PART II MASTER PLAN

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PART II

Chapter 1. ISSUES ON WATER RESOURCES MANAGEMENT AND DEVELOPMENT

CHAPTER 1. ISSUES ON WATER RESOURCES MANAGEMENT AND DEVELOPMENT

1.1 Issues on Water Resources Management and Development in Malawi

Investigations and analyses of the present condition in Malawi (see **Part I: Chapter 2 to Chapter 6**) have revealed a variety of issues related to water resources management and development. The issues are summarized and identified in each sector; namely, Institution, hydrological analysis and monitoring, groundwater/water quality, irrigation/forestry, domestic water, hydropower, and international rivers in the table below. In Phase II, the JICA Project Team for the Project for National Water Resources Master Plan in the Republic of Malawi proposed countermeasures in the Master Plan (M/P) to mitigate or resolve these issues in line with the IWRM or SWAp concepts.

Table 1.1.1 Issues on Water Resources Management and Development

No.	Themes	Issues
1	Institution	Recently, a Water Bill for the improvement of institutions related to water resources has been enacted. However, there are still institutional problems as listed below. - Some water-related agencies still have ambiguities in function, role and coverage area. - Information such as water rights and water facilities has not been managed properly. - There has been no proper coordinated management between the hydropower sector and other water-use sector under the Ministry from the viewpoint of regulation of water use. - Chronic budgetary deficit and manpower shortage has led to the malfunction of water-related organizations
2	Hydrological Analysis/ Monitoring	Basic systems and tools to manage hydrological information exist in MoAIWD; however, some systems are in dysfunctional performance or uncontrolled situation. - The number of operational hydrological stations is decreasing. The density of rainfall stations is very low, so that the location of discharge stations should be clarified for water resources monitoring. - Data collection and transmission systems malfunction in some river basins. - The related department does not properly grasp and confirm the condition of monitored data. In addition, some of the information is not updated appropriately (for example, discharge rating curves). - Flood and draught records are not summarized and shared properly among the related agencies.
3	Groundwater/ Water Quality	The preparation of proper monitoring systems and training on monitoring and analysis have been progressing with the assistance of ODA development partners; however, proper monitoring is not still carried out due to shortage of materials/measurements, standards and budget. - Periodical and fixed point observation is not carried out for water quantity and quality. - Measurement facilities in laboratories are not enough and the maintenance condition of facilities is not good. - Information is not arranged and managed properly for assessment and dissemination. - Water quality standards based on future development are not arranged.
4	Irrigation/ Forestry	Although consultations and researches on agricultural facilities and agricultural development are being carried out, investigations and understanding in terms of water distribution to users and their water use requirement have not been implemented. - Activities to crystallize GBI are ongoing in terms of availability of water resources in quantity and location of source. - Cadastral information especially regarding location of crop areas is not arranged. - Present condition of water usage cannot be grasped properly. For example, water rights on agricultural use (0.7 mil m^3/day) is obviously less than agricultural water demand (2.5 mil m^3/day). - So far, deforestation which may cause topsoil erosion is progressing.
5	Water Supply	Development of water supply system almost goes on as planned in MDG/MDGS; however, related agencies should address potential problems in future to supply sufficient water to water users in a sustainable way. - Rate of non-revenue water is still very high. - There are many problems in water use facilities such as aging, lack of performance capacity due to increase of water users, usage of inappropriate materials for water pipes, and siltation. - Recently, water supply coverage rate (the percentage of people within 200m of an improved water source) has decreased.
6	Hydropower	Although MoE has a strategy to develop electric power supply and distribution, consultations with respect to water use are not enough from the standpoint of water budget among water sectors. - Construction of hydropower dams has been planned by MoE and progressed without discussion on water use balance among related agencies. - Currently, the electricity shortage influences operating rate of water use facilities.
7	International Rivers	There is no critical problem with surrounding countries in water use; however, preparations and predictions are necessary to confirm future impact on neighboring countries.

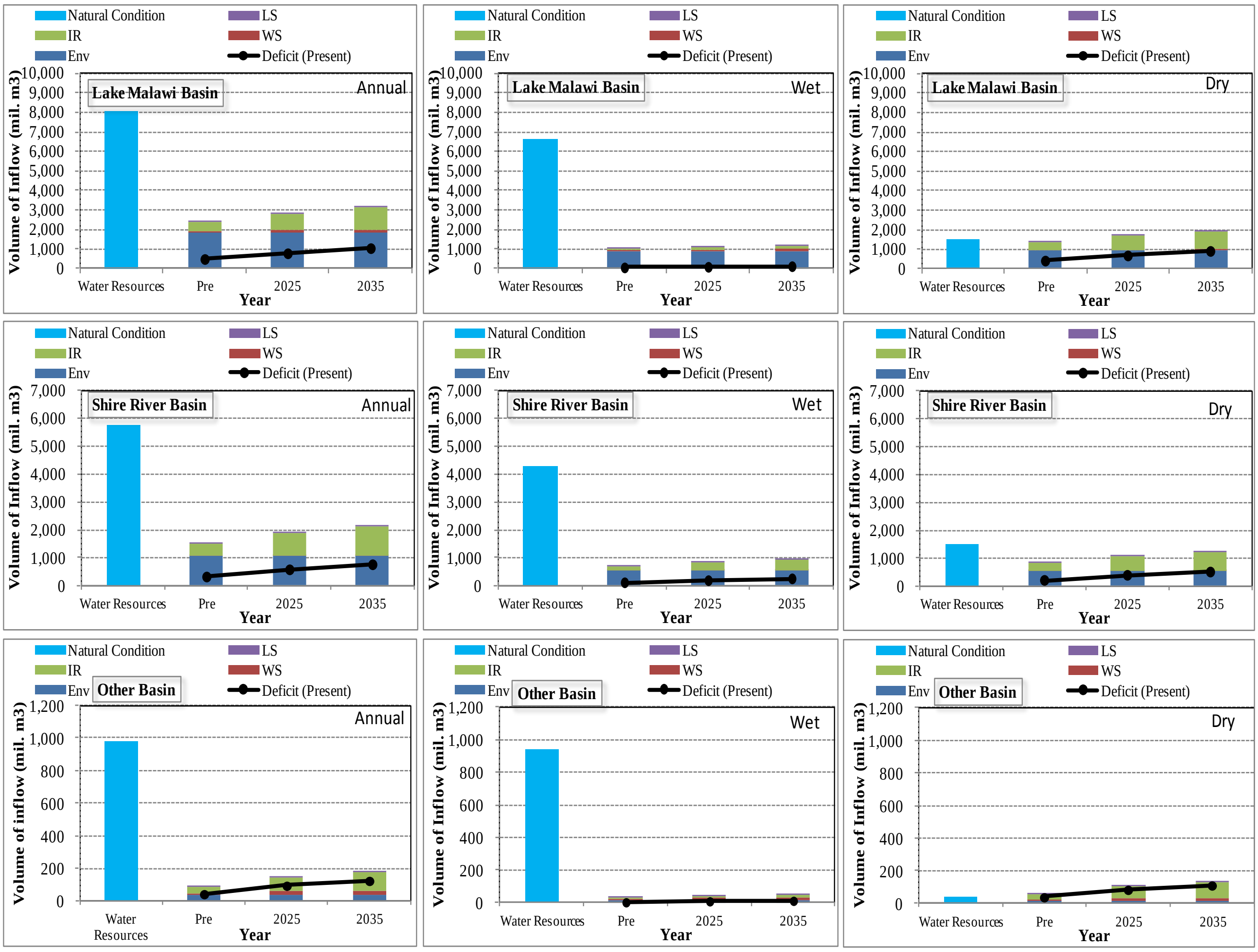
Source: Project Team

1.1.1 Water Scarcity in Malawi

As a result of basic analysis, it is obvious that annual water resources are more than the water demands even in year 2035. However, biased water resource conditions in season and location would significantly affect future water resources development.

The amount of water deficit can be seen as very low compared with the natural flow (See **Figure 1.1.1**). Particularly, water sufficiency in Malawi is very high with abundant surface water in the rainy season. However, the deficit water increases in the dry season with the increment of agricultural water requirement from surface flows. These mechanisms can be explained by the relationship between cropping patterns and effective rainfall as described in **Part I: Chapter 5**.

To fulfill the water demand in the dry season, countermeasures have to be proposed in the Project to distribute the biased water to problem areas and reserve it for the dry season.



Annual Wet Season Dry Season

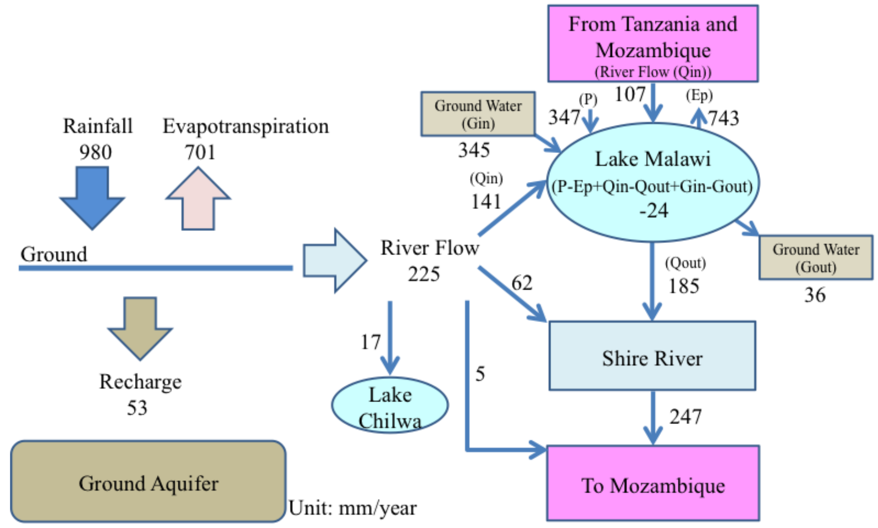
Source: Project Team

Figure 1.1.1 Water Balance

1.1.2 Basic Policy for Water Resources Development and Management

The general water resources balance in Malawi is evaluated in the Project by using the simulation model with 30 years hydro-meteorological data as shown in **Figure 1.1.2**. Averagely, out of the 980 mm water per year supplied to surface as precipitation, 23 percent (225 mm) and 5 percent (53 mm) runs off to the ground surface and penetrates into the ground, respectively, while the evaporative loss is estimated at 72 percent of the water supplied by precipitation. With regard to surface water, 63 percent of the surface water in Malawi flows into

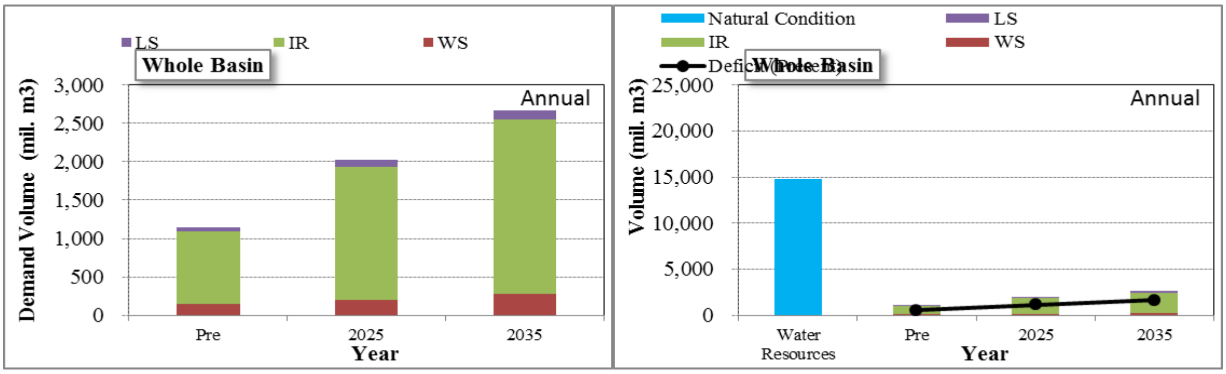
Lake Malawi and 28 percent flows directly to the Shire River. The catchment water of Lake Malawi flows into the Shire River with restricted conditions by the geography at outlet of the lake and the operation of Liwonde barrage. Due to the effect of the large storage function of Lake Malawi, the water flow of the Shire River is abundant throughout the year and fluctuates within a relatively narrow range compared with the other rivers. Furthermore, due to the steep slope (average slope is 1/240), 98 percent of hydropower in Malawi is generated using this characteristic of the Shire River.



Source: Project Team

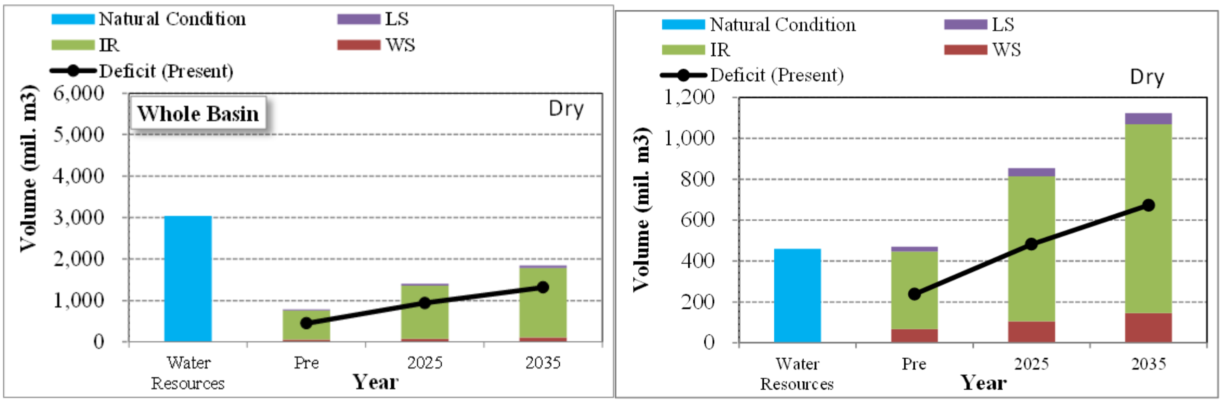
Figure 1.1.2 Natural Water Balance in Malawi

On the other hand, water demand is estimated at 1.1 billion m^3 per year (as of 2012), as shown in **Figure 1.1.3** (left figure). The irrigation and domestic water demand is 87 and 13 percent, respectively. This demand may increase 2.5 times up to 2035 year. Compared 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 as shown in **Figure 1.1.3** (right figure). That is to say, the water resource is predominant against water demand; however, the water shortage in dry season is prominent by seasonal fluctuation as shown in **Figure 1.1.3** and **Figure 1.1.4**.



Source: Project Team

Figure 1.1.3 Transition of Water Demand (Left) and Comparison between Annual Water Demand and Water Resources (Right)



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

Figure 1.1.4 Comparison between Water Demand and Water Resources (Left: Dry Season, Right: Driest Month)

Under the condition of water utilization, discussions on water usage are underway based on concepts of SWAp, which is the basic scheme of water utilization by each sector in Malawi. In addition, the water resources development and management is about to be enhanced based on the new Water Resources Law approved in March 2013. Under the circumstances, the Project Team considers that MoAIWD should be responsible for the water resources development and management after the dissolution of NWDP-II. Development partners such as the World Bank start to assist to facilitate the establishment of a basin management organization based on the Water Resources Act of 2013. From the result of analysis, the Project Team recommends that the enhancement of capacity of MoAIWD is essential for making policies and directions on water resources development and management.

As a result of the studies on the condition of water resources development and management by MoAIWD, it seems that the capacity of MoAIWD is still insufficient for information management, planning and implementation about water resources development and management, although NWDP and NWDP-II have been supporting the implementation of water resources development projects. Especially, the most basic information management is not conducted properly due to the shortage of personnel and facilities, impeding the planning process. Therefore, resolution of the above-mentioned issues is recognized as the key element for basin management and water resources development and management in Malawi.

1.1.3 Challenges to the Formulation of Master Plan for Water Resources Development and Management

(1) Potential for Water Resources Development

The total volume of water resources per year is predominantly larger than the water demand in Malawi. However, 95 percent of rainfall concentrating in the rainy season causes prominent water shortage in the dry season. Since the water demand will quadruple in total volume per year in the target year 2035, the water shortage becomes more severe than the present condition. This situation is predicted based on the water balance simulation in **Part I: Chapter 6**, in consideration of the results of projection of major social elements in the Project. As a matter of 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 results so far collected, the Project Team share 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 in terms of balance between water resources and locations of irrigable area (which is the dominant water user in Malawi), so that water resources developments should be implemented in concord with the limited budgetary conditions and the natural and social environments.

The balance between the water resources and irrigation demands by WRA is presented in **Figure 1.1.5.** 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.

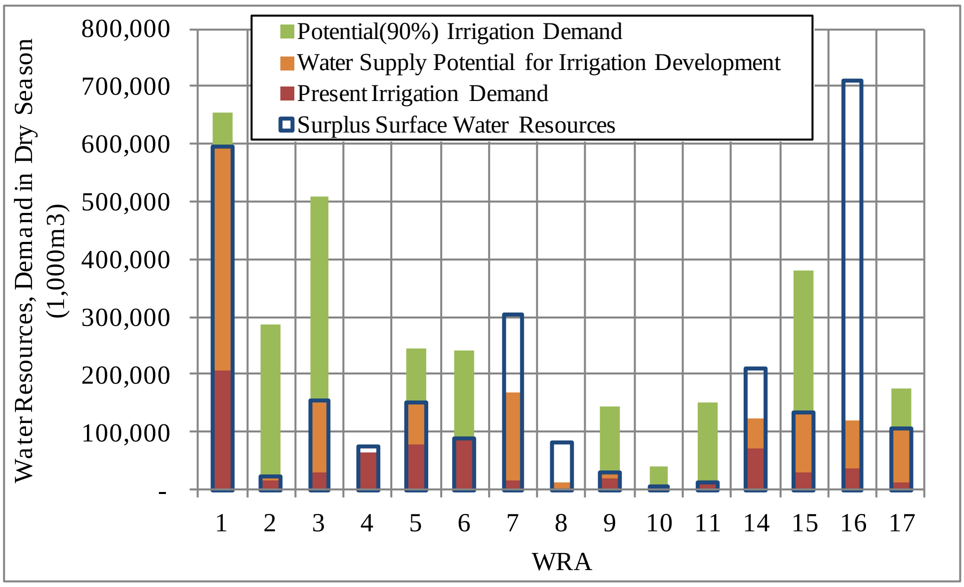


Figure 1.1.5 Comparison between Water Resources and Irrigable Area by WRA

(2) Establishment of Appropriate Organizational Frame

The integrated water resources development and management shall be implemented by the National Water Resources Authority and the Catchment Management Committee in accordance with the new Water Resources Law. According to MoAIWD, the World Bank will support the establishment of the above organizations in the future. In the Master Plan, therefore, the framework and functions of the above organizations are proposed in order to implement the integrated water resources development and management properly corresponding to the characteristics of each river basin in Malawi. In addition, the relationship between the water resources master plan described in the law and the Master Plan established through the technical assistance by this JICA Project is consulted together and the consultation carried out, so that the Master Plan will effectively contribute to the water resources management and development in Malawi in the future.

(3) Low Data Reliability and Inadequate Monitoring System

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

(4) Unorganized Water-Related Facilities and Water Rights Information

Information about water utilization facilities and water rights is essential for sustainable water resources development and management. However, information about water utilization from such facilities 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 consideration of impacts to each other because there is lack of process and consciousness to investigate the water budget between the 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 staff members and enhancement of the organization is necessary after the formulation of the Master Plan.

1.1.4 Basic Policy for Formulation of the Master Plan (M/P)

(1) Target Year of Water Resources Development and Management

The long-term target year for the M/P of water resources development and management has been set as the year 2035 in the First Steering Committee Meeting held in May 2012, and the short and middle term target years were set as 2020 and 2025, respectively. The components of water resources development and management plans in water sectors shall be formulated by the time frame.

(2) Basic Policy for Water Resources Development and Management

To satisfy the growing demand in Malawi, the key considerations for water resources development in Malawi are effective usage of: (a) the effective demand management in dry season, (b) the abundant water resources in rainy season; and (b) the 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 which is better than groundwater in terms of cost performance; 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 measures and control of cropping patterns will be needed for appropriate water resources development with no conflict between the sectors.

In addition, the main countermeasures for water resources management are: (a) appropriate monitoring of hydrological data and water quality; (b) enhancement of system and capacity of relevant agencies; and (c) 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, irrigation, and livestock. Regarding the environmental flow in Malawi, there is insufficient information about the users of environmental flow such as existence of protective species. In addition, there is no guideline to estimate environmental flow. Therefore, in the Project, hydrological index methodology (Q90: Average of 90 percent flow in descending order of daily flow discharge in a year) was applied to estimate environmental flow for the planning of hard countermeasures to ensure outflow for downstream water utilization and environment.

As a result of calculation of the environmental flow, it was assumed that the environmental flow is so huge that the volume is comparable to the irrigation water demand in a year. Therefore, if the priority of environmental flow is first, large-scale development of water use facilities will be needed everywhere to meet the domestic and irrigation water demands. Considering the situation and the financial condition of Malawi where about 40 percent of the revenue is the financial assistance from other countries, this is not suitable from the viewpoint of sustainable development.

In the circumstances, the influence to river discharge by water resources development has been examined, compared with the environmental flow, and the methodology of management of environmental flow has been finally 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 the guidelines and properly control the environmental flows by river basin.

(4) Safety Level of Water Usage

The safety level of water resources development has been set as the following table which resulted from discussions and consultations with MoAIWD and MoE. Especially about the irrigation sector, the Director of 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 the planning guidelines prepared by MoAIWD, hearing investigation results and past domestic water supply plans submitted to MoAIWD.

Table 1.1.2 Safety Levels for the 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

(5) Water Demand Estimation

Water Demand has been estimated by the methods described in **Part I: Chapter 5**.

PART II

Chapter 2. DEVELOPMENT PLAN FOR URBAN AND RURAL WATER SUPPLY

CHAPTER 2. DEVELOPMENT PLAN FOR URBAN AND RURAL WATER SUPPLY

2.1 Development Plan for Urban Water Supply

2.1.1 Planning Concepts

(1) General Concepts and Applicable Ordinances/Policies

1) Common Concept

The urban water supply network in Malawi faces many problems related to population increase, water scarcity and environmental pollution, which arise from sanitation issues. In the circumstances, the overall concept of urban water supply shall be formulated, considering equity, safety, sustainability and efficiency. The overall concept of the urban water supply sector is summarized as follows:

- To develop and optimize an efficient and sustainable domestic water supply system;
- To provide a healthy living environment and contribute to poverty eradication;
- To improve the water supply facilities in public facilities, especially schools;
- To spread a safe and hygienic custom;
- To socially and culturally promote receptive technologies and customs;
- To develop the mechanism of innovative fund supply and partnership for financial health; and
- To strengthen prevention of water contamination by establishing a monitoring system and an effective legal framework on the water board level.

2) Applicable Ordinances/Policies

The applicable ordinances/policies and the targeted indicators, etc., at each organization for urban water supply are as follows:

Table 2.1.1 Applicable Ordinances/Policies at each Organization Level

Organization Level		Ordinances / Policies/ Strategies (establishment year)	Term	Remarks
Worldwide		Millennium Development Goals of UN - Target 7	~2015	
National		Water Works Act (1995)	-	
		National Water Policy (2005)	-	
City	Lilongwe	Lilongwe City Development Strategy (2009)	~2015	
		Urban Development Master Plan (2010), etc.	~2030	
	Blantyre	Strategic Plan for Blantyre City Council 2011-2016 (2010)	~2016	
		Urban Structure Plan (2000)	-	No update
		Blantyre City Slum Upgrading Action Plan 2007-2015(2007)	~2015	
		Sanitation Master Plan Study for City of Blantyre (1995), etc.	-	No action
	Mzuzu	Mzuzu Development Plan 2009-2014 (2009)	~2014	
	Zomba	Urban Development Plan 2007-2012 (2007)	~2012	No update
Lilongwe Water Board		Corporate Plan 2012 to 2017 (2012)	~2017	
Blantyre Water Board		Strategic Plan 2004 – 2023 (2004)	~2023	
		Business Plan for 2007 to 2015 (2006)	~2015	
Northern Region Water Board (Mzuzu)		Strategic Business Plan 2009-2014 (2009)	~2014	
		Strategic Sanitation Plan for Mzuzu City, Rumphi Boma and Chintheche Centre for 2010 to 2025 (2010)	~2025	
Southern Region Water Board (Zomba)		Strategic and Implementation Plan 2011-2016 (2011)	~2016	
		Zomba Sub Scheme 2009 – 2014 Strategic Business Plan (2010)	~2014	

Source: Project Team

(2) Targeted Performance Indicators and their Priority

The water suppliers like the water boards shall make necessary endeavors on the use of limited water resources. In other words, the Water Demand Management (WDM) is a very important mission for water suppliers. Also, the first priorities of the missions of water suppliers, which are categorized by the performance indicator, are ranked as the access water and the reduction of non-revenue water (NRW), in this Master Plan. The general performance indicator by the International Benchmarking Network for Water and Sanitation Utilities (IBNET) is shown in **Table 2.1.2**. The IBNET established by the Department for International Development of the United Kingdom (UK) and the World Bank (WB) is an initiative to encourage water and sanitation utilities to compile and share a set of core cost and performance indicators. The indicator of IBNET is well-known as a common indicator used in worldwide water supply business.

Table 2.1.2 List of Performance Indicators and Categories and their Priorities

Category 1	Category 2	Category 3	Performance Indicators	Priority	Remarks
Aspects to be Improved mainly by Facility Investment	Overall	Supply Continuity	Continuity of service (hours/day)	High	(IBI_15.1), 24hr is best.
	Expansion	**Access Water**	**Water service access rate (%)**	**First**	(IBI_1.1), 100% by 2025
Aspects to be Improved mainly by Capacity Development	Technical Aspects	**NRW**	**Non-revenue water (%)**	**First**	(IBI_6.1), ≦20 % is better.
		Water Quality	Implementation of tests for residual chlorine at end users (%)	High	(IBI_15.3), "≧95 %" is better.
	Non-Technical Aspects	Financial Performance	Collection ratio (%)	High	(IBI_23.2), Cash income / Billed revenue "≧95%" is better.
			Operating ratio (billed revenue covering O&M cost excluding depreciation and financing charges) (%)	High	(IBI_24.1), "≧130%" is better.
		Staff Efficiency	Number of staff working specifically for water (Number/ 1000 water connections)	High	(IBI_12.1), "≦5 staff" is better.

Note: (IBI_15.1) is Reference No. of IBNET Indicator.
Source: IBNET

Targeted performance indicators which become the basis of the strategy are set for service coverages and NRW rate (and purification plant efficiency), similar to the many past studies on water supply development plans (Sogreah Reports[*1], SSI Report[*2], etc.) in Malawi. The targeted performance indicators are summarized in **Table 2.1.3**.

*1: There are three Sogreah reports for Lilongwe, Blantyre and Mzuzu as follows:

- Feasibility Study and Preliminary Design for Lilongwe's new water source, April 2010 (SOGREAH Consultants)

- Feasibility Study and Preliminary Design for Blantyre's New Raw Water Source and Other Purposes, August 2010 (SOGREAH Consultants)

-Feasibility Study and Preliminary Design of Multi-Purpose Water Source Development for Mzuzu & Mzimba and Surrounds, September 2010 (SOGREAH Consultants)

*2: SSI Report is:

- Preliminary and Detailed Design and Construction Supervision for Zomba and Mangochi Water Supplies, June 2010 (SSI Engineers Environmental Consultants)

Table 2.1.3 Targeted Performance Indicators of Four Cities

No.	Targeted Indicator	Time Frame: Short Term 2012-2020 (12–20)	Time Frame: Middle Term 2021-2025 (21–25)	Time Frame: Long Term 2026-2035 (26–35)	Formulator	Remarks
Service Coverage to Safe drinking water						
1	MDGs	Present to 95%↗	95%		World Bank	
2	National Water Policy		Present to 100%↗	100%	Malawi	
3	Lilongwe Water Board	Present to 95%↗	95% to 100%↗	100%	LWB	(Sogreah Report)
4	Blantyre Water Board				BWB	
	All BWB Area (Original: Scenario 1, 2)	P to 82.6%		82.6% to 87.1%↗ 87.1% to 86.9%		(Sogreah Report)
	All BWB Area (Secnario 3)	P to 82.6% 82.6% to 84.3%↗	84.3% to 100%↗	100%		(Project Team)
5	Mzuzu (Northern Region Water Board)		Present to 100%↗	100%	NRWB	(Sogreah Report)
6	Zomba (Southern Region Water Board) - Scenario 1, 2	Present to 76%↗ 76% to 95%↗	95% to 100%↗	100%	NRWB	(SSI Report by 2020)
	* In case of SSI's study, the service coverage will be forecasted to become 100% by 2015. However, the water availability, namely the real service coverage will be forecasted to become 82% by 2015 and 95% by 2020.					
Rate of Non Revenue Water (In this rate, it is included the unbilled consumption, commercial losses and distribution losses), excluding Production Losses						
1	Lilongwe Water Board	Presen to 25%↘	25% to 20%↘	20%	LWB	(Sogreah Report)
2	Blantyre Water Board				BWB	
	NRW Rate (Original: Scenario 1)			Present (53%) to 35%↘ 35%		(Sogreah Report)
	NRW Rate (WSIP: Scenario 2, 3)	30%↘	30% to 25%↘	25%		Recommendation by WB
3	Mzuzu (Northern Region Water Board)	Presen to 25%↘		25% to 20%↘ 20%	NRWB	(Sogreah Report)
4	Zomba (Southern Region Water Board) - Scenario 1, 2	Presen to 20%↘	20%		SRWB	(SSI Report by 2020)
Production Losses						
1	Lilongwe Water Board	Present to 5%↘	5%		LWB	(Sogreah Report)
2	Blantyre Water Board - Scenario 1, 2, 3		5%		BWB	(Sogreah Report)
3	Mzuzu (Northern Region Water Board)		5%		NRWB	(Sogreah Report)
4	Zomba (Southern Region Water Board) - Scenario 1, 2		5%		SRWB	(SSI Report by 2020)

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

(3) Challenges to 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 four cities in the past several years. Nevertheless, many challenges to water utilities in the four cities have been left behind. From the existing situations explained in **Part I: Subsection 5.1.2**, physical challenges concerning water supply of the four cities can be described as below.

Table 2.1.4 Challenges to the Existing Condition of the Four Cities

No. of Challenges	Challenges	Target City	Remarks
UWS-0	Low access to Improved Water Source	4 cities	Key challenge
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	Key challenge
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	Key challenge
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

Several key challenges including the above-mentioned physical challenges are outlined as below.

1) Low Access to Improved Water Source (UWS-0)

According to Malawi's target under the MDG-7 by 2015 (Millennium Development Goals of UN - Target 7), the percentage of access to improved water sources is 95% of the urban population (MGDS II target was 80%). In reality, however, safe water access at the 4 cities is low compared to the 95% target for 2015; e.g., 85.7%, 85.2%, 84.1% and 90.4% in Lilongwe, Blantyre, Mzuzu and Zomba cities, respectively, at the time of the 2008 Census. Especially, water supply coverage in peri-urban areas is poor and the informal settlements do not have adequate water supply. These residents have no choice but to depend on unsafe water sources for their water needs leading to the frequent outbreak of waterborne diseases.

Therefore, the rate of access to the improved water source shall be increased.

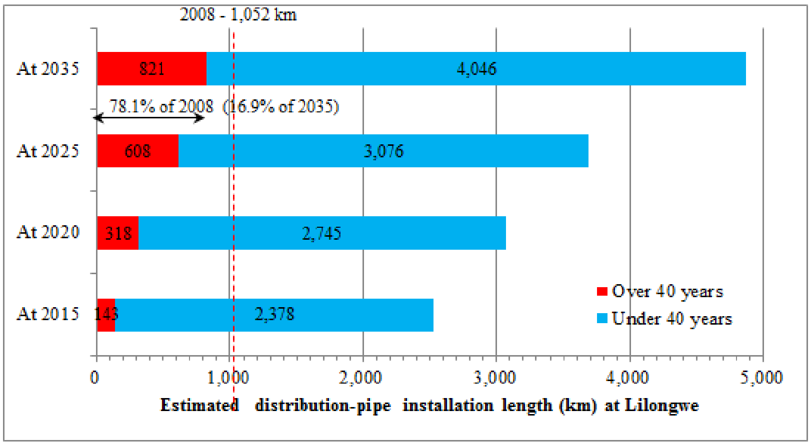
2) Necessity of New Raw Water Source (UWS-1, 5, 8, 9)

The capacity of raw water sources for the four cities will become insufficient in the near future due to the rapid population growth. Feasibility studies for new raw water sources of the cities except Zomba City have been conducted with financial assistance from the World Bank. Therefore, a feasibility study on a new raw water source for Zomba City will be needed, including development of new raw water sources, heightening of the existing Mulungudzi Dam, etc. (However, the heightening of Mulungudzi Dam is not recommended by the Water Resources Board of MoAIWD from the viewpoint of environment, because of the submergence of water falls located in the upstream part of the reservoir.). Also, the basic/detailed design for the new raw water sources for Lilongwe, Blantyre and Mzuzu cities will be needed for the future condition. At the same time, designs for additional new water treatment plants will be necessary to purify the water to adapt to rapid population growth.

3) Necessity of Rehabilitation of Aging Facilities (UWS-2, 3, 6, 7, 8, 9)

As described in the existing conditions in **Part I: Subsection 5.1.2**, most of the water supply facilities in the four cities are old. The aging water facilities may cause various problems, such as risk of accidents and failures with water supply interruption for a long time due to the deterioration of structural components. In addition, asbestos cement (AC) pipes are included in a part of the aging pipes, and they shall be replaced to avoid pipe-breakage failures, etc. Taking LWB for example, 78.1% of the total pipe length installed until 2008 will be 40 years old or over by 2035. (If the pipe length that will be installed in 2035 is included, the percentage of old pipes in the total installation length is estimated to be 16.9%.) The financial burden of LWB for the rehabilitation and maintenance of aging pipes will increase in addition to the installation of new pipes. (See **Figure 2.1.1**)

Therefore, appropriate countermeasures shall be taken according to the program, after implementing the functional diagnosis of water facilities.



Source: Project Team
Note: Pipe installation length is estimated by multiplying the increased population by "distribution pipe length per capita at 2008". Pipe installation length in 2008 is based on the "LWB corporate plan for 2009 to 2014 (2009)".

Figure 2.1.1 Forecast of Aged Distribution Pipelines in 2035

4) Necessity of Reduction of NRW (UWS-4, 8)

Non-revenue water (NRW) is the water produced but "lost" before it reaches the customer. The losses can be real losses (through leaks) or apparent losses (for example through theft or metering inaccuracies). High levels of NRW are detrimental to the financial viability of water boards as well as to the quality of water itself in an indirect manner. Each water board has taken various countermeasures to NRW. (NRW of Blantyre remains to possess the highest value in Malawi, and hence the NRW reduction program which is being funded by EU and EIB has been ongoing since 2009. Although achievements of the current program will need to be monitored for some period of time, additional measures shall be considered for the high NRW rate.)

All water boards need to continue the initiative to reduce the NRW. Among them, the rates of NRW of LWB and BWB are still high in recent years, and the BWB shall perform the cost containment effort further as described in **Part I: Chapter 5**. Hence, the LWB and BWB, especially, will need to put its NRW reduction program in place.

5) Financial Soundness and Water Tariff (UWS-11)

All of the water boards have prepared business plans as their strategic management tool for future financial soundness. However, in reality, there is the tariff gap between the Average Tariff and Full Cost Recovery Tariff. As reference, the financial statement of LWB for 2010-2011 and that of BWB for 2009-2010 are shown in **Table 2.1.5**. On a full-year basis, according to the income and financial statements, both water boards had a deficit, although there is a lot of funding from donors. (NRWB and SRWB are expected to have surplus after 2011. However, the total comprehensive income for the 2010 financial year of NRWB had a deficit during the implementation of “the commissioning process of Mzuzu Water Supply Project and the intermittent failure of the new Karonga water treatment plant”.)

Also, generally the current ratio should be more than 200% based on the financial statement. However, those of LWB and BWB are 169% and 151% respectively. This means that it would be difficult for both water boards to get short-term loans from creditors. In the case of Japan, the ratio of long-term capital to fixed asset is more than 100%. Both LWB and BWB have less than 100%, i.e., 97% in LWB and 92% in BWB at present. However, if the ratio will exceed 100%, a problem might be created, meaning that short-term capital is used in the procurement of fixed assets.

According to the “Malawi Water Sector Investment Plan”, the target indicator that the Government is using for the financial performance of water boards is the “Operating Ratio”. The operating ratio in 2010 was 0.84 for LWB and 0.97 for BWB, and they fell short of the government’s target of less 0.5. From this financial situation, it is assumed that the water boards do not have the capacity to fund any significant portion of capital expenditures in the urban water and future sanitation sector. Actually, the expenditure in urban areas has been financed with money lent by development partners and repaid by the Government (eventually through forgiveness of debt). (Source: “Malawi Water Sector Investment Plan, Vol. II”, World Bank, April 2012)

The financial issues described above might be resolved through the above-mentioned challenges (UWS 1 to 10). However, the presence of low-income inhabitants should be recognized again before the development of infrastructure. In this context, more than half of the population is to be served in the low income category, i.e., their income can only allow them to use water from kiosks (communal water points). This means that these people will be supplied with water at a subsidized tariff as a social obligation and there will be no cost recovery.

Since the ratio of revenue to operating cost of the water boards need to be improved, consideration should be given to the increase of urban water tariffs to move towards full cost reflective tariffs, and take efforts to reduce non-revenue water. This can release more funds for serving rural areas and informal settlements. Subsidy to water supply in Malawi is in the form of raising block tariff with two objectives. First, the tariff structure attempts to enable low-income earners in low-income areas to pay less than high-income earners. Second, the block tariff system ensures higher charges for higher consumption, regardless of location. (Source: "Human Settlements Working Paper Series, Water and sanitation in urban Malawi: Can the Millennium Development Goals be met? A study of Informal Settlements in Three Cities", The Scottish Government)

On the other hand, the interview survey on the willingness to pay for individual connection was implemented in Zomba City in 2008. A majority of the inhabitants said that water bills are affordable but the initial cost is too high. Of the households interviewed, 84.3% of those currently not connected showed willingness to be connected to piped water supply. It was established that 62.6% of households who do not currently have piped water supply are willing to pay for individual piped connections while 37.1% are willing to pay for communal water point (CWP) connection. Out of those willing to pay for individual connections, 21.8% indicated that they are prepared to pay up to MK500; 6.5% between MK501 and MK1,000 and 4.7% indicated being prepared to pay over MK1,000. However, of the households willing to pay for CWP supply, 15.2% indicated willingness to pay up to MK500, 0.1% between MK501 and MK1,000 while 0.2% are willing to pay over MK1,000. In other words, low income families using the CWP (Kiosk), show an intention not to pay MK500 or more, even for individual connection.

Table 2.1.6 is the average water tariff billed per cubic meter for the Water Board. Even if an average family in a low-income area is assumed to use 7m^3 per month, it will be a water tariff that exceeds their willingness-to-pay.

