REPUBLIC OF MALAWI
MINISTRY OF AGRICULTURE, IRRIGATION
AND WATER DEVELOPMENT (MoAIWD)

PROJECT FOR NATIONAL WATER RESOURCES MASTER PLAN IN THE REPUBLIC OF MALAWI

FINAL REPORT

Volume I: Summary

DECEMBER 2014

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

CTI ENGINEERING INTERNATIONAL CO., LTD
ORIENTAL CONSULTANTS CO., LTD.
NEWJEC Inc.

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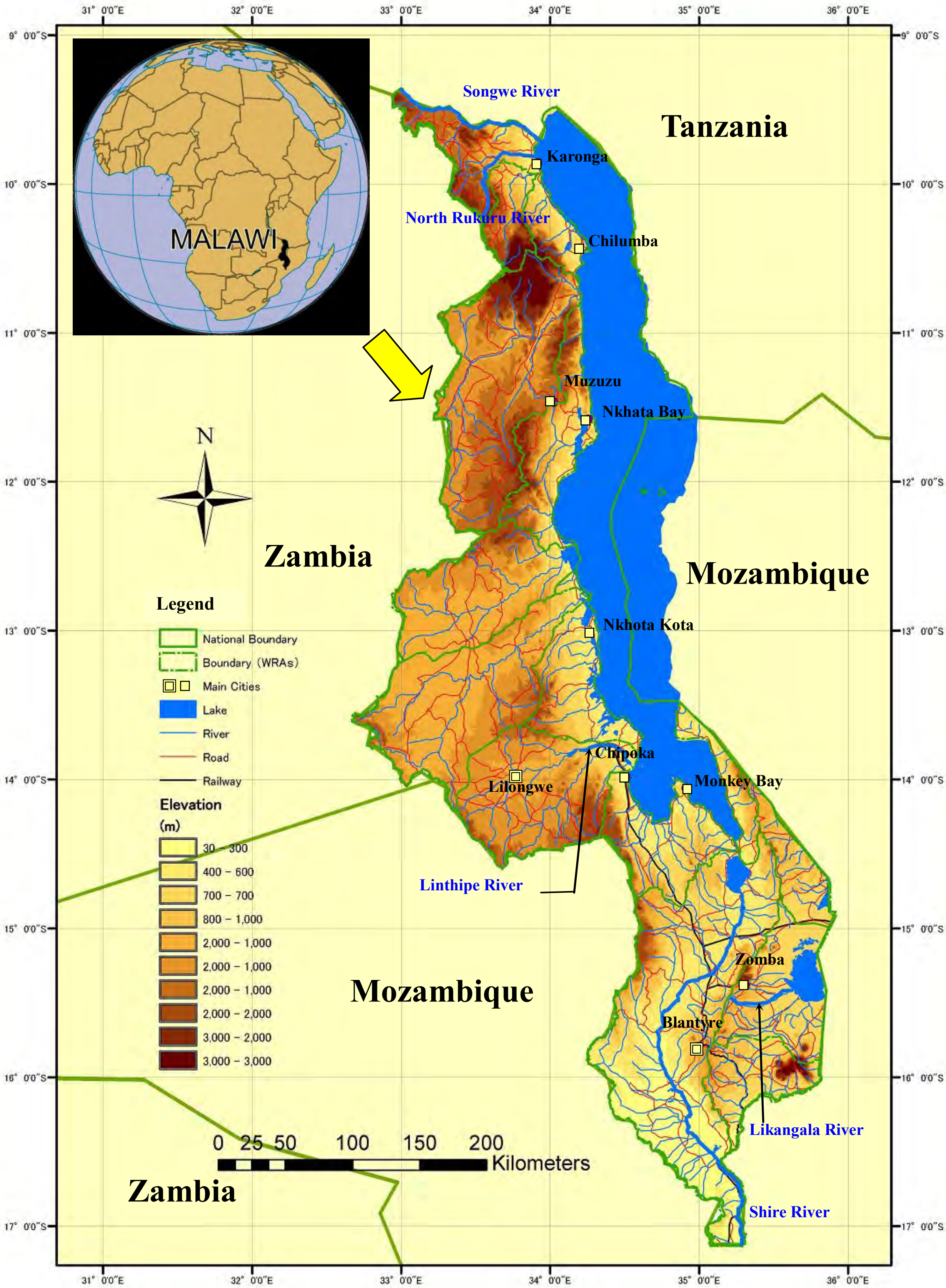
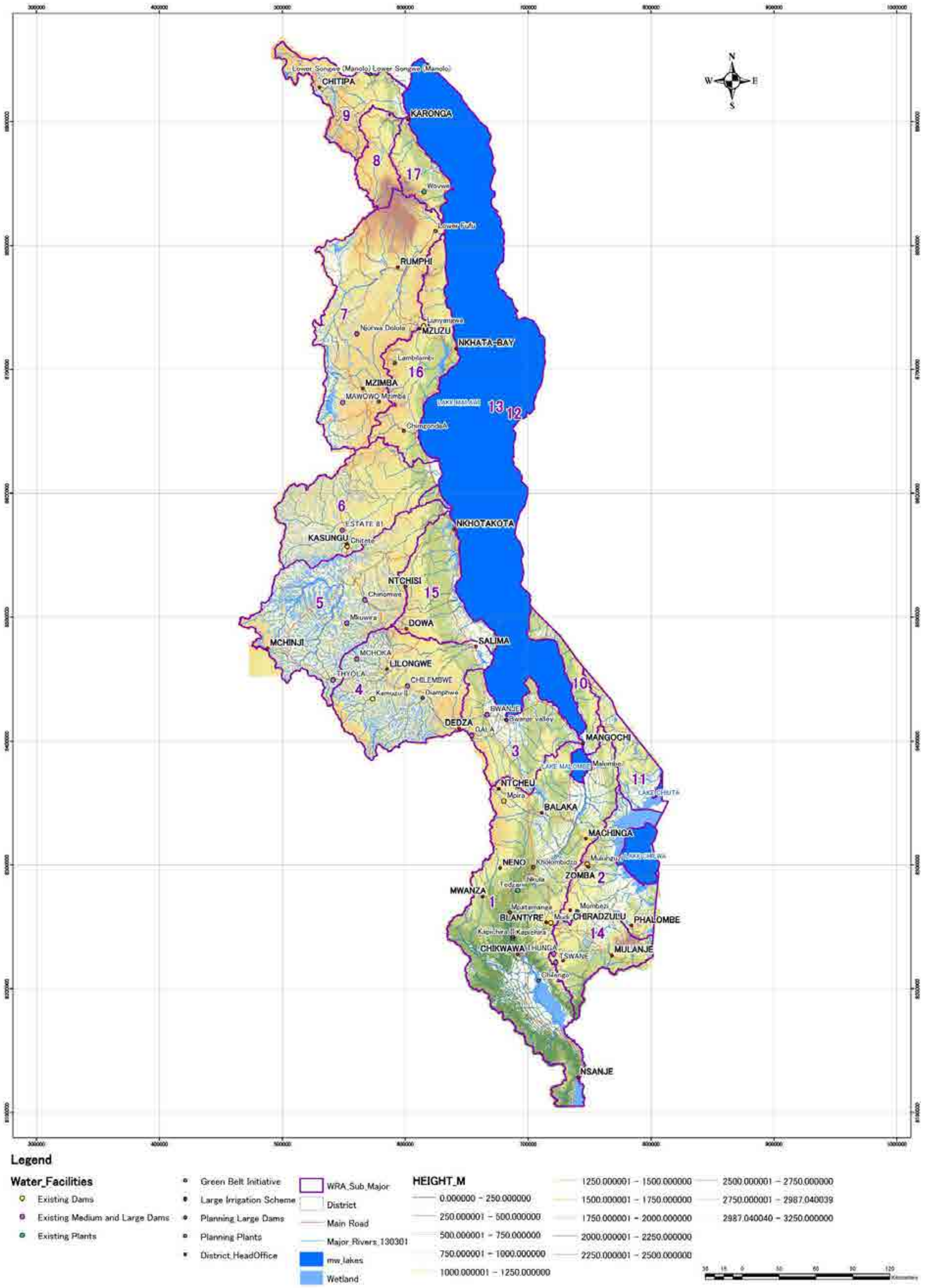
COMPOSITION OF FINAL REPORT

Volume I	**:**	**Summary**
Volume II	**:**	**Main Report**
Volume III	**:**	**Data Book**
Volume IV	**:**	**Photo Book**

EXCHANGE RATE
USD1.0=MWK329=EUR 0.77=JPY84.88
December 1, 2012



Location Map



Map of WRAs and Water Resources Development Facilities

Kamuzu I Dam

Water Treatment Plant in Zomba

Photo 2.8.15

Gravity Fed Water Supply (Mulanje)

Irrigation Intake at Bwanje Irrigation Scheme

Irrigation Canal at Bwanje Irrigation Scheme

Kamuzu Barrage at Liwonde

Photographs

 **Flood Mark near the Ruo River**	 **Dzalanyama Forest Reserve**
 **Rusa River (WRA 5) in Rainy Season (March, 2013)**	 **Rusa River (WRA 5) in Dry Season (October, 2013)**
 **Measurement Exercise 1**	 **Seminar on Draft Final Report (10th Oct 2014)**

Photographs

EXECUTIVE SUMMARY

Background and Objectives

Background

Average annual rainfall is about 1,000 mm in Malawi and many perennial flows exist. Generally, water resources are abundant as compared with the other African countries. Mineral resources in Malawi have hardly developed as compared with the neighboring countries. The Malawi Government aims to accomplish economic growth with the utilization of its water resources. Malawi's National Water Policy in 2005 and National Sanitation Policy in 2008 target "continuous and systematic water resources management and development" and "continuous offer of sanitary service and water supply." In the circumstances described above, appropriate approaches to the targets have to be implemented.

However, proper management and effective use of water resources have not been smoothly implemented and systematic basic information about water resources and water utilization were not updated after making the National Water-Resources Master Plan in 1986 with UNDP support. To overcome all the existing problems, the Malawi Government has considered integrating the water resources management policy based on the present water budget and water resources potential. The Malawi Government therefore tackles the renewal of the master plan as an item of primary importance. It requested assistance from the Government of Japan to establish a National Water Resources Master Plan together with the capacity building concerned.

In response to the request, the Japan International Cooperation Agency (JICA) dispatched an inquiry mission from February to March in 2011, and the Scope of Work (S/W) and the Minutes of Meeting (M/M) were signed by JICA and the Ministry of Irrigation and Water Development (MoIWD) in March 2011. The Project was commenced in March 2012, through the process of submitting the Interim Report in October 2013, and the Final Report was submitted to the MoAIWD in December 2014.

Objectives

The objectives of the Project are: (1) to formulate the national water resources master plan (the M/P); and (2) to transfer technology and knowledge to the Malawi counterpart personnel. Through establishment of the M/P, issues on the water resources management in Malawi are to be clarified and strategies for the improvement in capability of Malawi and the appropriate directions for water resources management are proposed. Thus, related agencies in Malawi will be able to perform integrated water resources management in the future. Moreover, the technical transfer regarding data collection, analysis, management and planning, etc., will be implemented in the Project through on-the-job training (OJT), seminars, workshops and so on.

The Project Area covers the entire Malawi country with an area of 118,000 km^2 and a population of 13.1 million.

Present Status surrounding the Project

Related Organizations

The management of national water resources is primarily under the responsibility of the Ministry of Agriculture, Irrigation and Water Development (MoAIWD) for policy-making, supervision and direction in the areas of irrigation and water supply. The Ministry of Natural Resources, Energy and Environment (MoNREE) is responsible for hydropower development. The MoAIWD is the central institution to facilitate the development and management of water resources in Malawi. Its primary responsibilities are to ensure access to safe water and sanitation, the provision of safe drinking water to rural communities, water resources management, provision of irrigation scheme, and the collection as well as monitoring of hydrological data and catchment protection to support policy formulation. In addition, Water

Resources Board, local governments, and Water Boards are relevant organizations in the water resources development and management.

Major Industries

Agriculture is the most important sector of the Malawi economy. It employs about 80% of the total workforce, contributes over 80% to foreign exchange earnings, accounts for 39% of gross domestic product (GDP) and contributes significantly to national and household food security. The agricultural sector has two main subsectors; the smallholder subsector (contributes more than 70% to agricultural GDP), and the estate subsector (contributes less than 30% to agricultural GDP). Smallholders cultivate mainly food crops such as maize, cassava and sweet potato to meet subsistence requirements. Estates focus on high value cash crops for export such as tobacco, tea, sugar, coffee and macadamia.

River Basins

Malawi is divided into 17 water resource areas (WRAs) based on the river basins. Some WRAs consist of one river basin and others are composed of several small river basins. Moreover, WRAs are divided into water resource units (WRUs).

Meteorology and Hydrology

The climate of Malawi is categorized as sub-tropical and divided into three weather variations such as warm-wet (November to April), cool-dry winter (May to August) and hot-dry seasons (September to October). The warm-wet season is recognized as the rainy season with about 95% of annual rainfall expected. In whole Malawi, the average annual rainfall in the latest 3 decades is 971 mm, ranging between approx. 700 mm and 1,200 mm. In the rainy season, runoff yield is about 20% of rainfall depth. The annual runoff ratios of rivers in Malawi fluctuate between 0.2 and 0.3 based on the collected rainfall and discharge data in the Project.

In hydrological monitoring, 139 stations consisting of 136 MoAIWD stations and 3 Water Board stations are operational and 164 stations are closed. On the other hand, MoNREE manages meteorological monitoring. There have been about 800 rainfall stations in the 1980's, but there are only between 100 and 200 operational rainfall stations at present. Evaporation and other climatic data have been recorded at all the meteorological stations, and MoNREE manages 23 meteorological stations.

Groundwater monitoring in 2012 was carried out at only 18 boreholes out of the established 35 boreholes. Regarding water quality monitoring, there are 195 water quality monitoring points in Malawi which are classified into three categories: surface water, pollution control located at outlets of effluent sources and groundwater. Periodical monitoring for those stations is not made due to budgetary constraints.

Evaluation on 1986 Water Resources Master Plan

The Master Plan of 1986 (NWRMP 1986) proposed many water supply projects for both urban and rural areas. Due to the difficulty in pursuing the implementation results of numerous water supply projects proposed in the NWRMP 1986, the progress of water supply situations was examined by referring to actual and proposed service coverage of accessing improved water. An achieved service coverage ratio is 93% in 2010 to planned 65% in 2005 in urban areas, 72% in 2010 to planned 68% in 2005 in rural areas, and 75% in 2010 to planned 67% in 2005 in total. Thus the progress of actual water supply exceeds the planned figures.

NWRMP 1986 planned to increase the hydropower generation capacity of 230 MW from 178 MW in 1986 up to 408 MW until 2001. However, actual capacity increase remains at 140 MW at present.

As similar to water supply, progress of irrigation development is evaluated using a parameter of irrigation area. NWRMP 1986 planned the irrigation area from 19,400 ha in 1985 to 39,500 ha. The actual irrigation development achieved exceeding results as 67,000 ha in 2005 and 90,600 ha in 2011.

Existing Water Use

Water Supply

The nationwide accessibility to safe water was 83% in 2011. Accessibility in rural areas is 81% with continuous improvement; however, the accessibility decreased from 92% in 2010 to 88% in 2011, because of failure of the water supply infrastructure and the high urban population growth rate.**Irrigation Development**

The cumulative area under irrigation for smallholder increased from 37,960 ha in 2009/10 to 42,181 ha in 2010/11. Meanwhile, the total irrigation area of the estate which mainly cultivates sugar and tea was 48,382 ha in 2010/11.

Hydropower Generation

The installed capacity of existing hydropower is 286MW, of which 98% is generated from cascaded run-of-the-river power plants on the Shire River and the remaining 2% is on the Wovwe River.

Basic Policy of Master Plan Formulation

Target Year

The target year of the Master Plan for water resources development and management was set in 2035 as a long-term target, 2025 as a middle-term target and 2020 as a short-term target.

Basic Policy for Water Resources Development and Management

To satisfy growing demand in Malawi, the key considerations for water resources development in Malawi are effective usage of; 1) effective water demand management in dry season, 2) abundant water resources in rainy season, 3) constantly abundant water resources of Lake Malawi and the Shire River.

The main countermeasures for water resources management are; 1) appropriate monitoring for hydrological data and water quality, 2) enhancement of system and capacity of relevant agencies, and 3) strengthening of basin management system based on the basin characteristics studied in the Project.

Priority in Water Utilization

The priority order of consumptive water use is domestic water and irrigation and livestock. Regarding the environmental flow, in the Malawi there is insufficient information about the user of environmental flow such as existence of protective species. In addition, there is no guideline to estimate environmental flow in Malawi. In the circumstance, influence to the river discharge by water resources development is examined and compared with the environmental flow. As a result of the examination, a direction of management of environmental flow is suggested in the Project. In fact, monitoring and detailed investigation for the environmental flow and clarification of precious species should be done in Malawi to modify guidelines and properly control the environmental flows by river basin.

Safety Level of Water Usage

The safety level of water resources development for consumptive uses is set at 20-yaer drought for 4 cities water supply, 10-year drought for rural towns and market centers, 5-year drought for rural villages, and 5-year drought for irrigation.

Urban and Rural Water Supply Development Plan

4 Cities' Water Supply Development

The water supply plans for 4 cities were evaluated, and an implementation priority was given based on the results of existing feasibility studies and detailed designs. First priority was given to extension of existing water treatment works in Zomba, and groundwater borehole and raising of Kamuzu dam I in Lilongwe follow it as second and third priorities. The followings are planned service coverage, non-revenue water (NRW) rate, and project cost in each city in the target year of 2035. The economic internal rate of return (EIRR) ranges from 10% to 21%. They show high economic efficiency.

1. Lilongwe: Service coverage of 100%, NRW rate of 20%, Project cost of 517.1 million USD
2. Brantyre: Service coverage of 86.9%, NRW rate of 25%, Project cost of 315.4 million USD
3. Mzuzu: Service coverage of 100%, NRW rate of 20%, Project cost of 228.5 million USD
4. Zomba: Service coverage of 100%, NRW rate of 20%, Project cost of 29.2 million USD

Rural Water Supply Development for Towns

Northern, Central and Southern Regional Water Boards (RWBs) supply domestic water to towns in Malawi. In accordance with population projection in target towns, RWBs conduct mainly rehabilitation of the existing supply networks and their extension. 7 water supply schemes in northern region, 20 in the central and 22 in the southern are planned, and their total project cost aggregates 143.3 million USD. The EIRR shows high economic efficiency of 17.3%.

Rural Water Supply Development for Market Centers

Targeting market centers of 154 in total as a rural center, which extend 34 in northern region, 58 in the central and 62 in the southern, water supply facilities are planned by gravity-fed or borehole system in accordance with population increase and facilities' aging. Planned service coverage is set at 98% in 2035 from 73% in 2015. The total project cost aggregates 123.2 million USD, and the EIRR shows high economic efficiency of 15.1%.

Rural Water Supply Development for Villages

Targeting villages in the rural areas, water supply facilities are planned by gravity-fed or borehole system to supply safe water to the villagers. Planned access rate is set at 98% in 2035 from 73 - 95% in 2015. The total project cost aggregates 424.2 million USD, and the EIRR was not computed due to basic human needs basis.

Irrigation Water Supply Development Plan

Irrigation Development Scenarios

The two development scenarios were set up: one is a realistic development at 2,500 ha/year, and the other one is a little ambitious development at 5,000 ha/year. The latter one is nearly equal to the standard development rate of SADC countries.

Cropping Patterns and Non-structural Applications

In view of the result of initial water balance analysis, it is proved that water is still available at early stage of the dry season. Therefore, the possibility of crop diversification, such as shifting crop cultivation and application of early growing crops (early maturing varieties), are proposed for saving available water as a non-structural application. In the case annual irrigation area increases at 5,000 ha/year, the cropping modification could reduce the total cost by 34% from the normal cropping.

Planning Concepts

Clarified was the water balance between water resources potential and irrigation water demand in two scenarios through water balance simulation by Water Resources Unit (WRU). Structural components shall be arranged water intake facilities of weir or pump, conveyance and distribution canal system, and water distribution or storage ponds. Their suitable components shall be determined depending on the water availability and their topographic features.

Stepwise Implementation Program of the Irrigation Development and Economic Efficiency

Following the above concepts, the suitable irrigation development facilities were proposed by WRU, and the stepwise implementation program was proposed until 2035 by giving the priority of each WRU project considering the parameters of cost efficiency, development effects and water supply potential. The total project cost aggregates 914.9 million USD, and the EIRR shows low economic efficiency of 2.2 - 3.2% in both scenarios due to setting maize as the major crops newly planting for the development areas.

Hydropower Development Plan

Hydrological Evaluation Hydropower Development

Hydropower development projects are planned by MoNREE until 2030 and some of the projects have been proceeded in accordance with the plans. Hydropower development projects are evaluated and compiled from the view point of Integrated Water Resources Management (IWRM) on the present and future conditions.

It can be said that hydropower projects in Malawi are feasible from standpoint of the water resources. Furthermore, cascaded development proposed in the master plan level study of WB1998 is more beneficial than single development. Therefore, for proceeding projects, feasibility studies and further design studies are recommended for practical hydropower development.

Necessity of Data/Information Sharing

Since meteorological data such as rainfall data is being observed by MoNREE, and hydrological data such as river flow data by MoAIWD, sharing these data for studies on hydropower development is very important to manage hydropower generation.

Water Resources Management

New Institution for Water Resources Management

Based on the implication of the Water Resources Act enacted in 2013 and the IWRM policy, coordination of all relevant stakeholders centering on the NWRA and catchment management committees among them may be the great challenge in realizing the Malawi IWRM. The NWRA is an independent organization, but it is closely related to the MoAIWD, so that the NWRA shall have a mutual relationship with MoAIWD to exchange and share information regarding water resources management and development projects. Regarding relevant governmental agencies out of MoAIWD, the NWRA shall conduct a sector-wide coordination among them.

In near future, NWRA will monitor the hydrological data including surface water, groundwater and water quality, and will manage them. In order to smoothly transfer the existing monitoring and management works to NWRA, MoAiwd shall improve their data management system as the integrated hydrological information management system at first.

Recommendations

Various issues were encountered in the course of survey on existing conditions and plan formulation in the Water Resources Master Plan. Relatively abundant water resources compared with other African countries are one of a few drivers to uplift the Malawian economy in the future. These issues are not only to be overcome for future efficient water resources management but also to be essential factors for uplifting the economy. Thus the issues shall be enumerated below as recommendations.

Institutional Strengthening of MoAIWD and Smooth Transition of its Functions to NWRA

New Water Resources Act was enacted in 2013, and new organization of NWRA will be established in near future based on the stipulation of the Act. Through establishment of new organization, management of water right system will be empowered so that the financial base of water resources management is expected to be much more robust. Hydrological monitoring section including groundwater and water quality monitoring will move to NWRA in the near future. The smooth transition from MoAIWD and reform to agile institution is expected to be made.

Furthermore, the 28 district water offices have been mainly conducted hydrological monitoring including water level observation and discharge measurement. However, poor working conditions of the stations and shortage of staffs in the offices could be observed in the course of the survey. In order to activate the hydrological monitoring through collaboration with such local institutions or merger of them into NWRA, intensive institutional reform is indispensable with perspectives of future activation including the local institutions.

Strengthening of Monitoring System covering Surface Water, Groundwater and Water Quality, and Sharing and Utilization of Monitored Data

Essential is periodical groundwater table monitoring at testing wells and water quality monitoring at the designated points as well as monitoring of water level and discharge measurement, and archiving of the monitored data in a database system. Furthermore, an integrated data management system shall be established through additionally archiving of the observed data in the water-related projects.

The integrated database system will be transferred to NWRA, and NWRA shall establish the data providing system or data access system for the related agencies as well as MoAIWD. In this context, NWRA will be a data center of Malawi in hydrological and water quality so that long-lasting stagnation in this field will be solved for activating of hydrological and water quality monitoring.

Promotion of Urban and Rural Water Supply

The cost estimation clarified that the project costs is very huge, namely those for the four cities amounting to 1.19 billion USD, towns 140 million USD, combination of market centers and rural communities 550 million USD. Access to safe water is the minimum security to support the people living safe and comfortable in urban as well as rural areas. Official assistances should be confirmed from the World Bank, AfDB and other development partners in order to finance those project costs.

It is required to implement rehabilitation of water distribution networks to cope with the leak of water and to reduce NRW in urban areas as well as to develop new water sources. As for boreholes in rural water supply, equipment utilizing jetting method or brushing method is effective to restore their function which is deteriorated by clogging and subsoil sedimentation.

Promotion of Irrigation Development and the Coordination with the Irrigation Master Plan by the World Bank

Development of the water resources potential by WRU is proposed in the Irrigation Development Plan. Though the Irrigation Master Plan was started by the World Bank during the period of the JICA Project, coordination between the two projects was not necessarily conducted in satisfactory manner due to a time limitation. As JICA Project Team provided the results of water balance simulation for the World Bank Master Plan Team, which is still working in Malawi, it is expected that the Master Plan of the JICA Project will be utilized by them.

Furthermore, GBI (Green Belt Initiative) is also a national project for the irrigation. A large amount of investment is indispensable by private investors to promote cash cropping from the viewpoint of economic growth as well as supplying irrigation water to smallholders. Thus, such efforts to invite private investment should be conducted by the whole country with arranging conditions which attract foreigners to make investment easily.

Further Study on Environmental Flow

Environment is one of the important users with considering the management of water resources development where environmental flow should be set for the conservation. However, its priority has to be lowered in this Master Plan because environmental factors are not specified to conserve and it may even disturb the water resources development according to a hydrological approach. It is recommended that environmental flow should be set by appropriate approach in feasibility studies on water resources development of rivers in the future, considering the survival property of specified conservation targets.

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ACRONYMS AND ABBREVIATIONS

ACDF	:	Africa Catalytic Growth Fund
ADC	:	Area Development Committee
ADD	:	Agriculture Development Division
ADMARC	:	Agricultural Development and Marketing Corporation
ADP	:	Agriculture Development Programe
AEC	:	Area Executive Committee
AfDB	:	African Development Bank
AIDs	:	Acquired Immuno Deficiency Syndrome
AUSAID	:	Australian Agency for International Development
BCC	:	Blantyre City Council
BGS	:	British Geological Survey
BOD	:	Biochemical Oxygen Demand
BWB	:	Blantyre Water Board
CA	:	Capacity Assessment
CBM	:	Community-Based Management
CD	:	Capacity building
CDO	:	Community Development Officer
CIDA	:	Canadian International Development Aid
CRWB	:	Central Region Water Board
CSOs	:	Civil Society Organizations
COD	:	Chemical Oxygen Demand
CWP	:	Community Water Point
CWR	:	Crop Water Requirement
DAs	:	District Assembly
DAO	:	District Agriculture office
DC	:	District Committee
DCCMS	:	Department of Climate Change and Meteorological Services
DCP	:	Doppler Current Profiler
DCT	:	District Coordinate Team
D/D	:	Detail Design
DDC	:	District Development Committee
DEM	:	Digital Elevation Model
DHI	:	Danish Hydrological Institute
DEC	:	District Executive Committee
DPD	:	Department of Planning and Development
DoI	:	Department of Irrigation Services
DoE	:	Department of Energy Affairs, MoNREE
EAD	:	Environmental Affairs Department
EIA	:	Environmental Impact Assessment
EIB	:	European Investment Bank
EIRR	:	Economic Internal Rate of Return
ESCOM	:	Electricity Supply Corporation of Malawi Limited
EU	:	European Union
FAO	:	Food and Agriculture Organization of the United Nations
F/S	:	Feasibility Study
GBI	:	Green Belt Initiative
GDP	:	Gross Domestic Product
GIS	:	Geographic Information System
GPS	:	Global Positioning Syste
GWP	:	Global Water Partnership
ha	:	hectare
HA	:	Health Assistant

HD	:	High Density
HIV	:	Human Immunodeficiency Virus
HPP	:	Hydropower Plant
HQ	:	Headquarters
HRPU	:	Human Resources Planning Unit
HSA	:	Health Surveillance Assistant
IDA	:	International Development Association
IAEA	:	International Atomic Energy Agency
IEE	:	Initial Environmental Examination
IFAD	:	Internat ional Fund for Agricultural Development
IPP	:	Independent Power Producer
IT	:	Information Technology
ITCZ	:	Inter Tropical Convergence Zone
ISD	:	Irrigation Service Division
IWA	:	International Water Association
IWRM	:	Integrated Water Resources Management
JICA	:	Japan International Cooperation Agency
JPC	:	Joint Permanent Commissions
JPY	:	Japanese Yen
JSR	:	Joint Sector Review
LCC	:	Lilongwe City Council
LD	:	Low Density
LWB	:	Lilongwe Water Board
MBS	:	Malawi Bureau of Standard
MCA	:	Millennium Challenge Account
MCC	:	Millennium Challenge Corporation
MD	:	Middle Density
MDGs	:	Millennium Development Goals
M&E	:	Monitoring and Evaluation
MDPC	:	Ministry of Development, Planning and Cooperation
MEGS	:	Malawi Economic Growth Strategy
MEIP	:	Malawi Electricity Investment Plan
MG	:	Malawi Government
MGDS	:	Malawi Growth and Development Strategy
MIS	:	Management Information System
MK	:	Malawi Kwacha
MoAIWD	:	Ministry of Agriculture, Irrigation and Water Development
MoAFS	:	Ministry of Agriculture and Food Security
MoEM	:	Ministry of Energy and Mine (former MoNREE)
MoF	:	Ministry of Finance
MoIWD	:	Ministry of Irrigation and Water Development
MoLGRD	:	Ministry of Local Government and Rural Development
MoNREE	:	Ministry of Natural Resources, Energy and Environment
MoPW	:	Ministry of Public Works
MoWDI	:	Ministry of Water Development and Irrigation (fomer MoAIWD)
MP	:	Member of Parliament
M/P	:	Master Plan
MPRS	:	Malawi Poverty Reduction Strategy
MPUWSP	:	Malawi Peri-Urban Water and Sanitation Project
MW	:	Mega Watts
NFRA	:	National Food Reserve Agency
NGO	:	Non Governmental Organization
NIB	:	National irrigation Board
NIPDS	:	National Irrigation Policy and Development Strategy

NRW	:	Non Revenue Water
NRWB	:	Northern Region Water Board
NSO	:	National Statistical Office
NSP	:	National Sanitation Policy
NWDP	:	National Water Development Project
NWP	:	National Water Policy
NWRA	:	National Water Resources Authority
NWRMP	:	National Water Resources Master Plan
ODA	:	Official Development Aid
OJT	:	On-the-Job Training
O&M	:	Operation and Maintenance
OPC	:	Office of President and Cabinet
OPEC	:	Organization of the Petroleum Exporting Countries
PMU	:	Project Management Unit
POW	:	Plan of Work
PPP	:	Private Public Partnership
PRSP	:	Poverty Reduction Strategy Paper
PSB	:	Programme Steering Board
PSIP	:	Public Sector Investment Programme
PV	:	Photovoltaic
RE	:	Rural Electrification
RGF	:	Rapid Gravity Filters
RWBs	:	Regional Water Boards
SAFRIEND	:	The Southern Africa Flow Regimes from International Experimental and Network Data
SADC	:	Southern Africa Development Community
SAPP	:	Southern Africal Power Pool
SC	:	Steering Committee
SEA	:	Strategic Environmental Assessment
SFPDP	:	Smallholder Flood Plains Development Programmes
SFFRFM	:	Smallholder Farmers Fertilizer Revolving Fund of Malawi
SRBMP	:	Shire River Basin Management Program
SRWB	:	Southern Region Water Board
S.T.A	:	Sub Traditional Authority
TAs	:	Traditional Authorities
TNA	:	Training Needs Assessment
STA	:	Senior Traditional Authority
TAMS	:	Tippett, Abbett, McCarthy and Stratton Engineers
TC	:	Technical Committee
TCC	:	Tobacco Control Commission
THA	:	Traditional Housing Area
UNDP	:	United Nations Development Plan
UNICEF	:	United Nations Children's Fund
US AID	:	United States Agency for International Development
US$	:	United States Dollar
VDC	:	Village Development Committee
VHC	:	Village Health Committee
VHWC	:	Village Health and Water Committee
VIP	:	Ventilated Improved Pit
VLOM	:	Village Level Operations and Maintenance
WASH	:	The Water, Sanitation and Hygiene Project
WB	:	World Bank
WES	:	Water and Environmental Sanitation
WMA	:	Water Monitoring Assistant

WPCs	:	Water Point Committees
WRAs	:	Water Resources Areas
WRB	:	Water Resources Board
WRD	:	Water Resource Division
WRF	:	Water Resources Fund
WRIS	:	Water Resources Investment Strategy
WRM	:	Water Resources Management
WRUs	:	Water Resources Units
WQEO	:	Water Quality and Environmental Officer
WSGPG	:	Water and Sanitation Development Partners Group
WUA	:	Water Users Association
WUP	:	Water Utility Partnership
WWA	:	Water Works Act
WWTP	:	Wastewater Treatment Plant
ZAMCOM	:	Zambezi Watercourse Commission

CHAPTER 1. INTRODUCTION

1.1 Background of the Project

Average annual rainfall is about 1,000 mm in Malawi and many perennial flows exist. Generally, water resources are abundant as compared with the other African countries. Mineral resources in Malawi have hardly developed as compared with the neighboring countries. The Malawi Government aims to accomplish economic growth with the utilization of its water resources.

Water resources development and utilization to accomplish economic growth is the main part in the Malawi Growth Development Strategy (MGDS). Malawi's National Water Policy in 2005 and National Sanitation Policy in 2008 target "continuous and systematic water resources management and development" and "continuous offer of sanitary service and water supply." In the circumstances described above, appropriate approaches to the targets have to be implemented.

However, proper management and effective use of water resources have not been smoothly implemented and systematic basic information about water resources and water utilization were not updated after making the National Water-Resources Master Plan in 1986 with UNDP support.

To overcome all the existing problems, the Malawi Government has considered integrating the water resources management policy based on the present water budget and water resources potential. The Malawi Government therefore tackles the renewal of the master plan as an item of primary importance. It requested assistance from the Government of Japan to establish a National Water Resources Master Plan together with the capacity building concerned.

In response to the request, the Japan International Cooperation Agency (JICA) dispatched an inquiry mission from February to March in 2011 to perform a preparatory study for the master plan. The inquiry mission conducted investigations on the background of the request and its contents. It also investigated the present cooperation by other development partners, the contents of full-fledged investigation, the implementation organization in Malawi, etc. Subsequently, the Scope of Work (S/W) and the Minutes of Meeting (M/M) were signed by JICA and the Ministry of Irrigation and Water Development (MoAIWD) on March 4, 2011.

1.2 Objective of the Project

The objectives of the Project are: (1) to formulate the national water resources master plan (the M/P); and (2) to transfer technology and knowledge to the Malawi counterpart personnel.

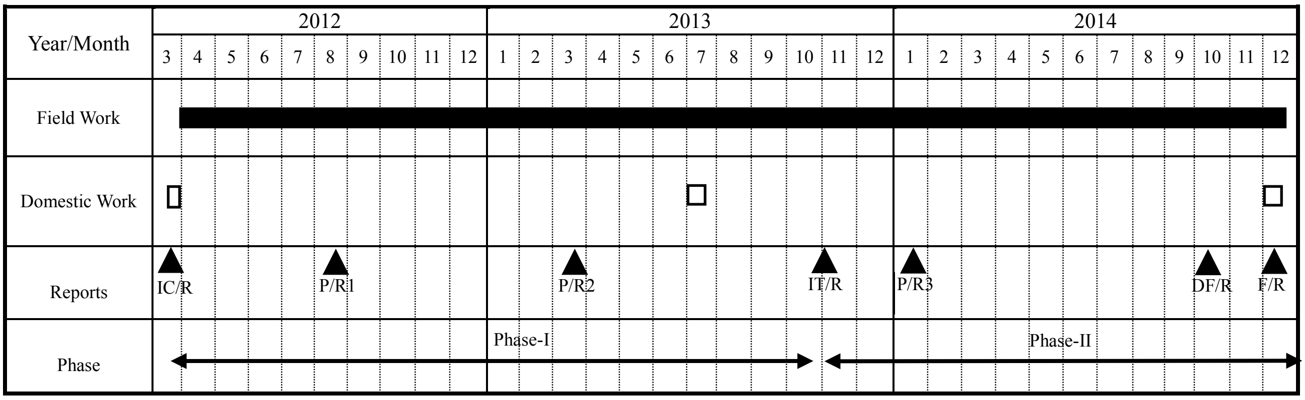
Through establishment of the M/P, issues on the water resources management in Malawi are to be clarified and strategies for the improvement in capability of Malawi and the appropriate directions for water resources management are proposed. Thus, related agencies in Malawi will be able to perform integrated water resources management in the future. Moreover, the technical transfer regarding data collection, analysis, management and planning, etc., will be implemented in the Project through on-the-job training (OJT), seminars, workshops and so on.

1.3 Project Area

The Project Area covers the entire Malawi country with an area of 118,000 km^2 and a population of 13.1 million (Source: Population and Housing Census, 2008).

1.4 Project Schedule

The Project is scheduled for a period of thirty months as shown in **Figure 1.1**. To present project progress and results during the Project, several reports will be submitted to related organizations based on the following schedule.



Legend：IC/R: Inception Report; P/R1: Progress Report 1; P/R2: Progress Report 2; P/R3: Progress Report 3,
IT/R: Interim Report, DF/R: Draft Final Report; F/R: Final Report
Phase-I: Water resources assessment
Phase-II: Formulation of water resources master plan

Figure 1.1 Schedule of the Project

1.5 Staffing Plan

The composition of the JICA Project Team is as shown in the following **Table 1.1.**

Table 1.1 Composition of the JICA Project Team

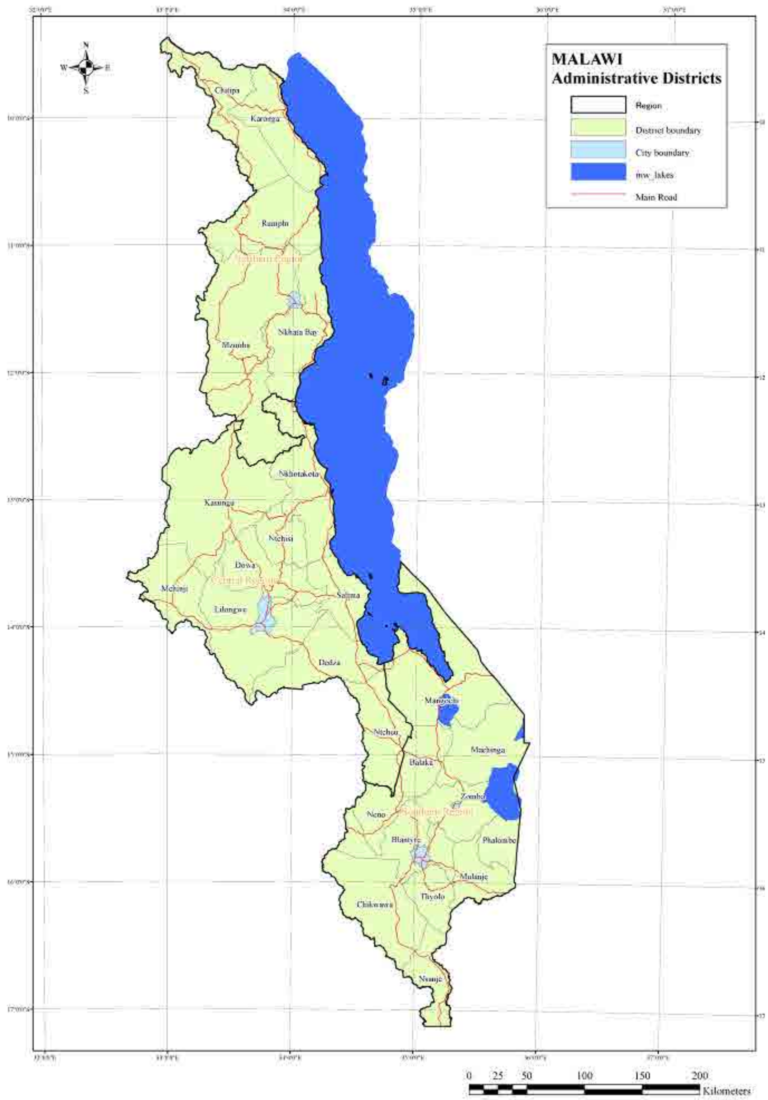
Name	Designation or Field of Specialty
Kanehiro MORISHITA	Team Leader / Water Resource Management
Toshihiro GOTO	Co-Team Leader / Water Resource Development
Hironobu KUROE	Urban Water Supply
Masahiro YAMAGUCHI	Rural Water Supply
Seiichi YAMAKAWA	Agriculture and Irrigation
Takao SARUHASHI	Hydro power
Kenji MORITA	Hydrological Monitoring
Masakazu MIYAGI	Hydrology/ Water Balance/ Flood Control
Hirokazu UEDA	Geology/ Water Quality
Manabu MAYA	GIS Database
Tomoko MIZUYORI	Capacity Development
Sebastian JARA	Environmental and Social Consideration
Makoto YAJIMA	Economic and Financial Evaluation
Toshiaki SATAKE	Construction Plan/ Design

CHAPTER 2. INSTITUTIONAL AND SOCIO-ECONOMIC CONDITIONS

2.1 Administrative Setup and Boundary

The Republic of Malawi is a landlocked country in Southeast Africa which borders with Mozambique to the east, south and west, Zambia to the northwest, and Tanzania to the northeast. Parts of the border are along the lakeshore or within Lake Malawi, which separates the country from Tanzania and Mozambique. About 93.2% of its land area of 118,484 km^2 is situated within the Zambezi river basin and 86.1% of its population live in this basin (Water and Sanitation Sector Joint Sector Review, 2009). Malawi is a member state of the Zambezi Watercourse Commission (ZAMCOM). The population is approximately 13.1 million with the average growth rate of 2.8% (Population and Housing Census, 2008). Chichewa is the language most widely spoken all over the country, and English is the official administrative language. The four urban centers of Malawi are Lilongwe, Blantyre, Mzuzu and Zomba.

The country is composed of three regions: the northern, central and southern region. There are 28 districts below the level of region as the administrative boundary. The commercial centers like Lilongwe in Lilongwe District encounter higher population growth rates due to the growing urbanization and the influx of people looking for better economic opportunities as well as jobs. Next to Lilongwe, the districts of Mchinji, Chitipa and Karonga, which are the northern borders with Tanzania and Zambia, are seeing higher growth rates due to trading activities. Mwanza District was divided into Mwanza and Neno in 2007, which made the total number of districts 28. A map showing the district boundaries is given in **Figure 2.1**. Under the districts, there are the traditional authorities (TAs) whose leaders are chosen by traditional parentage. Villages are small entities in terms of the number of people. Generally, their respective communities based on traditional rules and values chose the village chiefs. Some 80% of them live in the rural areas.



Source: Project Team

Figure 2.1 Administrative Districts of Malawi

2.2 Present Institutional Framework of Water Resources Management

Water resources have multifunctional roles for different purposes: agriculture, industrial production, potable water for drinking and domestic use, and hydropower generation. Currently, different ministries and institutions are taking charge of respective areas of water use. The management of national water resources is primarily under the responsibility of the Ministry of Agriculture, Irrigation and Water Development (MoAIWD) for policy-making, supervision and direction in the areas of irrigation and water supply. The Ministry of Natural Resources, Energy and Environment (MoNREE) is responsible for hydropower development. There is already a master plan on energy development including hydropower produced for the MoNREE. **Table 2.1** shows the governmental bodies for the water sector.

Table 2.1 Institutional Setting, Roles and Responsibilities

Institutions	Roles and Responsibilities
Ministry of Agriculture, Irrigation and Water Development	Monitor, regulate, investment and set policies for the water sector.
Ministry of Natural Resources, Energy and Environment	Generate and supply hydropower energy
Ministry of Health	Sanitation and hygiene education
Water Resources Board	Water tariff setting, water right, license
Water Boards	Implement water supply services
Local government	Plan and coordinate water supply and sanitation services

Source: Completion Report on the Dispatch of Expert to the Government of the Republic of Malawi in the Field of Water Resources Phase I revised by the Project Team.

2.2.1 Ministry of Agriculture, Irrigation and Water Development

The MoAIWD is the central institution to facilitate the development and management of water resources in Malawi. Its primary responsibilities are to ensure access to safe water and sanitation, the provision of safe drinking water to rural communities, water resources management, provision of irrigation scheme, and the collection as well as monitoring of hydrological data and catchment protection to support policy formulation. The Ministry has four technical departments and three administrative departments related to water as shown in **Table 2.2**.

Table 2.2 Administrative Departments of MoAIWD as of 2012

Departments	Sections
Department of Water Resources	Surface water, Ground water, Water quality
Department of Water Supply	Operation maintenance monitoring & evaluation, Planning design and construction
Department of Sanitation	Sanitation
Department of Irrigation Services	Planning design and operation, Irrigation management, Research and development, Administration
Department of Administration	Planning, Administration
Department of Human Resources	Human resources
Department of Finance	Finance

Source: The Ministry of Water Development and Irrigation Organogram, 2012

Among the above four technical departments, the Department of Water Resources is the main actor in terms of water resources management. It has the roles of (i) management and development of surface water, including observation, assessment and conservation of surface water; (ii) management and development of groundwater including monitoring of groundwater; (iii) water quality monitoring, assessment and management including contamination control; (iv) management of laws and regulations on water resources; and (v) management of transboundary water resources.

On the other hand, from the aspect of relationship between the central and regional organizations of MoAIWD, the headquarters is located in Lilongwe, the three regional water development offices are in the Northern, Central and Southern regions respectively, and district water offices are located in 28 of the districts. The role of each regional office is to provide support and role coordination among their districts. In the district water office, appropriate staff are assigned from the sector (department) of water resources, water supply and administration, depending on the requirement of each district. For example, there are no positions/posts assigned from the water resources sector including hydrological services in some districts. Besides, the

Department of Irrigation Services has a different system. It has the irrigation services headquarters in Lilongwe, eight irrigation service divisions (ISDs) at the regional level, and 25 district irrigation offices. The eight ISDs will be reorganized into three ISDs in future.

As a serious issue regarding the MoAIWD organization in both central and regional level, a lot of positions/posts that are necessary to properly manage the organization are vacant mainly due to shortfall in human resources and financial constraints.

2.2.2 Water Resources Board

The Water Resources Board (WRB) in the Department of Water Resources under the MoAIWD is in charge of managing the water rights and abstraction fees (for water use and discharge of wastewater) for both public and private sectors. The number of water users is recorded; however, data management for water rights is not enough condition to draw and examine actual conditions of water allocation.

The Water Resources Board has granted water rights for 911 water users as of August 2011. Water boards, private companies, farmers, investors, etc., are granted with water rights and, in some instances, a water user can hold a number of water rights. For example, the water board requested water rights for water users in its jurisdictional area. Unfortunately, the Water Resources Board keeps a record of the number of water users but not water rights due to the lack of tools and manpower. Hence, many unregistered water users, as well as records on the number of water users, might exist in the whole of Malawi.

2.2.3 Local Government (District Council and City/Town Council)

District councils are primarily responsible for rural and urban water supply and sanitation services. In urban areas where both district and city/town councils exist, there is a demarcation of responsibility between the district council and the city/town council. The District Council looks after the operation and maintenance of rural water supply and sanitation while the city/town council looks after those of the city/town center. In districts where there is no council due to the small size of town, the district council looks after the whole district.

2.2.4 Water Boards

Five water boards have been established as parastatal organizations under the Water Works Act of 1995. Two of them, the Blantyre and Lilongwe water boards, serve the two cities and their peri-urban areas. The other three boards (Northern, Central and Southern Region water boards) were established to provide water to wide ranges of other 2 cities, towns and commercial centers. According to the Water Works Act, the boards are responsible for, among others, the promotion of sanitation services and enforcement of water works by-laws related to the construction of delivery and connection facilities of services for water supply and sanitation in declared water areas. (However, in reality, sewerage services are currently the responsibility of city assemblies.)

Water boards are targeting the cities and towns where profitability is relatively high. On the other hand, in other rural areas (Market center: 5,000-10,000 people scale, and Villages), the MoAIWD or other development partners are constructed water supply facilities, and the residents, Water Users' Associations (WUAs) and Water Point Committees (WPCs) are responsible for the maintenance of facilities.

In addition to the water boards, the WASAMA (Water Services Association of Malawi) has been in existence to address common issues, etc., of tariff adjustment between water boards and GoM to make sure that these five boards are operating effectively.

2.3 National Development Policies and Legislation

Major legislations and regulations related to water resources management are elaborated in the following sections. In addition to this section, the new National Water Resources Act which was enacted in 2013, will be described in detail in Chapter 14 Water Resources Management.

2.3.1 Malawi Vision 2020

In this strategic policy document, it is stated that Malawi envisions a long-term aspiration of becoming an environmentally sustainable middle-income economy by the year 2020. The effort to produce this document started in 1996. This document notes a shift of approach of economic and development strategies. The economy of Malawi prior to this document was primarily dependent on natural comparative advantage. The process of drawing this long-term vision helped the country to realize and comprehend the importance of taking strategic approaches to all social and economic sectors to create competitive advantage to underpin significant economic growth and to support people in Malawi.

In terms of the water sector, the importance was noted to enhance protection of water resources and catchment area management. It also realizes that there are threats of depletion of water resources due to deforestation, drought conditions, and poor management of water supply systems. It also outlines strategic options to prevent pollution of water, conserve catchment areas and improve water supply systems.

2.3.2 Malawi Growth and Development Strategy II (MGDS II)

This is a strategic policy tool to attain the goals in the medium term spelt out in Malawi Vision 2020. Strategies to tackle challenges in key sectors and areas are formulated and steps outlined. Following the successful implementation of MGDS from 2006 to 2011, the Government of Malawi has set forth with the implementation of MGDS II for the term from 2011 to 2016. MGDS II aims to continue reducing poverty through sustainable economic growth and infrastructure development, identifying nine key priority areas and six thematic areas to work on. Green Belt Irrigation and Water Development is one of the identified key priority areas.

Access to safe and potable water is one key goal in water development strategy. In recent years, various efforts were made to improve access to potable water. MGDS II states that total water supply coverage has increased from 58% in 2004 to 76% in 2009. In rural areas, 58% in 2004 was improved from 64% in 2008. However, despite these achievements, there are considerable challenges urging the country to tackle in the water sector. These include such challenges as relatively low access to potable water in the rural areas, aging infrastructure, inadequate maintenance capacity, theft and vandalism resulting in more than 30% non-functionality of the infrastructure.

In view of the growing industrial and commercial development, water is seen as a multipurpose resource to produce power, to source irrigation and to meet the domestic daily demand. These increasing demands in different fields have conflicting interests in usage of water; therefore, the efficient use of water resources is deemed to be a key important issue. However, the institutional framework is frequently altered and different plans are laid so that monitoring of the progress needs a concerted effort among the relevant stakeholders.

2.3.3 National Water Policy (2005)

The National Water Policy was revised in 2005 and 2007 to clarify the issues that were in some part vague in the previous version and set clear objectives to work on. This policy document was produced in conjunction with a number of challenges that the water and sanitation sector is facing and conservation and management of water resources as well as operation and maintenance of facilities. These conceptual ventures include putting in place of mechanisms such as Integrated Water Resources Management (IWRM) and Community-Based Management (CBM). In this policy document, 13 water related sectors are covered, which are: Water Resources Management and Development, Water Quality and Pollution Control, Urban, Peri-Urban and Market Centers Water Services, Rural Water Services, Agriculture Services, Irrigation Services, Navigation Services, Fisheries, Hydropower Generation, Eco-Tourism and Recreation, Forestry, Disaster Management, Policy Monitoring and Evaluation. These set out specific objectives and strategies for each sector for the future development.

2.3.4 National Sanitation Policy

Preparatory works of the National Sanitation Policy started in 2007 supported by the Canadian International Development Agency with inputs from the main stakeholders including various government ministries, local governments (District and City assemblies), UNICEF, the water boards, and civil society. The Cabinet adopted National Sanitation Policy in October 2008. The overall policy goal is to promote improved sanitation and safe hygiene practices for improved health and socioeconomic development for the people of Malawi. The overall policy objective is to achieve universal access to improved sanitation, and safe hygiene practices while ensuring sustainable environmental management for the economic growth.

2.3.5 Water Works Act (No. 17 of 1995)

This act provides for the establishment of Water Board's water-areas and for administration of such water-areas for the development, operation and maintenance of waterworks and waterborne sewerage sanitation in Malawi and for matters incidental thereto or connected therewith.

The power of the Board shall include the power to levy and enforce payment of rates in accordance with the Act, and power to engage in research or investigation in connection with water supply and waterborne sewerage sanitation either alone or by arrangement or in conjunction with other persons. Based on this Act, five water boards such as Blantyre, Lilongwe, The Northern Region, the Central Region and the Southern Region Water Boards were established.

2.4 Demography

The National Statistical Office (NSO) is the main government department responsible for the collection and dissemination of official statistics under the 1967 Statistics Act. Regarding demographic information, the NSO releases the "Population and Housing Census" in every 10 years (most recent census was released in year 2008).

