels would be useful. ・ According to DC staff, the solar pump system can fill a farm tank which has a capacity of 120 m^3 in a day.

Photos

Location	Photo	Comments
Pump Station		There are 22 panels in total. The scheme uses 20 panels for irrigation. Two panels are used by a private farmer.
Submersible Pump Set		It seems to be in good condition.
Farm Storage Tank		According to DC staff, the solar pump system can fill this tank which has a capacity of 120 m3 in a day.
Irrigation Area		According to IO, farmland has been reducing because of intrusion of the lake water.

Scheme Map


Storage Tank
Serengeti Irrigation Area
Solar Pump Station for Serengeti Scheme
Image © 2016 CNES / Astrium
Google Earth