Table 2.1.5 Income and Financial Statements of LWB and BWB (2009-2012)

Item of Account	Lilongwe Water Board				Blantyre Water Board			Remarks
	2012	2011	2010	Growth Rate	2010	2009	Growth Rate	
	(1000MWK)	(1000MWK)	(1000MWK)	(%)	(1000MWK)	(1000MWK)	(%)	
Income Statement								
Income	2,357,552	2,267,585	5,732,079	4.0%	2,412,591	1,943,492	24.1%	
Water sales	2,207,546	1,940,938	1,766,880	13.7%	1,889,827	1,576,383	19.9%	
Other income	53,867	236,685	49,976	-77.2%	512,470	361,367	41.8%	
Finance income	1,260	2,398	8,785	-47.5%	10,294	5,742	79.3%	
Exchange difference	-	5,718	-	-	-	-	-	
Additions to home ownership fund	11,465	1,197	2,643	857.8%	-	-	-	
Revaluation of plant and equipment	-	-	3,903,795	-	-	-	-	
Income tax on other comprehensive income	83,414	80,649	-	3.4%	-	-	-	
Expenses	-2,426,006	-2,378,268	-3,084,188	2.0%	-2,335,790	-2,051,357	13.9%	
Staff costs	-673,823	-599,380	-646,606	12.4%	-627,477	-501,670	25.1%	
Administration and general expenses	-303,855	-319,890	-323,063	-5.0%	-356,191	-211,114	68.7%	
Plant, motor vehicle and operating expenses	-415,186	-354,247	-271,595	17.2%	-397,249	-271,248	46.5%	
Chemicals	-94,995	-94,820	-103,412	0.2%	-55,241	-82,474	-33.0%	
Depreciation	-462,653	-459,259	-225,753	0.7%	-187,349	-189,811	-1.3%	
Impairment loss on plant and equipment	-	-	-52,688	-	-62,940	-38,769	62.3%	
Electricity	-288,770	-215,128	-168,214	34.2%	-534,534	-528,308	1.2%	
Provision for doubtful debts	-	-132,404	-69,324	-	-	-	-	
Finance expenses	-9,566	-8,147	-3,072	17.4%	-49,341	-133,124	-62.9%	
Exchange difference	-	-	-31,098	-	-	-2,728	-	
Income tax expense	-177,158	-194,993	-35,251	-9.1%	-65,468	-92,111	-28.9%	
Income tax on other comprehensive income	-	-	-1,154,112	-	-	-	-	
Total comprehensive (loss) / income for the year	-68,454	-110,683	2,647,891	-38.2%	76,801	-107,865	-171.2%	
Account of Finance								
Asset	15,216,067	15,170,917	15,473,701	0.3%	3,921,785	3,913,839	0.2%	
Fixed Asset (Non-current Asset)	14,037,001	14,142,969	14,173,811	-0.7%	3,080,918	3,088,240	-0.2%	
Property, plant and equipment	13,259,421	13,483,975	13,693,765	-1.7%	2,772,018	2,735,772	1.3%	
Home ownership Loans	-	-	-	-	36,765	31,572	16.4%	
Deferred tax assets	777,580	658,994	480,046	18.0%	272,135	320,896	-15.2%	
Current Assets	1,179,066	1,027,948	1,299,890	14.7%	840,867	825,599	1.8%	
Inventories	412,098	375,480	467,542	9.8%	91,295	90,450	0.9%	
Trade and other receivables	667,986	612,072	573,297	9.1%	651,228	653,184	-0.3%	
Cash and cash equivalents	88,651	30,078	249,176	194.7%	87,103	72,371	20.4%	
Home ownership loans	-	-	-	-	7,509	5,862	28.1%	
Tax recoverable	10,331	10,318	9,875	0.1%	3,732	3,732	0.0%	
Equity and Liabilities	15,216,067	15,170,917	15,473,701	0.3%	3,921,785	3,913,839	0.2%	
Equity	10,372,219	10,296,952	10,540,851	0.7%	2,149,539	824,285	160.8%	
Capital contribution	4,581,857	4,458,307	4,591,523	2.8%	1,433,961	185,508	673.0%	
Revaluation reserve	6,766,833	6,961,465	7,149,647	-2.8%	1,220,776	1,256,032	-2.8%	
Accumulated losses	-976,471	-1,122,820	-1,200,319	-13.0%	-505,198	-617,255	-18.2%	
Liabilities	4,843,848	4,873,965	4,932,850	-0.6%	1,772,246	3,089,554	-42.6%	
Non-current Liability	4,145,700	4,128,875	4,337,835	0.4%	1,214,992	2,455,225	-50.5%	
Deferred tax liability	3,525,548	3,475,955	3,361,611	1.4%	720,974	708,251	1.8%	
Long term borrowings	620,152	652,920	767,311	-5.0%	253,717	1,537,636	-83.5%	
Employee benefits liabilities	-	-	208,913	-	240,301	209,338	14.8%	
Current Liabilities	698,148	745,090	595,015	-6.3%	557,254	634,329	-12.2%	
Trade and other payables	592,831	638,542	571,744	-7.2%	386,321	484,041	-20.2%	
Current portion of borrowings	25,235	74,687	0	-66.2%	9,854	10,084	-2.3%	
Current income tax liabilities	47,419	2,412	2,008	1866.0%	3,984	2,768	43.9%	
Bank overdrafts	32,663	29,449	21,263	10.9%	157,095	137,436	14.3%	
Current Ratio	169%	138%	218%		151%	130%		
Ratio Long-term Capital to Fixed Asset	97%	98%	95%		92%	94%		Long-term Capital= Equity + Noncurrent Liability

Source: Project Team, based on the data from LWB Financial Statements in 2011 and BWB Annual Report in 2010

Table 2.1.6 Average Tariff per Cubic Meter Billed (MK/m^3), 2010

Item	BWB	LWB	NRWB	CRWB	SRWB	Remarks
Average tariff per m^3 billed (MK/m^3), 2010	122	86	126	112	102	
Average tariff per low-income household (MK/7m^3)	854	602	882	784	714	Assumed as 7m^3 per low-income family.

Source: Project Team, based on the data from "Malawi Water Sector Investment Plan" Vol. II, The World Bank, April 2012

2.1.2 Development Goals

The development goals of short-, middle- and long-term for 4 cities concerning performance indicators, have been set as shown in **Table 2.1.3** by taking into consideration the following conditions:

- Lilongwe - As the concrete goals, the 95% of 2015 and 100% of 2025 for access rate 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 the "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 - Three scenarios (Scenario 1, 2 and 3) are considered in the Project. The new water source for all scenarios 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 "Malawi Water Sector Investment Plan (WSIP by World Bank, 2012)". Also, the same unit water consumption per capita is used for all scenarios. As the concrete goals, the 82.6% as the estimated access rate at 2013 from existing condition is used for Scenario 1, 2 and 3. Then, the 87.1% of 2029 of access rate for Scenarios 1 and 2, is set from the medium scenario of "Sogreah Report (2010)", and it is the intermediate value between BWB strategic plan target (100%: high scenario) and current 70% (low scenario). As for coverage at 2029 of Scenario 3, the value of 100% is adopted by project team. The NRW rates by 2035 of Scenario 1 are based on Sogreah Report, and its rates by 2035 of Scenario 2 and 3 are based on "WSIP (2012)". The facility plan of Scenario 2 and 3 are planned with reference to the concept of Scenario 1 of Sogreah Report.

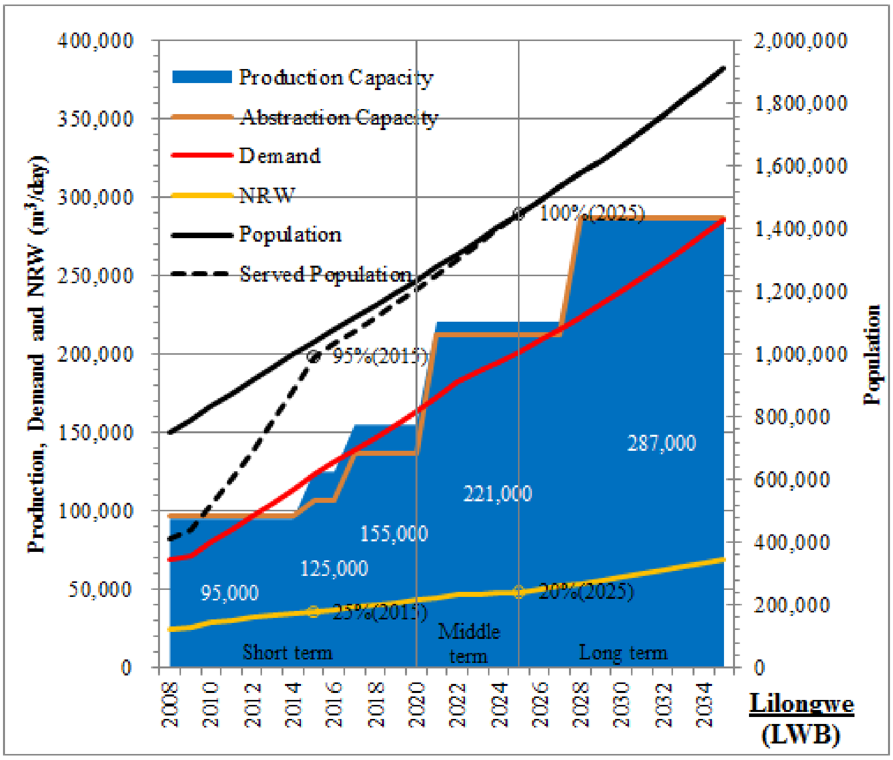
Table 2.1.7 Target Served Population and NRW Rate of Each Scenario of Blantyre

	Target Served Population				Target NRW rate				Remarks
	2013	2019	2029	2035	2012	2025	2029	2035	
Scenario 1	82.6%	-	87.1%	86.9%	49.5%	↘	35.0%	35.0%	original Sogreah demand
Scenario 2	82.6%	-	87.1%	86.9%	30.0%	25.0%	→	25.0%	WSIP demand
Scenario 3	82.6%	84.3%	100.0%	100.0%	30.0%	25.0%	→	25.0%	by the Project

Note 1. Target NRW rates of Scenario 2 and 3 are changed from WSIP.
Note 2. Scenario 1-3 are same unit water consumption per capita.
Source: Project Team, based on the data from "Malawi Water Sector Investment Plan" (World Bank), Sogreah Report (2010)

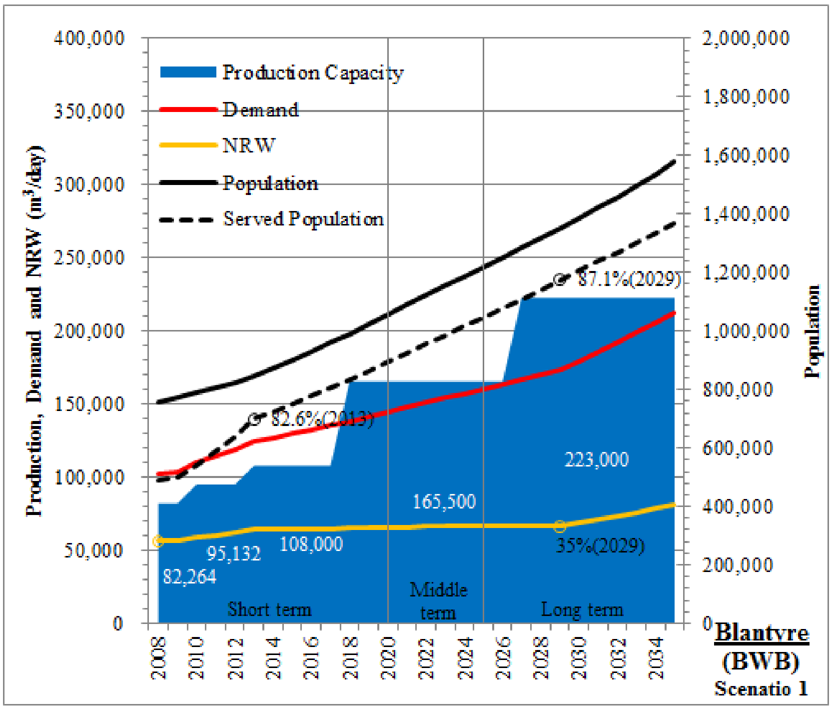
- Mzuzu - All design conditions and parameters are based on original "Sogreah Report (2010)". (Incidentally, the development plan for Mzuzu is until 2040.) The 100% of access rate at 2025 refers to the "Nation Policy", and NRW rates at 2015 and 2030 are based on "Sogreah Report". The water abstraction capacity will be increased by the construction of two dams although construction of the first dam is behind schedule.
- Zomba - The water demand of Scenario 1 by 2020 is based on original "SSI Report (2010)", the water demand from 2021 to 2035 has been forecasted by the Project Team. (Real access rate is targeted to 100% at 2025 for National Water Policy from 95% at 2020 of SSI.) The unit water consumption of domestic-use for Scenario 2 is in reference to the unit consumption of Mzuzu. The institutional/commercial/industrial consumption for Scenario 2 is calculated as annual growth rate of 1.8% by the Project Team. (1.8% is the 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.

The development goals for the 4 cities development plans are shown in **Figure 2.1.2** to **Figure 2.1.8**.



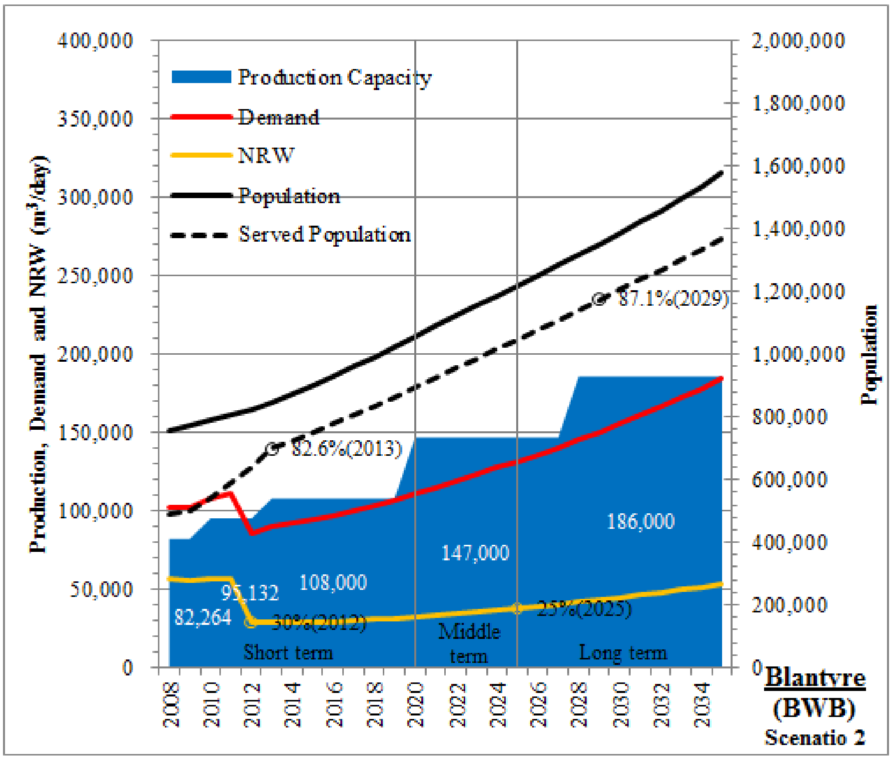
Source: Sogreah Report and LWB future investment plan

Figure 2.1.2 Coverage and Expansion Plan for Lilongwe Water Supply Facilities



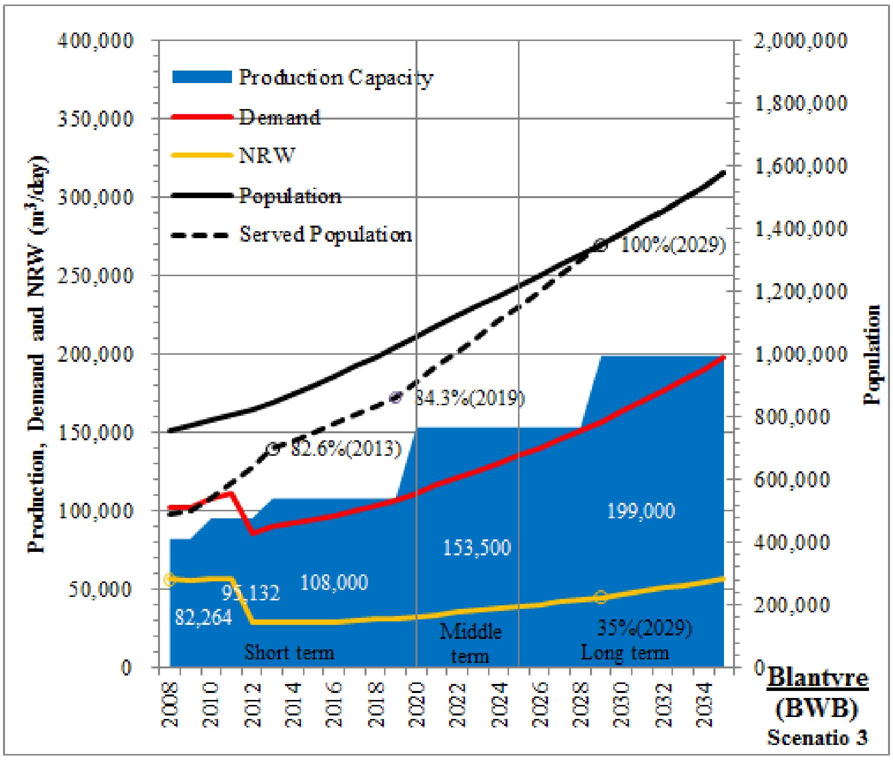
Source: Sogreah Report (WB revised raw-water source option to Walker's ferry.)

Figure 2.1.3 Coverage and Expansion Plan for Blantyre Water Supply Facilities (Scenario 1)



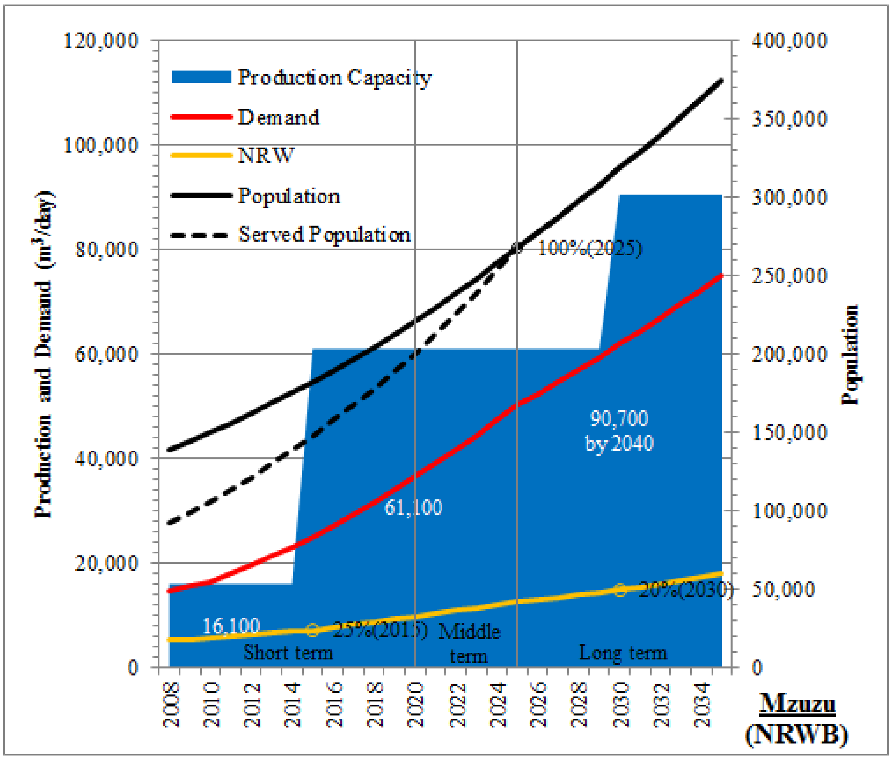
Source: Sogreah Report (WB revised raw-water source option to Walker's ferry, and revised NRW rate.)

Figure 2.1.4 Coverage and Expansion Plan for Blantyre Water Supply Facilities (Scenario 2)



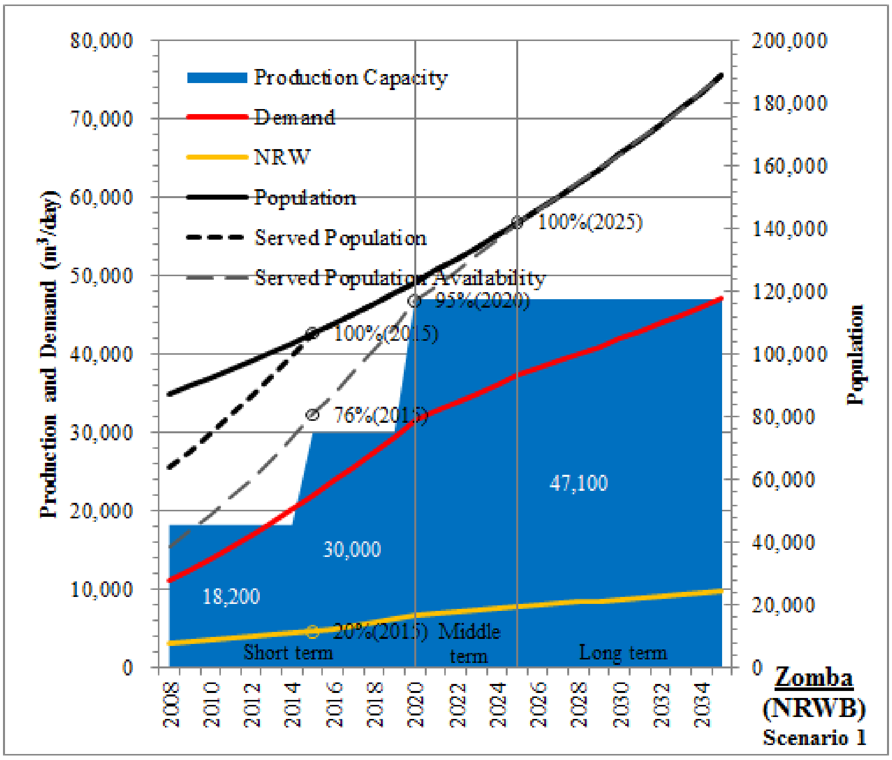
Source: Sogreah Report (WB revised raw-water source option to Walker's ferry, and revised NRW rate.)

Figure 2.1.5 Coverage and Expansion Plan for Blantyre Water Supply Facilities (Scenario 3)



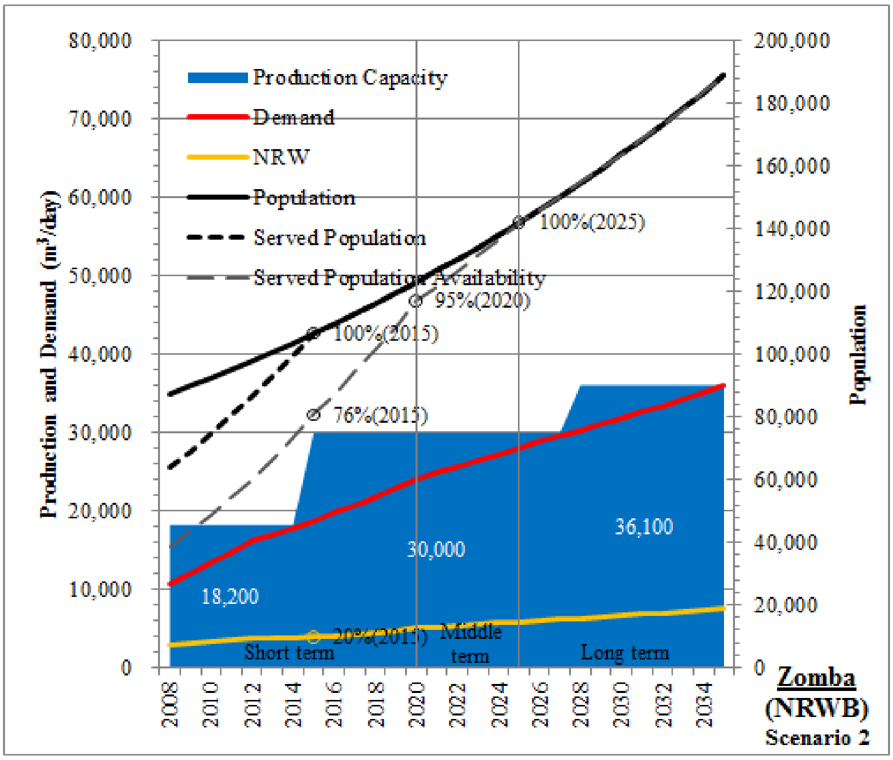
Source: Sogreah Report

Figure 2.1.6 Coverage and Expansion Plan for Mzuzu Water Supply Facilities



Source: Project Team from 2021 to 2035, and SSI Report by 2020

Figure 2.1.7 Coverage and Expansion Plan for Zomba Water Supply Facilities (Scenario 1)



Source: Project Team

Figure 2.1.8 Coverage and Expansion Plan for Zomba Water Supply Facilities (Scenario 2)

2.1.3 Strategy and Roadmap for Short, Middle and Long Term

(1) Basic Strategy

In consideration of the above-mentioned concepts, performance indicators and challenges, the strategy for urban water supply in the water resources master plan has been formulated. The strategy is divided into short (emergency), middle and long-term, and the roadmap is formulated based on the strategies and time schedule with the action plan in detail in **Table 2.1.9**.

Strategy for 4 cities' Urban Water Supply Sector:

- Strategy 1: To access safe drinking water (and basic sanitation) [To step up Access Rate]
- Strategy 2: To reduce Production Losses (to 5%) and NRW value (less than 20-25%)
- Strategy 3: To develop New Raw Water Resources and to be sustained/supplied safe water (Rehabilitation and Construction of New Facilities)
- Strategy 4: To strengthen Financial Soundness of water supply and to optimize Water Tariff.

(2) Roadmap for Short, Middle and Long Term

In this item, the breakdown of basic strategy and its roadmap for each target period is presented.

1) Strategy 1: To step up Access Rate

The water service areas and its target year are based on each development goal above. Except for Scenario 1 and 2 of Blantyre, the coverage by 2035 is able to cater to a value of 100% at 2025 of "National Water Strategy", as shown in **Figure 2.1.3** and **Figure 2.1.4**. The actual planning value for the coverage (of Scenario 1 and 2) of Blantyre by WB is 87% at 2035. Although the Scenario 3 of Blantyre is made by the Project and it is not an official plan, further feasible study (forecast and examination) will be needed for the security of water.

2) Strategy 2: To reduce Production Losses (to 5%) and NRW Value (less than 20-25%)

The Non-Revenue Water Reduction Program has a beneficial effect on the reduction of NRW. The NRW reduction Program consists of three approaches. One is the Technical Approach for NRW reduction. Second is the Regulatory Approach or Administrative Approach, which set up the regulation or act/law for water and the new water tariff. Third is the Behavioral Approach, which is the education for water saving, demand control, etc. The above-mentioned three approaches are summarized as follows:

(i) Technical Management

- Construction Management - Techniques and Supervision
- Water Resources Development - Groundwater, Dams, Water loss reduction of transmission (by lining, replace, etc.)
- Water recycling - Rain water harvesting (groundwater conservation) – Treated waste water recycling
- Utilization of Water-Saving Devices (toilet, tap)

(ii) Regulation Approach

- Water Tariff System - Specific Tariff (flow meter basis)
- 24 hour services (Non-24 hour continuous supply pipes under groundwater, may create water quality problems.)
- Bill Collection System - Automatic check off (Improvement of Collection Ratio)
- Rain water Harvesting,
- Recycling Water Regulations
- Asset Management Database - Asset Replacement schedule (budget preparation)
- Regulation at the time of water shortage, outage and performance decline of facilities (i.e. banning the use of hose, etc.)

(iii) Behavioral Approach

- Water-Saving Education - Social study classes, Practice of water-saving
- Advertisements - Radio, Television and News papers
- Campaigns - Facility demonstrations, water saving campaigns - Patrolling with inhabitants

In the above technical management, the fundamental component of the water loss reduction plan involves the rehabilitation of the city’s distribution system to the acceptable standard as a component of the expansion of the network. Each water board is currently implementing such a program. Appropriate metering will also be implemented to enable the operator to monitor and correct technical losses that become evident. Conceptually bulk metering systems should be implemented to enable the operator to measure the following:

- The volume of raw water drawn from all sources of supply;
- The volume of treated water used for filter backwash;
- The volume of treated water conveyed to the reservoirs;
- The volumes discharged from the reservoirs to each pressure zone and/or supply district;
- Service meters at all supply points with priority to all large commercial and institutional customers.
- The commercial losses will be addressed through appropriate management by each of water board.

Specifically, for the above measures, it will be necessitated "the equipment provision", "the dispatch of experts to support development for NRW" and "Capacity building", etc.

3) Strategy 3: To develop New Raw Water Resources and to be sustained/supplied safe water (Renewal and New Construction of Facilities)

The development plan (rehabilitation and construction of new facilities) for each city are based on each development goal above. Except for Mzuzu by 2040, the target year is by 2035. The Blantyre and Zomba only have three and two scenarios for their development plan (see **Chapter 2.1.2**).

4) Strategy 4: To strengthen Financial Soundness of water supply and optimize Water Tariff.

Although several development projects and programs by the international assistance (funds of WB, EIB, etc.) are performed, all water boards lack funds for sufficient investment in rehabilitations and service extensions for high NRW rate. For customers to be willing to pay their bills regularly, it has been important to provide good and reliable services. And it is important to perform the programs for the improvement of financial soundness. To increase revenues, it is important to have a good bill collection efficiency (amount collected/amount billed * 100), and an equitable tariff system will be needed. On the other hand, the legal bail-out plan and the development of legal systems shall be taken into consideration for the disadvantaged. As for Strategy 4, the following measures are to be considered:

- Asset and Accounting Management Database - Evaluation of assets, etc.
- Improvement for Operation ratio.
- Legal bail-out plan for the disadvantaged, Development of legal systems.
- Escalating tariff system, and Monitoring of tariff by third-party.
- Appropriate management (monitoring, control and its framework) for metering, water leakage.
- Appropriate staffing and organization. Total number of staff per thousand connection is desired to be less than 5 people.

5) Other Strategies

As for other strategies, the following measures are to be considered.

- Improvement of service (Continuity of service hours = 24hours, etc.)
- Amelioration of raw water quality
- Amelioration of drinking water quality
- Raising of public awareness to water, sanitation and hygiene program (by using mass media, advertisement, etc.)

The breakdown for basic strategy and its roadmap are shown in **Table 2.1.8.** For the roadmap for implementing above strategies, the target year (milestone) is set from the year of development goal for the water demand forecasts of each development plan. Other strategies except the development plan are set from the importance and urgency degree of actual issues objectively.

Table 2.1.8 Breakdown of Strategies and its Roadmap

No.	Strategies / Organizations	Time Frame																								Challenge No.	Target Organ	Remarks
		Short Term 2012-2020									Middle Term 2021-2025					Long Term 2026-2035												
		12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35			
1	**To access to safe drinking water (and basic sanitation)【 To step up Service-coverage Rate 】**																											
	Millennium Development Goals (WB)				MDG 7.C: 95% by 2015	95%																				UWS-0	Nationwide	for Urban
	National Policy (Malawi)														National Policy: 100% by 2025	100%										UWS-0	Nationwide	
-a	Lilongwe (LWB)				●	95%									●	100%										UWS-0	Lilongwe	
-b	Blantyre (BWB)		●	82.6%															●	87.1%					86.9%	UWS-0	Blantyre	
-c	Mzuzu (NRWB)														●	100%										UWS-0	Mzuzu	
-d	Zomba (SRWB)				●	76%				●	95%				●	100%										UWS-0	Zomba	
2	**To reduce Production Losses (to 5%) and NRW value (less than 20-25%)**																											
-a	Lilongwe (LWB)				●	25%									●	20%										UWS-4	Lilongwe	
-b'	Blantyre (BWB) - Scenario 1																		●	35%						UWS-8	Blantyre	
-b	- Scenario 2	●	30%												●	25%										UWS-8	Blantyre	Adopted Scenario
-c	Mzuzu (NRWB)				●	25%														●	20%					-	Mzuzu	
-d	Zomba (SRWB)				●	20%																				-	Zomba	
3	**To develop New Raw Water Resources and to be sustained / supplied safe water (Renewal and New Construction of Facilities)**																									UWS-1, 2, 3, 5, 6, 7, 9, 10		
-a	Lilongwe (LWB)				● 125000m3/d		●	155000m3/d			●	221000m3/d						●	287000m3/d							UWS-1, 2, 3	Lilongwe	Production
-a					● 107000m3/d		●	137000m3/d			●	212000m3/d						●	287000m3/d							UWS-1, 2, 3	Lilongwe	Abstraction
-b'	Blantyre (BWB) - Scenario 1		●	108000m3/d				●	165500m3/d								●	223000m3/d								UWS-5, 6, 7	Blantyre	
-b	- Scenario 2		●	108000m3/d						●	147000m3/d							●	186000m3/d							UWS-5, 6, 7	Blantyre	Adopted Scenario
-c	Mzuzu (NRWB)				●	61100m3/d															●	90700m3/d				UWS-9	Mzuzu	
-d'	Zomba (SRWB) - Scenario 1				●	30000m3/d				●	47100m3/d															UWS-10	Zomba	
-d	- Scenario 2				●	30000m3/d												●	36100m3/d							UWS-10	Zomba	Adopted Scenario
4	**To strengthen Financial Soundness of water supply and To optimize Water Tariff.**																									UWS-11		
-a	Asset & Accounting Management Database									●																UWS-11	4 cities	
-b	Improvement for operation ratio									●					●										●	UWS-11	4 cities	
-c	Legal bail-out plan for the disadvantaged, Development of Legal systems									●					●											UWS-11	4 cities	
-d	Escalating tariff system									●					●										●	UWS-11	4 cities	
-e	Appropriate management (monitoring, control and its framework) for metering, water leakage									●					●											UWS-11	4 cities	
-f	Appropriate staffing and organization									●																UWS-11	Ministry and 4 cities	
5	**Others**																									-		
-a	Improvement of service (Continuity of service hours, etc.)									●																-	4 cities	
-b	Amelioration of raw water quality									●																-	4 cities	
-c	Amelioration of drinking water quality									●																-	4 cities	
-d	Heightening of public awareness to water, sanitation and hygiene									●																-	4 cities	
-e	Strengthening of maintenance technology of waterworks facility									●																-	4 cities	

Note: Each scenario of Blantyre and Zomba are shown in Subsection 2.1.2 .
Source: Project Team

2.1.4 Recommendation for Human Resource Development and Capacity Building

One of the major hindrances to the promotion of the urban water supply sector's strategy and management in Malawi by "the water boards and the MoAIWD" is inadequate financial and human capacity to implement the PDCA cycle of given tasks. The country does not have enough trained personnel to formulate policies and strategies, both at the technical and professional levels. The water board responsible for the actual operation/management is also similar. The lack of financial resources has only helped to exacerbate the situation. Therefore, right capacity buildings to related department staffs shall be needed, and it will be important as one of the improvement plan of the financial standing and organization of water utility account.

On the other hand, the efficiency of the organization should be promoted at the same time along with the promotion of the efficiency of the facility. According to the annual report of each water board, the number of staff working specifically for 1000 water connections is 12 persons for LWB, 14.7 for BWB, 6.2 for NRWB, and 3.6 for SRWB. Although SRWB is appropriate, the staff numbers per 1000 connections of other boards are more than 5 people (more than the recommended value of IBNET).

2.1.5 Recommendation for the Maintenance Program of Waterworks Facility

The maintenance for water supply facilities influences the safety and stability of drinking water; hence, it shall be carried out adequately, effectively and rationally. The day-to-day maintenance for waterworks facility is classified in two parts: the operation management and the maintenance engineering generally. The program concerning the maintenance of waterworks facility is formulated from these two aspects, and it shall be performed. The program contents for 4 cities are considered as follows:

(1) Operation Management

- Recording of operation and control management, Recording of job and operating diary;
- Preparation of operation management manual, (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.);
- 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.); and
- Water quality control (for the target water quality, the appropriate sampling and monitoring, the planning and recording of water quality inspection, etc.).

(2) Maintenance Engineering

- 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).
- Encouragement of compliance to manual.
- Preventive and Corrective maintenance, Reliability risk evaluation.

2.1.6 Prioritized List of Four Cities

(1) Program, Projects and Activities for the Four Cities

Although there are other priorities for urban water supply sector, "Access rate (Strategy 1)" and "Non-Revenue Water (Strategy 2)" as shown in **Table 2.1.2** are prioritized in this plan.

In order to step up the "Access rate (Strategy 1)", the "Implementation of development plan (Strategy 3)" is required. Also, in order to improve the "Financial Soundness (Strategy 4)", the reduction of "NRW (Strategy 2)" is required. Hence they are related to each other for sustainable water utility.

The feasible program, projects and activities for urban water supply sector of 4 cities are picked out and shown in **Table 2.1.9**, in reference to actual ongoing projects and planning of NWDPII by WB, EIB, etc. These feasible program, projects and activities are weighted the degree of emergency, importance and aging, and the conclusive priority is ranked as High-priority in case of 2 or more degrees, and in case of 1 degree is Middle-priority. (Zero degree is Low-priority.)

Table 2.1.9 List of Programs, Projects and Activities and their Priority

Program	Projects / Activities	Programme Category: Facility Investment: Overall	Programme Category: Facility Investment: Expansion	Programme Category: Capacity Development: Technical Aspects	Programme Category: Capacity Development: Non-technical aspects	Category of Target Facility: Storage	Category of Target Facility: Intake & Transmission	Category of Target Facility: Purification Plant	Category of Target Facility: Transmission	Category of Target Facility: Distribution	Category of Target Facility: Others	Concepts: Equity	Concepts: Safety	Concepts: Sustainability	Concepts: Efficiency	Strategies (No.) 1: To step up Service-coverage Rate	Strategies (No.) 2: To reduce NRW value	Strategies (No.) 3: To develop New Raw Water Resources and to be sustained / supplied safe water: New Construction	Strategies (No.) 3: To develop New Raw Water Resources and to be sustained / supplied safe water: Renewal (Aging Facilities)	Strategies (No.) 4: To strengthen Financial Soundness	Strategies (No.) 4: To optimize Water Tariff	Strategies (No.) 5: Others	Priority: Urgency Degree	Priority: Important degree	Priority: Aging Degree	**Conclusive Priority**	Remarks
Lilongwe (LWB)																											
LW-1	Develop new groundwater borehole (+10,000 m^3/d)		○				○					○		○		○		○					●	●		High	Study is ongoing.
LW-2	Extension TWII (purification plant: +30,000 m^3/d)		○					○				○		○		○		○					●	●		High	Study is ongoing.
LW-3	Raising of Kamzu dam 1 and associated rehabilitation works (+30,000 m^3/d)	○	○			○						○		○	○	○			○				●	●	●	High	Study is ongoing.
LW-4	Extension TWII(2nd) (purification plant: +30,000 m^3/d) and Technical Assistance		○	○				○				○		○		○		○					●	●		High	
LW-5	Catchment area conservation and rehabilitation			○	○						○		○	○					○			○raw water quality	●			Medium	Technical cooperation
LW-6	Network improvement	○							○	○				○	○	○	○		○	○	○		●	●	●	High	
LW-7	Full implementation GIS/Hydraulic Model	○		○							○	○		○		○		○		○	○		●	●		High	
LW-8	Phase 1, New water source Diamphwe dam including transports system (+75,000 m^3/d, TW+66000 m^3/d)		○			○	○	○	○			○		○		○		○					●	●		High	
LW-9	Implementation telemetry system	○									○	○		○		○	○	○					●			Middle	
LW-10	Rehabilitation of TWII	○						○						○	○	○	○		○	○	○		●	●	●	High	
LW-11	Network expansion		○						○	○		○		○		○		○					●	●		High	
LW-12	Review of water demand study		○								○	○		○		○		○					●	●		High	
LW-13	Phase 2, New water source Diamphwe dam including transports system (Dam+75,000 m^3/d, TW+66000 m^3/d)		○			○	○	○	○			○		○		○		○						●		Middle	
Blantyre (BWB)																											Scenario 2
BW-1	Network improvement	○							○	○									○	○	○		●	●	●	High	
BW-2	additional NRW reduction programme	○		○	○						○	○		○	○		○		○	○	○		●	●		High	Technical cooperation (Dispatch of expert, Equipment provision, etc)
BW-3	Metering and Water leakage control	○		○	○						○	○		○	○		○		○	○	○		●	●	●	High	
BW-4	Phase 1, New water source from Shire River including transports system (+39,000 m^3/d)		○			○	○	○	○			○		○		○		○					●	●		High	
BW-5	Network expansion		○						○	○		○		○		○		○					●	●		High	
BW-6	Poverty program (Kiosk and Toilet development)		○		○					○		○		○		○		○			○		●	●		High	
BW-7	Phase 2, New water source from Shire River including transports system (+39,000 m^3/d)		○			○	○	○	○			○		○		○		○						●		Middle	
BW-8	Review of water demand study		○								○	○		○		○		○						●		Middle	
Mzuzu (NRWB)																											
MW-1	Phase 1, New water source Lambilambi dam including transports system (+45,000 m^3/d)		○			○	○	○	○			○		○		○		○					●	●		High	
MW-2	Network improvement	○							○	○									○	○	○		●	●	●	High	
MW-3	Re-examination of water demand and raw water source study		○								○	○		○		○		○						●		Middle	
MW-4	Phase2, New water source Lichelemu dam inclusing transports system (+29,600 m^3/d)		○			○	○	○	○			○		○		○		○						●		Middle	
MW-5	Network expansion		○						○	○		○		○		○		○					●	●		High	
MW-6	NRW reduction programme	○		○	○						○	○		○	○		○		○	○	○		●	●		High	
Zomba (SRWB)																											Scenario 2 (- dam raising)
ZW-1	Expansion existing TW (18,200 to 30,000 m^3/d)		○			○	○	○	○			○		○		○		○					●	●		High	Construction is ongoing.
ZW-2	Network improvement	○							○	○									○	○	○		●	●	●	High	
ZW-3	Feasibility study of water demand and new raw water source		○								○	○		○		○		○					●	●		High	
(ZW-4a1)	New water source dam including transports system (+17,100 m^3/d)		○			○	○	○	○			○		○		○		○					●	●		High	(Scenario 1)
ZW-4a2	Raising of Mulunguzi dam and associated rehabilitation works (+6,100 m^3/d)	○	○			○	○	○	○			○		○		○		○						●		Middle	Scenario 2a
ZW-4b2	Develop new groundwater borehole (+6,100 m^3/d)		○			○	○	○	○			○		○		○		○						●		Middle	Scenario 2b
(ZW-5a1)	Network expansion		○						○	○		○		○		○		○					●	●		High	(Scenario 1)
ZW-5a2	Network expansion		○						○	○		○		○		○		○					●	●		High	Scenario 2a, 2b
Others																											Target Organization
OW-1	Capacity Building for Water demand management			○	○						○	○		○	○		○			○	○	○	●	●		High	4 cities
OW-2	Programme for Water Saving (improvement of awareness, usage of water saving device, regulation change, etc.)			○	○						○	○		○	○		○			○	○	○	●	●		High	4 cities
OW-3	Improvement Programme of Water, Sanitation and Hygiene awareness				○						○	○			○		○			○	○	○	●	●		High	4 cities
OW-4	Maintenance Programme of Waterworks Facility	○		○	○						○		○	○	○		○			○	○	○	●			Middle	4 cities
OW-5	Improvement of service (Continuity of service hours, etc.)	○		○							○											○				Low	
OW-6	Amelioration of raw water quality				○						○											○				Low	Refer to another section
OW-7	Amelioration of drinking water quality			○	○						○											○				Low	
OW-8	Optimization of water tariff structure				○						○	○									○	○				Low	
OW-9	Optimization of organization structure	○			○						○				○							○				Low	

Source: Project Team

(2) Action Plan and Implementation Schedule

The program, projects and activities except the priority of "Low" in **Table 2.1.9**, are formulated as concrete action plans or implementation schedules. (Refer to **Table 2.1.10**)

As for the fundamental action plan of the program, projects and activities, the following respects shall 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.

Development plans for each city are described in the next section.

In two cities, namely, Blantyre and Zomba of this master plan, the three scenarios for Blantyre and two scenarios for Zomba have been prepared in consideration of the past feasibility studies. However, the conclusive scenario of two cities as official plans could not be decided at the present stage, because no detailed study has been carried out yet. Notwithstanding, the Scenario 3 for Blantyre has water access rate of 100%, and the Scenario 2 for Zomba has a water demand plan by 2035 (extension from 2020 to 2035 in the Project) although the feasibility study for raw water sources have not been performed yet. Hence, the scenario (3 for Blantyre and 2 for Zomba) should be examined by conducting a feasibility study.