In addition, based on the Census 2008, the NSO published the "Malawi Population Projection" which describes the projected results for the period from 2008 to 2050 for the national projections and from 2008 to 2030 for the district projections. Moreover, based on the population projection document, the "Malawi Population Data Sheet 2012" was also issued by the NSO, figuring out the condition of demographic characteristics in 2012. **Table 2.3** shows historical changes of demographic condition of Malawi between 1966 and 2008, and **Table 2.4** presents spatial population distribution by region.

Table 2.3 Historical Change of Demographic Conditions of Malawi

Indicators	Census 1966	Census 1977	Census 1987	Census 1998	Census 2008
Population	4,039,583	5,547,460	7,988,507	9,933,868	13,077,160
Intercensal growth rate	3.3	2.9	3.7	2.0	2.8
Density (pop/sq.km)	43	59	85	105	139
Percentage of urban population	5.0	8.5	10.7	14.0	15.3

Source: Demographic and Health Survey 2010

Table 2.4 Spatial Population Distribution in Malawi

Region	1987	1998	2008
Northern Region	911,787 (11.4%)	1,233,560 (12.4%)	1,708,930 (13.1%)
Central Region	3,110,986 (38.9%)	4,066,340 (40.9%)	5,510,195 (42.1%)
Southern Region	3,965,734 (49.6%)	4,633,968 (46.6%)	5,858,035 (44.8%)

Source: Census 2008; (%): percentage against total population

The NSO projected population by the Cohort Component Method, which can calculate the future size of population, taking into account the effects of mortality, fertility and migration. The projected population distribution by region is summarized in **Table 2.5**.

Table 2.5 Estimated Population for Year 2011, 2025, 2035

(mil. person)

Items	2008	2011	2025	2035
Total	13,077,160	14,388,550	22,358,190	30,296,833
North Region	1,7108,930	1,891,579	3,003,745	4,086,546
Central Region	5,510,195	6,145,539	9,952,421	13,654,484
South Region	5,858,035	6,351,432	9,402,024	12,555,803

Source: Population Projection in Malawi and Census 2008

2.5 Land Use

The most recent land use map was established in 1993 interpreting the satellite images taken in 1990/91 through the satellite remote sensing project "Forest Resource Mapping and Biomass Assessment for Malawi, 1993" under the Ministry of Forestry and Natural Resources. According to the map, agricultural land use dominates 48.8% of the whole Malawi (including low density agricultural area) followed by the forest area (22.4%) and the water surface area (20.5%), while Build-up area is interpreted as only 0.2% of the whole Malawi.

2.6 Agriculture, Livestock, Fishery and Industries

(1) Agriculture and Livestock

Agriculture is the most important sector of the Malawi economy. It employs about 80% of the total workforce, contributes over 80% to foreign exchange earnings, accounts for 39% of gross domestic product (GDP) and contributes significantly to national and household food security. The agricultural sector has two main subsectors; the smallholder subsector (contributes more than 70% to agricultural GDP), and the estate subsector (contributes less than 30% to agricultural GDP). Smallholders cultivate mainly food crops such as maize, cassava and sweet potato to meet subsistence requirements. Estates focus on high value cash crops for export such as tobacco, tea, sugar, coffee and macadamia. Smallholder farmers cultivate small and fragmented landholdings under customary land tenure with yields lower than in the estate sector.

Poultry, goats, cattle and pigs are the main types of livestock. In the Central and Northern regions, livestock production is mainly associated with smallholders, while in the Lower Shire valley, large herds of cattle are found associated with milk/meat production industries in Blantyre.

(2) Fisheries

The importance of the fisheries sector that comprises capture fisheries, aquaculture and aquarium trade in Malawi's economy is widely recognized. Fish contributes substantially to the economy as it directly employs nearly 60,000 people in fishing while over 450,000 people are engaged in fish processing, fish marketing, boat building and engine repair. Furthermore, nearly 1.6 million people in lakeshore communities are supported by the fishing industry. With 24% of the surface area of the country covered by water, both large- and small-scale capture fisheries contribute to food security and the poverty reduction goal of the GoM as highlighted in the MGDS and the Agricultural Sector-wide approach (ASWAp). The fisheries resources contribute over 60% of animal protein in the national diet of Malawians. The sector remains one of the few economic activities along the shores of Lake Malawi that generates surplus.

(3) Industries

According to the Interim Country Strategy Paper (AfDB, 2011), Malawi's GDP at 2000 constant prices was estimated at USD2.7 billion in 2009. Among them, the industry sector with 16% of GDP in 2009 grew at an average of 6.9% between 2007 and 2009 (In 2010 the sector grew by 21.3%). About half of industrial production originated in food, beverages, tobacco, textiles, clothing and leather goods. Labor force of industry and services accounts for 10% of the total population as of 2003.

CHAPTER 3. NATURAL CONDITIONS

3.1 River Basins

Malawi is divided into 17 water resource areas (WRAs) based on the river basins as shown in **Table 3.1**. Some WRAs consist of one river basin and others are composed of several small river basins. Moreover, WRAs are divided into water resource units (WRUs) as shown in **Table 3.1**, which presents a list of main rivers, lakeshore rivers and the major tributaries in the WRUs selected in consideration of the existing or previously existing hydrological stations. Boundaries of WRAs and WRUs, as well as river systems and lakes, are as shown in **Figure 3.1**.

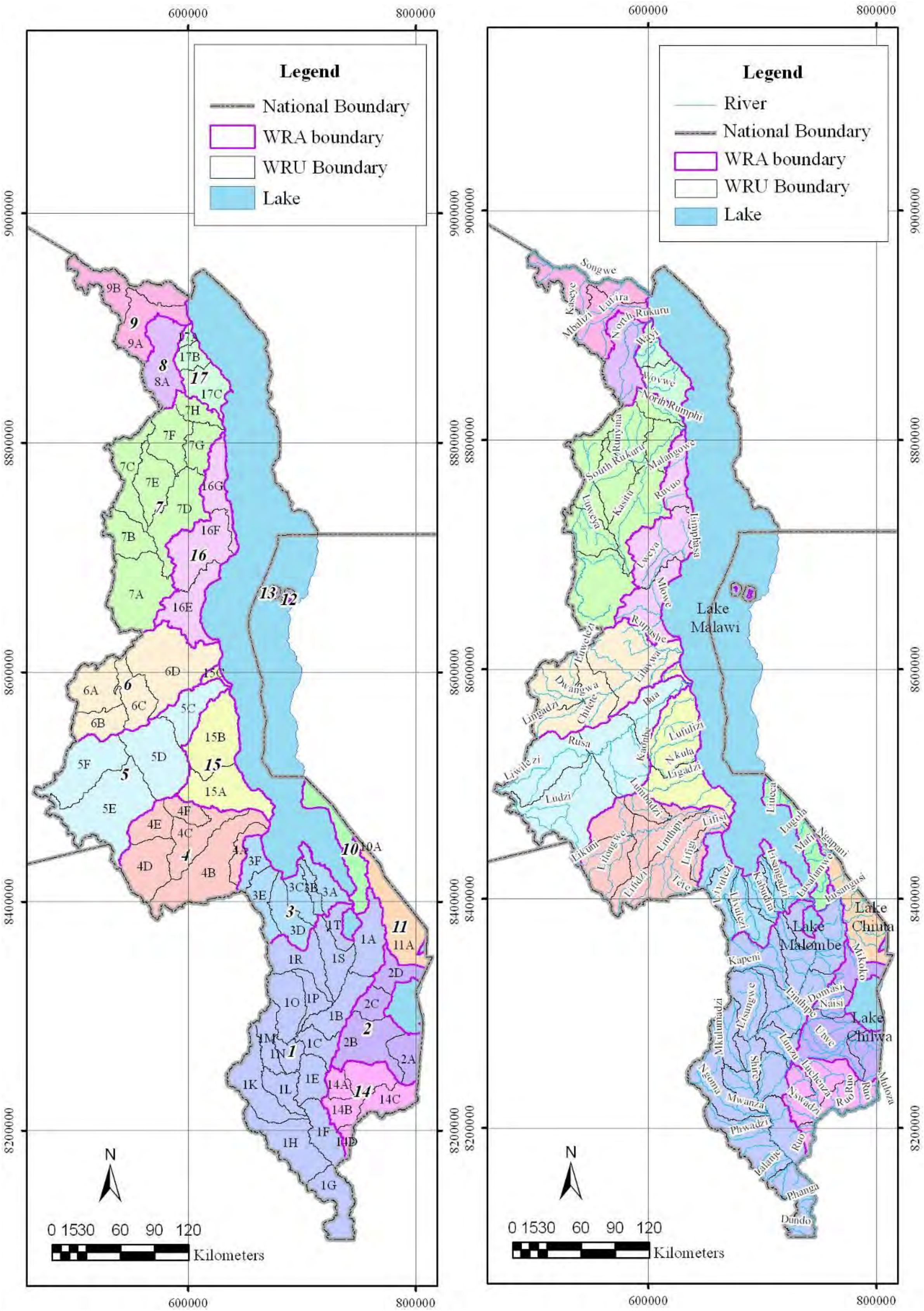
Fifteen (15) of the 17 WRAs excluding WRA-2 (Lake Chilwa) and WRA-11 (Lake Chiuta) belong to the river basins of tributaries of the Zambezi International River, which include the Lake Malawi Basin and the Shire River Basin of the only outflow river from Lake Malawi. The total basin area of the 15 WRAs is about 87 thousand km^2, or 93% of the total basin area of Malawi. Except WRA-1 (Shire) and WRA-14 (Ruo), all rivers of the other 13 WRAs flow into Lake Malawi.

Table 3.1 List of WRAs and WRUs in Malawi

WRAs (Water Resources Areas)		WRUs (Water Resources Units)		Catchment Area [i] (km^2)	Catchment Area [ii] (km^2)
No.	Name	Qty. of Units	Name of Unit		
1	Shire	16	A to T	18,910.6	18,945
2	Lake Chilwa	4	A to D	4,567.6	4,981
3	South West Lakeshore	6	A to F	4,997.8	4,958
4	Linthipe	6	A to F	8,884.8	8,641
5	Bua	4	C to F	10,658.1	10,654
6	Dwangwa	4	A to D	7,750.5	7,768
7	South Rukuru/North Rumphi	8	A to H	12,719.2	12,705
8	North Rukuru	1	A	2,088.3	2,091
9	Songwe/Lufira	2	A to B	3,729.7	3,680
10	South East Lakeshore	1	A	1,658.7	1,540
11	Lake Chiuta	1	A	2,442.7	2,462
12	Likoma Island	1	-	17.3	18.7
13	Chizumulu Island	1	-	3.3	3.3
14	Ruo	4	A to D	3,518.9	3,494
15	Nkhota-kota Lakeshore	3	A to C	4,819.2	4,949
16	Nkhata-Bay Lakeshore	3	E to G	5,532.7	5,458
17	Karonga Lakeshore	3	A to C	1,945.1	1,928
			Total (Continental Area)	**94,244.6**	**94,276**
			Total Lake Area	**23,855.8**	**24,208**
			Total Area	**118,100.4**	**118,484**

[i] GIS data of MoAIWD; [ii] Area in the National Water Resources Master Plan (1986)
Source: Project Team

There are four major lakes in Malawi: Lake Malawi, Lake Chilwa, Lake Chiuta and Lake Malombe. Among them, Lake Malawi is the third biggest freshwater lake in Africa and the eighth all over the world. Its water surface area is about 29 thousand km^2 and its catchment area spreads to around 98 thousand km^2 consisting of 64 thousand km^2 in Malawi, 27 thousand km^2 in Tanzania and the rests in Mozambique. The lake is 570 km in length and 16-80 km in width, and the total volume is about 8 thousand km^3. The mean lake level is about 474 m above mean sea level. Lake Malawi has quite an important role not only from the viewpoint of water resources but also national tourism, transportation and fishery industries in Malawi.



Source: Project Team

Figure 3.1 Relation between WRAs, WRUs and Rivers, Lakes

3.2 Topography

The most important geomorphic feature of Malawi is that The Great Rift Valley extends across Malawi from north to south and the depressed rift forms Lake Malawi. The Shire River flows to the south from the lake along the Valley. The geomorphic feature is classified into the four divisions mentioned below.

(1) Lowland in the Rift Valley

The lowland areas are under approximately 600 m in elevation and correspond to the lakeshore of Lake Malawi (WRA-3, the western area of WRA-15, 16 and 17) and floodplain areas of the Shire River (a large part of WRA-1). In the floodplain areas, marshy meadows named “Dambo” are distributed. They are flooded in the rainy season.

(2) Escarpment

The escarpment areas comprise steep slopes between highland and lowland on the west side of Lake Malawi and both banks of the Shire valley. In the northern district, mountain areas have 2,000 to 2,500 m in elevation neighboring Lake Malawi, and these areas form remarkable scarps (corresponding to the north-west margin of WRA-7 and 16).

Large rivers form the outlet on the highland (for example, Lilongwe River in WRA-4, Bua River in WRA-5, Dowangwa River in WRA-6, etc.) and these branched rivers flow to the lake across the escarpment areas eroding the ground surface continuously and thus bedrock outcrops are well exposed on the slope surface. The subsoil is generally thin, and vegetation is relatively poor compared to the highland and lowland areas.

(3) Highland

The highland areas of 900 to 1,400 m in elevation comprise a great part of the land area of Malawi except Lake Malawi. The geomorphology shows gentle ground undulations and the subsoil is composed of laterites in which basement rocks have decomposed to red clay. These places in which the relatively thick laterites are underlain tend to form the “Dambo” area.

(4) Mountains

In the northern district, mountain ranges which have elevations of 1,400 to 2,500 m such as the Ruwenya Hills in WRA-9 and Nyika Plateau in Northern WRA-7, the Viphya Mountains which comprise a great watershed between WRA-7 and WRA-16 are orientated north to south. In highland areas of the middle to southern district, the mountains of over 2,000 m high tend to exist in isolation. Representative mountains are the Dedza Mountain located in WRA-4 which is 2,198 m high, the Zomba Mountain located in WRA-2 which is 2,098 m high, and the Mulanje Mountain located in WRA-14 which is 3,000 m high. The mountains mentioned above are generally constituted of massive igneous rocks. Residual soils or weathered rocks are very thin and vegetation is poorly growing.

3.3 Hydrogeology

3.3.1 Outline of Geology

Large parts of the highland areas of Malawi are underlain by crystalline metamorphic complex belonging to the Mozambique Tectonic Belt. These rock bodies are comprised of mainly gneiss, schist, quartzite and granulate of Pre-Cambria to Early Paleozoic age. On the highland areas, these fresh rocks are overlaid thickly with decomposed materials and these outcrops are rarely visible on the surface. On the escarpment areas, the fresh rock bodies can be observed well due to constant incising by rivers or gullies.

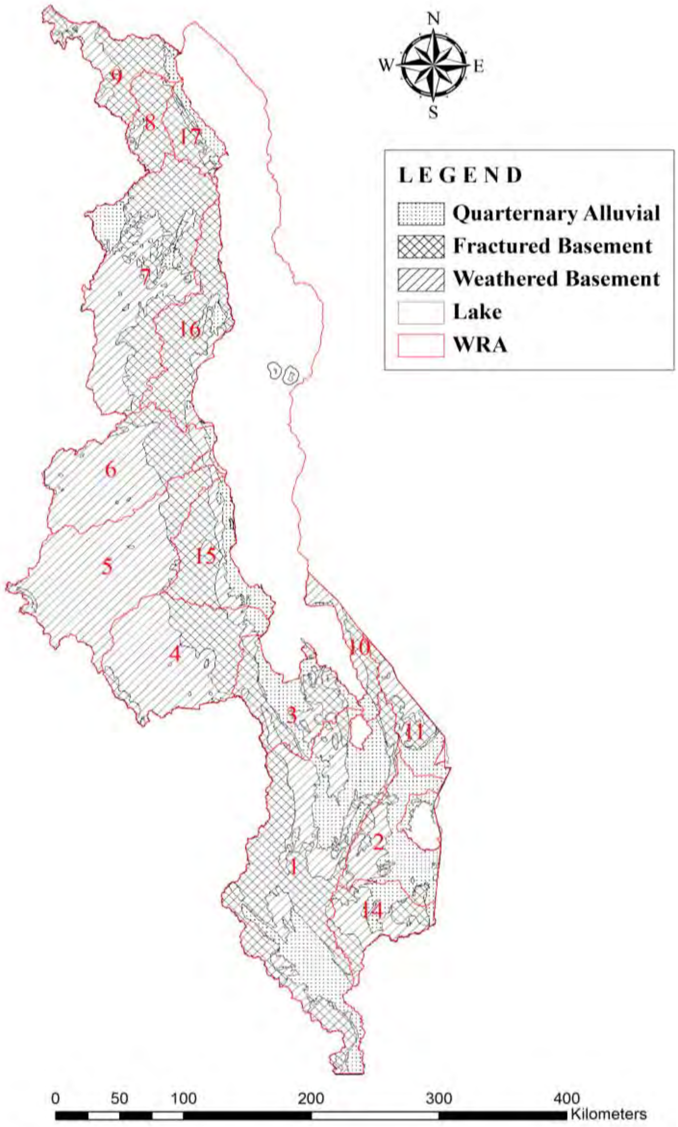
Igneous rocks composed of Dolerite, Basalt, Gabbro and Granite are scattered on various districts in Malawi. Almost all of these rocks are magmatic intrusions occurred during Jurassic to Cretaceous age, and mainly form mountain areas due to larger resistance against erosion and weathering than metamorphic rocks.

Karro sedimentary sequences deposited in Permian to Triassic age are distributed as small outcrops in the northern and southern areas of Malawi. These sedimentary rocks are constituted of sandstone, shale, red mudstone and coal bed. Rocks in the sequence are well cemented by calcite and indurate. The basal boundary of the Karro sequence is not exposed in any distribution area; however, the thickness has been estimated as exceeding 3,500 m in accordance with past geological survey.

On the lowland areas, basement rocks are thickly covered by Quaternary alluvium deposits composed of unconsolidated clay, silt, sand and gravel. These sedimentary faces reflect transitions of the past river channels, and are highly variable in vertical succession and lateral extent.

3.3.2 Aquifer

According to geological conditions on ground surface, three categories of aquifer have been broadly identified: Weathered Basement (WB), Fractured Basement (FB), and Quaternary Alluvial (QA). These distributions in Malawi are shown in **Figure 3.2**, and the characters of each aquifer type are summarized in **Table 3.2**.



Source: Project Team

Figure 3.2 Distribution of Aquifers in Malawi

Table 3.2 Summary of Aquifer Characteristics

Aquifer Class	Geological Conditions	Hydraulic Characteristics	Expected Water Yield
Weathered Basement	• Subsurface: Laterite comprised of indurate clay. • Upper Weathered Zone: Decomposed basement comprised of clayey sand mixing gravels. • Lower Weathered Zone (The most permeable zone): Separated blocks of basement due to weathering. • The thickness generally ranges from 15 to 30 m, but remarkably varies at localities.	Groundwater is basically transmitted as laminar flow along blocks in lower weathered zone. In case that laterite layer overlays on weathered zone, presence of groundwater would not be expected because fine materials preclude recharge from infiltrating rainfall. The permeability depends on weathering degree in the most part but also source rock of basement in some little.	Weathered aquifers have very large potential of groundwater development and these are the most widely spread in Malawi; however, the water yield is relatively low at a single borehole.
Fractured Basement	Discontinuous planes such as joints, cracks, fractures, and geological faults in all basement rock-mass.	Groundwater cannot flow into massive rock body, but can flow only along discontinuous planes. Laminar flow theory does not apply to fractured basement because of random flow. Groundwater capacity depends on density of joint development and joint clearance.	Generally low
Quaternary Alluvial	• Lakeshore sediments • River channel deposits • Alluvial fan or Colluvium at toe of mountains or escarpments • Sediments mentioned above are comprised of clay, silt, sand and gravel, but gradation patterns are largely different at localities. • The thickness generally ranges from 40 to 80 m.	Groundwater is basically transmitted as laminar flow between particles. Permeability of the aquifer depends on particle size. Coarser particles tend to be higher permeable.	Yield of coarse sediments such as river channel deposit are expected to be high. On the other hand, clayey sediments have poor potential of groundwater yield.

Source: Project Team

3.4 Meteorology and Hydrology

3.4.1 Meteorology

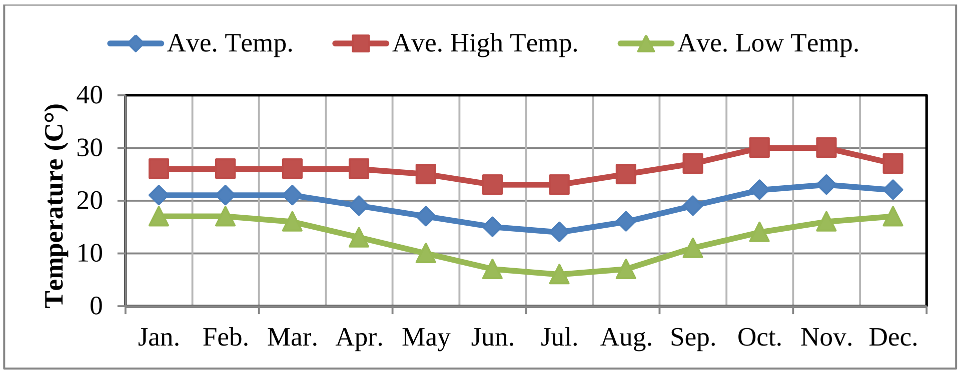
The climate of Malawi is categorized as sub-tropical and divided into three weather variations such as warm-wet (November to April), cool-dry winter (May to August) and hot-dry seasons (September to October). The warm-wet season is recognized as the rainy season with about 95% of annual rainfall expected. The relative humidity in the rainy season is higher than that of the dry season, while the polygon line of pan-evaporation generally yields opposite reaction to the humidity as shown in **Figure 3.3**.

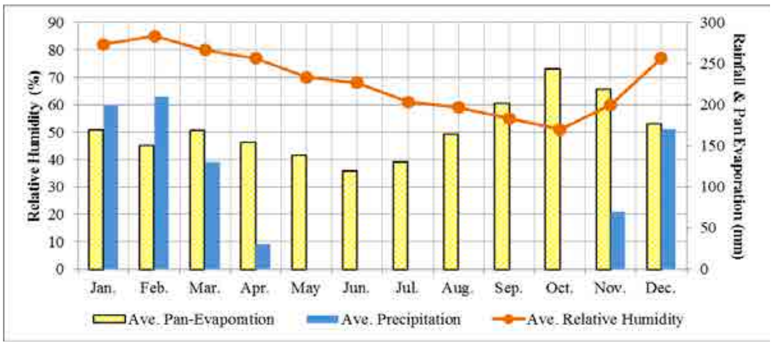
3.4.2 Hydrology

(1) Annual Rainfall

In whole Malawi, the average annual rainfall in the latest 3 decades is 971 mm which was calculated by the Thiesen Polygon Method in the Project and ranges between approx. 700 mm and 1,200 mm. The annual rainfalls for WRAs range from 400 mm to 1,800 mm depending on the topographic and climatic conditions.

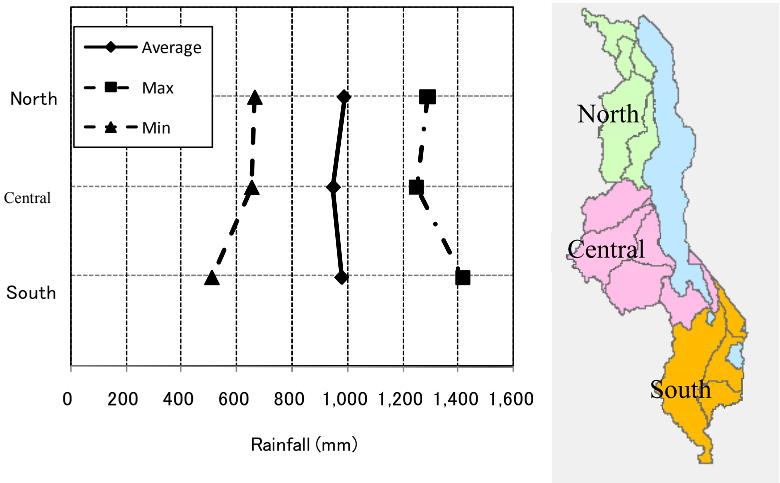
Annual rainfall characteristic by region is shown in **Figure 3.4**. The difference between maximum and minimum annual rainfall is about 600 mm in the northern and central regions; however, the southern region has a relatively large difference of 1,000 mm compared with that of other regions. Thus, it may be said that the variability of rainfall in the southern region is higher than the other regions.





Source: weatherbase (http://www.weatherbase.com),
Graph made by Project Team

Figure 3.3 Average Climate Condition at Lilongwe



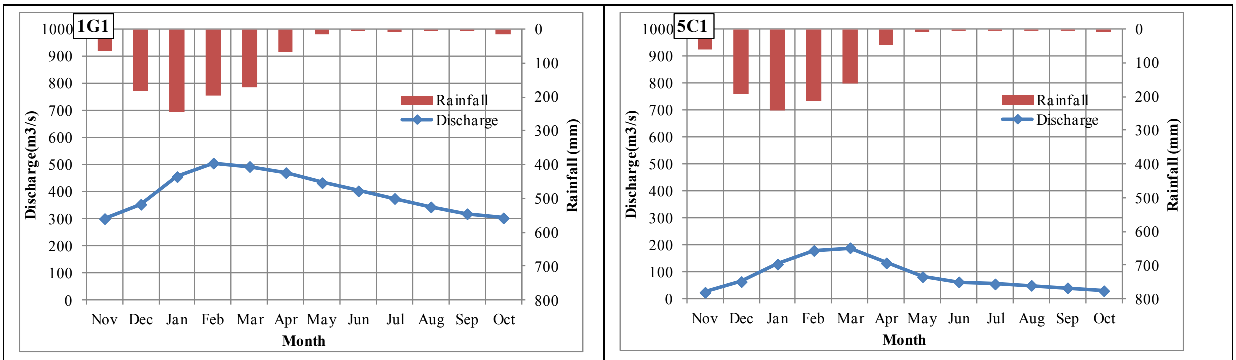
Source: Project Team

Figure 3.4 Annual Rainfall by Region

(2) Rainfall and Runoff

To confirm the characteristics of rainfall and runoff conditions, typical rainfall and discharge data were arranged in **Figure 3.5**. The data at 1G1 discharge station in the Shire River basin and 5C1 in the Bua River basin are shown as typical river discharges in which the water flows in the river course throughout the year.

As for 1G1 station, the large discharge continues until April after peak rainfall occurs in January. The river flow discharge keeps a large value even in the dry season compared with the other rivers in Malawi due to the outflow from the Lake Malawi. With regard to 5C1 station, the peak discharge occurs in March after peak rainfall occurs in January. In the dry season, the discharge decreases to less than half of the peak discharge in the rainy season while the rainfall depth is almost zero.

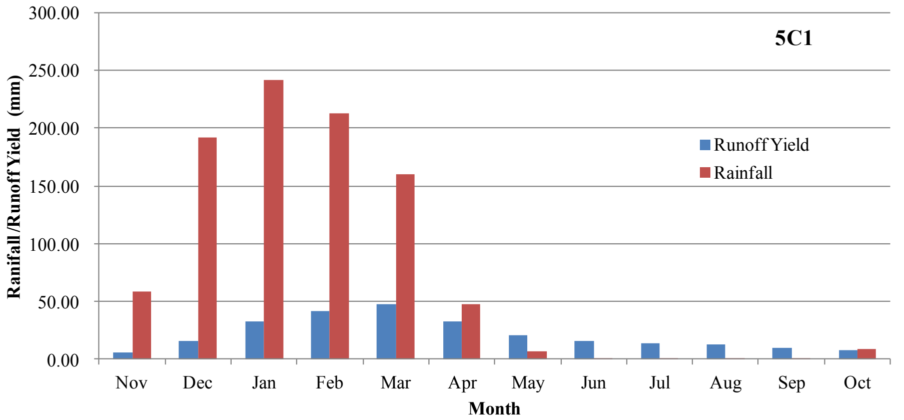


Source: Project Team

Source: Project Team

Figure 3.5 Rainfall and Runoff at 1G1 in the Shire River and 5C1 in the Bua River

Monthly runoff yield and rainfall depth of 5C1 station are shown in **Figure 3.6** as an example. The runoff yields are calculated dividing annual runoff by basin area. In the rainy season, runoff yield is about 20% of rainfall depth. In the recession period of the dry season, runoff yield become a little bit higher than rainfall depth because of base flow. The annual runoff ratios of rivers in Malawi fluctuate between 0.2 and 0.3 based on the collected rainfall and discharge data in the Project.



Source: Project Team

Figure 3.6 Monthly Runoff Yield and Rainfall (5C1)

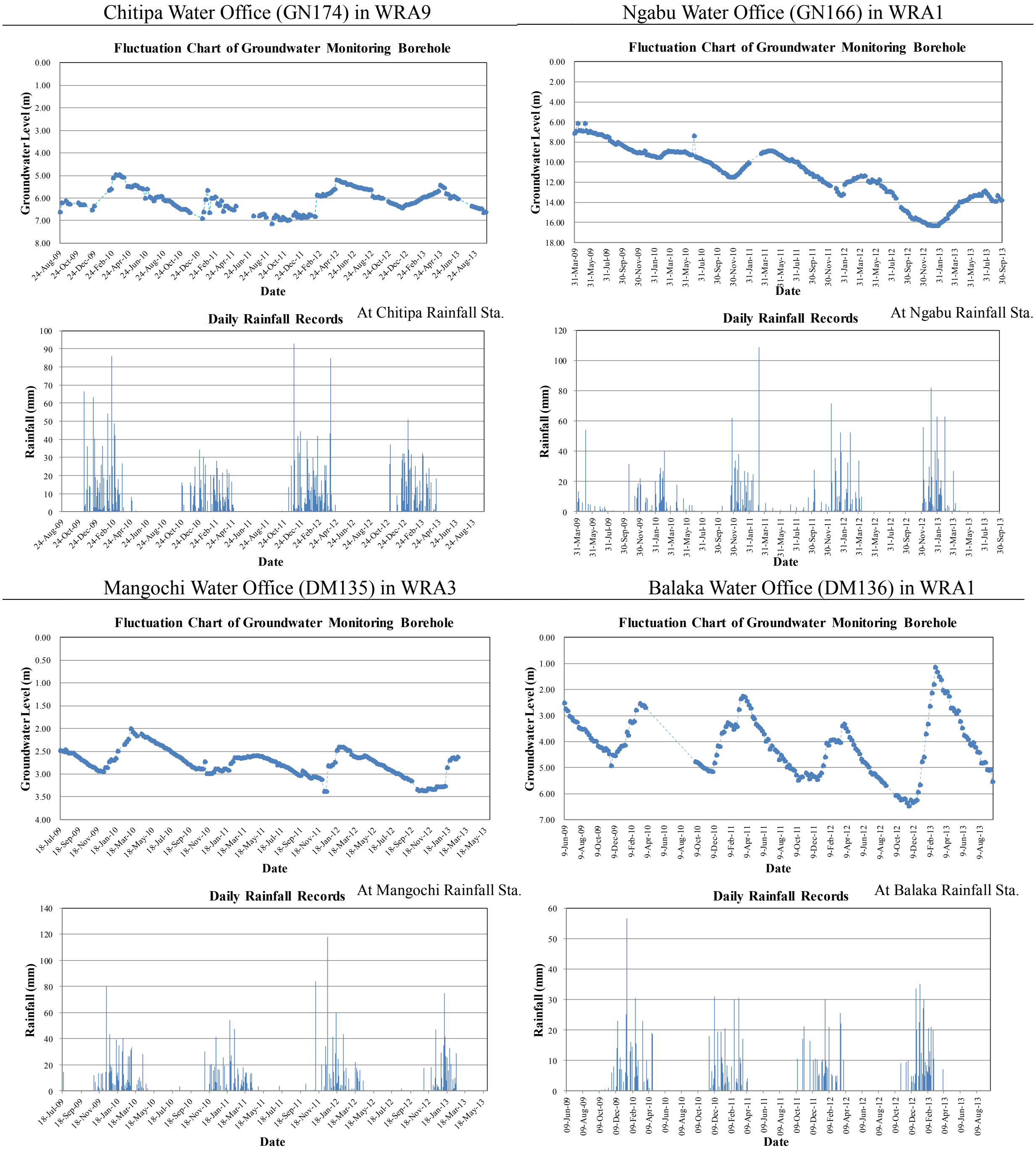
3.4.3 Groundwater

Groundwater fluctuation has a strong correspondence with precipitation intensity in the whole country of Malawi. Water tables rise at the commencement of rainy season during November to December, and peak in March. In the dry season the water tables gradually drop until the next rainy season, e.g., GN174 (Chitipa Water Office), DM136 (Balaka Water Office) and GN166 (Nagabu Water Office).

The gap of seasonal water tables between dry season and rainy season ranges from 2.0 to 3.0 m in the highland area, and the top water tables come after three or four months from the commencement of the rainy season. This timing of the gap between precipitation and groundwater rise seems to reflect the rate of infiltration into unsaturated zone.

At the boreholes situated on the lakeshore plain such as DM135 (Mangochi Water Office), the fluctuation profiles are drawn as seasonal cycles but water table differences which range approx. 1.0 m are smaller than those of the boreholes in the highland area. Therefore, it seems that groundwater tables in the lakeshore are influenced by inflow from Lake Malawi rather than rainfall.

In the south region, groundwater table in the watershed of the Shire River has dropped repeating the periodic cycles since the monitoring began (i.e., DM136 and GN166). According to the rainfall record covering these monitoring wells, annual rainfall has decreased year by year and this is considered as the main reason why groundwater level in the watershed of Shire River has dropped together with the decrease of precipitation in the monitoring period, as shown in **Figure 3.7**. On the other hand, the bottom of groundwater level at GN174 has sustained at almost the same level and this is attributed to the steady precipitation in the north region. This relationship between groundwater fluctuation and precipitation may enable the prediction of potential volume of groundwater using only the rainfall records.



Source: Project Team

Figure 3.7 Chronological Changes of Groundwater Fluctuation

3.4.4 Monitoring Network and Activities

(1) Hydrological Monitoring

More than 300 hydrological stations exist in Malawi and the number of operational stations historically has changed. According to the National Water Resources Master Plan (1986), 173 stations were installed in 1986. Among them, 149 stations including 52 stations with daily chart automatic recorders were river gauging stations for water level and discharge observation, and the other 24 stations were gauging stations for water level observation. According to the report of the Ministry of Water Development in 2003 regarding the Strengthening of the Water Resources Board, there were 194 stations being operational in 2002, of which 170 stations were river gauging stations for water level and discharge observation, and the remaining 24 stations were gauging stations for water level observation.

On the other hand, the Ministry of Agriculture, Irrigation and Water Development in 2011 stated in its report regarding the Consultancy Services for Establishment of Water Resources Monitoring System that 139 stations consisting of 136 MoAIWD stations and 3 Water Board stations are operational and 164 stations are closed.

Spatial distribution of the present operational stations is considered that the stations cover most of the sites to be reference points of WRAs and major rivers. Some sites not to be covered by the present operational stations can be dealt with by rehabilitating closed stations operated in past since Malawi historically had a very comprehensive network of the hydrological monitoring stations.

Regarding discharge measurement, it has been and is being carried out by staff of the district water offices of MoAIWD using several types of propeller current meters. Discharge measurement in high flow has been carried out using propeller current meters from bridge or using cableway not using float since float measurement has not been common in MoAIWD. Flood camping (where teams went out in the field during the wet season months to measure discharge at high flows) were conducted every wet season in the 1980s, but no flood camping has been done since the early 1990s. Then, at present certain districts still undertake discharge measurement fairly and regularly several times a year, but in some districts no measurement has been undertaken in many years.

(2) Meteorological Monitoring

The Department of Climate Change and Meteorological Services under MoNREE manages meteorological monitoring. There have been about 800 rainfall stations in the 1980's, but there are only between 100 and 200 operational rainfall stations at present in Malawi (MoAIWD 2011).

Evaporation and other climatic data have been recorded at all the meteorological stations. The Department manages 23 meteorological stations.

(3) Groundwater Monitoring

The Groundwater Division of the Department of Water Resources under MoAIWD manages groundwater monitoring. Thirty-five (35) monitoring wells were constructed during 2009-2010 in Malawi. Although the boreholes for only monitoring were established with much effort, the monitoring in 2012 was carried out at only 18 boreholes out of the established 35 boreholes owing to several troubles: vandalism, no data collection, poor maintenance works and so on.

(4) Water Quality Monitoring

The Water Quality Service Division of the Department of Water Resources of MoAIWD manages water quality monitoring. The Division has jurisdiction over the Central, South and North Water Laboratories which are the only governmental water research laboratories. The Central Water Laboratory which is the most advanced in Malawi was established in 1973, and dedicated to conduct simultaneous water quality monitoring in Malawi since the early 1980s. It has enough equipment to analyze most of the chemical and biological constituents of drinking water and effluent defined by the Malawi Bureau of Standards and equipment to analyze and collect samples in situ (i.e., EC/TDS/pH meter, etc.). Recently, a modern instrument for pesticide analysis and the Gas Chromatography (GC) were installed in the laboratory by grant aid; however, it has never been operated due to lack of trained personnel for operation and maintenance as well as consumables for the GC.

The South Water Laboratory in Blantyre and the North Water Laboratory in Mzuzu were established in 1993. The both laboratories are small and have less equipment for analysis than the Central Water Laboratory, and lack of computer to be used exclusively to store analysis data. The functions of these laboratories are very limited due to poor equipment, shortage of staff and budgetary constraint.

There are 195 water quality monitoring points in Malawi which are classified in three categories: surface water, pollution control located at outlets of effluent sources and groundwater. Many water quality monitoring points were selected from hydrological stations, and all groundwater points were selected from monitoring wells constructed after 2009. The exact coordinates of each sampling point are not available due to the lack of GPS instruments except the monitoring points selected from hydrological stations and monitoring wells while approximate locations were determined using 1:250,000 topographic maps.

3.5 Floods and Droughts

Several flood events had affected Malawi in 1985 to 2010. Based on the past studies and records, it is obvious that more than ten flood events in these 25 years have affected, particularly, the southern region. In the area, the Shire River flows southward from the Malawi Lake to the national boundary through the wide floodplain which has suffered from gradual floods caused by seasonal rising of the water level of the Shire River. The Northern Region also had been severely affected by floods. Particularly, there is a high frequency of flood in the Songwe River. In addition, several districts in the Central Region and the Northern Region have also been affected by floods.

Regarding droughts, Malawian people suffered from serious drought disasters over the last few decades. According to EM-DAT of the WHO Collaborating Center for Research on the Epidemiology of Disasters (CRED), the droughts occurred seven times between 1987 and 2012 as shown in **Table 3.3** with about 21 million people affected. Furthermore, the CRED reported that the number of people affected by droughts since 1965 was almost 20 million while floods have only affected close to 2 million people over the same period.

Table 3.3 Representative Droughts between 1987 and 2012

Start (Month/Year)	Location	Fatality	Total Affected People
08/2012	Balaka, Blantyre, Chikhaw, etc.	nil	1,630,007
10/2007	Karonga, Mzimba (North), etc.	nil	520,000
10/2005	Southern and central region	nil	5,100,000
02/2002	Balaka, Nlantyre, Chikwawa, etc.	500	2,829,435
04/1992	Dedza, Dowa, Mzimba, Nkho, etc.	nil	7,000,000
02/1990	N.A.	nil	2,800,000
1987	South	nil	1,429,267
Total			21,308,709

Source: EM-DAT, CRED

3.6 Ecosystem

3.6.1 Terrestrial Flora and Fauna

According to the National Herbarium and Botanical Gardens, Malawi has about 5,500 to 6,000 flowering plants estimated on the bases of herbarium species. However, a number of species had undergone taxonomic revision; consequently, the exact number of flowering plants is unknown. Likewise, the number of non-flowering plants (Bryophytes and Pteridophytes) has not been updated with new studies, but it has been estimated that the number of Bryophytes could be 250 species.

On the other hand, 261 are considered threatened, vulnerable, rare or endangered out of the estimated 5,000 plant species or over; however, only 11 plant species have legal protection. Recent studies indicate that a large number of plant species are vulnerable since their populations are declining due to over-exploitation and habitat degradation.

About 192 mammal species were recorded, from which 125 are small mammals such as bats and rodents. According to the International Union for Conservation of Nature (IUCN), there are 8 mammals under threat being the black rhinoceros which is critically endangered.

The number of species of birds recorded in Malawi reaches 648 which were not updated recently. Current data on conservation status of birds is lacking; therefore, only nine species continue to be listed on the IUCN Red Data List (2010).

3.6.2 Aquatic Flora and Fauna

All amphibians are associated with aquatic ecosystems in Malawi. About 11 amphibian species are threatened according to IUCN (2010). As for reptiles, 12 species are endemic to Malawi.

Malawi is one of the countries with rich fish diversity. It contributes about 14% of world freshwater fishes. The total number of fish species that can be found in Malawi is estimated to be more than 1,000 species. Over 800 fish species have inhabited in Lake Malawi alone. About 9% of Lake Malawi fish species are endemic to Lake Malawi and 95% of these species are haplochromine cichlids, which are internationally recognized as an outstanding example of rapid speciation.

The IUCN conducted a red list assessment of 423 Malawian fish species in 2005. The assessment showed that 65.72% of Malawian fishes were of least concern implying that they were quite abundant, 27.42% were vulnerable, 4.12% had no enough data for assessment, 2.36% were endangered while 0.47% were not evaluated. The endangered fish species were from the two most species diverse families of fishes in Malawi: Cichlidae and Cyprinidae. The ten species are probably endangered due to over exploitation by fishermen for commercial purposes.

As for aquatic plants, from the point of view of water resources management, the water hyacinth (Eichhornia crassipes) is the most widespread and the most harmful among the plant invasive species in Malawi. Presently, water hyacinth is in most parts of Malawi, including the far north of the country. Water hyacinth covers the water surfaces interfering with the free flow of water and its dense mats reduce the amount of light that penetrates through it affecting the growth of plankton.

The major impact of water hyacinth in Malawi is related to its interference with the power generation at Nkula and Tedzani stations in lower Shire, resulting in intermittent blackouts affecting the economy. It was estimated that ESCOM (Electricity Supply Commission of Malawi) spend about MK 3 million/month to mechanically remove the weeds.

3.6.3 Forestry

Based on the World Bank study, the forest area aggregated 44,515 km^2 covering 47% of entire Malawi land area in 1972/73; however, it was reduced to 26,428 km^2 and the coverage of 28% in 1990/91. For these 18 years 19% of the forest area disappeared all over the Malawi, of which reduction rate is about 41%. In this period, the reduction rates by region are 27% in the northern region, 51% in the central region, and 45% in the southern region. Thus the deforestation/degradation proceeded in the central and southern regions due to their higher population density.

Regarding deforestation/degradation process, it has been clearly proceeding particularly in the village forest areas in customary forest and in the forest reserve areas. It may occur mainly due to augmentation of agricultural land and logging for charcoal production and utilization of firewood.

CHAPTER 4. REVIEW OF EXISTING PLANS AND ACTIVITIES

4.1 National Water Resources Development and Management Context

4.1.1 National Development and Management Strategies Related to Water Resources

Since 1998 when Malawi Vision 2020 was launched, the Malawi Government had implemented two medium-term national development strategies: the Malawi Poverty Reduction Strategy (MPRS:2004-2007) and the Malawi Growth and Development Strategy (MGDS:2006-2011). The MGDS II, therefore, becomes the third national development strategy.

Annual reviews were conducted throughout the period of MGDS to draw lessons from its implementation. These lessons, among other things, informed the strategic direction of the MGDS II. After the similar process of MGDS formulation, the MGDS II was designed to attain the country's Vision 2020, overarching operational medium term strategy for Malawi for the next five years, 2011 to 2016. MGDS II improves the following new fields by adding projects for immediate implementation and elaborates the key strategies in comparison with the previous MGDS;

- The Green Belt Irrigation Project clearly stated as modified key priority area, namely, the "Green Belt Irrigation and Water Development."
- The Nsanje World Inland Port Project also stated as a modified key priority area, namely, the "Transport Infrastructure and Nsanje World Inland Port."
- "Climate Change, Natural Resources and Environmental Management" is newly added among the key priority areas as a burning issue.

4.1.2 Development Achievement under the Strategies in the Recent Decade

The series of 5-year development strategies on the national level indicate that situations related to water resources development and management could be improved using the typical indicators described in the strategies. The indicators stated in the strategies, however, are inconsistent, particularly, those in the MPRS. **Table 4.1** gives the comparison of indicators between the MGDS and the MGDS II. Based on the clarified indicators, the plan achievements and issues are as discussed below.

(1) General Indicators

GDP annual growth rate and income per capita have steadily increased as inflation has calmed down in these 5 years. Only the literacy rate has not improved faster than planned, although the poverty level also shows significant improvement.

(2) Energy

In proportion to the increase of electricity access rate, population using solid fuels has decreased. The access rate of electricity itself, however, is still very low. Regarding this issue, MGDS II states the following:

"This lack of reliable power is a key constraint to development in Malawi. The current installed capacity of 283 Megawatts is far much less than the estimated demand of 334 Megawatts. Unavailability of access to modern energy services contributes to low economic activity and productivity, lower quality of life and deters new investments across the country, in particular affecting key sectors of mining and manufacturing."

Table 4.1 Baseline and Target Indicators in the MGDS and MGDS II

Indicators	MGDS 2006/2007 – 2010/2011		MGDS II 2011/2012 – 2016/2017	
	Baseline in 2005	Target for 2011	Baseline in 2010	Target for 2016
General				
Minimum annual growth rate of GDP	3.5%	6.0%	7.5%	7.3%
Inflation rate	16.9%	5.0%	6.3%	5.9%
Poverty headcount measured by consumption based on poverty line	52.4%	30.4%	39%	37%
Income per capita	170 USD	450 USD	380 USD	727 USD
Female literacy rate	51%	85%	59%	89%
Youth literacy rate (age 15 to 24)	75%	95%	86%	95%
Natural Resources				
Proportion of land area covered by forest	27%	30%	35%	50%
Energy				
Access of electricity	7%	10%	9%	15%
Proportion of population using solid fuels	94%	85%	78%	
Water and Sanitation				
Percentage of population with access to safe portable water	66%	80%	81%	86%
Percentage of population with access to improved sanitation	(83%)	(95%)	46%	75%
Number of dams constructed	75	750		
Transportation				
Transport cost as a percentage of export/import	56%	12%		
Increase in passengers using water transport			9,935	630,000
Increase in cargo/tonnage using water transport			56,457 tons	160,600 tons
Irrigation				
Output from irrigation agriculture			482,555 tons	1,292,555 tons

Note:Figures in parentheses are based on basic type of sanitation.
Source: Malawi Growth and Development Strategy 2006-2011、Malawi Water Sector Investment Plan

(3) Water and Sanitation

The water and sanitation sector made notable achievements including the promotion of Water and Sanitation Hygiene (WASH). The MGDS II also states as follows:

"In recent years, access to potable water has improved throughout the country. Statistics show that total water supply coverage has increased from 58% in 2004 to 76% in 2009. In 2008, water supply coverage in rural areas of Malawi was at 64%. Despite these achievements, there are considerable challenges facing the country in the water sector. These include relatively low access to potable water, aging infrastructure, inadequate maintenance capacity, theft and vandalism resulting in more than 30% non-functionality of the infrastructure."

(4) Water Transport

At present the Shire Zambezi waterway, as well as the Nsanje Port, is closed. There are enormous efforts to be made, including newly constructing various infrastructure connecting to the port, installation of international port facilities, waterway dredging and clean-up of thickly growing water hyacinth, and so on.

(5) Irrigation

The progress in irrigation could not be evaluated due to lack of related data in the strategy papers. As for the Greenbelt Irrigation project, it will utilize the available abundant water resources in Malawi and increase the irrigation area from 90,000 ha to 400,000 ha out of the potential 1 million ha.

4.2 Review of 1986 Master Plan

4.2.1 Water Supply

In general, water supply projects are governed by various parameters, particularly, future population projection. The Master Plan of 1986 (NWRMP 1986) proposed many water supply projects for both urban and rural areas. Due to the difficulty in pursuing the implementation results of numerous water supply projects proposed in the NWRMP 1986, the progress of water supply situations was examined by referring to actual and proposed service coverage of accessing improved water. Malawi has a rapid population growth so that the service coverage will reduce in parallel with population growth and expansion of dwelling areas. **Table 4.2** enumerates the baseline data in 1985, planning projection in 2005, and actual recent data in 2010. In fact, population served by water supply in both urban and rural areas has been significantly increasing.

Although these achievements of water supply places Malawi at a high position among the African countries in consideration of GDP per capita, the following issues should be solved in the next stage immediately:

- The very large amount of investment required for upgrading the water supply system in both cities of Lilongwe and Blantyre.
- The wide differences in access rates to improved water across districts in Malawi as pointed out by the World Bank. A number of rural districts in the North have access rates of above 80%; whereas; some districts in the Center and the South have rates lower than 40%.

Table 4.2 Comparison between Water Supply planned in NWRMP 1986 and the Present Water Supply Situation

		Urban Areas	Rural Areas	Total
1985 Condition	Population	870,000	6,190,000	7,060,000
	Service Coverage	79%	33%	39%
2005 Target Planning	Population	3,590,000	10,070,000	13,660,000
	Service Coverage	65%	68%	67%
2010 Actual Condition	Population	2,232,000	11,716,000	13,948,000
	Service Coverage	93%	72%	75%

Source: NWRMP 1986 and Water Sector Investment Plan, WoAIWD, 2012

4.2.2 Hydropower Generation

The NWRMP 1986 summarized hydropower development based mainly on the study conducted by Tippett, Abbett, McCarthy and Stratton Engineers (TAMS) for the Electricity Supply Corporation of Malawi (ESCOM). The recommended Program of major power development is as shown in **Table 4.3**. To compare with the demand forecast, the table also shows the forecasted demand in the base case.

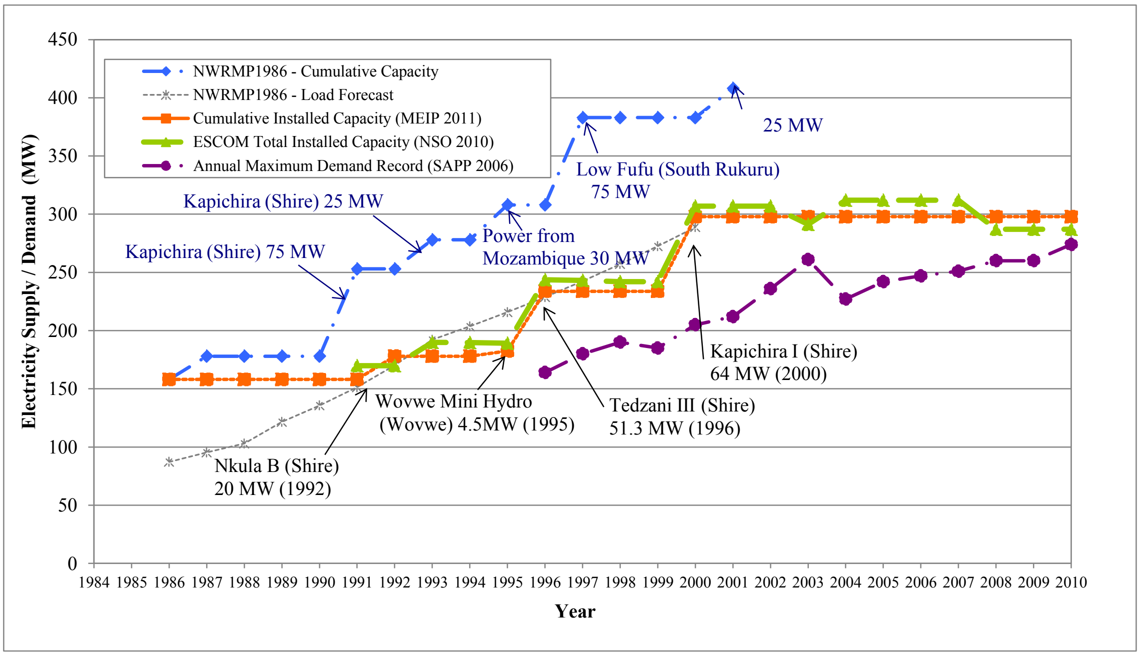
Hydropower installations after 1986 are the Nkula B (20MW in 1992), Wovwe (4.5MW in 1995), Tedzani III (51.2MW in 1996), and Kapichira I (64MW in 2000). Though electricity demand has not increased as forecasted in 1986, no hydropower plant has been installed as programmed in NWRMP 1986.

Figure 4.1 gives a comparison between programs in NWRMP 1986 and the actual condition (installation of power plants and demand). The operation years and installed capacities are based on Malawi Electricity Investment Plan (MEIP) 2011, and electricity demand is based on values from the Annual Reports of the South African Power Pool (SAPP).