Table 2.1.10 Short, Middle and Long Term Action Plan and Implementation Schedule

Program	Projects / Activities	Short Term 2012-2020	Middle Term 2021-2025	Long Term 2026-2035	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)					●					◆		LWB	IDA	5,200	Study is ongoing. LWB Investment Plan
LW-2	Extension TWII (purification plant: +30,000 m³/d)						●				◆		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)				●							◆	LWB	EIB	5,100	Study is ongoing. LWB Investment Plan
LW-4	Extension TWII(2nd) (purification plant: +30,000 m³/d) and Technical Assistance						●				◆		LWB	(JICA)	9,700	LWB Investment Plan
LW-5	Catchment area conservation and rehabilitation									●		◆	LWB	(JICA)	0	LWB Investment Plan Technical cooperation
LW-6	Network improvement							●	●			◆	LWB	(WB)	200	LWB Investment Plan
LW-7	Full implementation GIS/Hydraulic Model									●	◆		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)				●	●	●	●			◆		LWB	(WB)	195,420	LWB Investment Plan
LW-9	Implementation telemetry system									●	◆		LWB	(WB)	300	LWB Investment Plan Technical cooperation
LW-10	Rehabilitation of TWII						●					◆	LWB	(WB)	4,000	LWB Investment Plan
LW-11	Network expansion							●	●		◆		LWB	(WB)	225,800	LWB Investment Plan
LW-12	Review of water demand study									●	◆		LWB	-	1,500	
LW-13	Phase 2, New water source Diamphwe dam including transports system (Dam+75,000 m³/d, TW+66000 m³/d)				●	●	●	●			◆		LWB	(WB)	66,640	LWB Investment Plan
Blantyre (BWB)		133,808	80,831	107,302											321,940	Scenario 2
BW-1	Network improvement							●	●			◆	BWB	(WB)	9,000	
BW-2	additional NRW reduction programme									●		◆	BWB	-	5,000	Technical cooperation (Dispatch of expert, Equipment provision, etc)
BW-3	Metering and Water leakage control									●		◆	BWB	-		
BW-4	Phase 1, New water source from Shire River including transports system (+39,000 m³/d)				●	●	●	●			◆		BWB	(WB)	91,970	
BW-5	Network expansion							●	●		◆		BWB	-	129,800	
BW-6	Poverty program (Kiosk and Toilet development)								●		◆		BWB	-	14,000	
BW-7	Phase 2, New water source from Shire River including transports system (+39,000 m³/d)				●	●	●	●			◆		BWB	(WB)	70,670	
BW-8	Review of water demand study									●	◆		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)				●	●	●	●			◆		NRWB	(WB)	72,140	
MW-2	Network improvement							●	●			◆	NRWB	-	1,800	
MW-3	Re-examination of water demand and raw water source study									●	◆		NRWB	-	1,000	
MW-4	Phase2, New water source Lichelemu dam inclusing transports system (+29,600 m³/d)				●	●	●	●			◆		NRWB	(WB)	73,790	
MW-5	Network expansion							●	●		◆		NRWB	-	80,800	
MW-6	NRW reduction programme									●		◆	NRWB	-	3,500	Technical cooperation
Zomba (SRWB)		5,353	5,703	11,543											22,600	Scenario 2 (- dam raising)
ZW-1	Expansion existing TW (18,200 to 30,000 m³/d)				●	●	●	●			◆		SRWB	(WB)	- (8,140)	Construction is ongoing.
ZW-2	Network improvement							●	●			◆	SRWB	-	3,600	
ZW-3	Feasibility study of water demand and new raw water source									●	◆		SRWB	-	1,500	
(ZW-4a1)	New water source dam including transports system (+17,100 m³/d)				●	●	●	●			◆		SRWB	-	42,000	(Scenario 1)
ZW-4a2	Raising of Mulunguzi dam and associated rehabilitation works (+6,100 m³/d)				●	●	●	●			◆		SRWB	-	10,200	Scenario 2a
(ZW-4b2)	Develop new groundwater borehole (+6,100 m³/d)				●	●	●	●			◆		SRWB	-	3,870	Scenario 2b
(ZW-5a1)	Network expansion							●	●		◆		SRWB	-	15,500	(Scenario 1)
ZW-5a2	Network expansion							●	●		◆		SRWB	-	7,300	Scenario 2a, 2b
Others		2,900	0	0											2,900	
OW-1	Capacity Building for Water demand management									●	◆		all WB	-	800	Technical cooperation
OW-2	Programme for Water Saving (improvement of awareness, usage of water saving device, regulation change, etc.)									●	◆		all WB	-	600	Technical cooperation
OW-3	Improvement Programme of Water, Sanitation and Hygiene awareness									●	◆		all WB	-	500	Technical cooperation
OW-4	Maintenance Programme of Waterworks Facility									●	◆		all WB	-	1,000	Technical cooperation

Implementation schedule (Time Frame; ■ = scheduled year):

Program	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
LW-1			■	■																				
LW-2			■	■																				
LW-3			■	■	■	■																		
LW-4				■	■																			
LW-5				■	■	■	■	■	■															
LW-6				■	■	■																		
LW-7						■																		
LW-8				■	■	■	■	■	■	■	■													
LW-9						■																		
LW-10								■	■	■														
LW-11							■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
LW-12								■	■															
LW-13															■	■	■							
BW-1				■	■	■	■	■																
BW-2					■	■	■																	
BW-3					■	■	■																	
BW-4					■	■	■	■	■															
BW-5							■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
BW-6									■	■	■	■												
BW-7													■	■	■	■	■							
BW-8											■	■												
MW-1				■	■	■	■																	
MW-2								■	■	■	■	■												
MW-3													■	■										
MW-4															■	■	■	■	■					
MW-5						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
MW-6								■	■	■														
ZW-1			■	■																				
ZW-2						■	■	■	■	■														
ZW-3				■	■																			
(ZW-4a1)						■	■	■	■	■														
ZW-4a2														■	■	■	■							
(ZW-4b2)																■	■							
(ZW-5a1)								■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
ZW-5a2								■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
OW-1							■	■																
OW-2						■	■	■																
OW-3							■	■																
OW-4							■	■																

Source: Project Team

(3) Emphasis on Severity of Project and its Components

Even though the feasibility studies and detailed design are implemented for the four cities, each plan has differences in the level of planning and project scales as shown in **Table 2.1.11**. In the studies, all projects for water supply are evaluated from many viewpoints and as a consequence optimistic plans are selected in each city. 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 2.1.11 Condition of Development of Water Supply Facilities for Four 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 2.1.12**.

Table 2.1.12 Rank of Severity for Project in City Level and Components

Priority of City level	Component	Projects / Activities	Evaluation Indicator						
			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, WB

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 compared with the other ones for Blantyre, Mzuzu and Zomba. The construction of all proposed facilities is recognized as essential works to satisfy the water demand in 2035, especially the construction of 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 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 year 2040. 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. Due to this situation, it can be seen that the maturity of water supply plan for Mzuzu City is lower level compared with those of Lilongwe and Blantyre. In addition, the number of served population of Mzuzu City ranks third among the four 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 the volume of those of Blantyre, Lilongwe and Mzuzu. The plan should be revised in terms of (i) per capita water consumption; and (ii) 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, Zomba City has the lowest number among the four cities.

2.1.7 Components of Urban Water Supply

(1) Development Plan for Lilongwe

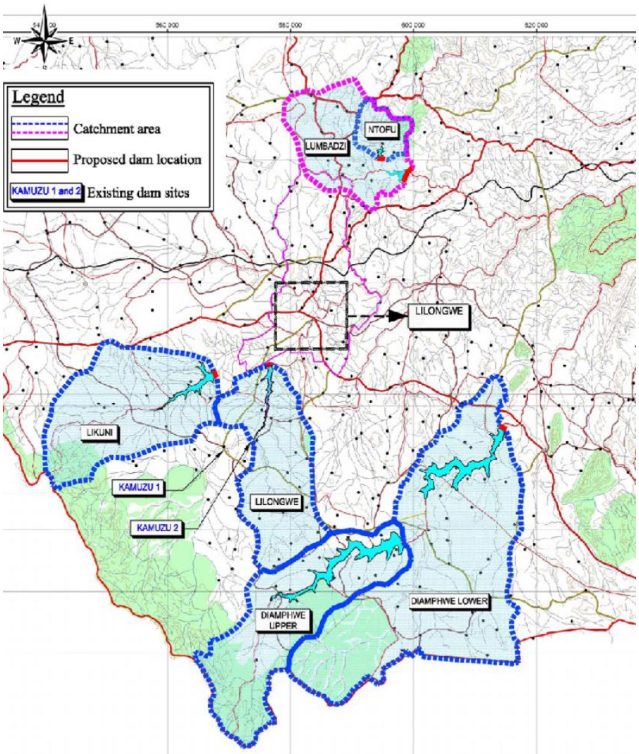
According to the "Feasibility Studies and Preliminary Design for Lilongwe's New Water Source, Sogreah, 2010" (hereinafter called as Sogreah Report), the recommended plan for Lilongwe by 2035 is as follows. (However, the development plan from the present to 2017 is partially changed by the “LWB future investment plan” with EIB and WB, hereinafter called as the “Investment Plan”.)

1) New Raw Water Source and Water Demand Assessment in Sogreah Report (LW-8, 11, 13)

In the water demand assessment of the Sogreah Report, the need for irrigation, fisheries and hydropower aside from water supply demand has been examined. As the feasible dam site, the following six sites have been examined from the standpoint of hydrology, geology, seismology, lithology, hydrogeology, construction material, environment, socio-economy and so on. Eventually, Diamphwe Upper and Lower Diamphwe River were selected as the suitable dam sites.

1. Dam on Lower Diamphwe/Linthipe River;
2. Dam on Upper Diamphwe River;
3. Dam on Lilongwe (Third) River;
4. Dam on Lumbadzi River;
5. Dam on Likuni River;
6. Dam on Ntofu River

Furthermore, the study on multipurpose use was conducted and the five options for Lower and Upper Diamphwe as shown in **Table 2.1.13** and **Figure 2.1.9**, were compared with regard to water supply, fisheries and irrigation. The Lower Diamphwe Dam of Option 3 is recommended as the optimal plan. The weighted final scores of the five options are shown in **Table 2.1.14**.



Source: Sogreah Report (2010)

Figure 2.1.9 Proposed Dam Sites with the Corresponding Catchment Areas

Table 2.1.13 Weighted Final Scores of the Five Options

Criteria	Weighting Factor	Options				
		1	2	3	4	5
		Diamphwe Upper: Drinking water supply + fisheries	Diamphwe Lower: Drinking water supply + fisheries	Diamphwe Lower: Drinking water supply + fisheries + irrigation	Diamphwe Lower: Drinking water supply + fisheries + Hydropower	Diamphwe Lower: Drinking water supply + fisheries + irrigation + hydropower
Environment						
Environmental and social impact	1.0	6.9	10.0	9.2	0.0	0.0
Finance						
Initial Capital Costs	1.0	10.0	7.6	6.0	0.8	0.0
LWB financial performance	1.0	10.0	0.0	3.9	9.5	9.5
GoM cash flows	1.0	0.8	0.0	2.7	9.7	10.0
Economy						
Cost Benefit Analysis	1.0	0.7	0.0	10.0	0.3	6.4
Security						
Power source	0.5	5.0	2.5	2.5	2.5	2.5
Water supply services						
Supply along pipeline route	0.5	4.3	5.0	5.0	5.0	5.0
Total		37.7	25.1	39.3	27.8	33.4
Total (rounded)		38	25	39	28	33

Source: Sogreah Report (2010)

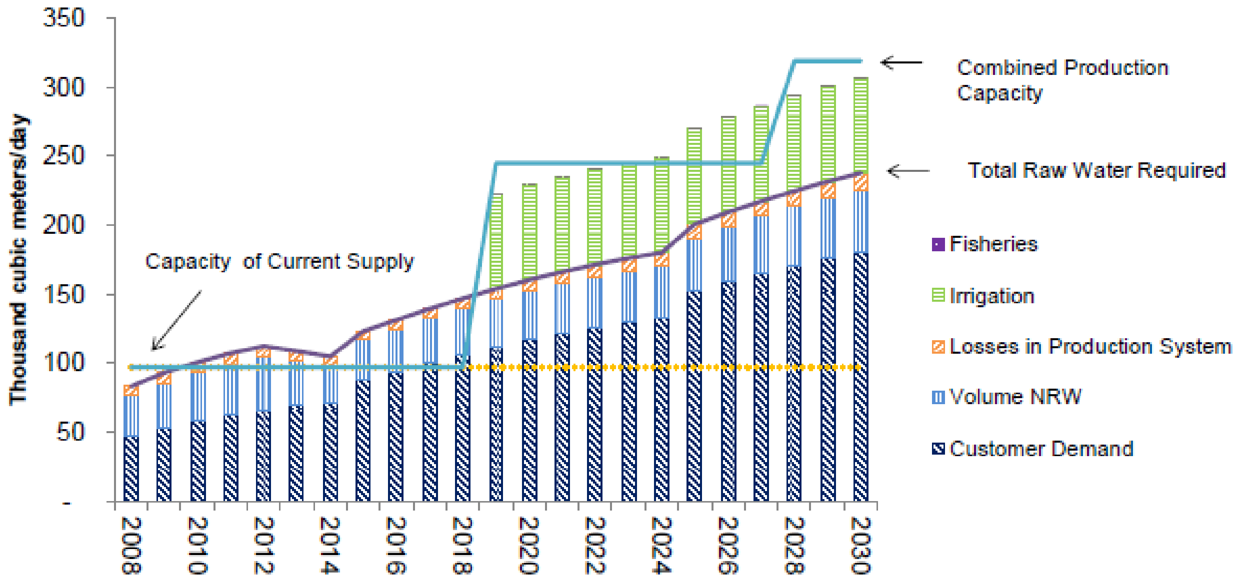
As a conclusion, in order to meet the water demand for multipurpose use, the following average resource capacities are required.

Table 2.1.14 Future Water Demand as a Multi-purpose Use for Lilongwe

	Unit	2015	2025	2035
Lilongwe Water Supply				
Lilongwe City	m^3/d	119,410	196,103	280,295
Surrounded Areas (*)	m^3/d	3,085	4,017	4,939
Bunda College	m^3/d	716	831	973
Total (Raw Water)	m^3/d	123,211	200,951	286,206
Irrigation				
Depending on the Site	m^3/d	From 1,900 to 68,900	From 1,900 to 68,900	From 1,900 to 68,900
Fisheries				
	m^3/d	300	300	300
Total Required Average Resource Capacity				
Total	m^3/d	**125,411 to 192,4115,406**	**203,151 to 270,151**	**288,406 to 355,406**

Source: Sogreah Report (2010)

The water needs in the Lilongwe supply area and the current supply capacity are shown in **Figure 2.1.10.**



Source: Malawi Water Sector Investment Plan, Vol. I, World Bank, April 2012

Figure 2.1.10 Lilongwe's Water Needs and Current Capacity

2) Summary of Recommended Planning Facilities in Sogreah Report (LW-8, 11, 13)

Although the development of a new raw water sources is planned for multi-purpose use, including irrigation and fisheries as shown in **Figure 2.1.10**, the development plan for water supply only shows as follows to clarify the condition of urban water supply.

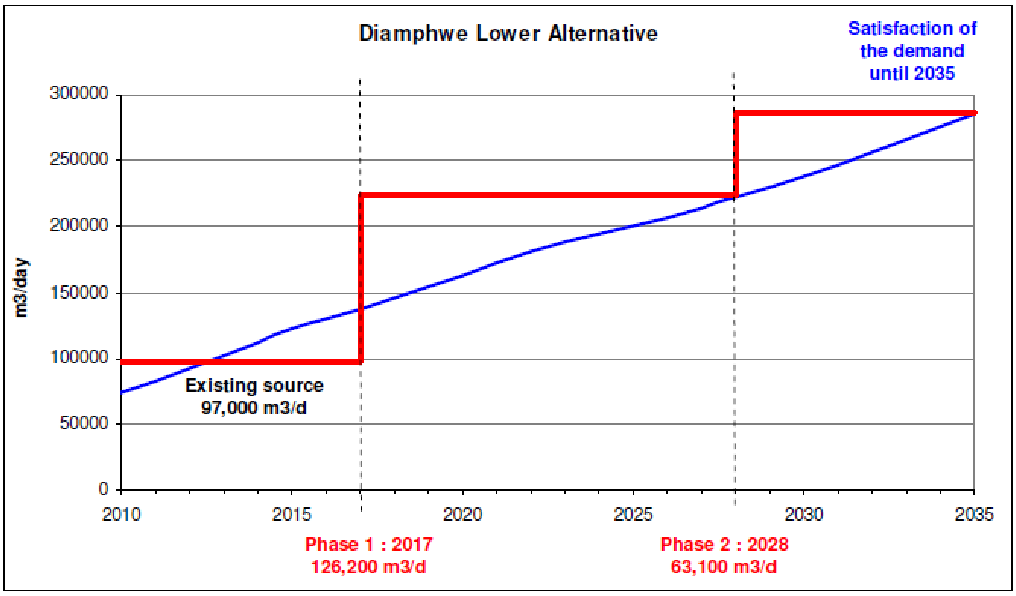
(i) Dam Capacity for Water Supply Purpose

Table 2.1.15 Future Water Demand as a Multipurpose Use for Lilongwe

Diamphe LowerVolumes (m3/day)	Average Demand		Peak Demand	
	Phase 1	Phase 2	Phase 1	Phase 2
Abstraction capacity	126,200	189,300	147,650	221,480
Treatment capacity	126,200	189,300	147,650	221,480
Production & Transfer capacity	119,890	179,840	140,270	210,410

Source: Sogreah Report (2010)

In the original plan, the capacity of the facility is proposed to be 2/3 (of the final capacity) in Phase 1 and 1/3 in Phase 2, as shown in **Figure 2.1.11**.



Source: Sogreah Report (2010)

Figure 2.1.11 Lower Diamphwe Phasing: Average Demand and Production Capacities

(ii) Drinking Water Treatment Plant

Location

Site close to Lower Diamphwe Dam (There is no possibility to convey raw water by gravity from the dam in the future.)

Capacity

The total capacity required of the new WTP is:

- Average 190,000 m^3/d
- Maximum 221,480 m^3/d
- The phasing being:
- Phase 1: 147,650 m^3/d
- Phase 2: 73,830 m^3/d (i.e., 221,000 m^3/d in total)

Treated Water Tanks

Water tanks shall be constructed at the outlet of the WTP in order to provide flexibility in the operation of the plant in case of operational problems whether on the transmission system or at the plant itself. The storage volume required to facilitate the operation is estimated to be around 2 hours of production (at daily average flow). Therefore, the proposed treated water tanks are as follows:

- 10,000 m^3 in Phase 1
- 5,000 m^3 in Phase 2 (i.e., 15,000 m^3 in total).

(iii) Water Transmission System from the Dam to Lilongwe City

The characteristics of the raw water pumping station from the dam to the WTP, and the characteristics of the treated water pumping station from the WTP to the balancing tank are shown below. The raw water pumping station is located near the Lower Diamphwe Dam, and the treated water pumping station is located in the new water treatment plant (TW) site, as shown in **Figure 2.1.15.**

Raw Water Pumping Station Characteristics

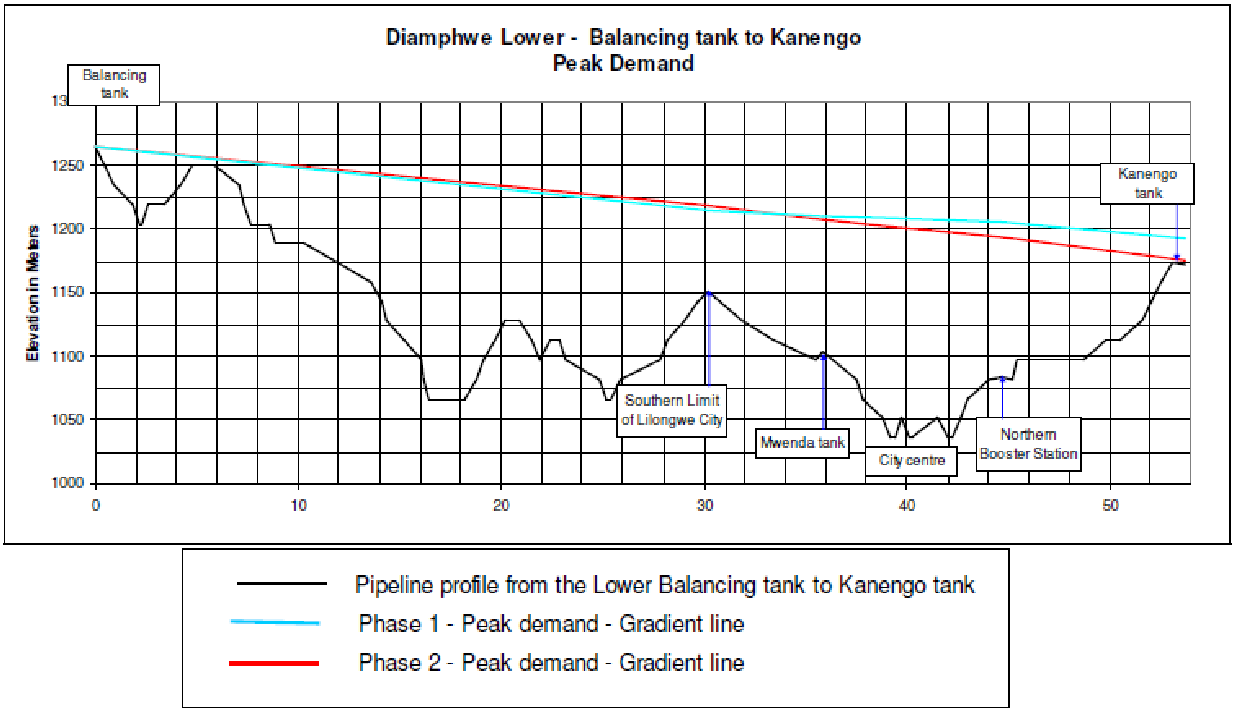
Average water level in the reservoir	1173 m
WTP ground level	1195 m
WTP water inlet level	1198 m
Treated water tank bottom level	1190 m
Static head	25 m
Peak flow	221,480 m3/d = 2.56 m3/s
Pipeline length	2500 m
Pipeline diameter phase 1	DN 1000 mm
Pipeline diameter phase 2	DN 800 mm
Headlosses phase 1	7.7 m
Headlosses phase 2	9.0 m
Average net head (phase 2)	34 m
Efficiency	76 %
Required pumping power	1145 kW

Treated Water Pumping Station Characteristics

Average suction level	1192 m
Balancing tank elevation	1265 m
Static head	73 m
Peak flow	210,900 m3/d = 2.44 m3/s
Pipeline length	1950 m
Pipeline diameter phase 1	DN 1000 mm
Pipeline diameter phase 2	DN 800 mm
Headlosses phase 1	6.0 m
Headlosses phase 2	7.0 m
Average net head	80 m
Efficiency	76 %
Required pumping power	2568 kW

Water Gradient Line (Peak Demand)

The hydraulic profile for the supply from balancing-tank of treated water to Kanengo tanks by gravity is shown in **Figure 2.1.12**. (The locations of balancing tank and Kanengo tank are shown in **Figure 2.1.14**. The pipe flow from balancing-tank of treated water to Kanengo tank is the gravity flow pipe, and the transmission pipe of the northern area from Kanengo tank is the pressurized pipe. The hydraulic design of transmission pipeline between the Diamphwe balancing tank and the Lilongwe cities network shall be designed by ensuring the necessary water-head until the Kanengo tank.)



Source: Sogreah Report (2010)

Figure 2.1.12 Hydraulic Profile of Lower (Treated Water) Balancing Tank to Kanengo Tank

3) Summary of Recommended Planning Facilities in the Project (LW-8, 11, 13)

The above-mentioned "descriptions and design capacities for each facility" has been studied in "Sogreah Report (2010)". However, the development plan by 2017 have been re-examined by "LWB future investment plan (2013)" after the study of "Sogreah Report (2010)". Since there is a difference of the development abstraction and treatment water quantity between "Sogreah (2010)" and "Investment Plan (2013)", as shown in , the capacities of Diamphwe Dam and others will changed in future study. The development plan for the Project is supposed to be the following way and concepts:

- The facility capacity by 2017 is based on the "future investment plan", and the facility capacity of 2018-2035 is based on the finite difference of demand of "Sogreah Report (2010)".
- The difference of the abstraction and production capacity by 2017 is adjusted by 2035. (See **Figure 2.1.2** and **Figure 2.1.13** .)
- The discrepancies of the capacity and installation location between "the raw water sources" and "the water treatment plants" assume that it is solved by installing the transmission pipe and pump from Diamphwe Dam to existing TW1 and 2. (See **Figure 2.1.14**)
- Basic concepts for each facility design are depending on design ways of "Sogreah Report".
- The operation start year of new Diamphwe Dam is 2021 for Phase 1 and 2029 for Phase 2.

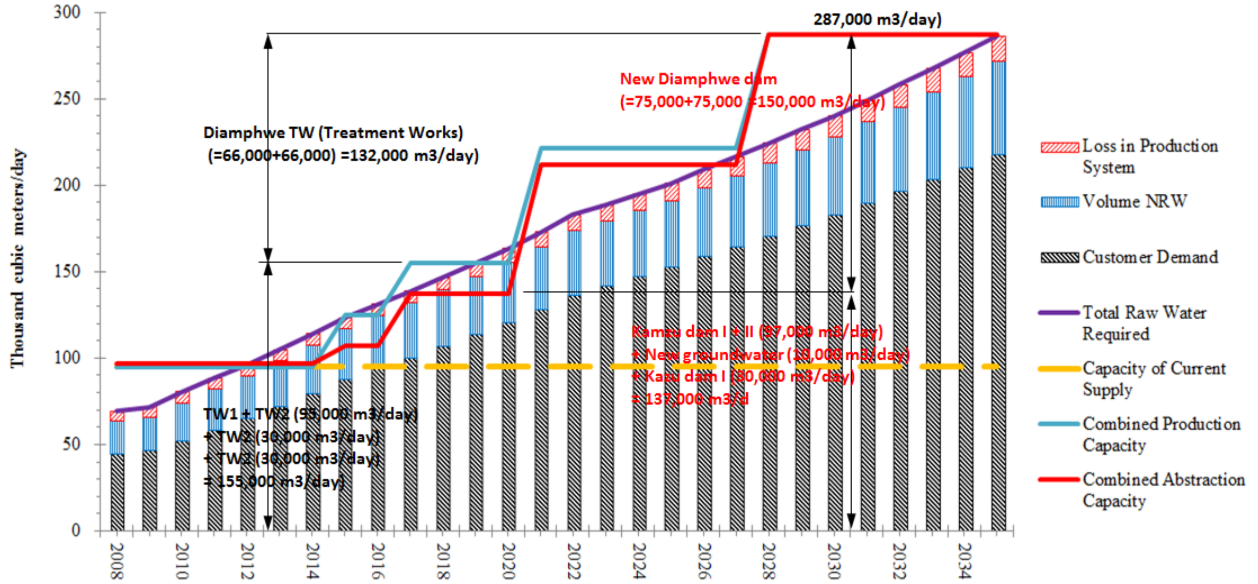
The facilities in the Project were re-examined by above-mentioned way, and the scale of the future facility are supposed as shown in **Figure 2.1.14** and **Figure 2.1.13** to **Figure 2.1.16**. However, the above assumption will be changed by results of new feasibility study by EIB and WB.

Table 2.1.16 Lower Diamphwe and Other Facilities in the Project

Abstraction, Treatment, Transfer Capacity		Average Demand (in m^3/day)						Daily Peak Demand (in m3/day)					
		Exisiting	Phase 1 Borehole	Phase 2 Rainsing Kamzu1	Phase 3 Diamphe Phase1	Phase 4 Diamphe Phase2	Total	Exisiting	Phase 1 Borehole	Phase 2 Rainsing Kamzu1	Phase 3 Diamphe Phase1	Phase 4 Diamphe Phase2	Total
Abstraction Capacity	All LWB	97,000	107,000	137,000	212,000	287,000	287,000	113,490	125,190	160,290	248,040	335,790	335,790
Additional Abstraction Capacity	Kamzu 1+2 + New Borehole	97,000	10,000	30,000	-	-	137,000	113,490	11,700	35,100	-	-	160,290
	Diamphe Dam (Dam)	-	-	-	75,000	75,000	150,000	-	-	-	87,750	87,750	175,500
Treatment Capacity	All LWB	95,000	125,000	155,000	221,000	287,000	287,000	111,150	146,250	181,350	258,570	335,790	335,790
Additional Treatment Plant Capacity	TW1+TW2	95,000	30,000	30,000	-	-	155,000	111,150	35,100	35,100	-	-	181,350
	New TW	-	-	-	66,000	66,000	132,000	-	-	-	77,220	77,220	154,440
Production & Transfer Capacty	All LWB	90,250	118,750	147,250	209,950	272,650	272,650	105,590	138,940	172,280	245,640	319,000	319,000
Raw Water Pumping Station 1 (to New TW)	Dam - New TW, RP2	-	-	-	66,000	66,000	132,000	-	-	-	77,220	77,220	154,440
	Raw water Pumping Station (RP1)	-	-	-	(0.76 m3/s)	(0.76 m3/s)	(1.53 m3/s)	-	-	-	(2.84 m3/s)	(3.69 m3/s)	(3.69 m3/s)
	Transmission Pipe	-	-	-	(0.76 m3/s)	(0.76 m3/s)	(1.53 m3/s)	ϕ 900mm pipe*2			(2.84 m3/s)	(3.69 m3/s)	(3.69 m3/s)
Raw Water Pumping Station 2 (to RWT)	Dam - RWT	-	-	-	9,000	9,000	18,000	-	-	-	10,530	10,530	21,060
	Raw water Pumping Station (RP2)	-	-	-	(0.10 m3/s)	(0.10 m3/s)	(0.21 m3/s)	-	-	-	(0.12 m3/s)	(0.12 m3/s)	(0.24 m3/s)
	Transmission Pipe	-	-	-	(0.10 m3/s)	(0.10 m3/s)	(0.21 m3/s)	ϕ 400mm pipe*2			(0.12 m3/s)	(0.12 m3/s)	(0.24 m3/s)
New Treatment Works (New TW) (SP1: New TW - Kanengo Reservoir)	New TW	-	-	-	66,000	66,000	132,000	-	-	-	77,220	77,220	154,440
	Water Tank	-	-	-	(5,500 m3)	(5,500 m3)	(11,000 m3)	-	-	-	-	-	-
	Treated water Pumping Station (SP1)	-	-	-	(0.76 m3/s)	(0.76 m3/s)	(1.53 m3/s)	-	-	-	(0.89 m3/s)	(0.89 m3/s)	(1.79 m3/s)
	Transmission Pipe	-	-	-	(0.76 m3/s)	(0.76 m3/s)	(1.53 m3/s)	ϕ 900mm pipe*2			(0.89 m3/s)	(0.89 m3/s)	(1.79 m3/s)
	Balancing Tank	-	-	-	(2,750 m3)	(2,750 m3)	(5,500 m3)	-	-	-	-	-	-
	Transmission Pipe	-	-	-	(0.76 m3/s)	(0.76 m3/s)	(1.53 m3/s)	ϕ 900mm pipe*2			(0.89 m3/s)	(0.89 m3/s)	(1.79 m3/s)
Raw Water Tank	Balancing Tank	-	-	-	(375 m3)	(375 m3)	(750 m3)	-	-	-	-	-	-
	Transmission Pipe	-	-	-	(0.10 m3/s)	(0.10 m3/s)	(0.21 m3/s)	ϕ 400mm pipe*2			(0.12 m3/s)	(0.12 m3/s)	(0.24 m3/s)

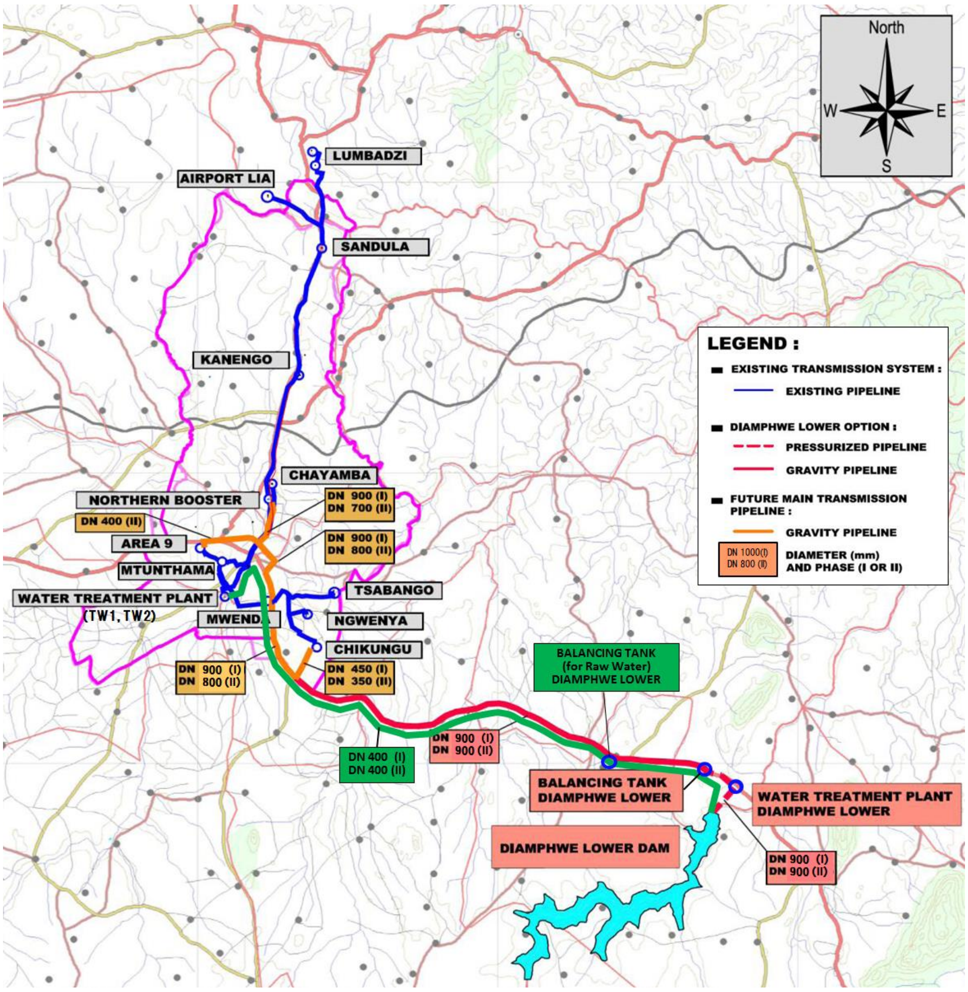
Note. [shaded] is proposed by Project Team. Other values are WSIP report.

Source: Project Team, WSIP report (2012)



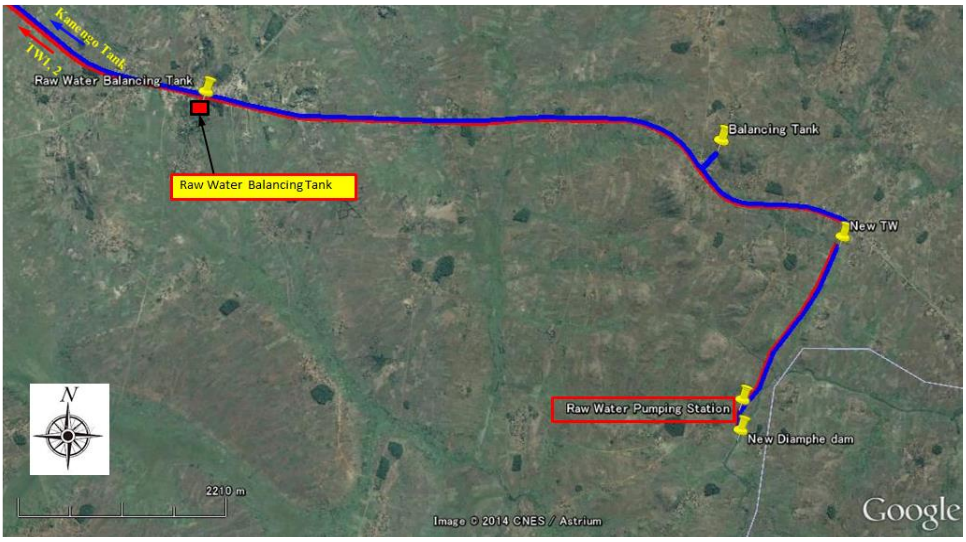
Note: The development plan of abstraction / production by 2017 is Investment Plan (2013), and 2018 to 2035 is Project Team.
Source: Project Team, based on Sogreah Report (2010) and Investment Plan (2013)

Figure 2.1.13 Supposed Water Needs and Capacities for LWB



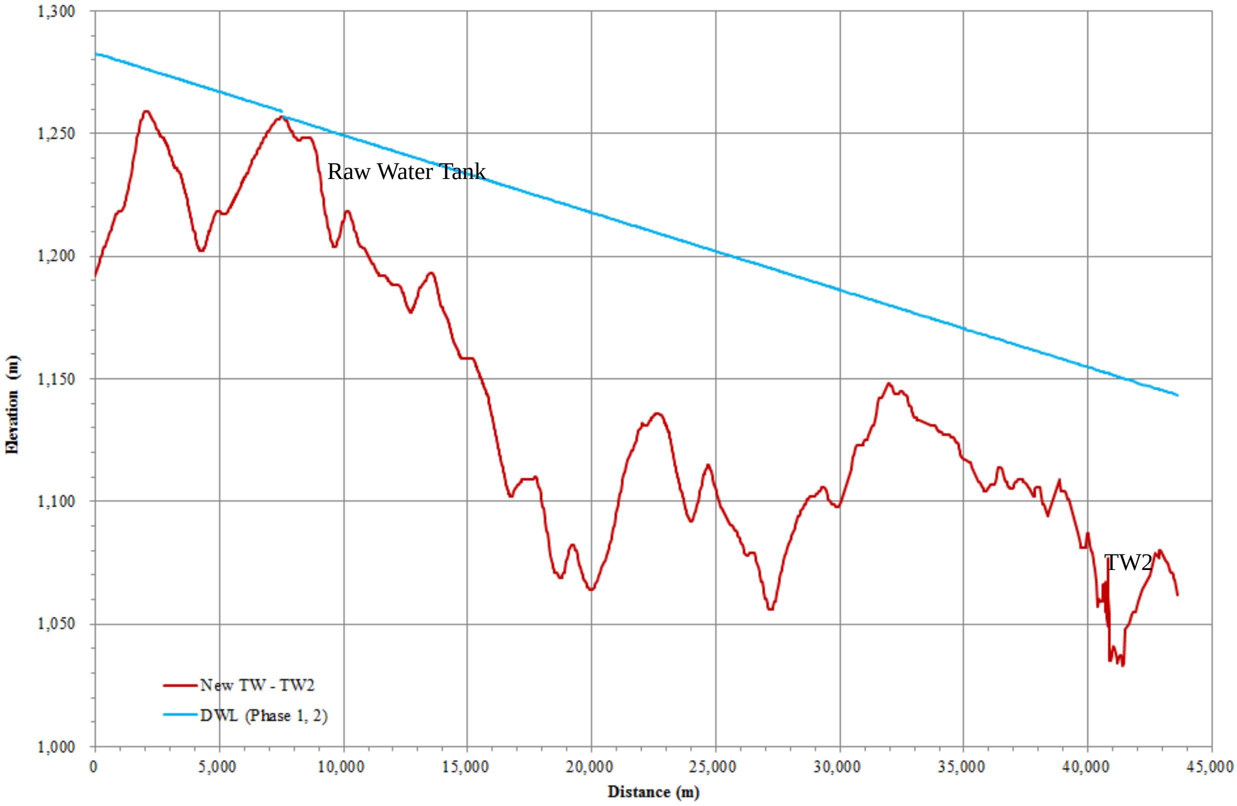
Source: Sogreah Report (2010), Project Team

Figure 2.1.14 New Main Network for Lilongwe Waterworks Facility



Source: Project Team, Google Earth

Figure 2.1.15 Method of Examination for Facilities of Lower Diamphwe – Balancing Tank



Source: Project Team (Topographic data uses GPS data of site survey and Google data.)

Figure 2.1.16 Hydraulic Profile of Raw Water Balancing Tank to TW 2

4) Catchment Area Conservation and Rehabilitation (LW-5)

The raw water of LWB is supplied from Lilongwe River which originates from the Dzalanyama Forest Reserve. The Forest Reserve has been gazetted as a protected area primarily for catchment protection, inter alia providing all the water of Lilongwe City through the Kamuzu I and Kamuzu II dams; and biodiversity conservation having a variety of flora and fauna, including endemic bird species.

The current rate of deforestation and forest degradation in and around Dzalanyama Forest Reserve has potential devastating effects on water quality and quantity. Therefore, the technical cooperation shall be augmented furthering the implementation of the forest policy and legal framework, because it promotes the conservation and rehabilitation for forest reserve of Lilongwe watershed.

5) Other Development Plans

The programs "LW-1" - "LW-4", "LW-6" - "LW-7" and "LW-9" - "LW-10" have been formulated with reference to "LWB future investment plan" by EIB and WB. The LW-12 shall be re-studied for the future water demand in consideration of the further social needs and changes (population, standard of living).

The development plans of the above-mentioned LW-1 to 13 are summarized in **Table 2.1.20** and **Table 2.1.21**.

(2) Development Plan for Blantyre

According to the “Consultancy Services for Feasibility Studies and Preliminary Design for Blantyre’s New Raw Water Source and Other Purposes, Sogreah, 2010” (hereinafter called Sogreah Report), the recommended plan for Blantyre is as follows. However, the present development plan is changed from the Mombezi Dam of the recommendation of "Sogreah Report" to the Shire River near Walker's Ferry, by "Malawi Water Sector Investment Plan (2012, WSIP)" of WB. In addition, the newest results of the BWB's NRW reduction program by EIB has been taken into consideration, and the value of future demand forecast has been changed and adopted it by WSIP of WB. (Other parameters including population have not changed.) In the Project, the case of the water demand of original Sogreah Report is designated as "Scenario 1", the case of the decreased water demand by NRW program is designated as "Scenario 2", and the case which mixed "the increase for 100% of access water rate" and "the decrease by NRW program" is designated as "Scenario 3". The development plan in the Project adopts "Scenario 2", because there is the technical adequacy (for the setting of water tariff and energy cost, the intake capacity from Shire River during dry season, the investment effect, etc.) from the recommendation by WSIP of WB. However, its scenario shall be re-examined by performing a future water demand study in consideration of the social needs and changes furthermore.

1) New Raw Water Source and Water Demand Assessment (BW-4, 5, 7)

In the water demand assessment of the Sogreah Report, the needs of irrigation, fisheries and hydropower besides water supply demand have been examined. As feasible dam site, the following 16 sites were examined from the standpoint of hydrology, geology, seismology, lithology, hydrogeology, construction material, environment, socio- economy, etc.:

1. Walkers Ferry expansion;
2. Matope Shire River Intake;
3. Namadzi River Intake;
4. Mulanje Mountain Rivers (Lichenya, Likhubula, Thuchila, Phalombe, Ruo and Muloza) Intakes;
5. Dam on Mombezi River;
6. Dam at Magomero on Namadzi River;
7. Dam at Namadzi on Namadzi River;
8. Dam on Nansadi River;
9. Dam on Lower Domasi River;
10. Dam on Nswadzi River;
11. Dam on Upper Domasi River;
12. Dam on Ruo River;
13. Dam on Kikhubula River;
14. Dam on Tuchila River;
15. Dam on Lirangwe River; and
16. Dam on Lichenya River;

As a result, the following combinations are selected as suitable dam and intake sites:

- Shire River at Walker's Ferry (augmentation of existing scheme);
- Shire River at Matope;
- Mombezi + Magomero Dams;
- Mombezi Dam + Namadzi River Intake (by pumping);
- Mombezi Dam + Mulanje River Intake (by gravity);
- Mombezi + Lirangwe Dams; and
- Mombezi + Magomero + Lirangwe Dams.

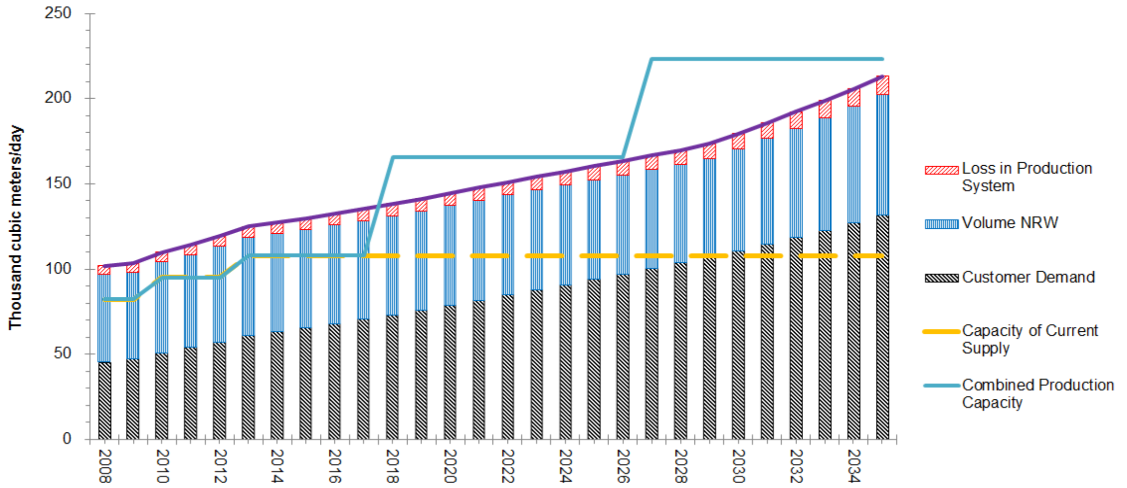
Furthermore, although the study for multipurpose use has been conducted, there was no superiority of multipurpose use. The following seven options were finally compared. Eventually, the Mombezi–Makuwa option (Mombezi Dam as Stage 1) was recommended as the optimal plan. The weighted final scores of the 7 options are shown in **Table 2.1.17**. However, after that, as a result of consultation with the World Bank, GoM and BWB, the optimal plan was changed to the Walker's Ferry option with excellent environmental and economic efficiency.

Table 2.1.17 Weighted Final Scores of Seven Options

Scheme	Environment	Economy	Security	Multi-purposeness	Weighted Score	Ranking
Walkers Ferry	10.0	10.0	7.0	5.6	8.3	3
Matope	8.6	8.8	8.3	5.6	8.1	6
Mombezi Magomero	3.6	8.0	10.0	10.0	8.3	3
Mombezi Makuwa	5.7	8.6	9.7	10.0	8.7	1
Mombezi Mulanje	5.0	8.3	10.0	10.0	8.6	2
Mombezi Lilangwe	2.9	8.0	8.3	10.0	7.6	7
Mombezi-Magomero -Lilongwe	2.9	9.7	8.6	10.0	8.3	3
Weighting	1	2	2	1		

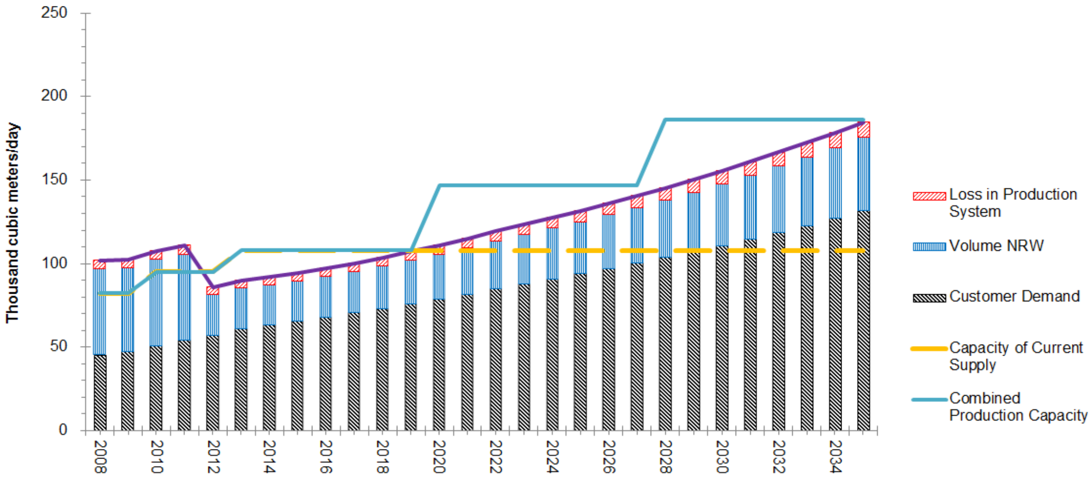
Source: Sogreah report (2010)

As a conclusion, in order to meet the water demand, the average resource capacities if Scenario 1 of "Sogreah Report (2010)" as shown in **Figure 2.1.17** are required. In addition, the average resource capacities of Scenario 2 which is based on "WSIP (2012)" is shown in **Figure 2.1.18**, and the average resource capacities of Scenario 3 which is based on "100% of access rate" and "NRW reduction effect of WSIP" is shown in **Figure 2.1.19**.



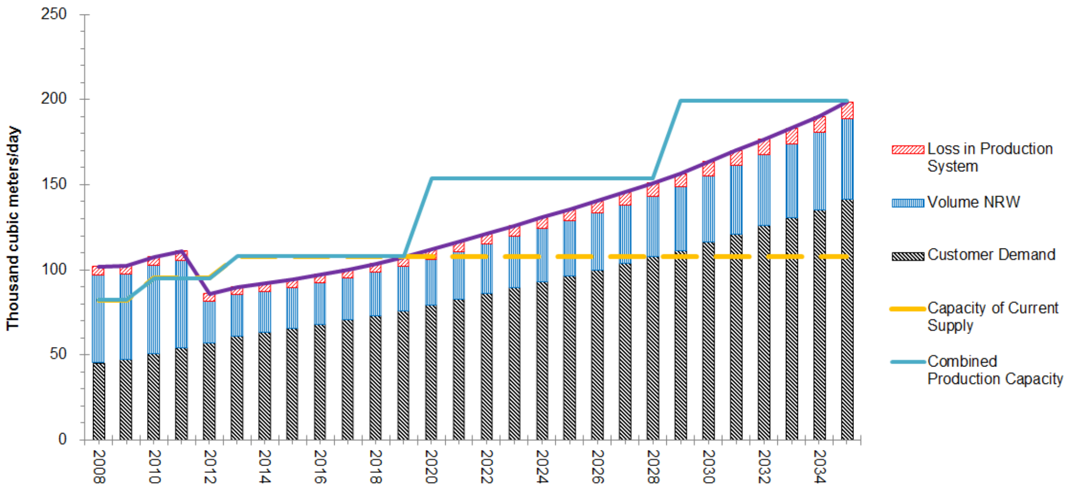
Source: Sogreah Report (2010)

Figure 2.1.17 Blantyre's Water Needs and Current Capacity (Scenario 1)



Source: Malawi Water Sector Investment Plan, Vol. I, The World Bank, April 2012

Figure 2.1.18 Blantyre's Water Needs and Current Capacity (Scenario 2)



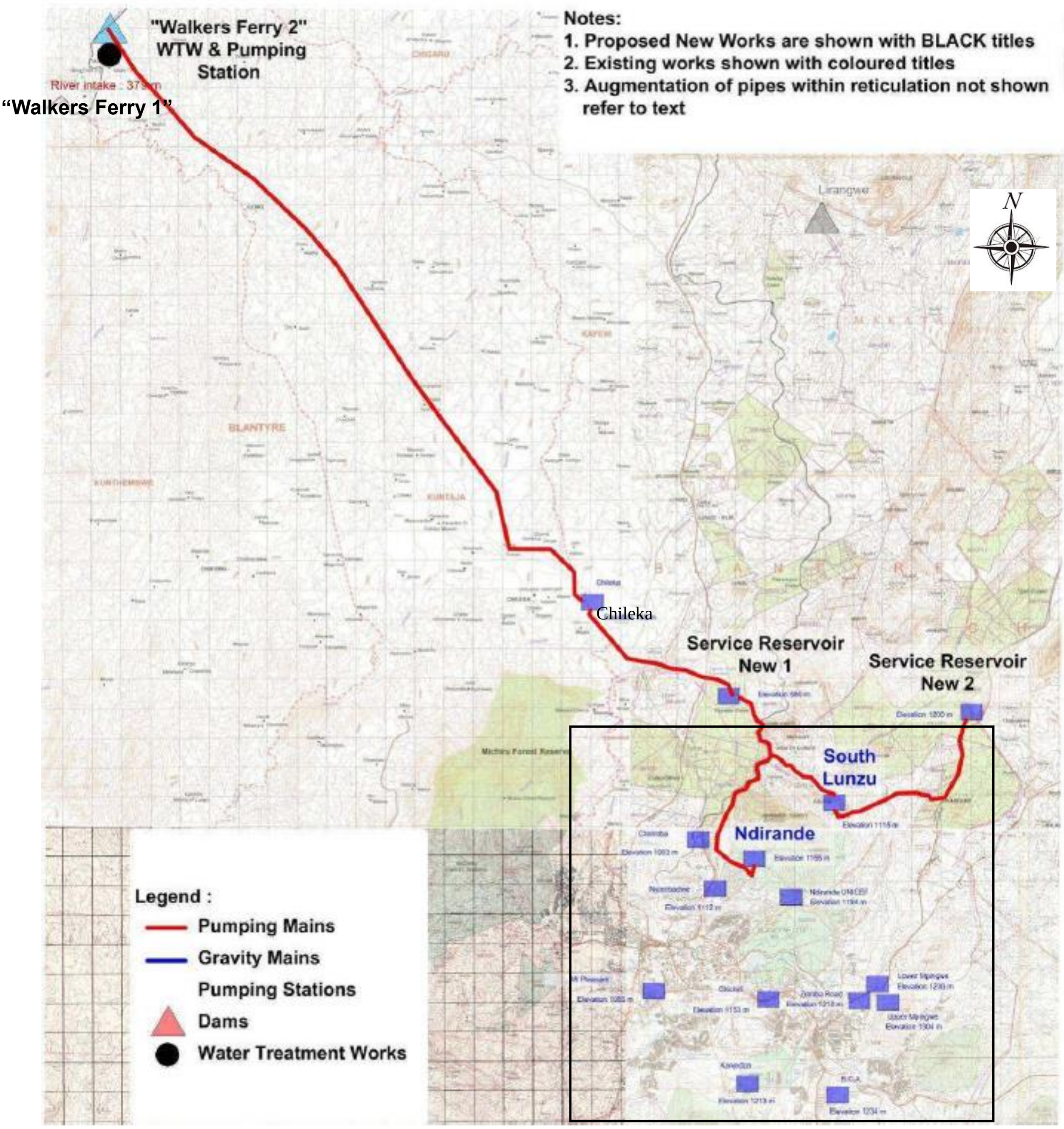
Source: Project Team based on Malawi Water Sector Invest

Figure 2.1.19 Blantyre's Water Needs and Current Capacity (Scenario 3)

2) Summary of Recommended Planning Facilities (BW-4, 5, 7)

(i) General Arrangement

The scheme considers a new water intake and Water Treatment Works (WTW) at Walker's Ferry as shown in **Figure 2.1.20**. Raw water is abstracted from the Shire River by pumping to a new WTW being located near to the existing one. After treatment the potable water is pumped to the existing Chileka service reservoir, and then to the proposed service reservoir NEW1, sited at elevation of 880m from where it is further distributed by pumping to South Lunzu and Ndirande service reservoirs, then from South Lunzu to the other new service reservoir, NEW 2.



Source: Sogreah Report (2010)

See **Figure 2.1.22**

Figure 2.1.20 Walker's Ferry Scheme General Arrangement

(ii) Intake Works

Walker's Ferry WTW could be augmented reasonably and easily since there is sufficient water in the Shire River and there is land available to the northeast of the existing plant for the expansion.

There is, however, the siltation issue to be addressed. Currently siltation occurs around the intake and has to be dredged to maintain flow to the raw water pumps. The situation is exacerbated when ESCOM lowers the water level behind their barrage which could lead to the water bypassing the intake point.

Several options were considered in the volume of the BKS report, entitled Walker's Ferry Silt Exclusion, April 2002. The recommendation was for a new intake 4.3km upstream of the current intake. (BKS report is "NWDP, BWB Engineering Studies, Final Report, BKS Global Ltd, September 2002".)

(iii) Water Treatment Works

Location

The location of the new treatment plant is proposed adjacent to the existing plant to maximize the use of common facilities such as chemical storage, access roads, control rooms, etc.

Capacity

The capacity of each stage will be half the additional requirement to meet the 2035 peak demand (for the medium demand scenario) by using the planning concept of the "Sogreah Report", i.e., 57,500 m^3/d (Scenario 1), 39,000 m^3/d (Scenario 2), and 45,500 m^3/d (Scenario 3).

Clear Water Tank and High Lift Pump Station

A new clear water tank (CWT) is proposed to be constructed at the outlet of the WTP augmentation in order to provide flexibility in the operation of the plant and in the clear water pumping system in case of operational problems respectively in the treated water transmission system or at the plant. The storage volume of 4 hours of production (at daily peak flow) is necessary to make the operation easier and allows for the contact time for chlorine dosing. Therefore, the proposed treated water tanks are:

- Scenario 1

10,500 m^3 for stage 1; and

10,500 m^3 for stage 2 (i.e., 21,000 m^3 in total).

- Scenario 2

7,200 m^3 for stage 1; and

7,200 m^3 for stage 2 (i.e., 14,400 m^3 in total).

- Scenario 3

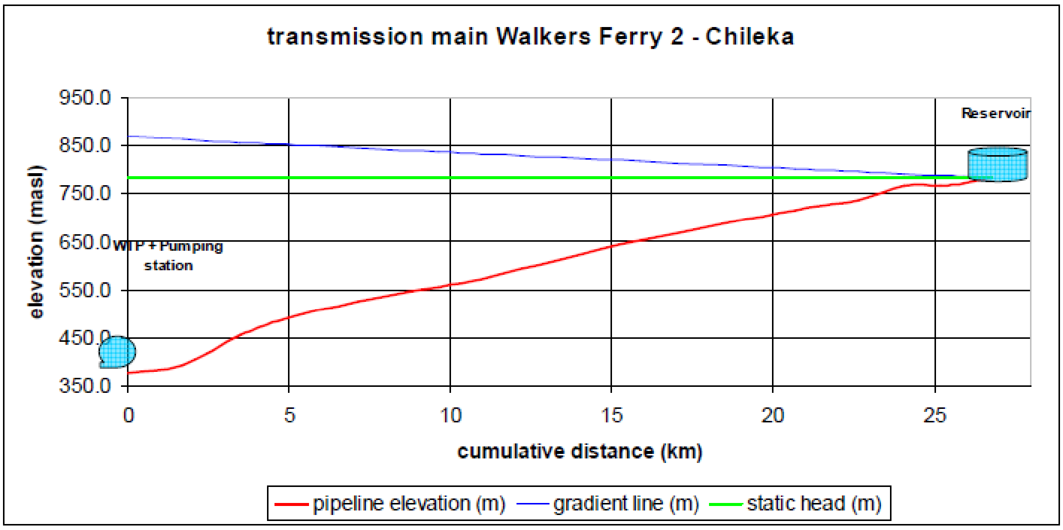
8,400 m^3 for stage 1; and

8,400 m^3 for stage 2 (i.e., 16,800 m^3 in total).

(iv) Water Transmission System from the Dam to Blantyre City

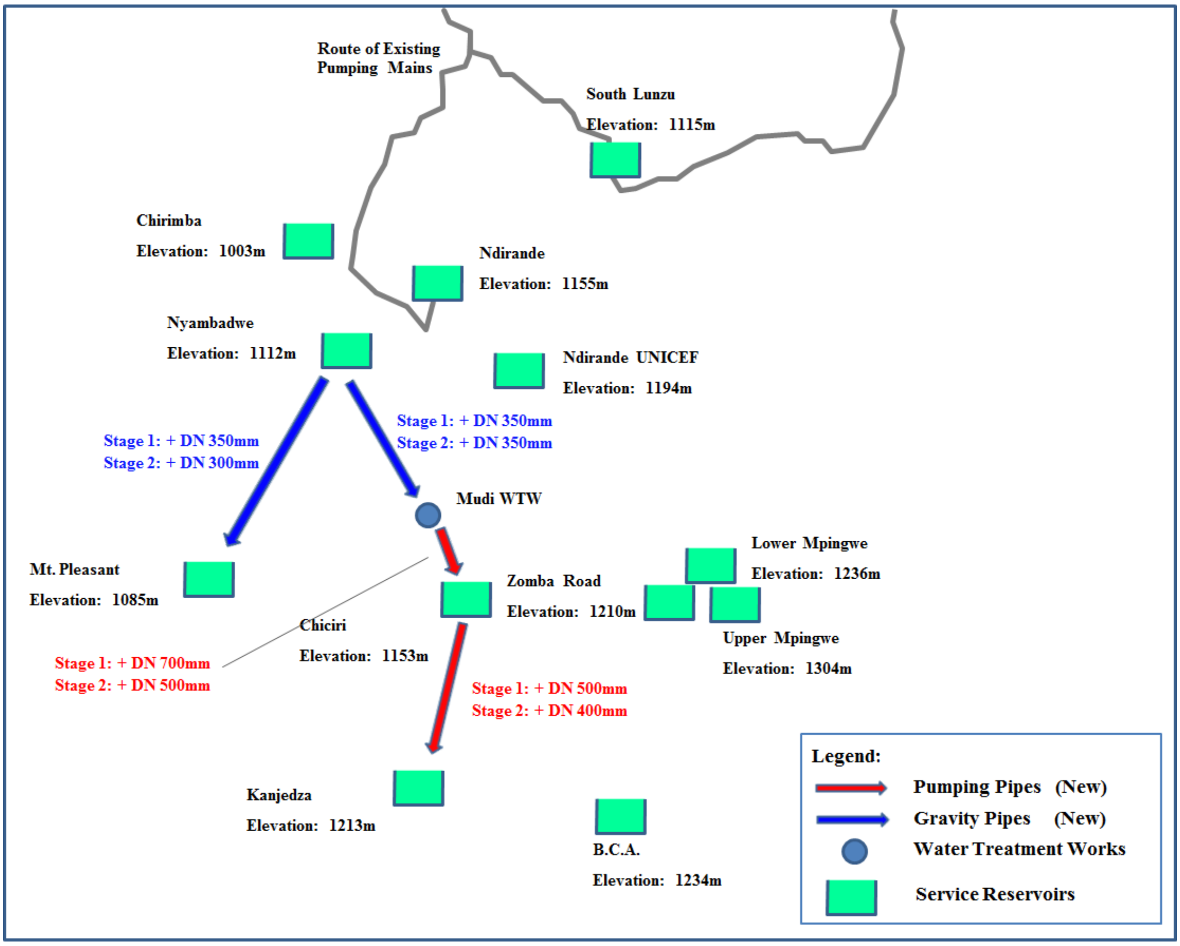
The hydraulic profile for the main transmission pipeline from the Walkers Ferry to Chileka Tank is shown in **Figure 2.1.21**.

The area squared off in **Figure 2.1.20** is magnified in **Figure 2.1.22**. Some pipelines as shown in **Figure 2.1.22** within the reticulation between the service reservoirs are also proposed for augmentation to meet the future distribution demands in the "Sogreah Report".



Source: Sogreah Report (2010)

Figure 2.1.21 Walker's Ferry 2 Scheme - Transmission Main to Chileka



Source: Sogreah Report (2010)

Figure 2.1.22 Reticulation Network Augmentation (Proposed Transmission Pipes)

3) Other Development Plans

The BW-1 is the improvement work for its water supply network. The "NRW reduction program" of

BW-2 and “Metering and Water leakage control” of BW-3 shall be studied for the NRW reduction and financial soundness furthermore. The “Kiosk and Toilet development (to the peri-urban area)” of BW-6 is recommended as a poverty program. The BW-8 shall be studied for the future water demand and the achievement of 100% of access rate. The development plans of above-mentioned BW-1 to 8 are summarized in **Table 2.1.20** and **Figure 2.1.21**.

(3) Development Plan for Mzuzu (and Ekwendeni)

According to the “Feasibility Studies and Preliminary Design of Multi-Purpose Water Source Development for Mzuzu & Mzimba and Surrounds, Sogreah, 2010” (hereinafter called as Sogreah Report), the recommended plan for future Mzuzu is as follows:

1) New Raw Water Source and Water Demand Assessment (MW-1, 4, 5)

Further to the review of the recommendations of previous studies and a detailed examination of the maps covering the area, several potential sites for the construction of a dam were selected for further analysis (see **Figure 2.1.23**). They are as follows (designated by river names):

Lambilambi, Lichelemu, Lwafwa, Rumphi, Lusangazi, and Kafurufuru. (All the sites except the Lusangazi are located to the southwest of Mzuzu, mainly in the South Vyphia Forest.)

In the above dam sites, the inflow to Rumphi dam site is too small. Therefore, the above dam sites except Rumphi were studied as new raw water source sites. The outputs from the technical, economic, financial and environmental studies were converted into marks given to the different alternatives. The results are summarized in **Table 2.1.21**. (From the conclusions of reservoirs simulations, two dams have to be constructed to meet the long term water demand, except for alternative-1 of Lichelemu. The first dam construction scheme is Stage 1, and the second dam scheme is called as Stage 2.) Consequently, Lambilambi Dam as Stage 1 has been recommended as the optimal plan. In Stage 2, a dam on Lichelemu River will be recommended to meet Mzuzu water demand beyond year 2040.

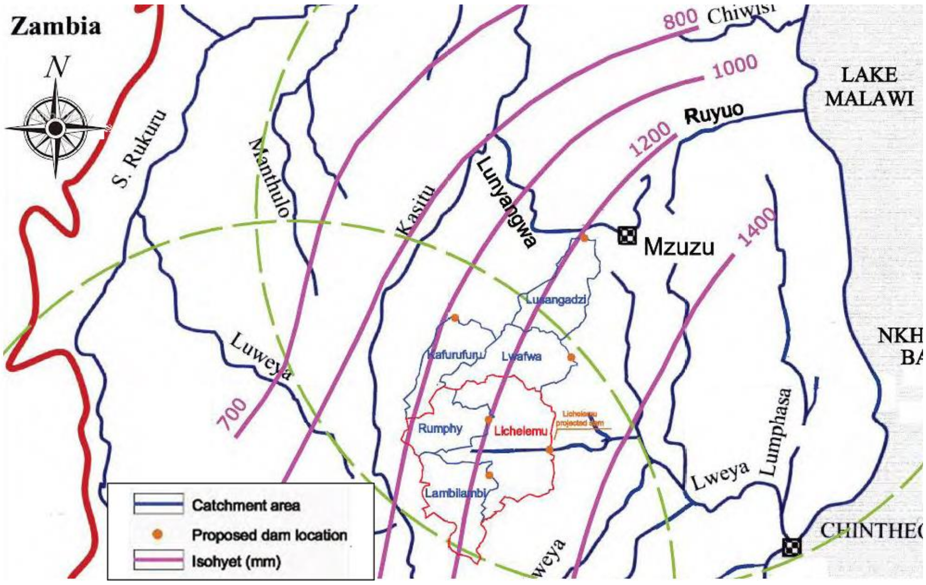
However, in WSIP of 2012 by WB, it does not put out the conclusion of the dam site of Stage 2. In WSIP, it is described that “The conclusion of stage 2 does not make sense to decide now. By 2020, better information on population growth, as well as any changes in hydrology patterns, will allow better decisions to be made”.

The future plan of Stage 2 shall be re-examined by performing a future water demand study in consideration of the social needs and changes (population, standard of living) furthermore.

Table 2.1.18 Weighted Final Scores of Eight Dam Site Options

Parameter		Altenatives	1A Lichelemu w. supply	1B Lichelemu w.supply+hydropower	2 Lusangazi+ Lambilambi	3 Lwafwa+ Lambilambi	4 Lambilambi+ Lusangazi	5 Lambilambi+ Lwafwa	6 Lusangazi+ Lwafwa	7 Lwafwa+ Lusangazi	8 Lambilambi+ Lichelemu
Technical	Risk on feasibility	Ranking	6	6	2	6	1	4	5	9	2
		Mark	3	3	7.5	3	9	6	5	1	7.5
	Reliability	Ranking	6	8	4	4	1	1	6	6	1
		Mark	2.5	2.5	5.5	5.5	8	8	2.5	2.5	8
Environmental	Impact	Ranking	1	1	6	4	6	4	5	8	3
		Mark	8.5	8.5	3.5	5.5	3.5	5.5	1.5	1.5	7
Financial	Initial capital cost	Ranking	6	9	1	6	3	3	1	6	3
		Mark	3	1	8.5	3	6	6	8.5	3	6
	Impact on NRWB	Ranking	2	1	8	7	2	2	7	9	2
		Mark	6.5	9	4	2.5	6.5	6.5	2.5	1	6.5
	Impact on GoM	Ranking	9	7	5	7	3	2	1	4	5
		Mark	1	2.5	4.5	2.5	7	8	9	6	4.5
Economic	Cost Benefit Analysis	Ranking	3	1	2	8	3	3	3	8	3
		Mark	5	9	8	1.5	5	5	5	1.5	5
Overal assesment		Ranking	7	5	4	8	1	1	6	9	3
		Mark	29.5	35.5	41.5	23.5	45	45	34	16.5	44.5

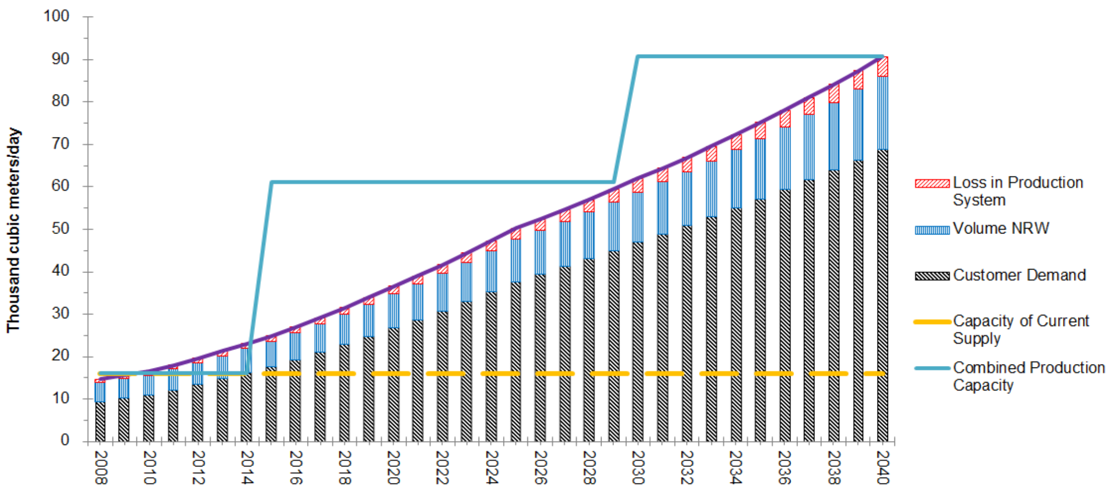
Source: Sogreah Report (2010)



Source: Sogreah Report (2010)

Figure 2.1.23 Reticulation Network Augmentation (Proposed Transmission Pipes)

As a conclusion, in order to meet the water demand, the following average resource capacities are required:



Source: Malawi Water Sector Investment Plan, Vol. I, World Bank, April 2012

Figure 2.1.24 Mzuzu's Water Needs and Current Capacity

2) Summary of Recommended Planning Facilities (MW-1, 4, 5)

The following gives a summary of the facilities for Option 8 (Lambilambi + Lichelemu).

(i) Water Treatment Plant

Location

WTP Site (A) is located at 1.5 km south of Lusangazi Reservoir (constructed in 2008), close to the junction of M1 Road with the old National Road. This area is flat enough and has enough space to construct the new plant. The coordinates of the site are roughly (to be refined at the preliminary design stage): X=605665, Y=8728422. The elevation is around 1,355 m.

Capacity

The new source is expected to provide 27.2 MCM (million cubic meters) per year of raw water in the long term (2040), i.e., 74,600 m³ per day on average and 89,520 m³ per day to meet the maximum day demand factor 1.2. Considering 5% of losses in the raw water transmission system and the WTP, the corresponding volumes of treated water are 70,870 m³ per day on average and 85,050 m³ per day to meet the maximum water demand.

The required capacity of the new WTP is, therefore, 85,000 m³ per day for the year 2040. The construction will be implemented in two phases of 51,300 m³ per day (Phase 1: daily peak) and 33,750 m3 per day (Phase 2: Daily Peak).

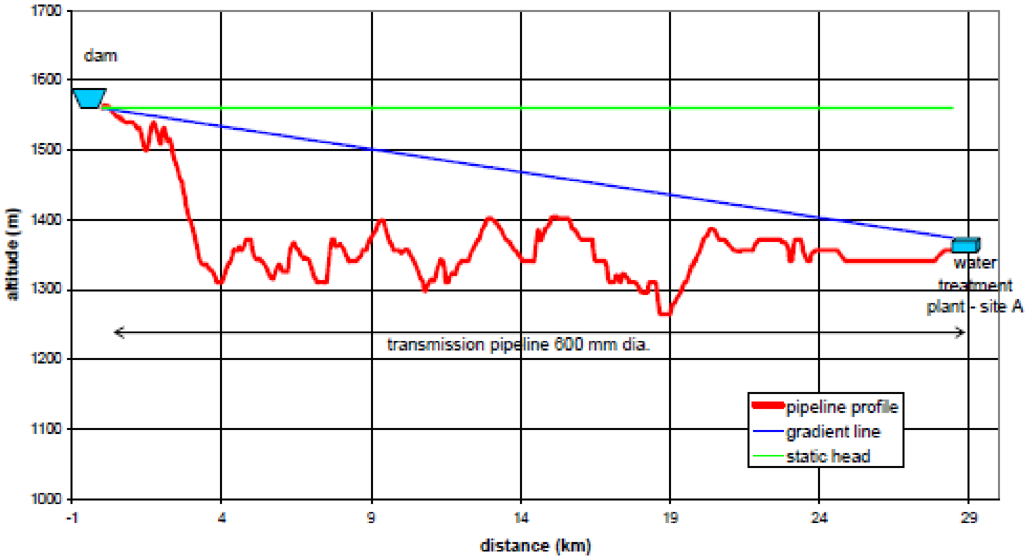
Treated Water Tank

Water tanks will be constructed at the outlet of the WTP in order to provide flexibility in the operation of the plant and of the treated water pumping station in case of operational problems respectively on the treated water transmission system or at the plant. The storage volume necessary to make the operation easier is estimated at around 4 hours of production (at daily peak flow). Therefore, the proposed treated water tanks are:

- 7,500 m³ in Phase 1
- 7,500 m³ in Phase 2 (i.e., 15,000 m³ in total)

(ii) Water Transmission System from the Dam to the Mzuzu City

Lambilambi Dam (of Stage 1) is the only selected site from where water can gravitate to the city. The dam site is located at an elevation of 1540 m with a maximum water level of 1560 m, whereas the proposed site of the water treatment plant is at 1355 m (Site A). The pipeline diameter from dam to WTP site is 600 mm. (See **Figure 2.1.25**.)



Source: Sogreah Report (2010)

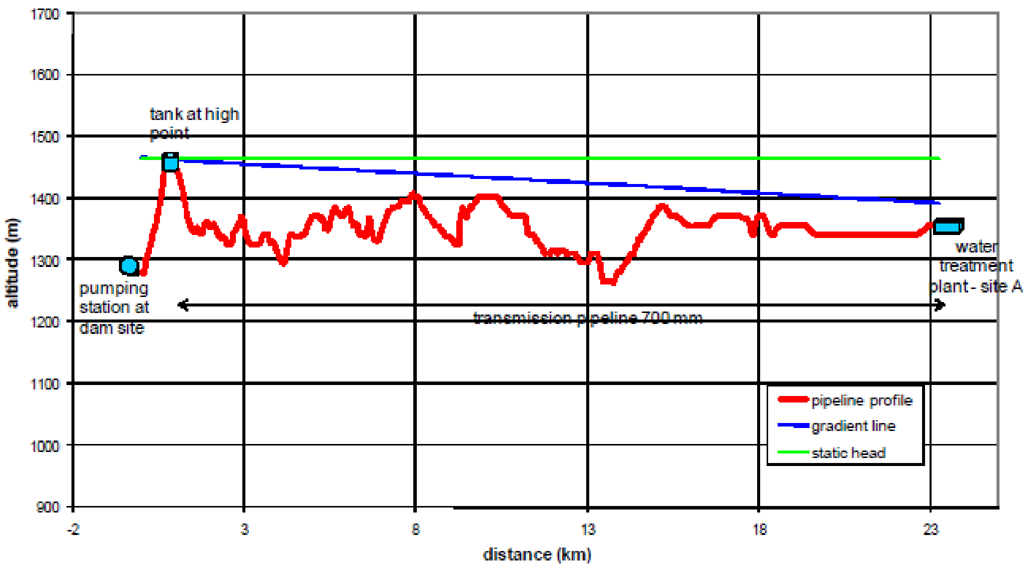
Figure 2.1.25 Lambilambi – Water Transmission System (Stage 1)

Lichelemu Dam (of Stage 2) is located 26 km of the new water treatment plant (Site A). The maximum water level in the reservoir is 1,283m and the river bed is 1,265 m. Since the water treatment plant will be located at an elevation of nearly 1,355 m, a pumping station is necessary. The water will be pumped from the dam to the highest spot next to the dam and then it will gravitate to the treatment plant. At the top of the hill close to the dam site, a balancing tank will be constructed at the interface between the pumping line from the dam and the gravity pipeline to the treatment plant.

The transmission system from Lichelemu Dam to the treatment plant includes the following:

- Pumping station,
- Pipeline from the pumping station to the highest spot,
- Balancing tank at the highest point,
- Pipeline from the tank to the WTP.

Table 2.1.19 Summarizes the Main Facility Items of This Future Plan.



Source: Sogreah Report (2010)

Figure 2.1.26 Lichelemu - Water Transmission System (Stage 2)

Table 2.1.19 Summary of Planning Facilities (Option 8)

			phase 1: LAMBILAMBI		phase 2: LICHELEMU	
dam	height		25	m	24.1	m
	length		192	m	286	m
	embankment volume		0.255	Mm3	0.238	Mm3
reservoir	total volume		21	Mm3	15	Mm3
	dead storage		6	Mm3	3	Mm3
	surface		170	ha	492	ha
	land use		forest, dead woods		forest	
	max abstracted water		16.4	Mm3/y	16.9	Mm3/y
	meet demand until		2029		>2040	
transmission system to WTP	pumping station	peak flow		l/s	643	l/s
		net head		m	197	m
		power		kW	1635	kW
	transmission pipeline to WTP	peak flow	624	l/s	643	l/s
		diameter	600	mm	700	mm
		length	28.5	km	23.2	km
		max pressure	295	m	200	m
	balancing tank	volume		m3	2400	m3
water treatment plant	location		site A			
	capacity		42500	m3/d	85000	m3/d
transmission to service reservoir	transmission to Lusangazi reservoir	pumping/gravity	pumping		transmission to service reservoir designed for year 2025	
		peak flow	107	l/s		
		net head	16	m		
		pipe diameter	300	mm		
		pipe length	1.5	km		
		pumping power	22	kW		
	transmission to Geisha & MBC	pumping/gravity	gravity			
		peak flow	329	l/s		
		net head	45	m		
		part 1 diameter	500	mm		
		part 1 length	3.2	km		
		part 2 diameter	400	m		
		part 2 length	5.7	km		
		pumping power		kW		

Source: Sogreah Report (2010)

3) Other Development Plans

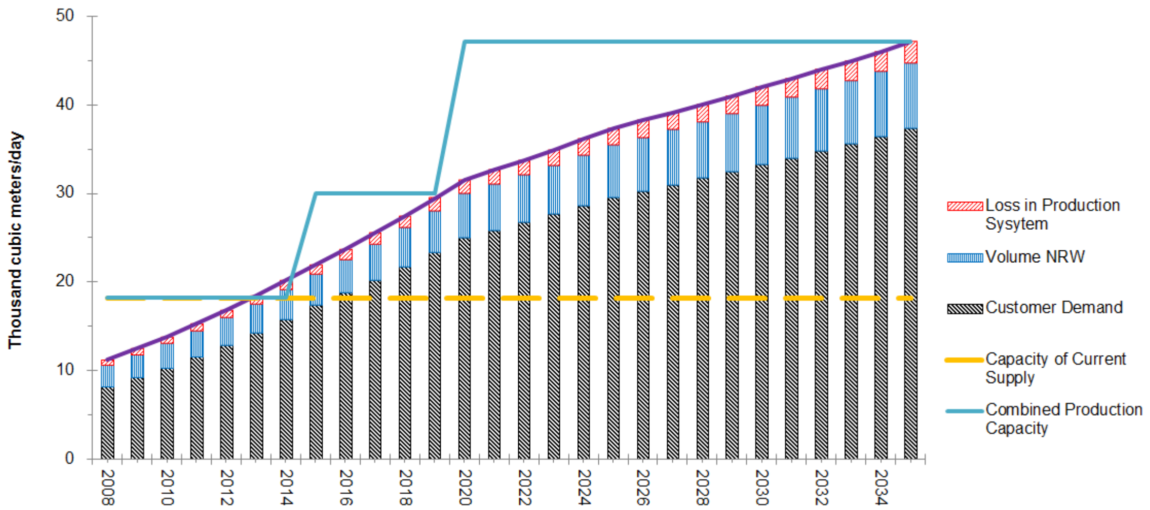
The MW-2 is the improvement work for its water supply network, after development of "new water source Lambilambi Dam". The MW-3 of "Re-examination of water demand and raw water source study" have been also recommended in "WSIP Report", and it shall be studied for re-examination of future water demand. The NRW reduction program of MW-6 is better to be studied, although there is no emergency degree, compared with BWB and LWB. The development plans of above-mentioned MW-1 to 6 are summarized in **Table 2.1.20** and **Table 2.1.21.**

(4) Development Plan for Zomba

According to the "Preliminary and Detailed Design and Construction Supervision for Zomba and Mangochi Water Supplies, SSI, 2010" (hereinafter called as SSI Report), the development plan is up to 2020. Therefore, the development plan up to 2035 is modified in the Project, and plans are prepared for "Scenario 1" and "Scenario 2".