Table 4.3 Program of Major Power Development Recommended in NWRMP 1986

Year	Name of Project (River Name)	Power or Units Proposed for Installation (MW)	Cumulative Generation (MW)	Firm Flow (m^3/s)	Demand Forecast in Base Case (MW)	Project Implementation
(1986)	(Existing capacity)	-	178	-		
1991	Kapichira (Shire)	3 x 25	253	136	151.3	Phase I in 2000 (2 x 32 MW)
1993		1 x 25	278		192.1	Phase II is in progress
1995	Power from Mozambique	30	308	-	215.8	Not yet
1997	Low Fufu with dam at Rumphi or Henga valley (South Rukuru)	3 x 25	383	24	242.5	Not yet
2001		1 x 25	408	24	288.8	Not yet

Source: Project Team based on NWRMP 1986



Source: Project Team based on (1) NWRMP 1986, (2) MEIP 2011, (3) Statistical Year Book 2011, (4) SAPP Annual Report

Figure 4.1 Comparison between NWRMP1986 Programs and Actual Installation and Demand

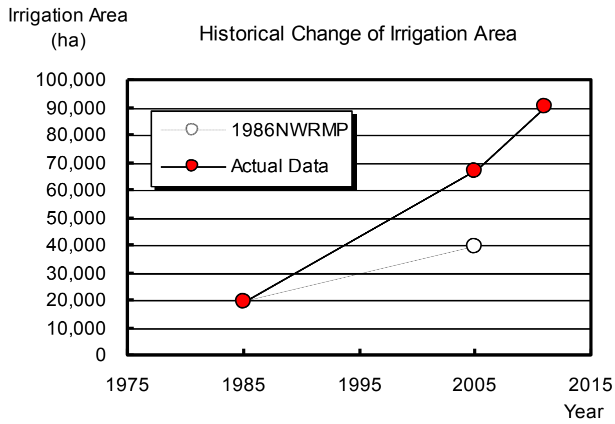
4.2.3 Irrigation

In the planning stage of the NWRMP 1986 in1985, two large-scale sugarcane estates extending to 16,000 ha were mainly irrigated. The 15 schemes of small-scale irrigation with a total area of 3,440 ha were under operation at that time and over 2 million ha of land was under cultivation almost entirely under rain-fed condition. Hence, only one percent of the total cultivated area was under irrigation in 1985 so that the consumptive use of water by irrigation was regarded as very little.

The NWRMP 1986 mainly proposed two kinds of projects located in the Lower Shire valley: the large scale gravity project and the pilot pumped irrigation scheme. Regarding the large irrigation projects, soil conditions in the project area are suitable for irrigation. A gravity canal from Kapichira Falls to irrigate about 20,000 ha of new land and 9,000 ha of existing area of sugarcane estates was planned to be constructed in the master plan. As for the pilot pumped project, self-help irrigation schemes with an area of 100 ha was recommended for providing agricultural data/information to the major irrigation projects in the valley.

In 2011, two kinds of irrigation areas were found in Malawi: one is estate farming and the other one is the smallholders' irrigation area. These conditions have been described in Chapter 5 Water Utilization. The agricultural estates consist of 65 estates widely ranging from 2 ha to 22,000 ha, and they apply various irrigation methods: gravity-fed, dams, motorized pump, sprinkler, pivot sprinkler and drip watering. Their irrigated area is 48,382 ha in total. On the other hand, smallholders' irrigation schemes with an aggregate area of 42,181 ha are also widely distributed over the country, employing various watering methods like gravity-fed, motorized pump, treadle pump and water containers. As a result, the total irrigation area was 90,563 ha in 2011. The World Bank in its report indicated 67,000 ha as the actual irrigated area in 2005.

The above-mentioned progress of irrigation projects in entire Malawi is depicted in the following figure. Although irrigation development has progressed more rapidly than planned by the NWRMP 1986, the irrigation area occupancy rate to the arable area of 3,994,000 ha is still 2.3% as in 2011.



Source: 5 and 6 in the reference and Project Team

Figure 4.2 Comparison between Irrigation Areas Projected in NWRMP 1986 and the Actual Achievement

CHAPTER 5. WATER UTILIZATION

5.1 Domestic and Industrial Water Supply and Sanitation

5.1.1 General Conditions

The Malawi Sector Performance Report covers seven (7) principal areas; namely, sector financing, water resources management, water for production, access to and use of water and sanitation services, equity, functionality, and the management of water services. The report is based on the Welfare Monitoring Survey and the Demographic and Health Survey (the sampling research).

The report in 2011 reflects the nationwide accessibility to safe water of 83%. Accessibility in rural areas is 81% with continuous improvement; however, the accessibility decreased from 92% in 2010 to 88% in 2011, because of failure of the water supply infrastructure and the high urban population growth rate. **Table 5.1** summarizes the headline indicators of access and use of water supply services.

Table 5.1 Water Supply Headline Indicators

Performance Themes and Headline Indicators		Performance Trends						Target Details
		2006	2007	2008	2009	2010	2011	
1	Percentage of people within 500 m (rural) and 200 m (urban) of an improved water source	75	81	80	80	79	83	National: MGDS I: 80% access within 500m by 2011 from 66% baseline in 2005
		73	79	77	78	77	81	Rural: MDG: 67% by 2015 MGDS I: 75% by 2016 JSR: 75% by 2011, 85% by 2015
		94	98	94	94	92	88	Urban: MDG: 95% by 2015 MGDS II: 86% by 2016
2	Percentage of people whose average total time to collect drinking water is less than 30 minutes					57		
						54		
						76		
3	Equity standard deviation of district access to safe water	10.16	10.24	8.89	10.97	14.9		

Source: Welfare Monitoring Survey, 2011

5.1.2 Water Supply in Four Cities

(1) Lilongwe Water Board (LWB)

As of 2008, the LWB had a supply coverage of about 400 km^2. However, the water service area was extended, and it is about 450 km^2 at present. Through over 46,000 metered connections the LWB supplies potable water to domestic, institutional, industrial as well as commercial customers and reaches out to people of approximately 66% (Individual connection: 45%, Kiosk: 19%, Institutions: 2%) in its supply area. The supply area is demarcated into three zones; namely, Northern Zone, Central Zone and Southern Zone. Although the market area for LWB is the city of Lilongwe, the utility serves other areas as directed by GoM. At the moment, the LWB sells the water in bulk to the Central Region Water Board to their service areas.

(2) Blantyre Water Board (BWB)

The Mudi Dam Scheme of 1953 and the Walker's Ferry Scheme of 1963 for the banks of the Shire River were started because of the rapid increase of population and water demand. The water service area expanded from 390 km^2 in 1972 to 760 km^2 at present including the area outside of the Blantyre City. The BWB has established 10 water supply zones in its supply network within the boundaries of Blantyre City. In addition, two supplemental zones were built outside of these boundaries for the Walker's Ferry Settlement and the Chileka Village Area. Currently, the BWB water supply zones have re-grouped from 12 zones into three zones (Kabula, Soche, Limbe).

90% of raw water comes from Walker's Ferry on the Shire River Bank and remaining 10% is extracted from the Mudi Dam. The BWB supplies people of approximately 65% (individual connection: 53%, Kiosk: 12%) in its supply area through 40,000 metered connections.

(3) Mzuzu City (Mzuzu Zone of Northern Region Water Board)

The Northern Region Water Board (NRWB) was established as a parastatal organization under the Waterworks Act of 1995. The NRWB operates as a decentralized organization structure composed of 3 Zones and 9 Schemes. (A zone is a collection of two or more schemes.) Mzuzu zone is one of them and it is the biggest zone having the service population of 118,422, being composed of the Mzuzu and Ekwendeni schemes. (Ekwendeni Township is 24 km outside Mzuzu.) The NRWB has embarked on a prioritized rehabilitation and expansion works (PrEw) project to rehabilitate and expand the current water supply system in Mzuzu by installing three additional water reservoirs, an additional water source and new pressure zones to boost water pressure.

On the other hand, the National Sanitation Policy places responsibility for sanitation under the water boards. However, in reality, water boards are not responsible for it. Only the NRWB among the five water boards have formulated the strategic sanitation plan for Mzuzu City, Rumphi Boma and Chintheche Centre for 2010-2025 in cooperation with Mzuzu City Council, etc. It should be noted that the water-related sanitation component is in the process of being transferred to the NRWB.

(4) Zomba City (Zomba Sub-Scheme of Southern Region Water Board)

The Southern Region Water Board (SRWB) was established in the same manner as the other two regional water board and operates as a decentralized organization structure composed of 5 Schemes and 23 Sub-schemes. Zomba sub-scheme is one of them, and it covers the Zomba Municipality. It supplies about 53% of the total water volume that the SRWB provides to all its customers, and it is having the served population (production) of 82% (89%) of the Zomba Scheme.

The Zomba Sub-Scheme dates back to the 1950s, and it had originally abstracted raw water from the Mulunguzi River. After that, due to acute shortage of water supply, the GoM initiated a project of augmenting and extending the water supply system including construction of a more reliable water resource. The project was commenced in 2001 included the following components: the rock-fill Mulunguzi Dam with a volume of 3.375 million m^3; 500 mm delivery pipeline; 400 mm diameter pressure penstock; 12,200 m^3/day capacity conventional treatment plant designed for 2005 water demand after taking into account the old treatment capacity; storage tanks and a total of 41.3 km pipelines of asbestos cement (AC), PVC, galvanized iron (GI) and ductile iron (DI) pipes.

5.1.3 Water Supply in Other Urban Areas

Table 5.2 gives an outline of the water service of the Northern, Central and Southern region water boards. Population of the service areas (towns/cities) in 2012 was estimated from the population projection of the National Census in 2008. Approximately one million people are living in the service areas.

Service population was estimated based on the number of connections the information of which was collected from those regional water boards through the Study. As the result of estimation, water served population is approximately 610,000 in 2012, corresponding to 60% of the population. Difference between this percentage and results of the welfare monitoring survey, 88.2% of piped water and communal tap, can be from base population.

The three regional water boards have 52 water schemes in total. Water supply hours in the dry season vary from 11 to 24 hours in the Northern Region, 1 to 24 hours in the Central Region, and 2 to 24 hours in the Southern Region.

Table 5.2 Outline of the Northern, Central and Southern Region Water Boards

Item	NRWB	CRWB	SRWB	Total
Estimated population of the towns/cities of the service areas in 2012	311,212	344,266	353,184	1,008,662
Water served population in 2012	211,497	151,922	245,305	608,724
Number of water schemes	9	20	23	52
Water service rate (%)	68.0%	44.1%	69.5%	60.3%
Water supply hours in the dry season	11-24	1-24	2-24	-
Water supply hours in the rainy season	12-24	1-24	8-24	-

Source: The Regional Water Boards

5.1.4 Water Supply in Rural Area

The number of active water points in rural areas is as shown in **Table 5.3**. A total of 68,265 water points exist in the whole country of Malawi. Some 87% of the water points are composed of boreholes and the gravity-fed rural water supply schemes.

Table 5.3 Number of Water Points in Rural Areas

Region	Number of Water Points in Rural Areas				
	Total	Tap	Borehole	Shallow Well	Protected Spring
Northern Region	14,944	5,086	6,016	3,829	13
Central Region	22,932	3,815	15,724	2,966	427
Southern Region	30,389	12,446	16,390	1,464	89
Total	68,265	21,347	38,130	8,259	529

Source: Water Supply Department, MoAIWD, 2012

(1) Boreholes

Based on Census 2008, 48% of the total Malawi population and about 55% of the rural population uses boreholes as of drinking water sources in the dry season. There are 38,130 boreholes in Malawi: 6,016 in the northern region, 15,724 in the central region and 16,390 in the southern region.

(2) Gravity-fed Supply System

According to the Water Supply Department of MoAIWD, there are 86 rural piped water schemes in Malawi. A lot of gravity-fed schemes were constructed by MoAIWD or the development partner agencies since the first scheme was installed in 1968. Number of taps served by gravity-fed is 21,347 in total: 5,086 in northern region, 3,815 in central region and 12,446 in southern region. Currently, 9 schemes out of 86 are under rehabilitation, and the rehabilitation/expansion of 21 schemes are planned.

5.1.5 Sanitation/Sewerage

The inadequate disposal of human excreta is associated with a range of waterborne diseases including diarrhea, cholera, etc. Options for sanitation facilities by national definition for excreta disposal include a flush/poor-flush toilet to sewer system, a flush toilet to septic tank, an improved latrine, VIP, eco-san toilet and basic latrine. Existing condition of the access to the sanitation services is summarized in the Headline indicators of Malawi Sector Performance Report, 2011. Some data is shown in **Table 5.4** sourced by the Welfare Monitoring Survey 2011(WMS2011).

Table 5.4 Sanitation Services Headline Indicators

<table>
<tr><th colspan="2" rowspan="2">Performance Themes and Headline Indicators</th><th colspan="6">Performance Trends</th><th rowspan="2">Target Details</th></tr>
<tr><th>2006</th><th>2007</th><th>2008</th><th>2009</th><th>2010</th><th>2011</th></tr>
<tr><td rowspan="3">1</td><td rowspan="3">Percentage of people that use improved sanitation

Disaggregated by rural, town and market centers and Urban

Figures given as:
1) Upper: Improved
2) Middle: Basic
3) Low: No toilet</td><td>29
53
18</td><td>47
44
9</td><td>35
59
6</td><td>46
48
7</td><td>9
81
11</td><td></td><td>National:
MGDS II: 95% by 2011 from 83% baseline (2005)
ODF Strategy paper: 100% by 2015</td></tr>
<tr><td>27
53
19</td><td>43
47
10</td><td>29
64
7</td><td>44
48
7</td><td>7
82
11</td><td></td><td>Rural:
MDG: 67% by 2015
MGDS I: 75% by 2016
JSR: 75% by 2011, 85% by 2015</td></tr>
<tr><td>45
51
4</td><td>79
21
0.4</td><td>61
38
1</td><td>50
47
3</td><td>22
85
3</td><td></td><td>Urban:
MDG: 95% by 2015
MGDS II: 80% by 2016</td></tr>
<tr><td>2</td><td>Schools with “adequate” WASH facilities; Percentage of schools with improved water supply

Average number of boys and girls per improved toilet drophole</td><td></td><td></td><td>81.5

122</td><td></td><td>78.2

120</td><td></td><td>Target: 100% schools with improved water supply
Target: 60 learners per drophole</td></tr>
<tr><td>3</td><td>Percentage of households observed to have functioning facilities with soap or ash besides the toilet</td><td></td><td></td><td></td><td></td><td></td><td>No data</td><td>MDGS II: increased awareness of hygiene
Targets set by National Handwashing Campaign 2011-12</td></tr>
</table>

Source: Welfare Monitoring Survey, 2011 (WMS2011)

5.2 Irrigation

5.2.1 Farming

The agricultural sector has two main sub-sectors: the smallholder sub-sector (contributes more than 70 percent to agricultural GDP), and the estate sub-sector (contributes less than 30 percent to agricultural GDP). Smallholders mainly cultivate food crops such as maize (the main starchy staple), cassava and sweet potatoes to meet subsistence requirements. Estates focus on high value cash crops for export such as tobacco, tea, sugar, coffee and macadamia. Smallholder farmers cultivate small and fragmented landholdings under customary land tenure with yields lower than the estate sector.

5.2.2 Smallholder Farming

Most of the ordinary farmers belong to this farming and receive assistance from the Government. According to the Annual Report of 2010/11, the cumulative area under irrigation for smallholder increased from 37,960 ha in 2009/10 to 42,181 ha in 2010/11(11.1% increase). There are four types of irrigation methods and **Table 5.5** shows the irrigation area and benefitted farmers by type of irrigation method in the year 2010/2011.

Table 5.5 Irrigation Area and Benefitted Farmers by Type of Irrigation Method in 2010/2011

Irrigation Method	Number of Schemes	Area Utilized for Irrigation (ha)	Beneficiaries		
			Male	Female	Total
Gravity Fed	2,954	22,028	38,212	29,837	68,049
Motorized Pump	865	2,875	13,363	10,562	24,056
Treadle Pump	12,157	12,162	71,880	50,788	122,658
Watering Can	27,820	5,116	72,561	46,564	119,125
Total	43,796	42,181	196,016	137,751	333,888

Source: DOI Annual Report, 2010/11

5.2.3 Estate Farming

The total irrigation area used by the private sector in the year 2010/11 was 48,382 ha. The estate sector was mainly in the sugar and tea industry; however, some private irrigation farmers were doing partial irrigation in the tobacco industry while a few others were growing cereals and vegetables. Illovo Sugar Malawi has around 60% of estate land and has associate factories in neighboring countries, i.e., Zambia, Tanzania, Swaziland and South Africa.

The methods used included motorized pumping, drip irrigation, sprinkler and center pivot systems. Based on the information, estate survey had been carried out. The total amount of irrigation areas is around 60,000 ha. This result is used for the estimation of irrigation area.

5.2.4 Irrigation Potential Area

Table 5.6 gives the overall picture of irrigation development in Malawi for both smallholder farmers and the estates.

Table 5.6 Irrigation Potential Area

ISD	Area (ha)				Estate (ha)	Small holder (ha)	(2)／(1) (%)
	Total	Arable	(1)Irrig. Potential	(2)Under Irrig.			
Shire V.	684,000	313,215	80,000	27,808	23,990	3,818	34.8
Blantyre	1,023,900	604,101	51,876	8,467	2,383	6,084	16.3
Machinga	1,340,000	550,000	203,000	6,820	1,800	5,020	3.4
Lilongwe	1,042,457	600,000	48,190	23,808	11,820	11,988	49.4
Salima	656,410	357,713	94,500	9,227	8,010	1,217	9.8
Kasungu	1,584,550	966,100	50,000	5,506	179	5,327	11.0
Mzuzu	476,900	228,483	48,000	6,836	200	6,636	14.2
Karonga	862,700	374,500	35,000	2,091	-	2,091	6.0
Total	7,670,917	3,994,112	610,566	90,563	48,382	42,181	14.8

Source: Annual Report 2010/11 Annex 7b, DOI

5.3 Navigation

In contrast to water use for the above-mentioned drinking, industries and irrigation, navigation is one of the types of water utilization without water consumption on the specific navigable water body and thus called on-stream water use. Inland navigation system in Malawi could be divided into two areas of water body, Lake Malawi and Shire Zambezi waterway, where the impounded or flowing water is suitable for ship navigation.

Regarding infrastructure of inland water transport, the MGDS II pointed out an importance for the national economic growth as follows:

"Water transport is relatively cheaper than any other mode of transport. It provides a better and cheaper alternative for transporting bulky and heavy goods domestically and internationally. Malawi has an advantage in water transport as it is endowed with lakes and navigable rivers. However, the country's water transport system is not fully developed and faces a number of challenges including dilapidated port infrastructure; aging fleet of vessels; and capacity problems."

5.4 Hydropower Generation

The water used for hydropower generation comes back to the river and is non-consumptive use. The installed capacity of existing hydropower is 286MW, of which 98% is on the Shire River and the remaining 2% is on the Wovwe River.

Existing water-related infrastructures for hydropower are listed below. The information in this table has been provided by ESCOM. All of these hydropower plants are run-of-the-river type, which takes water within the range of the natural flow to generate electricity because it has no or only small reservoir/pondage to regulate river flow. This type normally takes charge of the base load in the daily load curve. Hydropower plants are usually operated above the minimum operation level (MOL) so as not to be higher than full supply level (FSL). Operation of the reservoir is as follows:

- If the reservoir water level is under the MOL, river inflow will be only stored in the reservoir without generating power.
- If the reservoir water level is above the MOL, river inflow will be discharged through generating power. In this case, if the river inflow is larger than maximum power discharge, surplus water will be discharged from the spillway so as not to be higher than FSL. It means that all of the river inflow will be discharged downstream as power discharge or spilled discharge in case the water level is about to FSL

Table 5.7 List of Existing Hydropower Plants and their Salient Features

River	Dam Name	Dam Height [m]	Full Supply Level [masl]	Minimum Operation Level [masl]	Power Plant	Tail Water Level [masl]	Gross Head [m]	Installed Capacity [MW]	Maximum Power Discharge [m^3/s]
Shire	Nkula	12	376	374.5	Nkula A	326	50	3 x 8	3 x 23
					Nkula B	326	50	5 x 20	5 x 39
	Tedzani	10	318.53	315.78	Tedzani I	283.5	35.03	2 x 10	2 x 30
					Tedzani II	283.5	35.03	2 x 10	2 x 30
					Tedzani III	276.8	41.73	2 x 26.35	67.5 + 68.3
	Kapichira	30	147	144	Kapichira I	86	61	2 x 32.4	2 x 67.3
Wovwe	Wovwe	1	1107.5	1105	Wovwe	591.9	515.3	3 x 1.45	3 x 0.339

Source: Project Team, based on interview and data provided by ESCOM in September, 2012

As described in former sections, 98% of electricity is supplied from cascaded run-of-the-river power plants on the Shire River, the only outlet of Lake Malawi.

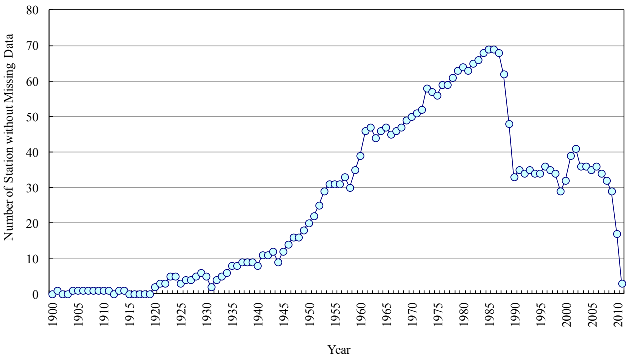
Malawi's electricity supply depends too much on hydropower generation on the Shire River. As for hydropower generation in the Shire River, there are issues which cause negative impact to hydropower generation such as siltation and weed infestation at the intake of the reservoir, flood damage to the power stations, operation of the Liwonde Barrage, and cross-group coordination.

Furthermore, existing hydropower plants have been sometimes suffering from mechanical troubles due to long period operation, floating aquatic weeds and debris being transported in the river. Therefore, diversification of power sources and rehabilitation of existing power plants are important issues for energy security in Malawi.

CHAPTER 6. BASIC ANALYSIS

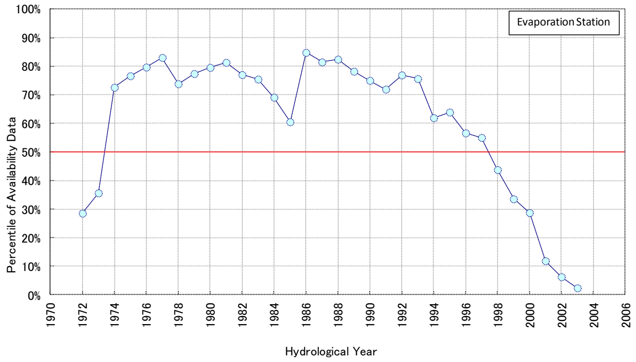
6.1 Hydrological Analysis

The number of rainfall stations without missing data had decreased from 1980s as shown in **Figure 6.1**. **Figure 6.2** shows evaporation data availability. Data with over 50% of the year is from 1974–1997 (24 years).



Source: Project Team

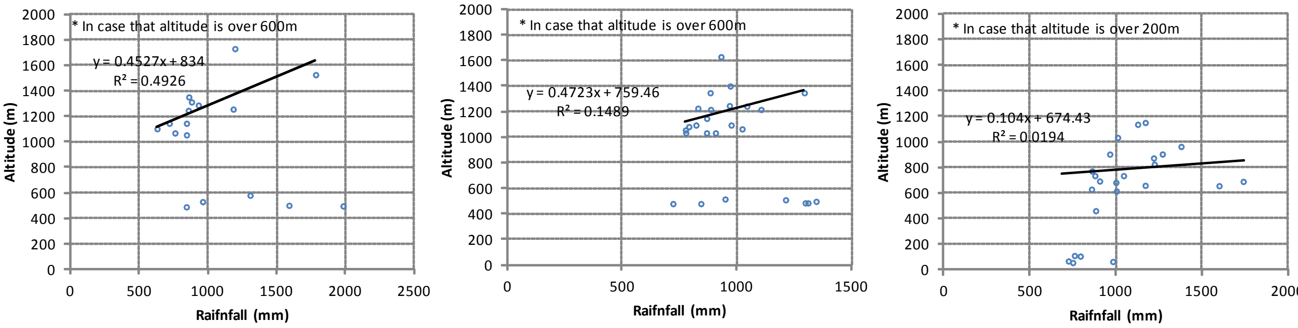
Figure 6.1 Number of Rainfall Station without Missing Data



Source: Project Team

Figure 6.2 Percentile of Availability of Pan Evaporation Station Data

Figure 6.3 shows the relationship between altitude and rainfall. There is positive correlation in altitudes of over 600 m where is around Lake Malawi in the north and central regions and 200 m where is around lower Shire River in which there is no relation between rainfall and altitude so that rainfall depends on the characteristics of the area.

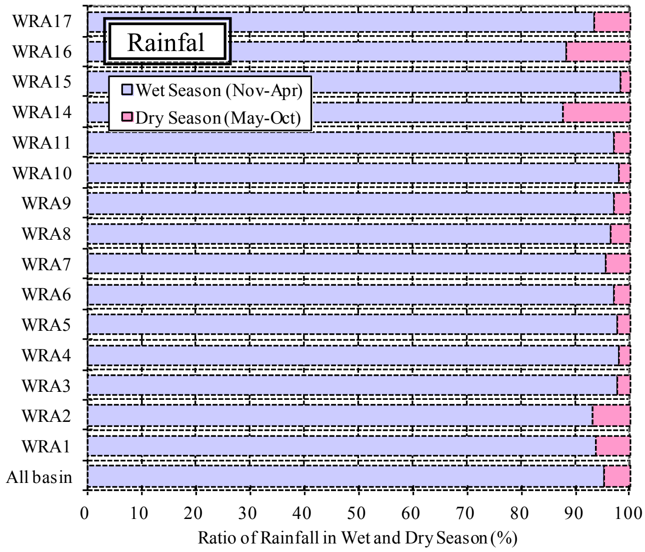


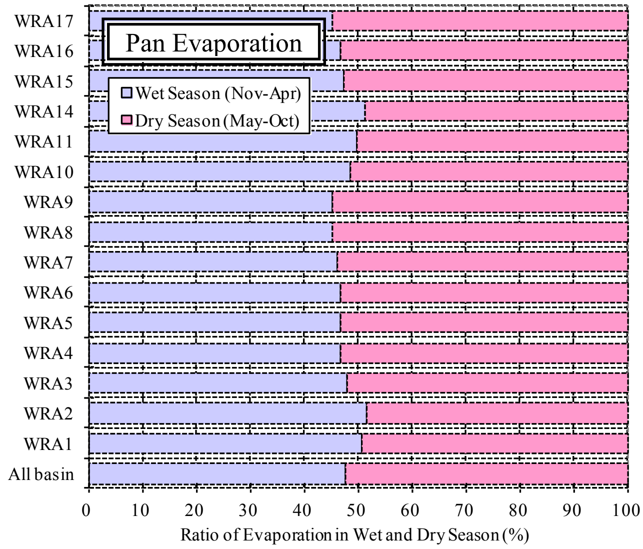
North Region Central Region South Region

Source: Project Team

Figure 6.3 Relationship between Altitude and Average Rainfall

Figure 6.4 shows that annual rainfall in wet season is 95%. This means that water shortage, which occurs in case there is difference between amount of water resources and water demand, tends to occur in the dry season. On the other hand, evaporation in the dry season is little bit higher than that in the wet season as shown in **Figure 6.4**.





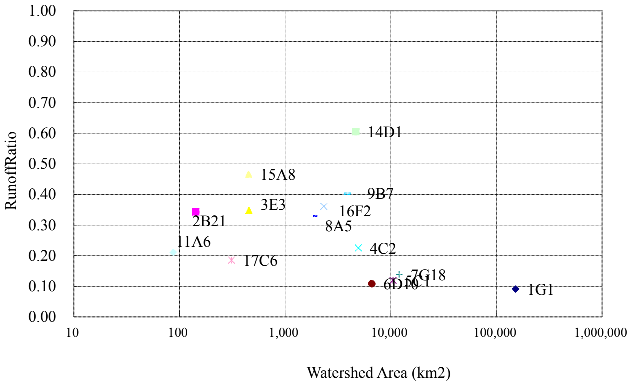
Source: Project Team

Figure 6.4 Ratio of Rainfall and Pan Evaporation in Wet and Dry Season

For discharge analysis, the gap filling is carried out for utilizing available data. The missing data is filled by the available station in the same WRA of which the correlation coefficient is higher than 0.7.

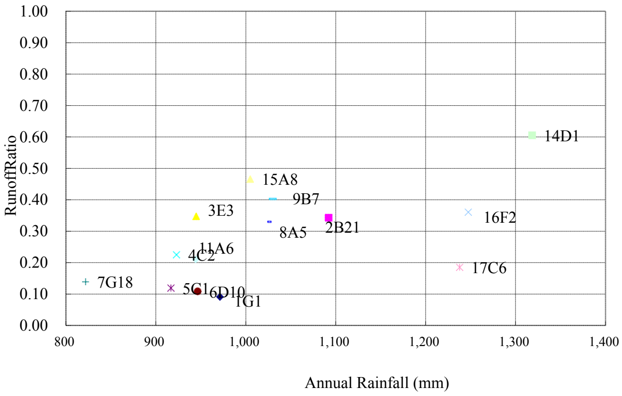
Discharge is calculated from water level and rating curve. Therefore, the accuracy of them is to be confirmed in addition to discharge itself by field survey. The accuracy of discharge is verified by double mass curve between discharge and rainfall, rating curve and discharge by observation.

The relationship between runoff ratio and watershed area is shown in **Figure 6.5**. There is negative correlation between runoff ratio and watershed area. It means that a lot of rainfall flows to river in small basin. On the other hand, there is positive correlation between runoff ratio and annual rainfall shown in **Figure 6.6**. When annual rainfall is high, the intensity seems high and soil is likely to be wet. Therefore, a lot of rainfall flows to river.



Source: Project Team

Figure 6.5 Relation between Area and Runoff Ratio

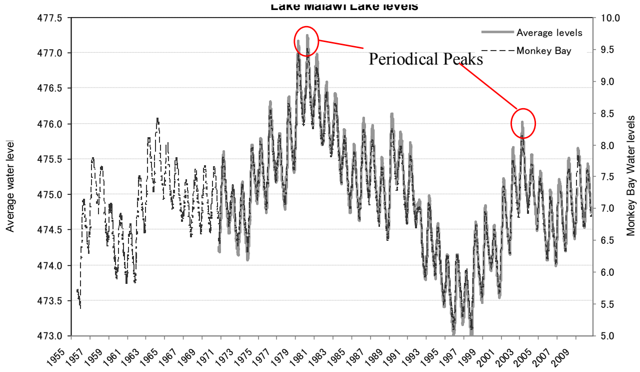


Source: Project Team

Figure 6.6 Relation between Annual Rainfall and Runoff Ratio

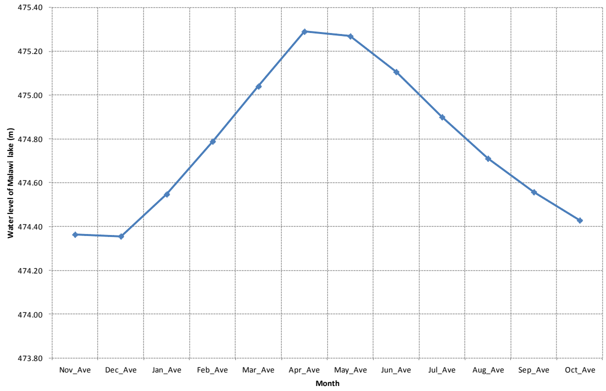
The water level of Lake Malawi collected from MoAIWD is shown in **Figure 6.7**. The water level shows periodical changes with peaks in April 1980 and April 2003. The recorded highest water level was about 477 m in 1980 and the lowest level, 473 m in 1995 and 1997. The water level fluctuated 4 m during the recent six decades.

The water level of Lake Malawi peaks around April and May after the wet season. The variation of water level is 1 m throughout the year (**Figure 6.8**).



Source: Project Team

Figure 6.7 Fluctuations of Water Level of Lake Malawi



Source: Project Team (Average of 1981-2008)

Figure 6.8 Average Monthly Water Level of Lake Malawi

6.2 Groundwater

The land of Malawi generally is divided into three geologic terranes, the rift valley areas overlaid by thick alluvium, the plateau area composed of weathered materials, and the mountain area exposing basement rocks. Although the aquifer structures on a micro scale have never cleared yet due to poor geological investigation, the aquifer units can be considered to correspond to the three terranes on a macro scale, and that is, the distributions of aquifers are regarded as just three aquifers, the Quaternary alluvium (AL), the weathered basement (WB) and the fractured basement rock (FB)

The annual groundwater discharge is considered to be balanced by recharge if the groundwater is in a steady state groundwater flow assuming that a sufficiently long period of groundwater storage is considered to be negligible. In that case, recharge can be calculated in accordance with Darcy's Law. Darcian flow can transmit into particle spaces of WB and AL but cannot transmit into basement rocks which are basically considered to be impermeable. Recharge considered with Darcy's theory can be calculated by the following formula:

$$Q = T \times i \times W$$

Where, Q	:	Groundwater Discharge,
T	:	Transmissivity
i	:	Hydraulic Gradient,
W	:	Area width throughout groundwater flows

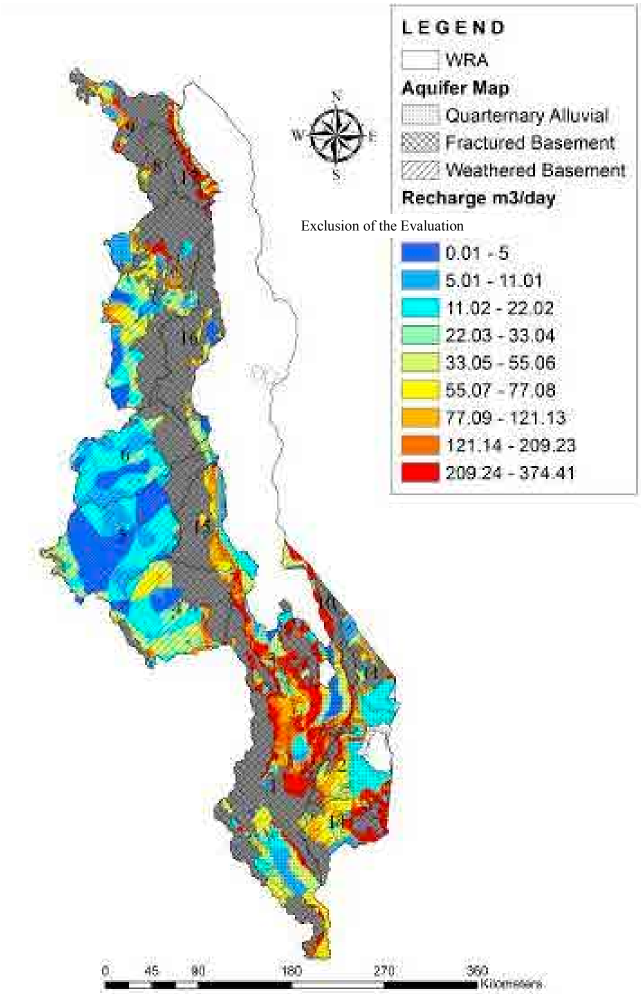
The estimates of groundwater recharge derived using Darcian Flow method take the range of 4 to 201mm/year in case that an average value in each WRA is regarded as the representative recharge amount. Distributions of the recharge intensity as shown in **Figure 6.9** indicate that the recharge intensities are dominated by hydraulic gradients rather than quantities of transmissivity, i.e., the recharge intensity clearly tend to be higher than 100mm/year at the feet of mountain areas, such as the surroundings Zomba Mountain and Mulanje Mountain, hills in Blantyre, Ntcheu, Balaka and Mangochi district in the southern region, whereas the plateau plane including Lilongwe, Mchinji and Kasungu district in the central region shows small amount of recharge less than 20mm/year owing to very gentle geomorphic surfaces and low transmissivities in the weathered basement aquifers.

This approach should be considered on evaluating groundwater potential as follows;

- ✓ The Darcy Flow method assumes that whenever aquifers saturate under semi-confined environment, there will be no water loss or no water supply from outside of the aquifer in the calculation areas. That is to say, this method ignores the infiltration to groundwater from precipitation and discharge from groundwater to rivers.
- ✓ This method is constituted of a simple formula based on Darcy's theory, but it cannot represent a

chronological change of groundwater fluctuation. Thus the analyzed results indicate only the aquifer's groundwater potential and this method cannot make the evaluation in the future situation.

Precipitation is the most important source of groundwater recharge in Malawi. The appropriateness of the recharge intensity have to be cross-checked with actual utilization of boreholes.



Source: Project Team

Figure 6.9 Recharge Intensities calculated by Darcian Flow Method

6.3 Projection of Population

In the Project, regarding the population forecast of the four cities (Lilongwe, Blantyre, Mzuzu, Zomba), the values of WB's projects which were studied for 4 cities in detail, are adopted . The population forecast of urban and rural areas except the four cities is based on the forecast of the Census 2008. (There is a difference in both estimations concerning the four cities, and the values of WB's project is smaller.)

6.4 Water Demand

6.4.1 Domestic and Industrial Water

Domestic water demand has been estimated category-wise as follows:

(a)Category-1: Water for the Four Principal Cities is served by the Water Boards

(b)Category-2: Water for Towns is served by the Water Boards

(c)Category-3: Water for Rural Areas is served by improved water source, managed by water users associations or water committees, or does not have access to the improved water.

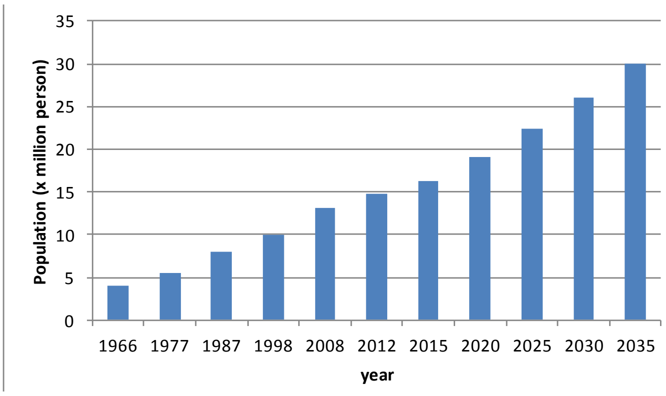
Table 6.1 shows the sources of information for the estimation of population in each service category.

Table 6.1 Approach to Estimate Population

Category	Area	Population Projection Benchmark
Urban	Lilongwe, Blantyre, Mzuzu and Zomba	Estimation of SOGREAH Feasibility Study Reports for Lilongwe, Blantyre, Mzuzu and SSI Report for Zomba.
	Towns and bomas served by the Regional Water Boards (Except Mzuzu and Zomba)	Information from Northern, Central and Southern Regional Water Boards, and population growth rates of NSO.
Rural	Areas other than the above rural area	Population of 2008 Census and unit of design water supply.

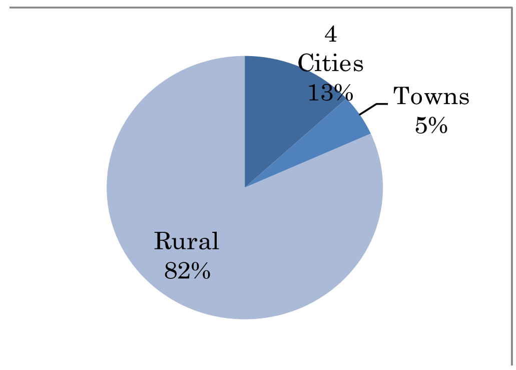
Source: Project Team

Water demand of cities and towns is estimated by each city/town population. Population in rural area is estimated in district-wise by decreasing the urban population. Water for the industry, commercial and institute is estimated based on data of the Water Boards. Total population and ratio of population are shown in **Figure 6.10** and **Figure 6.11** respectively.



Source: Project Team

Figure 6.10 Total Population of Malawi in 1966-2035



Source: Project Team

Figure 6.11 Ratio of the Population in 2012

The target shown in **Table 6.2** is applied to the water coverage rate of the water demand projection in the Project in conformity with the "National Water Development Program".

Table 6.2 Recommended Water Supply Target

Target for Access - Water	2015	2025	2030
Urban	95%	98%	98%
Rural	73%	98%	98%

Source: Project Team

Daily water consumption in urban and rural area is summarized in **Table 6.3**.

Table 6.3 Daily Water Consumption per Capita adopted to Water Demand Projection

Category	Area	Condition
Population with water service of the Water Board	Lilongue, Blantyre, Mzuzu and Zomba	Values used in SOREAH Feasibility Study in 2010 and SSI Report in 2010
	3 Regional Water Boards	93 L/c/d in 2015-2020, 115 L/c/d in 2025 and 130 L/c/d in 2035 for household connection. 36 L/c/d in 2012-2020 and 50L/c/d in 2025-2035 for communal points in 2012-2035. 27L/c/d for Borehole/Shallow well and no access to Safety Water
Population with improved water source in rural area	Market Center	45 L/c/d in 2012-2020 & 50 L/c/d in 2012-2035
	Gravity-fed piped water supply	40 L/c/d in 2012-2035
	Borehole, Protected Shallow well and Spring	36 L/c/d in 2012-2035
Population without improved water source like pond & stream under no treatment	Rural Area	27 L/c/d in 2012-2035

Source: Project Team

Table 6.4 shows results of water demand projection. Approximately 239 million m3/year will increase by around 2.5 times higher to 580 m3/year. Since water consumption per capita of the urban area is larger than that of the rural area, when the population in urban area will constantly increase, the demand for drinking water will increase more rapidly than the relation of linearity.

Table 6.4 Results of Water Demand Projection

Category	unit	2012	2015	2020	2025	2030	2035
Urban Area	m^3/day	339,502	386,933	478,058	588,877	732,489	900,939
	million m^3/year	123.9	141.2	174.5	214.9	267.4	328.8
Rural Area	m^3/day	369,399	410,091	459,424	550,883	635,447	731,793
	million m^3/year	134.8	149.7	167.7	201.1	231.9	267.1
Total	m^3/day	708,901	797,024	937,482	1,139,759	1,367,936	1,632,732
	million m^3/year	258.7	290.9	342.2	416.0	499.3	595.9

Source: Project Team

6.4.2 Agriculture

(1) Demand Calculation for Irrigation Water

The approach used to estimate irrigation demand can be summarized into three main steps:

Step 1: Determine irrigated area for selected crops;

- Crop area estimations
- Irrigated area estimation

Step 2: Determine crop water and irrigation requirements; and

Step 3: Determine irrigation demand

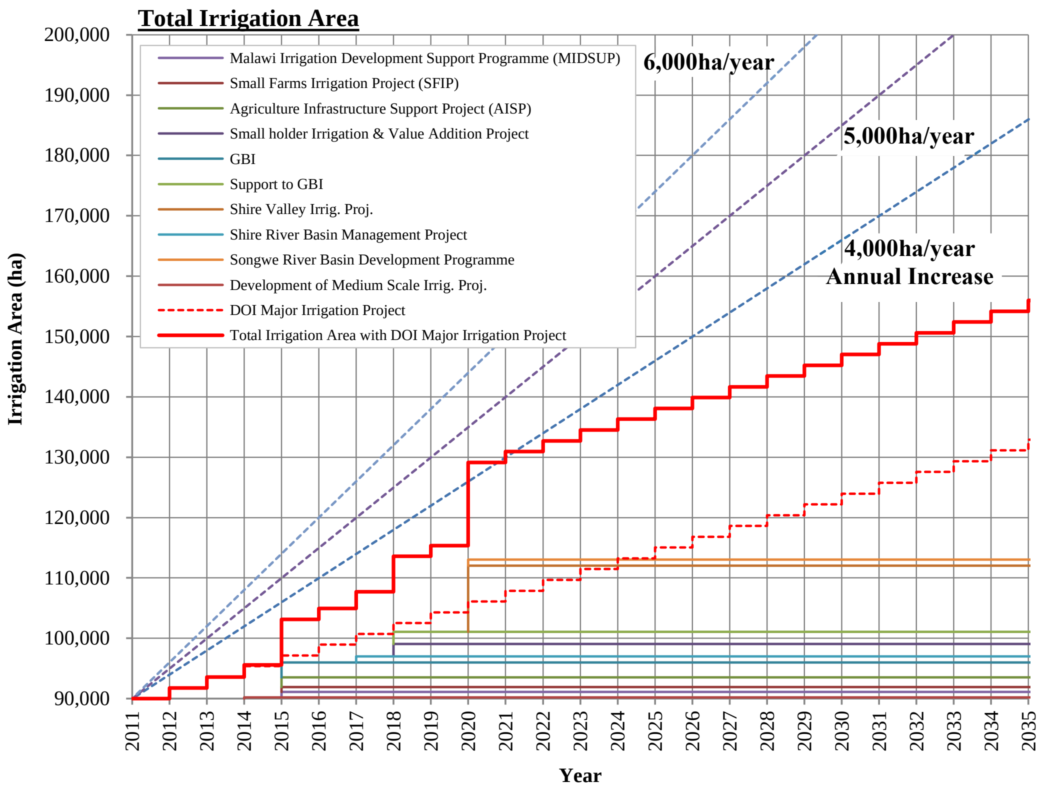
Base year water demand is calculated and summarized in **Table 6.5**.

For annual increase, DOI is applying 5,000 ha for annual increase in irrigation planning shown in **Figure 6.12**.

Table 6.5 Base Year Water Demand

WRA	Irrigated Area(ha)	Monthly gross water requirement ($x10^3m^3$)												Total
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	29,564	14,091	8,775	18,508	44,781	56,725	48,292	22,117	15,060	28,292	37,305	44,099	23,217	361,261
2	3,320	0	0	0	3	615	693	3,387	5,268	6,162	995	558	505	18,185
3	2,368	720	647	433	326	1,753	3,892	6,281	9,233	8,461	1,309	936	815	34,805
4	4,668	421	201	1,345	102	2,818	8,045	14,105	19,288	18,788	2,200	2,160	1,549	71,022
5	6,159	593	293	1,839	469	2,640	7,716	18,359	24,880	23,657	1,716	1,728	554	84,444
6	9,918	2,157	1,227	7,251	14,589	19,618	19,572	12,265	9,729	14,631	16,206	20,348	6,345	143,939
7	2,840	0	0	0	15	140	888	3,303	5,904	5,900	880	282	20	17,331
8	445	0	0	0	0	259	550	473	845	985	510	296	171	4,089
9	2,119	3	0	0	0	1,546	3,273	2,343	4,152	4,857	2,330	1,664	1,185	21,354
10	531	130	125	98	183	407	709	1,372	2,001	1,841	443	232	67	7,608
11	1,160	355	312	237	231	1,058	2,226	2,996	4,391	4,119	821	647	610	18,004
12+13	7	0	0	0	0	0	0	0	0	0	0	0	0	0
14	14,749	1	0	0	4	2,820	2,043	12,021	17,881	24,340	13,395	1,405	101	74,010
15	6,589	15	266	0	5	2,195	6,588	3,785	4,389	6,299	6,153	5,005	1,275	35,974
16	4,823	2	102	0	9	1,101	4,511	6,878	11,373	10,826	3,107	1,886	918	40,714
17	982	0	28	0	0	1,221	3,112	1,743	2,835	2,965	904	1,232	1,238	15,278
Total	90,242	18,487	11,977	29,711	60,718	94,917	112,110	111,429	137,228	162,123	88,271	82,476	38,570	948,016

Source: Project Team



Source: Project Team

Figure 6.12 Relations between Demand Forecast and Ongoing/Future Projects

(2) Water Demand for Livestock

The following steps were taken to provide water demand for livestock:

1) Livestock population and livestock ratio:
2) Consumption Figures for Livestock:
3) Water demand for livestock:

6.4.3 Hydropower

There are three existing hydropower dams on the Shire River in WRA 1 (Nkula, Tedzani, and Kapichira), one small hydropower weir (Wovwe) on the Wovwe River in WRA-17, and 15 planning hydropower projects in WRA-1, 5, 7, 9, 14, and 16. The water used for hydropower generation will return to the river and is non-consumptive use except for the Lower Fufu HPP on the South Rukuru River and the North Rumphi River, which turbine discharge directly flows into the Malawi Lake through tailrace. **Table 6.6** summarizes maximum water demand for hydropower in each WRA.

Table 6.6 Summary of Maximum Water Demand for Hydropower in each WRA

WRA	River	Maximum Plant Discharge	Hydropower Plant of the largest maximum plant discharge	Remarks
1	The Shire River	418 m^3/s	Mpatamanga HPP (Planning)	
5	The Bua River	60 m^3/s	Chasombo HPP (Planning)	
7	The South Rukuru River The North Rumphi River	Total 40 m^3/s	Lower Fufu HPP (Planning)	Used water will not return to the river
9	The Songwe River	159 m^3/s	Middle Songwe (Sofwe) HPP (Planning)	
14	The Ruo River	60 m^3/s	Zoa Falls HPP (Planning)	
16	The Dwambazi River	20 m^3/s	Chimgonda HPP (Planning)	
17	The Wovwe River	1 m^3/s	Wovwe HPP (Existing)	

Source: Project Team

6.5 Water Balance

6.5.1 Water Balance Simulation Model

(1) Outline of the Simulation Model

The water balance simulation model is constructed to evaluate water balance in Malawi. There are watersheds flowing into and out from Lake Malawi. These are modeled. The model of Lake Malawi is constructed separately because it is needed to consider inflow from countries other than Malawi.

The rainfall runoff model (MIKE-SHE) is applied to calculate water balance in Malawi using rainfall, evaporation, discharge, land use and geological condition. MIKE-SHE is a distributed physics model developed by DHI. Runoff and Recharge are calculated from rainfall and evaporation. For groundwater, tank model is applied.

Furthermore, the water utilization model (MIKE BASIN) is constructed for calculating allocation of water. The water balance is represented by inputting the result of rainfall runoff model and water demand.

The flowchart of construction of the model is shown in **Figure 6.13**. Input data to calibrate the water balance simulation model by MIKE-SHE is shown in **Table 6.7**.

(2) Calibration of Rainfall Runoff Model

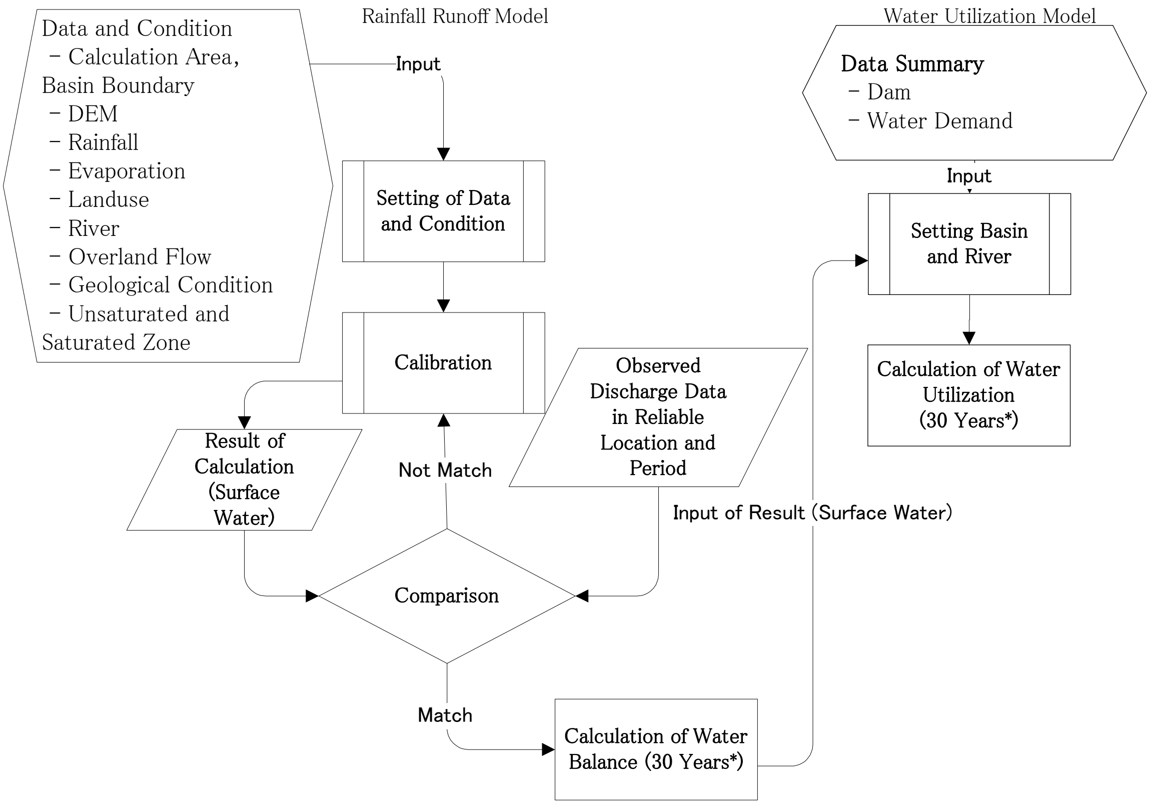
The calibration is implemented by comparison of observed and calculated monthly flow volume in annual and dry season for the 6 year period from 1980 to 1986. It is determined considering the year (1986) which is the year of formulation of the National Water Resources Master Plan leading to the development of water resources and reliable duration of the evaporation data (after 1980). The calibration station is determined considering period and reliability of existing discharge data at downstream.

The results are shown in **Table 6.8** as the correlation coefficient between observed and calculated monthly flow volume (when calculating the correlation of coefficient, the observed data was selected depending upon the accuracy). The correlation coefficient is very high ranging from 0.71 to 0.99; therefore, it can be said that the parameters can be applied for the other basins and the applicability of the model is proven to utilize simulation results for the master plan study.

Table 6.7 Input Data of the Simulation Model

Item		Explanation
Observed Data	Rainfall (Daily)	The rainfall is applied in calibration period. It is given by WRA and calculated by Thiessen method. The different Thiessen polygon by day is used depending on available station.
	Evaporation (Daily)	The evaporation is applied in calibration period. It is given by WRA and calculated by Thiessen method. The different Thiessen polygon by day is used depending on available station.
Geographical Information	Land Use Map	The land use map made in 1990 is applied. Land use is classified into 6 classes: Forest land, Grassland, Cropland, Wetland, settlements, and Other land.
	Soil, Geological Map	The soil, geological map made in 1987 is applied. It is classified into 3 categories, basement rock, alluvial sediment, and weathered basement
	DEM	SRTM made in 2000 is applied. SRTM is stored DEM in mesh size of 90m.
	Basin Boundary	Basin Boundary is delineated from SRTM based on WRU.
	Groundwater Basin Boundary	Groundwater basin boundary is delineated based on basin boundary.
	River Network	Major rivers are considered to carry the water from upstream to downstream.
	Cross Section	Cross section is made based on DEM. It is assumed to be simple shape.
Others	Position of Observatories	Hydrological Station
	Mesh size	1 km mesh size
	Map Coordination	Arc 1960 UTM Zone 36S

Source: Project Team



Source: Project Team

Figure 6.13 Flow Diagram of Model Construction and Simulation

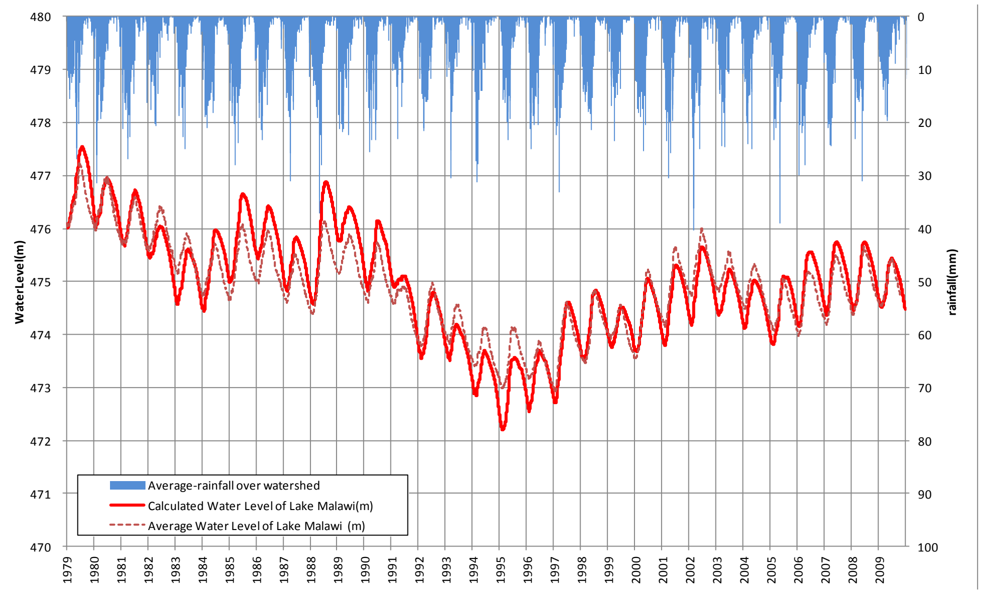
Table 6.8 Application Result

WRA	Evaluation Station	Applicability (Correlation Coefficient of Volume)		Note
		In Whole Year	In Dry Season	
1	1P2	0.90	0.89	
2	2B22	0.96	0.71	1983/5-1985/10
3	3E3	0.94	0.91	
4	4C2	0.96	0.79	
5	5D1	0.99	0.87	
6	6D10	0.93	0.98	
7	7G14	0.97	0.95	
	7H3	0.76	0.80	
8	8A5	0.86	0.94	1981/11-1986/10
9	9A2	0.99	0.91	
11	11A7	0.83	0.85	1981/11-1986/4
14	14B2	0.80	0.80	
	14C8	0.84	0.81	
15	15A8	0.91	0.91	
16	16F2	0.90	0.92	
17	17C6	0.75	0.78	1980/11-1985/4

Source: Project Team

6.5.2 Water Balance Model of Lake Malawi

Lake Malawi is bordered by three countries, Malawi, Tanzania and Mozambique, whose rivers flow into the Lake Malawi. On the other hand, outflow from Lake Malawi is only through the Shire River which is at the southern tip. To estimate the impact on water level and outflow of Lake Malawi due to water intake, water balance model of Lake Malawi is constructed. Calibration period is for 30 years from November 1981 to October 2010. The result is shown in **Figure 6.14**. The variation of wet season and dry season and the annual variation are well represented by the model.

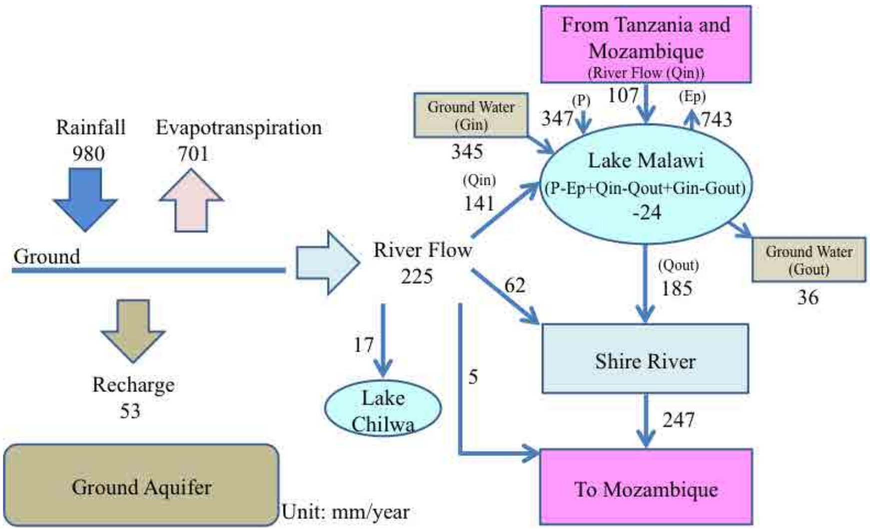


Source: Project Team

Figure 6.14 Calibration of Water Level of Lake Malawi

6.5.3 Estimation of Water Resources in Malawi

The water balance in Malawi is calculated by the average of 30 years from November 1980 to October 2010 applying the rainfall runoff model and the water balance model of Lake Malawi as shown in **Figure 6.15**.



Source: Project Team

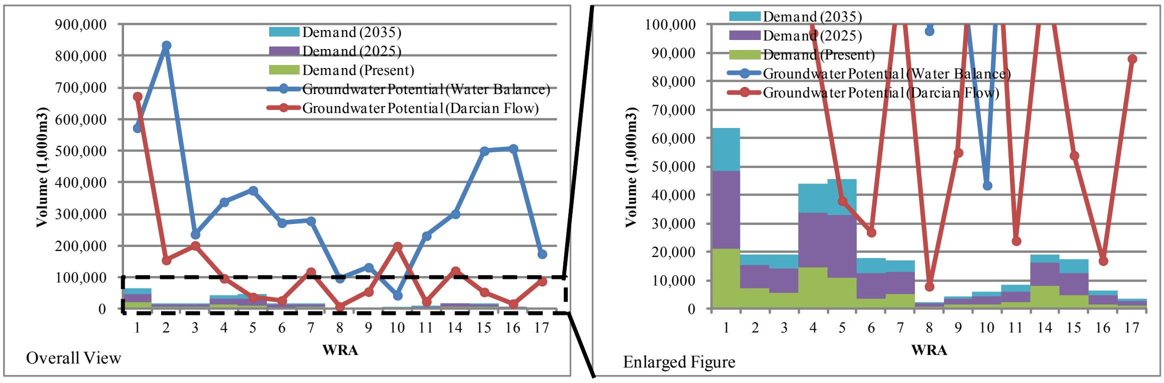
Figure 6.15 Water Balance in Malawi

6.5.4 Water Utilization Model

To estimate water balance in Malawi, water resources amount and water demand are compared so that water deficit is estimated. For the calculation of surface water balance, the water utilization model (MIKE BASIN) was established. The river flow discharge is calculated by the verified rainfall runoff model. Therefore, calibration of the water utilization model is not needed. **Figure 6.17** and **Figure 6.18** show sufficiency of water demand at present and 2035 in 10-year drought. There is regional and seasonal imbalance between water resources and water demand.

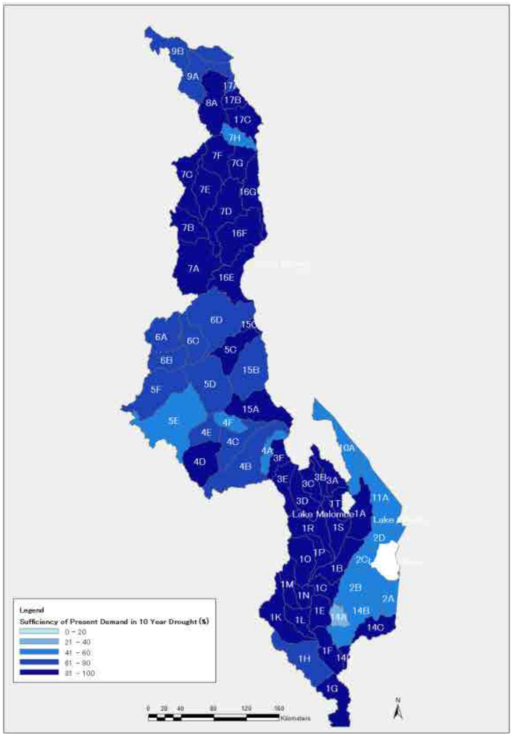
For groundwater balance, volume of recharge and water demand of groundwater is compared to study sustainability in water use as shown in **Figure 6.16**.

Water balance in Lake Malawi at present and in the future (2025, 2035) has been studied. The impact is evaluated by summarizing the water level in Lake Malawi and drought discharge of the Shire River (outflow of Lake Malawi).



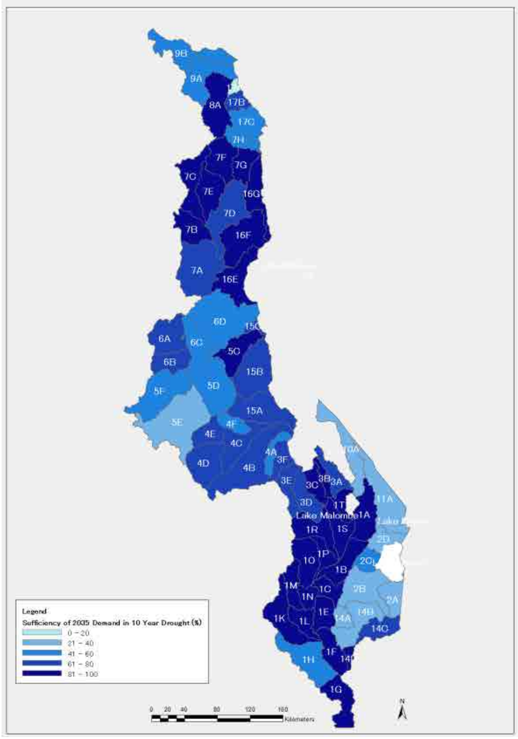
Source: Project Team

Figure 6.16 Groundwater Balance



Source: Project Team

Figure 6.17 Sufficiency of Water Demand by WRU at Present Condition in 10-Year Drought



Source: Project Team

Figure 6.18 Sufficiency of Water Demand by WRU in 2035

6.6 Water Quality

A part of the water environment in Malawi has been cleared by water quality monitoring in the Project despite there being only a few monitoring stations. This report will mention some issues found in the monitoring throughout the country as mentioned below.

- ✓ Most of the monitoring wells were contaminated with human wastes, feces and urine probably, but the contamination into groundwater was not under natural conditions, rather it was caused by dirty water directly flowing into wells from the surface due to the failure of well structures. In order to measure true underground aqueous conditions, firm seal structures to prevent flowing surface water must be built up to deep aquifer in monitoring wells.
- ✓ Shallow groundwater struck within 5m deep is generally not safe to drink, thus groundwater development should aim at deeper aquifer than 15m in which human's contamination from surface can be avoided.
- ✓ Trends of concentration of nutritive salts were quite different between the rainy and dry season. On the highland areas, that may be a reason why soluble substances might be concentrated in the river due to the remarkable drop of the flow rate in the dry season. In the rainy season, possible eutrophication was identified mid or downstream of major rivers in both the low and high land areas. The eutrophication might be brought about by the discharge of untreated waste water from sewage works or irrigation facilities.
- ✓ In the rainy season, turbidity tends to be higher further downstream, particularly on the Shire River and the Lithipe-Lilongwe River. The rise in the degree of turbidity appears to show evidence of land erosion caused by an expansion of disorderly deforestation or cultivation.
- ✓ In urban areas, deterioration of aqueous environments was clearly recognized via both visual checking and water quality testing. Currently, most of the pollutants originate from household effluents, but in future heavy metals or organic solvents will cause serious health problems to water users on the downstream areas from effluent sources, coinciding with further industrialization.

- ✓ High concentrations of fluoride derived from hydrothermal or other geological factors appeared in the watersheds of the Lithipe River and the Shire River although the trends varied seasonally. They are not serious threats to human health now, but the water sources containing such high concentrations of fluoride (>10mg/l) could cause harmful injuries to human existence in Malawi. These dangerous water sources must be avoided by specifying the origins and mechanisms of concentrating fluoride compounds in nature.

6.7 Tendency of Climate Change Impact

The Project Team used the re-gridded data by UNDP to investigate the tendency of climate change impact in Malawi. Water Balance Simulation was carried out by using the incremental ratios of rainfall and evapotranspiration converted from the change values of temperature. The results of the simulation are summarized by emission scenario in **Table 6.9**. Regardless of scenario, the rainfall and evapotranspiration demonstrate a small upward trend, while the river flow and recharge has a small decrease trend.

Table 6.9 Water Balance by Climate Change Scenario

Unit: mm

WRA	P	Ep	Q	Re	Re/P
Present	980	701	225	53	5%
B1	981	711	219	51	5%
A1B	983	714	218	51	5%
A2	989	717	221	52	5%

Source: Project Team

6.8 Concept of GIS

The GIS database was developed to conduct hydrological analysis and master planning efficiently.
In developing the GIS database, the Project made clear definitions of database table and folder framework.

CHAPTER 7. CAPACITY DEVELOPMENT

7.1 Target Organization and Department

The Human Resources Planning Unit (HRPU) has conducted a capacity assessment and training plan. The Project Team will review HRPU's report and conduct discussions with HRPU to further facilitate the implementation of the capacity development program outlined by the HRPU. The target organization and department will be within the Ministry of Agriculture, Irrigation and Water Development to maximize the impact of training in order to incorporate the acquired skills into the updating process of the Master Plan.

7.2 Capacity Development Program during the Project

The capacity development program was implemented during the Project to facilitate understanding on the planning process of the master plan.

7.2.1 Program Schedule and Contents

The program was held during the data collection activities in Phase I. Seminars on each topic were conducted during the Phase I period starting from August 2012 to March 2013.

7.2.2 Progress of Individual Programs

(1) GIS Introduction Workshop

Interviews and assessment prior to the training revealed that, in general, the participants did not have any practical knowledge on the GIS system. Therefore, the program was prepared to start with a general explanation on the GPS and GIS systems, applications and possible practical usage of the technology. The participants were selected among the government staff at the headquarters of the Ministry who may be in charge of data compilation, processing and planning for projects and statistics presently or in the future. Most participants had very little knowledge on the GIS technology at the onset of the training session. After the course and practical exercises, the assessment result improved by 2.7 points on average, where the full point is 5.0.

(2) Hydrological Observation and Monitoring (Discharge Measurement and Cross Section Survey)

Participants generally had some knowledge and experience on flow measurement and cross sectional survey prior to the training. Before the training, most of the participants were not familiar with the mechanical equipment like the Total Station and Propeller-type Electric Current Meter. The course then gave an introductory overview of the technical equipment that are useful for flow measurement. The understanding rate on most evaluation questions was 50% before the training. After the training the understanding rate increased to almost 100% with three exceptions.

(3) Hydrology and Hydrological Data Management

Participants generally had some knowledge on hydrology and data management. This course focused more on the theoretical understanding of basic and medium advanced hydrology. Basic understanding of hydrology and cross sectional survey for which training was conducted two weeks before was relatively higher than other subject matters. Especially, conceptual runoff models and tank models, and procedures of runoff analysis are relatively advanced technical procedures that further exercises to fully understand them are needed.

(4) Data Management for Groundwater Resources

All officers and technicians need some training in different areas regarding groundwater. It is critical that the importance of groundwater analysis would be put on analysis and presentation of data in different forms including maps (practical GIS), manipulation of different information on different maps and diagram presentation. It is a wish of the Division that the capacity be strengthened to be able to produce maps, models using the local groundwater data. This would be useful in areas of groundwater exploration, groundwater risk assessment, scientific opinion paper presentation and writing among others.

7.2.3 Policy Guidance and Institutional Functions

A capacity development program was implemented to enhance policy formulation capacity and the understanding of implementation activities of various institutions with regard to water resources management. The main focus of the training was to learn about the policy implementation strategies. The training was held in Japan.

(1) Policy and Implementation Strategies: Training I

Period: 03 December to 15 December 2012

Objectives: The course was programmed to learn about the functions and policy implementation mechanisms of institutions, particularly:

- ➢ The Integrated Water Resources Management, Japanese practices
- ➢ Sustainable water resources management policy implementation
- ➢ Water utilization facilities coordinated management

The program included lectures and presentations as well as discussions at various institutions and visits of facilities. At the end of the training, the participants presented the following lessons learnt:

- The conflict resolution of international watercourses is a matter of interest for Malawi and Tanzania boarders along Lake Malawi. It would be useful to learn the perspective of international laws and other countries' examples.
- The water resources management strategies in Japan that are planned with consideration to the biospheres at the downstreams are very practical and useful example for Malawi water resources.
- The multi-dam control and policies are very useful for water resources management in Malawi. The purpose of the dams is multi-faceted: water control, water utilization and recreation. Currently the scale of dams in Malawi is very small. From a strategic water resources management viewpoint, dams should be planned as multi-purpose for Malawi.
- Flooding has become an issue also in Malawi. A coping strategy is needed to be elaborated.

(2) Policy and Implementation Strategies: Training II

Period: 01 September to 26 September 2013

Objectives: The course was programmed for middle officers to learn about the functions and policy implementation mechanisms of institutions, particularly:

- ➢ The Integrated Water Resources Management, River Management
- ➢ Surface water, groundwater utilization and management
- ➢ Sustainable water resources management policy implementation
- ➢ Water utilization facilities coordinated management

Lectures and presentations were given at institutions and water utilization facilities. Participants actively participated in the discussions and question and answer sessions. The main narratives of lessons learnt from the course are summarized below.

- The institutional structure matters to implement effective water resources management interventions. The overlap of roles and responsibilities among the ministries in Malawi is causing conflicts of interest in the water sector management.
- The things have to be done as they are planned and initiated. Implementation is a very important factor to put things forward.
- Very limited resources are utilized with elaborate planning and operation in Japan. In Malawi, resources are not efficiently used. There are needs to improve planning and implementation.

7.2.4 Technical Seminars in October and November 2013

During the consultants visit in October and November 2013, the following trainings and seminars were conducted for the officers of the Ministry. Groundwater analysis and hydropower and water resources seminars were also planned for the month of April 2013. In the course of preparation of the Master Plan, interactions and discussions were held between the key government officials of the Ministry and the Project Team to improve the quality of outputs.

(1) GIS Data Management Training

Before the training, the participants almost had no experience to process water resources data and geo-spatial information data on the GIS software. However, they learned the concern to manage the location and the water resources data together by gaining knowledge such as coordinate reference system, map accuracy and software operation.

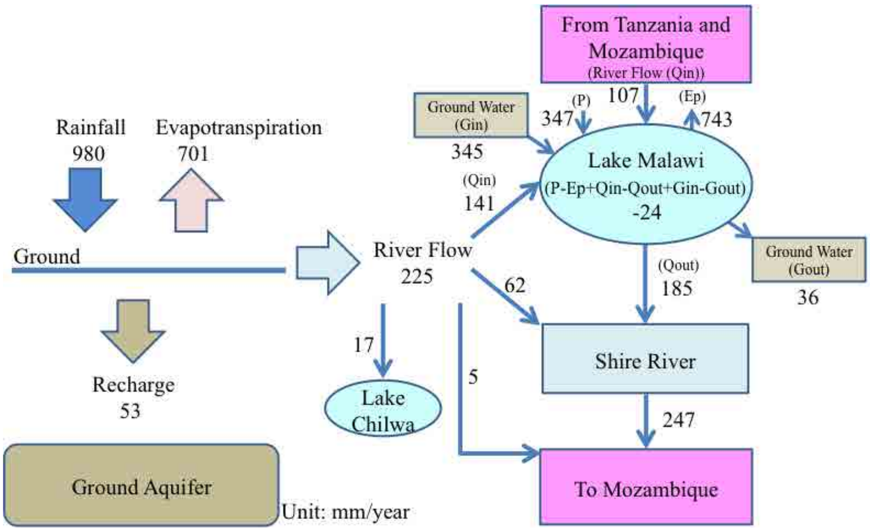
(2) Rainfall Runoff and Water Utilization Modeling

Before the training, the participants had little knowledge about hydrological modeling. After the training, they learned the outline of modeling and operation of the water utilization model.

CHAPTER 8. BASIC POLICY FOR WATER RESOURCES MANAGEMENT AND DEVELOPMENT

8.1 Condition of Water Resources in Malawi

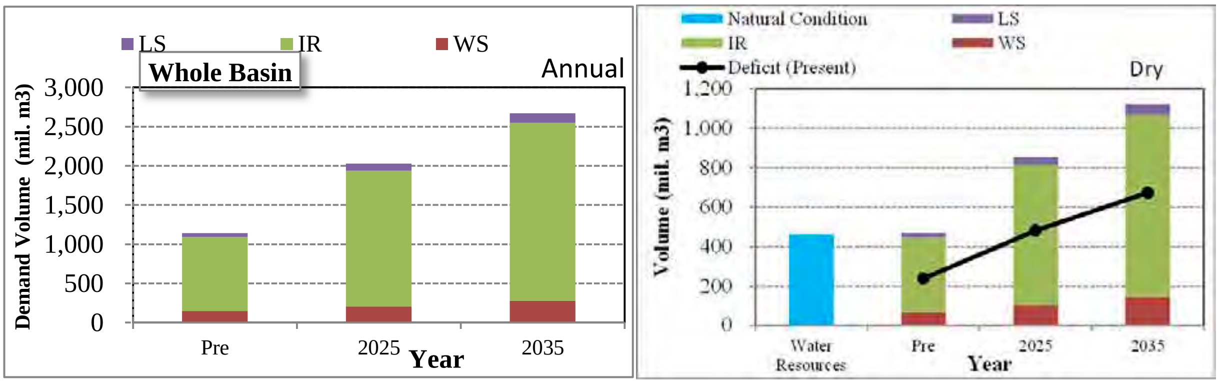
The general water resources balance in Malawi is evaluated in the Project by using the simulation model with 30 years hydro-meteorological data and shown in **Figure 8.1**. Averagely, the 980 mm water per year supplies to surface as precipitation, 23 percent (225 mm) and 5 percent (53 mm) of which runs off to the ground surface and penetrates into the ground respectively, while the evaporative loss is estimated at 72 percent of the supplied water by precipitation. About the surface water, 63 percent of the surface water in Malawi flows into Lake Malawi and 28 percent flows directly to the Shire River.



Source: Project Team

Figure 8.1 Natural Water Balance in Malawi

On the other hand, the water demand is estimated at 1.1 billion m^3 per year (as of 2012) in total, which the breakout is shown in **Figure 8.2** (left figure). The irrigation and domestic water demand is 87 and 13 percent respectively. It increases 2.5 times up to 2035 year. Comparing with the annual average water resources (excluding water resources in Lake Malawi) and annual water demand, the water resources is 20 times (at present) and 10 times (in the future) of water demand; however, the water shortage in dry season is prominent by seasonal fluctuation as shown in **Figure 8.2** (right figure).



Source: Project Team
LS: Livestock, IR: Irrigation, WS: Water supply
Right Figure is sum total of WRA2, 4, 5, 6, 9, 10, 11, 17

Figure 8.2 Transition of Water Demand (left) and Comparison between Annual Water Demand and Water Resources (right)

8.1.1 Challenges in the Formulation of Master Plan for Water Resources Development and Management

There are a variety of issues related to water resources management and development in Malawi. The Project Team proposed component projects in the M/P to mitigate or resolve these issues in line with IWRM or SWAp concepts.

(1) Potential for Water Resources Development

As a matter of the fact, the water demand may increase corresponding to natural water distribution in the future; however, it can be said at any case that it is difficult to implement nationwide water resources development, management and allocation along various policies of MoAIWD unless a Master Plan is in place. In consultation with MoAIWD based on the study result so far, we shared a common understanding that the utilization of abundant water resources in rainy season is most important; however, MoAIWD should realize that there are methods to adapt to seasonal fluctuations of water resources so that water resources developments will implement in concord with the limited budgetary conditions and, natural and social environments.

The balance between the water resources and irrigation demands by WRA is presented in **Figure 8.3**. Especially, the water resources abound in WRA4, 7, 14 and 16 compared with the vistaed irrigation water demand which is total amount of "Present Water Demand" and "Water Supply for irrigation Development". In case of water resources development, the balance should be considered to save water and construction cost for water use facilities.

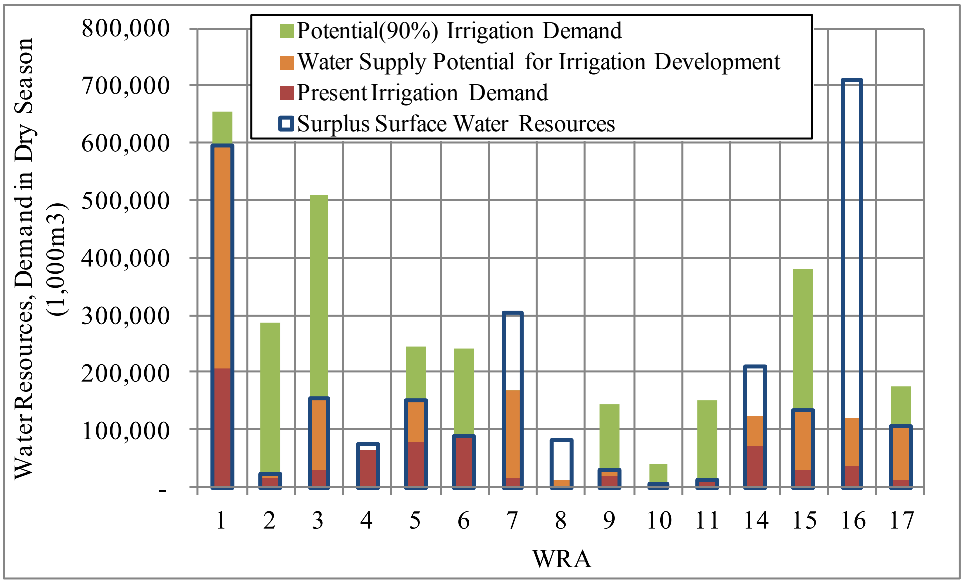


Figure 8.3 Comparison between Water Resources and Irrigable Area by WRA

(2) Establishment of Appropriate Organizational Frame

The integrated water resources development and management would be implemented by National Water Resources Authority and Catchment Management Committee in accordance with New Water Resources Act. According to MoAIWD, World Bank will support to construct above organizations in the future. Therefore, in the Master Plan, the framework and function are proposed to implement the integrated water resources development and management properly by above organizations.

(3) Low Data Reliability and Inadequate Monitoring System

The hydrological observation network has been shrinking and at the current moment, some major stations are not operated even at the important control points for monitoring water resources. The lack of consciousness of MoAIWD members and malfunction of regional offices are reflected on the situation as well as the financial restriction. In addition, it took much time to collect, confirm and check hydrological data in quality and quantity due to improper arrangement of hydrological data in MoAIWD.

(4) Unorganized Water related Facilities and Water Rights Information

The information about water utilization facilities and water rights is essential for sustainable water resources development and management. However, the information about water utilization such as dams, reservoirs, irrigation facilities, intake point, intake amount, etc. is not managed and arranged properly and the condition breeds problems for water resources development and management.

(5) Lack of Consideration in terms of Water Balance

In Malawi, the feasibility of each project related to water resources management is examined without due considerations of impacts to each other because there is lack of process and consciousness to investigate the water budget between water sectors in the WRU level. In the Project, the study method is led so that MoAIWD can implement such study in the future. The follow-up for capacity building of staffs and enhancement of organization is necessary after the formulation of the Master Plan.

8.1.2 Basic Policy of Formulation of M/P

(1) Target Year of Water Resources Development and Management

The long-term target year for the M/P for water resources development and management was set in 2035 on the first steering committee that was held on May 2012, and the short- and middle- term target year is set 2020, 2025 respectively.

(2) Basic Policy for Water Resources Development and Management

To satisfy growing demand in Malawi, the key considerations for water resources development in Malawi are effective usage of; 1) effective water demand management in dry season, 2) abundant water resources in rainy season, 3) constantly abundant water resources of Lake Malawi and the Shire River. The water source except for the purpose of rural domestic water supply in Malawi is mainly surface water; however, to meet the water requirement from water sectors, in the future, the usage of groundwater and rationalization of water use such as water-saving measure and control of cropping pattern will be needed for appropriate water resources development to prevent conflictions between the sectors.

In addition, the main countermeasures for water resources management are; 1) appropriate monitoring for hydrological data and water quality, 2) enhancement of system and capacity of relevant agencies, and 3) strengthening of basin management system based on the basin characteristics studied in the Project.

(3) Priority in Water Supply

In the consultation with MoAIWD, the priority order of consumptive water use is domestic water and irrigation and livestock. Regarding the environmental flow, in the Malawi there is insufficient information about the user of environmental flow such as existence of protective species. In addition, there is no guideline to estimate environmental flow in Malawi. In the circumstance, influence to the river discharge by water resources development is examined and compared with the environmental flow As a result of the examination, a direction of management of environmental flow is suggested in the Project. In fact, monitoring and detailed investigation for the environmental flow and clarification of precious species should be done in Malawi to modify guidelines and properly control the environmental flows by river basin. Actually, the environmental flows by the hydrological method, which is Q_{90} recommended by MoAIWD in case of construction of dam, are very huge as same as irrigation water demand.

(4) Safety Level of Water Usage

The safety level of water resources development is set as the following table which resulted from discussions and consultations with MoAIWD and MoE. Especially about the irrigation sector, the DoI approved it in the consultations in consideration of the case of other countries and the balance between safety level and volume of investment. The safety level of domestic water supply was determined in accordance with planning guidelines prepared by MoAIWD, hearing investigation results and past domestic water supply plans which are submitted to MoAIWD.

Table 8.1 Safety level for Master Plan

Sector	Level	Drought Year	Target Year	Setting Method
Irrigation and Livestock	Large and small scale	5-year drought	2035	- Consultations with DoI
Domestic	Major 4 cities (Lilongwe, Blantyre, Mzuzu and Zomba)	20-year drought	2035	- Consultation with MoAIWD - WB report - F/S reports for Cities
	Towns and Market centers	10-year drought	2035	- Consultation with MoAIWD - WB report - Guideline of MoAIWD - F/S reports for Market Centers
	Rural areas	5-year drought	2035	- Consultation with MoAIWD
Hydropower	Capacity Factor (Annual average energy/Installed capacity)		2035	- Consultation with MoE

Source: Project Team

CHAPTER 9. DEVELOPMENT PLAN FOR URBAN AND RURAL WATER SUPPLY

9.1 Development Plan for Urban Water Supply

9.1.1 Challenges Raised from the Existing Condition

There have been many projects funded by the World Bank, the European Union (EU), etc., for the water supply sector in the urban areas of the 4 cities in the past several years. Nevertheless, many challenges to water utilities in 4 cities have still left behind. Physical challenges concerning the water supply of 4 cities can be described as below.

Table 9.1 Challenges Raised from the Existing Condition of Four Cities

No. of Challenges	Challenges	Target City
UWS-0	Low access to Improved Water Source	4 cities
UWS-1	To prepare the Basic/Detailed Design of New Raw Water Source and Additional Water Treatment Works	Lilongwe
UWS-2	To prepare the Functional Diagnosis of Detailed Design of Water Transmission System (Pump Stations, Transmission Mains, Service Reservoirs)	Lilongwe
UWS-3	To prepare the Functional Diagnosis of Design of Distribution Pipe Network	Lilongwe
UWS-4	To prepare the Program for further reduction of NRW	Lilongwe
UWS-5	To prepare the Basic/Detailed Design of New Raw Water Source and Additional Water Treatment Works	Blantyre
UWS-6	To prepare the Functional Diagnosis and Detailed Design of Water Transmission System (Pump Stations, Transmission Mains, Service Reservoirs)	Blantyre
UWS-7	To prepare the Functional Diagnosis of Design of Distribution Pipe Network	Blantyre
UWS-8	To prepare the Program for further reduction of NRW	Blantyre
UWS-9	To prepare the Basic / Detailed Design and of New Raw Water Source and Additional Water Treatment Works, and the Functional Diagnosis and Detailed Design of Water Supply System (Intake, Treatment Plant, Pump Stations, Transmission Mains, Service Reservoirs, Distribution Pipes)	Mzuzu
UWS-10	To conduct the Feasibility Study of New Raw Water Sources and prepare the Functional Diagnosis and Detailed Design of Water Supply System (Intake, Treatment Plant, Pump Stations, Transmission Mains, Service Reservoirs, Distribution Pipes)	Zomba
UWS-11	Financial Soundness and Water Tariff	Lilongwe, Blantyre

Source: Project Team

9.1.2 Planning Concepts

The urban water supply networks in Malawi face many problems related to population increase, water scarcity, and environmental pollution which arise from sanitation issues. In the circumstance, the overall concepts of urban water supply shall be formulated, with considering the equity, safety, sustainability and efficiency. In addition, more than 10 applicable ordinances/policies issued from related organizations was applied for establishment of planning concepts and indicators.

(1) Targeted Performance Indicators and Development Goal

The first priories of the tasks of water suppliers, which are categorized by the performance indicator, are ranked as the service coverage and the reduction of non-revenue water (NRW). Targeted performance indicators which become the basis of the strategy are set for service coverages and NRW rate (and purification plant efficiency) in the many past studies for water supply development plan in Malawi. The targeted performance indicators are summarized in **Table 9.2**.

(2) Development Goals

Actually, in 2 cities of Blantyre and Zomba of this master plan, the 3 scenarios for Blantyre and 2 scenarios for Zomba have been prepared in consideration of the past feasibility studies. However, the conclusive scenario of 2 cities as official plan are not able to decide at the present stage, because the detailed study is not carried out. Notwithstanding, the Scenario 3 for Blantyre have water service coverage of 100%, and the Scenario 2 for Zomba have water demand plan by 2035 (extension from 2020 to 2035 in the Project) although the feasibility study of raw water sources have not performed. Hence, its scenario (3 for Blantyre and 2 for Zomba) should be examined by conducting the feasibility study.

The development goals of short-, middle- and long-term for 4 cities concerning performance indicators, are set as shown in **Table 9.2** by taking into consideration the following conditions;

- Lilongwe - As the concrete goals, the 95% of 2015 and 100% of 2025 for service coverage are set from "MDGs and National Policy". In addition, the 25% of 2015 and 20% of 2025 for NRW and other parameters such as population forecast, water demand by 2035, are based on "Sogreah Report (2010)". The facility plan to be invested by 2017 is based on "LWB Future Investment Plan (2013)", the facility plan after 2018 is supposed by the Project. The abstraction capacity (water source capacity) will be increased by the construction of borehole, heightening of Kamuz Dam and the construction of Diamphwe upper and lower dams.
- Blantyre - Among three conceivable scenarios, the senario-2 is adopted in the Project from the viewpoint of technical adequacy which proved by WISP of WB. As the concrete goals, the 82.6% as the estimated service coverage at 2013 from existing condition is used for the scenario and the 87.1% at 2029 which is set by the intermediate value between BWB strategic plan target (100%: high scenario) and current 70% (low scenario). The NRW rates by 2035 of Scenario 2 are based on "WSIP (2012)". The facility plan of Scenario 2 is planned with reference to the concept of Sogreah Report. In addition, the new water source for the scenario is changed to "Shire River near Walker's Ferry" from "Mombezi dam" against the disadvantage of location of raw water source in accordance with the evaluation result of WSIP of WB.
- Mzuzu - All of design conditions and parameters are based on original "Sogreah Report (2010)". (Incidentally, the development plan for Mzuzu is until 2040.) The 100% of service coverage at 2025 refers to the “Nation Policy”, and NRW rates at 2015 and 2030 are based on “Sogreah Report”. The water abstraction capacity will be increased by the construction of two dams although the construction of first dam is behind schedule.
- Zomba - Service coverage is targeted to 100% at 2025 for National Water Policy from 95% at 2020 of SSI. The unit water consumption of domestic-use for adopted scenario is in reference to the unit consumption of Mzuzu due to tremendous value setting of the original plan by Zomba. The institutional/commercial/industrial consumption for the scenario is calculated as annual growth rate of 1.8% by project team (1.8% is an average growth rate of Lilongwe and Blantyre). When the water demand go over the capacity of the existing Mulunguzi dam, the development of new water sources will be necessary (e.g. raising up Mulunguzi dam).

Table 9.2 Targeted Performance Indicators of 4 Cities

<table>
<tr><th rowspan="4">No.</th><th rowspan="4">Targeted Indicator</th><th colspan="24">Time Frame</th><th rowspan="4">Formulator</th><th rowspan="4">Remarks</th></tr>
<tr><th colspan="9">Short Term</th><th colspan="5">Middle Term</th><th colspan="10">Long Term</th></tr>
<tr><th colspan="9">2012-2020</th><th colspan="5">2021-2025</th><th colspan="10">2026-2035</th></tr>
<tr><th>12</th><th>13</th><th>14</th><th>15</th><th>16</th><th>17</th><th>18</th><th>19</th><th>20</th><th>21</th><th>22</th><th>23</th><th>24</th><th>25</th><th>26</th><th>27</th><th>28</th><th>29</th><th>30</th><th>31</th><th>32</th><th>33</th><th>34</th><th>35</th></tr>
<tr><td colspan="26">Service Coverage to Safe drinking water</td><td></td><td></td></tr>
<tr><td>1</td><td>MDGs</td><td colspan="4">Present to 95%↗</td><td colspan="20">95%</td><td>World Bank</td><td></td></tr>
<tr><td>2</td><td>National Water Policy</td><td colspan="14">Present to 100%↗</td><td colspan="10">100%</td><td>Malawi</td><td></td></tr>
<tr><td>3</td><td>Lilongwe Water Board</td><td colspan="4">Present to 95%↗</td><td colspan="10">95% to 100%↗</td><td colspan="10">100%</td><td>LWB</td><td>(Sogreah Report)</td></tr>
<tr><td>4</td><td>Blantyre Water Board</td><td colspan="2">P to 82.6%</td><td colspan="16">82.6% to 87.1%↗</td><td colspan="6">87.1% to 86.9%</td><td>BWB</td><td>(Sogreah Report)</td></tr>
<tr><td>5</td><td>Mzuzu (Northern Region Water Board)</td><td colspan="14">Present to 100%↗</td><td colspan="10">100%</td><td>NRWB</td><td>(Sogreah Report)</td></tr>
<tr><td>6</td><td>Zomba (Southern Region Water Board)</td><td colspan="4">Present to 76%↗</td><td colspan="5">76% to 95%↗</td><td colspan="5">95% to 100%↗</td><td colspan="10">100%</td><td>NRWB</td><td>(SSI Report by 2020)</td></tr>
<tr><td colspan="26">Rate of Non Revenue Water (In this rate, it is included the unbilled consumption, commercial losses and distribution losses), excluding Production Losses</td><td></td><td></td></tr>
<tr><td>1</td><td>Lilongwe Water Board</td><td colspan="4">Presen to 25%↘</td><td colspan="10">25% to 20%↘</td><td colspan="10">20%</td><td>LWB</td><td>(Sogreah Report)</td></tr>
<tr><td>2</td><td>Blantyre Water Board</td><td>30%↘</td><td colspan="13">30% to 25%↘</td><td colspan="10">25%</td><td>BWB</td><td>Recommendation by WB</td></tr>
<tr><td>3</td><td>Mzuzu (Northern Region Water Board)</td><td colspan="4">Presen to 25%↘</td><td colspan="15">25% to 20%↘</td><td colspan="5">20%</td><td>NRWB</td><td>(Sogreah Report)</td></tr>
<tr><td>4</td><td>Zomba (Southern Region Water Board)</td><td colspan="4">Presen to 20%↘</td><td colspan="20">20%</td><td>SRWB</td><td>(SSI Report by 2020)</td></tr>
<tr><td colspan="26">Production Losses</td><td></td><td></td></tr>
<tr><td>1</td><td>Lilongwe Water Board</td><td colspan="4">Present to 5%↘</td><td colspan="20">5%</td><td>LWB</td><td>(Sogreah Report)</td></tr>
<tr><td>2</td><td>Blantyre Water Board</td><td colspan="24">5%</td><td>BWB</td><td>(Sogreah Report)</td></tr>
<tr><td>3</td><td>Mzuzu (Northern Region Water Board)</td><td colspan="24">5%</td><td>NRWB</td><td>(Sogreah Report)</td></tr>
<tr><td>4</td><td>Zomba (Southern Region Water Board)</td><td colspan="24">5%</td><td>SRWB</td><td>(SSI Report by 2020)</td></tr>
</table>

Note. In above table, the cell of blue color shows an upward trend, and the cell of pink color shows a downward trend for each indicators.

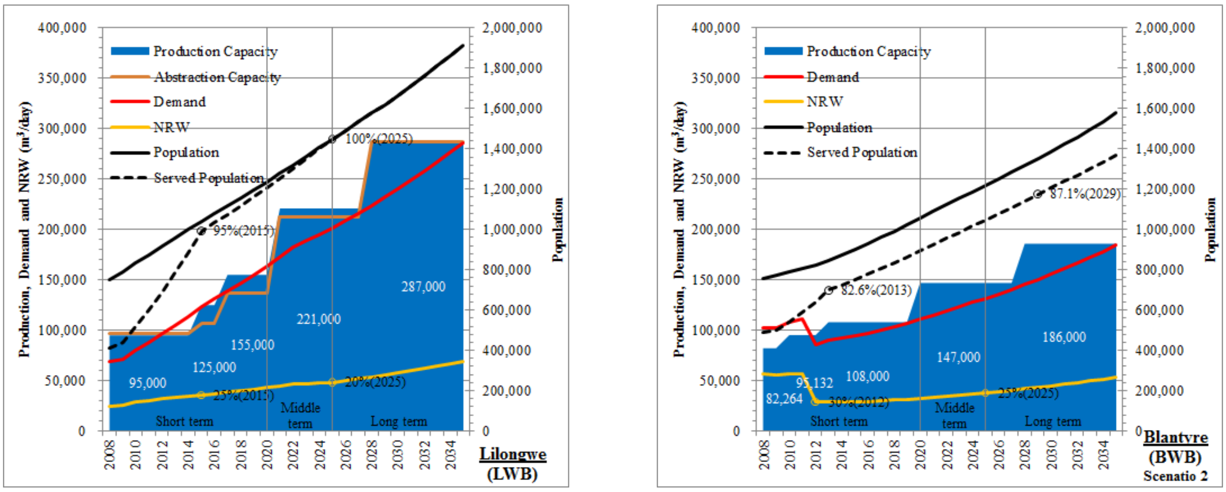
Source: Project Team

9.1.3 Action Plan and Implementation Schedule

The programme, projects and activities are formulated as concrete action plan or implementation schedule. As for the fundamental action plan of the programme, projects and activities, following respects will be considered and scheduled;

- To promote the development plans in order to meet the increase in the supply amount by the water resources development. – "projects based on NWDPII", etc.
- To control the water demand – "reduction of NRW", "water leakage control and monitoring", "installation of water-saving technology", "enlightenment to water user", etc.
- To re-examine water demand study. – "cooperation between urban planning and water supply study", "re-examination of population forecast at middle-term", etc.

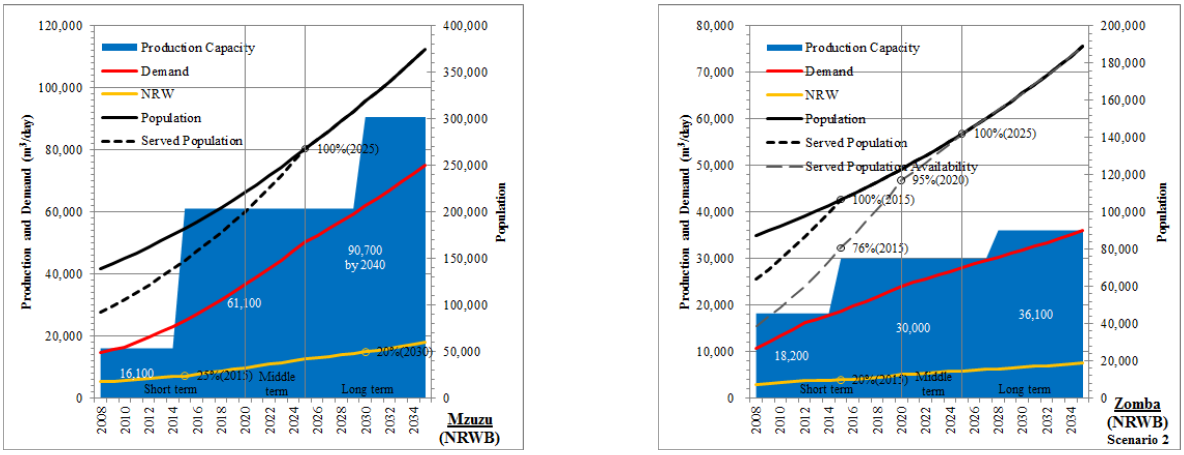
The implementation plan with project components/activities is summarized in **Table 9.2**.



Source: Sogreah Report and LWB future investment plan

Source: Sogreah Report and WB

Figure 9.1 Coverage and Expansion Plan for Lilongwe and Blantyre Water Supply Facilities



Source: Sogreah Report

Source: Sogreah report and Project Team

Figure 9.2 Coverage and Expansion Plan for Mzuzu and Zomba Water Supply Facilities

Table 9.3 Short, Middle and Long Term Action Plan and Implementation Schedule

Program	Projects / Activities	Time Frame: Short Term 2012-2020 (12-20)	Time Frame: Middle Term 2021-2025 (21-25)	Time Frame: Long Term 2026-2035 (26-35)	Storage	Intake & Transmission	Purification Plan	Transmission	Distribution	Others	New Construction	Rehabilitation	Responsible Organ: Main	Responsible Organ: Associate	Budget (Thousand US$)	Remarks
Lilongwe (LWB)		218,669	120,751	179,540											518,960	
LW-1	Develop new groundwater borehole (+10,000 m³/d)	14-15				●					◆		LWB	IDA	5,200	Study is ongoing. LWB Investment Plan
LW-2	Extension TWII (purification plant: +30,000 m³/d)	14-15					●				◆		LWB	IDA	5,000	Study is ongoing. LWB Investment Plan
LW-3	Raising of Kamzu dam 1 and associated rehabilitation works (+30,000 m³/d)	14-17			●							◆	LWB	EIB	5,100	Study is ongoing. LWB Investment Plan
LW-4	Extension TWII(2nd) (purification plant: +30,000 m³/d) and Technical Assistance	15-16					●				◆		LWB	(JICA)	9,700	LWB Investment Plan
LW-5	Catchment area conservation and rehabilitation	15-20								●		◆	LWB	(JICA)	0	LWB Investment Plan Technical cooperation
LW-6	Network improvement	15-17						●	●			◆	LWB	(WB)	200	LWB Investment Plan
LW-7	Full implementation GIS/Hydraulic Model	17								●	◆		LWB	(WB)	100	Technical cooperation
LW-8	Phase 1, New water source Diamphwe dam including transports system (+75,000 m³/d, TW+66000 m³/d)	15-20	21-22		●	●	●	●			◆		LWB	(WB)	195,420	LWB Investment Plan
LW-9	Implementation telemetry system	17								●	◆		LWB	(WB)	300	LWB Investment Plan Technical cooperation
LW-10	Rehabilitation of TWII	19-20	21				●					◆	LWB	(WB)	4,000	LWB Investment Plan
LW-11	Network expansion	18-20	21-25	26-33				●	●		◆		LWB	(WB)	225,800	LWB Investment Plan
LW-12	Review of water demand study	19-20								●	◆		LWB	-	1,500	
LW-13	Phase 2, New water source Diamphwe dam including transports system (Dam+75,000 m³/d, TW+66000 m³/d)			26-28	●	●	●	●			◆		LWB	(WB)	66,640	LWB Investment Plan
Blantyre (BWB)		133,808	80,831	107,302											321,940	Scenario 2
BW-1	Network improvement	15-19						●	●			◆	BWB	(WB)	9,000	
BW-2	additional NRW reduction programme	16-18								●		◆	BWB	-	5,000	Technical cooperation (Dispatch of expert, Equipment provision, etc)
BW-3	Metering and Water leakage control	16-18								●		◆	BWB	-		
BW-4	Phase 1, New water source from Shire River including transports system (+39,000 m³/d)	16-20			●	●	●	●			◆		BWB	(WB)	91,970	
BW-5	Network expansion	18-20	21-25	26-33				●	●		◆		BWB	-	129,800	
BW-6	Poverty program (Kiosk and Toilet development)	20	21-23						●		◆		BWB	-	14,000	
BW-7	Phase 2, New water source from Shire River including transports system (+39,000 m³/d)		24-25	26-28	●	●	●	●			◆		BWB	(WB)	70,670	
BW-8	Review of water demand study		22-23							●	◆		BWB	-	1,500	
Mzuzu (NRWB)		94,205	27,011	111,814											233,030	
MW-1	Phase 1, New water source Lambilambi dam including transports system (+45,000 m³/d)	15-18			●	●	●	●			◆		NRWB	(WB)	72,140	
MW-2	Network improvement	19-20	21-23					●	●			◆	NRWB	-	1,800	
MW-3	Re-examination of water demand and raw water source study		24-25							●	◆		NRWB	-	1,000	
MW-4	Phase2, New water source Lichelemu dam inclusing transports system (+29,600 m³/d)			26-30	●	●	●	●			◆		NRWB	(WB)	73,790	
MW-5	Network expansion	17-20	21-25	26-33				●	●		◆		NRWB	-	80,800	
MW-6	NRW reduction programme	19-20								●		◆	NRWB	-	3,500	Technical cooperation
Zomba (SRWB)		3,853	5,703	11,543											21,100	Scenario 2 (- dam raising)
ZW-1	Expansion existing TW (18,200 to 30,000 m³/d)	14-15			●	●	●	●			◆		SRWB	(WB)	- (8,140)	Construction is ongoing.
ZW-2	Network improvement	17-20	21					●	●			◆	SRWB	-	3,600	
ZW-4a2	Raising of Mulunguzi dam and associated rehabilitation works (+6,100 m³/d)		25	26-28	●	●	●	●			◆		#REF!	-	10,200	Scenario 2a
ZW-5a2	Network expansion	19-20	21-25	26-33				●	●		◆		SRWB	-	7,300	Scenario 2a, 2b

Note: (WB) or (JICA) is indicating that "Although WB or JICA has been planned it but not yet decided.".
"-" is indicating that "Although the Project Team has planned it, the donor is not yet decided.".

Source: Project Team

9.1.4 Evaluation of Severity of Project and its Components

Even though the feasibility studies and detailed design are implemented for the 4 cities, each plan has differences in the level of planning and project scales as shown in **Table 9.4**. In the studies, all projects for water supply are evaluated from many viewpoints and as a consequence optimistic plans are selected in each city. As for the maturity, feasibility studies and/or more detailed investigations or discussions are necessary for Blantyre, Mzuzu and Zomba Cities in terms of following matters.

In addition, in the Project, Economic Internal Rate Return (EIRR) is estimated as one of the indicator for development of water supply for each city. The values of EIRR is more than 10 % (social discount rate) ,which means that all proposed projects for the cities are feasible to implement.