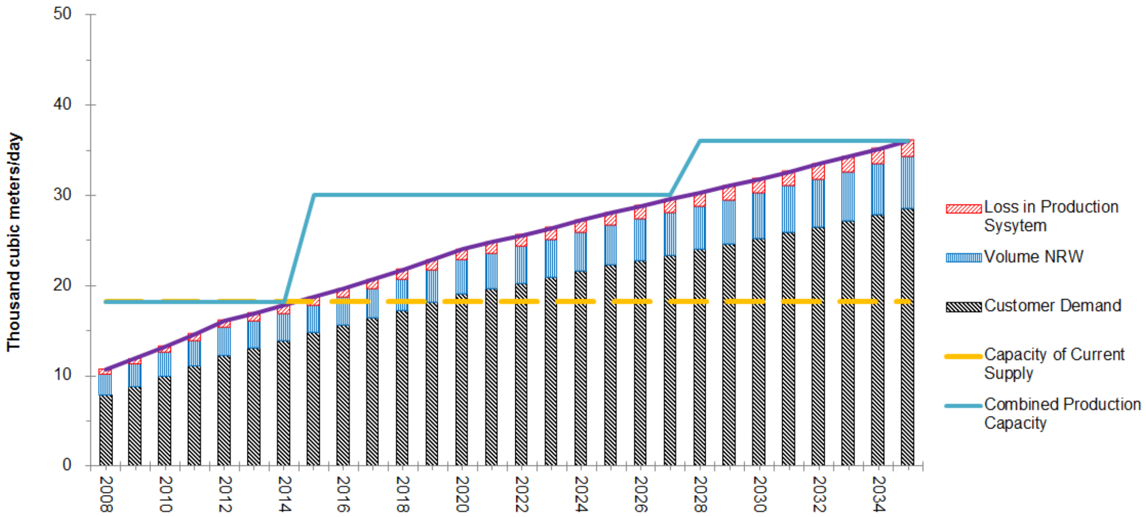
The water demand of "Scenario 1" by 2020 is based on original "SSI Report (2010)", then from 2021 to 2035 is forecasted by the Project. (The real access rate will be targeted to 100% at 2025 for National Water Policy from 95% at 2020 of SSI.) The unit water consumption of domestic-use for "Scenario 2" is applied the unit consumption of Mzuzu. The institutional/commercial/industrial consumption for "Scenario 2" is calculated as annual growth rate of 1.8%. (1.8% is the average growth rate of Lilongwe and Blantyre).

In order to meet the water demand, the average resource capacities for each scenario are required as shown in **Figure 2.1.27** (Scenario 1) and **Figure 2.1.28** (Scenario 2).



Source: Project Team based on the data from the SSI Report (2010)

Figure 2.1.27 Zomba's Water Needs and Current Capacity (Scenario 1)



Source: Project Team

Figure 2.1.28 Zomba's Water Needs and Current Capacity (Scenario 2)

1) New Raw Water Source (ZW-4, 5)

The detailed designs for water supply facilities (Water Treatment Plant, Transmission/Distribution Pipes, Storage Tanks, Pump Stations) targeted at 2020, has been achieved by making efficient use of the water source of the existing Mulunguzi Dam. However, the future water demand by 2035 will need new raw water source. In the water demand forecast of the Project, new sources of "17,100 m^3/day for Scenario 1" and "6,100 m^3/day for Scenario 2" are required. The water demand forecast (Scenario 1) of Zomba sub-scheme is assumed in the following ways in the present SSI detailed design report.

The unit water consumption per capita for domestic use is predicted to be "250 l/day for Low Density housing area (LDHA)", "180 l/day for Medium Density housing area (MDHA)", "100 l/day for High Density Permanent housing area (HDHPA)" and "80 l/day for High Density Traditional housing area (HDHTA)". Although the percentage of Communal Water Point (CWP) in HDHTA is unknown, it seems that every category's value is greater. (e.g., Unit consumption per all population of Blantyre is 73 l/day, and those of Lilongwe and Mzuzu is 98 and 109 l/day.)

In addition, the demands of institutional/commercial/industrial are predicted as 95% (80%) of the domestic water demand at 2020 (2035). This value seems greater even in this case. (e.g., Lilongwe: 16%, Blantyre: 31%, Mzuzu: 38%)

From the point of view above, it will be recommended that "Scenario 2" is adopted as the demand forecast.

Although the feasibility study for new raw water source after 2020 shall be studied, the new borehole or the raising of Mulunguzi Dam will be recommended as new raw water source in case of "Scenario 2".

2) Water Treatment Works

Although the feasibility study for new water source shall be needed for the location and feasibility, etc., the estimated capacity is as follows:

The capacity of existing water treatment works will be updated to 30,000 m^3/d by 2015. The additional average capacity of final stage will be the additional requirement to meet the 2035 peak demand by using the planning concept of "SSI Report", i.e., 17,100 m^3/d. (Scenario 1, daily peak: 22,230 m^3/d), 6,100 m^3/d. (Scenario 2, daily peak: 7,930 m^3/d). (Maximum day demand factor is adopted: 1.3 by SSI report.)

3) Other Development Plans

The ZW-1 of "expansion existing TW" has been starting the work from the result in the SSI Report. The ZW-2 is the improvement work for its water supply network. The ZW-3 shall be studied for new raw water source development. The development plans of above-mentioned MW-1 to 6 are summarized in **Table 2.1.20** and **Table 2.1.21**.

(5) Summarized List of Development Plans for 4 Cities

The list of development plans for the 4 cities which is summarized in the above items (1) to (4) is shown in **Table 2.1.8** to **Table 2.1.9** .

Table 2.1.20 Summarized List of the Development Plan for 4 Cities (1/2)

Program No.	Responsible Organ		Name of Project	Budget (Thousand US$)	Development capacity (m^3/day)	Served Population (inh.)	Outline / Scope of the Projects	Status	Type	Remarks
	Main	Associate								
Lilongwe (LWB)				518,960						
LW-1	LWB	IDA	Develop new groundwater borehole (+10,000 m3/d)	5,200	10,000	66,700	Hydrological study and design, construction and construction supervision for boreholes of New groundwater resources	Ongoing	New	Study is ongoing. LWB Investment Plan
LW-2	LWB	IDA	Extension TWII (purification plant: +30,000 m3/d)	5,000	30,000	200,099	Detailed design, construction and construction supervision, for expanding the capacity of TW2 (Treatment Works 2).	Ongoing	New	Study is ongoing. LWB Investment Plan
LW-3	LWB	EIB	Raising of Kamzu dam 1 and associated rehabilitation works (+30,000 m3/d)	5,100	30,000	200,099	Basic/detailed design and construction supervision for raising of Kamzu dam 1 and associated rehabilitation works	Ongoing	Rehabilitation	Study is ongoing. LWB Investment Plan
LW-4	LWB	JICA	Extension TWII(2nd) (purification plant: +30,000 m3/d) and Technical Assistance	9,700	30,000	200,099	Detailed design and construction supervision, for expanding the capacity of TW2 (Treatment Works 2). Technical Assistance for "Review of the Bye-Laws", "Development of water safety plans for LWB", "Development of policies for operation and new developments", "Development of a Customer Services Charter", "Training and Capacity building".	-	New	
LW-5	LWB	JICA	Catchment area conservation and rehabilitation	-	-	-	Catchment area conservation and rehabilitation. Technical cooperation activities for "Forest Reserve Conservation and Management", "River Bank and Downstream activities", "Livelihoods Improvement".	-	Rehabilitation	LWB Investment Plan Technical cooperation
LW-6	LWB	(WB)	Network improvement	200	-	913,785	Detailed Design, construction and construction supervision for the improvement works of water supply network of LWB.	-	Rehabilitation	LWB Investment Plan
LW-7	LWB	(WB)	Full implementation GIS/Hydraulic Model	100	-	-	Preparation of GIS/Hydraulic Model of water supply network for optimizing the water management.	-	New	Technical cooperation
LW-8	LWB	(WB)	Phase 1, New water source Diamphwe dam including transports system (+75,000 m3/d, TW+66000 m3/d)	195,420	75,000	500,247	Basic/detailed design, construction and construction supervision for New water source Diamphwe dam (Phase 1) including transports system.	-	New	LWB Investment Plan
LW-9	LWB	(WB)	Implementation telemetry system	300	-	-	Implementation and management programme of telemetry system for efficient management of water demand.	-	New	LWB Investment Plan Technical cooperation
LW-10	LWB	(WB)	Rehabilitation of TWII	4,000	-	-	Detailed design, construction and construction supervision the rehabilitation works of TW2	-	Rehabilitation	LWB Investment Plan
LW-11	LWB	(WB)	Network expansion	225,800	-	1,000,495	Detailed Design, construction and construction supervision for the expansion works of water supply network of LWB.	-	New	LWB Investment Plan
LW-12	LWB	-	Review of water demand study	1,500	-	-	Further review of water demand study for future water demand forecast and its facilities plan.	-	New	
LW-13	LWB	(WB)	Phase 2, New water source Diamphwe dam including transports system (Dam+75,000 m3/d, TW+66000 m3/d)	66,640	75,000	500,247	Basic/detailed design, construction and construction supervision for New water source Diamphwe dam (Phase 2) including transports system.	-	New	LWB Investment Plan
Blantyre (BWB)				321,940						
BW-1	BWB	(WB)	Network improvement	9,000	-	796,112	Detailed Design, construction and construction supervision for the improvement works of water supply network of BWB.	-	New	
BW-2	BWB	-	additional NRW reduction programme	5,000	-	-	Technical cooperation (Dispatch of expert, Equipment provision, etc), for additional NRW reduction programme, based on the results of the current NRW reduction program.	-	New	Technical cooperation (Dispatch of expert, Equipment provision, etc)
BW-3	BWB	-	Metering and Water leakage control		-	-	Technical cooperation (Dispatch of expert, Equipment provision, etc) for Metering and Water leakage control programme, based on the results of the current NRW reduction program.	-	New	
BW-4	BWB	(WB)	Phase 1, New water source from Shire River including transports system (+39,000 m3/d)	91,970	39,000	287,485	Basic/detailed design, construction and construction supervision for New water source (Phase 1) from Shire River including transports system.	-	New	
BW-5	BWB	-	Network expansion	129,800	-	574,970	Detailed Design, construction and construction supervision for the expansion works of water supply network of BWB.	-	New	
BW-6	BWB	-	Poverty program (Kiosk and Toilet development)	14,000	-	-	Basic/detailed design, construction, construction supervision for the Kiosks and public toilets as one of the legal bail-out plan for the disadvantaged.	-	New	
BW-7	BWB	(WB)	Phase 2, New water source from Shire River including transports system (+39,000 m3/d)	70,670	39,000	287,485	Basic/detailed design, construction and construction supervision for New water source (Phase 2) from Shire River including transports system.	-	New	
BW-8	BWB	-	Review of water demand study	1,500	-	-	Further review of water demand study for future water demand forecast including the plan of achievement of 100% coverage and its facilities plan.	-	New	

Source: Project Team, WB

Table 2.1.21 Summarized List of the Development Plan for 4 cities (2/2)

Program No.	Responsible Organ		Name of Project	Budget (Thousand US$)	Development capacity (m^3/day)	Served Population (inh.)	Outline / Scope of the Projects	Status	Type	Remarks
	Main	Associate								
Mzuzu (NRWB)				**233,030**						
MW-1	NRWB	(WB)	Phase 1, New water source Lambilambi dam including transports system (+45,000 m3/d)	72,140	45,000	215,811	Basic/detailed design, construction and construction supervision for New water source Lambilambi dam (Phase 1) including transports system.	-	New	
MW-2	NRWB	-	Network improvement	1,800	-	77,212	Detailed Design, construction and construction supervision for the improvement works of water supply network of Mzuzu city.	-	Rehabilitation	
MW-3	NRWB	-	Re-examination of water demand and raw water source study	1,000	-	-	Further review of water demand study for future water demand forecast including the review of the unit water consumption per capita, the population forecast. Its facilities plan.	-	New	
MW-4	NRWB	(WB)	Phase2, New water source Lichelemu dam inclusing transports system (+29,600 m3/d)	73,790	29,600	141,955	Basic/detailed design, construction and construction supervision for New water source Lichelemu dam (Phase 2) including transports system.	-	New	
MW-5	NRWB	-	Network expansion	80,800	-	357,766	Detailed Design, construction and construction supervision for the expansion works of water supply network of Mzuzu city.	-	New	
MW-6	NRWB	-	NRW reduction programme	3,500	-	-	Technical cooperation (Dispatch of expert, Equipment provision, etc) for NRW reduction programme.	-	New	Technical cooperation
Zomba (SRWB)				**22,600**						
ZW-1	SRWB	(WB)	Expansion existing TW (18,200 to 30,000 m3/d)	- (8,140)	11,800	61,792	Detailed design, construction and construction supervision, for expanding the capacity of existing Treatment Works.	Ongoing	New	Construction is ongoing.
ZW-2	SRWB	-	Network improvement	3,600	-	157,098	Detailed Design, construction and construction supervision for the improvement works of water supply network of Zomba city.	-	Rehabilitation	
ZW-3	SRWB	-	Feasibility study of water demand and new raw water source	1,500	-	-	Feasibility study for future water demand forecast and new raw water source, including options of the raising of Mulunguzi dam or groundwater development.	-	New	
ZW-4a2	SRWB	-	Raising of Mulunguzi dam and associated rehabilitation works (+6,100 m3/d)	10,200	6,100	31,943	Basic/detailed design and construction supervision for raising of Mulunguzi dam and associated rehabilitation works	-	Rehabilitation	Scenario 2a
ZW-5a2	SRWB	-	Network expansion	7,300	-	31,943	Detailed Design, construction and construction supervision for the expansion works of water supply network of Zomba city.	-	New	Scenario 2a, 2b
Others				**2,900**						
OW-1	all WB	-	Capacity Building for Water demand management	800	-	-	Capacity Building for Water demand management as one of the improvement plan of the financial standing and organization of water utility account.	-	New	Technical cooperation
OW-2	all WB	-	Programme for Water Saving (improvement of awareness, usage of water saving device, regulation change, etc.)	600	-	-	Technical cooperation (Dispatch of expert, Equipment provision, etc) programme for Water Saving, including the "improvement of awareness", "usage of water saving device", "regulation change", etc.	-	New	Technical cooperation
OW-3	all WB	-	Improvement Programme of Water, Sanitation and Hygiene awareness	500	-	-	The implementation of the water, sanitation and hygiene education and promotion program. Program consists of Institutional Building / Training and Capacity Building / Service Delivery.	-	New	Technical cooperation
OW-4	all WB	-	Maintenance Programme of Waterworks Facility	1,000	-	-	Technical cooperation (Dispatch of expert, Equipment provision, etc) of maintenance programme (Operation management, Maintenance Engineering) of Waterworks Facility.	-	New	Technical cooperation

Source: Project Team, WB

2.1.8 Water Supply for Towns by Regional Water Boards

(1) Target

The following policies and targets are applied to the planning:

- Malawi Water Sector Investment Plan (2012): 95% in2015, 98% in 2025-2030
- Planning Year: 2020, 2025, 2035

(2) Planning Concept

Development concept of the Water Supply Master Plan for the towns will be as follows:

- Secure the stable and safe water source.
- Improve efficiency of operation.
- Protect the catchment area

1) Secure the Stable and Safe Water Source

Water supply schemes to towns are managed by the regional water boards. The types of water source used by the Boards are river water, lake water, and groundwater by borehole. Some towns have dams for river water use. Recently, many water supply schemes faced the shortage of water source from rivers and boreholes since water demand had increased due to population growth. Hence, the potential of river discharge should be examined in detail and be planned in anticipation of shifting of intake location or alternatives of water source. In addition, when river flow does not have enough supply capacity, there shall be alternatives for new/additional groundwater development or dam construction based on detailed surveys conducted in consideration of demand projection.

The potential of groundwater was reviewed in this Project; however, evaluation of the potential requires more detailed investigation including test drillings for actual implementation, especially, the boreholes to be operated by power pump for urban areas. On the other hand, it is necessary to monitor water quality. When intake point is near the housing area, there is the possibility that wastewater from their drain can contaminate the water source.

In addition to normal water analysis, waterborne diseases such as schistosomiasis are required to be monitored. If existence of schistosomiasis is observed, the treatment method and results of the investigation should be reported to the Ministry of Health and other agencies concerned.

Schistosomiasis

Schistosomiasis is a group of infectious diseases caused by Schistosoma in humans. Infection occurs with the contact of surface water which is contaminated by the infective larvae (cercariae) developed in the intermediate snail hosts. According to the WHO guidelines for Drinking-water, it is said that infection occurs through skin penetration when people are exposed to free-swimming cercariae, and does not occur through consumption of drinking-water. Meanwhile, the risk of transmission is summarized as below.

Health significance	High
Persistence in water supplies	Short (Detection period for infective stage in water at 20°C is up to 1 week)
Resistance to chlorine	Moderate (99% inactivation at 20°C generally in 1–30 min)
Relative infectivity:	High (infective doses can be 1–100 organisms or particles)
Important animal source	Yes

The fact sheet 2.17 of WHO (Fact sheets on environmental sanitation) mentions that the necessary contact time to kill cercariae is 30 minutes with the 1mg/L residual chlorine. Therefore, the removal of Schistosoma requires sufficient chlorination.

Therefore, the infection by consumption of drinking water can be ignored, but there is still a potential risk of infection through bathing of insufficiently treated water. The risk could be eliminated by sufficient water treatment because the cercariae is removed by filtration and inactivated by disinfection. On the other hand, the following countermeasures are effective: the prevention of water source contamination of the excreta of hosts like humans and animals, and the control of freshwater terrestrial snails which could be intermediate hosts.

2) Economical and Efficient Improvement and Expansion of the Schemes

Since 20-30 years have passed after the construction of many water supply schemes, the following challenges have occurred:

- Aging of the facility is making inefficient operation and maintenance.
- Aging facilities, machinery and equipment cause risks to hinder functions and increase operational cost year by year.
- Additionally, the capacity of the facility was designed on the old demand projection. Therefore, it is recommendable that the water schemes be rehabilitated considering its extension based on the demand projection.
- Necessity and timing of the extension of water supply schemes of the regional water boards shall be reviewed.

<u>Non-Revenue Water by RWB</u>

Blantyre Water Board has started investigations and actions on countermeasure for NRW. However, the regional water boards are not ready to conduct such activities by themselves due to restrictions of performance capacity and budgetary conditions. NRW countermeasures will contribute to saving water and financial strengthening of the water boards. Normally, the project for non-revenue water management shall be composed of the following items:

- Review of existing water supply condition
- Water balance analysis
- Leakage survey
- Hydraulic analysis of net work
- Improvement of water fee collection
- NRW Survey Annual Plan
- Pilot project
- Extension plan for all service area

3) Protection of Catchment Areas

Deforestation in the catchment area worsens the river discharge and water quality and causes silting problems at the intake point/dam storage. Protection of the catchment area needs to be approached through the control of deforestation and reforestation as follows:

- Joint possession of information on deforestation by concerned organizations
- Research on the existing conditions
- Establishment of countermeasures

(3) Road Map, Development Goal and Priority List

The development plans for towns managed by three (3) regional water boards are arranged by the following process:

- Water Demand in 2020-2035 is estimated based on 2012 population served in Water Service Area of the Boards.
- 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.
- When the ratio of the existing water intake capacity against water demand projection is low and population is larger in the water supply schemes of the regional water boards, the water supply scheme is selected with higher priority (see “factor for priority on plan” in **Table 2.1.22**).

Table 2.1.22 Outline of Project of Regional Water Boards

Service Area		Towns
Responsible Entity		Regional Water Board
Contents of the Project		Rehabilitation/Expansion of Water Supply Facilities to meet future water demand
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: Table 6.4.18**
Project	Facility	Rehabilitation /Expansion
	Organization	Capacity Development of RWB maintenance)
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

The following **Table 2.1.23** to **Table 2.1.25** show scheme-wise priority selections in 3 regional water boards. Priorities A, B and C correspond to short, middle and long-term planning.

Table 2.1.23 Existing Intake Capacity and Future Water Demand of the WSS of NRWB

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%			

Source: Project Team, RWB

Table 2.1.24 Existing Intake Capacity and Future Water Demand of the WSS of CRWB

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				

Source: Project Team, RWB

Table 2.1.25 Existing Intake Capacity and Future Water Demand of the WSS of SRWB

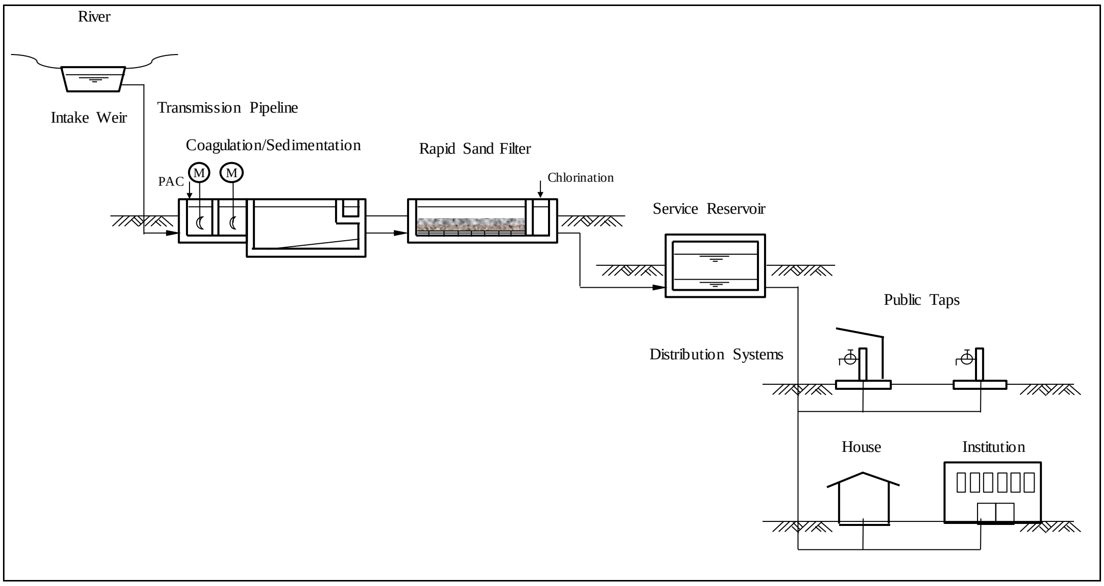
Region	District	Water Scheme	Population in 2012	Type of Water Source	Population projected in 2035	Existing Facilities Intake Capacity (m^3/day)	Regional Water Board Projected Water Demand of the Water Schems (m^3/day)						Intake condition = Existing Intake capa/ Prjected Water Demand	Priority by Population 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

(4) Component of Water Supply Scheme

Figure 2.1.29 shows components of water schemes by surface water. Schemes by groundwater are basically the same to the system shown in **Figure 2.2.4** for Market Center.

- Intake from river, lake
- Transmission pipe from Intake to Treatment Plant
- Treatment Plant (Injection of chemicals, Coagulation, Sedimentation, Rapid sand filter, Chlorination, reservoirs)
- Transmission pipe from Reservoir of Treatment Plant to Distribution Tank, Distribution System, Service Device



Source: Project Team

Figure 2.1.29 Components of WSS by Surface Water

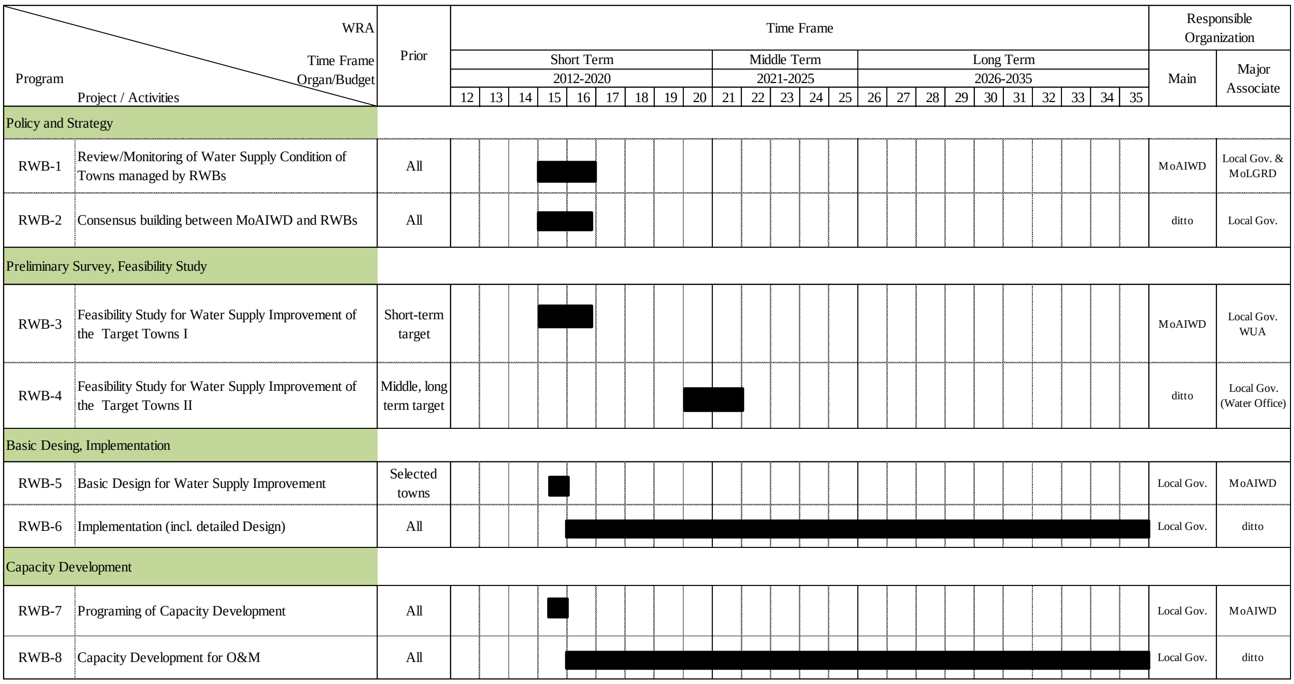
(5) Action Plan and Implementation List

Figure 2.1.30 shows the action plan for implementation in towns.

Review and monitoring of target towns shall firstly be conducted to investigate and modify priority settings. Currently, the business plans of the three regional water boards are prepared by themselves because they are independent public organizations. However, MoAIWD needs to establish a consensus with the 3 boards to work out a balanced policy system for the whole country as the overall context to promote the procedure for development.

Feasibility Study for the target towns is required by two terms. First Study will be conducted for the towns on short-term plan, and Second Study for the middle and long-term plan. Part of the towns will be selected as emergency, and Basic Design will be conducted antecedently in 2015. Implementation of the Project will be started in 2016.

The towns selected for the short-term plan are given in **Table 2.1.23** to **Table 2.1.25** (Rank "A"). Population of the water service area is estimated at almost 1.5 to 2.5 times in 2012 to 2035 because proportion of house connection and demand is supposed to have increased as mentioned in **Part I: Chapter 5**. Improvement of water supply facilities and procurement of equipment is in progress under the National Water Development Program (NWDP) and the World Bank in 8 towns. The significant point of the Project mentioned above will be the stability of water source. Potentiality of river discharge and groundwater should be researched cautiously.



Source: Project Team

Figure 2.1.30 Components of WSS by Surface Water

Table 2.1.26 shows the outline of the projects for RWBs when the implementation is conducted on schedule, together with the scheme number to be improved and the projected population of 2035.

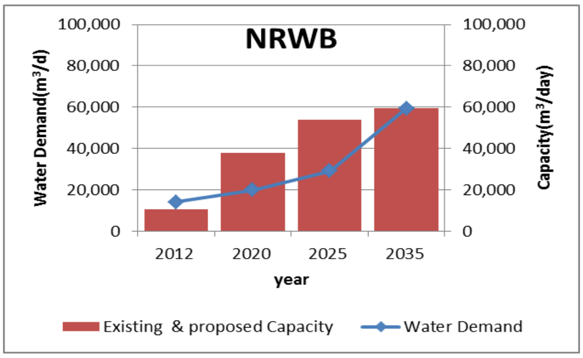
Figure 2.1.31 to **Figure 2.1.33** show water demand projections and intake capacity when implementation is conducted on the selected schedule (short, middle and long-term plan). It is clearly understood that the existing intake water capacity will be almost half in 2020 under the setting of water demand projection.

It goes without saying that this selection is done roughly based on the condition of water supply facilities in 2012. Each regional water board has to conduct more detailed investigations or feasibility studies, and consequently modify its business plan.

Table 2.1.26 Outline of the Short, Middle and Long Term Projects

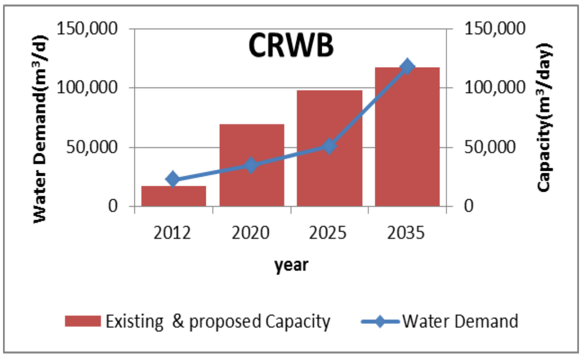
Service Area	Responsible Entity	Outline of Project, Idea of Priority Selection	2012-2020 (Short Term Plan)		2021-2025 (Middle Term Plan)		2026-2035 (Long Term Plan)	
			No. of Schemes	Population	No. of Schemes	Population	No. of Schemes	Population
Towns in Northern Region	NRWB	-Rehabilitation/ Expansion of Facilities -Necessity of Intake Capacity - Scale of population in town	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



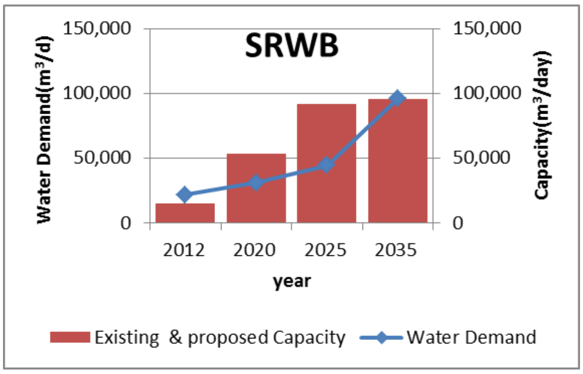
Source: Project Team

Figure 2.1.31 Water Demand and Project Implementation for NRWB



Source: Project Team

Figure 2.1.32 Water Demand and Project Implementation for CRWB



Source: Project Team

Figure 2.1.33 Water Demand and Project Implementation for SRWB

(6) Recommendation for Capacity Development

The following points are recommended for the capacity development of staff members of RWBs:

- Operation of the Water Treatment Plant

According to the field survey, flocculation and sedimentation were omitted in the treatment process even for the rapid filtration system in some schemes as explained in **Part I: Chapter 5**. Following the capacity development scheme is required from the operators of the treatment plan.

- Non-Revenue Water

As mentioned in **Part I: Chapter 5**, amount of non-revenue water is around 20-30% including water loss. From the viewpoint of effective use of water resources and finance, following the capacity development scheme is required.

Water loss at the water treatment plant, leakage loss in the distribution pipeline shall be accurately measured.

2.2 Rural Water Supply

2.2.1 Development Concept

The development concept of the Water Supply Master Plan for the rural areas is as follows:

- Market Center Project as High Priority

  The market center is the core of rural and urban areas, and there is a tendency that population growth is high in market centers due to migration from rural areas. It is thus important to implement urgent water supply facilities in the market center.

- Project for Gravity-Fed Piped Water Scheme in Rural Areas

  Twenty to thirty years have passed after the construction of gravity-fed water supply projects. The water supply facilities are then aged and damaged in many places. It is important to conduct rehabilitation/expansion of facilities. The population covered by the Project is almost 8% of the rural area.

- Monitoring and Evaluation of Existing Borehole and Protected Shallow Wells

  Improvement of community O&M capacity is an urgent issue for the borehole schemes. Monitoring and capacity development assistance has been implemented in these years, but more efforts are required.

- New Borehole Drilling

  Around 30% or around 3 million people do not have access to safe potable water. If aquifer is available, the borehole is an effective approach to ensure water in the rural areas.

Water supply projects in rural areas are carried out by MoAIWD, the local government and the concerned regional water boards. **Table 2.2.1** shows the responsibilities and activities of these 3 organizations in the Project.

Table 2.2.1 Responsibilities and Activities of MoAIWD, Local Government and Regional Water Boards concerned in the Project

<table>
<tr><th>Category</th><th>MoAIWD</th><th>Local Government</th><th>Three Regional Water Boards</th></tr>
<tr><td>Market Center</td><td>Policy, Law, Strategy
Planning & Programming
Monitoring & Evaluation
Coordinating Funds
Coordination of Research and Development
Facilitating transfer MCWSS to RWBs</td><td rowspan="3">Coordinating Activities
Managing and supervising WUA
Participating in Planning & management
Monitoring & Evaluation
Facilitating formation of WUA’s or other management arrangement</td><td>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</td></tr>
<tr><td>Gravity-Fed Rural Water Schemes</td><td rowspan="2">Policy, Law, Strategy
Planning & Programming
Monitoring & Evaluation
Coordinating Funds
Coordination of Research and Development</td><td>Providing technical assistance and OJT to communities</td></tr>
<tr><td>Borehole, Protected Shallow Well, Protected Spring</td><td>-</td></tr>
</table>

Source: Project Team

2.2.2 Market Center

(1) Target

The following policies and targets are applied to the planning:

- Malawi Water Sector Investment Plan (2012): 73% in 2015, 98% in 2025-2030
- Planning Year: 2020, 2025, 2035

(2) Planning Concept

Development concept of the Water Supply Master Plan for the towns will be as follows:

- Secure the stable and safety water source
- Improve service level
- Sustainable operation by RWB/WUA

(3) Promotion of the Project for Market Center

As mentioned in the **Part I: Section 5.1.3**, the Market Center is very important as a core of rural area. The lists of market centers are in **Table 2.2.3** up to **Table 2.2.5**. This list is basically prepared from the information provided by MoAIWD and the regional water offices.

Out of 154 in the list, 18 market centers are managed by the regional water boards. The others have few water supply schemes, i.e., only the hand-pump is the means of water supply.

Detailed population and existing condition have been collected from the district assembles, health offices and water offices.

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

- This list shows the total of 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 capacity of the water scheme is not enough to satisfy the water demand.

(4) Road Map, Development Goal and Priority List

Table 2.2.3 up to **Table 2.2.5** give the lists of market centers together with the population projection in 2015 to 2035 and priority settings. When a water supply scheme is planned to be managed by the regional water boards, the rank is set to “A”. The schemes prioritized by MoLGRD as “No. 1” are also given “A”. Scale of population is also used as a factor for prioritization. **Figure 2.2.1** shows the location of market centers. Total priority is selected through the evaluation and the scale of population.

Table 2.2.2 Outline of the Market Center Project

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

Source: Project Team

Table 2.2.3 List of Market Centers (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 2.2.4 List of Market Centers (2/3)

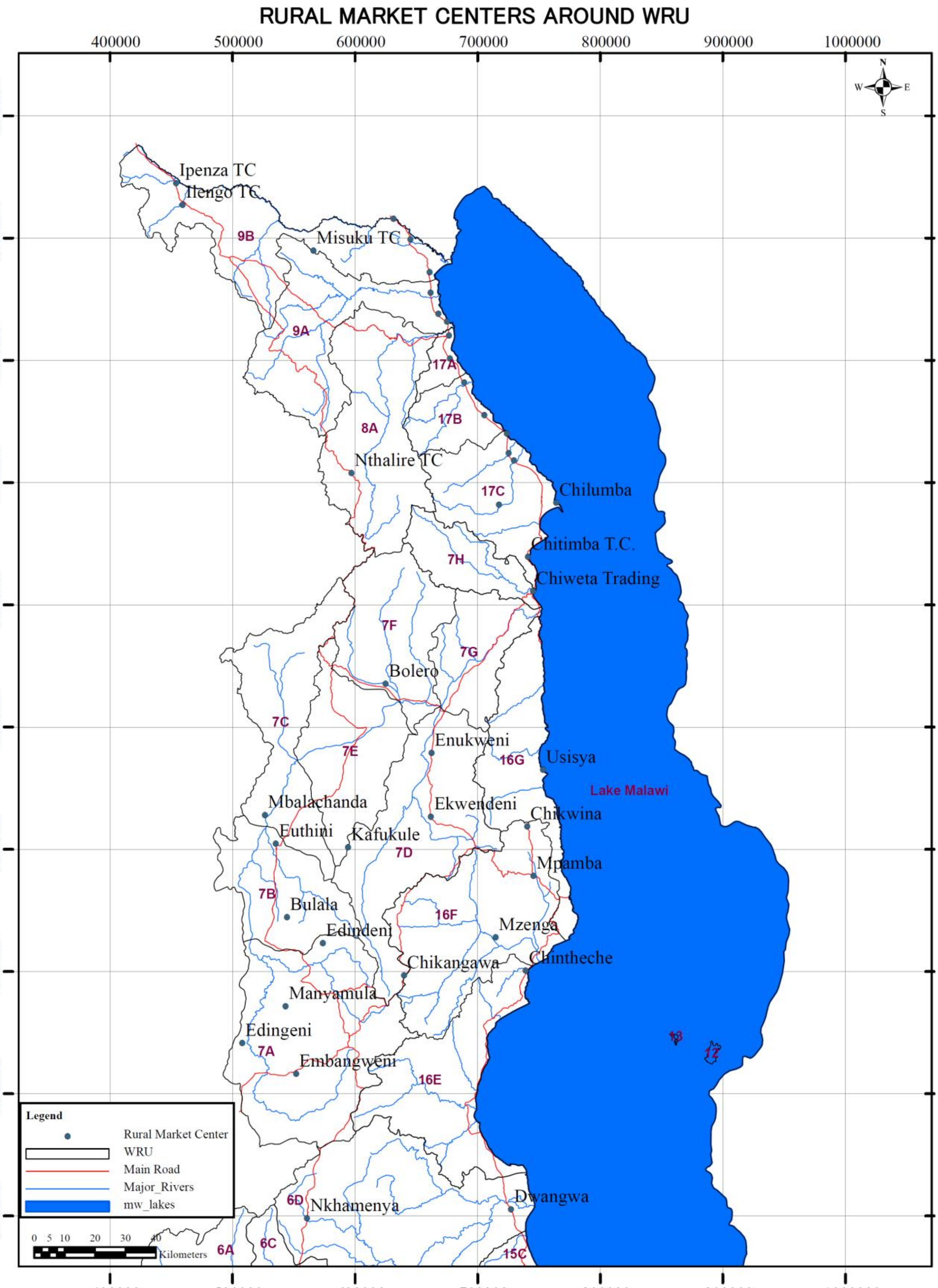
Region	District	Rural market centre	Population in 2012	Population in District in 2012	Population 2015	Population 2020	Population 2025	Population 2030	Population 2035	Proposed water source	Priority of MoLGRD	Under Project (management of RWB/planning)	Priority by Population in 2035 / by MoLGED / Under 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 2.2.5 List of Market Center (3/3)

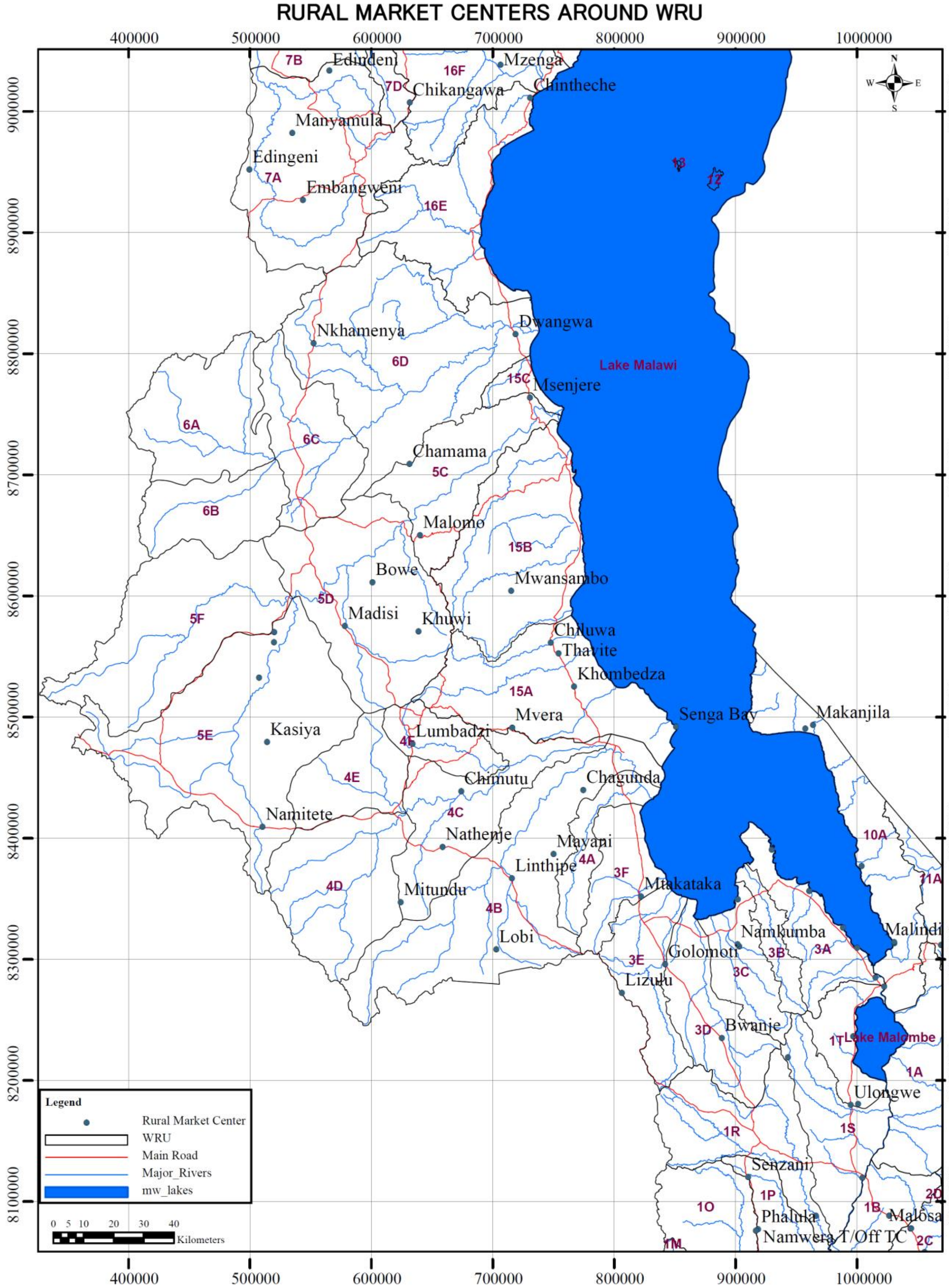
Region	District	Rural market centre	Population in 2012	Population in District in 2012	Population 2015	Population 2020	Population 2025	Population 2030	Population 2035	Proposed water source	Priority of MoLGRD	Under Project (management of RWB/planning)	Priority by Population in 2035 / by MoLGED / Under 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



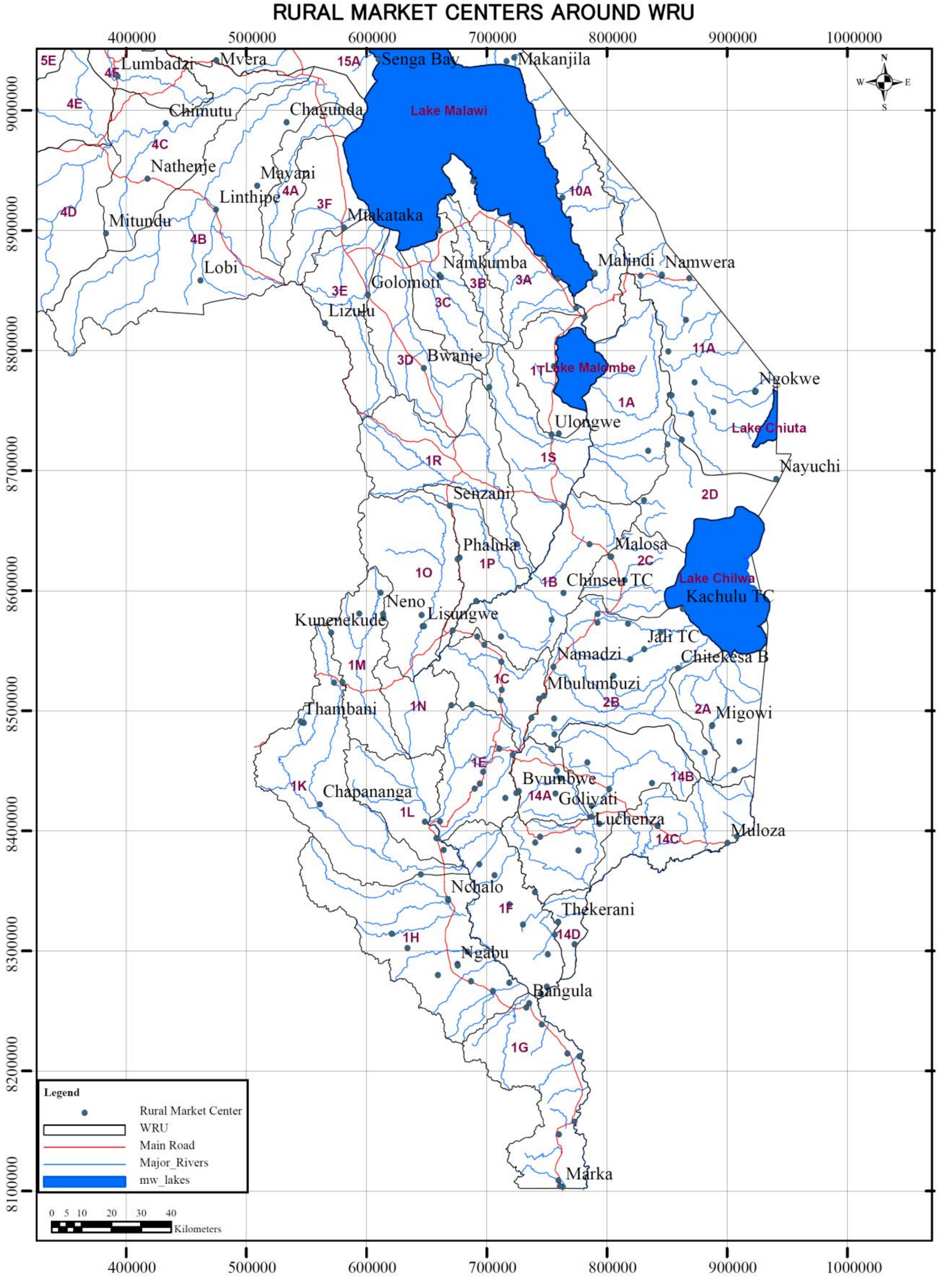
Source: Project Team, MoLGRD, NSO

Figure 2.2.1 Location Map of Market Centers (North)



Source: Project Team, MoLGRD, NSO

Figure 2.2.2 Location Map of Market Centers (Central)



Source: Project Team, MoLGRD, NSO

Figure 2.2.3 Location Map of Market Centers (South)

(5) Availability of Water Source

A majority of the water sources for market centers is the groundwater with power pump. Others are the lake and river water. Availability of groundwater as to quantity and quality needs to be reviewed and investigated well because the water demand for market centers is larger than the amount for communities and information on the water source is not enough.