Table 9.4 Condition of Development of Water Supply Facilities for 4 Cities

Cities	Project Cost (mil USD)	EIRR (%)	Served Population (2035)		Construction cost per capita (USD)	Study level by Development Partners	Maturity of Project for Target Year (2035)		Major Facilities to abstract water resources
			by Project	Total			Level	Condition	
Lilongwe	517.1	13.2	1,027,696	1,914,280	503	F/S	High	It has a tight schedule to increment of abstruction and production capacity.	Borehole, heightning of dam, two dams
Brantyre	315.4	19.4	1,577,208	827,879	200	F/S	Middle	WB concluded to the construction of Waker ferry pumping station but not Monbezi; however, MoAIWD will be further detalied investigations.	Dam or Pumping Station
Mzuzu	228.5	10.1	375,216	226,914	609	F/S	Low	WB mentioned dam site of stage II should be examined with enough informationby 2020.	Two dams
Zomba	29.2	20.7	189,042	89,329	155	D/D (Taget year 2020)	Low	Necessity of detailed study because per capita water consumption is larger than Lilongwe and Nlantyre. Construction of dam have been already started	Dam(2020) and heightniing of dam(2030)

Source: Project Team, WB

Judging from indicators: number of served population by proposed projects, technical difficulty, cost, maturity of project and emergency, the priority order of construction of facilities are scored and ranked as shown in **Table 9.5.**

Table 9.5 Rank of Severity for Project in City Level and Components

Priority of City level	Component	Projects / Activities	Severity from Population	Thechnical Difficulty	Cost	Maturity	Emergency	Total Score	Rank
Lilongwe (LWB)									
First	Com-1 (LW-1 to 2)	Groundwater borehole+Extension TWII	2	8	8	10	10	38	2
	Com-2 (LW-3 to 7)	Raising of Kamzu dam 1 and associated rehabilitation works, Extension TWII(2nd), Catcment area conservation and rehabilitation, Network Improvement(with NRW programme), Full implementation of GIS/Hydraulic model	4	4	7	10	10	35	3
	Com-3 (LW-8 to 11)	Phase 1, New water source Diamphwe dam including transports system, telemetry system, rehabilitation of TWII, Network expansion with NRW Programme	9	2	1	5	5	22	7
	Com-4 (LW-12 to 13)	Review of water demand study, Phase 2, New water source Diamphwe dam including transports system	10	2	6	5	1	24	6
Blantyre (BWB)									
Second	Com-1 (BW-1 to 4)	Network improvement with additional NRW reduction programme, metering and water leakage control, Phase 1, New water source from Shire River including transports system	7	6	2	5	10	30	4
	Com-2 (BW-4 to 8)	Poverty program (Kiosk and Toilet development), Phase 2, New water source from Shire River including transports system, Review of water demand study	7	6	3	5	1	22	7
Mzuzu (NRWB)									
Third	Com-1 (MW-1 to 2)	Phase 1, New water source Lambilambi dam including transports system, Network improvement	6	2	5	5	10	28	5
	MW-3 to 6)	Re-examination of water demand and raw water source study, Phase2, New water source Lichelemu dam including transports system, Network expansion, NRW reduction programme	5	2	4	1	5	17	10
Zomba (SRWB)									
Fourth	Com-1 (ZW-1 to 2)	Expansion existing TW, Network improvement (On-going)	3	10	10	10	10	43	1
	Com-2 (ZW-4a to 5a)	Raising of Mulunguzi dam and associated rehabilitation works, Network expansion	1	4	9	1	5	20	9

Source: Project Team

In addition, since the number of served population of each town is smaller than that of the four cities, the severity in the four cities is more significant than the towns. EIRR of towns is estimated at 17.30%.

1) Lilongwe City

The maturity of plans is very high compare with the other ones for Blantyre, Mzuzu and Zomba. The construction of all proposed facilities are recognized as essential works to satisfy the water demand in 2035, especially the construction two dams (Diamphwe lower and upper). In addition, the number of served population is the highest among the cities. In this context, the water supply plan for the Lilongwe City can be said to be the highest priority task.

2) Blantyre City

Regarding development of water source, WSIP-WB recommended the installation of Walker’s Ferry instead of Mombezi dam; however, MoAIWD did not conclude the selection clearly. Whichever plan is selected, the water source capacity will be more than the water demand in 2035. In this context, it can be said that the maturity of project in Blantyre is lower level compared with the plan of Lilongwe City. In addition, the number of served population of Blantyre City is the second largest following that of the Lilongwe City.

3) Mzuzu City

Although the construction of two dams was planned to develop water source capacity (Stage 1 Lambilmbi dam, Stage 2: Lichelemu dam) , WSIP-WB is recommended to reexamine the dam site for stage 2 to meet water demand beyond 2040 year. Thus, the development plan of water source capacity for Mzuzu City by 2026 was almost fixed but the plan should be reviewed to meet future water demand and examine more effective use of property of water facilities in consideration of future conditions. Because of this situation, it can be seen that the maturity of water supply plan for Mzuzu City is lower level compared with that of Lilongwe and Blantyre. In addition, the number of served population of the Mzuzu City ranks third among 4 cities with a large difference with Lilongwe and Blantyre.

4) Zomba City

In the detailed designed study, the unit water consumption per capita for domestic use of Zomba city is twice or three times of the volume of that of Blantyre, Lilongwe and Mzuzu. The plan should be revised in terms of 1) per capita water consumption and 2) new water resources development after 2020 although the heightening of Mulunguzi dam is proposed to meet future water demand with review of water consumption in the Project. In this sense, the maturity of water supply plan for Zomba City is lower level in comparison with Blantyre and Mzuzu City. As for the number of served population, the Zomba City has the lowest number among 4 cities.

9.1.5 Water Supply for Towns by Regional Water Boards

(1) Planning Concept

Regional water boards (RWB) supply domestic water to towns in Malawi. The development plan for towns managed by 3 Regional Water Boards is arranged by the following process

- Service coverage: 95% in2015, 98% in 2025-2030 (in accordance with WB-WISP)
- Water demand in 2020-2035 is estimated based on 2012 population in Service Area of the RWBs.
- Intake capacity of water source in 2012, by the water sources from river/lake/groundwater/dam, is reviewed in order to compare with water demand projection.
- In accordance with "factor for priority" in **Table 9.6**, the water supply scheme is prioritized.

Table 9.6 Outline of Project of Regional Water Boards

Service Area		Towns
Contents of the Project		Rehabilitation/Expansion of Water Supply Facilities to meet future water demand (including Capacity Development of RWB for maintenance)
Demand Projection	Population	Population in Service Area
	Growth Rare	Estimated from Census 2008
Water Consumption		Using Expected Water Consumption, Service Rate of House connection, Public tap showing **Part I.**
Factor for Priority on Plan		- Intake Condition= Existing Intake Capacity/Water Demand in 2012 <60%: A, 61-90%: B, 90%< : C - Population in 2035 <10,000 : C, 10,000-50,000: B, 50,000< : A - Combination of Priority by Intake Condition & Population AA, AB, BA -> Priority A -> Short-term BB, AC, CA -> Priority B -> Middle-term Others -> C -> Long-term

Source: Project Team

(2) Priority Order of Development by Scheme

Following **Table 9.7** shows Scheme-wise priority selection in 3 Regional Water Boards. Setting of priority of A, B and C are corresponding to short, middle and long term planning. Both surface water and groundwater will be developed for water supply to the towns.

Table 9.7 Existing Intake Capacity and Future Water Demand of the WSS

Region	District	Water Scheme	Population in 2012	Type of Water Source	Population projected in 2035	Existing Facilities Intake Capacity (m^3/day)	Regional Water Board Projected Water Demand of the Water Schems (m^3/day)						Intake condition = Existing Intake capa/ Prjected Water Demand	Priority by Population of 2035	Priority by Intake Condition	Priority by population and intake conditrion
							2,012	2,015	2,020	2,025	2,030	2,035				
North	Chitipa	CHITIPA Boma	23,313	Borehole	75,918	780	1,237	1,721	2,575	4,271	7,135	10,431	63%	A	B	A
	Karonga	KARONGA Boma	45,368	Lake	97,696	3,600	3,628	3,968	4,744	6,780	10,315	14,143	99%	A	C	B
		CHILUMBA	21,732	Lake	43,455	1,195	1,552	1,810	2,320	3,404	4,952	6,598	77%	B	B	B
	Nkhata Bay	NKHATABAY	24,334	Lake	36,632	1,944	1,802	1,883	2,366	3,309	4,568	5,794	108%	B	C	C
		CHINTHECHE	7,933	Lake	15,863	850	876	915	1,032	1,366	1,946	2,552	97%	B	C	C
	Rumphi	RUMPHI	44,122	River	73,354	1,008	2,361	2,800	3,652	5,550	8,051	10,522	43%	A	A	A
	Mzimba	MZIMBA	27,824	River	63,672	1,224	2,566	2,763	3,241	4,533	6,840	9,359	48%	A	A	A
	Total				406,588	10,601	14,024	15,859	19,931	29,214	43,807	59,400	76%			
Region	District	Water Scheme	Population in 2012	Type of Water Source	Population projected in 2035	Existing Facilities Intake Capacity (m^3/day)	Regional Water Board Projected Water Demand of the Water Schems (m^3/day)						Intake condition = Existing Intake capa/ Prjected Water Demand	Priority by Population of 2035	Priority by Intake Condition	Priority by population and intake conditrion
							2,012	2,015	2,020	2,025	2,030	2,035				
Central	Kasungu	KASUNGU	66,117	Dam	143,321	2,432	3,034	3,803	4,968	7,500	13,270	20,390	80%	A	B	A
	Nkhotakota	NKHOTAKOTA	32,729	Borehole	55,923	936	1,735	2,217	2,951	4,470	6,394	8,352	54%	A	A	A
		DWANGWA	12,662	Borehole	26,009	288	459	603	822	1,293	2,327	3,599	63%	B	B	B
	Ntchisi	NTCHISI	18,404	Borehole	38,483	576	828	1,015	1,296	1,948	3,480	5,379	70%	B	B	B
	Dowa	DOWA	16,298	Borehole & River	39,293	576	636	874	1,242	1,971	3,561	5,540	91%	B	C	C
		MPONELA	20,745	Borehole	50,013	576	719	1,022	1,493	2,423	4,445	6,963	80%	A	B	A
		MADISI	10,507	Borehole	25,331	288	357	521	776	1,263	2,287	3,561	81%	B	B	B
	Salima	SALIMA	42,838	Borehole	89,575	2,400	2,274	2,727	3,403	4,948	8,563	13,041	106%	A	C	B
		SENGA-BAY	2,929	Borehole	5,718	360	240	277	332	483	655	807	150%	C	C	C
		CHIPOKA	3,371	Lake	6,582	504	303	345	407	535	808	1,136	166%	C	C	C
		PARACHUTTE BATTALLION	1,346	Borehole	1,346	158	623	644	664	711	744	777	25%	C	A	B
		MAFCO	5,457	Lake	5,457	1,800	2,910	2,991	3,057	3,241	3,390	3,547	62%	C	B	C
	Lilongwe Rural	LIKUNI	52,160	Borehole	92,620	2,400	2,802	3,343	4,149	5,911	9,636	14,042	86%	A	B	A
		BUNDA	27,109	Dam	48,137	478	502	917	1,573	2,710	4,620	6,881	95%	B	C	C
	Mchinji	MCHINJI	17,288	Borehole & River	39,737	1,000	1,586	1,793	2,088	2,893	4,349	5,933	63%	B	B	B
		KOCHILIRA	4,515	Borehole	10,043	432	410	512	670	926	1,374	1,932	105%	B	C	C
	Dedza	DEDZA	36,747	Borehole	66,850	720	1,573	2,056	2,792	4,436	6,722	9,080	46%	A	A	A
		BEMBEKE	1,937	River	3,308	57	89	114	152	224	356	509	64%	C	B	C
		DEDZA SECONDARY SCHOOL	2,982	River	5,093	160	381	444	539	692	938	1,222	42%	C	A	B
	Ntcheu	NTCHEU	14,953	Borehole & River	34,915	1,500	879	1,101	1,437	2,208	3,443	4,835	171%	B	C	C
	Total				787,754	17,641	22,338	27,320	34,811	50,786	81,362	117,526				
Region	District	Water Scheme	Population in 2012	Type of Water Source	Population projected in 2035	Existing Facilities Intake Capacity (m^3/day)	Regional Water Board Projected Water Demand of the Water Schems (m^3/day)						Intake condition = Existing Intake capa/ Prjected Water Demand	Priority by Population of 2035	Priority by Intake Condition	Priority by population and intake conditrion
							2,012	2,015	2,020	2,025	2,030	2,035				
South	Mangochi	MANGOCHI	34,944	River	80,322	2,700	2,895	3,205	3,852	5,523	8,442	11,618	93%	A	C	B
		MONKEYBAY	14,300	Lake	32,467	1,498	1,824	2,012	2,408	3,213	4,430	5,806	82%	B	B	B
		NAMWERA	7,626	Borehole	17,314	108	398	465	593	882	1,575	2,458	27%	B	A	A
	Machinga	MACHINGA	3,909	River	8,184	108	914	965	1,098	1,347	1,718	2,132	12%	C	A	B
		LIWONDE	26,977	River	61,593	1,531	2,028	2,204	2,589	3,757	5,951	8,337	76%	A	B	A
	Balaka	BALAKA	31,340	Dam	78,360	1,629	1,907	2,286	2,990	4,642	7,463	10,646	85%	A	B	A
	Zomba rural	DOMASI	144,186	River	284,564	923	569	587	645	887	1,290	1,675	162%	A	C	B
		CHAWE	8,065	River	12,243	144	566	582	638	753	898	1,040	25%	B	A	A
	Chiradzulu	CHIRADZULU	2,426	River	3,683	101	234	253	298	411	559	695	43%	C	A	B
		NAMADZI Trading Center	3,182	River	4,287	142	217	219	233	308	431	541	66%	C	B	C
	Mwanza	MWANZA	2,835	River	3,819	576	1,100	1,474	2,130	3,480	6,541	10,218	52%	C	A	B
	Thyolo	THYOLO	29,305	River	74,947	840	1,094	1,171	1,353	1,803	2,565	3,396	77%	A	B	A
	Thyolo	LUCHENZA	9,501	Borehole & River	20,595	346	924	1,005	1,183	1,634	2,634	3,771	37%	B	A	A
		MIKOLONGWE	15,356	Borehole & River	24,827	36	62	67	78	105	142	177	58%	B	A	A
	Mulanje	MULANJE	684	River	1,047	1,700	2,097	2,216	2,516	3,263	4,237	5,144	81%	C	B	C
		MULOZA Trading Center	20,685	Borehole	28,233	302	408	499	665	1,036	1,310	1,504	74%	B	B	B
	Phalombe	PHALOMBE	7,826	River	10,682	330	453	572	786	1,215	2,275	3,662	73%	B	B	B
	Chikwawa	CHIKWAWA	7,865	Borehole	25,737	648	1,407	1,706	2,258	3,416	4,549	5,562	46%	B	A	A
		NGABU Trading Center	18,674	Borehole	36,879	576	783	896	1,117	1,640	2,859	4,339	74%	B	B	B
		NCHALO Trading Center	15,453	Borehole	30,518	432	613	788	1,101	1,759	3,157	4,857	70%	B	B	B
	Nsanje	NSANJE	17,821	Borehole	35,194	504	883	1,123	1,555	2,382	3,954	5,841	57%	B	A	A
		BANGULA	21,928	Borehole	39,433	130	442	519	666	988	1,676	2,502	29%	B	A	A
	Total				914,926	15,303	21,817	24,814	30,753	44,446	68,656	95,921				

Source: Project Team, RWB

(3) Outline of the Projects

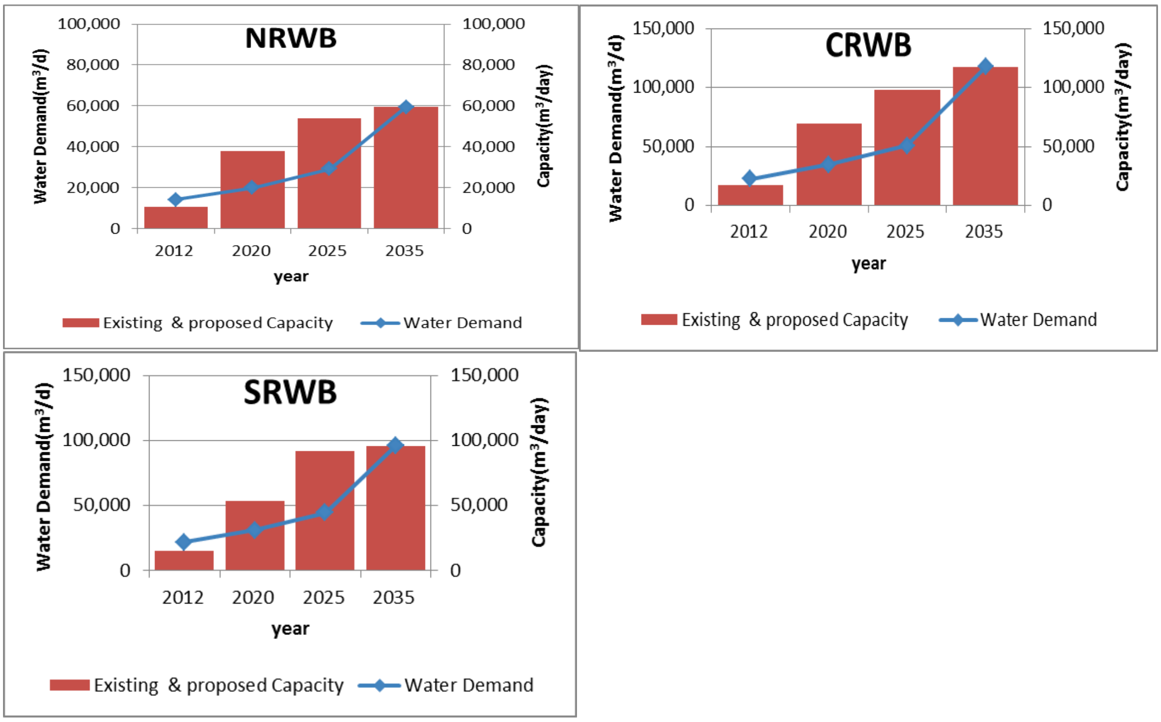
Table 9.8 shows outline of the Projects for RWBs when the implementation will conducted on schedule, with scheme number to be improved and projected population of 2035. **Figure 9.3** shows water demand projection and intake capacity when the implementation will be conducted on the schedule of short-, middle- and long-term plan as selected. It is clear to understand that the existing intake water capacity will be almost half in 2020 under setting of water demand projection.

It goes without saying this selection is done roughly based on the condition of water supply facilities in 2012, each Regional Water Boards have to conduct more detailed investigation or feasibility studies, and consequently modify their Business Plan.

Table 9.8 Outline of the Projects in Short, Middle and Long-terms

Service Area	Responsible entity	Outline of Project, Idea of Priority Selection	2012-2020(Short Term Plan)		2021-2025(Middle Term Plan)		2026-2035(Long Term Plan)	
			No. of Schemes	Population	No. of Schemes	Population	No. of Schemes	Population
Towns in Northern Region	NRWB	-Rehabilitation/ Expansion of Facilities -Necessity of Intake Capacity -Scale of population in town-wise	3	212,943	2	141,151	2	52,494
Towns in Central Region	CRWB	Ditto	5	408,727	7	225,576	8	153,451
Towns in Southern Region WB	SRWB	ditto	10	390,244	10	519,349	2	5,334

Source: Project Team



Source: Project Team

Figure 9.3 Water Demand and Project Implementation for NRWB

9.2 Rural Water Supply

9.2.1 Development Concept

Development concept of the Water supply master plan for the rural area is as follows.

- Proceeding the Project for Market Center as high priority: Market Center is core of the rural area, and there is tendency of high growing population in the Market Center by immigration from rural area. It is important to conduct implementation of the water supply facility in haste.
- Proceeding the Project for Gravity-fed Piped Water Schemes in Rural Area: 20-30 years have passed around after construction of Gravity-fed water supply project. Then, water supply facilities are aged and damaged in many places. It is important to conduct rehabilitation/expansion. The population covered by the Project is almost 8% of the rural area.
- Monitoring & Evaluation of Existing Borehole & Protected Shallow Wells: Improvement of O&M capacity by the communities is urgent issue for the schemes by borehole. Monitoring and capacity development assistance has been implemented in these years, but it is required to more strength.
- New Borehole Drilling: Still there is around 30%, i.e., around 3 million people have no access to the safety water. If aquifer is available, borehole is effective approach to ensure water in the rural area.

Water supply projects in the rural area are carried out by MoAIWD, Local government and concerning Regional Water Boards. **Table 9.9** responsibilities shows and activities of these 3 organizations on the Project.

Table 9.9 Responsibilities and Activities of these 3 Organizations on the Project

Category	MoAIWD	Local Government	3 Regional Water Boards
Market Center	Policy, Law, Strategy Planning & Programming Monitoring & Evaluation Coordinating Funds Coordination of Research and Development Facilitating transfer MCWSS to RWBs	Coordinating Activities Managing and supervising WUA Participating in Planning & management Monitoring & Evaluation Facilitating formation of WUA's or other management arrangement	Recruitment & supervision of F/S Consul.& Contractors Planning & Implementing Project Providing technical assistance and OJT to communities Management of the scheme when LG transfer to RWBs
Gravity-fed Rural water Schemes	Policy, Law, Strategy Planning & Programming Monitoring & Evaluation Coordinating Funds Coordination of Research and Development		Providing technical assistance and OJT to communities
Boreholes, Protected shallow well, Protected spring			-

Source: Project Team

9.2.2 Market Center

(1) Promotion of the Project for Market Center

As mentioned in the Part I Section 5.1.3, Market Center is very important as a core of rural area. **Table 9.11** to **Table 9.13** shows the list of Market Centers. This list is basically prepared by the information provided by MoAIWD and Regional Water Offices.

18 market centers of 154 in the list have been managed by the Regional Water Boards. Others have few water supply schemes, i.e., only hand-pump is means of water supply.

Detailed population and existing condition has been collected from District Assembles, Health Office and Water Offices.

Existing water supply conditions in the market center are as follows.

- This list shows totally 154 market centers
- Water source is mountainous stream or groundwater
- Water scheme is Gravity-fed rural water supply or borehole with hand pump
- Population has increased, and the capacity of water scheme is not enough to supply water demand.

(2) Road Map, Development Goal and Priority List

Table 9.11 to **Table 9.13** shows list of Market Center with Population Projection in 2015 to 2035 and priority setting. When water supply scheme has been or planned to manage by the Regional Water Boards, the rank is set to “A”. The schemes prioritized by MoLGRD as “No.1” is given “A”, too. Scale of the population is also used as a factor to prioritize. Total priority was selected these evaluation and scale of population.

Table 9.10 Outline of Project of Market Center

Service Area		Towns
Responsible Entity		MoAIWD
Contents of the Project		Rehabilitation/Expansion/New Construction of Water Supply Facilities to meet future water demand Water supplied population: 73% in2015, 98% in 2025-2035
Demand Projection	Population	Population in Market Center incl. Market function
	Growth Rare	Based on Estimated from Census 2008
Water Consumption		Using Expected Water Consumption, Service Rate of House connection, Public tap
Factor for Priority on Plan		RWB manages/plan to manage water supply scheme : A MoLGRD gives Priority as NO.1: A Population in 2035 <5,000 : C, 5,000-10,000: B, 10,000< : A Combination of Priority by RWB management & MoLGRD & Priority AAA → A → Short-term Out of “A” and “C” → B → Middle-term Population “ C” → C → Long-term

Source: Project Team

(3) Availability of Water Source

Majority of water source for the Market Centers is by groundwater with power pump. Others are by lake and river water. Availability of groundwater as quantity and quality needs to be reviewed and investigated well because the water demand for the Market Center is larger than the amount for Communities and information of the water source is not enough.

(4) Component of Water Supply Scheme

Facility’s component for Market Center is Borehole, Elevated tank (if there is suitable site, it is better to place on ground), Distribution with public taps. Center of Market Center can be used house connection, especially in commercial zone.

Table 9.11 List of Market Center (1/3)

Region	District	Rural market centre	Population in 2012	Population in District in 2012	Population 2015	Population 2020	Population 2025	Population 2030	Population 2035	Proposed water source	Priority of MoLGRD	Under Project (management of RWB/planning)	Priority by Population in 2035 / by MoLGED / Under Project "Y"
North	Chitipa	Nthalire	5,400	15,998	5,933	6,949	8,133	9,491	11,021	Groundwater	No.1		A
		Misuku	6,000		6,592	7,722	9,037	10,545	12,245	River	No.2		A
		Kameme	4,598		5,052	5,917	6,925	8,081	9,384	Groundwater			B
	Karonga	Songwe	4,000	25,504	4,422	5,224	6,144	7,199	8,367	Groundwater		Y	A
		Chilumba	7,039		7,782	9,193	10,813	12,668	14,724	Lake	No.1	Y	A
		Nyungwe	2,573		2,844	3,360	3,952	4,630	5,382	Groundwater			B
		Chitimba	3,957		4,374	5,168	6,078	7,121	8,277	Groundwater			B
		Kaporo	4,218		4,663	5,508	6,479	7,591	8,823	Groundwater	No.2		B
		Mulare	3,716		4,083	4,824	5,674	6,647	7,726	Groundwater			B
	Nkhata-Bay	Mzenga	8,705	34,083	9,438	10,756	12,160	13,683	15,256	Groundwater	No.1		A
		Usisya	6,341		6,875	7,835	8,857	9,967	11,113	River	No.2		A
		Kande	1,078		1,169	1,332	1,506	1,694	1,889	Groundwater			C
		Mpamba	9,220		9,997	11,393	12,880	14,494	16,160	Groundwater			A
		Chintheche	4,205		4,559	5,196	5,874	6,610	7,370	Lake			B
		Chikwina	4,535		4,917	5,603	6,334	7,128	7,948	River		Y	A
	Likoma	Likoma	7,683	7,683	8,335	9,505	10,755	12,339	14,140	Lake			A
	Rumphi	Katowo	3,718	37,977	4,084	4,767	5,554	6,442	7,434	River	No.1		A
		Nchenachena	6,691		7,349	8,580	9,995	11,593	13,379	River	No.2		A
		Livingstonia	9,321		10,238	11,953	13,925	16,151	18,638	River			A
		Mphompha	4,887		5,368	6,267	7,301	8,468	9,773	Groundwater			B
		Bolero	8,046		8,838	10,318	12,020	13,941	16,088	River			A
		Chiweta	5,314		5,837	6,815	7,939	9,208	10,626	Groundwater			A
	Mzimba	Euthini	5,699	51,092	6,271	7,365	8,579	9,936	11,396	Groundwater	No.1		A
		Emfeni	1,925		2,118	2,488	2,898	3,356	3,849	Groundwater	No.2		C
		Ekwendeni	13,695		15,069	17,698	20,616	23,876	27,386	River			A
		Mbalachanda	3,750		4,126	4,846	5,645	6,538	7,499	Groundwater			B
		Bulala	2,984		3,283	3,856	4,492	5,202	5,967	Groundwater			B
		Edingeni	5,503		6,055	7,112	8,284	9,594	11,004	Groundwater			A
		Chikangawa	2,751		3,027	3,555	4,141	4,796	5,501	River			B
		Embangweni	5,489		6,040	7,093	8,263	9,570	10,976	Groundwater			A
		Champhira	1,875		2,063	2,423	2,823	3,269	3,749	River			C
		Kafukule	2,500		2,751	3,231	3,763	4,359	4,999	Groundwater			C
		Manyamula	1,832		2,016	2,368	2,758	3,194	3,663	Groundwater			C
		Jenda	3,089		3,399	3,992	4,650	5,385	6,177	Groundwater			B
	Total	**34**	**172,337**						**337,932**				

Source: Project Team, RWB management, MoLGRD

Table 9.12 List of Market Center (2/3)

Region	District	Rural market centre	Population in 2012	Population in District in 2012	Population 2015	Population 2020	Population 2025	Population 2030	Population 2035	Proposed water source	Priority of MoLGRD	Under Project (management of RWB/planning)	Priority by Population in 2035 / by MoLGED / Under Project "Y"
Central	Kasungu	Nkhamenya	6,990	24,216	8,607	11,782	15,569	20,094	25,057	River	No.1	Y	A
		Chisemphere	3,540		4,359	5,967	7,885	10,177	12,691	River	No.2	Y	A
		Chamama	7,400		9,113	12,474	16,484	21,274	26,528	River			A
		Santhe	6,286		7,741	10,596	14,002	18,071	22,535	River		Y	A
	Nkhotakota	Msenjere	3,730	43,622	4,141	4,923	5,833	6,892	8,085	Groundwater	No.1		A
		Dwambazi	8,000		8,882	10,559	12,510	14,781	17,342	River	No.2		A
		Dwangwa	12,662		14,058	16,712	19,801	23,395	27,448	Groundwater		Y	A
		Mwasambo	6,400		7,105	8,447	10,008	11,825	13,873	Groundwater			A
		Benga	4,130		4,585	5,451	6,458	7,631	8,953	Groundwater	No.2		B
		Bua	2,190		2,431	2,890	3,425	4,046	4,747	Groundwater	No.1		C
		Liwalazi	1,980		2,198	2,613	3,096	3,658	4,292	Groundwater	No.2		C
		Kasitu	2,100		2,331	2,772	3,284	3,880	4,552	Groundwater	No.2		C
		Ngala	2,430		2,698	3,207	3,800	4,490	5,267	Groundwater	No.2		B
	Ntchisi	Malomo	4,200	6,108	4,670	5,570	5,185	6,165	5,741	Groundwater	No.1		A
		Khuwi	1,908		2,122	2,530	2,355	2,801	2,608	Groundwater	No.2		C
	Dowa	Madisi	10,500	31,538	11,533	13,506	15,831	18,497	21,568	Groundwater		Y	A
		Nambuma	4,870		5,349	6,264	7,342	8,579	10,003	Groundwater	No.1		A
		Bowe	3,400		3,734	4,373	5,126	5,990	6,984	Groundwater	No.2		B
		Mvera	3,968		4,358	5,104	5,982	6,990	8,151	Groundwater			B
		Mponela	4,300		4,723	5,531	6,483	7,575	8,833	Groundwater	No.1	Y	A
		Lumbazi	4,500		4,943	5,788	6,785	7,927	9,243	Groundwater	No.1	Y	A
	Salima	Thavite	1,460	16,100	1,615	1,906	2,247	2,653	3,125	Groundwater	No.1		C
		Chagunda	1,800		1,991	2,350	2,770	3,270	3,852	Groundwater	No.2		C
		Khombedza	2,800		3,097	3,655	4,309	5,087	5,993	Groundwater			B
		Chipoka	7,640		8,450	9,974	11,756	13,881	16,351	River		Y	A
		Kaphatenga	2,400		2,654	3,133	3,693	4,360	5,137	Groundwater	No.1		A
	Lilongwe	Kasiya	3,915	47,973	4,460	5,476	6,630	7,965	9,439	Groundwater		Y	A
		Nkhoma	5,320		6,060	7,441	9,009	10,823	12,826	Groundwater	No.2		A
		Nsaru	2,620		2,984	3,664	4,436	5,330	6,316	Groundwater		Y	A
		Namitete	6,891		7,850	9,638	11,669	14,020	16,613	Groundwater			A
		Sinyala	2,400		2,734	3,357	4,064	4,883	5,786	Groundwater			B
		Mitundu	6,872		7,828	9,612	11,637	13,981	16,568	Groundwater		Y	A
		Nathenje	5,645		6,430	7,896	9,559	11,485	13,609	River			A
		Chimutu	2,800		3,189	3,916	4,741	5,697	6,750	Groundwater			B
		Lumbadzi	7,400		8,429	10,350	12,531	15,055	17,840	Groundwater		Y	A
		Kabudula	2,130		2,426	2,979	3,607	4,333	5,135	Groundwater	No.2		B
		Mpingu	1,980		2,255	2,769	3,353	4,028	4,774	Groundwater	No.2		C
	Mchinji	Mkanda	8,750	28,135	9,390	10,602	12,023	13,665	15,537	Groundwater	No.1	Y	A
		Kapiri	5,645		6,058	6,840	7,757	8,816	10,024	Groundwater	No.1		A
		Kamwendo	10,110		10,850	12,251	13,893	15,790	17,953	Groundwater		Y	A
		Kochirira	1,780		1,910	2,157	2,446	2,780	3,161	Groundwater	No.1		C
		Nthema	1,850		1,985	2,242	2,542	2,889	3,285	Groundwater	No.2		C
	Dedza	Mtakataka	6,369	35,849	7,604	10,012	12,826	16,131	19,732	Groundwater	No.1		A
		Mayani	5,039		6,016	7,921	10,147	12,762	15,611	Groundwater	No.2		A
		Linthipe	3,886		4,639	6,108	7,825	9,841	12,038	Groundwater		Y	A
		Lobi	9,905		11,826	15,571	19,947	25,086	30,687	Groundwater			A
		Golomoti	6,400		7,641	10,061	12,888	16,209	19,828	Groundwater			A
		Chimbiya	1,750		2,089	2,751	3,524	4,432	5,422	Groundwater	No.2		B
		Bembeke	2,500		2,985	3,930	5,034	6,332	7,745	River	No.1		A
	Ntcheu	Lizulu	4,696	30,991	5,221	6,227	7,412	8,813	10,444	River			A
		Senzani	5,333		5,930	7,073	8,419	10,011	11,863	Groundwater	No.2		A
		Bwanje	4,137		4,601	5,487	6,531	7,766	9,202	Groundwater			B
		Bilila	3,665		4,076	4,861	5,786	6,880	8,153	Groundwater			B
		Tsangano	2,659		2,957	3,526	4,198	4,991	5,915	River			B
		Manjawira	3,000		3,336	3,978	4,736	5,631	6,673	River	No.2		B
		Chingeni	2,700		3,002	3,581	4,262	5,068	6,005	River	No.2		B
		Mlangeni	3,000		3,336	3,978	4,736	5,631	6,673	Groundwater	No.1		A
		Kampepuza	1,800		2,001	2,387	2,841	3,379	4,004	River	No.2		C
	Central Region	**58**	**264,532**	**264,532**					**634,567**				

Source: Project Team, RWB management, MoLGRD

Table 9.13 List of Market Center (3/3)

Region	District	Rural market centre	Population in 2012	Population in District in 2012	Population 2015	Population 2020	Population 2025	Population 2030	Population 2035	Proposed water source	Priority of MoLGRD	Under Project (management of RWB/planning)	Priority by Population in 2035 / by MoLGED / Under Project "Y"
South	Mangochi	Makanjira	5,800	40,758	6,289	7,178	8,174	9,305	10,551	Groundwater			A
		Malindi	6,800		7,373	8,416	9,583	10,909	12,371	Groundwater	No.1		A
		Namwera	6,500		7,047	8,045	9,160	10,427	11,825	Groundwater		Y	A
		Nankumba	1,200		1,301	1,485	1,691	1,925	2,183	Groundwater			C
		Chilipa	2,108		2,286	2,609	2,971	3,382	3,835	Groundwater			C
		Maldeco	5,400		5,862	6,745	7,781	8,949	10,271	Lake		Y	A
		Namiyasi	3,450		3,745	4,310	4,971	5,717	6,562	Lake	No.1		A
		Monkey Bay	6,300		6,839	7,870	9,078	10,440	11,983	Lake		Y	A
		Cape Maclear	3,200		3,474	3,997	4,611	5,303	6,086	Lake	No.1		A
	Balaka	Phalula	7,293	17,873	7,959	9,240	10,740	12,448	14,402	River	No.1		A
		Ulongwe	5,311		5,796	6,729	7,821	9,065	10,488	Groundwater	No.2		A
		Mangochi Turn off	3,100		3,383	3,928	4,565	5,291	6,122	Groundwater	No.1		A
		Kachenga	2,170		2,368	2,750	3,196	3,704	4,285	Groundwater	No.2		C
	Machinga	Nayuchi	3,200	11,096	3,474	3,997	4,611	5,303	6,086	Groundwater	No.1		A
		Ngokwe	1,800		1,954	2,248	2,594	2,983	3,424	Groundwater	No.2		C
		Chikweo	1,740		1,889	2,173	2,507	2,883	3,309	Groundwater			C
		Nsanama	2,175		2,361	2,717	3,134	3,604	4,137	River		Y	C
		Ntaja	2,181		2,368	2,725	3,143	3,615	4,149	River		Y	C
	Zomba	Namwera T/Off	1,800	23,550	1,998	2,389	2,865	3,424	4,087	River		Y	C
		Turn Off (Malosa)	1,202		1,334	1,595	1,913	2,286	2,729	River			C
		Chinseu	2,700		2,997	3,583	4,297	5,136	6,130	River	No.1		A
		Jali	3,240		3,596	4,300	5,156	6,163	7,356	River	No.2		B
		Kachulu	1,348		1,496	1,789	2,145	2,564	3,061	Groundwater			C
		Mayaka	3,400		3,774	4,512	5,411	6,468	7,719	Groundwater			B
		Chingale	3,600		3,996	4,777	5,729	6,848	8,173	River			B
		Malosa	2,145		2,381	2,846	3,414	4,080	4,870	River	No. 1		C
		Thondwe	4,115		4,568	5,461	6,549	7,828	9,343	Groundwater	No.1	Y	A
	Chiradzulu	Namadzi	2,944	14,944	3,227	3,780	4,454	5,236	6,163	River	SRWB manages water		B
		Namitambo	1,500		1,644	1,926	2,270	2,668	3,140	Groundwater	No.1		C
		Mbulumbuzi	3,100		3,398	3,981	4,690	5,514	6,490	Groundwater	No.2		B
		Mbulumbuzi	3,120		3,420	4,007	4,721	5,550	6,532	Groundwater	No.1		A
		Nguludi	2,150		2,357	2,761	3,253	3,824	4,501	Groundwater	No.1		C
		Milepa	2,130		2,335	2,735	3,223	3,789	4,459	Groundwater	No.1		C
	Blantyre	Lirange Nkula	7,620	12,274	9,182	12,239	15,876	20,174	24,935	Groundwater	SRWB manages water		A
		Linjidzi	3,194		3,848	5,130	6,654	8,455	10,451	Groundwater	No.1		A
		Chikuli	1,460		1,759	2,345	3,042	3,865	4,778	Groundwater	No.2		C
	Mwanza	Thambani	4,200	8,000	4,493	5,037	5,639	6,277	6,955	Groundwater	No.1		A
		Kunenekude	3,800		4,065	4,558	5,102	5,679	6,293	Groundwater	No.2		B
	Neno	Neno	2,281	4,631	2,451	2,782	3,177	3,639	4,181	Groundwater	No.1		C
		Lisungwi	2,350		2,525	2,867	3,274	3,749	4,308	Groundwater	No.2		C
	Thyolo	Thekerani	4,087	39,392	4,615	5,597	6,714	7,988	9,394	Groundwater			B
		Goliati	6,804		7,683	9,318	11,178	13,299	15,640	Groundwater	No.1		A
		Bvumbwe	8,800		9,937	12,051	14,457	17,200	20,228	Groundwater	No.2		A
		Luchenza	16,901		19,084	23,145	27,766	33,034	38,848	River	SRWB manages water	Y	A
		Masamanjati	2,800		3,162	3,834	4,600	5,473	6,436	Groundwater	No.2		B
	Mulanje	Muloza	5,248	18,110	5,497	5,918	6,325	6,704	7,039	Groundwater		Y	A
		Chinyama	1,347		1,411	1,519	1,623	1,721	1,807	River	No.2		C
		Nkando	1,375		1,440	1,550	1,657	1,756	1,844	River		Y	C
		Mkando	5,285		5,536	5,960	6,369	6,751	7,089	Groundwater	No.1		A
		Kamwendo	4,855		5,085	5,475	5,851	6,202	6,512	River	No.1		A
	Phalombe	Migowi	2,456	19,896	2,581	2,827	3,115	3,421	3,759	River	No.1		C
		Chitekesa	1,895		1,991	2,181	2,404	2,639	2,901	River	No.1		C
		Sombani	6,120		6,431	7,044	7,763	8,524	9,368	River	No. 1		B
		Mulomba	2,125		2,233	2,446	2,695	2,960	3,253	Groundwater	No.1		C
		Chiringa	3,120		3,279	3,591	3,957	4,346	4,776	River	No. 1		C
		Phaloni	4,180		4,393	4,811	5,302	5,822	6,398	River	No.1		A
	Chikwawa	Chapananga	6,027	40,239	6,264	6,700	7,192	7,696	8,227	River	No.1		A
		Ngabu	15,889		16,511	17,661	18,959	20,287	21,687	Groundwater	SRWB manages water	Y	A
		Nchalo	18,323		19,042	20,367	21,865	23,395	25,010	Groundwater	SRWB manages water		A
	Nsanje	Bangula	10,147	17,428	10,936	12,487	14,401	16,525	19,020	Groundwater	SRWB manages water scheme		A
		Miseu Folo	4,250		4,580	5,230	6,032	6,922	7,967	Groundwater	No.2	Y	A
		Marka	3,032		3,267	3,731	4,303	4,937	5,683	Groundwater			B
	Southern Region	**62**	**268,191**	**268,191**					**511,605**				

Source: Project Team, RWB management, MoLGRD

9.2.3 Community served by Gravity-fed Piped Water Supply Scheme

People of rural area is categorized in Market Center and Community (village). Market Center is like semi-urban and the community was almost categorized by water source, surface water by gravity-fed piped water supply scheme and groundwater by borehole. First Gravity-fed Rural Water Supply Scheme was installed in 1968, and many schemes have been installed in 1970-1980. According to the interview survey to the officers of the District Water Offices, the following challenges were pointed out.

Rehabilitation projects have been conducted by MoAIWD and/or NGO in these years. Water supply facilities were rehabilitated and expanded for increased population. In addition, management system by Water Users Association(WUA) has been introduced in accordance with the Guidelines as described below for the sustainability of the project.

The scheme of gravity-fed piped water supply has large water users, which is considered more than 10,000 of population in many cases. This project includes many communities under the large project area. It is very important that MoAIWD will take initiatives for smooth proceeding of the project and care of organizing water user association.

(1) Promotion of the Project for Gravity-fed Piped Water Supply

Basically, if there are the gravity-fed piped water supply projects (on-going or planned projects) in some areas, the areas are given priority to conduct water supply in rural communities because of the efficiency of the Project. **Table 9.15** to **Table 9.17** are the project list of gravity-fed piped water supply.

Table 9.14 Priority of Gravity-fed Piped Water Supply

Service Area		Towns
Responsible Entity		Local Government assisted by MoAIWD
Contents of the Project		Rehabilitation/Expansion of Gravity-fed Piped Water Supply Facilities, Water supplied population: 73% in2015, 98% in 2025-2035
Demand Projection	Population	Existing Water Supply Schemes
	Growth Rare	Estimated from Census 2008
Water Consumption		40 L/p/d
Factor for Priority on Plan		Population in 2035, estimated from Planned population of existing water supply schemes with growth rate of District from Census 2008 <10,000: C, 10,000-50,000: B, 50,000<: A Rate of No-Access Population to Safety from Census 2008 <30%: A, 30%<:B Availability of the Fund YES: A, NO: B Combination of Priority Fund availability=A → A Short-term Population & Accessibility AA, AB, BA → B → Middle-term Others → C Long-term

(2) Availability of Water Source

Majority of water source for the gravity-fed water supply schemes is river water with the slow filtration system.

(3) Component of Water Supply Scheme

Gravity-fed water supply scheme is composed of Intake, transmission pipe, treatment plant, service reservoir and distribution equipment.

Table 9.15 List of Gravity-fed Piped Rural Water Supply Schemes (1/3)

Region	District	Scheme	Existing Schemes: Designed Population	Existing Schemes: Number of taps	Existing Schemes: Design flow (m^3/day)	Existing Schemes: Year completed	Existing Schemes: Estimated growth rate(%)	Population in 2012 estimated from Existing Schemes	** Rate 2012 Census Population to 2012 estimated population	Population in 2012 estimated by tap water share of District in Cessus 2008	Population Projection for the Project estimated based on Designed Population with Assumption of availability: 2015	2020	2025	2030	2035	Fund	Proportion of no access to Safety Water(%) in District 2008 Census	Priority by Population	No Access to safety water	Fund	Priority by Population &Accessibility&Fund
North	MZIMBA	Champhira South	32,000	206	1334.88	1987	3.4	71,391	0.22	15,706	76,973	90,404	105,307	121,961	139,889		27.3%	A	B	B	B
	MZIMBA	Champhira North	24,000	211	1367.28	1984	3.4	59,192	0.22	13,022	63,821	74,957	87,313	101,121	115,986		27.3%	A	B	B	B
	MZIMBA	Luwazi	8,000	72	466.56	1981	3.4	21,813	0.22	4,799	23,518	27,622	32,175	37,263	42,741		27.3%	B	B	B	C
	MZIMBA	Luzi	8,000	51	330.48	1975	3.4	26,658	0.22	5,865	28,743	33,758	39,323	45,541	52,236		27.3%	A	B	B	B
	MZIMBA	Msaka	3,000	48	311.04	1986	3.4	6,920	0.22	1,523	7,462	8,764	10,208	11,823	13,560		27.3%	B	B	B	C
	MZIMBA	Khosolo	10,356	139	900.72	1983	3.4	26,410	0.22	5,810	28,475	33,444	38,957	45,117	51,750		27.3%	A	B	B	B
	RUMPHI	Nkhamanga	12,000	168	1088.64	1978	3.0	31,828	0.39	12,413	14,945	18,417	24,168	27,155	31,430	ACGF & WB	30.3%	B	A	A	A
	RUMPHI	Hewe	8,000	60	388.8	1977	3.0	21,855	0.39	8,524	10,262	12,646	16,595	18,646	21,582	AFDB	30.3%	B	A	A	A
	RUMPHI	Ng'onga	2,000	48	311.04	1972	3.0	6,334	0.39	2,470	2,974	3,665	4,810	5,404	6,255	AFDB	30.3%	C	A	A	A
	RUMPHI	Livingstonia	3,000	21	136.08	1984	3.0	6,664	0.39	2,599	3,129	3,856	5,060	5,685	6,581	AFDB	30.3%	C	A	A	A
	RUMPHI	Muhuju	1,000	61	395.28	1973	3.0	3,075	0.39	1,199	1,444	1,779	2,335	2,623	3,036	AFDB	30.3%	C	A	A	A
	RUMPHI	Ntchenachena	3,200	122	790.56	2002	3.0	4,175	0.39	1,628	1,961	2,416	3,170	3,562	4,123	AFDB	30.3%	C	A	A	A
	RUMPHI	Chitimba	950	64	414.72	1997	3.0	1,437	0.39	560	675	831	1,091	1,226	1,419	AFDB	30.3%	C	A	A	A
	RUMPHI	Bale	4,800	36	233.28	1994	3.0	7,934	0.39	3,094	3,725	4,591	6,024	6,769	7,835		30.3%	C	A	B	C
	NKATA BAY	Lifutazi	11,000	64	414.72	1987	2.8	21,342	0.22	4,695	19,683	25,173	30,212	33,997	37,907		46.4%	B	A	B	B
	NKATA BAY	Msese	7,560	32	207.36	1991	2.8	13,134	0.22	2,889	12,113	15,491	18,593	20,922	23,328		46.4%	B	A	B	B
	NKATA BAY	Luwawa	8,880	74	479.52	1999	2.8	12,369	0.22	2,721	11,407	14,589	17,510	19,704	21,970		46.4%	B	A	B	B
	NKATA BAY	Usisya	14880	124	803.52	1997	2.8	21,903	0.22	4,819	20,201	25,835	31,007	34,892	38,904	WB	46.4%	B	A	A	A
	NKATA BAY	Ruarwe	1008	12	77.76	1995	2.8	1,568	0.22	345	1,446	1,849	2,220	2,498	2,785		46.4%	C	A	B	C
	KARONGA	Lufira/Karonga	30,000	250	1620	1983	3.4	76,506	0.14	10,711	51,344	64,876	86,898	100,824	116,395		19.9%	A	B	B	B
	KARONGA	Chilumba	4,000	37	239.76	1975	3.4	13,329	0.14	1,866	8,945	11,303	15,140	17,566	20,278		19.9%	B	B	B	C
	KARONGA	Ighembe	4,000	36	233.28	1983	3.4	10,201	0.14	1,428	6,846	8,650	11,586	13,443	15,519		19.9%	B	B	B	C
	KARONGA	Iponga	5,600	37	239.76	1983	3.4	14,281	0.14	1,999	9,584	12,110	16,221	18,820	21,727		19.9%	B	B	B	C
	CHITIPA	Chisenga/Chitipa	2,800	204	1321.92	1986	3.5	6,617	0.22	1,456	4,089	5,032	6,404	6,998	7,598		37.2%	C	A	B	C
	CHITIPA	Misuku	8760	73	473.04	1984	3.5	22,177	0.22	4,879	13,703	16,865	21,462	23,453	25,463	WB	37.2%	B	A	A	A
	CHITIPA	Nthalire	6120	51	330.48	1983	3.5	16,035	0.22	3,528	9,908	12,195	15,519	16,958	18,412	ISP	37.2%	B	A	A	A
	CHITIPA	Sekwa	10200	85	550.8	1997	3.5	16,511	0.22	3,632	10,202	12,556	15,979	17,461	18,958		37.2%	B	A	B	B
	CHITIPA	Chinunkha	4200	35	226.8	1975	3.5	14,491	0.22	3,188	8,954	11,020	14,024	15,325	16,639		37.2%	B	A	B	B
	CHITIPA	Ifumbo	3600	30	194.4	1982	3.5	9,763	0.22	2,148	6,033	7,424	9,448	10,325	11,210		37.2%	B	A	B	B
	CHITIPA	Chintekwa	5160	43	278.64	1998	3.5	8,070	0.22	1,775	4,987	6,137	7,810	8,534	9,266		37.2%	C	A	B	C
Total of Northern Region			248,074	2,494				573,982		131,292	467,552	568,255	696,568	795,617	904,782						

Source: Project Team, MoAIWD

Table 9.16 List of Gravity-fed Piped Rural Water Supply Schemes (2/3)

Region	District	Scheme	Existing Schemes: Designed Population	Existing Schemes: Number of taps	Existing Schemes: Design flow (m^3/day)	Existing Schemes: Year completed	Existing Schemes: Estimated growth rate(%)	Population in 2012 estimated from Existing Schemes	** Rate 2012 Census Population to 2012 estimated population	Population in 2012 estimated by tap water share of District in Cessus 2008	Population Projection for the Project estimated based on Designed Population with Assumption of availability: 2015	2020	2025	2030	2035	Fund	Proportion of no access to Safety Water(%) in District 2008 Census	Priority by Population	No Access to safety water	Fund	Priority by Population &Accessibility&Fund
Central	NTCHEU	Mpira Balaka	222000	1850		1992	2.5	354,900	0.11	39,039	88,512	137,985	180,606	204,573	231,659	AFDB	24.1%	A	B	A	A
	NTCHEU	Dombole	22,000	146	946.08	1984	2.5	42,852	0.11	4,714	10,687	16,661	21,807	24,701	27,971		24.1%	B	B	B	C
	NTCHEU	Ntonda	25,000	109	706.32	1980	2.5	53,750	0.11	5,913	13,405	20,898	27,353	30,983	35,085	AFDB	24.1%	B	B	A	A
	NTCHEU	Sanjike	12,000	40	259.2	1980	2.5	25,800	0.11	2,838	6,435	10,031	13,129	14,872	16,841		24.1%	B	B	B	C
	NTCHEU	Kasinje	14,000	95	615.6	1983	2.5	27,951	0.11	3,075	6,971	10,867	14,224	16,112	18,245		24.1%	B	B	B	C
	NTCHEU	Nanyangu	20,000	118	764.64	1983	2.5	39,930	0.11	4,392	9,959	15,525	20,320	23,017	26,064		24.1%	B	B	B	C
	NTCHEU	Kalitsiro	1,000	13	84.24	1977	2.5	2,315	0.11	255	577	900	1,178	1,335	1,511	WB	24.1%	C	B	A	A
	NTCHEU	Chilobwe	1,200	14	90.72	1975	2.5	2,919	0.11	321	728	1,135	1,485	1,683	1,905	WB	24.1%	C	B	A	A
	NTCHEU	Lizulu	6,000	34	220.32	1978	2.5	13,553	0.11	1,491	3,380	5,269	6,897	7,812	8,847	WB	24.1%	C	B	A	A
	MCHINJI	Mchinji	20,000	105	680.4	1976	3.5	66,672	0.44	29,336	55,245	81,155	92,031	104,597	118,927		37.5%	A	A	B	B
	DEDZA	Ngwere	4200	35	226.8	1976	2.6	10,314	0.24	2,475	9,221	15,966	20,453	25,723	31,466	WB	34.5%	B	A	A	A
	DEDZA	Mongwera	1,400	10	64.8	1983	2.6	2,872	0.24	689	2,568	4,447	5,696	7,164	8,764		34.5%	C	A	B	C
	DEDZA	Mvula	8760	73	473.04	1983	2.6	17,973	0.24	4,314	16,069	27,824	35,644	44,828	54,836	ACGF	34.5%	A	A	A	A
	DEDZA	Ngodzi	19800	165	1069.2	2006	2.6	22,511	0.24	5,403	20,126	34,849	44,643	56,146	68,681		34.5%	A	A	B	B
	NKHOTAKOTA	Mwansambo/ Kasakula	25,000	238	1542.24	1984	2.9	54,095	0.16	8,655	30,306	51,958	70,330	82,695	97,012		34.6%	A	A	B	B
	NKHOTAKOTA	Mwansambo/ Mwadzama	18,000	100	648	1983	2.9	40,078	0.16	6,412	22,453	38,494	52,106	61,267	71,874		34.6%	A	A	B	B
	NKHOTAKOTA	Dwambazi	20000	250	1620	2004	2.9	24,431	0.16	3,909	13,687	23,466	31,763	37,348	43,814		34.6%	B	A	B	B
	SALIMA	Chipoka	10080	84	544.32	1991	3.2	18,926	0.49	9,274	20,923	24,697	29,111	34,372	40,490		19.4%	B	B	B	C
	NTCHISI	Mpamira	1680	14	90.72	1983	3.0	3,844	2.04	7,841	17,778	27,715	36,276	41,090	46,530		33.1%	B	A	B	B
Total of Central Region			452,120	3,493				825,686		140,345	349,031	549,841	705,054	820,317	950,523						

Source: Project Team, MoAIWD

Table 9.17 List of Gravity-fed Piped Rural Water Supply Schemes (3/3)

Region	District	Scheme	Existing Schemes					Population in 2012 estimated from Existing Schemes	** Rate 2012 Census Population to 2012 estimated population	Population in 2012 estimated by tap water share of District in Cessus 2008	Population Projection for the Project estimated based on Designed Population with Assumption of availability					Fund	Proportion of no access to Safety Water(%) in District 2008 Census	Priority by Population	No Access to safety water	Fund	Priority by Population &Accessibility&Fund
			Designed Population	Number of taps	Design flow (m^3/day)	Year completed	Estimated growth rate(%)				2015	2020	2025	2030	2035						
South	MANGOCHI	Lingamasa	12,000	210	1360.8	1981	2.7	26,687	1.59	42,432	37,733	33,034	37,615	42,819	48,557		24.4%	B	B	B	C
	BALAKA	Mpira-Balaka	222000	1,850	11988	1983	2.3	419,634	0.14	58,749	103,665	148,582	200,728	235,894	276,315	ACGF	17.0%	A	B	A	A
	MACHINGA	Kawinga	70,000	500	3240	1983	2.9	155,858	0.13	20,262	59,061	97,859	131,985	155,433	182,702	AFDB	33.0%	A	A	A	A
	MACHINGA	Liwonde	23,000	235	1522.8	1983	2.9	51,210	0.13	6,657	19,406	32,154	43,367	51,071	60,031	AFDB	33.0%	A	A	A	A
	MACHINGA	Naungu	1800	15	97.2	2001	2.9	2,396	0.13	311	908	1,504	2,029	2,389	2,808	AFDB	33.0%	C	A	A	A
	MACHINGA	Nkala	1080	9	58.32	2002	2.9	1,397	0.13	182	529	877	1,183	1,393	1,637	AFDB	33.0%	C	A	A	A
	MACHINGA	Chagwa	7,000	230	1490.4	1976	2.9	19,039	0.13	2,475	7,214	11,954	16,123	18,987	22,318	AFDB	33.0%	B	A	A	A
	MACHINGA	Chinkwenzule	2,000	9	58.32	1983	2.9	4,453	0.13	579	1,687	2,796	3,771	4,441	5,220	AFDB	33.0%	C	A	A	A
	MACHINGA	Lifani	20,000	151	978.48	1977	2.9	52,863	0.13	6,872	20,032	33,192	44,766	52,719	61,968	AFDB	33.0%	A	A	A	A
	MACHINGA	Zumulu	23,500	42	272.16	2001	2.9	31,277	0.13	4,066	11,852	19,638	26,486	31,191	36,664	AFDB	33.0%	B	A	A	A
	MACHINGA	Chanyungu	7800	65	421.2	2000	2.9	10,682	0.13	1,389	4,048	6,707	9,046	10,653	12,522	AFDB	33.0%	B	A	A	A
	MACHINGA	Chanyungu 2	1320	11	71.28	1983	2.9	2,939	0.13	382	1,114	1,845	2,489	2,931	3,445	AFDB	33.0%	C	A	A	A
	MACHINGA	Machinga	1200	10	64.8	1983	2.9	2,672	0.13	347	1,012	1,678	2,263	2,665	3,132	AFDB	33.0%	C	A	A	A
	MACHINGA	Doza	1320	11	71.28	2003	2.9	1,659	0.13	216	629	1,042	1,405	1,655	1,945	AFDB	33.0%	C	A	A	A
	MACHINGA	Mirala	13,000	146	946.08	1985	2.9	27,337	0.13	3,554	10,359	17,164	23,149	27,262	32,045	AFDB	33.0%	B	A	A	A
	MACHINGA	Mangale	1320	11	71.28	1983	2.9	2,939	0.13	382	1,114	1,845	2,489	2,931	3,445	AFDB	33.0%	C	A	A	A
	ZOMBA	Zomba East-Domasi	100,000	852	5520.96	1981	0.6	119,657	0.22	26,325	85,040	143,756	181,052	198,009	215,201	ACGF	19.1%	A	B	A	A
	ZOMBA	Zomba west	60,000	366	2371.68	1986	0.6	69,679	0.22	15,329	49,521	83,712	105,430	115,305	125,316	AFDB	19.1%	A	B	A	A
	ZOMBA	Makwawa south	8040	67	434.16	1986	0.6	9,337	0.22	2,054	6,636	11,217	14,128	15,451	16,792	AFDB	19.1%	B	B	A	A
	ZOMBA	Makwawa North	16,000	59	382.32	1986	0.6	18,581	0.22	4,088	13,205	22,323	28,115	30,748	33,417	AFDB	19.1%	B	B	A	A
	ZOMBA	Chingale	5,000	60	388.8	1968	0.6	6,467	0.22	1,423	4,596	7,769	9,785	10,701	11,630	AFDB	19.1%	B	B	A	A
	MULANJE	Namitambo	60,000	432	2799.36	1979	2.0	113,072	0.13	14,699	26,371	38,042	46,915	50,389	53,956	AFDB	22.3%	A	B	A	A
	MULANJE	Mulanje West	90,000	398	2579.04	1975	2.0	183,590	0.13	23,867	42,816	61,766	76,174	81,814	87,605	AFDB	22.3%	A	B	A	A
	MULANJE	Mulanje SW	24,000	181	1172.88	1989	2.0	37,104	0.13	4,823	8,653	12,483	15,395	16,535	17,705	AFDB	22.3%	B	B	A	A
	MULANJE	Lichenya	46,000	575	3726	1982	2.0	81,689	0.13	10,620	19,051	27,483	33,894	36,403	38,980	AFDB	22.3%	B	B	A	A
	MULANJE	Muloza East	32,000	89	576.72	1983	2.0	55,713	0.13	7,243	12,993	18,744	23,116	24,828	26,585	AFDB	22.3%	B	B	A	A
	MULANJE	Nalipiri	9,000	55	356.4	1983	2.0	15,669	0.13	2,037	3,654	5,272	6,501	6,983	7,477	AFDB	22.3%	C	B	A	A
	MULANJE	Chambe	28,000	460	2980.8	1979	2.0	52,767	0.13	6,860	12,306	17,753	21,894	23,515	25,179		22.3%	B	B	B	C
	MULANJE	Muloza crater	15,000	100	648	1983	2.0	26,115	0.13	3,395	6,091	8,786	10,836	11,638	12,462		22.3%	B	B	B	C
	MULANJE	Nalipili	25920	216	1399.68	1983	2.0	45,127	0.13	5,867	10,525	15,182	18,724	20,110	21,534		22.3%	B	B	B	C
	MULANJE	Phwera	32000	46	298.08	1983	2.0	55,713	0.13	7,243	12,993	18,744	23,116	24,828	26,585	AFDB	22.3%	B	B	A	A
	MULANJE	Nansato school	3000	7	45.36	1983	2.0	5,223	0.13	679	1,218	1,757	2,167	2,328	2,492		22.3%	C	B	B	C
	MULANJE	Mbewa VH		18	116.64	1983	2.0	0	0.13	0	0	0	0	0	0		22.3%	C	B	B	C
	PHALOMBE	Phalombe Major	145,000	907	5877.36	2005	3.1	174,149	0.28	48,762	56,428	64,095	84,047	96,620	110,518		14.5%	A	B	B	B
	PHALOMBE	Sombani	54,400	300	1944	1979	3.1	144,503	0.28	40,461	46,822	53,184	69,739	80,172	91,704		14.5%	A	B	B	B
	PHALOMBE	Phalombe Minor	46000	100	648	2005	3.1	55,247	0.28	15,469	17,901	20,334	26,663	30,652	35,061		14.5%	B	B	B	C
	PHALOMBE	Sakanena(Action aid)	4920	41	265.68	2007	3.1	5,559	0.28	1,557	1,801	2,046	2,683	3,084	3,528		14.5%	C	B	B	C
	PHALOMBE	Migowi	9,420	90	583.2	1971	3.1	31,945	0.28	8,944	10,351	11,757	15,417	17,723	20,273		14.5%	B	B	B	C
	PHALOMBE	Chiringa	3,200	41	265.68	1972	3.1	10,525	0.28	2,947	3,410	3,874	5,080	5,840	6,680		14.5%	C	B	B	C
	THYOLO	Didi	12,000	37	239.76	2005	2.5	13,916	0.38	5,288	12,295	19,301	23,155	27,548	32,396		35.2%	B	A	B	B
	THYOLO	Sankhulani	15,000	181	1172.88	2005	2.5	17,395	0.38	6,610	15,368	24,126	28,943	34,434	40,495	DAPP & UNICEF	35.2%	B	A	A	A
	THYOLO	Limphagwi	8000	85	550.8	1983	2.5	15,972	0.38	6,069	14,111	22,152	26,575	31,617	37,181		35.2%	B	A	B	B
	THYOLO	Mvumoni	9,000	85	550.8	2005	2.5	10,437	0.38	3,966	9,221	14,476	17,366	20,661	24,297		35.2%	B	A	B	B
	THYOLO	Mdala	1920	16	103.68	2005	2.5	2,227	0.38	846	1,967	3,088	3,705	4,408	5,183		35.2%	C	A	B	C
	THYOLO	Kalintulo	1440	12	77.76	1983	2.5	2,875	0.38	1,092	2,540	3,987	4,783	5,691	6,693		35.2%	C	A	B	C
	CHIKWAWA	Mwanza/ chapananga	60000	500	3240	1983	2.0	104,461	0.26	27,160	70,751	114,342	122,748	131,341	140,404	WB	26.3%	A	B	A	A
	CHIKWAWA	East Bank	18720	156	1010.88	1997	2.0	24,701	0.26	6,422	16,730	27,037	29,025	31,057	33,199	ACGD	26.3%	B	B	A	A
	MWANZA	Thabwani	4900	28	181.44	1983	4.1	15,094	0.05	755	3,550	6,345	7,047	6,637	6,030		28.5%	C	B	B	C
	MWANZA	Kukhoma	3500	15	97.2	1983	4.1	10,782	0.05	539	2,535	4,532	5,034	4,740	4,307		28.5%	C	B	B	C
	MWANZA	Nsupe	4080	34	220.32	1999	4.1	6,608	0.05	330	1,554	2,778	3,085	2,905	2,640		28.5%	C	B	B	C
	MWANZA	Mpeni	9189	47	304.56	1983	4.1	28,307	0.05	1,415	6,657	11,898	13,216	12,446	11,308		28.5%	B	B	B	C
	NSANJE	Mapelela	1200	10	64.8	2001	2.1	1,477	0.44	650	1,226	1,803	2,079	2,386	2,746		18.9%	C	B	B	C
	NSANJE	Chididi	3120	26	168.48	1972	2.1	7,017	0.44	3,088	5,826	8,564	9,877	11,334	13,045		18.9%	B	B	B	C
Total of Southern Region			1,377,309	10,197	35,472			2,391,741		0	897,077	1,326,377	1,666,401	1,875,312	2,105,356						
Total of all Malawi			2,077,503	16,184	35,472			3,791,410							3,960,661						

Source: Project Team, MOAIWD

9.2.4 Communities served by Borehole

(1) Newly Installation of the Borehole/Protected Shallow Well

There is still necessity of newly installation of boreholes/protected shallow wells. And, there is possibility the remained area has some more difficulty in topography, hydrogeology and accessibility of the drilling machine.

Priority A, B and C was given by two representative rates : rate of no access to the safety water source and rate of community standpipe (=gravity-fed piped water supply) shown in **Table 9.8**. The priority of projects by district is established by the combination of priorities of those rates.

Table 9.18 Outline of Project of Regional Water Boards

Service Area		Towns
Responsible Entity		Local Government assisted by MoAIWD
Contents of the Project		Rehabilitation/New of Water Supply Facilities by Borehole, Water supplied population: 95% in2015, 98% in 2025-2035
Demand Projection	Population	Population of the Community/part of Community
	Growth Rare	Estimated from Census 2008
Water Consumption		One Borehole for 27-36 L/p/d
Factor for Priority on Plan		Rate of No-Access Population to Safety water against Rural Area Population in 2012, estimated from Census 2008 <25%: A, 26-30%: B, 31%< : C Rate of Gravity-fed water=Rate of Community Stand Pipe in 2012, estimated Census 2008, means possibility of surface water <5% : A, 6-14%: B, 15%< : C **Combination of Priority by Intake Condition & Population** AA, AB, BA → A → Short-term BB, AC, CA → B → Middle-term Others → C → Long-term

Source: Project Team

The priority is shown in **Table 9.19** by district. However, the construction of community borehole should be implemented based on basic human needs. In this context, the construction of boreholes for communities should be carried out if requested.

Table 9.19 Project list of the Population served by Borehole with District's Priority

Region/District	Case 1: Borehole = Community population - Census base population						Population served by Borehole = Community total Population - `opulation by Gravity-fed Project- Population without safety water						Rate of unimproved water source	Priority by Rate of unimprovement	No. of Existing gravity-fed Schemes	Rate of Community stand pipe in Rural Water (2008 Census)	Priority by Rate of Community Stando Pipe	Priority of Borehole
	2012	2015	2020	2025	2030	2035	2012	2015	2020	2025	2030	2035						
All Malawi	**9,348,577**	**10,297,882**	**10,952,810**	**12,391,082**	**14,266,077**	**16,408,636**	**9,348,577**	**9,406,256**	**9,562,786**	**10,735,484**	**12,403,477**	**14,323,072**						
Northern Region	**1,146,393**	**1,239,464**	**1,315,181**	**1,490,607**	**1,723,184**	**1,986,257**	**1,146,393**	**916,143**	**928,153**	**1,035,511**	**1,204,246**	**1,399,295**						
CHITIPA	127,489	133,359	136,475	145,272	158,748	172,355	127,489	101,073	96,739	94,706	103,491	112,362	37.2%	C	7	14.0%	B	C
KARONGA	177,912	195,852	209,665	239,975	278,432	321,432	177,912	134,570	132,233	136,258	158,094	182,510	19.9%	A	4	8.3%	B	A
NKHATABAY	148,182	153,030	164,058	190,834	225,525	264,765	148,182	111,326	110,722	131,879	161,403	196,007	46.4%	C	5	9.3%	B	C
RUMPHI	84,411	75,619	74,662	78,363	88,047	101,911	84,411	67,609	64,791	65,409	73,492	85,064	30.3%	C	8	27.7%	C	C
MZIMBA	608,400	681,604	730,321	836,163	972,433	1,125,794	608,400	501,565	523,668	607,258	707,764	823,350	27.3%	B	6	7.3%	B	B
LIKOMA	0	0	0	0	0	0												
Central Region	**4,097,360**	**4,572,140**	**4,936,272**	**5,689,243**	**6,616,974**	**7,696,929**	**4,097,360**	**4,422,282**	**4,658,679**	**5,365,301**	**6,246,767**	**7,276,770**						
KASUNGU	539,397	604,205	665,813	795,905	960,236	1,157,706	539,397	618,396	690,558	838,825	1,016,457	1,229,912	49.8%	C		3.8%	A	B
NKHOTAKOTA	207,988	227,813	242,729	279,567	328,719	385,629	207,988	184,035	156,888	163,373	192,096	225,353	34.6%	C	3	8.5%	B	C
NTCHISI	203,104	223,774	245,113	287,020	338,209	399,262	203,104	226,696	252,034	297,226	350,060	413,097	33.1%	C	1	3.7%	A	B
DOWA	495,807	575,698	652,222	799,776	970,206	1,167,583	495,807	580,784	661,582	816,462	992,174	1,195,669	47.6%	C		1.6%	A	B
SALIMA	271,841	300,419	325,711	375,382	434,202	500,545	271,841	288,743	312,748	361,951	417,967	480,963	19.4%	A	1	3.3%	A	A
LILONGWE Rural	1,101,248	1,204,731	1,281,430	1,437,735	1,625,044	1,842,305	1,101,248	1,208,480	1,289,440	1,452,250	1,643,261	1,864,815	37.0%	C		1.2%	A	B
MCHINJI	369,363	437,283	478,015	561,871	670,453	799,212	369,363	423,227	450,152	543,213	653,385	784,597	37.5%	C	1	7.3%	B	C
DEDZA	544,529	586,425	614,648	677,686	752,661	836,309	544,529	553,444	549,578	594,257	644,110	700,455	34.5%	C	4	2.3%	A	B
NTCHEU	364,083	411,791	430,591	474,302	537,245	608,378	364,083	338,477	295,698	297,744	337,257	381,910	24.1%	A	8	14.5%	B	A
Southern Region	**4,104,824**	**4,486,278**	**4,701,357**	**5,211,232**	**5,925,919**	**6,725,450**	**4,104,824**	**4,067,830**	**3,975,955**	**4,334,672**	**4,952,464**	**5,647,008**						
MANGOCHI	672,530	774,972	849,911	1,006,574	1,209,919	1,449,625	672,530	784,318	877,599	1,052,787	1,267,862	1,521,792	24.4%	A	1	5.9%	B	A
MACHINGA	404,606	451,392	482,724	550,910	648,780	762,601	404,606	368,327	321,873	333,966	393,296	462,295	33.0%	C	14	10.9%	B	C
ZOMBA Rural	502,944	542,520	561,783	604,191	660,778	718,149	502,944	433,434	355,673	344,607	376,883	409,604	19.1%	A	5	8.7%	B	A
ZOMBA CITY	0	0	0	0	0	0	0	0	0	0	0	0				76.5%		
CHIRADZULO	264,820	283,500	293,913	313,406	334,981	356,355	264,820	283,079	294,225	314,700	336,633	358,363	12.6%	A		1.5%	A	A
BLANTYRE rural	215,590	226,124	216,956	222,975	231,250	236,433	215,590	225,653	218,499	228,016	237,072	242,743	21.5%	A		6.9%	B	A
MWANZA	67,345	58,847	57,234	54,683	51,495	46,790	67,345	47,223	34,697	29,649	27,921	25,369	28.5%	B	4	4.3%	A	A
THYOLO	500,034	512,616	526,045	563,889	614,741	667,753	500,034	485,198	473,024	501,872	536,858	572,131	35.2%	C	5	4.5%	A	B
MULANJE	397,611	419,337	420,867	433,600	465,706	498,669	397,611	349,379	300,296	284,904	306,000	327,659	22.3%	A	12	17.7%	C	B
PHALOMBE	187,930	225,289	222,837	229,739	264,106	302,095	187,930	199,839	206,484	208,295	239,454	273,897	14.5%	A	6	38.2%	C	B
CHIKWAWA	368,988	394,700	424,408	485,108	564,427	654,786	368,988	341,983	326,750	392,506	471,094	561,533	26.3%	B	2	8.5%	B	B
NSANJE	200,123	218,915	234,048	265,012	302,845	346,906	200,123	215,510	228,221	259,014	295,933	338,913	18.9%	A	1	1.8%	A	A
BALAKA	220,545	253,665	267,098	300,266	352,871	413,335	220,545	209,182	194,350	201,987	237,373	278,047	17.0%	A	1	20.5%	C	B
NENO	101,757	124,401	143,531	180,880	224,020	271,955	101,757	124,706	144,263	182,369	226,086	274,661	32.8%	C		0.9%	A	B

Source: Project Team

(2) Availability of Water Source

In the remained area, where boreholes do not exist, it is because of the difficulty to find good aquifers and the bad accessibility to area for the drilling machines. It is recommended that the groundwater section of MoAIWD in coordination with the local government facilitates the borehole construction, even in the technical field.

(3) Promotion of Rehabilitation

At present majority of non-functional condition was caused by mechanical problems of the pumps. It is important to proceed rehabilitation works to approach more economical efficiency. In order to secure the sustainability of the schemes, actions for strengthening of operational organization are essential.

(4) Component of Water Supply Scheme

The borehole system is composed of borehole with 50-100m in depth, hand-pump and platform with washing basin.

9.2.5 Summary of Rural Area Projects

Table 9.20 shows the results of rural water supply project when all the projects are proceeded on the priority, i.e., water supply for Market Center, Communities by GFWS. As mentioned above, implementation of Borehole is conducted in all districts simultaneously.

Table 9.20 Results of the Project for Rural Area

Service Area	Responsible entity	Outline of Project, Idea of Priority Selection	2012-2020 (Short Term Plan)		2021-2025 (Middle Term Plan)		2026-2035 (Long Term Plan)	
			No. of Schemes	Population	No. of Schemes	Population	No. of Schemes	Population
Market Centers	District Council/Regional Water Boards/MoAIWD/MoLGRD	New WSS, Priority on Population, Infra Project of MoLGRD	81	1,094,438	35	249,342	38	140,324
Communities by Gravity-fed Water Supply	District Council/MoAIWD	Rehabilitation & Expansion & Establishment of WUA	47	2,112,983	22	1,358,125	33	516,327
Communities by Borehole Water Supply	District Council/MoAIWD	Accessibility to Safety Water, Possibility of Groundwater	All District	2,546,778 (increased population)	All District	3,349,732 (increased population)	All District	4,356,115 (increased population)

Source: Project Team

CHAPTER 10. DEVELOPMENT PLAN FOR IRRIGATION WATER SUPPLY

10.1 Planning Frame and Concepts

Malawi depends on rain-fed agriculture to achieve food security, increased incomes and sustainable economic growth. Over-dependence on rain-fed agriculture has led to low agricultural production and productivity due to weather shocks and natural disasters. A well-developed water system is therefore critical for irrigation intensification. Irrigation has the potential to increase agricultural production and productivity through intensified farming. This will improve food security and rural livelihoods; promote agricultural diversification and value addition; reduce rural-urban migration; and contribute to sustainable economic growth and development. In due consideration of the above, planning frame is set up for target year including step-wise improvement, and irrigation development scenarios how irrigation area will increase until the target year.

10.1.1 Design Drought

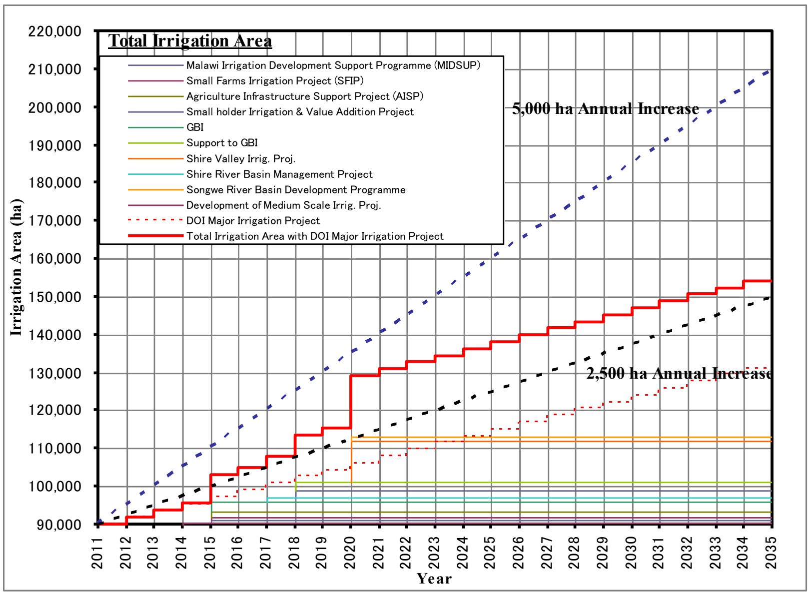
In order to cover the water deficit, the design drought is set at 5-year drought as determined through discussion with Department of Irrigation (DOI).

10.1.2 Step-wise Improvement

Almost 25 years until 2035 as the final target year of the master plan will be divided into three terms: namely, short-term until 2020, mid-term until 2025, and long-term until 2035. The irrigation development schemes shall be arranged in accordance with the parameters of irrigation development effects which are (a) cost efficiency, (b) availability of water resources, and (c) high development effectiveness.

10.1.3 Irrigation Development Scenarios

Discussion was made on annual irrigation development with DOI. Both sides agreed on the two development scenarios: one is a realistic development at 2,500 ha/year, and the other one is a little ambitious development at 5,000 ha/year. The latter one is nearly equal to the standard development rate of SADC countries as presented in **Figure 10.1**. The figure depicts the existing ongoing and planned irrigation development projects as well. The total irrigation areas in 2035 are 150,000 ha in the lower scenario with an annual area increase of 2,500 ha and 210,000 ha in the higher scenario with an annual area increase of 5,000 ha.



Source: Project Team, MoAIWD

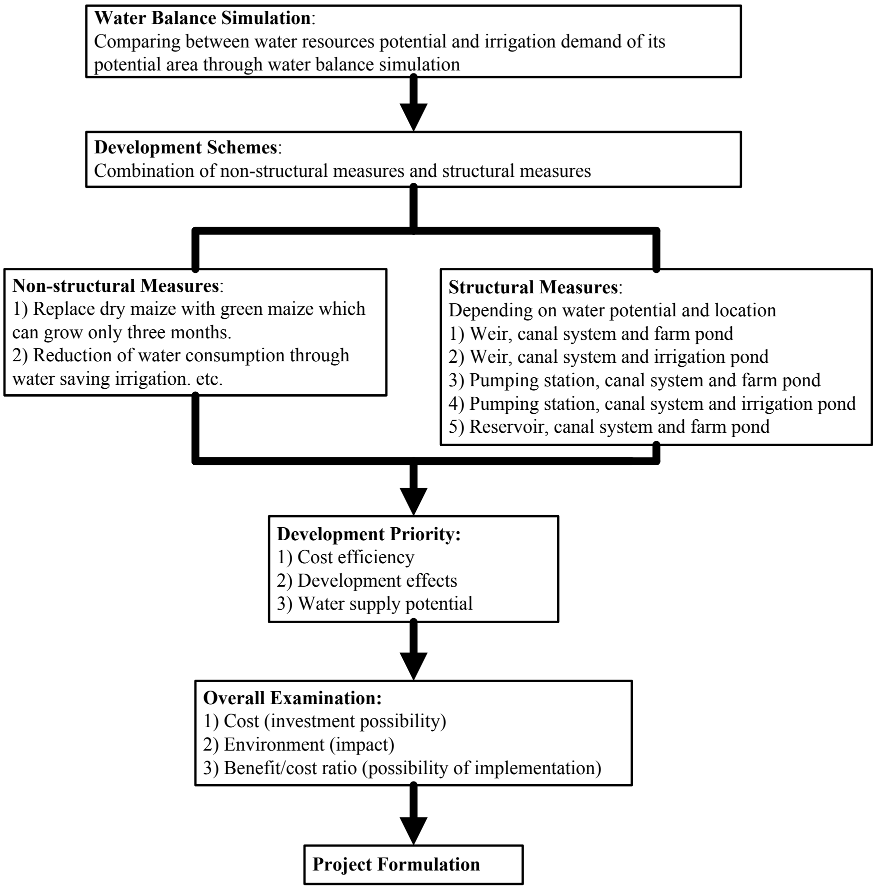
Figure 10.1 Irrigation Development Scenarios

10.1.4 Planning Concepts

Irrigation development plan shall be formulated in the following process and concepts.

a) Decision making in development possibility shall depend on the water balance between water resources potential and irrigation water demand in two scenarios through water balance simulation.
b) Irrigation development schemes shall combine structural measures and non-structural measures.
c) Structural components shall be arranged water intake facilities of weir or pump, conveyance and distribution canal system, and water distribution or storage ponds. Their suitable components shall be determined depending on the water availability and their topographic features. Furthermore, reservoir scheme could be proposed for meeting a large amount of water deficit.
d) Non-structural measures could be applied as replacement of normal crops to earlier growing crops or introduction of water saving cultivation.
e) For almost 25 years of long-term improvement, step- and area-wise irrigation development plan shall be developed through giving the priority based on cost efficiency, development effects, and water supply potential.
f) Finally project viability shall be examined judging from investment possibility in cost, environmental impact, and benefit and cost ratio as implementation possibility.

Those planning process and concepts are presented in **Figure 10.2**.



Source: Project Team

Figure 10.2 Irrigation Water Development Process

10.2 Irrigation Development Area and Non-structural Application

Prior to describing the water balance analysis, its preconditions are summarized below: (a) irrigation potential area, (b) cropping patterns and non-structural application, and (c) other irrigation factors such as existing irrigation methods and irrigation efficiency.

10.2.1 Irrigation Potential Area

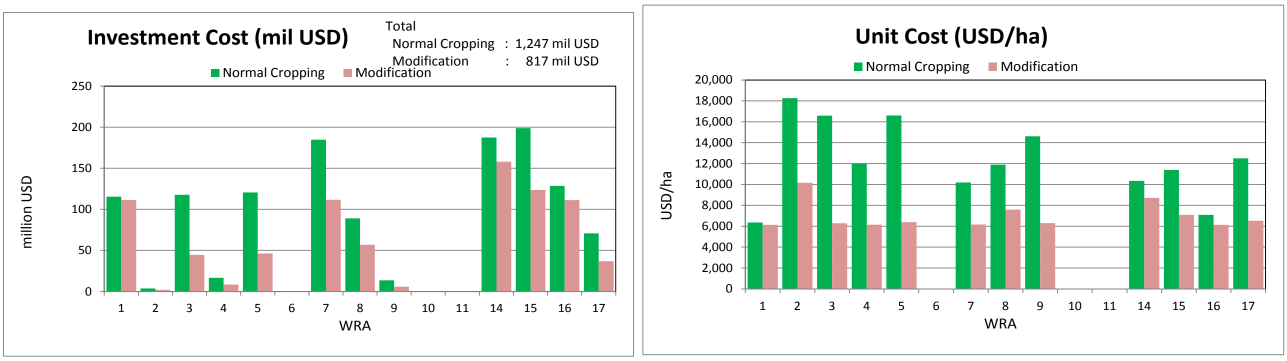
The Irrigation Master Plan in Malawi financed by World Bank is now under studying. Regarding the irrigation potential area, the Master Plan team examined and formulated it through the analysis of GIS data such as topography, land use, population, soil condition, land gradient, environment, and so on as estimated 4,137,000 ha. To clarify possibility of irrigation development, the water balance simulation is conducted using the potential area as an upper limit for the development by Water Resources Area (WRA).

10.2.2 Cropping Patterns and Non-structural Application

The modification of cropping pattern can be reduced the water consumption of irrigation area as shown in **Figure 10.3**, which results in cost-effective irrigation development without a large scale of water use facilities. In addition, in view of the result of initial water balance analysis, it is proved that water is still available at early stage of the dry season. Therefore, the possibility of crop diversification, such as shifting crop cultivation and application of early growing crops (early maturing varieties), are proposed for saving available water as a non-structural application. In the case annual irrigation area increases at 5,000 ha/year, the cropping modification could reduce the total cost by 34% from the normal cropping as presented in **Figure 10.4**.

Source: Project Team

Figure 10.3 Effects on Water Deficit by Cropping Pattern Modification



Source: Project Team

Figure 10.4 Economic Effects of Croppring Pattern Modification

10.2.3 Irrigation Efficiency by Irrigation Method

Irrigation return flow is set at 10% in the paddy and 0% in the other crop fields. Irrigation efficiency set at as shown in the following table through the consultation with DOI during and after the second Steering Committee.

Table 10.1 Irrigation Efficiency by Irrigation Method

Irrigation Method	Conveyance	Field application	Overall
Surface (border, furrow, basin)	80%	60%	48%
Sprinkler	90%	75%	68%
Drip	90%	90%	81%

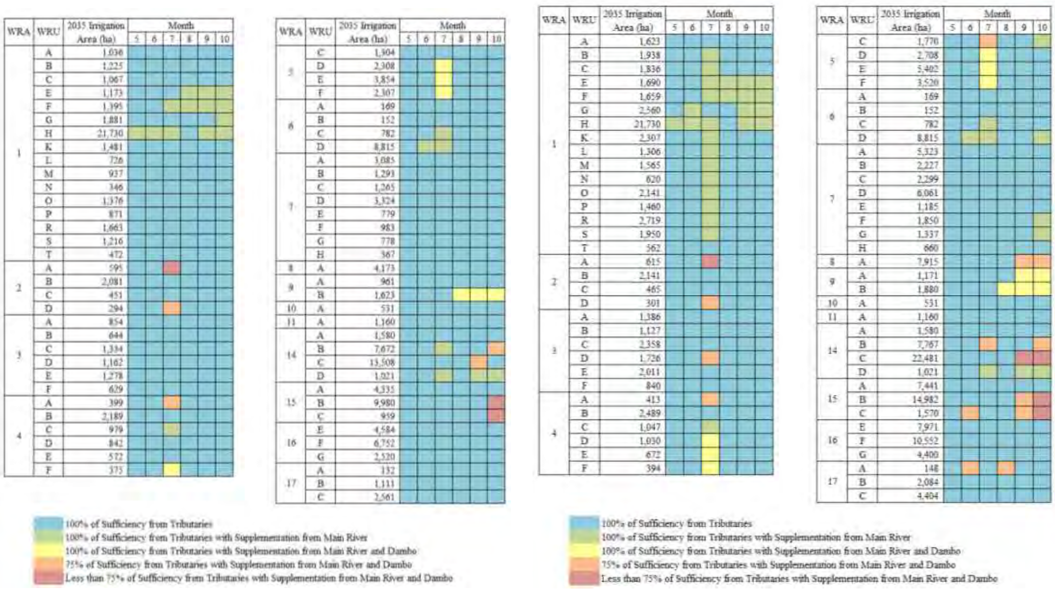
Source: Project Team

10.3 Water Balance Analysis

Water balance analysis is described including allocation of irrigation development area and estimation of irrigation water demand including livestock.

10.3.1 Water Balance Analysis

Using the monthly cropping pattern and its water demand for irrigation and water supply and livestock demands, water balance analysis is made by Water Resources Area. The results of water balance analysis in the dry season, from May to October, are depicted in **Figure 10.4**. As presented in both figures, most WRUs could satisfactorily receive irrigation water from own sub-basin, their mainstream and Dambo. The particular WRAs, however, could not receive enough water. Out of 66 WRUs, some water deficit occurs in 7 and 11 WRUs in the dry season under 2,500 ha/year and 5,000 ha/year of the development scenarios, respectively. In other words, irrigation water development can be made without large storage facilities in 59 WRUs which is equivalent to 89% of all WRUs, in the 2,500 ha/year development scenario.



Source: Project Team

Figure 10.4 Irrigation Water Supply Potential by WRU in 2,500ha/year and 5,000ha/year Scenario

10.4 Structural Measures

10.4.1 Criteria of Structural Measures to be applied

From the viewpoints of topography, river features, advantageous location of intake facilities, and suppleness of structural component, the following four structural components as shown below are considered applicable for irrigation development.

Table 10.2 Applicability Criteria for Structural Measures in Irrigation Development

Structural Component			Applicability Criteria	Cost
1	a	Weir along tributaries	Normal prototype of structural component, without storage facilities	Low
	b	Canal/pipe works		
	c	Farm pond for water distribution		
2	a	Weir along tributaries	In addition to prototype, supplementarily supplying water from mainstream using pump facilities or Dambo, without storage facilities	Medium
	b	Canal/pipe works		
	c	Pump station along mainstream		
	d	Farm pond for water distribution		
3	a	Weir along tributaries	In addition to prototype, supplementarily supplying water from mainstream using pump facilities or Dambo, with irrigation pond to store the surplus water coping with water deficit	Medium
	b	Canal/pipe works		
	c	Pump station along mainstream		
	d	Irrigation pond for water storage		
4	a	Weir along tributaries	In addition to prototype, supplementarily supplying water from Lake Malawi using pump facilities coping with water deficit as well, without storage facilities	High
	b	Canal/pipe works		
	c	Pump station along Lake Malawi		
	d	Farm pond for water distribution		

Source: Project Team

Furthermore, the above structural components could be arranged from the external and surrounding conditions for easy understandings.

Table 10.3 Applicability Criteria for Structural Measures in Irrigation Development

Water Balance and Location of Sub-basin	Water Sources		Major Facilities to be Applied
Normal	Tributaries	a	Weir
		b	Canal/pipe works
		c	Farm pond for water distribution
	Tributaries and mainstream/ Dambo	a	Weir along tributaries
		b	Canal/pipe works
		c	Farm pond for water distribution
		d	Pump facilities
Deficit in the mountainous sub-basin	Tributaries and mainstream/ Dambo	a	Weir along tributaries
		b	Canal/pipe works
		c	Irrigation pond for water storage
		d	Pump facilities
Deficit along the Lake Malawi sub-basin	Tributaries and Lake Malawi	a	Weir along tributaries
		b	Canal/pipe works
		c	Farm pond for water distribution
		d	Pump facilities

Source: Project Team

10.4.2 Unit Cost for Structural Measures in Irrigation Development

Irrigation development costs are worked out multiplying irrigation area by unit cost (USD/ha) obtained from similar project costs and the data from the relevant reports. Unit costs are shown below following the above-mentioned applicability criteria.

Table 10.4 Unit Costs for Structural Measures

Irrigation Facilities		Unit Cost	Remarks
1	Weir + Canal/Pipe + Farm Pond	4,800 USD/ha	Prototype
2	Weir + Canal/Pipe + Pump Station + Farm Pond	10,100 USD/ha	Pump along the mainstream Additional 5,300 USD/ha on No.1
3	Weir + Canal/Pipe + Pump Station + Irrigation Pond	10,500 USD/ha	Pump along the mainstream
4	Weir + Canal/Pipe + Pump Station + Farm Pond	13,300 USD/ha	Pump along the Lake Malawi Additional 8,500 USD/ha on No.1

Source: Project Team

10.5 Project Cost and Implementation Program

10.5.1 Project Cost Estimate

Summary of condition of cost estimation is shown as follows.

Table 10.5 Conditions of Cost Estimation

Breakdown	Conditions of Cost Estimate
(1) Construction Cost	Labor, material and equipment for construction
(2) Physical Contingency	12% of the total sum of construction costs
(3) Engineering Service	10% of the total sum of construction costs and physical contingencies
(4) Administration Cost	4% of the total sum of construction costs, physical contingencies and engineering service costs

Source: Project Team

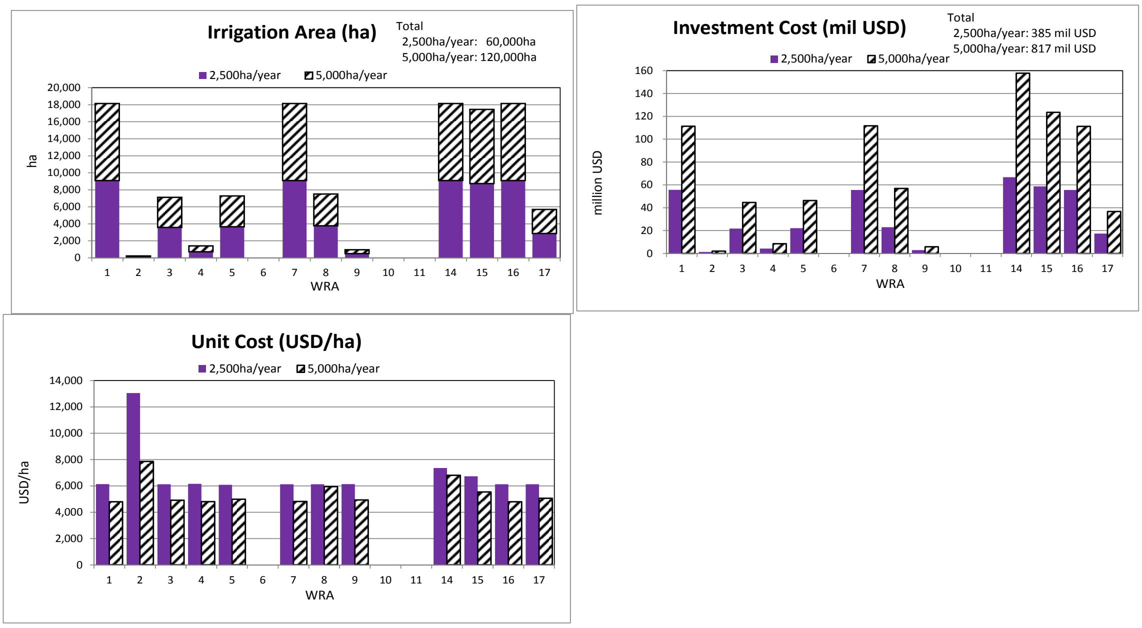
Using construction cost and the above conditions, the project cost is estimated as summarized in the following table. The total project costs are 385 million USD and 817 million USD, in 2,500 ha/year and 5,000 ha/year, respectively.

Table 10.6 Project Cost Estimated

WRA	2,500 ha/year	5,000 ha/year	WRA	2,500 ha/year	5,000 ha/year
1	55.60	111.36	10	-	-
2	1.33	2.07	11	-	-
3	21.74	44.63	12	-	-
4	4.25	8.50	13	-	-
5	22.05	46.35	14	66.75	157.85
6	-	-	15	58.71	123.56
7	55.55	111.70	16	55.56	111.31
8	22.92	56.89	17	17.36	36.72
9	2.86	5.88	Total	384.68	816.82

Source: Project Team

The following figure presents irrigation development area, project cost and unit cost by WRA. The figure shows irrigation development relatively concentrates five WRAs because of rich water supply potential: Shire (WRA 1), South Rukuru (WRA 7), Ruo (WRA 14) Lakeshore basins (WRA 15 and WRA 16).



Source: Project Team

Figure 10.5 Estimation Results of Project Cost by WRA

10.5.2 Project Prioritization

In order to formulate implementation program, project of which area is equivalent to Water Resources Unit shall be prioritized in a quantitative manner. Cost efficiency, development effect and water supply potential would be selected as considerable parameters for prioritization. Those parameters are expressed as follows:

- Cost efficiency: unit project cost per area
- Development effect: extent of irrigation development area
- Water supply potential: water supply potential per area

Table 10.7 Ranking Score for Prioritization of the Project

Parameter	Ranking Score in 2,500 ha/year Scenario			Ranking Score in 5,000 ha/year Scenario		
	3	2	1	3	2	1
Cost Efficiency	less than 6,500 USD/ha	6,500 USD/ha to 7,000 USD/ha	more than 7,000 USD/ha	less than 6,500 USD/ha	6,500 USD/ha to 7,000 USD/ha	more than 7,000 USD/ha
Development Effect	more than 1,000 ha	500 to 1,000 ha	less than 500 ha	more than 2,000 ha	1,000 to 2,000 ha	less than 1000 ha
Water Supply Potential	more than 60 m^3/ha	30 to 60 m^3/ha	less than 30 m^3/ha	more than 60 m^3/ha	30 to 60 m^3/ha	less than 30 m^3/ha

Source: Project Team

10.5.3 Implementation Plan

To formulate the implementation plan, the following project implementation period is set up in accordance with extent of the irrigation development area.

Table 10.8 Implementation Period Setting

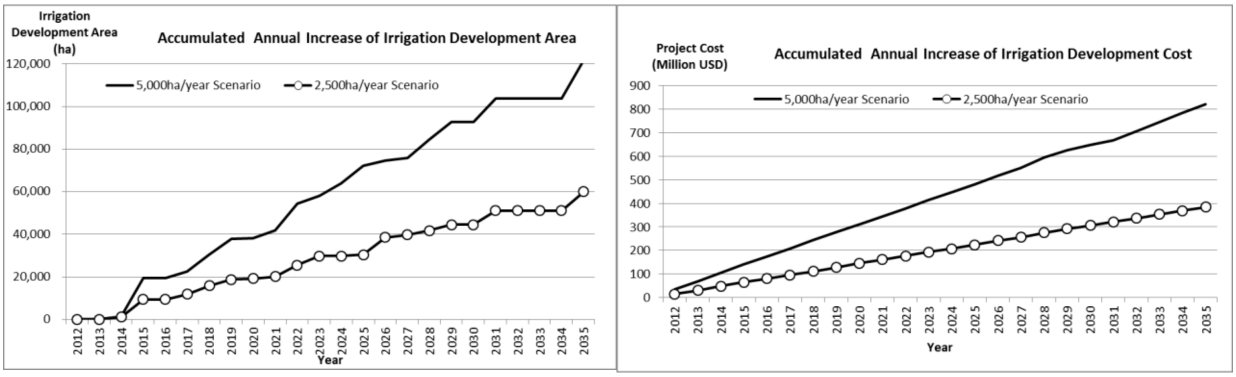
Implementation Period	Irrigation Area in Development Scenario	
	2,500 ha/year	5,000 ha/year
2 Years	less than 500 ha	less than 1,000 ha
3 Years	500 to 1,000 ha	1,000 to 2,000 ha
4 Years	more than 1,000 ha	more than 2,000 ha

Source: Project Team

Implementation plan is formulated in accordance with two irrigation development scenarios in the following manner.

- Ordering priority given as the ranking score as shown in **Table 10.7**: high priority in early stage,
- Using implementation period of each project as shown in **Table 10.8**, and giving average annual project cost (total project cost/implementation year), and
- Forming smooth yearly increase of irrigation development cost for investment.

The result of formation of implementation plan is presented in **Table 10.9** for 2,500 ha/year development scenario and in **Table 10.10** for 5,000 ha/year one. In addition **Figure 10.6** presents accumulation of annual increase of development area and investment cost.



Source: Project Team

Figure 10.6 Formation of Implementation Plan from Area and Cost

Table 10.9 Implementation Plan in 2,500 ha/year Development Scenario

Summary of Implementation Schedule of Irrigation Development Area (2500ha/year)

Unit: ha

WRA	WRU	Irrigation Area (ha)	Project Cost (mil USD)	Unit Cost (USD/ha)	Implementation Period (year)	Ranking	Time Frame																							
							Short Term									Middle Term					Long Term									
							2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
1	A	584	3.61	6,182	3	7							584																	
	B	710	4.37	6,155	3	7							710																	
	C	766	4.70	6,136	3	7							766																	
	E	515	3.33	6,466	3	1			515																					
	F	263	1.64	6,236	2	13								263																
	G	677	4.25	6,278	3	1			677																					
	K	823	5.05	6,136	3	7							823																	
	L	578	3.55	6,142	3	7						578																		
	M	626	3.85	6,150	3	32															626									
	N	273	1.68	6,154	2	44																	273							
	O	761	4.68	6,150	3	32																761								
	P	587	3.62	6,167	3	32																		587						
	R	1,051	6.48	6,166	4	1				1,051																				
	S	731	4.5	6,142	3	7							731																	
	T	90	0.55	6,111	2	13								90																
2	A	21	0.6	30,000	2	44																	21							
	B	60	0.4	5,982	2	13									60															
	C	14	0.09	6,278	2	13								14																
	D	7	0.25	37,774	2	44																	7							
3	A	530	3.28	6,189	3	32																	530							
	B	481	2.96	6,154	2	44																	481							
	C	1,020	6.28	6,157	4	13										1,020														
	D	562	3.45	6,139	3	32														562										
	E	730	4.48	6,137	3	32																		730						
	F	211	1.29	6,114	2	32																	211							
4	A	15	0.10	6,761	2	32																	15							
	B	299	1.84	6,154	2	13									299															
	C	67	0.43	6,418	2	13							67																	
	D	187	1.15	6,150	2	13								187																
	E	100	0.61	6,102	2	13								100																
	F	19	0.12	6,192	2	13								19																
5	C	464	2.28	4,914	2	44																464								
	D	399	2.50	6,266	2	44																	399							
	E	1,543	9.69	6,280	4	13												1,543												
	F	1,209	7.58	6,270	4	13											1,209													
7	A	2,229	13.71	6,151	4	13								2,229																
	B	930	5.73	6,161	3	32															930									
	C	1,030	6.32	6,136	4	13											1,030													
	D	2,727	16.78	6,153	4	13												2,727												
	E	405	2.49	6,148	2	44																				405				
	F	864	5.30	6,134	3	32																		864						
	G	557	3.42	6,140	3	32																		557						
	H	292	1.80	6,164	2	13							292																	
8	A	3,728	22.92	6,148	4	13															3,728									
9	A	209	1.28	6,124	2	44																				209				
	B	256	1.58	6,172	2	44																				256				
14	B	95	3.22	33,853	2	57																				95				
	C	8,974	63.53	7,079	4	44																								8,974
15	A	3,094	19.02	6,147	4	13											3,094													
	B	4,983	35.37	7,098	4	44																				4,983				
	C	608	4.32	7,105	3	56																				608				
16	E	3,374	20.75	6,150	4	1				3,374																				
	F	3,785	23.29	6,153	4	1				3,785																				
	G	1,873	11.52	6,151	4	1						1,873																		
17	A	16	0.10	6,314	2	44																			16					
	B	970	5.97	6,155	3	32															970									
	C	1,836	11.29	6,149	4	13															1,836									
Total		59,808	384.93				0	0	1,192	8,210	0	2,451	3,973	2,903	359	1,020	5,333	4,270	0	562	8,090	1,225	1,936	2,738	16	6,556	0	0	0	8,974
Accumulated Irrigation Development Area							0	0	1,192	9,402	9,402	11,853	15,826	18,729	19,088	20,108	25,441	29,711	29,711	30,273	38,363	39,588	41,524	44,262	44,278	50,834	50,834	50,834	50,834	59,808

Table 10.10 Implementation Plan in 5,000 ha/year Development Scenario

Table: Summary of Implementation Schedule of Irrigation Development Area (5000ha/year)

Unit: ha

WRA	WRU	Irrigation Area (ha)	Project Cost (mil USD)	Unit Cost (USD/ha)	Implementation Period (year)	Ranking	Time Frame																							
							Short Term									Middle Term					Long Term									
							2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
1	A	1,171	7.20	6,149	3	5							1,171																	
	B	1,422	8.93	6,280	3	5							1,422																	
	C	1,534	9.63	6,278	3	5							1,534																	
	E	1,032	6.82	6,609	3	5						1,032																		
	F	527	3.31	6,281	2	12								527																
	G	1,356	8.77	6,468	3	1			1,356																					
	K	1,649	10.36	6,283	3	5							1,649																	
	L	1,158	7.27	6,278	3	5						1,158																		
	M	1,254	7.87	6,276	3	28											1,254													
	N	547	3.43	6,271	2	41													547											
	O	1,525	9.61	6,302	3	28														1,525										
	P	1,176	7.39	6,284	3	28														1,176										
	R	2,107	15.81	7,504	4	28															2,107									
	S	1,464	9.2	6,270	3	5							1,464																	
	T	180	1.10	6,111	2	12								180																
2	A	41	0.8	19,756	2	41														41										
	B	120	0.8	6,231	2	12									120															
	C	29	0.19	6,627	2	28										29														
	D	13	0.32	24,175	2	41														13										
3	A	1,063	6.53	6,143	3	28														1,063										
	B	964	5.94	6,162	2	41													964											
	C	2,044	12.57	6,150	4	12								2,044																
	D	1,125	7.99	7,102	3	53																	1,125							
	E	1,462	9.00	6,156	3	28											1,462													
	F	422	2.60	6,161	2	28										422														
4	A	30	0.21	7,099	2	41														30										
	B	600	3.69	6,150	2	12						600																		
	C	135	0.84	6,215	2	12									135															
	D	376	2.31	6,144	2	12						376																		
	E	200	1.22	6,102	2	12								200																
	F	39	0.23	5,934	2	12								39																
5	C	930	6.68	7,183	2	55																930								
	D	799	5.02	6,283	2	41													799											
	E	3,091	19.42	6,283	4	12										3,091														
	F	2,422	15.23	6,288	4	12											2,422													
7	A	4,467	27.47	6,150	4	12								4,467																
	B	1,864	11.46	6,148	3	28														1,864										
	C	2,064	12.70	6,153	4	12											2,064													
	D	5,464	33.61	6,151	4	12											5,464													
	E	811	4.99	6,153	2	41														811										
	F	1,730	10.86	6,277	3	28													1,730											
	G	1,115	7.00	6,278	3	28														1,115										
	H	584	3.61	6,182	2	12							584																	
8	A	7,470	56.89	7,616	4	41																	7,470							
9	A	418	2.64	6,316	2	41															418									
	B	515	3.24	6,291	2	41														515										
14	B	190	4.05	21,289	2	55																190								
	C	17,911	153.80	8,587	4	41																								17,911
15	A	8,200	44.01	5,367	4	12																		8,200						
	B	9,986	70.90	7,100	4	41																				9,986				
	C	1,219	8.65	7,096	3	53																				1,219				
16	E	6,761	41.57	6,148	4	1				6,761																				
	F	7,586	46.65	6,149	4	1				7,586																				
	G	3,754	23.09	6,151	4	1				3,754																				
17	A	32	0.25	7,892	2	55																			32					
	B	1,943	11.96	6,155	3	28													1,943											
	C	3,679	24.51	6,662	4	28												3,679												
Total		121,770	822.14				0	0	1,356	18,101	0	3,166	7,824	7,457	256	3,542	12,666	3,679	5,983	8,153	2,525	1,120	8,595	8,200	32	11,205	0	0	0	17,911
Accumulated Irrigation Development Area							0	0	1,356	19,457	19,457	22,623	30,447	37,904	38,159	41,701	54,367	58,046	64,029	72,182	74,707	75,827	84,422	92,622	92,654	103,859	103,859	103,859	103,859	121,770

CHAPTER 11. DEVELOPMENT PLAN FOR HYDROPOWER

11.1 Background of Development Plan for Hydropower

Hydropower development projects are planned by Ministry of Natural Resources, Energy and Environment (MoNREE) until 2030 and some of the projects have been proceeded in accordance with the plans. In this section, hydropower development projects are evaluated and compiled from the view point of Integrated Water Resources Management (IWRM) on the present and future conditions.