(6) Component of Water Supply Scheme

Facility components of market centers are the borehole, elevated tank (if there is suitable site, it is better to place on ground), distribution pipe with public taps. The market center can be used for house connections, especially, in commercial zone.

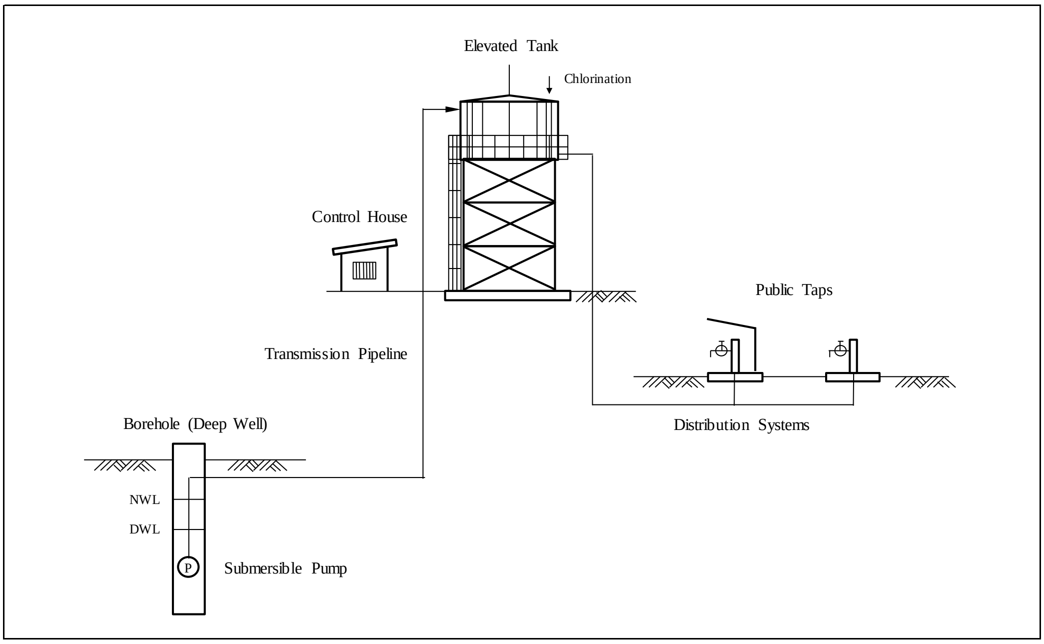


Figure 2.2.4 Schematic Diagram of Facilities for Market Centers

(7) Action Plan and Implementation List

Action plan and Implementation is described in Subsection 2.2.5 .

(8) Recommendation for Capacity Development

In the case of Market Center, the promotion body is MoAIWD based on the request of the Local Government. However, MoAIWD does not have personnel to handle promotion of market centers, and communication between MoAIWD and the local government is not enough.

To facilitate water supply infrastructure in market centers, the following are needed to strengthen the communication of information on the market center among the MoAIWD, local government and MoLGRD:

- Capacity Development of Water Supply Section in the District Water Office (DWO) in order to plan the Market Center Project.
- Coordination of finance for the improvement of Market Center in MoAIWD.
- Participation of Regional Water Boards.

2.2.3 Community served by Gravity-Fed Piped Water Supply Scheme

People in rural area are categorized into people in Market Center and people in Community (village). Market Center is like semi-urban are as mentioned in **Subsection 2.2.2** and community is almost categorized by water source, surface water by gravity-fed piped water supply scheme, and groundwater by borehole.

As mentioned in **Part I: Chapter 5**, the 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 with the officials of district water offices, the following challenges were pointed out. Besides, the mechanism of information transfer from District Water Office to the Direction of Water Supply of MoAIWD is not functioning well at present.

Intake Facility:

- The water quality is getting worse due to pollution (human activities) upstream
- Aging and insufficient capacity
- Damage of intake tank/weir by flood disaster and scouring.

Treatment Facility:

- The treatment plant has not been operated for almost 10 years
- Treatment facility is not included in the water scheme

Storage/Transmission:

- Aging/Damage of sedimentation tank
- Aging/Damage of storage tank
- Insufficient capacity of sedimentation/storage tank
- Poor design or improper location (elevation) of tank, no air valve, poor size of pipeline.

Management:

- Poor management of operation and maintenance
- Poor finance because water tariff has not been collected
- High rate of vandalism

Rehabilitation projects have been conducted by MoAIWD and/or NGO all 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.

In order to facilitate the project for gravity-fed piped water supply, the following approach is required:

- Outline of the water demand and challenges of the scheme should be grasped by MoAIWD, Local Government and District Water Office.
- Preliminary survey of the water supply schemes by MoAIWD and the local government.
- Drawing up of the Priority List.
- Coordination to implement the program with financial issues.

The scheme of gravity-fed piped water supply has large water users, which is considered as 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) Target

The following policies and targets are applied to the planning:

- Malawi Water Sector Investment Plan (2012): 73% in 2015, 98% in 2025-2030
- Planning Year: 2020, 2025, 2035

(2) Planning Concept

Development concepts of the gravity-fed piped water supply are as follows:

- Secure a stable and safe water source
- Improve efficiency of operation
- Improve service level by sustainable operation under WUA

(3) Promotion of the Project for Gravity-Fed Piped Water Supply

Basically, if there are gravity-fed piped water supply projects in some areas, the areas are given priority to conduct water supply in rural communities because of the efficiency of the Project. **Table 2.2.7** to **Table 2.2.9** are the project list of gravity-fed piped water supply, and **Figure 2.2.5** is the location map of gravity-fed rural water supply schemes.

Table 2.2.6 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
Demand Projection	Population	Existing Water Supply Schemes
	Growth Rate	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

Table 2.2.7 List of Gravity-Fed Piped Rural Water Supply Schemes (1/3)

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						
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 2.2.8 List of Gravity-Fed Piped Rural Water Supply Schemes (2/3)

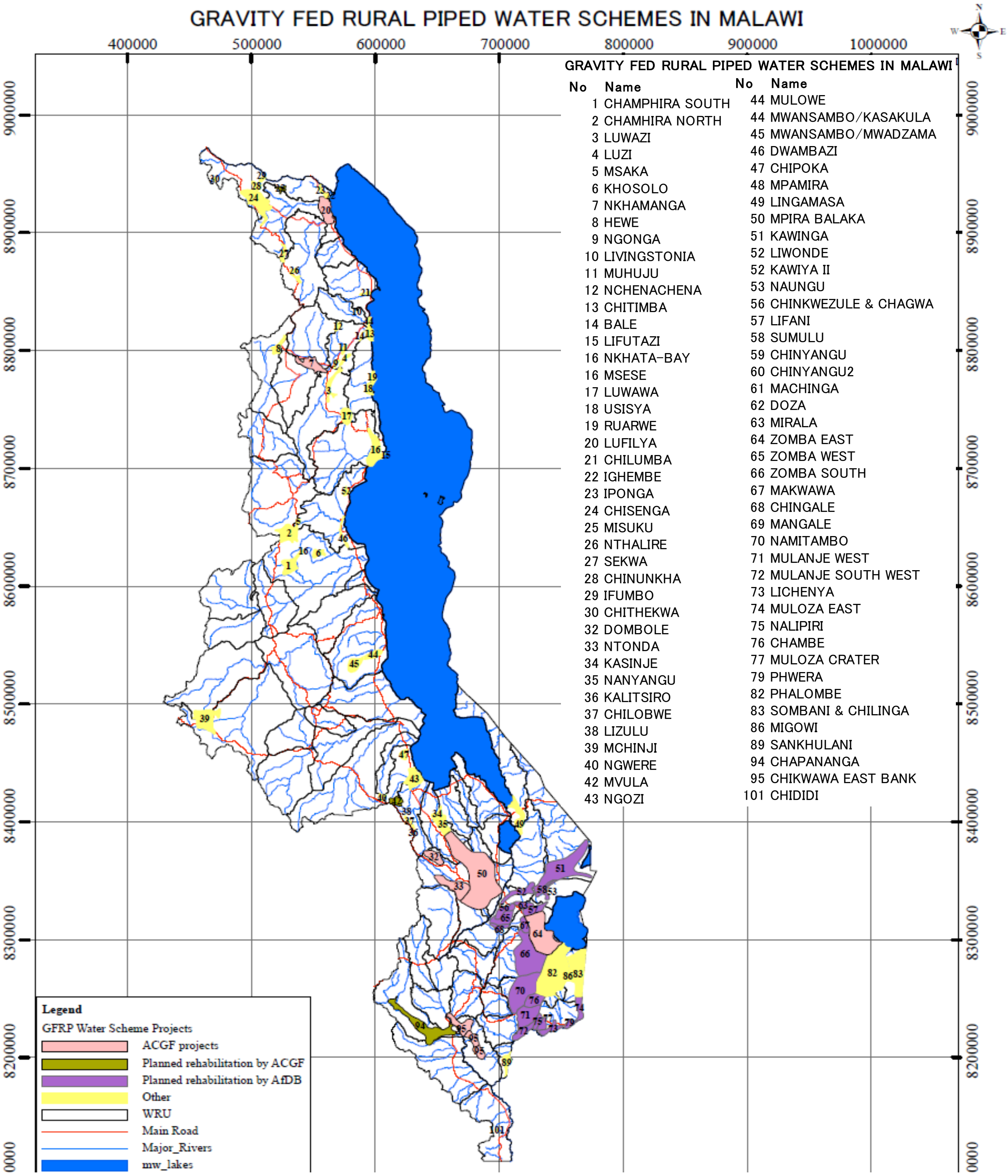
Region	District	Scheme	Existing Schemes					Population in 2012 estimated from Existing Schemes	** Rate 2012 Census Population to 2012 estimated population	Population in 2012 estimated by tap water share of District in Cessus 2008	Population Projection for the Project estimated based on Designed Population 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						
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 2.2.9 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						
	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
South	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



Source MoAIWD

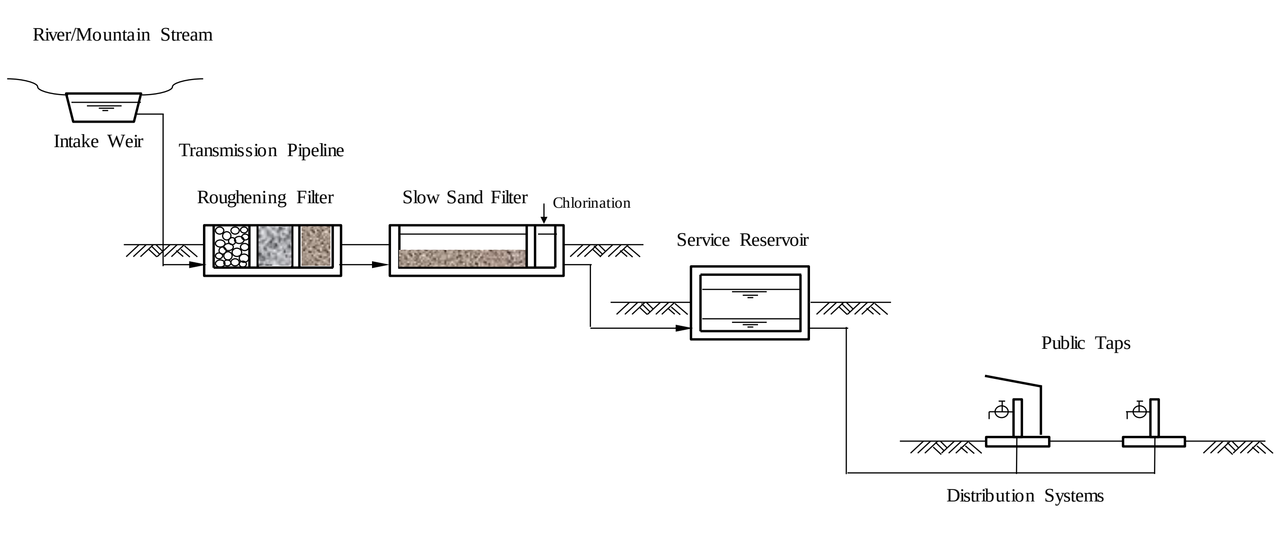
Figure 2.2.5 Location Map of the Gravity-Fed Rural Water Supply Schemes

(4) Availability of Water Source

A majority of the water sources for gravity-fed water supply schemes is river water with the slow filtration system as shown in **Figure 2.2.6**.

(5) Component of Water Supply Scheme

Gravity-fed water supply scheme is composed of intake, transmission pipe, treatment plant, service reservoir and distribution equipment. According to the field survey, it was observed that no treatment is made even for high turgidity. **Figure 2.2.6** shows the case with slow sand filter.



Source: Project Team

Figure 2.2.6 Component of WSS by Gravity-Fed Piped Water Supply

(6) Recommendation for Capacity Development

Rehabilitation and expansion of the gravity-fed piped water supply schemes is ongoing. However, many schemes still remain in their present condition and their information is not enough.

To facilitate water supply infrastructure in the gravity-fed projects, the following need to be strengthened:

- Mutual communication of information of schemes among MoAIWD, Local Government and MoLGRD.
- Capacity development of water supply section (District Water Office) at planning level.
- Coordination of finance for the improvement of gravity-fed projects in MoAIWD
- Participation of regional water boards offices/Local Government/WUAs of Target Communities in the planning and implementation stages.

(7) Action Plan and Implementation List

Action plan and Implementation list is shown and explained in **Subsection 2.2.5** .

2.2.4 Communities served by Borehole

(1) Promote Rehabilitation

At present, the majority of non-functional condition was caused by mechanical problems of the pumps. It is important to proceed with the rehabilitation works for more economical efficiency. In order to secure the sustainability of the schemes, actions for strengthening of operational organization are essential. In this context, the following actions were proposed in the Water Supply TWG meeting held in December 2013:

- Develop capacity of Rural Water Supply Management Structures.
- Increase community ownership and responsibility towards water points through education and publicity (e.g. community radio).

- Strengthen coordination role and develop capacity at district level for operation and maintenance activities.
- Develop a mechanism to measure unaccounted water in the water supply system managed by WUAs.
- Strengthen the O&M framework and encourage the engagement of other stakeholders to roll out and share with other districts.
- Reinforce the collection and submission of data using a standard template from district offices.
- Support community policing and the promotion of locking systems as a way to address vandalism.
- Conduct review and strengthen the management of water supply guidelines and manuals.

(2) Installation of New Borehole/Protected Shallow Well

There is still necessity of installation of new boreholes/protected shallow wells, and there is possibility the remaining area has some more difficulty in topography, hydrogeology and accessibility of drilling machine. It is recommendable for the research section of MoAIWD to evaluate the potential of groundwater development regionally or district-wise.

New installation or rehabilitation of non-functional boreholes has been conducted by NGO, Malawi Government and other donors. Around 5,400 new boreholes and 2,500 of borehole rehabilitation have been conducted under NWDP2, African Development Bank and UNICEF.

(3) Target

The following policies and targets are applied to the planning:

- Malawi Water Sector Investment Plan (2012): 95% in 2015, 98% in 2025-2030
- Planning Year: 2020, 2025, 2035

(4) Planning Concept

Development concept of the Water Supply Master Plan for the towns shall be as follows:

- Proceed with the rehabilitation work.
- Strengthen the operation and maintenance capacity of the water supply committees.
- New borehole construction for areas with few boreholes with no possibility of gravity-fed water supply.

Table 2.2.10 shows the calculated population served by boreholes. This population is estimated from the population of rural area except the population of Market Center and Gravity-Fed Water Supply Project.

Priority A, B and C were given by rate of no access to safe water source and rate of community standpipe (= gravity-fed piped water supply) shown in **Table 2.2.10** When no access to safe water is low, priority is high. When the rate of community standpipe is high, there is possibility to apply surface water like river and stream. Priority of borehole is evaluated to be low in such cases.

Table 2.2.10 Outline of Project of Regional Water Boards

Service Area		Towns
Responsible Entity		Local Government assisted by MoAIWD
Contents of the Project		Rehabilitation/New Water Supply Facilities of Borehole
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 Safe 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 Standpipe 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 2.2.11** 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 2.2.11 Project List of 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

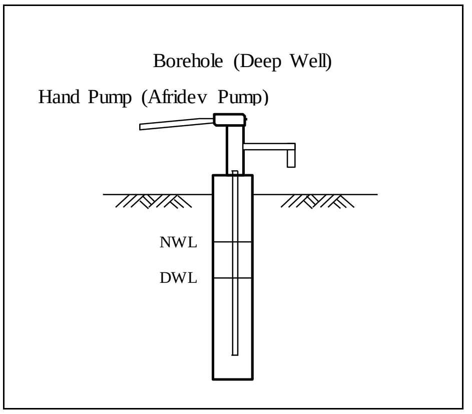
Source: Project Team

(5) Availability of Water Source

Some areas remain without borehole because of the difficulty to find good aquifers and the bad accessibility for drilling machines. It is recommended that the groundwater section of MoAIWD, in coordination with the local government, shall facilitate borehole construction, including technical assistance.

(6) Component of Water Supply Scheme

Components of borehole system are presented in **Figure 2.2.7** The system is composed of borehole with 50-100m in depth, hand-pump and platform with washing basin.



Source: Project Team

Figure 2.2.7 Borehole for Community

2.2.5 Action Plan and Implementation List for Rural Water Supply (Market Center, GFWS)

Figure 2.2.8 shows the action plan for rural water supply.

It is important to establish/introduce a “System” of planning – implementation for the Market Center and Gravity-Fed Piped Water Supply at first. Regional water offices and Local Governments (including District Water Office) need to review and grasp the real condition of these schemes. Periodical reporting system needs to be established at first. MoAIWD needs to establish concerned unit with staff, review priority and coordinate financial preparation.

Similar to the towns in **Subsection 2.1.8** , Feasibility Study is required when the water source is not confirmed. Basic Design can be started only in the schemes where the water source is not confirmed.

Table 2.2.12 is the list of market centers selected for the short-term plan. The schemes managed by the regional water boards are included in this list; however, there is possibility that the water supply facilities are aged and inadequate capacity. Required study point on water source is also shown in the table.

In the case of gravity-fed piped water supply schemes, ongoing schemes and those being funded are selected for the short-term plan as shown in **Table 2.2.13**. Feasibility study needs to be implemented for the schemes if the schemes are still uncertain plan of short-term and other schemes, middle-term plan in first stage.

In the case of borehole, Water, Sanitation and Hygiene Promotion Program (WASH) and “Groundwater Development & Management Program” is ongoing as mentioned in **Part I: Chapter 5**. MoAIWD needs to monitor the progress of these programs, and take financial measure when some districts still have lower access to safe water than the others.

Program	Project / Activities (WRA / Time Frame / Organ/Budget)	Prior	Time Frame: Short Term 2012-2020 (12–20), Middle Term 2021-2025 (21–25), Long Term 2026-2035 (26–35)	ponsible Organ: Main	ponsible Organ: Major
Market Center					
RW-1	Establishment of System & Organization for Market Center Project	All		MoAIWD	Local Gov. & MoLGRD
RW-2	Review/Monitoring of Water Supply Condition of Market Centers	All		ditto	Local Gov.
RW-3	Fesibility Study/Basic Desingn of Water Supply Project	Listed	for Short & Middle Term; for Short & Middle Term	ditto	Local Gov. & MoLGRD
RW-4	Implementation of the Project incl. Detailed Design	Listed		ditto	ditto
RW-5	Capacity Developmet of WUA	All		ditto	ditto
Gravity-fed Piped Water Supply					
RW-6	Establishment of System & Organization for Gravity-fed Piped Water Supply Project	All		MoAIWD	Local Gov. WUA
RW-7	Review/Monitoring of Water Supply Condition of Existing Schemes	All		ditto	Local Gov. (Water Office)
RW-8	Fesibility Study/Basic Desingn for Rehabilitation/Expansion of Water Supply Project	Listed	for Short & Middle Term; for Short & Middle Term	ditto	ditto
RW-9	Implementation of the Project incl. Detailed Design	Listed		ditto	Local Gov., WUA
RW-10	Capacity Developmet of WUA	All		ditto	ditto
Borehole					
RW-11	Monitoring of Borehole Schemes	All	Continuous Monitoring	Local Gov.	MoAIWD
RW-12	Implementation of Rehabilitation	All		Local Gov.	ditto
RW-13	Implementation of New Borehole Scheme	All		Local Gov.	ditto
RW-14	Capacity Development of Water Committee	All		MoAIWD	Local Gov.

Source: Project Team

Figure 2.2.8 Action Plan for Rural Water Supply

Table 2.2.12 List of Market Centers Selected for the Short-Term Plan

Region	District	Rural market centre	Population in 2012	Population 2020	Population 2025	Population 2035	Remarks	Project			
								Review Existing WSS & Water Source	Type by Borehole	Type by river	Type by Lake Water
North	Chitipa	Nthalire	5,400	6,949	8,133	11,021	Emergency by MoLGRD	✓	✓		
		Misuku	6,000	7,722	9,037	12,245		✓		✓	
	Karonga	Songwe	4,000	5,224	6,144	8,367	On-going/RWB Managing	-	-	-	-
		Chilumba	7,039	9,193	10,813	14,724	On-going/RWB Managing	-	-	-	-
	Nkhata-Bay	Mzenga	8,705	10,756	12,160	15,256		✓	✓		
		Usisya	6,341	7,835	8,857	11,113		✓		✓	
		Mpamba	9,220	11,393	12,880	16,160		✓	✓		
		Chikwina	4,535	5,603	6,334	7,948	On-going/RWB Managing	-	-	-	-
	Likoma	Likoma	7,683	9,505	10,755	14,140		✓			✓
	Rumphi	Katowo	3,718	4,767	5,554	7,434	Emergency by MoLGRD	✓		✓	
		Nchenachena	6,691	8,580	9,995	13,379	Nchenachena Gravity fed system	✓		✓	
		Livingstonia	9,321	11,953	13,925	18,638		✓		✓	
		Bolero	8,046	10,318	12,020	16,088		✓		✓	
		Chiweta	5,314	6,815	7,939	10,626		✓	✓		
	Mzimba	Euthini	5,699	7,365	8,579	11,396	Emergency by MoLGRD	✓	✓		
		Ekwendeni	13,695	17,698	20,616	27,386	Center is supplied by Mzuzu	✓		✓	
		Edingeni	5,503	7,112	8,284	11,004		✓	✓		
		Embangweni	5,489	7,093	8,263	10,976		✓	✓		
Central	Kasungu	Nkhamenya	6,990	11,782	15,569	25,057	On-going/RWB Managing	-	-	-	-
		Chisemphere	3,540	5,967	7,885	12,691	On-going/RWB Managing	-	-	-	-
		Chamama	7,400	12,474	16,484	26,528		✓		✓	
		Santhe	6,286	10,596	14,002	22,535	On-going/RWB Managing	-	-	-	-
	Nkhotakota	Msenjere	3,730	4,923	5,833	8,085	Emergency by MoLGRD	✓	✓		
		Dwambazi	8,000	10,559	12,510	17,342		✓		✓	
		Dwangwa	12,662	16,712	19,801	27,448	On-going/RWB Managing	-	-	-	-
		Mwasambo	6,400	8,447	10,008	13,873		✓	✓		
	Ntchisi	Malomo	4,200	5,570	5,185	5,741	Emergency by MoLGRD	✓	✓		
	Dowa	Madisi	10,500	13,506	15,831	21,568	On-going/RWB Managing	-	-	-	-
		Nambuma	4,870	6,264	7,342	10,003	Emergency	✓	✓		
		Mponela	4,300	5,531	6,483	8,833	On-going/RWB Managing	-	-	-	-
		Lumbazi	4,500	5,788	6,785	9,243	On-going/RWB Managing	-	-	-	-
		Chipoka	7,640	9,974	11,756	16,351	On-going/RWB Managing	-	-	-	-
		Kaphatenga	2,400	3,133	3,693	5,137	Emergency by MoLGRD	✓	✓		
	Lilongwe	Kasiya	3,915	5,476	6,630	9,439	On-going/RWB Managing	-	-	-	-
		Nkhoma	5,320	7,441	9,009	12,826		✓	✓		
		Nsaru	2,620	3,664	4,436	6,316	On-going/RWB Managing	-	-	-	-
		Namitete	6,891	9,638	11,669	16,613		✓	✓		
		Mitundu	6,872	9,612	11,637	16,568	On-going/RWB Managing	-	-	-	-
		Nathenje	5,645	7,896	9,559	13,609	On-going/RWB Managing	-	-	-	-
		Lumbadzi	7,400	10,350	12,531	17,840	On-going/RWB Managing	-	-	-	-
	Mchinji	Mkanda	8,750	10,602	12,023	15,537	On-going/RWB Managing	-	-	-	-
		Kapiri	5,645	6,840	7,757	10,024	Emergency by MoLGRD	✓	✓		
		Kamwendo	10,110	12,251	13,893	17,953	On-going/RWB Managing	-	-	-	-
	Dedza	Mtakataka	6,369	10,012	12,826	19,732	Emergency by MoLGRD	✓	✓		
		Mayani	5,039	7,921	10,147	15,611		✓	✓		
		Linthipe	3,886	6,108	7,825	12,038	On-going/RWB Managing	-	-	-	-
		Lobi	9,905	15,571	19,947	30,687		✓	✓		
		Golomoti	6,400	10,061	12,888	19,828		✓	✓		
		Bembeke	2,500	3,930	5,034	7,745	Served by New Mvula Scheme	✓		✓	
	Ntcheu	Lizulu	4,696	6,227	7,412	10,444		✓		✓	
		Senzani	5,333	7,073	8,419	11,863		✓	✓		
		Mlangeni	3,000	3,978	4,736	6,673	Emergency by MoLGRD	✓	✓		
South	Mangochi	Makanjira	5,800	7,178	8,174	10,551		✓	✓		
		Malindi	6,800	8,416	9,583	12,371	Emergency by MoLGRD	✓	✓		
		Namwera	6,500	8,045	9,160	11,825	On-going/RWB Managing	-	-	-	-
		Maldeco	5,400	6,745	7,781	10,271	On-going/RWB Managing	-	-	-	-
		Namiyasi	3,450	4,310	4,971	6,562	Emergency by MoLGRD	✓			✓
		Monkey Bay	6,300	7,870	9,078	11,983	On-going/RWB Managing	-	-	-	-
		Cape Maclear	3,200	3,997	4,611	6,086	Emergency by MoLGRD	✓			✓
	Balaka	Phalula	7,293	9,240	10,740	14,402	Emergency by MoLGRD	✓		✓	
		Ulongwe	5,311	6,729	7,821	10,488	Emergency by MoLGRD	✓	✓		
		angochi Turn o	3,100	3,928	4,565	6,122	Emergency by MoLGRD	✓	✓		
	Machinga	Nayuchi	3,200	3,997	4,611	6,086	Emergency by MoLGRD	✓	✓		
		Chinseu	2,700	3,583	4,297	6,130	Emergency by MoLGRD	✓		✓	
		Thondwe	4,115	5,461	6,549	9,343	On-going/RWB Managing	-	-	-	-
		Mbulumbuzi	3,120	4,007	4,721	6,532	Emergency by MoLGRD	✓	✓		
	Blantyre	Lirange Nkula	7,620	12,239	15,876	24,935	On-going/RWB Managing	-	-	-	-
		Linjidzi	3,194	5,130	6,654	10,451	Emergency by MoLGRD	✓	✓		
	Mwanza	Thambani	4,200	5,037	5,639	6,955	Emergency by MoLGRD	✓	✓		
		Goliati	6,804	9,318	11,178	15,640	Emergency by MoLGRD	✓	✓		
		Bvumbwe	8,800	12,051	14,457	20,228		✓	✓		
		Luchenza	16,901	23,145	27,766	38,848	On-going/RWB Managing	-	-	-	-
	Mulanje	Muloza	5,248	5,918	6,325	7,039	On-going/RWB Managing	-	-	-	-
		Mkando	5,285	5,960	6,369	7,089	Emergency by MoLGRD	✓	✓		
		Kamwendo	4,855	5,475	5,851	6,512	Emergency by MoLGRD	✓		✓	
		Phaloni	4,180	4,811	5,302	6,398	Emergency by MoLGRD	✓		✓	
	Chikwawa	Chapananga	6,027	6,700	7,192	8,227	Emergency by MoLGRD	✓		✓	
		Ngabu	15,889	17,661	18,959	21,687	On-going/RWB Managing	-	-	-	-
		Nchalo	18,323	20,367	21,865	25,010	On-going/RWB Managing	-	-	-	-
	Nsanje	Bangula	10,147	12,487	14,401	19,020	On-going/RWB Managing	-	-	-	-
		Miseu Folo	4,250	5,230	6,032	7,967	On-going/RWB Managing	-	-	-	-

Source: Project Team, RWB, MoLGRD

Table 2.2.13 Project of the Gravity-Fed Piped Water Supply for the Short-Term Plan

Region	District	Scheme	Original Schemes		Planned Population				On-going/Possibility
			Designed Population	Constructed Year	2,012	2,020	2,025	2,035	
North	RUMPHI	Nkhamanga	12,000	1978	31,828	40,815	47,549	63,643	ACGF & WB
	RUMPHI	Hewe	8,000	1977	21,855	28,026	32,651	43,701	AFDB
	RUMPHI	Ng'onga	2,000	1972	6,334	8,122	9,463	12,665	AFDB
	RUMPHI	Livingstonia	3,000	1984	6,664	8,545	9,955	13,325	AFDB
	RUMPHI	Muhuju	1,000	1973	3,075	3,943	4,594	6,148	AFDB
	RUMPHI	Ntchenachena	3,200	2002	4,175	5,354	6,238	8,349	AFDB
	RUMPHI	Chitimba	950	1997	1,437	1,843	2,147	2,873	AFDB
	NKATA BA	Usisya	14,880	1997	21,903	27,064	30,596	38,389	WB
	CHITIPA	Misuku	8,760	1984	22,177	28,540	33,401	45,260	WB
	CHITIPA	Nthalire	6,120	1983	16,035	20,637	24,151	32,727	ISP
Central	NTCHEU	Mpira Balaka	222,000	1992	354,900	470,652	560,229	789,378	AFDB
	NTCHEU	Ntonda	25,000	1980	53,750	71,281	84,847	119,552	AFDB
	NTCHEU	Kalitsiro	1,000	1977	2,315	3,070	3,655	5,150	WB
	NTCHEU	Chilobwe	1,200	1975	2,919	3,871	4,608	6,493	WB
	NTCHEU	Lizulu	6,000	1978	13,553	17,973	21,394	30,145	WB
	DEDZA	Ngwere	4,200	1976	10,314	16,213	20,769	31,952	WB
	DEDZA	Mvula	8,760	1983	17,973	28,254	36,194	55,683	ACGF
South	BALAKA	Mpira-Balaka	222,000	1983	419,634	531,714	618,008	828,726	ACGF
	MACHINGA	Kawinga	70,000	1983	155,858	194,687	224,581	296,443	AFDB
	MACHINGA	Liwonde	23,000	1983	51,210	63,969	73,791	97,403	AFDB
	MACHINGA	Naungu	1,800	2001	2,396	2,993	3,452	4,557	AFDB
	MACHINGA	Nkala	1,080	2002	1,397	1,745	2,013	2,657	AFDB
	MACHINGA	Chagwa	7,000	1976	19,039	23,782	27,434	36,212	AFDB
	MACHINGA	Chinkwenzule	2,000	1983	4,453	5,562	6,417	8,470	AFDB
	MACHINGA	Lifani	20,000	1977	52,863	66,033	76,172	100,546	AFDB
	MACHINGA	Zumulu	23,500	2001	31,277	39,069	45,068	59,489	AFDB
	MACHINGA	Chanyungu	7,800	2000	10,682	13,344	15,392	20,318	AFDB
	MACHINGA	Chanyungu 2	1,320	1983	2,939	3,671	4,235	5,590	AFDB
	MACHINGA	Machinga	1,200	1983	2,672	3,337	3,850	5,082	AFDB
	MACHINGA	Doza	1,320	2003	1,659	2,073	2,391	3,156	AFDB
	MACHINGA	Mirala	13,000	1985	27,337	34,147	39,390	51,994	AFDB
	MACHINGA	Mangale	1,320	1983	2,939	3,671	4,235	5,590	AFDB
	ZOMBA	Zomba East-Doma	100,000	1981	119,657	158,787	190,435	271,671	ACGF
	ZOMBA	Zomba west	60,000	1986	69,679	92,465	110,894	158,199	AFDB
	ZOMBA	Makwawa south	8,040	1986	9,337	12,390	14,860	21,199	AFDB
	ZOMBA	Makwawa North	16,000	1986	18,581	24,657	29,572	42,186	AFDB
	ZOMBA	Chingale	5,000	1968	6,467	8,581	10,292	14,682	AFDB
	MULANJE	Namitambo	60,000	1979	113,072	127,511	136,274	151,662	AFDB
	MULANJE	Mulanje West	90,000	1975	183,590	207,033	221,261	246,246	AFDB
	MULANJE	Mulanje SW	24,000	1989	37,104	41,841	44,717	49,766	AFDB
	MULANJE	Lichenya	46,000	1982	81,689	92,120	98,451	109,568	AFDB
	MULANJE	Muloza East	32,000	1983	55,713	62,827	67,145	74,726	AFDB
	MULANJE	Nalipiri	9,000	1983	15,669	17,670	18,884	21,017	AFDB
	MULANJE	Phwera	32,000	1983	55,713	62,827	67,145	74,726	AFDB
	THYOLO	Sankhulani	15,000	2005	17,395	23,822	28,579	39,985	DAPP & UNICEF
	CHIKWAW	Mwanza/ chapana	60,000	1983	104,461	116,114	124,650	142,580	WB
	CHIKWAW	East Bank	18,720	1997	24,701	27,456	29,474	33,714	ACGD

Source: Project Team, RWB, MoLGRD

Table 2.2.14 shows the results for rural water supply projects when all the projects are proceeded on the priority, i.e., water supply for Market Center, Communities by GFWS. As mentioned above, borehole implementation is conducted in all districts simultaneously. Population of the target year 2035 is applied for Market Center and Gravity-Fed Piped Water Supply projects.

Table 2.2.14 Results for the Water Supply Project for Rural Areas

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 with Gravity-Fed Water Supply	District Council/MoAIWD	Rehabilitation, Expansion & Establishment of WUA	47	2,112,983	22	1,358,125	33	516,327
Communities with Borehole Water Supply	District Council/MoAIWD	Accessibility to Safe Water; Possibility of Groundwater	All Districts	2,546,778 (increased population)	All Districts	3,349,732 (increased population)	All Districts	4,356,115 (increased population)

Source: Project Team

PART II

Chapter 3. DEVELOPMENT PLAN FOR IRRIGATION WATER SUPPLY

CHAPTER 3. DEVELOPMENT PLAN FOR IRRIGATION WATER SUPPLY

The National Irrigation Policy and Development Strategy was formulated in 2011 to provide a clear statement of the Government's aspirations for the irrigation sector as provided in the Malawi Growth and Development Strategy (MGDS), and to highlight the strategy for attaining irrigation development objectives.

The occurrence of droughts and their effect on agricultural production have resulted in increased emphasis on irrigation development. The role of the government in irrigation development and management is that of a facilitator in a market oriented economy. Current high population growth rates demand much more of irrigated agriculture than in the past and Malawi needs to realize a major growth in both agricultural production and export earnings to meet the needs of the expanding population and at the same time provide for some improvement in per capita food consumption. Considering the relatively limited land and water resources in the country, irrigation could provide a significant technical means to increase agricultural output.

Sustainable irrigation development can be achieved within a policy framework which reflects national development policy hence the need for a clear and comprehensive policy to guide irrigation development in Malawi. There is also a need to view irrigation in the broad context of national development so that it contributes to the socio-economic advancement of the population. Irrigation must also fit into a strategy of sustainable and environmentally appropriate natural resources development and management.

3.1 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 of how irrigation area will increase until the target year.

3.1.1 Design Drought

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

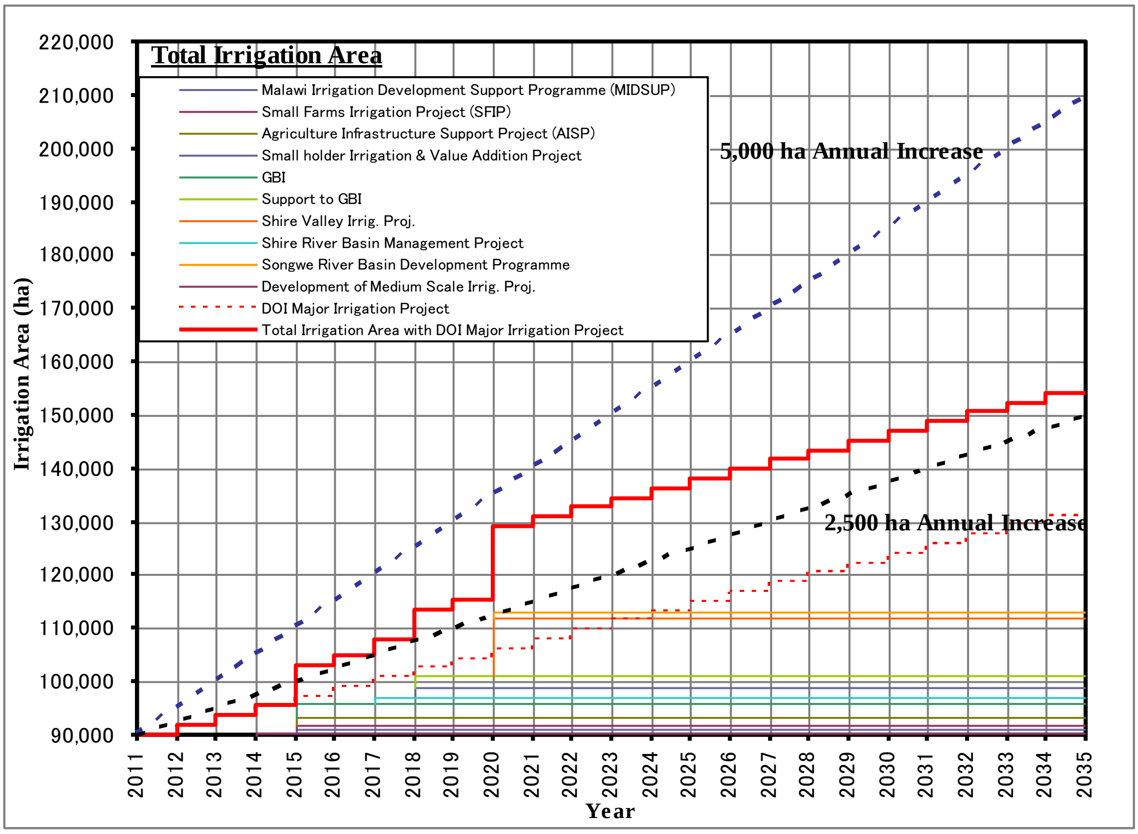
3.1.2 Step-wise Improvement

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 will be arranged in accordance with the parameters of irrigation development effects which are: (1) cost efficiency; (2) availability of water resources; and (3) high development effectiveness.