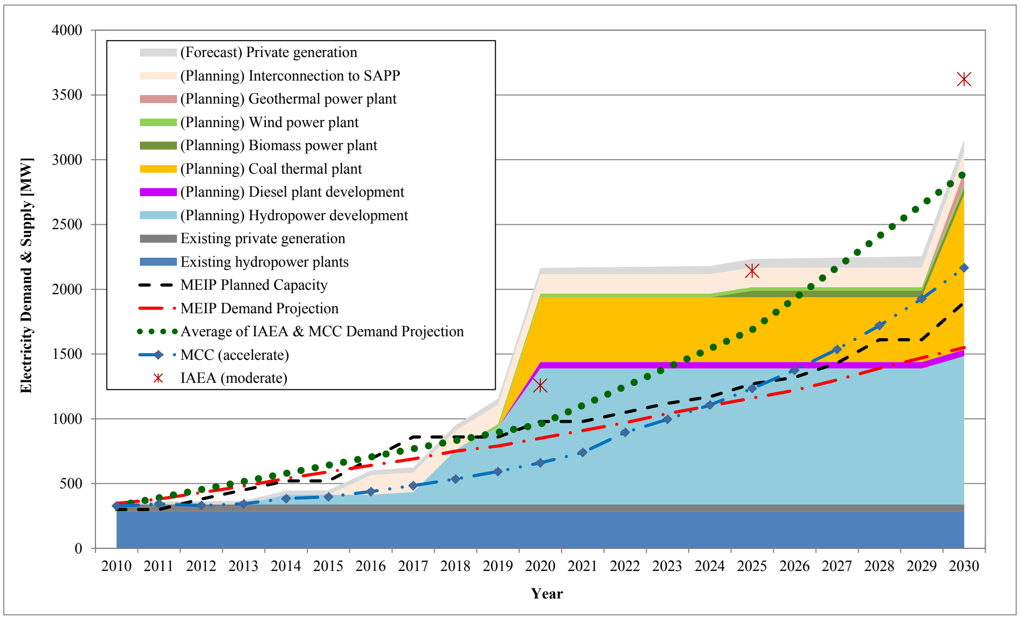
11.2 Road Map of Electric Power Development

Although hydropower development and its operation year tend to be fluctuate due to budgetary and procurement conditions, the projected operation year is determined by MoNREE as summarized table below.

Table 11.1 Evaluation Result for Hydropower Generation Water Demand

Short term (-2020)	**Demand Side Management (DSM),** Hydropower development Diesel plant development
Medium term (2021-2025)	**Hydropower development** Coal fired power development Biomass, Wind Interconnection to SAPP
Long term (2026-2035)	**Coal fired power development** Hydropower development Geothermal power development

Overview of the road map of electric power development is as follows. In short term, electricity demand will be mainly covered by Demand Side Management (DSM), which means promotion of efficient electricity usage such as lowering peak demand. During this period, fast hydropower development such as expansion of power generation will follow it. In the medium term, electricity demand will be mainly covered by large hydropower development, followed by coal fired power development and interconnection to SAPP (Southern African Power Pool) and other renewable energy (biomass, wind). In the long term after 2026, electricity demand will be mainly covered by coal fired power development followed by hydropower and geothermal power development.



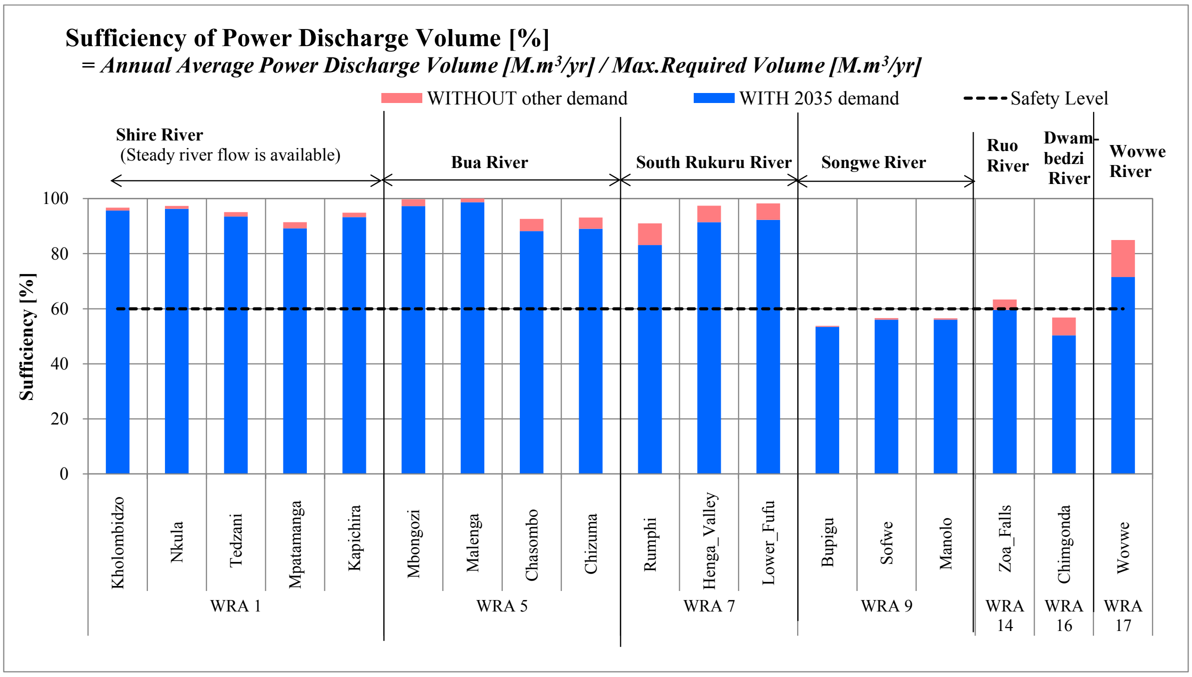
*DSM (Demand Side Management) is not counted as power generation
Source: Project Team based on Report by expert on electricity (2013) and MCC (2011)

Figure 11.1 Time Line of Electric Power Development

11.3 Evaluation Results for Hydropower Development

Hydropower reservoir operation simulation and energy calculation were conducted for each hydropower reservoir. Water use sufficiency for hydropower generation was evaluated in consideration of safety level on annual water demand volume for hydropower generation. **Figure 11.2** shows comparison result between "With" other water demand at upper stream of the river and "Without" other water demand at upper stream of the river. Because the water resources development at upper stream of river basin in future will affect and decrease river flows into the hydropower reservoir, this result here can evaluate the impact to hydropower generation.

According to the result shown below, hydropower projects in WRA-1 (Shire), WRA-5 (Bua), WRA-7 (South Rukuru), and WRA-17 (Wovwe) are feasible from the viewpoint of water resources sufficiency even in the case of water sufficiency of "With" upper stream water use. On the other hand, projects of hydropower projects in WRA-9 (Songwe), and WRA-16 (Dwambezi) require detailed optimization studies on design and operation in feasibility studies. In addition, there was only poor data record of river discharge data of gauging stations of the Songwe River and the Dwambezi River, which made lower reliability of low flow analysis results. Therefore, discharge measurement on these rivers will be essential for water resource development as well as hydropower development.



Source: Project Team

Figure 11.2 Evaluation Result for Hydropower Generation on Water Demand

11.3.1 Recommendation and Conclusion on Hydropower Development

According to the results, it can be said that hydropower projects in Malawi are feasible from standpoint of the water resources. Furthermore, cascaded development proposed in the master plan level study of WB1998 is more beneficial than single development. Therefore, for proceeding projects, feasibility studies and further design studies are recommended for practical hydropower development.

11.4 Information Sharing

Because meteorological data such as rainfall data is being observed by MoNREE, and hydrological data such as river flow data by MoAIWD, sharing these data for studies on hydropower development is very important to manage hydropower generation. In consideration of increasing of water demand for irrigation or urban use, necessity for developing multipurpose dam including hydropower will be rise up from now on. Furthermore, developing upper stream of the watershed affects the river flow conditions of lower stream facilities and environment. Therefore, sharing these data (hydrological data, meteorological data) and integrated development of the watershed will be more and more important. From the view points above, cooperation with MoNREE and MoAIWD will be more and more important.

11.5 Facility Management

11.5.1 Sediment Management

Sedimentation in hydropower reservoir is one of the most important issues for sustainable power generation. Sedimentation in the reservoirs causes not only decreasing of storage capacity of the reservoir but also cavitation and damages of power generation turbines by inflowing from intakes.

At present, sedimentation in the existing hydropower reservoirs, such as Nkula, Tedzani, and Kapichira is serious. According to ESCOM (Electricity Supply Corporation of Malawi Limited), most of these sediments come from the tributaries of lower stream of the Kamuzu Barrage at Liwonde. Because the river bank of the tributaries are not protected, the soil from the cropped lands besides the rivers flows into the rivers when floods occur.

As for countermeasures, dredging / excavation and scouring are applied. Because these reservoirs play the important role of power generation in the whole Malawi, it is not impossible to lower the reservoir water level to flush sedimentation. Therefore, dredging is the main countermeasures at present. According to ESCOM, the dredger in the Nkula reservoir operates 16 hours a day for whole year. These removed sediment are fertile and can be utilized as kinds of fertilizer for agriculture.

Although, removing sediment by dredging / excavation would be the major countermeasure for short-term, integrated river basin sediment management including decreasing sediment inflow by check dams and land use management would be necessary for middle- and long-term countermeasures. One of the important countermeasures to decrease sediment inflow from tributaries is check dams on the tributaries at upper stream, where sediment inflow amount is large. From the viewpoint of watershed management, protecting crop land besides the rivers from erosion and protecting forests from deforestation are also efficient countermeasures.

11.5.2 Weed Management

Vegetation flows into intakes is also problems for hydropower generation. ESCOM are suffering from removing vegetation at the intake. Some of vegetation comes from passing through Kamuzu Barrage at Liwonde, and others from tributaries. As for countermeasures, removing weeds at upstream point of the Liwonde is effective, and volume passing through Liwonde has been decreased. However, weeds flowing together with sediment from the tributaries have been increasing because of the same reason above mentioned for sedimentation. Therefore, as mentioned above, protecting river bank to prevent from soil erosion will be important for this countermeasures. Furthermore, it will be effective to restrict land use as cropland along the river.

11.6 Conflict Management

As mentioned above, water demand at upper stream for irrigation will have impacts on hydropower generation because used water by irrigation never flow back to the river. Water use for hydropower will gain far much benefit. On the other hand, water use for irrigation will be essential for protecting food security in this country. There are sometimes conflicts on water use among multi sectors especially with irrigation and hydropower, for example in the South Rukuru River and the Shire River. In such cases, it will be essential among sectors of each water use to discuss each other how much amount the water demand to be developed. As opportunities for discussion each other, activities and organizations such as Sector Wide Approach (SWAp), or River Basin Authority (RBA) will play important roles for solving conflictions. Shire River Basin Management Project (SRBMP) supported by World Bank plays important roles for conflict management as well as facilities management.

CHAPTER 12. WATER RELATED DISASTER

12.1 Background of Disaster Related to Water

12.1.1 General Disaster Conditions

More than 47 natural disasters were recorded in this three decades and these disasters range from droughts, earthquakes, epidemics, floods and storms. Among them, floods have the highest frequency followed by droughts while storms were the least in occurrence. The 1991 flood recorded the second highest economic damage following the damage by earthquake occurred in 1989.

In addition, it is highlighted that more people were affected by droughts, than any other disaster, from the year 1992 through 2007 with the highest affected population in 1992. According to the report "Malawi and Southern Africa : Climatic Variability and Economic performance (2003, WB)", 6 districts, namely, Karonga, Salima, Zomba, Chikwawa and Nsanje Districts, are vulnerable to flood and drought events.

The report for Flood Risk Management Strategy for Malawi is developed for DoDMA in 2010 with assistance of UNDP. The strategy comprises a description of the existing situation; an account of challenges faced, issues, opportunities and options; the presentation of flood risk management strategies,; and an implementation plan. However, according to DoDMA, the activities are behind schedule to be re-arranged and there is necessary to harmonize with the DRM activities and idea of Water Bill (2013).

12.2 Integrated Flood Management (IFM)

12.2.1 Objectives and Policy of Flood Control

Flood disaster should be prevent and mitigate in consideration of activities for other disasters to effectively utilize of systems, functions, human resources, budget related agencies as to DRM. In addition, the Malawi government states that all stakeholders in the country will align their activities towards this policy in order to ensure that resilience to disasters is built at national, local and community levels" in the National Disaster Risk Management Policy. Therefore, flood disaster risk management should be also integrated with National DRM and countermeasures should be done involving all stakeholders from government units and civilian groups. In this context, integrated flood management (IFM) should be recommended in the Malawi).

The integrated management of land and water is very important for the river basins in Malawi. The IFM plan should aim to mitigate flood damage for all the flood inundation areas. However, the flood damage area is too extensive and scattering to manage. Efficiency of large-scale structural measures that aim to deal with the flood of Malawi may be very low because the flood damage areas are less developed and less populated. Therefore, appropriate flood management made of a best mix of structural and non-structural measures should be applied to build a resilient society to floods

12.2.2 Flood Conditions and Strategies for Flood Management

(1) Flood Prevention and Mitigation in Habitual Flood Damage Area

Investigations and analysis to find out vulnerable areas have been carried out by the Malawi government and in the Project. In the next stage, more detailed study and implementation of measures should be done to mitigate and prevent from flood damage in habitual flood areas. The measures should consist of structure and non-structural measures in consideration of climate change impacts and cost-benefit.

(2) Creation of Flood Resilience Land Use

Disorderly land developments in flood prone area increase flood damage potential as well as flood discharges (risk). In Malawi, definition of river area and cadastral area are not well-arranged to develop backlands and riverine areas properly. In the stakeholder meeting held on September 2014, there are recommendations from stakeholders to regulate the cultivation in the riverine area for not increasing the sedimentation flow which cause hindering of river facilities and occurrence of over-flow floods from river channels.

Land degradation and poor farming practices has led to heavy siltation in most of the large rivers and river facilities consequently reducing their depths and capacities. This simply means that the same amount of water that could not flood a few years ago when the rivers were deep is currently flooding. There are some rivers, e.g. Lifidzi, which have been completely filled up with silts; places close to where it joins Linthipe River. There is no trace of river course as any drop of water that finds its way into the river spreads and floods into villages and fields that lies below it. In addition, People live in flood prone area is also problem to prevent from direct and in-direct flood damage. The countermeasures should be examined and proposed circumstantially in consideration of non-structural and structural measures including implementation agencies and communities.

(3) Ensuring of Safe Evacuation

To save human lives is the first priority of the IFM plan. Appropriate response to floods is also important to minimize flood damages. Flood forecasting and warning system as well as evacuation system with community-based flood management is a tool to lead people to safe places during floods. As of September 2014, the flood forecasting and warning system is about to introduce with technical assistance by WB in the Shire River Basin. Similar activities and projects should be implemented in the flood habitual areas.

12.2.3 Objectives and Roadmap for IMF

The objectives of IFM plan is to provide a roadmap for building a resilient society to floods in Malawi. The roadmap for IFM is modified based on the flooding conditions, present framework of related agencies, policies and strategies. The outline of short-, middle- and long-term plans was proposed by "Flood Risk Management Strategy (2010)"; however, the strategy was formulated before starting the DRM activities by DoDMA and the enactment of the Water Bill, and occurrence of the largest flood (2011). In terms of the condition, the strategy should be re-arranged and proposed in the Project.

12.2.4 Action Plans for IMF Roadmap

Action plans for IMF proposed as follows:

- Improvement of Flood Risk Management Strategy in consideration of DRM Preparation
- Formulation of River Zoning and Preparation of Hazard Maps
- Risk Assessment to select priority areas and formulate flood mitigation plans in the future.
- Strengthening of Information Management System to smoothly furnish the information to the authority and related agencies or water users for the purpose of integrated water resources management.
- Feasibility Study for Major Vulnerable Area to clarify necessary measures and inventions in the vulnerable areas before flood mitigation works are implemented adhockery by local governments
- Investigation for Flash Flood Conditions
- Preparation of Technical Guidelines for Flood Protection Works
- Capacity Building for Flood Protection and Mitigation Activities
- Implementation of Flood Warning System
- Implementation of Flood Protection Works
- Implementation of Response and Recovery Works(F-12)

CHAPTER 13. PLAN FOR SOIL EROSION MEASURES

13.1 Investigation Results

Present condition and issues on sediment runoff are investigated through survey and analysis targeting some pilot basins. As a result of the investigations and analysis, the following can be cited as findings though these are acquired from quite limited survey results:

- Volume of suspended sediment is fairly bigger in rainy season than in dry season.
- The volume of suspended sediment is inversely proportional to forest coverage ratio.
- Sediment runoff is not so big in Malawi though it may vary depending on catchment condition.

13.2 Condition and Direction of Watershed Conservation

Soil erosion and degradation of watershed are mainly caused by deforestation due to low electrification rate, expansion of cropland, population growth, poverty, low literacy and insufficient observation which are the challenges for watershed conservation. The major key to solve the challenges is how to secure energy under the population growth and poverty. The reliance of biomass which generate energy from firewood, charcoal, etc. is 93% in 2000 and the National Energy Policy sets that it shall be decreased to 50% in 2020, at the same time, electricity is increased from 2.3% to 40%. Now in Malawi, 94% of electricity is generated by hydropower and still hydropower generation will be the major electricity energy source in the future. Hydropower plays quite an important role in electric power generation and the effective and stable utilization of hydropower is required for the country's development. Therefore, to prevent sedimentation in the hydropower reservoirs, the soil erosion measures and watershed conservation such as afforestation should be carried out. For biomass such as charcoal, sustainable utilization and management is necessary in order not to adversely affect various sectors.

13.3 Road Map and Activities

Considering the assessment of sediment volume and the location of existing and planned dams, the priority WRUs are selected to take actions on soil erosion measures and watershed conservation. The actions for soil erosion and watershed conservation listed below should be implemented from the priority WRAs.

- Establishment of Conservation and Co-management Plans (The soil and forest conservation and co-management plan for watershed)
- Utilization of Effective Fuel and Electricity instead of Firewood
- Promotion of Afforestation, Village Forest Area and Agroforestry
- Contour Farming for Existing Farm to reduce soil erosion from farm
- Setting of Restricted Zoning on Settlement and Farm to prevent expansion of unregulated development and destruction of forestland and watershed.
- Installation of Sedimentation Tank and, Riprap, etc. to prevent soil erosion from watersheds
- Governing by NWRA and CMS with related Agencies
- Promotion of Changes in the Consciousness and Capacity Building for village people
- Monitoring and Evaluation to estimate amount of soil erosion, sediment runoff and sedimentation in reservoir are necessary to observe

Upon implementation, considering the PDCA cycle, non-structural and structural measures are carried out after planning though some of them are implemented in parallel. And then, with monitoring and evaluation, proper maintenance and management are conducted and it is reflected to planning again. It is repeatedly carried out to spiral up for better soil erosion measures and watershed conservation.

CHAPTER 14. WATER RESOURCES MANAGEMENT

14.1 Integrated Water Resources Management in Malawi

Water resources management which follows the principles of Integrated Water Resources Management (IWRM) has been recognized and adopted by key players who utilize water for various social and/or economic activities in a very wide cross-section of sectors. IWRM has proven to be a flexible approach to water management that can adapt to diverse local and national contexts.

The Integrated Water Resources Management System has become a common conceptual framework for management and utilization of water resources. In Malawi the high level government officials are well sensitized about the concept; however, the institutional structure is still in the transitional process. The following items were made to improve the issues identified as above, for upgrading the institutional activities of Ministries towards the IWRM, including a proposal of setting a new department with operational teams for district coordination and international cooperation activities.

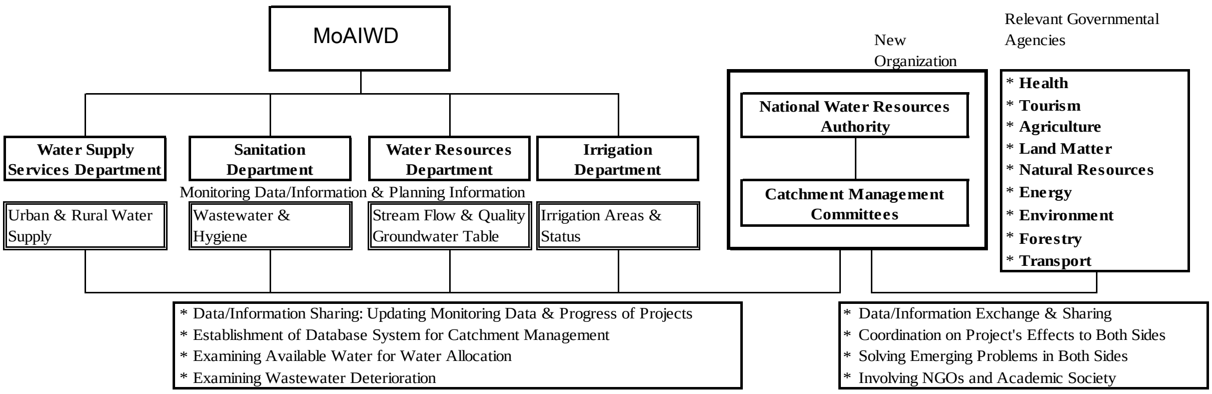
14.2 Institutional System for Integrated Management

The establishment of the National Water Resources Authority and the Catchment Management Committee will greatly contribute to the realization of IWRM in Malawi. Based on the Water Resources Act of 2013, the function of both organizations are as summarized below.

14.2.1 Managerial Coordination of the Organizations

(1) Overview for IWRM Coordination

Based on the implication of the Water Resources Act and the IWRM policy, coordination of all relevant stakeholders centering on the NWRA and catchment management committees among them may be the great challenge in realizing the Malawi IWRM. The NWRA is an independent organization, but it is closely related to the MoAIWD, so that the NWRA shall has a mutual relationship with MoAIWD to exchange and share information regarding water resources management and development projects. Regarding relevant governmental agencies out of MoAIWD, the NWRA shall conduct a sector-wide coordination among them. The proper relationship between them is illustrated in the next figure.

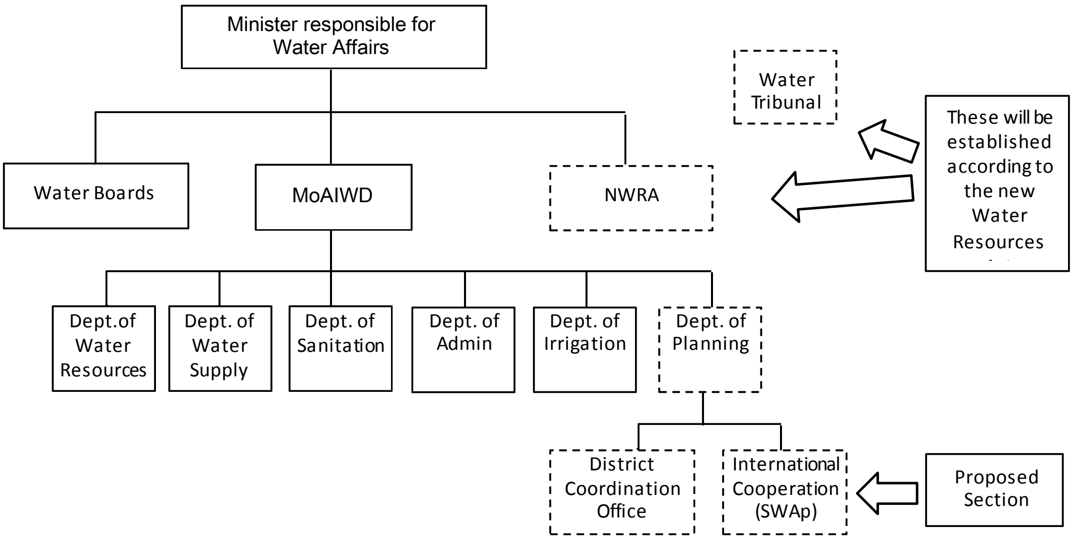


Source: Project Team

Figure 14.1 Organizational Relationship and Necessary Coordination Works

(2) Proposals on Strengthening the Institutional Capacity of the Water Resources Management

The Project Team identified issues which need interventions for improvement and proposed new units for IWRM. These new units will serve as the focal points for navigating the water sector policy, upgrading the district office activities around the country and international interventions. **Table 14.2** illustrates a proposed structure of the Ministry of Water Development and Irrigation (MoAIWD) and NWRA. The sections indicated by the dotted squares are the new institutional units that are proposed in this Master Plan.



Source: Project Team
Note: Water Tribunal will be set up according to the National Water Resources Act of 2013

Figure 14.2 Proposed Organizational Structures of MoAIWD and NWRA

1) Institutional Framework for the National Resources Authority

The transitional process of establishment of the NWRA requires gradual transfer of certain mandates of which the Ministry is currently in charge. Projects that are needed for capacity building of NWRA are outlined in **Table 14.1**.

Table 14.1 Projects Recommended for Institutional Strengthening of NWRA

Project Theme and Background	Project Components	Target Stakeholders
1.Classification of Rivers		
For the purpose of river water management there needs to be a classification system of rivers with regulations covering – water quality standards, conservation rules, management system by classifications among others.	**1.** Draw a set of classification criteria **2.** Draw rules and regulations according to the classification of rivers **3.** Inform stakeholders of the protocols who undertake any activities related to the rivers	**1.** NWRA officials **2.** Surface water section **3.** River water users
2.Buffer Zones Management of Rivers		
To facilitate riparian management, such as river and lake waters, buffer zones need to be set in place to avoid siltation and contamination of water by cultivation activities at riversides. However, in practice there need to be alternative ways of gardening as people are gaining food and income from such practices.	**1.** Draw a set of classification criteria **2.** Draw rules and regulations according to the classification of rivers **3.** Assist raising awareness and other means of gardening by providing water through pipes or something.	**1.** NWRA officials **2.** Ministry responsible for water affairs **3.** River water users
3. Catchment Area Management		
Catchment Area Management is a key to manage and supervise 17 Water Resources Areas (WRA) also indicated catchments across Malawi. A catchment area management committees will cares for 1 or more catchment areas.	**1.** Draw guidelines for catchment area management **2.** Establish catchment area committee **3.** Implement activities concerning water allocation, conservation and control of water usage.	**1.** NWRA officials **2.** MoAIWD officials **3.** District councils **4.** Water users
4. Registration of Water Users Association		
Many water users associations have been established to monitor and manage water usage. However, those entities are currently not registered or regulated by any legal constitutions. Many farmers associations created WUAs under department of irrigation as well as Blantyre Water Board and Lilongwe Water Board but there is no supervising entity to regulate and support WUAs at the operational level.	**1.** List and register all WUAs in Malawi **2.** Facilitate WUAs to create and agree on constitutions **3.** Sensitize to pay water license charges to NWRA	**1.** WUAs **2.** District Councils **3.** NWRA officials **4.** Ministry responsible for water affairs

Source: Project Team, Water Resources Act

2) Water Sector Wide Approach

The structure of Sector-Wide Approach (SWAp) is established in order to strengthen a management system with participation of relevant stakeholders to the water sector. As noted that the technical working groups are only reporting individual projects and interventions progress, the SWG is unable to identify strategic challenges, and make appropriate policy interventions and plan adequate projects or programs. Therefore, for the functionality of TWGs and SWGs to be coordinated to focus more on the strategic interventions and policy formulation, the government officials of the departments from the Ministry have to be involved in the respective TWGs to coordinate, report the planning activities of TWGs and liaise with the Secretariat for the overall coordination. **Figure 14.3** proposes the structure of SWAp with a ministry official attached to TWGs.

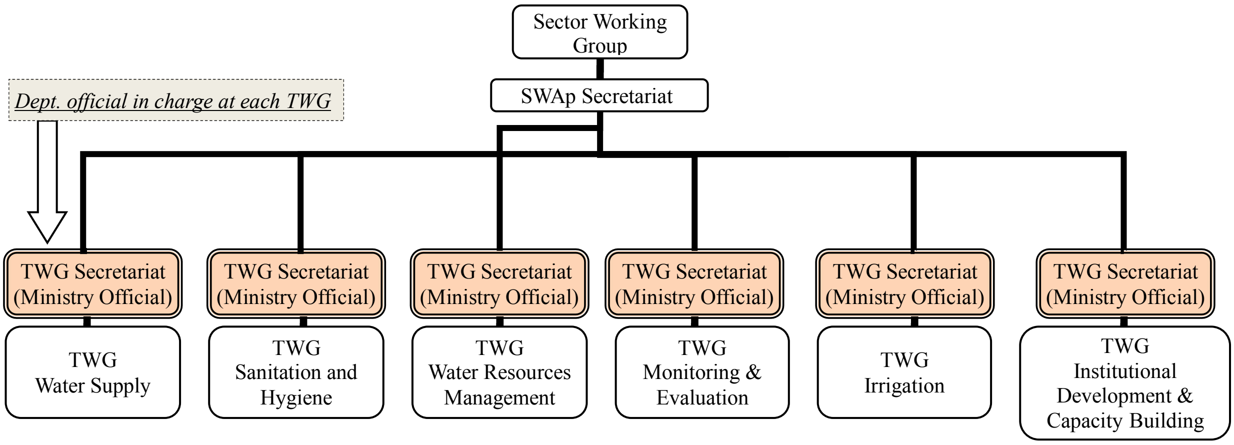


Figure 14.3 Proposed Organizational Structure for Water Sector Technical Working Group

14.3 Surface Water Management

14.3.1 Information Management Conditions

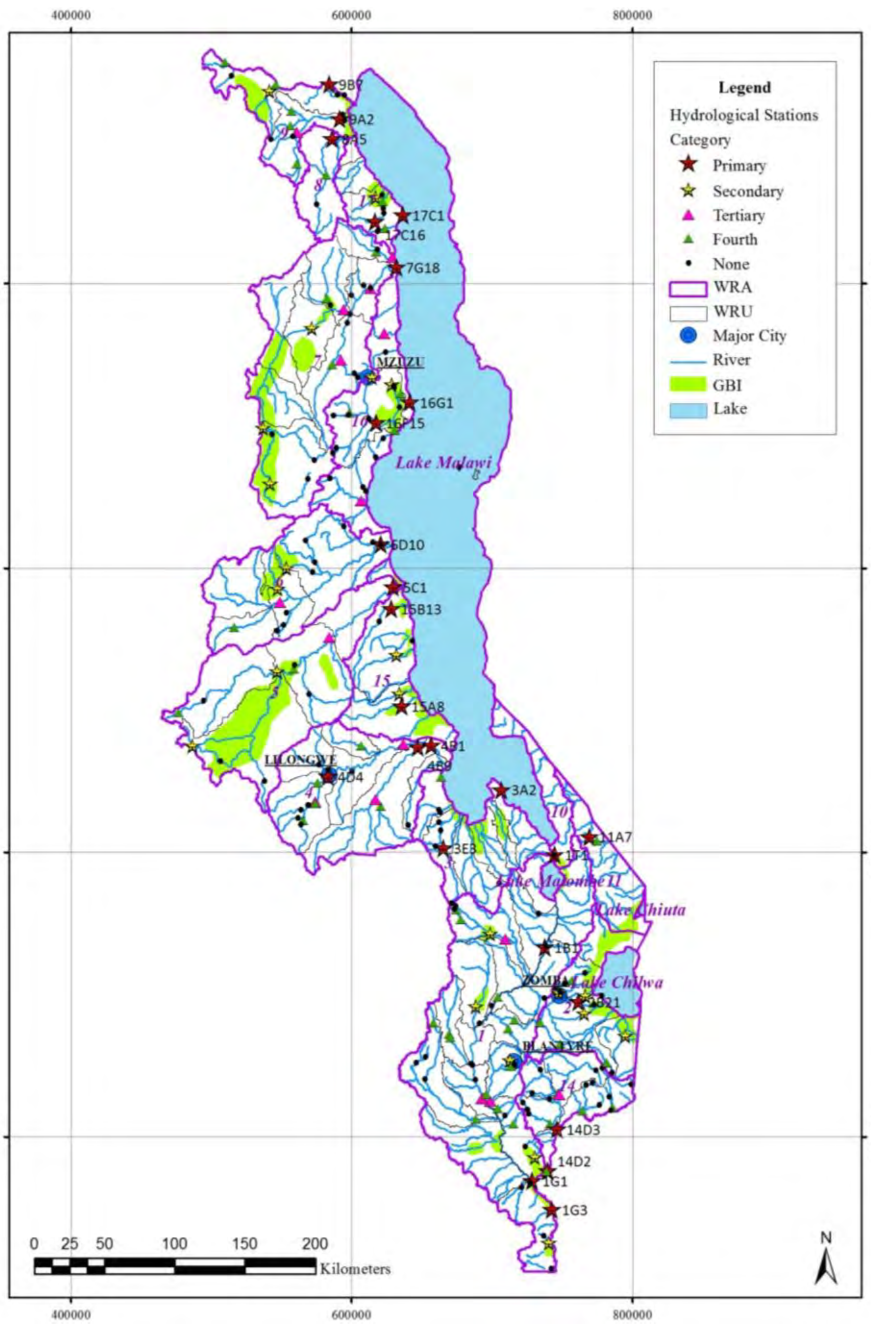
Data and information are basis of activities for water resources management, such as assessment of existing water resources and development potential, proper water allocation and water use management, water resources conservation, and examination of plan of water resources management and development. In Malawi, rainfall observation started in the beginning of the 1900's, water level and discharge observed from late 1940's, and groundwater monitored from 1970's in some area although they have some interruption period.

14.3.2 Water Level Observation and Discharge Measurement

Since more than 300 hydrological stations historically existed in Malawi, presently, 139 stations consisting of 136 MoAIWD stations and 3 Water Board stations are operational and 164 stations are closed. Among operational stations, stations with acceptable operational condition are only about 40%. However, improvement and/or rehabilitation of existing hydrological stations and installation of new stations are not implemented mainly due to shortage of funds. Presently, about 20 automatic gauging stations are operational or will be operational in the near future; namely, the SADC-HYCOS (Southern African Development Community Hydrological Cycle Observing System) stations, stations with data logger installed by AfDB, and those at the Mulunguzi Dam run by the Zomba Water Board. Prioritized stations are shown in **Table 14.2** and **Figure 14.4**.

Table 14.2 Activities for Short-, Middle- and Long Term Plans

Terms	Concrete Activities
Short	**<u>"Observation System (Organization and Human Resources)"</u>** The following activities shall be carried out in order to develop the system for proper observation and proper collection and management of the observed data in the prioritized stations: ➢ To set and allocate proper remuneration to gauge readers; ➢ To conduct training to gauge readers engaged in prioritized stations; ➢ To strengthen district offices such as employment of necessary staff for vacant positions, training of staff, securement of transportation and increase in budget for prompt activities; and ➢ To strengthen data management system in the headquarters. In order to develop a reliable and stable O&M structure for the above water level observation system, the following activities shall be implemented: ➢ Setting a rule for confirming situation of gauge reader, observation station and equipment, as well as confirming and recording each station's situation at regular interval based on the rule; and ➢ Acquiring and keeping proper number of staff. **<u>"Observation Network (Station and Equipment)"</u>** Improvement and rehabilitation of stations and equipment shall be implemented for reliable and stable observation in the prioritized stations. Definitely, the following activities shall be done depending on the priority of a station: ➢ Confirmation of present status of a station and Rehabilitation and/or reinstallation of staff gauges; ➢ Maintenance of circumstances around stations including mowing, cutting trees and clearing and rehabilitation and/or installation of fence as required; ➢ Maintenance of access road to stations; ➢ Rehabilitation and reinstallation of facilities for high flow measurement in Primary level stations, and; ➢ Cross sectional survey for sections of discharge measurement from Primary to Tertiary level of stations. **<u>"Observation Activities"</u>** ➢ Discharge measurement shall be restarted and continuously at stations where confirmation of present status and rehabilitation will be done. Based on the results of discharge measurement, confirmation of availability of existing rating curves and those for update activity shall be conducted.
Middle	**<u>"Observation System (Organization and Human Resources)"</u>** ➢ Same activities as the short term shall be continuously carried out;. ➢ Redevelopment of the system for proper observation shall be carried out targeting stations with high necessity; ➢ A system for proper O&M corresponding to automation of a station shall be developed; and ➢ The development and reinforcement of systems that can carry out proper frequency discharge measurements for increased rehabilitated stations shall proceed. **<u>"Observation Network (Station and Equipment)"</u>** ➢ Same activities as the short term shall be continuously carried out for the improvement and rehabilitation of stations and equipment targeting the stations with high necessity; ➢ Improvement and rehabilitation of stations and equipment targeting stations with high necessity; and ➢ Installation of automatic water level gauges shall proceed at stations considered to have high necessity. **<u>"Observation Activities"</u>** ➢ Same activities as the short term
Long	**<u>"Observation System (Organization and Human Resources)"</u>** ➢ The reliable and stable observation system and its O&M structure developed by the middle term plan shall be properly maintained. ➢ Redevelopment of the system for proper observation shall be carried out targeting the reopened stations ➢ In case that installation of new stations and/or automatic stations with/without telemeter system will be promoted, the system for proper operation of those stations shall be reinforced. **<u>"Observation Network (Station and Equipment)"</u>** ➢ The stations and equipment installed or rehabilitated by the middle term plan shall be properly maintained. ➢ Rehabilitation of a station shall be carried out targeting the reopened stations considered to have high necessity. ➢ Installation of a new stations and automatic water level gauging stations shall proceed as required. ➢ The introduction of telemeter system for stations where observation data can be used for flood forecasting and warning, or stations that are extremely important from water use aspect and need timely data shall be promoted.



Source: Project Team

Figure 14.4 Prioritized Water Level and Discharge Gauging Stations

14.3.3 Rainfall Observation

Meteorological observation including rainfall observation is managed by the Department of Climate Change and Meteorological Services under MoNREE. In the Project, 23 stations among 69 stations are selected as the stations that have sufficient daily rainfall data. Even in this case, the covered area of one station is large at 1,000 to 2,500 km^2 and 1,400 km^2 on average. In addition, spacial distribution of the stations is not adequately spread evenly; for example, there are no stations in the upstream of WRA 6 and WRA 8. Further, there is no daily rainfall data available after the 1990's in almost half of the 69 stations. To improve the conditions mentioned above, the short- , middle- and long-term plans are established as described below.

Moreover, from the viewpoint of water resources management, MoAIWD needs to be provided with rainfall data by the Department of Climate Change and Meteorological Services since MoAIWD does not manage any rainfall station. A Framework for timely data sharing is also required to be developed.

Table 14.3 Activities for Short-, Middle- and Long Term Plans

Terms	Concrete Activities
Short	**"Observation System (Organization and Human Resources)"** In order to develop the reliable and stable rainfall observation system, the following activities shall be implemented: ➢ Training to assigned gauge readers ➢ Preparation of manual for reviewing observation data ➢ Strengthening of the structure/system of collection, input and management of the data. In order to develop a reliable and stable O&M structure, the following activities shall be implemented: ➢ Setting a firm rule and duty for confirming necessary activities of gauge reader ➢ Acquiring and keeping proper number of staff in the Department of Climate Change and Meteorological Services. **"Observation Network (Station and Equipment)"** Reliable gauging stations shall be increased aiming at development of the reliable and well-distributed observation network consisting of about 100 stations at least. Ideal condition is: (i) at least one station exists in each WRU for basin-based water resources management; and/or (ii) covered area of each station reaches to about 1,000 km^2.
Middle and Long	The observation network shall be continuously reinforced by installing rainfall gauging stations as required to the area where there are no reliable operating stations and/or few stations in the basin. ➢ Installation of automatic rainfall gauge to existing rainfall gauging stations shall be promoted as required, with the aim of: (i) ensuring substitutability of observation; (ii) ensuring data quality by confirmation and comparison of observation data; and (iii) investigating rainfall intensity. ➢ The reliable and stable rainfall observation system and its O&M structure developed in the short term plan shall also be established and maintained to newly reinforced stations in medium and long term. ➢ The introduction of telemeter system for stations of which observation data can be used for flood forecasting and warning in flood prone area shall be promoted as required.

14.3.4 Environmental Flow

Normally, environmental flow is the ensured flow for river environment in order to reduce the impact of human activities such as intake for irrigation and domestic water. Meanwhile, since the rivers in Malawi tend to dry up in the dry season, firstly, the purpose for ensuring the environmental flow, for example securing specific species or recreation, should be clarified, and secondarily, the volume of environmental flow at control points should be determined through detailed studies and researches. Especially, when there is a large-scale water resources development, the environmental flow should be secured with compensation for environment and water users at the lower stream. As irrigation development progresses, the sufficiency of river flow will decrease. However, by modification of cropping pattern, it is improved to some extent. Irrigation sector is the most water consumption user; therefore, the development shall proceed carefully considering the impact of intake on river environment.

14.4 Groundwater Management

In consideration of the growing population in Malawi, groundwater development shall aim at the following two points: (a) To sustain pumping volume from boreholes within groundwater recharge volume; and (b) To raise effectiveness and capacity of pumping.

14.4.1 Guideline for Groundwater Development

(1) Potential Volume of Groundwater Resources in Malawi

The groundwater potential generally corresponds to recharge volume. The recharge volume each WRA in Malawi have been roughly estimated using the Darcian flow method and the water balance method in the Master Plan. Almost all of the WRUs have sufficient groundwater available to supply water for demands by 2035 apart from WRU 5D and 5E. Only 5D and 5E watersheds including parts of Mchinji, Dowa, Nitchisi and Lilongwe districts will get into shortage of water by approx. 5 million m^3 in 2035. These water resource areas generally consist of flat lands on a series of plateau and indicate the lowest recharge (4 mm/year) in Malawi. Thus, the Malawi Government has to manage carefully to exploit groundwater resources not depending on the considerations of localized groundwater in these areas.

(2) Village Area

As a result of investigations based on the examination records of boreholes, the influence area will never extend over 50m from pumping borehole no matter what aquifer conditions exist as long as the fixed supply rate (18.8 liter/min) is obeyed. That is to say, sustainable water supply will be realized in 100m interval between boreholes if an aquifer has potential yield larger than the fixed supply rate (see **Figure 14.5**).

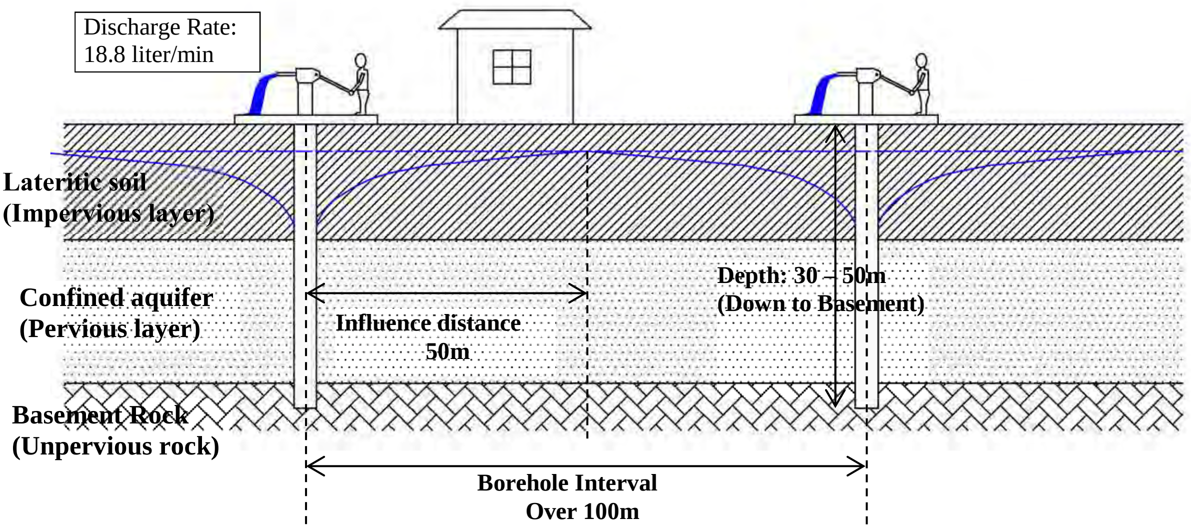


Figure 14.5 Adequate Borehole Placement in Village Area

(3) Guideline for Market Centers

Market centers which require the consumption rate less than 150 m^3/day are not expected to have positive economic effect on mass-water supply facilities. The water supply using Afridev-hand pump is a more appropriate measure for a small market center as well as normal supply scheme for the villages. Boreholes for middle to large scaled market centers with consumption rate of 250-1,000m^3/day are basically installed with motive pump per borehole. If excellent alluvial aquifer which has high transmissivity more than 30 m^2/day can serve a large amount of water adjacent to a market center, taking water by well group will have higher productivity and cost effectiveness rather than single utilization of borehole. However, a well group influences drawdowns of other boreholes in a wide area. A well group has to be set at least 1 km from other boreholes. The borehole depth shall be up to 70m in order to take water from some aquifers. **Table 14.4** presents rough lodestars for groundwater development planning. The detailed plan of water supply to an individual market center requires site investigation including social conditions, topographic and geological conditions, etc., by feasibility studies.

Table 14.4 Conceptual Schemes of Groundwater Development for Market Centers

Aquifer	Population reserved from borehole in Market Center	Design consumption (m^3/day)	Pump Spec.	Borehole Placing Pattern	Numbers of Borehole or Group	Borehole Depth (m)	Recommended Discharge (m^3/BH/day)
AL	< 3,000	< 150	Afridev	Single	< 15	30 - 50	10
	5,000	250	Motive	Single	1 - 4	50	80 - 250
	10,000	500	Motive	Single	2 - 5	50 - 70	100 - 250
	20,000	1,000	Motive	Group	One group	70 - 100	350
	30,000 <	1,500	Motive	Group	More than 2 groups	70 - 100	300
WB	< 3,000	< 150	Afridev	Single	< 15	30 - 50	10
	5,000	250	Motive	Single	5	50	50 - 60
	10,000	500	Motive	Single	7 - 10	50 - 70	60 - 80
	20,000 <	1,000	Motive	Single	10<	50 - 70	120

Source: Project Team

14.4.2 Groundwater Management Plan

In Malawi, groundwater resources will become more important to satisfy water demand in the increasing population of rural areas. However, the responsibilities and rules of groundwater data management have been absent and a lot of valuable borehole data have disappeared since the 1990's, although groundwater development has rapidly expanded. Sustainable usage of groundwater will be required to formulate a competent and systematic management system of which MoAIWD staff can constantly steer by themselves. This report shows several road maps and activities for establishing groundwater management system in the short (up to 2020), middle (up to 2025) and long term (up to 2035) as follows.

Table 14.5 Activities for Short-, Middle- and Long Term Plans

Terms	Concrete Activities
Short	In order to establish the framework of the groundwater management system, the following activities shall be implemented: ➢ Establishment of a borehole database and managing it effectively. ➢ Establishment of comprehensive guideline for groundwater management system, which consists of basic/technical knowledge of groundwater and routine manual for administrative procedures, procurement, data processing, data format, maintenance of database, etc. In order to strengthen executive capacity of the Groundwater Division of MoAIWD, the following activities shall be implemented: ➢ Establishment of "Groundwater Management Section" which shall specialize in data processing, analyzing and evaluating groundwater resources in the Groundwater Division. ➢ Capacity building and staffing of hydro-geological experts for data management, evaluation and planning groundwater development via training schemes. In order to identify the existing boreholes, the following activities shall be implemented: ➢ Inventory survey for groundwater sources (boreholes and shallow wells). ➢ Staffing with personnel to implement the survey.
Middle and Long	In order to operate and maintain the groundwater management system established according to activities in the short term, the following activities shall be implemented: ➢ Feeding back the outputs and these evaluation of activities in the short and middle terms into the guideline. ➢ Continuing training on management operation and maintenance (O&M). ➢ Keeping budget sufficient for O&M of groundwater management system every year.

Although much data regarding groundwater had accumulated, the data formats and storage media are not standardized and these generally are stored haphazardly at different storage places. Data users therefore cannot utilize groundwater information of Malawi conveniently and it takes a long time to collect and analyze the data. It seems that there have been many cases in which valuable data was buried and not used due to lack of communication between departments of the ministry and badly stored data. The future management system for groundwater has to realize more systematic based on IT principles and a rigorous guideline. This report gives several recommendations on the framework of a sustainable management system for Malawi.

14.4.3 Groundwater Monitoring

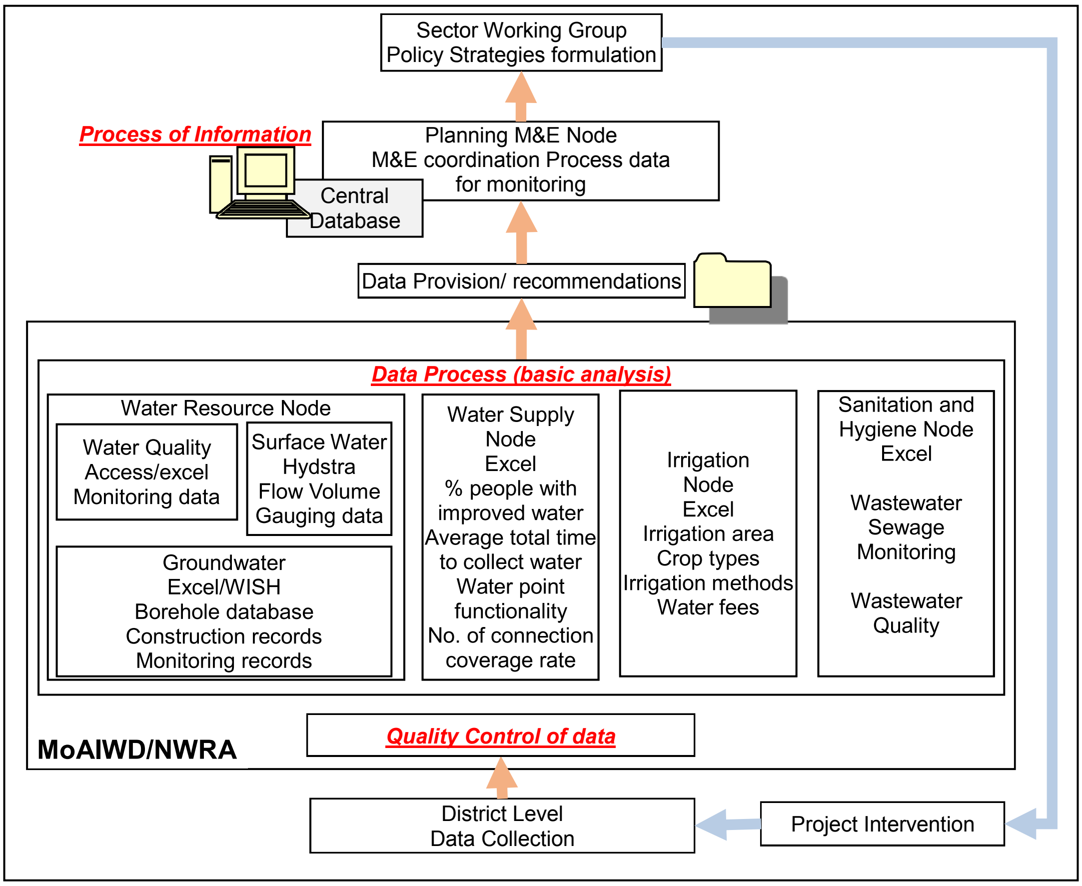
Regular groundwater monitoring in Malawi began in 2009 and in 2013 automatic groundwater leveling was brought at available monitoring wells. The circumstance of groundwater monitoring has been improved step by step. However, the monitoring is conducted at just 30 wells and it still remains insufficient for discovering groundwater status and predicting changes in future. The MoAIWD staff had not become familiar with the data logger, thus the current monitoring frame still has vulnerability in the viewpoint of sustainability. Groundwater monitoring is only one method to see groundwater dynamics immediately, thus the future monitoring scheme shall aim to sustain dense monitoring network in long term for contributing to groundwater management.