3.1.3 Irrigation Development Scenarios

Discussion has been made on annual irrigation development with DOI. Both sides agreed on the two development scenarios: One is the 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 3.1.1**. The figure depicts the existing ongoing and planned irrigation development projects as well, and these projects/schemes are enumerated in **Table 3.1.1** and **Table 3.1.2**.

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, MoAIRD

Figure 3.1.1 Irrigation Development Scenarios

Table 3.1.1 Major Projects for Implementation

Item No.	Project Name	Irrigation Area (ha)	F/S	Implement-ation	Crops	Remarks
1	Malawi Irrigation Development Support Program (MIDSUP)	900		2015	Varies	Ongoing
2	Small Farms Irrigation Project (SFIP)	1,600	1 yr.	2015	Rice & others	Ongoing
3	Agriculture Infrastructure Support Project (AISP)	1,600		2015	Horticulture & maize	Ongoing
4	Small holder Irrigation & Value Addition Project	3,345		~2018		Ongoing
5	GBI	2,500		2015	Rice & Sugarcane	Ongoing
6	Support to GBI	4,650	F/S	2018		
7	Shire Valley Irrigation Project	11,000	F/S	2020	Sugarcane, Rice, Cotton	D/D: 2 yrs.
8	Shire River Basin Management Project	1,000		2017		Ongoing
9	Songwe River Basin Development Program	1,000	F/S	2020		
10	Development of Medium Scale Irrigation Project	200		2014		Ongoing

Source: Project Team, OPC, MoAIWD, WB

Table 3.1.2 Major Irrigation Projects of DOI

ISD	Status	Name of Project		Irrigation Area (ha)	Major Crops	Water Source
Karonga	Ongoing	Nothla/Ilora-Ngosi Irrigation Site (GBI-Pilot)		1,200		L. Malawi
		Mphenga Corled		480		Wovwe R.
		Timoti Irrigation S.		75		Tinofi R.
		Ukanga Irrigation Site		61		Nyungwe R.
Mzuzu	Ongoing	Limphasa (Gravity)		403	rice	Limphasa R.

Source: Project Team, MoAIWD

3.1.4 Planning Concepts

The irrigation development plan shall be formulated in the following process and concepts:

(1) 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.

(2) Irrigation development schemes shall combine structural measures and non-structural measures.

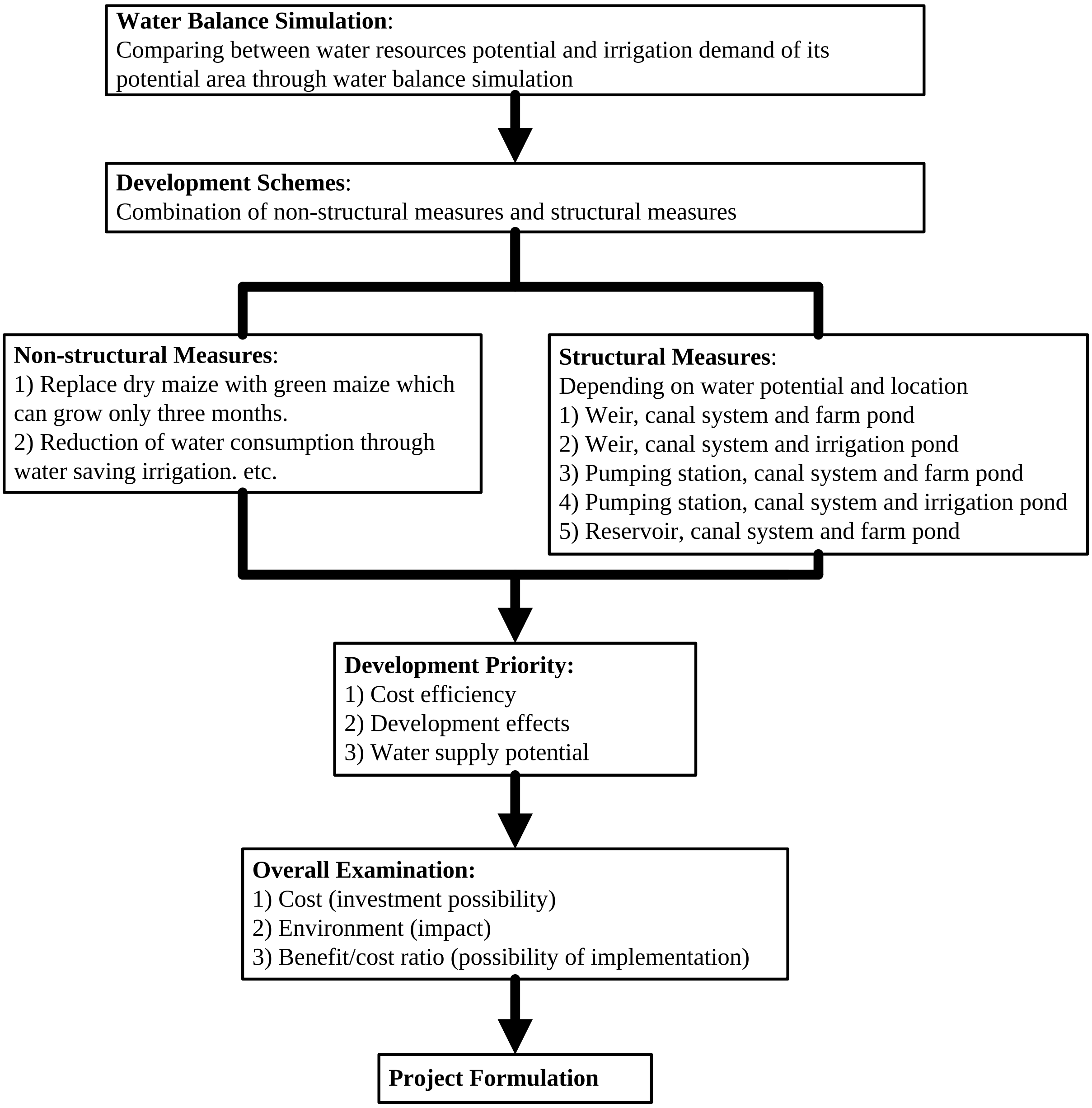
(3) Structural components shall be arranged water intake facilities of weir or pump, conveyance and distribution canal system, and water distribution or storage ponds. Their suitable components shall be determined depending on the water availability and their topographic features. Furthermore, reservoir scheme could be proposed for meeting a large amount of water deficit.

(4) Non-structural measures could be applied as replacement of normal crops to earlier growing crops or introduction of water saving cultivation.

(5) 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.

(6) Finally project viability shall be examined judging from investment possibility in cost, environmental impact, and benefit and cost ratio as implementation possibility.

The planning process and concepts are presented in **Figure 3.1.2**.



Source: Project Team

Figure 3.1.2 Irrigation Water Development Process

3.2 Irrigation Development Area and Non-Structural Application

Prior to describing the water balance analysis, its preconditions are summarized below: (1) irrigation potential area, (2) cropping patterns and non-structural application, and (3) other irrigation factors such as existing irrigation methods and irrigation efficiency.

3.2.1 Irrigation Potential Area

The irrigation potential area, provided by DOI, is the same as that of the WRIS (Water Resources Investment Strategy financed by the World Bank) report compiled in April 2011, as shown in **Table 3.2.1**. On the other hand, the Irrigation Master Plan in Malawi financed by the World Bank is now under study. 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 summarized in **Table 3.2.2**. There are some discrepancies between the area of DOI and that of the Master Plan. The water balance simulation is conducted using the latter potential area as an upper limit for irrigation development by Water Resources Area (WRA).

Table 3.2.1 Irrigation Potential Area by DOI

WRA	Irrigation Potential Area by DOI	WRA	Irrigation Potential Area by DOI	WRA	Irrigation Potential Area by DOI
1	103,450	7	31,200	14	28,100
2	61,500	8	1,700	15	94,500
3	43,300	9	18,300	16	16,800
4	4,890	10	3,600	17	15,000
5	21,200	11	12,630		
6	28,800	12/13	-	Total	484,970

Source: DOI/WRIS; Unit: ha

Table 3.2.2 Irrigation Potential Area in the Irrigation Master Plan

WRA	Potential Area	WRA	Potential Area
1	761,100	9	107,300
2	228,900	10	46,100
3	253,400	11	128,600
4	555,100	14	169,500
5	752,900	15	192,000
6	313,800	16	66,500
7	504,300	17	37,500
8	20,800	Total	4,137,800

Source: SMEC, World Bank's Study Team.
Unit: ha

3.2.2 Cropping Patterns and Non-Structural Application

Based on the results of initial water balance analysis, it is proven that water is still available at the early stage of the dry season. Therefore, the possibility of crop diversification, such as shifting crop cultivation and application of early growing crops, are proposed for saving available water as a non-structural application. The following three applications were examined.

Green Maize Cultivation: It is said that Green Maize takes only three months to cultivate and that it is a life line for the farmers. Therefore, Green Maize is adopted for the dry season cultivation.

(1) Shifting Dry Maize/Wheat Cultivation: Dry maize/wheat may start growing from April. Sometimes, however, June and July become cooler and crops cannot grow properly. According to DOI, they interviewed some farmers on this fact, and most farmers were reluctant to take such measure of shifting dry maize/wheat cultivation. Therefore, this measure is not adopted.

(2) Early Growing Rice: There are around 12 varieties of rice in Malawi and "Pussa 33" seems to be suitable for early cropping. Cultivation period is from 112 to 140 days depending on the climate, and the yield is high, around 6 tons/ha.

Following the above considerations, Green Maize Cultivation and Early Growing of Rice are adopted as the non-structural applications. The cropping pattern/irrigation requirement of Chileka Climate Station is shown in **Figure 3.2.1** as an example.

The modification of cropping pattern can be reduced the water consumption of irrigation area as shown in **Figure 3.2.3**, which results in cost-effective irrigation development without a large scale of water use facilities. Furthermore, the economic effects of the above-mentioned cropping modification are examined through water balance analysis and preliminary arrangement of necessary irrigation facilities in WRAs. In the case of annual irrigation area increase at 5,000 ha/year, the cropping modification could reduce the total cost by 34% from the normal cropping as presented in **Figure 3.2.2**. Thus, the irrigation plan hereinafter will be developed adopting the Green Maize Cultivation and the Early Growing of Rice in the dry season.

Normal Cropping Pattern:

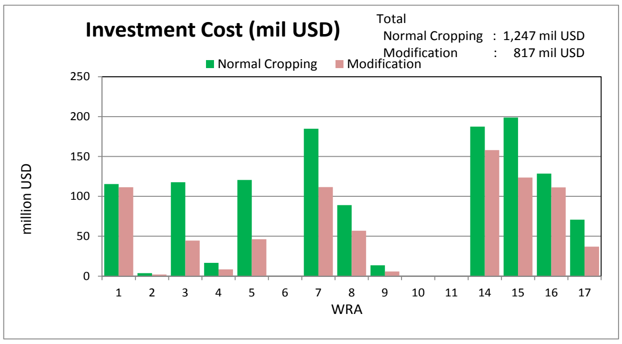
Crop	Month 1	2	3	4	5 (Dry Season)	6 (Dry Season)	7 (Dry Season)	8 (Dry Season)	9 (Dry Season)	10 (Dry Season)	11	12
Maize Dry					17	52	131	194	169	4		
Maize Wet	15	14	8	0							0	0
Rice Dry					117	258	134	194	216	83		
Rice Wet	23	15	12								98	126
Cotton	6	13	35	75	28						0	0
Tobacco	21	6	6	7						38	56	43
Sugercane	35	21	46	111	137	106	32		36	85	112	60
Coffee	0	0	10	74	108	106	115	155	176	176	96	21
Tea	1	0	13	81	115	110	119	161	183	185	105	20

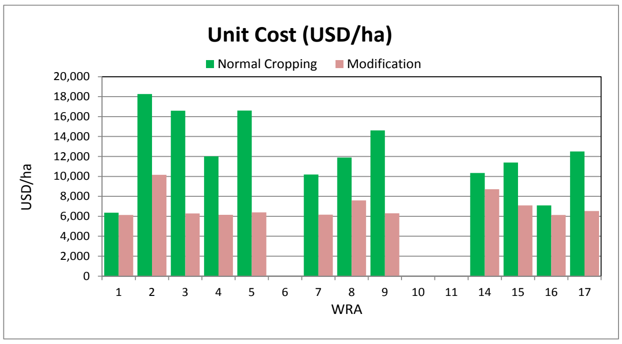
Application of Green Maize and Early Growing Rice:

Crop	Month 1	2	3	4	5 (Dry Season)	6 (Dry Season)	7 (Dry Season)	8 (Dry Season)	9 (Dry Season)	10 (Dry Season)	11	12
Green Maize					17	52	131	0				
Maize Wet	15	14	8	0							0	0
Early Rice					117	258	134	194	71			
Rice Wet	23	15	12								98	126
Cotton	6	13	35	75	28						0	0
Tobacco	21	6	6	7						38	56	43
Sugercane	35	21	46	111	137	106	32		36	85	112	60
Coffee	0	0	10	74	108	106	115	155	176	176	96	21
Tea	1	0	13	81	115	110	119	161	183	185	105	20
Total	101	69	129	348	523	632	530	510	466	484	466	270

Note: The value is irrigation requirement in mm/month.
Source: Project Team, WB, DOI

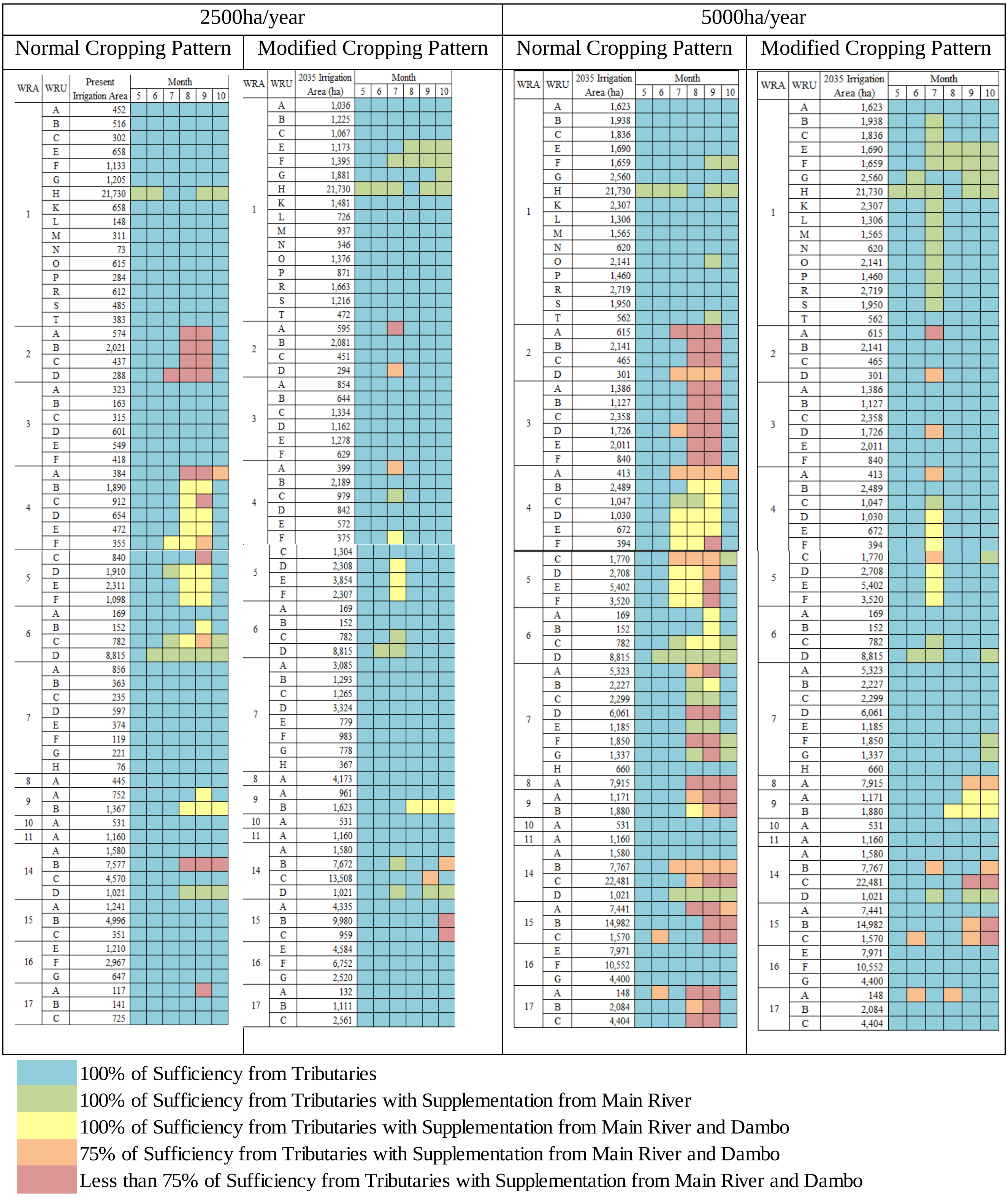
Figure 3.2.1 Cropping Pattern/Irrigation Requirement of Chileka Climate Station





Source: Project Team

Figure 3.2.2 Economic Effects of Cropping Pattern Modification



Source: Project Team

Figure 3.2.3 Effects on Water Deficit by Cropping Pattern Modification (2035 Year)

3.2.3 Other Irrigation Factors

(1) Irrigation Return Flow

Irrigation return flow is set at 10% for paddy and 0% for other crop fields.

(2) Irrigation Method

It is reported that the method of gravity-fed and motorized pump (M/P) will be increased to 65%, while treadle pump (T/P) and watering can (W/C) will become 35% as shown the table below.

Table 3.2.3 Irrigation Area by Irrigation Method

Irrigation Method	Number of Schemes	Area Utilized for Irrigation (ha)	Ratio of Irrigation Method (%)		Future Method (%)
Gravity Fed	2,954	22,028	52.2	59	65
Motorized Pump (M/P)	865	2,875	6.8		
Treadle Pump (T/P)	12,157	12,162	28.8	41	35
Watering Can (W/C)	27,820	5,116	12.2		
Total	43,796	42,181	100		100

Source: DOI Annual Report, 2010/11

In view of the irrigation method, actual water consumption for treadle pumps and watering cans may be less than that of the gravity-fed and motorized pump methods. The reduction rate of water consumption for treadle pump and watering can is to be taken as 20%.

In the irrigation development plan, however, the proposed irrigation methods are mainly gravity-fed type and motorized pump type, so that the plan will not consider/include the above reduction.

(3) Irrigation Efficiency

Irrigation efficiency set as shown in the following table through the consultation with DOI during and after the Second Steering Committee Meeting.

Table 3.2.4 rrigation Efficiency by Irrigation Method

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

Source: Project Team

3.3 Water Balance Analysis

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

3.3.1 Allocation of Irrigation Development Area

Existing and planned irrigation areas are allocated to water resource areas (WRAs) in the following manner.

(1) Existing Irrigation Area

There is no available data on existing irrigation area by WRA so that most likely values were allocated to the WRAs from the total area of 90,000 ha utilizing various data sources of FAO report and district information.

(2) Irrigation Development Area

Following the two development scenarios of 2,500 ha/year and 5,000 ha/year, the irrigation development areas are allocated in consideration of a suitable balance between water demands from irrigation development areas and water development potentials from surface water simulation. After some trial and error approach, the irrigation development area by WRA is determined in the two scenarios.

Those irrigation areas are tabulated below.

Table 3.3.1 Existing and Irrigation Development Areas

Unit: ha

WRA	Present	Development Scenarios	
		2,500ha/year	5,000ha/year
	2011	2035	2035
1	29,564	38,596	47,665
2	3,320	3,421	3,523
3	2,368	5,901	9,448
4	4,668	5,355	6,046
5	6,159	9,773	13,401
6	9,918	9,918	9,918
7	2,840	11,873	20,941
8	445	4,173	7,915
9	2,119	2,584	3,050
10	531	531	531
11	1,160	1,160	1,160
14	14,749	23,781	32,849
15	6,589	15,274	23,993
16	4,823	13,856	22,924
17	982	3,804	6,636
Total	90,235	150,000	210,000

Source: Project Team

3.3.2 Estimation of Water Demand

Based on the irrigation development areas in the two development scenarios, water demand is estimated including livestock demand. The livestock population in the target years is estimated using ratio to projected human population. Unit water consumption of livestock is shown below.

Table 3.3.2 Consumption Figures for Livestock

	Water consumption (l/animal/day)	
Type of livestock	HR Wallingford (2003)	This assessment
Beef cattle	25–45	40
Dairy cattle	40–60	
Pigs	10–20	15
Sheep and goats	4–10	7
Chickens	30–40 per 100 birds	35 per 100 birds

Source: WRIS (Water Resources Investment Strategy)

Irrigation and livestock water demands are shown in **Table 3.3.3** and **Table 3.3.4** in accordance with the two irrigation development scenarios.

Table 3.3.3 Irrigation and Livestock Water Demands in 2,500 ha/year Scenario

Unit: m^3/year

WRA	Present			WRA	2020		
	Irrigation	Livestock	Total		Irrigation	Livestock	Total
1	361,261,289	11,332,212	372,593,500	1	383,877,231	13,327,288	397,204,519
2	18,185,172	3,250,912	21,436,085	2	8,235,363	3,951,093	12,186,456
3	34,804,822	2,882,417	37,687,238	3	19,207,000	2,602,792	21,809,792
4	71,021,657	6,458,333	77,479,990	4	39,760,793	12,479,757	52,240,550
5	84,443,769	6,978,125	91,421,894	5	50,792,193	10,638,111	61,430,304
6	143,938,714	2,209,747	146,148,461	6	125,494,105	2,338,019	127,832,124
7	17,330,972	3,689,596	21,020,568	7	20,117,695	17,795,865	37,913,560
8	4,088,837	388,793	4,477,630	8	3,112,255	500,833	3,613,088
9	21,353,830	1,930,059	23,283,889	9	16,235,176	2,499,465	18,734,641
10	7,607,614	448,055	8,055,669	10	4,492,858	618,525	5,111,383
11	18,003,753	1,480,764	19,484,517	11	10,933,164	1,134,638	12,067,803
14	74,009,846	3,846,227	77,856,072	14	54,878,359	4,491,368	59,369,727
15	35,973,559	1,996,068	37,969,627	15	28,538,331	2,473,788	31,012,119
16	40,714,029	522,491	41,236,520	16	22,676,425	985,890	23,662,316
17	15,278,160	995,630	16,273,789	17	11,230,460	1,314,451	12,544,911
Total	948,016,021	48,409,428	996,425,449	Total	799,581,406	77,151,884	876,733,291
WRA	2025			WRA	2035		
	Irrigation	Livestock	Total		Irrigation	Livestock	Total
1	386,407,355	15,420,751	401,828,106	1	386,233,940	20,654,771	406,888,711
2	8,235,363	4,440,203	12,675,566	2	8,288,218	5,772,901	14,061,119
3	19,207,000	3,035,812	22,242,812	3	45,611,027	4,106,096	49,717,123
4	39,760,793	14,638,418	54,399,211	4	39,886,867	19,968,922	59,855,789
5	50,792,193	12,620,284	63,412,477	5	56,528,399	17,359,984	73,888,384
6	125,494,105	2,845,701	128,339,805	6	125,494,105	3,970,685	129,464,790
7	26,872,467	20,701,133	47,573,601	7	27,754,610	27,836,774	55,591,384
8	29,283,658	572,215	29,855,872	8	29,181,152	755,841	29,936,994
9	18,205,856	2,648,501	20,854,357	9	19,794,876	3,508,490	23,303,367
10	4,492,858	741,808	5,234,666	10	4,492,858	1,029,607	5,522,464
11	10,933,164	1,352,771	12,285,936	11	10,933,164	1,867,380	12,800,544
14	54,878,359	4,923,023	59,801,383	14	91,649,885	6,247,296	97,897,181
15	28,538,331	2,933,901	31,472,232	15	66,097,930	4,026,800	70,124,730
16	43,949,413	1,150,553	45,099,966	16	63,236,961	1,551,478	64,788,439
17	11,230,460	1,530,740	12,761,200	17	43,545,285	2,061,307	45,606,592
Total	858,281,374	89,555,816	947,837,189	Total	1,018,729,278	120,718,333	1,139,447,610

Source: Project Team

Table 3.3.4 Irrigation and Livestock Water Demands in 5,000 ha/year Scenario

Unit: m^3/year

WRA	Present			WRA	2020		
	Irrigation	Livestock	Total		Irrigation	Livestock	Total
1	361,261,289	11,332,212	372,593,500	1	425,623,092	13,327,288	438,950,380
2	18,185,172	3,250,912	21,436,085	2	8,423,377	3,951,093	12,374,470
3	34,804,822	2,882,417	37,687,238	3	19,207,000	2,602,792	21,809,792
4	71,021,657	6,458,333	77,479,990	4	44,665,234	12,479,757	57,144,991
5	84,443,769	6,978,125	91,421,894	5	65,916,249	10,638,111	76,554,360
6	143,938,714	2,209,747	146,148,461	6	125,494,105	2,338,019	127,832,124
7	17,330,972	3,689,596	21,020,568	7	33,715,501	17,795,865	51,511,367
8	4,088,837	388,793	4,477,630	8	3,112,255	500,833	3,613,088
9	21,353,830	1,930,059	23,283,889	9	16,235,176	2,499,465	18,734,641
10	7,607,614	448,055	8,055,669	10	4,492,858	618,525	5,111,383
11	18,003,753	1,480,764	19,484,517	11	10,933,164	1,134,638	12,067,803
14	74,009,846	3,846,227	77,856,072	14	54,878,359	4,491,368	59,369,727
15	35,973,559	1,996,068	37,969,627	15	28,538,331	2,473,788	31,012,119
16	40,714,029	522,491	41,236,520	16	22,676,425	985,890	23,662,316
17	15,278,160	995,630	16,273,789	17	11,230,460	1,314,451	12,544,911
Total	948,016,021	48,409,428	996,425,449	Total	875,141,585	77,151,884	952,293,470
WRA	2025			WRA	2035		
	Irrigation	Livestock	Total		Irrigation	Livestock	Total
1	430,683,357	15,420,751	446,104,108	1	430,509,942	20,654,771	451,164,713
2	8,423,377	4,440,203	12,863,580	2	8,530,034	5,772,901	14,302,935
3	19,207,000	3,035,812	22,242,812	3	72,119,062	4,106,096	76,225,158
4	44,665,234	14,638,418	59,303,652	4	44,937,165	19,968,922	64,906,087
5	65,916,249	12,620,284	78,536,533	5	77,470,727	17,359,984	94,830,711
6	125,494,105	2,845,701	128,339,805	6	125,494,105	3,970,685	129,464,790
7	47,225,093	20,701,133	67,926,226	7	49,072,882	27,836,774	76,909,656
8	3,112,255	572,215	3,684,469	8	55,352,737	755,841	56,108,578
9	20,176,550	2,648,501	22,825,051	9	23,368,599	3,508,490	26,877,089
10	4,492,858	741,808	5,234,666	10	4,492,858	1,029,607	5,522,464
11	10,933,164	1,352,771	12,285,936	11	10,933,164	1,867,380	12,800,544
14	54,878,359	4,923,023	59,801,383	14	128,566,255	6,247,296	134,813,551
15	28,538,331	2,933,901	31,472,232	15	103,805,480	4,026,800	107,832,280
16	104,116,754	1,150,553	105,267,308	16	103,957,267	1,551,478	105,508,745
17	11,230,460	1,530,740	12,761,200	17	75,987,400	2,061,307	78,048,707
Total	979,093,145	89,555,816	1,068,648,961	Total	1,314,597,676	120,718,333	1,435,316,009

Source: Project Team

3.3.3 Water Balance Analysis

Using the monthly cropping pattern and its demand for irrigation and water supply and livestock demands, water balance analysis is made by the Water Resources Unit, which is divided into a few to several parts of WRA. The results of water balance analysis in the dry season, from May to October, are illustrated in **Figure 3.3.1** and **Figure 3.3.2**, in two development scenarios of 2,500 ha/year and 5,000 ha/year, respectively.

WRA	WRU	2035 Irrigation Area (ha)	Month					
			5	6	7	8	9	10
1	A	1,036						
	B	1,225						
	C	1,067						
	E	1,173						
	F	1,395						
	G	1,881						
	H	21,730						
	K	1,481						
	L	726						
	M	937						
	N	346						
	O	1,376						
	P	871						
	R	1,663						
	S	1,216						
	T	472						
2	A	595						
	B	2,081						
	C	451						
	D	294						
3	A	854						
	B	644						
	C	1,334						
	D	1,162						
	E	1,278						
	F	629						
4	A	399						
	B	2,189						
	C	979						
	D	842						
	E	572						
	F	375						

WRA	WRU	2035 Irrigation Area (ha)	Month					
			5	6	7	8	9	10
5	C	1,304						
	D	2,308						
	E	3,854						
	F	2,307						
6	A	169						
	B	152						
	C	782						
	D	8,815						
7	A	3,085						
	B	1,293						
	C	1,265						
	D	3,324						
	E	779						
	F	983						
	G	778						
	H	367						
8	A	4,173						
9	A	961						
	B	1,623						
10	A	531						
11	A	1,160						
14	A	1,580						
	B	7,672						
	C	13,508						
	D	1,021						
15	A	4,335						
	B	9,980						
	C	959						
16	E	4,584						
	F	6,752						
	G	2,520						
17	A	132						
	B	1,111						
	C	2,561						

- 100% of Sufficiency from Tributaries
- 100% of Sufficiency from Tributaries with Supplementation from Main River
- 100% of Sufficiency from Tributaries with Supplementation from Main River and Dambo
- 75% of Sufficiency from Tributaries with Supplementation from Main River and Dambo
- Less than 75% of Sufficiency from Tributaries with Supplementation from Main River and Dambo

Source: Project Team

Figure 3.3.1 Irrigation Water Supply Potential in the Dry Season by WRU in 2,500ha/year Scenario

WRA	WRU	2035 Irrigation Area (ha)	Month 5	6	7	8	9	10
1	A	1,623						
	B	1,938						
	C	1,836						
	E	1,690						
	F	1,659						
	G	2,560						
	H	21,730						
	K	2,307						
	L	1,306						
	M	1,565						
	N	620						
	O	2,141						
	P	1,460						
	R	2,719						
	S	1,950						
	T	562						
2	A	615						
	B	2,141						
	C	465						
	D	301						
3	A	1,386						
	B	1,127						
	C	2,358						
	D	1,726						
	E	2,011						
	F	840						
4	A	413						
	B	2,489						
	C	1,047						
	D	1,030						
	E	672						
	F	394						

WRA	WRU	2035 Irrigation Area (ha)	Month 5	6	7	8	9	10
5	C	1,770						
	D	2,708						
	E	5,402						
	F	3,520						
6	A	169						
	B	152						
	C	782						
	D	8,815						
7	A	5,323						
	B	2,227						
	C	2,299						
	D	6,061						
	E	1,185						
	F	1,850						
	G	1,337						
	H	660						
8	A	7,915						
9	A	1,171						
	B	1,880						
10	A	531						
11	A	1,160						
14	A	1,580						
	B	7,767						
	C	22,481						
	D	1,021						
15	A	7,441						
	B	14,982						
	C	1,570						
16	E	7,971						
	F	10,552						
	G	4,400						
17	A	148						
	B	2,084						
	C	4,404						

- 100% of Sufficiency from Tributaries
- 100% of Sufficiency from Tributaries with Supplementation from Main River
- 100% of Sufficiency from Tributaries with Supplementation from Main River and Dambo
- 75% of Sufficiency from Tributaries with Supplementation from Main River and Dambo
- Less than 75% of Sufficiency from Tributaries with Supplementation from Main River and Dambo

Source: Project Team

Figure 3.3.2 Irrigation Water Supply Potential in the Dry Season by WRU in 5,000ha/year Scenario

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. Those sub-basins are enumerated below. 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.

Table 3.3.5 WRUs with Water Deficit in the Dry Season

WRU	Water Deficit in 1000 m^3 in Annual Increase Scenario		Remarks
	2,500 ha/year	5,000 ha/year	
2A	173	195	Lake Chilwa basin
2D	75	82	Lake Chilwa basin
3D	-	38	
4A	83	128	Relatively small sub-basin
5C	-	199	Relatively small sub-basin
8A	-	3,388	North Rukuru basn
14B	1,291	1,374	Ruo basin
14C	1,810	17,223	Ruo basin
15B	6,419	16,932	
15C	445	1,535	Relatively small sub-basin
17A	-	126	Relatively small sub-basin

Source: Project Team

3.4 Structural Measures

3.4.1 Criteria of Structural Measures Applied

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

Table 3.4.1 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 easier comprehension.

Table 3.4.2 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 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

3.4.2 Unit Cost of Structural Measures in Irrigation Development

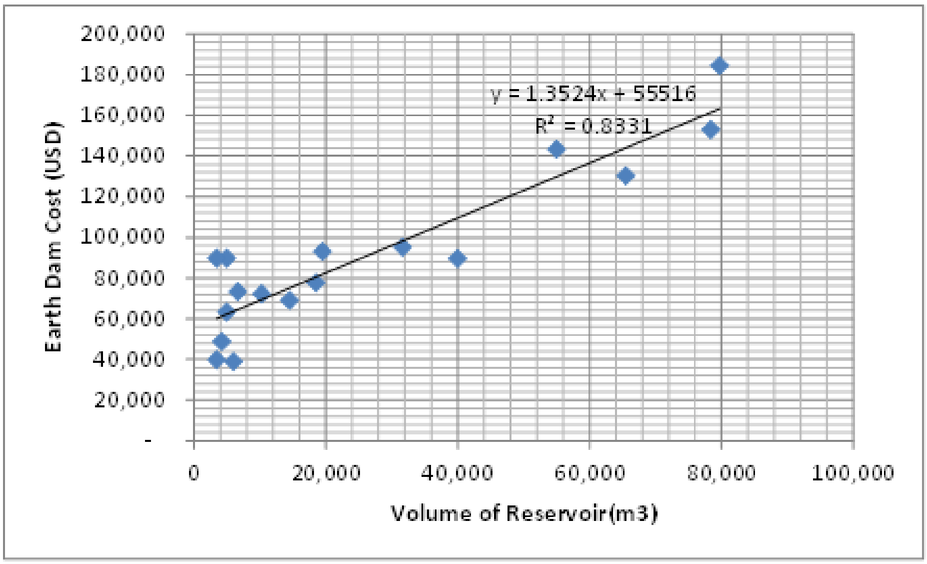
Irrigation development costs are worked out multiplying irrigation area by unit cost (USD/ha) obtained from similar project costs and the data from the relevant reports. Unit costs are shown below following the above-mentioned applicability criteria.

Table 3.4.3 Unit Costs of 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

In order to meet the water deficit, water storage facility is necessary. The costs of irrigation reservoir of earth dam are calculated by using the formula derived from the past and on-going similar projects. The approximate curve which shows the relation between earth dam cost and necessary capacity is shown in the following figure.



Source: MoAIWD & Project Team

Figure 3.4.1 Relation between Cost of Earth Dam and Reservoir Volume

3.5 Project Cost and Implementation Program

3.5.1 Project Cost Estimate

Summary of condition for cost estimation is shown as follows.

Table 3.5.1 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

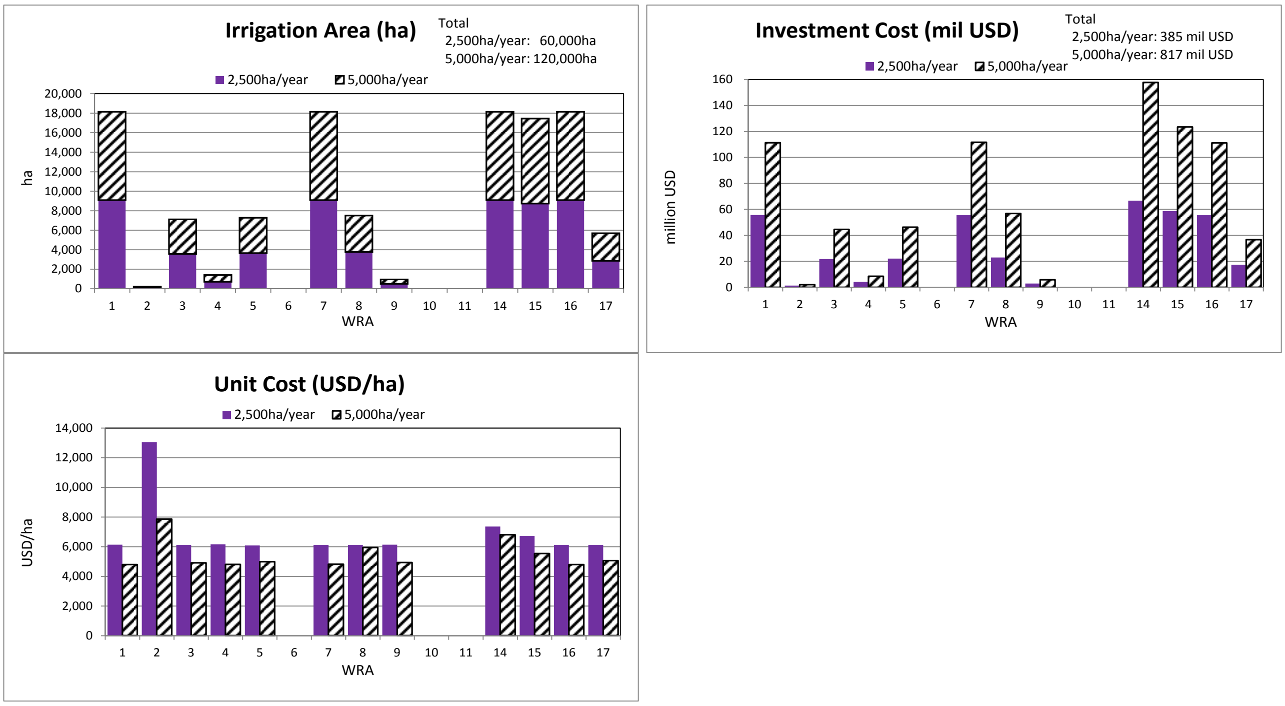
The construction cost has been estimated by WRUs as shown in **Table 3.5.3 to Table 3.5.11**. Using construction cost and the above conditions, the project is estimated as summarized in the following table. The total project costs are 385 million USD and 817 million USD, in 2,500 ha/year and 5,000 ha/year, respectively.

Table 3.5.2 Project Cost Estimate

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 that irrigation development relatively concentrates in five WRAs because of rich water supply potential: Shire (WRA 1), South Rukuru (WRA 7), Ruo (WRA 14), and Lakeshore basins (WRA 15 and WRA 16).