Table 14.6 Activities for Short-, Middle- and Long Term Plans

Terms	Concrete Activities
Short	In order to strengthen routine works of the automatic leveling, the following activities shall be implemented: ➢ Preparation of manual for collecting data from data loggers, tidying up data in computer, extracting data error, and maintaining data loggers. ➢ Staffing officers who collect monitoring data at sites. ➢ Keeping budget sufficient for expenditure of regular site-visits and consumables every year. In order to construct new monitoring wells, the following activities shall be implemented: ➢ Feasibility study each site ➢ Well construction
Middle and Long	In order to renew the existing wells, the following activities shall be implemented: ➢ Regularly confirming conditions of monitoring well and data logger. ➢ Keeping budget sufficient for expenditure of parts replacement of data logger and the relevant equipment every year.

14.5 Monitoring and Information Management System

The hydrological data sets are fragmented and inconsistent in MoAIWD. In addition, there is no proper system to manage data quality and data process for hydrological information. At present, two projects named as "Strengthening Water Sector Monitoring and Evaluation Project" and "Establishment of Water Resources Monitoring System" through NWDP-II were implemented to improve the data collection system and data quality. As a result, MoAIWD is aware how important to establish information management system. In the system, every department in MoAIWD provides information to the central databank. Then, the central databank can process the information so as to be used for policy decision making. In near future, NWRA will monitor the hydrological data including surface water, groundwater and water quality, and will manage them. A recommended schematic system of the information management is shown in next figure.



Source: Project Team

Figure 14.6 Schematic Flow of Data Management

In this context, further interventions are necessary in the form of training and technical assistance to make use of the system and the information stored in the database. **Table 14.7** summarizes the current progress of the training undertaken with regard to the monitoring and information system at different divisional nodes.

Table 14.7 Monitoring and Information System Capacity Development Needs

Nodal Division	Capacity Development Needs for MIS system	Current Situation (2014)
Water supply		
Urban Water	Training on testing and demonstration of the system	Need to be facilitated
Rural Water	Training on data collection and demonstration of the system	*EWB and WaterAid rolled out at 3 districts
Irrigation	Training on database development and usage	JICA assisted in 11 districts
Water Resources		
Water Quality	Water quality monitoring data collection Access database establishment	5 WBs trained under NWDPII
Surface Water	Training on testing and demonstration of the system Hydstra database	Need to be facilitated
Groundwater	Training on testing and demonstration of the system WISH database	Need to be facilitated
Sanitation and Hygiene	Training on database wastewater monitoring, wastewater quality	Need to be facilitated
Water Resources Board		
Improvement of the database system at the WRB is a stepping stone for the establishment of the National Water Resources Authority. All the water abstraction activities have to be registered and given a license number. License fees should be paid by the clients. The WRB has to keep the backup file of the database regularly updated to secure the database from any loss of the databank, virus contamination and/or any other disturbances such as theft.		
Library		
The library is in charge of collecting documents, reports, annual reports and technical data. All stored materials have to be numbered and entered into the archive database. Upgrading of the library activities and transforming it to the "National Water Resources Information Center" will help the country's information management on the national water resources management.		
ICT office		
This office is a new unit and should be placed under the Department of Administration at the Ministry where there will be personnel who can look after the computer equipment and the databank. The ICT office personnel can work on the databank maintenance. Once the system is networked, the ICT office is responsible for the networking system and server.		
District Water Office		
The district water offices have responsibility for water level measurement and discharge measurement at monitoring stations as well as water quality. However, only two offices have just one hydrologist and most offices have two or three staff members of the hydrological team as of September 2013. In addition, remuneration to gauge readers is not enough to ensure their commitment; thus, many stations are not being properly maintained and many gauges are now not even being read because of low remuneration to gauge reader. Furthermore, maintenance by district staff is also constrained by unavailability of staff, vehicles or fuel. As a result, about 70 stations are estimated to need reinstall or replacement of gauge plates among 136 present operational stations managed by MoAIWD.		

*EWB: Engineers without Boarders (Canada), WaterAid (UK)

14.6 Water Quality Conservation

In Malawi, water quality management and the relevant legal provision is definitely lagging behind other activities of water resources management. Water quality conservation is essentially the most important factor determining human health in water resources management, therefore the high level organization which has policy formulation shall take on the responsibility of water quality conservation apart from the central water laboratory and the new organization shall manage the whole of water quality monitoring scheme and a lot of risks by water degradation which threaten human health and ecosystem shall be mitigated by obeying the rigorous standards and guidelines. This report suggests several road-maps and activities for competent of water quality management centering on the Technical Working Group for Water Quality", as follows:

Table 14.8 Activities for Short-, Middle- and Long Term Plans

Terms	Concrete Activities
Short and Middle	In order to manage water quality, the following activities shall be implemented: ➢ Strengthening of members of Technical Working Group ➢ Building a system of prompt data sharing between the committee members ➢ Upgrade Dbase III to new database ➢ Drawing the basic design of new database system ➢ Training for O&M of the new database to the laboratory staff ➢ Preparation of manual for routine works such as the sampling procedure, tidying up data in computer, etc. ➢ Procurement of analytical and measurement instruments for pesticide, organic solvent and heavy metals, such as Gas Chromatograph & Mass Spectrometer, Inductively Coupled Plasma Mass Spectrometry, etc. ➢ Capacity building for O&M of the analytical and measurement instruments, data management and logical interpretation of analysis outputs ➢ Keeping budget sufficient for expenditure of O&M in each laboratory every year ➢ Inventory survey of water abstraction points except groundwater resources and the neighboring land-uses in the whole of Malawi ➢ Water quality analysis on conventional constituents analyzed in the Center Water Laboratory (26 parameters) at pilot points chosen from the water abstraction points ➢ Assigning the watershed class for environmental conservation to all rivers, marshes and lakes in Malawi
Long	In order to operate and maintain the water quality monitoring scheme established according to activities in the short term, the following activities shall be implemented; ➢ Feeding back the outputs and these evaluation of activities in the short and middle terms into the environmental water quality standards and guidelines ➢ Continuing training of O&M in each water laboratory

Source: Project Team

14.7 Sanitation

The maintenance of existing facilities needs to be improved to fulfill the Malawian standard on effluent discharges. A National Urban and Rural Sewage Development and Management Master Plan are highly recommended which implementation in turn will result in the protection of the water resources of the country.

(1) Institution in Charge of Sanitation Service in the Urban Areas

National Sanitation Policy 2008 is one of the guiding legislations that are relevant to Water Boards, in which it is stated that the policy transfers sanitation functions from City Assembly to Water Boards in line with the 1995 Water Works Act. According to the Annual Business Plan 2012/2013, however, this aspect is yet to be implemented and Water Board have not yet commenced any activities related to sanitation.

Currently, the city councils are the service providers in the urban areas of cities for centralized sewage collection, transportation, treatment and disposal. However, the Water Policy (2005) and Sanitation Policy (2008) stipulate that water utility companies are responsible for the service. Consequently, there is a need for definition and decision by the Malawian authorities on this issue. It is essential to define the importance as soon as possible in order to establish an institutional framework for sewage management in the urban areas in Malawi.

(2) Institution in Charge of Sanitation Promotion in the Rural Areas

Currently, the promotion of on-site sewage treatment such as the construction of pit latrines, septic tanks, etc., is made by the district councils conjointly with the Ministry of Health and MoAIWD (Sanitation and Hygiene Department). In this sense, these institutions need to be reinforced to increase the rate of sanitation in the rural areas.

14.8 Improvement of Management Plan for Water Development Facilities

14.8.1 Waterworks Facility for Domestic Water Supply

The management for the water supply facility influences the safety and stability of drinking water; hence it shall be carried out adequately, effectively and rationally. Following items should be considered for the operation and maintenance of the water supply schemes. The management for waterworks facility is generally classified in two: operation management and maintenance engineering. The short- and long-term plan concerning the operation and maintenance of waterworks facility is formulated from these two respects as follows:

Table 14.9 Activities for Short-, Middle- and Long Term Plans

Terms	Concrete Activities
Operation Management	
Short	➢ Examination and preparation of recording system for operation and control management, recording of job and operating diary. ➢ Preparation of operation management manual for water boards. (In this manual, the normal and aberrant values of the operation data, the normal and abnormal operating procedures, the accident response, restoration and its structure, etc., shall be described.) ➢ Procurement of necessary equipment for operations. ➢ Investigation of aging facilities and stocks of spare parts. ➢ Capacity development for responsible organizations and personnel.
Middle and Long	➢ Recording of operation and control management; Recording of job and operating diary. ➢ Database architecture (for the routine work, the information management, the water supply control and management, the facilities management, the equipment inspection and rehabilitation archival record, the asset management, etc.) ➢ Water quantity and pressure control (for the integrated management from intake facility to feeder pipe end, the appropriate control regulation, the promotion of efficiency of energy use, the effective leakage prevention, etc.) ➢ Water quality control (for the target water quality, the appropriate sampling and monitoring, the planning and recording of water quality inspection, etc.)
Maintenance Engineering	
Short	➢ Preparation of maintenance manuals ➢ Encouragement of compliance to manual ➢ Procurement of necessary machineries to maintain waterworks facilities ➢ Investigation of aging facilities ➢ Establishment of short, middle and long term maintenance plan ➢ Capacity development for responsible organizations and personnel
Middle and Long	➢ Maintenance operation (for the inspection, maintenance, repair) and Functional advancement (for the functional assessment of waterworks facility, the rebuilding or update or life-extension diagnostics) ➢ Preventive and corrective maintenance ➢ Reliability risk evaluation for facilities ➢ Database architecture to record maintenance and results and revise the maintenance plan

Source: Project Team

14.8.2 Irrigation Facilities

Irrigation management is strongly and closely related to the irrigation development schemes. In each irrigation development scheme, WUA shall be established. Simultaneously, Central Control Office shall be established there as well. The structure of the control office depends on the scale of irrigation development. On the assumption of organizing the Water Users Association (WUA) has a responsibility of the irrigation system working together with government irrigation officers. Normally there are three levels to maintain and control the irrigation system in the project area: (1) Central control office, (2) Local or diversion block control office, and (3) On-farm control office. In the condition mentioned above, short- , middle and long term plan is proposed in the next table.

Table 14.10 Activities for Short-, Middle- and Long Term Plans

Terms	Concrete Activities
Operation Management	
Short	<Necessary Conditions> Water Users Association (WUA) is established among the beneficial farmers in each irrigation area in parallel with the progress of the irrigation development project by 2020. Central Control Office (CCO) is established in each irrigation area, and necessary offices are also established depending on the project scale by 2020. <Activities> ➢ Collecting of on-farm information, and forming the communication and information sharing passage among the project sites, the Irrigation Service Division (ISD), and the Central Government (DOI). ➢ Gaining the operation and maintenance experiences at the project sites through controlling the irrigation facilities. ➢ Implementation of capacity development for proper operation and maintenance of the irrigation facilities by the ISD.
Middle and Long	<Necessary Conditions> Continuously establishing the WUAs and CCOs in parallel with the progress of irrigation development project until 2035. Formulating a strong network of irrigation information and human resources from the project sites to the DOI until 2035. <Activities> ➢ Continuously gaining operation and maintenance experiences at the project sites through controlling the irrigation facilities. ➢ Implementation of capacity development for proper operation and maintenance of the irrigation facilities by the ISD

Source: Project Team

CHAPTER 15. PROJECT IMPLEMENTATION PROGRAM

15.1 Cost Estimation

15.1.1 Condition of Cost Estimation

Project cost consists of construction costs for the contractors, land acquisition costs, physical contingencies, costs for engineering services for the preliminary and detailed design, construction supervision, and administration costs for owner's management. Cost of these items is estimated based on the conditions described in the next table.

Table 15.1 Conditions of Cost Estimation of Project Cost

Breakdown	Conditions of Cost Estimate
(1) Construction Cost	Labor, material and equipment for construction
(2) Land Acquisition Cost	Not considered except for the part of Water Supply for 4 Cities
(3) Physical Contingency	12% of the total sum of construction costs and land acquisition costs
(4) Engineering Service	10% of the total sum of construction costs, land acquisition costs and physical contingencies
(5) Administration Cost	4% of the total sum of construction costs, land acquisition costs, physical contingencies and engineering service costs

Source: Project Team

(1) Other Preconditions

1) Time of Cost Estimation

The costs for the Master Plan (M/P) is estimated in US dollars (USD) based on the currency exchange rate as of December 2012; namely, USD 1.00 = MK 329 = EURO 0.77. Construction costs and unit costs at the base year (2012) are estimated by using the following formula with correction coefficient. Correction coefficient is calculated on the basis of GDP deflator in the Malawi.

$$\text{Construction Cost at Basic Year (2012)} = \frac{\text{Construction Cost at the time}}{\text{Correction Coefficient}}$$

2) Breakdown of Foreign and Local Currency Cost and Service Life of Project Components

The investments are broken down into foreign and local currency costs on the basis of the past project reports by Word Bank. Similarly, the service life expectancies for elements comprising the scheme in this Project are set based on the past project reports.

15.1.2 Summary of Project Cost

In this Master Plan, the proposed projects are classified into four sectors; namely, Integrated Project, Water Supply for Four Cities, Water Supply for Towns and Rural Water Supply; and Water Supply for Agriculture and Irrigation. The summary of project cost and breakdown for each term of the proposed projects are shown in **Table 15.2** to **Table 15.4**.

Table 15.2 Summary of Project Cost in this Master Plan (1/3)

Unit: Million USD

Proposed Projects			Project Cost	Time Frame		
				Short Term (2012-2020)	Middle Term (2021-2025)	Long Term (2026-2035)
■Integrated Project						
	Upgraded Kamuzu Barrage		35.83	35.83	0.00	0.00
■Water Supply for 4 Cities						
	Lilongwe	New water source from Diamphwe dam	262.06	123.77	71.65	66.64
		Development new groundwater borehole (+10,000m3/d)	5.20	5.20	0.00	0.00
		Extension TWII (purification plant: +30,000m3/d)	5.00	5.00	0.00	0.00
		Raising Kamuzu dam I and associated rehabilitation works (+30,000m3/d)	5.10	5.10	0.00	0.00
		Extension TWII(2nd) (purification plant: +30,000m3/d) and Technical Assistance	9.70	9.70	0.00	0.00
		Network improvement	0.20	0.20	0.00	0.00
		Rehabilitation of TWII	4.00	2.66	1.34	0.00
		Network expansion	225.80	42.30	70.50	113.00
		Sub-total	517.06	193.93	143.49	179.64
	Blantyre	New water source from Shire river	162.64	91.97	2.58	68.09
		Network improvement	9.00	9.00	0.00	0.00
		Network expansion	129.80	24.33	40.55	64.92
		Poverty program (Kiosk and Toilet development)	14.00	3.50	10.50	0.00
		Sub-total	315.44	128.80	53.63	133.01
	Mzuzu	New water source from Lambilambi and Lichelemu dam	145.93	72.14	0.00	73.79
		Network improvement	1.80	0.70	1.10	0.00
		Network expansion	80.80	19.04	23.80	37.96
		Sub-total	228.53	91.88	24.90	111.75
	Zomba	Raising of Mulunguzi dam and associated rehabilitation works	10.20	0.00	0.23	9.97
		Expansion existing TW (18,200m3/d to 30,000m3/d)	8.14	8.14	0.00	0.00
		Network improvement	3.60	2.88	0.72	0.00
		Network expansion	7.30	0.98	2.45	3.87
		Sub-total	29.24	12.00	3.40	13.84
	Total		1,090.27	426.61	225.41	438.24

Source: Project Team

Table 15.3 Summary of Project Cost in this Master Plan (2/3)

Unit: Million USD

Proposed Projects			Project Cost	Time Frame		
				Short Term (2012-2020)	Middle Term (2021-2025)	Long Term (2026-2035)
■ Water Supply for Towns & Rural Water Supply						
Towns			143.28	65.06	61.55	16.67
Market center			123.23	77.52	24.86	20.85
Community by Gravity-fed WS			136.82	73.56	44.49	18.77
Community by Borehole WS			287.42	71.88	71.88	143.66
Total			690.75	288.02	202.78	199.95
■ Agriculture & Irrigation						
2,500ha/year	WRA	WRU				
	1	A	3.67	3.67	0.00	0.00
		B	4.48	4.48	0.00	0.00
		C	4.78	4.78	0.00	0.00
		E	3.44	3.44	0.00	0.00
		F	1.78	1.78	0.00	0.00
		G	4.26	4.26	0.00	0.00
		K	5.14	5.14	0.00	0.00
		L	3.62	3.62	0.00	0.00
		M	3.87	3.87	0.00	0.00
		N	1.71	0.00	1.71	0.00
		O	5.10	0.00	5.10	0.00
		P	3.65	3.65	0.00	0.00
		R	7.04	7.04	0.00	0.00
		S	4.57	4.57	0.00	0.00
		T	0.60	0.60	0.00	0.00
	2	A	0.56	0.00	0.00	0.56
		B	0.41	0.41	0.00	0.00
		C	0.09	0.09	0.00	0.00
		D	0.14	0.00	0.00	0.14
	3	A	3.76	0.00	0.00	3.76
		B	3.42	0.00	0.00	3.42
		C	7.25	0.00	5.44	1.81
		D	3.99	0.00	0.00	3.99
		E	5.19	0.00	0.00	5.19
		F	1.50	0.00	0.00	1.50
	4	A	0.23	0.00	0.00	0.23
		B	2.09	2.09	0.00	0.00
		C	0.44	0.44	0.00	0.00
		D	1.22	1.22	0.00	0.00
		E	0.64	0.64	0.00	0.00
		F	0.12	0.12	0.00	0.00
	5	C	3.11	0.00	0.00	3.11
		D	2.61	0.00	0.00	2.61
		E	10.17	10.17	0.00	0.00
		F	7.94	7.94	0.00	0.00
	7	A	14.68	14.68	0.00	0.00
		B	6.14	0.00	6.14	0.00
		C	6.77	6.77	0.00	0.00
		D	18.23	18.23	0.00	0.00
		E	2.70	0.00	0.00	2.70
		F	5.78	0.00	5.78	0.00
		G	3.72	0.00	3.72	0.00
		H	1.94	1.94	0.00	0.00
	8	A	24.94	12.47	12.47	0.00
	9	A	1.37	0.00	0.00	1.37
		B	1.64	0.00	1.64	0.00
	14	B	0.63	0.00	0.00	0.63
		C	63.88	0.00	0.00	63.88
	15	A	22.01	0.00	0.00	22.01
		B	46.81	0.00	0.00	46.81
		C	7.40	0.00	0.00	7.40
	16	E	24.00	12.00	12.00	0.00
		F	26.93	0.00	20.20	6.73
		G	13.33	6.67	6.67	0.00
	17	A	0.25	0.00	0.00	0.25
		B	6.91	0.00	0.00	6.91
		C	13.06	0.00	9.80	3.27
	Total		425.71	146.78	90.66	188.28

Source: Project Team

Table 15.4 Summary of Project Cost in this Master Plan (3/3)

Unit: Million USD

Proposed Projects				Project Cost	Time Frame: Short Term (2012-2020)	Time Frame: Middle Term (2021-2025)	Time Frame: Long Term (2026-2035)
■Agriculture & Irrigation							
5,000ha/year	WRA	WRU					
	1	A		7.36	7.36	0.00	0.00
		B		8.94	8.94	0.00	0.00
		C		9.54	9.54	0.00	0.00
		E		6.91	6.91	0.00	0.00
		F		3.53	3.53	0.00	0.00
		G		8.54	8.54	0.00	0.00
		K		10.28	10.28	0.00	0.00
		L		7.20	7.20	0.00	0.00
		M		7.73	7.73	0.00	0.00
		N		3.41	0.00	3.41	0.00
		O		10.18	6.79	3.39	0.00
		P		7.32	7.32	0.00	0.00
		R		14.07	14.07	0.00	0.00
		S		9.12	9.12	0.00	0.00
		T		1.22	1.22	0.00	0.00
	2	A		0.73	0.00	0.00	0.73
		B		0.81	0.81	0.00	0.00
		C		0.20	0.20	0.00	0.00
		D		0.21	0.00	0.00	0.21
	3	A		7.55	0.00	0.00	7.55
		B		6.84	0.00	0.00	6.84
		C		14.51	0.00	10.88	3.63
		D		19.33	0.00	0.00	19.33
		E		10.39	0.00	0.00	10.39
		F		3.00	0.00	0.00	3.00
	4	A		0.43	0.00	0.00	0.43
		B		4.16	4.16	0.00	0.00
		C		0.88	0.88	0.00	0.00
		D		2.42	2.42	0.00	0.00
		E		1.28	1.28	0.00	0.00
		F		0.24	0.24	0.00	0.00
	5	C		6.20	0.00	0.00	6.20
		D		5.25	0.00	0.00	5.25
		E		20.31	20.31	0.00	0.00
		F		15.92	15.92	0.00	0.00
	7	A		29.37	29.37	0.00	0.00
		B		12.25	8.17	4.08	0.00
		C		13.58	13.58	0.00	0.00
		D		36.48	36.48	0.00	0.00
		E		5.42	0.00	0.00	5.42
		F		11.54	7.69	3.85	0.00
		G		7.45	4.97	2.48	0.00
		H		3.89	3.89	0.00	0.00
	8	A		56.60	0.00	42.45	14.15
	9	A		2.75	0.00	0.00	2.75
		B		3.30	0.00	3.30	0.00
	14	B		1.48	0.00	0.00	1.48
		C		153.80	0.00	0.00	153.80
	15	A		45.38	0.00	0.00	45.38
		B		103.05	0.00	0.00	103.05
		C		15.87	0.00	0.00	15.87
	16	E		48.01	24.01	24.01	0.00
		F		53.85	0.00	53.85	0.00
		G		26.66	13.33	13.33	0.00
	17	A		0.46	0.00	0.00	0.46
		B		16.52	0.00	0.00	16.52
		C		31.21	0.00	23.41	7.80
	Total			914.93	296.25	188.44	430.24

Source: Project Team

15.2 Economic Evaluation of Projects

15.2.1 Methodology

(1) General

The main objective of the economic evaluation here is to examine the investment efficiency of the project. Internal Rate of Return (IRR) is used here as the indicator of the efficiency of a project investment. IRR used in economic evaluation is called Economic Internal Rate of Return (EIRR).

(2) Precondition

The following preconditions are assumed in the economic evaluation. Additional preconditions will be clarified as necessary.

1) Evaluation Period

The evaluation period is 2012 to 2060.

2) Standard Conversion Factor (SCF)

This project employs an SCF of 1.0 (one point zero), which is the value employed in Ministry of Water Development (2003), "The Integrated Water Resources Development Plan for Lake Malawi and Shire River System."

3) Other Preconditions

Price Level	:	Year 2012
Social Discount Rate	:	10% (in accordance with the above-mentioned document of the Ministry of Water Development)

15.2.2 Cost-Benefit Analysis of Projects

Cost-Benefit Analysis (CBA) is conducted for the projects of Domestic and Industrial Water Supply component excluding rural community water supply, and Irrigation component. CBA is necessary for the calculation of EIRR and it is not suitable for projects of rural community water supply because it is calculated for checking the efficiency of investment or GDP increase as mentioned above but projects of rural water supply are not conducted for GDP increase but for meeting the basic human needs of rural communities as well as correcting the disparities between urban and rural water supply from the viewpoint of political integration.

(1) Project Cost

The following items are included in the cost calculation:

- Construction
- Land acswquisition (if any)
- Engineering services
- Physical contingencies
- Administration cost
- O&M
- Replacement (if any)

(2) Project Benefit

1) Domestic and Industrial Water Supply

The benefit of the project of this component is calculated by the willingness-to-pay (WTP) for the supplied water.

Willingness-to-Pay (WTP)

According to JICA (2002), "Study on Economic Evaluation Methodology for Development Study, Part 9. Water Supply " (Japanese), various research results of WTP for supplied water by using the

Contingent Valuation Method (CVM) fall in the range of 3-5% of disposable income. Thus, the Project employs 5% of disposable income.

2) Irrigation

The benefit of the project of this component is the increase in income of farmers due to increase in agricultural production. Combination of irrigation development and change of variety to those grow faster contributes the increase in harvest in a year. It is assumed that maize and rice are cropped in the newly irrigated area, where they are cropped twice in a year from once in a year thanks to the irrigation development. In other words, productions of maize and rice will be doubled in the newly irrigated area by the project.

Economic prices of maize and rice are calculated based on the international price data of the Food and Agriculture Organization (FAO).

Multiplier Effect

Factor applied to the total direct benefits above, to represent the indirect economic benefits of irrigation, such as job creation in input and downstream (e.g. transport and agro-processing) sectors. 1.5 (one point five) is employed as the factor value according to the Ministry of Irrigation and Water Development (2011), "Water Resource Investment Strategy." It assumes that indirect benefits are 50% of direct benefits.

(3) Calculation Results

1) Domestic and Industrial Water Supply

The calculation results are shown in the following table.

Table 15.5 Calculation Results of Domestic and Industrial Water Supply

	EIRR (%)	NPV (Million USD)	B/C
Urban			
Lilongwe City	13.21	40.49	1.20
Blantyre City	19.39	97.97	1.85
Mzuzu City	10.06	0.38	1.00
Zomba City	20.67	16.20	2.26
Towns	17.30	50.10	1.81
Rural			
Market Center	15.14	30.49	1.54

Source: Project Team

EIRR of all projects are more than social discount rate (10%), they are efficient ones from the viewpoint of the national economy.

2) Irrigation

The calculation results are shown below.

Table 15.6 Calculation Results of Irrigation

	EIRR (%)	NPV (Million USD)	B/C
2,500ha Case	2.19	-86.24	0.41
5,000ha Case	3.16	-159.72	0.48

Source: Project Team

Although EIRRs are less than social discount rate (10%), they are all positive. It just means that such projects are inappropriate from the viewpoint of investment efficiency. It can be said that they are still meaningful in terms of food security of the people on the basis of the national economy.

15.3 Evaluation from Social and Environmental Aspects

15.3.1 Objectives of Evaluation from Social and Environmental Aspects

The principal objective of this evaluation is to examine the current condition of the natural and social environment and how the proposed projects in the M/P may have influence on them. If negative impacts are forecasted by the project's implementation, then, necessary mitigation measures will be examined.

15.3.2 Evaluation through IEE

Based on the scoping activities, the following mitigation measures are recommended for adverse impacts in each Sector.

Dam Sector

The table below summarizes the mitigation measures for adverse impacts expected in the sector of dams.

Table 15.7 Potential Negative Impacts and Mitigation Measures (Dam Sector)

Potential Impacts	Impact Stage	Mitigation Measure
Involuntary settlement	PL	• Conduct public consultation with Project affected person (PAPs) and local residents to explain the benefits of the project. For PAPs prepare detail analysis for compensation
Utilization of local resources	C	• Prepare utilization and post utilization plan for those areas from where materials will be extracted for construction of the dam
Traffic	C	• Control on the number of vehicles/equipment to avoid traffic congestion
Vector of diseases	O	• Implement medical check-up program
Infectious diseases such as HIV/AIDS	C	• Implement medical check-up program
Sediment	O	• The entrance of sediments into the dams will reduce its storage capacity as it already happen in many dams of Malawi. The well management of the water basin including forest management is recommended to minimize this impact.
Soil erosion	C	• Provision of drains with sediment traps
Protected Area, Flora &Fauna	PL, C	• 10 Dams in total are expected to be located in forest or proposed forest reserves. However, the list of forest reserves is old and some of them may not be in place presently. Therefore it is recommended to check these candidates' sites in the EIA stage to confirm the forest reserves. Anyway, many conflicts may arise if the project is to be located into a protected area. Some mitigation shall include the plantation of forest to be home of the biodiversity and to compensate deforestation due to the construction of the dams.
	O	• Minimum environmental flow shall be maintained downstream to support aquatic life.
Flow regime	O	• Minimum environmental flow shall be maintained downstream. Operation of Dam Manual must be prepared including this subject.
Air pollution (Dust, exhaust fumes from vehicles and equipment)	C, O	• Control on the number or speed of vehicles/ equipment • Watering of access road and operational places. Soil materials should be covered with sheet • Proper maintenance of vehicle and equipment
Water Pollution	C	• Provision of drains with sediment traps • Proper management of the construction • Proper management of waste oil from vehicle maintenance
	O	• Removal of vegetal before filling the dam
Waste	C	• Proper management of construction waste
Noise	C, O	• Trucks shall use exhaust mufflers to maintain the current noise levels • Control of number or speed of vehicles/ equipment • Adequate maintenance of equipment • Work schedule should be informed to the public and operation of heavy equipment should be limited to the day time only

Legend: PL: Planning Phase; C: Construction Phase, O: Operation Phase
Source: Project Team

1) Water Supply Sector

The activities to be implemented in the projects of this Sector depend on the type of water sources they use (surface or groundwater). Thus, mitigation measures are proposed for (a) projects using surface water as water source (Construction of Water Treatment Plant); and (b) projects using groundwater as water source (Construction of Boreholes). The following tables show the impacts and the mitigation measures for the two cases.

Table 15.8 Potential Negative Impacts and Mitigation Measures for Projects using Surface Water as Water Source (Water Supply Sector)

Potential Impacts	Impact Stage	Mitigation Measure
Utilization of local resources	C	• Prepare utilization and post utilization plan for those areas from where materials will be extracted for land reclamation of the facility site (water treatment Plant and intake)
Traffic	C	• Control on the number of vehicles/equipment to avoid traffic congestion
Infectious diseases such as HIV/AIDS	C	• Implement medical check-up program
Soil erosion	C	• Provision of drains with sediment traps
Flow regime	O	• Minimum environmental flow shall be maintained down stream
Flora & Fauna	O	• Minimum environmental flow shall be maintained downstream to support aquatic life.
Air pollution (Dust, exhaust fumes from vehicles and equipment)	C, O	• Control on the number or speed of vehicles/ equipment • Watering of access road and operational places. Soil materials should be covered with sheet • Proper maintenance of vehicle and equipment
Water Pollution	C	• Provision of drains with sediment traps • Proper management of waste oil from vehicle maintenance • Proper management of the construction
	O	• Proper management of chemicals and waste oil from equipment maintenance • Provision of treatment facility for wastewater and sludge originated from the water treatment plant
Waste	C,O	• Proper management of construction waste • Proper management of chemical waste
Noise	C, O	• Trucks shall use exhaust mufflers to maintain the current noise levels • Control of number or speed of vehicles/ equipment • Adequate maintenance of equipment • Work schedule should be informed to the public and operation of heavy equipment should be limited to the day time only
Bottom sediment	O	• Provision of treatment facility for wastewater and sludge originated from the water treatment plant

Legend: C: Construction Phase, O: Operation Phase
Source: Project Team

Table 15.9 Potential Negative Impacts and Mitigation Measures for Projects using Groundwater as Water Source (Water Supply Sector)

Potential Impacts	Impact Stage	Mitigation Measure
Infectious diseases such as HIV/AIDS	C	• Implement medical check-up program
Air pollution (Dust, exhaust fumes from truck of drill rig and power generator)	C, O	• Proper maintenance of vehicle and equipment
Water Pollution	C	• Provision of drains with sediment traps • Proper management of the borehole construction
Waste	C	• Proper management of construction waste
Noise	C, O	• Truck of drill rig shall use exhaust mufflers to maintain the current noise levels • Adequate maintenance of equipment • Operation of equipment should be limited to the day time only

Legend: C: Construction Phase, O: Operation Phase
Source: Project Team

2) Irrigation Sector

The following table shows the impacts that can be expected in the sector of irrigation and summarize the mitigation measures.

Table 15.10 Potential Negative Impacts and Mitigation Measures (Irrigation Sector)

Potential Impacts	Impact Stage	Mitigation Measure
Utilization of local resources	C	• Prepare utilization and post utilization plan for those areas from where materials will be extracted for land reclamation of the irrigation site
Traffic	C	• Control on the number of vehicles/equipment to avoid traffic congestion
Vector of diseases	O	• Implement medical check-up program
Infectious diseases such as HIV/AIDS	C	• Implement medical check-up program
Soil erosion	C	• Introduction of right agriculture practices • Provision of drains with sediment traps
Flow regime	O	• Minimum environmental flow shall be maintained downstream. Operation of Intake for Irrigation Manual must be prepared including this subject.
Air pollution (Dust, exhaust fumes from vehicles and equipment)	C, O	• Control on the number or speed of vehicles/ equipment • Watering of access road and operational places. Soil materials should be covered with sheet • Proper maintenance of vehicle and equipment
Water Pollution	C	• Provision of drains with sediment traps • Proper management of waste oil from vehicle maintenance • Proper management of the construction
	O	• Proper management of chemicals and waste oil from equipment maintenance • Implement training and education of farmers on the kind of chemicals they can use rationally • Check that only authorized chemicals are used at the site • Implement water quality monitoring for existing drinking wells. If affected, construct boreholes for affected people
		• Proper management of waste oil from equipment maintenance
Soil pollution	C, O	• Proper management of chemicals
Waste	C,O	• Proper management of construction waste • Proper management of chemical waste
Noise	C, O	• Trucks shall use exhaust mufflers to maintain the current noise levels • Control of number or speed of vehicles/ equipment • Adequate maintenance of equipment • Work schedule should be informed to the public and operation of heavy equipment should be limited to the day time only
Bottom sediment	O	• Proper management of chemicals and waste oil from equipment maintenance

Legend: C: Construction Phase, O: Operation Phase
Source: Project Team

15.3.3 Conclusion and Recommendations

In general, the projects proposed in the M/P will benefit three main sectors; namely, power generation, water supply and irrigation. As for power generation, high positive impact is expected on the current economic development of the country. As for water supply, high positive impacts are expected through the project implementation on the current health level of the beneficiary population by consuming potable water which in turn will allow the exercise of better hygiene practices in the households. As for irrigation, the socio-economic status of the population will be highly upgraded through the increase of agricultural production and employment opportunities. In addition food security for the population will be improved.

Some adverse impacts on the environment are also expected from the project implementation, which shall be diminished through the proposed mitigation measures. In this sense, especial attention must be given to the dam sector since it involves huge physical intervention and may need the resettlement of people living around the candidate site.

CHAPTER 16. RECMMENDATIONS

Various issues were encountered in the course of survey on existing conditions and plan formulation in the Water Resources Master Plan. Relatively abundant water resources compared with other African countries are one of a few drivers to uplift the Malawian economy in the future. These issues are not only to be overcome for future efficient water resources management but also to be essential factors for uplifting the economy. Thus the issues shall be enumerated below as recommendations.

(1) Institutional Strengthening of MoAIWD and Smooth Transition of its Functions to NWRA

New Water Resources Act was enacted in 2013, and new organization of NWRA will be established in near future based on the stipulation of the Act. Through establishment of new organization, management of water right system will be empowered so that the financial base of water resources management is expected to be much more robust. Hydrological monitoring section including groundwater and water quality monitoring will move to NWRA in the near future. The smooth transition from MoAIWD and reform to agile institution is expected to be made.

Furthermore, the 28 district water offices have been mainly conducted hydrological monitoring including water level observation and discharge measurement. However, poor working conditions of the stations and shortage of staffs in the offices could be observed in the course of the survey. In order to activate the hydrological monitoring through collaboration with such local institutions or merger of them into NWRA, intensive institutional reform is indispensable with perspectives of future activation including the local institutions.

(2) Strengthening of Monitoring System covering Surface Water, Groundwater and Water Quality, and Sharing and Utilization of Monitored Data

Essential is periodical groundwater table monitoring at testing wells and water quality monitoring at the designated points as well as monitoring of water level and discharge measurement, and archiving of the monitored data in a database system. Furthermore, an integrated data management system shall be established through additionally archiving of the observed data in the water-related projects.

The integrated database system will be transferred to NWRA, and NWRA shall establish the data providing system or data access system for the related agencies as well as MoAIWD. In this context, NWRA will be a data center of Malawi in hydrological and water quality so that long-lasting stagnation in this field will be solved for activating of hydrological and water quality monitoring.

(3) Promotion of Urban and Rural Water Supply

The cost estimation clarified that the project costs is very huge, namely those for the four cities amounting to 1.19 billion USD, towns 140 million USD, combination of market centers and rural communities 550 million USD. Access to safe water is the minimum security to support the people living safe and comfortable in urban as well as rural areas. Official assistances should be confirmed from the World Bank, AfDB and other development partners in order to finance those project costs.

It is required to implement rehabilitation of water distribution networks to cope with the leak of water and to reduce NRW in urban areas as well as to develop new water sources. As for boreholes in rural water supply, equipment utilizing jetting method or brushing method is effective to restore their function which is deteriorated by clogging and subsoil sedimentation.

(4) Promotion of Irrigation Development and the Coordination with the Irrigation Master Plan by the World Bank

Development of the water resources potential by WRU is proposed in the Irrigation Development Plan. Though the Irrigation Master Plan was started by the World Bank during the period of the JICA Project, coordination between the two projects was not necessarily conducted in satisfactory manner due to a time limitation. As JICA Project Team provided the results of water balance simulation for the World Bank Master Plan Team, which is still working in Malawi, it is expected that the Master Plan of the JICA Project will be utilized by them.

Furthermore, GBI (Green Belt Initiative) is also a national project for the irrigation. A large amount of investment is indispensable by private investors to promote cash cropping from the viewpoint of economic growth as well as supplying irrigation water to smallholders. Thus, such efforts to invite private investment should be conducted by the whole country with arranging conditions which attract foreigners to make investment easily.

(5) Further Study on Environmental Flow

Environment is one of the important users with considering the management of water resources development where environmental flow should be set for the conservation. However, its priority has to be lowered in this Master Plan because environmental factors are not specified to conserve and it may even disturb the water resources development according to a hydrological approach. It is recommended that environmental flow should be set by appropriate approach in feasibility studies on water resources development of rivers in the future, considering the survival property of specified conservation targets.

MINUTES OF MEETINGS

MINUTES OF THE FIRST STEERING COMMITTEE MEETING
ON
THE INCEPTION REPORT
FOR
THE PROJECT FOR NATIONAL WATER RESOURCES MASTER PLAN
IN THE REPUBLIC OF MALAWI

The Government of Japan, in response to the official request of the Government of the Republic of Malawi (hereinafter referred to as "the Republic of Malawi"), decided to conduct the Project for National Water Resources Master Plan in the Republic of Malawi (hereinafter referred to as "the Project") and the Japan International Cooperation Agency (hereinafter referred to as "JICA") dispatched the Project Team (hereinafter referred to as "the Team"), headed by Mr. Kanehiro MORISHITA of CTI Engineering International Co., Ltd., to the Republic of Malawi based on the Scope of Work (hereinafter referred to as "S/W") signed on 4th March, 2011.

The first steering committee meeting on the Draft Inception Report (hereinafter referred to as "the Draft IC/R") for the Project was held at the Ministry of Water Development and Irrigation (hereinafter referred to as "the MoWDI") in Lilongwe City on 26th May, 2012. At the meeting, the outline of the Project was explained by the Team and discussions were held between the Team and representatives of the steering committee members as described in the S/W. After the meeting, the MoWDI, the counterpart agency for the Project, received the Draft IC/R from the Team and agreed to provide comments to the Team by mid August, 2012.

As the result of discussions, both sides agreed on the matters described in the Attachment. The list of participants of the first steering committee meeting is shown in the Annex.

9th August, 2012
Lilongwe City, Malawi

Mr. Sadram C.Y. Maweru
Principal Secretary
Ministry of Water Development
and Irrigation

Mr. Kanehiro MORISHITA
Leader of the Project Team
Japan International Cooperation Agency

ATTACHMENT

1. Review of Plans and Policies including the Master Plan formulated in 1986

The Water Resources Master Plan established in 1986 (hereinafter referred to as "the 1986 M/P") will be reviewed in the Project to clarify the implementation status of the proposed projects and examine issues in case of no implementation. For the Project, the Team is to make effective use of the information and data used in the 1986 M/P, as well as the past study results, policies and legal frameworks regarding water resources in Malawi.

2. Collection and Accuracy of Data

According to initial surveys by the Team, the condition of data and information management had deteriorated in the recent years compared with the situation at the time of the 1986 M/P. For data collection and arrangement, the Team and MoWDI will make effort to forge an appropriate system/relationship which will contribute to the increase of precision of data and information. As mentioned in the S/W, a technical committee in charge of the management of the system/relationship should be established by the Malawian side. Regarding rainfall data, the Team will try to gather and utilize all data possible for major stations covering the whole of Malawi.

3. Conducting Capacity Building Program

In the Project, the Team will conduct a capacity building program including items related to hydrological data arrangement, hydrological analysis and tools for the analysis. Furthermore, in the New Master Plan to be formulated in the Project, the Team will propose plans and activities to be implemented for strengthening the present monitoring system for hydrological observation and capabilities to manage the facilities related to water resources.

4. Target Year for the New Master Plan

Steering Committee Members and the Team concluded that the target year for the New Master Plan shall be set at year 2035 in consideration of the schedules of plans and policies related to water resource development and management and the implementation period (20 years) of the 1986 M/P.

5. Reports and Meetings

Comments on the Draft IC/R will be submitted by MoWDI to the Team by mid August, 2012. Based on the comments, the Team will amend the draft IC/R and submit 30 copies of the final IC/R to MoWDI during the next field survey of the Project (from mid July to mid September, 2012). From then on, steering committee meetings and technical committee meetings shall be held at the time of submission of reports by the Team such as progress reports, interim report and draft final report.

6. Technical Committee and Counterparts

For smooth implementation of the Project, the Technical Committee will be established in accordance with the S/W. In addition, the MoWDI will assign the necessary number of capable counterpart personnel from relevant divisions and departments of MoWDI; namely, the Surface Water Resources

Division, Groundwater Division, Water Quality Division, Water Resource Board Secretariat, Water Supply Service Department, Irrigation Department and Sanitation Department.

7. Office Space

MoWDI will provide adequate office space to be shared by approximately 10 personnel, equipped with office equipment, telephone line and necessary furniture and fixtures in MoWDI in accordance with the S/W. It should be mentioned in this connection that the office space presently provided is not sufficient for the number of Team members.

ANNEX

FIRST STEERING COMMITTEE MEETING
ON
THE INCEPTION REPORT
FOR
THE PROJECT FOR NATIONAL WATER RESOURCES MASTER PLAN IN THE REPUBLIC OF MALAWI, May 26, 2012

LIST OF ATTENDANTS

MALAWI SIDE

NO.	NAMES	ORGANISATION	AGENCY	DESIGNATION
1	SANDRAM MAWERU	MINISTRY OF WATER DEVELOPMENT AND IRRIGATION	MINISTRY OF WATER DEVELOPMENT AND IRRIGATION	PRINCIPAL SECRETARY
2	BEN BOTOLO	MINISTRY OF ENERGY AND MINING	MINISTRY OF ENERGY AND MINING	PRINCIPAL SECRETARY
3	EDWIN KANYOMA	MINISTRY OF AGRICULTURE AND FOOD SECURITY	MINISTRY OF AGRICULTURE AND FOOD SECURITY	PRINCIPAL ECONOMIST
4	M. B. KANJAYE	MINISTRY OF WATER DEVELOPMENT AND IRRIGATION	WATER RESOURCES DEPARTMENT	DIRECTOR OF WATER RESOURCES
5	B.N.C. GONDWE	MINISTRY OF WATER DEVELOPMENT AND IRRIGATION	WATER SUPPLY DEPARTMENT	DIRECTOR OF WATER SUPPLY SERVICES
6	MAHMOUD A. FATTA	DEPARTMENT OF IRRIGATION, BADEA	DEPARTMENT OF IRRIGATION	EXPERT OF IRRIGATION
7	GOMEZGANI NGWIRA	MINISTRY OF WATER DEVELOPMENT AND IRRIGATION	PLANNING DEPARTMENT	ECONOMIST
8	PEPANI KALUWA	MINISTRY OF WATER DEVELOPMENT AND IRRIGATION	WATER RESOURCES DEPARTMENT	DEPUTY DIRECTOR OF WATER RESOURCES
9	TAWONGA MBALE	ENVIRONMENTAL AFFAIRS DEPARTMENT	ENVIRONMENTAL AFFAIRS DEPARTMENT	ASSISTANT DIRECTOR
10	O K MWAMSAMALI	MINISTRY OF WATER DEVELOPMENT AND IRRIGATION	WATER RESOURCES BOARD	CHIEF WATER RESOURCES OFFICE
11	GEOFFREY MAMBA	MINISTRY OF WATER DEVELOPMENT AND IRRIGATION	DEPARTMENT OF IRRIGATION	DIRECTOR OF IRRIGATION SERVICES

JAPANESE SIDE

1	SAITO KATSURO	JICA	JICA	JICA MALAWI OFFICE REPRESENTATIVE
2	MAKI YOSHIRA	JICA	O AND M PROJECT	EXPERT
3	YUJI UNE	JICA	O AND M PROJECT	CHIEF ADVISOR
4	MIZUYORI TOMOKO	MASTER PLAN STUDY TEAM	MP STUDY	EXPERT
5	SEBASTIAN JARA	MASTER PLAN STUDY TEAM	MP STUDY	EXPERT
6	TOSHIHIRO GOTO	MASTER PLAN STUDY TEAM	MP STUDY	EXPERT
7	RYOTA OJIMA	MASTER PLAN STUDY TEAM	MP STUDY	EXPERT

MINUTES OF STEERING COMMITTEE MEETING
ON
THE DRAFT FINAL REPORT
FOR
THE PROJECT FOR NATIONAL WATER RESOURCES MASTER PLAN
IN THE REPUBLIC OF MALAWI

AGREED UPON BETWEEN
THE MINISTRY OF AGRICULTURE, IRRIGATION AND WATER DEVELOPMENT
AND
THE PROJECT TEAM OF
JAPAN INTERNATIONAL COOPERATION AGENCY

9th October, 2014
Lilongwe

Mr. Kanehiro MORISHITA
The Project Team Leader
Japan International Cooperation Agency

Mr. Sandram C.Y. Maweru
Principal Secretary (Irrigation and Water Development)
Ministry of Agriculture, Irrigation and Water Development

Mr. Akihiro MIYAZAKI
Director
Water Resources Management Team 2
Global Environment Department
Japan International Cooperation Agency

Mrs. Modesta B. Kanjaye
Director
Department of Water Resources
Ministry of Agriculture, Irrigation and Water Development

The Project for National Water Resources Master Plan in the Republic of Malawi (hereinafter referred to as "the Project") has been carried out by the Project Team (hereinafter referred to as "the Team"), headed by Mr. Kanehiro MORISHITA of CTI Engineering International Co., Ltd., dispatched by Japan International Cooperation Agency (hereinafter referred to as "JICA").

The steering committee meeting on the Draft Final Report (hereinafter referred to as "the DF/R") for the Project was held at the Ministry of Agriculture, Irrigation and Water Development (hereinafter referred to as "MoAIWD") in Lilongwe on 8th October, 2014. At the meeting, the Team presented the DF/R and discussions were held between the Team and representatives of the steering committee members. The list of participants of the steering committee meeting is shown in the Annex.

During discussions, both sides agreed on the matters described as follows:

1. Contents of the DF/R

1.1 Collaboration with Organizations Related to the National Water Resources Master Plan (hereinafter referred to as "the Master Plan")

The Malawian side basically agreed on the substances of the DF/R, and they confirmed that its contents were generally aligned with the related plans such as the Irrigation Master Plan which is being prepared with assistance from World Bank. However, some of concerned personnel did not attend the meeting due to other commitments. Therefore, MoAIWD made a commitment to deliver the DF/R to all the stakeholders in order to share the information.

1.2 Priority Order

The Team specified the priority order of future development projects proposed in the DF/R based on the indicators such as severity, technical difficulty, cost, maturity, emergency, etc. The Malawian side agreed with the proposed order of the projects. If any comments regarding the order or indicators are offered by any related agencies, MoAIWD will inform the Team in writing with other comments as described in Article 1.4.

1.3 Early Maturing Variety

The DF/R proposed to promote early maturing crop varieties instead of longer one on a nationwide basis in order to mitigate shortage of water resources especially in dry season. If farmers harvest early on irrigation areas, the maize will be regarded as a value-added crop in the markets due to the sweet taste with higher water content. The Department of Irrigation (hereinafter referred to as "the DOI") of MoAIWD confirmed the fact that the change of cropping pattern is one of the best measures to save water resources and make a livelihood for the farmers.

1.4 Comments on the DF/R

The Malawian side agreed to submit comments, if any, on the DF/R to the Team by 14th November 2014 if any. The Department of Water Resources promised to collect and consolidate the comments from the related organizations before submitting to the Team.

2. Activation of the Master Plan

2.1 MoAIWD has not yet decided on the detailed authorization procedure of the Master Plan and it will commence the approval process of the Master Plan immediately after finalizing the DF/R. MoAIWD will inform the Team on the procedure after consulting the authorities.

2.2 Responsibility of Related Organizations

MoAIWD explained that the work described in (b) and (c) below shall be transferred to the National Water Resources Authority (hereinafter referred to as "NWRA") or the Catchment Management Committee according to the National Water Resources Act (2013) (hereinafter referred to as "the Act"), and the following are the responsibilities of related organizations after operationalization of NWRA:

(a) MoAIWD
- To make policies
- To oversee international cooperation issues

(b) NWRA (stipulated in Section-10 of the Act)
- To develop principles, guidelines and procedures for allocation of water resources,
- To monitor, and from time to time reassess, the National Water Policy and the National Water Resources Master Plan,
- To receive and determine applications for permits for water use,
- To monitor and enforce conditions attached to permits for water use,
- To regulate and protect water resources quality from adverse impacts, and others.

(c) Catchment Management Committees (stipulated in Section-29 of the Act)
- To advise on water resources conservation, use and allocation,
- To advise on the grant, adjustment, cancellation or variation of any licence and permit under this Act, and
- To advise on any other matters pertinent to the proper management of water resources.

2.3 Monitoring System of Hydrological Data

The Team pointed out weakness of monitoring system of hydrological data such as river flow rate, groundwater level, rainfall amount, and amount of water for irrigation, from the aspect of both observation facilities and human resources. And the Team emphasized the need for strengthening those existing system for accurate observation data is very important for proper management of water resources.

In response to that suggestion, MoAIWD explained that NWRA will improve the monitoring system.

ANNEX

ATTENDANTS LIST

MALAWIAN SIDE

NO.	NAMES	ORGANISATION	POSITION
1	MODESTA B. KANJAYE	MINISTRY OF AGRICULTURE, IRRIGATION AND WATER DEVELOPMENT	DIRECTOR OF WATER RESOURCES
2	N.B MWAMBAKULU	MINISTRY OF AGRICULTURE, IRRIGATION AND WATER DEVELOPMENT	DIRECTOR OF ADMINISTRATION
3	CHARLES MWALABU	MINISTRY OF AGRICULTURE, IRRIGATION AND WATER DEVELOPMENT	CHIEF IRRIGATION OFFICER
4	EMMA MBALAME	MINISTRY OF AGRICULTURE, IRRIGATION AND WATER DEVELOPMENT	DEPUTY DIRECTOR WATER SUPPLY SERVICES
5	OSWALD K MWAMSAMALI	MINISTRY OF AGRICULTURE, IRRIGATION AND WATER DEVELOPMENT	CHIEF WATER RESOURCES OFFICER
6	PRINCE MLETA	MINISTRY OF AGRICULTURE, IRRIGATION AND WATER DEVELOPMENT	DEPUTY DIRECTOR OF WATER RESOURCES, GROUND WATER
7	PEACHES PHIRI	MINISTRY OF AGRICULTURE, IRRIGATION AND WATER DEVELOPMENT	DEPUTY DIRECTOR OF WATER RESOURCES, WATER QUALITY
8	LAISON MSEU	MINISTRY OF AGRICULTURE, IRRIGATION AND WATER DEVELOPMENT	WATER RESOURCES DEVELOPMENT OFFICER
9	ALLAN KANTHEBWE	BLANTYRE WATER BOARD	DISTRIBUTION ENGINEER
10	G. SAGEME	CENTRAL REGION WATER BOARD	ACTING CHIEF EXECUTIVE OFFICER
11	ANDREW KACHEYO	SOUTHERN REGION WATER BOARD	PLANNING AND DEVELOPMENT MANAGER
12	T. MTEGHA	NORTHERN REGION WATER BOARD	CHIEF EXECUTIVE OFFICER
13	MACLENAN NYANG'WA	LILONGWE WATER BOARD	DIRECTOR OF TECHNICAL SERVICES

JAPANESE SIDE

NO.	NAMES	ORGANISATION	POSITION
1	AKIHIRO MIYAZAKI	JICA HQ	DIRECTOR
2	KOJI SHIMIZU	JICA HQ	DEPUTY DIRECTOR
3	JINTARO YAZAKI	JICA MALAWI OFFICE	ASSISTANT RESIDENT REPRESENTATIVE
4	KANEHIRO MORISHITA	JICA PROJECT TEAM	TEAM LEADER
5	TOSHIHIRO GOTO	JICA PROJECT TEAM	DEPUTY TEAM LEADER
6	MAKOTO YAJIMA	JICA PROJECT TEAM	EXPERT
7	MASAKAZU MIYAGI	JICA PROJECT TEAM	EXPERT
8	GODFREY KAPALAMULA	JICA MALAWI OFFICE	SENIOR PROGRAM OFFICER