Source: Project Team

Figure 3.5.1 Estimation Results of Project Cost by WRA

Table 3.5.3 Estimation of Construction Cost by WRU (1/9)

WRA	WRU	I.A (ha)	Possible Water Source	Water Source Allocation		Tentative Irrig. Facilities	Unit Cost (USD/ha)	Cost (mil US$)	Deficit (1000m³)	Storage Volume (1000m³)	Storage Cost (mil US$)	Remarks
1	A	584	Tri. of L. Malombe		584	Weir+F.P	4,800	2.81	0			Nsanama RMC, GBI Pilot-Lake Malombe (500 ha) ; rice 50%-Water source is L.Malombe. Shire R. banks & it's left bank are covered with Liwonde National Park. Tri. of L. Malombe=Masanje R.
		1,171	Tri. of L. Malombe		1,171	Weir+F.P	4,800	5.62	0			
								2.81				
								5.62				
	B	710	Tri. of Shire		710	Weir+F.P	4,800	3.41	0			Tri. of Shire = Likwenu, Lisanjala, Kaloti & Linjisi.
		1,422	Tri. of Shire	(8)	1,138	Weir+F.P	4,800	5.46	0			
			Shire R.	(2)	284	P. Stn.+F.P	5,300	1.51				
								3.41				
								6.97				
	C	766	Tri. of Shire		766	Weir+F.P	4,800	3.67	0			Tri. of Shire = Lirangwe & Lunzu
		1,534	Tri. of Shire	(8)	1,227	Weir+F.P	4,800	5.89	0			
			Shire R.	(2)	307	P. Stn.+F.P	5,300	1.63				
								3.67				
								7.52				
	E	515	Tri. of Shire	(5)	258	Weir+F.P	4,800	1.24	0			Blantyre, Tri. of Shire = Likhubula
			Shire R.	(5)	257	P. Stn.+F.P	5,300	1.36				
		1,032	Tri. of Shire	(3)	306	Weir+F.P	4,800	1.47	0			
			Shire R.	(7)	726	P. Stn.+F.P	5,300	3.85				
								2.60				
								5.32				
	F	263	Tri. of Shire	(3)	210	Weir+F.P	4,800	1.01	0			Tri. of Shire = Mapelera, Nkhate, Thangadzi East, Elephant marsh along Shire R., GBI Pilot-Chikhwawa / Chilengo (240 ha); maize 100%. Water source is Livunzu R.
			Shire R.	(7)	53	P. Stn.+F.P	5,300	0.28				
		527	Tri. of Shire	(3)	421	Weir+F.P	4,800	2.02	0			
			Shire R.	(7)	105	P. Stn.+F.P	5,300	0.56				
								1.29				
								2.58				
	G	677	Tri. of Shire	(8)	542	Weir+F.P	4,800	2.60	0			Tri. of Shire = Thangadzi, Nyaphambere, Phanga, Nyachipere & Dundo.
			Shire R.	(2)	135	P. Stn.+F.P	5,300	0.72				
		1,356	Tri. of Shire	(5)	678	Weir+F.P	4,800	3.25	0			
			Shire R.	(5)	678	P. Stn.+F.P	5,300	3.59				
								3.32				
								6.84				
	H	0	Tri. of Shire						0			Tri. of Shire = Nkhombedzi Wafodya, Namikalango, Chidyamanga & Mafume.
		0	Tri. of Shire						0			
	K	823	Tri. of Shire		823	Weir+F.P	4,800	3.95	0			Tri. of Shire = Mwanza.
		1,649	Tri. of Shire	(8)	1,319	Weir+F.P	4,800	6.33	0			
			Shire R.	(2)	330	P. Stn.+F.P	5,300	1.75				
								3.95				
								8.08				
	L	578	Tri. of Shire		578	Weir+F.P	4,800	2.77	0			Tri. of Shire = Mwambezi.
		1,158	Tri. of Shire	(8)	926	Weir+F.P	4,800	4.44	0			
			Shire R.	(2)	232	P. Stn.+F.P	5,300	1.23				
								2.77				
								5.67				
	M	626	Tri. of Shire		626	Weir+F.P	4,800	3.00	0			Tri. of Shire = Mkulumadzi. Neno & Mwanza
		1,254	Tri. of Shire	(8)	1,003	Weir+F.P	4,800	4.81	0			
			Shire R.	(2)	251	P. Stn.+F.P	5,300	1.33				
								3.00				
								6.14				
	N	273	Tri. of Shire		273	Weir+F.P	4,800	1.31	0			Mainly Forest land
		547	Tri. of Shire	(8)	438	Weir+F.P	4,800	2.10	0			
			Shire R.	(2)	109	P. Stn.+F.P	5,300	0.58				
								1.31				
								2.68				

Source: Project Team

Table 3.5.4 Estimation of Construction Cost by WRU (2/9)

WRA	WRU	I.A (ha)	Possible Water Source	Water Source Allocation		Tentative Irrig. Facilities	Unit Cost (USD/ha)	Cost (mil US$)	Deficit ($1000m^3$)	Storage Volume ($1000m^3$)	Storage Cost (mil US$)	Remarks
1	O	761	Tri. of Shire		761	Weir+F.P	4,800	3.65	0			
		1,525	Tri. of Shire	(8)	1,225	Weir+F.P	4,800	5.88	0			
			Shire R.	(2)	305	P. Stn.+F.P	5,300	1.62				
								3.65				
								7.50				
	P	587	Tri. of Shire		587	Weir+F.P	4,800	2.82	0			Tri. of Shire = Mulungzi.
		1,176	Tri. of Shire	(8)	941	Weir+F.P	4,800	4.52	0			
			Shire R.	(2)	235	P. Stn.+F.P	5,300	1.25				
								2.82				
								5.77				
	R	1,051	Tri. of Shire		1,051	Weir+F.P	4,800	5.05	0			Tri. of Shire = Rivi Rivi
		2,107	Tri. of Shire	(8)	2,107	Weir+F.P	4,800	10.11	0			
			Shire R.	(2)	421	P. Stn.+F.P	5,300	2.23				
								5.05				
								12.34				
	S	731	Tri. of Shire		731	Weir+F.P	4,800	3.51	0			Tri. of Shire = Nkasi
		1,464	Tri. of Shire	(8)	1,171	Weir+F.P	4,800	5.62	0			
			Shire R.	(2)	293	P. Stn.+F.P	5,300	1.55				
								3.51				
								7.17				
	T	90	Tri. of L. Malombe		90	Weir+F.P	4,800	0.43	0			This WRU is located west bank of L. Malombe.
		180	Tri. of L. Malombe		180	Weir+F.P	4,800	0.86	0			
								0.43				
								0.86				
	@2,500 ha							**43.59**			**0.00**	**43.59**
	@5,000 ha							**91.06**			**0.00**	**91.06**
2	A	21	Tri. of L. Chilwa		20.7	Weir+I.P	5,200	0.11	0			High salinity in L. Chilwa Water. Tri. of L. Chilwa = Migowi, Khongoloni & Mabongo.
									173	100 x 2	0.38	
		41	Tri. of L. Chilwa		41.4	Weir+I.P	5,200	0.22				
									195	110 x 2	0.41	
								0.11			0.38	
								0.22			0.41	
	B	60	Tri. of L. Chilwa		60	Weir+F.P	4,800	0.29	0			High salinity in L. Chilwa Water. Tri. of L. Chilwa = Likangala, Thondwe & Phalombe.
									0		0.00	
		120	Tri. of L. Chilwa		120	Weir+F.P	4,800	0.58				
									0			
								0.29			0.00	
								0.58			0.00	
	C	14	Tri. of L. Chilwa		14	Weir+F.P	4,800	0.07	0			High salinity in L. Chilwa Water. Tri. of L. Chilwa = Lingoni, Domasi, Songani & Naisi
									0		0.00	
		29	Tri. of L. Chilwa		29	Weir+F.P	4,800	0.14				
									0			
								0.07			0.00	
								0.14			0.00	

Source: Project Team

Table 3.5.5 Estimation of Construction Cost by WRU (3/9)

WRA	WRU	I.A (ha)	Possible Water Source	Water Source Allocation		Tentative Irrig. Facilities	Unit Cost (USD/ha)	Cost (mil US$)	Deficit (1000m³)	Storage Volume (1000m³)	Storage Cost (mil US$)	Remarks
2	D	7	Tri. of L. Chilwa		7	Weir+I.P	5,200	0.03	0			High salinity in L. Chilwa Water. Tri. of L. Chilwa = Mikoko. Liwonde Forest. Land is submerged in rainy season. Ntaja DMC
									75	85x1	0.17	
		13	Tri. of L. Chilwa		13	Weir+I.P	5,200	0.07				
									82	95x1	0.18	
								0.03			0.17	
								0.07			0.18	
	@2,500 ha							**0.50**			**0.55**	**1.05**
	@5,000 ha							**1.01**			**0.59**	**1.60**
3	A	530	Tri. of L. Malawi		530	Weir+F.P	4,800	2.55	0			Tri. of L. Malawi = Nakundu, Namingundi & Nasenga
		1,063	Tri. of L. Malawi		1,063	Weir+F.P	4,800	5.10				
									0			
								2.55				
								5.10				
	B	481	Tri. of L. Malawi		481	Weir+F.P	4,800	2.31	0			Tri. of L. Malawi = Lisangadzi.
		964	Tri. of L. Malawi		964	Weir+F.P	4,800	4.63				
									0			
								2.31				
								4.63				
	C	1,020	Tri. of L. Malawi		1,020	Weir+F.P	4,800	4.90	0			Tri. of L. Malawi = Nankholokolo & Kabudira
		2,044	Tri. of L. Malawi		2,044	Weir+F.P	4,800	9.81				
									0			
								4.90				
								9.81				
	D	562	Tri. of L. Malawi		562	Weir+F.P	4,800	2.70	0			Tri. of L. Malawi = Bwanje
		1,125	Tri. of L. Malawi	(8)	900	Weir+F.P	4,800	4.32	0			
			L. Malawi	(2)	225	P. Stn.+F.P	8,500	1.91				
											0.00	
								2.70				
								6.23			0.00	
	E	730	Tri. of L. Malawi		730	Weir+F.P	4,800	3.50	0			Tri. of L. Malawi = Livulezi & nadzipokwe
		1,462	Tri. of L. Malawi		1,462	Weir+F.P	4,800	7.02	0			
									0			
								3.50				
								7.02				
	F	211	Tri. of L. Malawi		211	Weir+F.P	4,800	1.01	0			Tri. of L. Malawi = Nadzipula
		422	Tri. of L. Malawi		422	Weir+F.P	4,800	2.03				
									0			
								1.01				
								2.03				
	@2,500 ha							**16.97**			**0.00**	**16.97**
	@5,000 ha							**34.82**			**0.00**	**34.82**

Source: Project Team

Table 3.5.6 Estimation of Construction Cost by WRU (4/9)

WRA	WRU	I.A (ha)	Possible Water Source	Water Source Allocation		Tentative Irrig. Facilities	Unit Cost (USD/ha)	Cost (mil US$)	Deficit (1000m³)	Storage Volume (1000m³)	Storage Cost (mil US$)	Remarks
4	A	15	Lifisi R.	(8)	12	Weir+F.P	4,800	0.06				Lifisi R.
			L. Malawi	(2)	3	P. Stn.+F.P	8,500	0.02				
											0.00	
		30	Lifisi R.	(8)	24	Weir+F.P	4,800	0.11				
			L. Malawi	(2)	6	P. Stn.+F.P	8,500	0.05				
											0.00	
								0.08			0.00	
								0.16			0.00	
	B	299	Linthipe R. & it's tri.		299	Weir+F.P	4,800	1.44	0			
		600	Linthipe R. & it's tri.		600	Weir+F.P	4,800	2.88	0			
								1.44				
								2.88				
	C	67	Nanjiri R.	(8)	54	Weir+F.P	4,800	0.26	0			
			Lilongwe R.	(2)	13	P. Stn.+F.P	5,300	0.07				
		135	Nanjiri R.	(8)	108	Weir+F.P	4,800	0.52				
			Lilongwe R.	(2)	27	P. Stn.+F.P	5,300	0.14				
									0			
								0.33				
								0.66				
	D	187	Tri. of L. Malawi		187	Weir+F.P	4,800	0.90	0			Tri. of L. Malawi = Likuni, Katete, Chaulongwe, etc.
		376	Tri. of L. Malawi		376	Weir+F.P	4,800	1.80	0			
								0.90				
								1.80				
	E	100	Mteza/ Lingadzi R.		100	Weir+F.P	4,800	0.48	0			Nsaru RMC
		200	Mteza/ Lingadzi R.	(6)	120	Weir+F.P	4,800	0.57	0			
			Dambo	(4)	80	Weir+F.P	4,800	0.38				
								0.48				
								0.95				
	F	19	Tri. of L. Malawi	(6)	12	Weir+F.P	4,800	0.06	0			
			Dambo	(4)	8	Weir+F.P	4,800	0.04				
		39	Tri. of L. Malawi	(6)	23	Weir+F.P	4,800	0.11	0			
			Dambo	(4)	15	Weir+F.P	4,800	0.07				
								0.10				
								0.18				
	@2,500 ha							**3.33**			**0.00**	**3.33**
	@5,000 ha							**6.63**			**0.00**	**6.63**
5	C	464	Tri. of Bua		371	Weir+F.P	4,800	1.78	0			
		930	Tri. of Bua	(8)	744	Weir+I.P	5,200	3.87	199			
			Bua R.	(2)	186	P. Stn.+F.P	5,300	0.99		220x1	0.35	
								1.78				
								4.86			0.35	
	D	399	Tri. of Bua	(6)	239	Weir+F.P	4,800	1.15	0			Tri. of Bua = Kasangadzi & Mutiti
			Bua R.	(2)	80	P. Stn.+F.P	5,300	0.42				
			Dambo	(2)	80	Weir+F.P	4,800	0.38				
		799	Tri. of Bua	(6)	479	Weir+F.P	4,800	2.30	0			
			Bua R.	(2)	160	P. Stn.+F.P	5,300	0.85				
			Dambo	(2)	160	Weir+F.P	4,800	0.77				
								1.95				
								3.92				

Source: Project Team

Table 3.5.7 Estimation of Construction Cost by WRU (5/9)

WRA	WRU	I.A (ha)	Possible Water Source	Water Source Allocation		Tentative Irrig. Facilities	Unit Cost (USD/ha)	Cost (mil US$)	Deficit (1000m³)	Storage Volume (1000m³)	Storage Cost (mil US$)	Remarks
5	E	1,543	Tri. of Bua	(6)	926	Weir+F.P	4,800	4.44	0			
			Bua R.	(2)	309	P. Stn.+F.P	5,300	1.64				
			Dambo	(2)	309	Weir+F.P	4,800	1.48				
		3,091	Tri. of Bua	(6)	1,855	Weir+F.P	4,800	8.90	0			
			Bua R.	(2)	618	P. Stn.+F.P	5,300	3.28				
			Dambo	(2)	618	Weir+F.P	4,800	2.97				
								7.56				
								15.15				
	F	1,209	Tri. of Bua	(6)	725	Weir+F.P	4,800	3.48	0			
			Bua R.	(2)	242	P. Stn.+F.P	5,300	1.28				
			Dambo	(2)	242	Weir+F.P	4,800	1.16				
		2,422	Tri. of Bua	(6)	1,453	Weir+F.P	4,800	6.98	0			
			Bua R.	(2)	484	P. Stn.+F.P	5,300	2.57				
			Dambo	(2)	484	Weir+F.P	4,800	2.33				
								5.92				
								11.88				
	@2,500 ha							**17.21**			**0.00**	**17.21**
	@5,000 ha							**35.81**			**0.35**	**36.16**
6	A	0	Tri. of Duwangua						0			Mainly Forest Land
		0	Tri. of Duwangua						0			
								0.00				
								0.00				
	B	0	Tri. of Duwangua						0			Mainly Forest Land
		0	Tri. of Duwangua						0			
								0.00				
								0.00				
	C	0	Tri. of Duwangua						0			Kasungu SRC,
		0	Tri. of Duwangua									
									0			
								0.00				
								0.00			0.00	
	D	0	Tri. of Duwangua						0			Dwangwa, Chisemphere & Chamama RMC
									0		0.00	
		0	Tri. of Duwangua						0			
									0			
								0.00			0.00	
								0.00			0.00	
	@2,500 ha							**0.00**			**0.00**	**0.00**
	@5,000 ha							**0.00**			**0.00**	**0.00**
7	A	2,229	Tri. of S. Rukuru		2,229	Weir+F.P	4,800	10.70	0			
		4,467	Tri. of S. Rukuru		4,467	Weir+F.P	4,800	21.44	0			
								10.70				
								21.44				

Source: Project Team

Table 3.5.8 Estimation of Construction Cost by WRU (6/9)

WRA	WRU	I.A (ha)	Possible Water Source	Water Source Allocation		Tentative Irrig. Facilities	Unit Cost (USD/ha)	Cost (mil US$)	Deficit (1000m³)	Storage Volume (1000m³)	Storage Cost (mil US$)	Remarks
7	B	930	Tri. of S. Rukuru		930	Weir+F.P	4,800	4.47	0			
		1,864	Tri. of S. Rukuru		1,864	Weir+F.P	4,800	8.95	0			
								4.47				
								8.95				
	C	1,030	Tri. of S. Rukuru		1,030	Weir+F.P	4,800	4.94	0			
		2,064	Tri. of S. Rukuru		2,064	Weir+F.P	4,800	9.91	0			
								4.94				
								9.91				
	D	2,727	Tri. of S. Rukuru		2,727	Weir+F.P	4,800	13.09	0			
		5,464	Tri. of S. Rukuru		5,464	Weir+F.P	4,800	26.23	0			
								13.09				
								26.23				
	E	405	Tri. of S. Rukuru		405	Weir+F.P	4,800	1.94	0			
		811	Tri. of S. Rukuru		811	Weir+F.P	4,800	3.89	0			
								1.94				
								3.89				
	F	864	Tri. of S. Rukuru		864	Weir+F.P	4,800	4.14	0			
		1730	Tri. of S. Rukuru	(8)	1,384	Weir+F.P	4,800	6.64	0			
			S. Rukuru R.	(2)	346	P. Stn.+F.P	5,300	1.83				
								4.14				
								8.47				
	G	557	Tri. of S. Rukuru		557	Weir+F.P	4,800	2.67	0			
								0.00				
		1,115	Tri. of S. Rukuru	(8)	892	Weir+F.P	4,800	4.28	0			
			S. Rukuru R.	(2)	223	P. Stn.+F.P	5,300	1.18				
								2.67				
								5.46				
	H	292	N. Rumphi		292	Weir+F.P	4,800	1.40	0			
		584	N. Rumphi		584	Weir+F.P	4,800	2.81	0			
								1.40				
								2.81				
	@2,500 ha							**43.35**			**0.00**	**43.35**
	@5,000 ha							**87.16**			**0.00**	**87.16**

Source: Project Team

Table 3.5.9 Estimation of Construction Cost by WRU (7/9)

WRA	WRU	I.A (ha)	Possible Water Source	Water Source Allocation		Tentative Irrig. Facilities	Unit Cost (USD/ha)	Cost (mil US$)	Deficit (1000m³)	Storage		Remarks
										Volume (1000m³)	Cost (mil US$)	
8	A	3,728	Tri. of N. Rukuru		3,728	Weir+F.P	4,800	17.89	0			Tri. of N. Rukuru = Mibanga & Mwesia
		7,470	Tri. of N. Rukuru	(6)	4,482	Weir+I.P	5,200	23.31				
			N. Rukuru R.	(4)	2,988	P. Stn.+F.P	5,300	15.84				
									3,388	1,900 x 2	5.25	
								17.89			0.00	
								39.15			5.25	
	@2,500 ha							**17.89**			**0.00**	**17.89**
	@5,000 ha							**39.15**			**5.25**	**44.40**
9	A	209	Tri. of Lufilya		209	Weir+F.P	4,800	1.00	0			Tri. of Lufilya = Kalenje, Chambo, Mbalizi,Sekwa, etc.
		418	Tri. of Lufilya	(6)	209	Weir+F.P	4,800	1.00	0			
			Lufilya R.	(2)	125	P. Stn.+F.P	5,300	0.66				
			Dambo	(2)	84	Weir+F.P	4,800	0.40				
								1.00				
								2.06				
	B	256	Tri. of Songwe		256	Weir+F.P	4,800	1.23	0			
		513	Tri. of Songwe	(5)	257	Weir+F.P	4,800	1.23	0			
			Songwe R.	(3)	154	P. Stn.+F.P	5,300	0.82				
			Dambo	(2)	103	Weir+F.P	4,800	0.49				
								1.23				
								2.54				
	@2,500 ha							**2.23**			**0.00**	**2.23**
	@5,000 ha							**4.60**			**0.00**	**4.60**
10	A	0	Tri. of L. Malawi									Tri. of L. Malawi = Nsinje, Liueca, Lilole, Lugola, Mafi, Mbwasi, Lusalumwe, etc.
		0	Tri. of L. Malawi									
								0.00			0.00	
								0.00			0.00	
	@2,500 ha							**0.00**			**0.00**	**0.00**
	@5,000 ha							**0.00**			**0.00**	**0.00**
11	A	0	Tri. of L. Chiuta									Tri. of L. Chiuta = Lifune, Chitundu, Sankhiwi, Mpili, etc. Other R. = Ngapani, Laurere, Luchima, Masongola, Lusangusi, Nyenyesi, etc.
		0	Tri. of L. Chiuta									
								0.00			0.00	
								0.00			0.00	
	@2,500 ha							**0.00**			**0.00**	**0.00**
	@5,000 ha							**0.00**			**0.00**	**0.00**
14	A	0	Tri. of Ruo									Tri. of Ruo = Chisombezi & Nansadi.
		0	Tri. of Ruo									
								0.00			0.00	
								0.00			0.00	
	B	95	Tri. of Ruo	(8)	76	Weir+I.P	5,200	0.39	0			Tri. of Ruo = Kwakwasi, Thuchila, Namlenga, Chisawani, etc.
			Ruo R.	(2)	19	P. Stn.+F.P	5,300	0.10	1,291	710x2	2.03	
		190	Tri. of Ruo	(8)	152	Weir+I.P	5,200	0.79				
				(2)	38	P. Stn.+F.P	5,300	0.20	1,374	760x2	2.17	
								0.49			2.03	
								0.99			2.17	

Source: Project Team

Table 3.5.10 Estimation of Construction Cost by WRU (8/9)

WRA	WRU	I.A (ha)	Possible Water Source	Water Source Allocation		Tentative Irrig. Facilities	Unit Cost (USD/ha)	Cost (mil US$)	Deficit (1000m³)	Storage Volume (1000m³)	Storage Cost (mil US$)	Remarks
14	C	8,974	Tri. of Ruo		8,974	Weir+I.P	5,200	46.66	0			Tri. of Ruo = Muloza, Lujeri, Lichenya, Tangusi, etc.
									1,810	500 x 4	2.93	
		17,911	Tri. of Ruo	(6)	10,746	Weir+I.P	5,200	55.88				
			Ruo R.	(4)	7,164	P. Stn.+F.P	5,300	37.97				
									17,223	4,800 x 4	26.19	
								46.66			2.93	
								93.85			26.19	
14	D	0	Tri. of Ruo									Tri. of Ruo = Chinyenyedi, Lisule, etc.
		0	Tri. of Ruo									
								0.00			0.00	
								0.00			0.00	
	@2,500 ha							**47.15**			**4.96**	**52.11**
	@5,000 ha							**94.84**			**28.36**	**123.20**
15	A	3,094	Tri. of L. Malawi		3,094	Weir+F.P	4,800	14.85	0			Tri. of L. Malawi = Chirua, Lingadzi, Namanda, etc.
									0			
		6,200	Tri. of L. Malawi	(8)	4,960	Weir+F.P	4,800	23.81	0			
			L. Malawi	(2)	1,240	P. Stn.+F.P	8,500	10.54				
											0.00	
								14.85			0.00	
								34.35			0.00	
15	B	4,983	Tri. of L. Malawi	(8)	3,986	Weir+F.P	4,800	19.14	0			Tri. of L. Malawi = Kaombe, Mbambara, Likoa, Kufulizi, Nkula, etc.
			L. Malawi	(2)	997	P. Stn.+F.P	8,500	8.47				
											0.00	
		9,986	Tri. of L. Malawi	(8)	7,989	Weir+F.P	4,800	38.35				
			L. Malawi	(2)	1,997	P. Stn.+F.P	8,500	16.98				
											0.00	
								27.61			0.00	
								55.33			0.00	
15	C	608	Tri. of L. Malawi	(8)	486	Weir+F.P	4,800	2.34	0			Tri. of L. Malawi = Liwaladzi, etc. U/R is forest land.
			L. Malawi	(2)	122	P. Stn.+F.P	8,500	1.03				
											0.00	
		1,219	Tri. of L. Malawi	(8)	975	Weir+F.P	4,800	4.68				
			L. Malawi	(2)	244	P. Stn.+F.P	8,500	2.07				
											0.00	
								3.37			0.00	
								6.75			0.00	
	@2,500 ha							**45.83**			**0.00**	**45.83**
	@5,000 ha							**96.43**			**0.00**	**96.43**
16	E	3,374	Tri. of L. Malawi		3,374	Weir+F.P	4,800	16.20	0			Tri. of L. Malawi = Kawiya, Mlowe, Luwawa, Dwambadzi, Mkoma, etc.
		6,761	Tri. of L. Malawi		6,761	Weir+F.P	4,800	32.45	0			
								16.20				
								32.45				
16	F	3,785	Tri. of L. Malawi		3,785	Weir+F.P	4,800	18.17	0			Tri. of L. Malawi = Kalwe, Limphasa, Kalijilwe, Luchelemu, Luweya, Kakwewa, etc.
		7,586	Tri. of L. Malawi		7,586	Weir+F.P	4,800	36.41	0			
								18.17				
								36.41				

Source: Project Team

Table 3.5.11 Estimation of Construction Cost by WRU (9/9)

WRA	WRU	I.A (ha)	Possible Water Source	Water Source Allocation		Tentative Irrig. Facilities	Unit Cost (USD/ha)	Cost (mil US$)	Deficit ($1000m^3$)	Storage Volume ($1000m^3$)	Storage Cost (mil US$)	Remarks
16	G	1,873	Tri. of L. Malawi		1,873	Weir+F.P	4,800	8.99	0			Tri. of L. Malawi = Malangowe, Chiwisi, Ruvuo, etc.
		3,754	Tri. of L. Malawi		3,754	Weir+F.P	4,800	18.02	0			
								8.99				
								18.02				
	@2,500 ha							**43.36**			**0.00**	**43.36**
	@5,000 ha							**86.88**			**0.00**	**86.88**
17	A	16	Tri. of L. Malawi		16	Weir+I.P	4,800	0.08	0			Tri. of L. Malawi = No major tributaries are found. Almost forest land. Karonga SRC
											0.00	
		32	Tri. of L. Malawi	(6)	19	Weir+F.P	4,800	0.09				
			L. Malawi	(4)	13	P. Stn.+F.P	8,500	0.11				
											0.00	
								0.08			0.00	
								0.20			0.00	
	B	970	Tri. of L. Malawi		970	Weir+F.P	4,800	4.66	0			Tri. of L. Malawi = Wayi. Almost forest land
									0		0.00	
		1,943	Tri. of L. Malawi		1,943	Weir+F.P	4,800	9.33				
											0.00	
								4.66			0.00	
								9.33			0.00	
	C	1,836	Tri. of L. Malawi		1,836	Weir+F.P	4,800	8.81	0			Tri. of L. Malawi = Nyungwe, Wovwe, Hara, etc.
									0		0.00	
		3,679	Tri. of L. Malawi		3,679	Weir+F.P	5,200	19.13				
											0.00	
								8.81			0.00	
								19.13			0.00	
	@2,500 ha							**13.55**			**0.00**	**13.55**
	@5,000 ha							**28.66**			**0.00**	**28.66**
Total	**@2,500 ha**							**294.96**			**5.51**	**300.47**
	@5,000 ha							**607.05**			**34.55**	**641.60**

Source: Project Team

3.5.2 Project Prioritization

In order to formulate the 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:

(1) Cost Efficiency: Unit project cost per area

(2) Development Effect: Extent of irrigation development area

(3) Water Supply Potential: Water supply potential per area

Considering the ranges of parameters, ranking score is set up as shown in the following table.

Table 3.5.12 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

3.5.3 Implementation Plan

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

Table 3.5.13 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

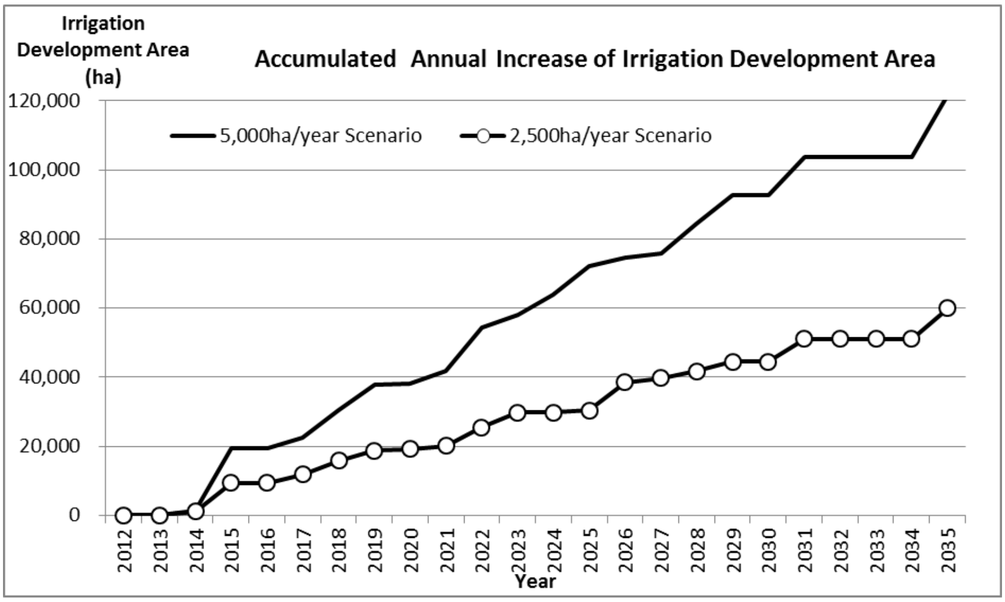
The implementation plan is formulated in accordance with the two irrigation development scenarios in the following manner:

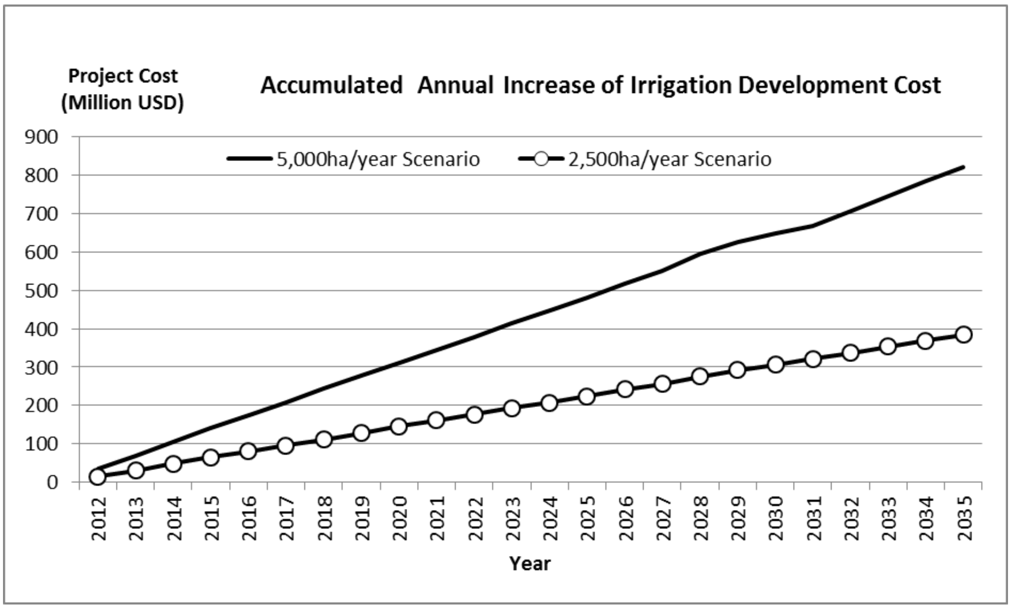
(1) Ordering priority given as the ranking score as shown in **Table 3.5.12**: high priority in early stage;

(2) Using implementation period of each project as shown in **Table 3.5.13**, and giving average annual project cost (total project cost/implementation year); and

(3) Forming smooth yearly increase of irrigation development cost for investment.

The result of formulation of the implementation plan is presented in **Table 3.5.14** for 2,500 ha/year development scenario and in **Table 3.5.15** for 5,000 ha/year one. In addition, **Figure 3.5.2** presents the accumulation of annual increase of development area and investment cost.





Source: Project Team

Figure 3.5.2 Formulation of Implementation Plan based on Area and Cost

Table 3.5.14 Implementation Plan in 2,500 ha/year Development Scenario

Summary of Implementation Schedule of Irrigation Development Area (2500ha 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 3.5.15 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

PART II

Chapter 4. DEVELOPMENT PLAN FOR HYDROPOWER

CHAPTER 4. DEVELOPMENT PLAN FOR HYDROPOWER

4.1 Background of Development Plan for Hydropower

As described in the **Part I: Section 5.4**, hydropower development projects until 2030 are planned by the Ministry of Natural Resources, Energy and Environment (MoNREE) and some of the projects have been implemented in accordance with the plans. In this section, hydropower development projects are evaluated and compiled from the viewpoint of Integrated Water Resources Management (IWRM) on the present and future conditions.

4.2 Planning Policy

4.2.1 Basic Policies

Hydropower development in Malawi has been carried out based on Malawi Electricity Investment Plan (MEIP 2011[i]), formulated by MoNREE. Hydropower development projects listed in MEIP 2011 are based on Power System Development Study and Operation Study prepared by World Bank in 1998 (WB 1998ii), which is positioned as the electricity master plan in Malawi.

4.2.2 Preconditions

Since hydropower projects with the target year 2035 have been already proposed in the study of electricity master plan and updated during the progress of related studies by MoNREE which planned to satisfy the electricity demand in the future, new hydropower projects will not be proposed in this Master Plan.

Basic conditions and parameters of hydropower projects are summarized in **Section 4.3** and evaluated from the standpoint of condition of water budget in **Section 4.4** . In this section, existing hydropower power plants and projects were reviewed, examined and complemented based on long-term water resources conditions for future integrated management of water resources.

4.2.3 Road Map of Electric Power Development

Although hydropower development and its operation year tend to fluctuate due to budgetary and procurement conditions, the projected operation year is determined by MoNREE as summarized in the table below. 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. 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 2020, electricity demand will be mainly covered by coal fired power development followed by hydropower and geothermal power development. In addition, in consultation with MoNREE, each term; namely, short, medium, and long term might be extended to approximately 5 years in consideration of current trend of power development. Therefore, term targets of electric power development can be summarized as the list below for discussion in this Master Plan for water resources management. Although there is a gap between the target year of this Master Plan and the target year of electric power sector in MEIP, the projected condition of hydropower development in 2035 would be the same as in 2030 since most of the hydropower development are expected to be completed before 2030.

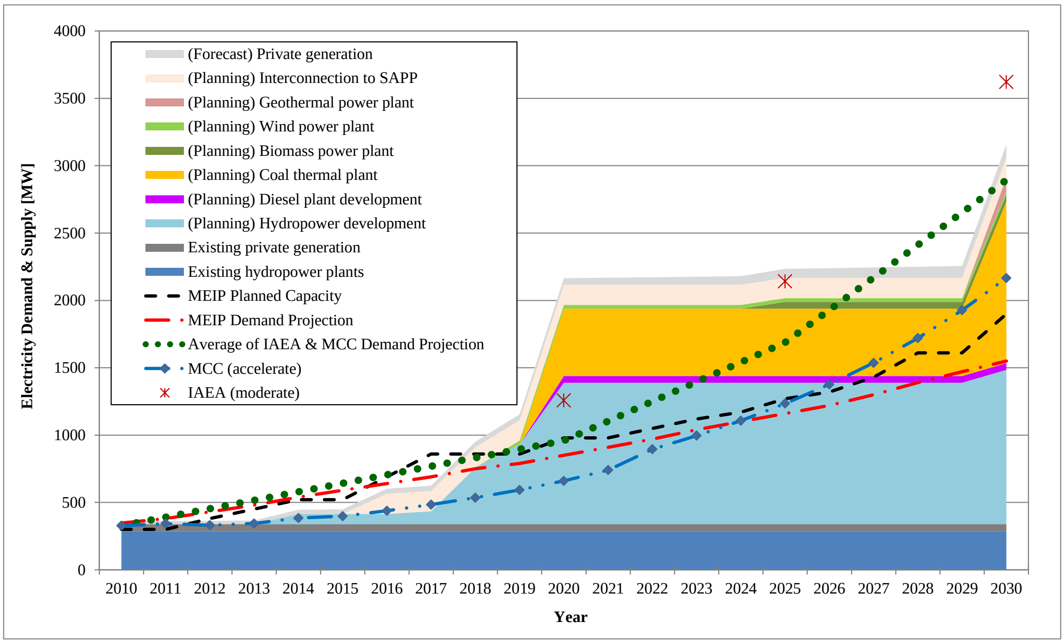
Short Term (-2020)	**Demand Side Management (DSM)** Hydropower development Diesel plant development
Medium Term (2021-2025)	**Hydropower development** Coal fired power development Biomass, Wind Interconnection to SAPP
Long Term (2026-2035)	**Coal fired power development** Hydropower development Geothermal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

Table 4.2.1 List of Power Development and the Projected Operation Years

Time Frame: Short Term 2012-2020; Middle Term 2021-2025; Long Term 2026-2035 (years 12–35)

	Projects (Power source / Name of Hydropower Project)	Category	WRA	Capacity [MW]	Projected Operation Year
Short	**DSM***	-	-	90	2010
2011-2020	**Hydropower**	**H**		**76**	
	Kaphicira II HPP	H	1	64	2013
126	Nkula A upgrade	H	1	12	2014
MW	**Diesel plant development**	**D**	-	**50**	**2015**
Medium	**Hydropower**	**H**		**819**	
	Chasombo	H	5	55	2018
2021-2025	Chizuma	H	5	50	2018
	Lower Fufu	H	7	100	2019
	Chimogonda	H	16	50	2018
1,547	Mptamanga	H	1	228	2020
MW	Zoa Falls	H	14	37	2016
	Kapichira III	H	1	35	2019
	Kholombidzo	H	1	170	2018
	Tedzani IV	H	1	20	2017
	Songwe Lower (Manolo)	H	9	74	2020
	Coal Fired Thermal Plant	**C**	-	**500**	**2020**
	Biomass	**B**	-	**50**	**2025**
	Wind	**W**	-	**28**	2019
	Interconnection to SAPP	**I**	-	**150**	2016
Long	**Hydropower**	**H**		**251**	
	Songwe Middle	H	9	80	2030
2026-2035	Songwe Upper	H	9	16	2030
	Rumphi	H	7	10	2020
	Henga Valley	H	7	28	2020
1,051 ~	Mbongozi	H	5	55	2020
1351	Malenga	H	5	62	2020
MW	**Coal Fired Thermal Plant**	**c**	-	**700**	**2030**
	Geothermal	**G**	-	**100**	**2030**

[Category] H: Hydropower, D: Diesel, C: Coal, B: Biomass, W: Wind, G: Geothermal, I: Interconnection
***DSM** (Demand Side Management) is not counted as power generation



*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 4.2.1 Time Line of Electric Power Development

4.3 Hydropower Development Plan in Malawi

4.3.1 List of Hydropower Development Projects

Hydropower facilities including existing plants and planned projects are summarized below as references to be used for the discussion on water use by hydropower. **Table 4.3.1** shows a list of existing hydropower plants, **Table 4.3.2** shows that of planned projects. **Figure 4.3.1** shows their locations. Hydropower projects have been planned as shown in **Table 4.3.2** according to several documents and information shared by MoNREE such as the Power System Development Study and Operation Study (WB, 1998) which is the Master Plan level study for electric power development; the Final Feasibility Study Report on The Integrated Water Resources Development Plan for Lake Malawi and Shire River System prepared by Norconsult in 2003 (Norconsult, 2003); the Feasibility Study for the Stabilization of the Course of the Songwe River in 2003 in the context of the Songwe River Basin Development Program (SRBDP 2003); the Malawi Electricity Investment Plan (MEIP 2011); and the results of interview with the Department of Energy Affairs (DoE) of MoNREE. Values shown in the table are based on WB1998 and available reports, which will be revised after completion of the Feasibility Study (F/S) and the Detailed Design (D/D) of each project.

Table 4.3.1 List of Existing Hydropower Plants and Salient Features

River	Site	Generation Capacity	Operation Year	Max. Plant Discharge [m^3/s]	Firm Discharge [m^3/s]	Reservoir Volume [M.m^3]	Dam Height [m]	Full Supply Level [masl]	Min. Operation Level [masl]	Tail Water Level [masl]
Shire (WRA-01)	Nkula A	3 x 8 MW = 24 MW	1966	69 (3x23m^3/s)	55	0.764 Mm^3 in 1996 (1.791 Mm^3 in 1973)	12	376 (376.4 because of siltation)	374.5	326
	Nkula B	3 x 20 MW = 60 MW	1980	195 (5x39 m^3/s)	156					
		1 x 20 MW = 20 MW	1986							
		1 x 20 MW = 20 MW	1992							
	Tedzani I	2 x 10 MW = 20 MW	1973	60 (2x30 m^3/s)	48	N/A	10	318.53	315.78	283.5
	Tedzani II	2 x 10 MW = 20 MW	1977	60 (2x30 m^3/s)	48					283.5
	Tedzani III	2 x 26.35 MW = 52.7 MW	1996	135.8 (67.5+68.3 m^3/s)	109					276.8
	Kapichira I	2 x 32.4 MW = 64.8 MW	2000	134.6 (2x67.3 m^3/s)	108	2.8 Mm^3 in 2004 (9.05 M.m^3 in 1996 study)	30	147	144	86
Wovwe (WRA-17)	Wovwe	3 x 1.45 MW = 4.35 MW	1995	1.017 (3x0.339 m^3/s)	0.82	N/A	1	1107.5	1105	591.9
Shire River Resources		281.5 MW		264 (max.)	211 (max.)					
Wovwe River Resources		4.35 MW		1.017	0.82					
Total Resources		285.85 MW								

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

Table 4.3.2 List of Hydropower Development Projects

WRA	River Name	No.	Project Name	Installed Capacity [MW]	Full Supply Level [masl]	Min. Operation Level [masl]	Tail Water Level [masl]	Dam Height [m]	Max. Plant Discharge [m^3/s]	Project Status	Finance (FS-DD, construction)	Project cost (Million USD)	Planned Operation Year*	Source
1	Shire	1	Nkula A upgrade	+12MW (24 → 36)	-	-	-	-	-	F/S	MCC	25	S	(5)
		2	Kholombidzo	170	471	467	396	24	285	F/S	AfDB, IPP	314	M	(1)(2)
		3	Tedzani IV (extension)	20	-	-	-	-	70	F/S	JICA, --	85	M	(4) (5)
		4	Mpatamanga	228	278	260	216	64	418	F/S	WB, IPP	300	M	(1)
		5	Kapichira II	64	147	144	86	30	127	2013 operation	MG	55	S (2013)	(1)
		6	Kapichira III (extention)	35	147	144	-	30	82	-	-	65	M	(5)
5	Bua	7	Mbongozi	55	1043	1013	900	76	50	M/P	-	263	L	(1)(5)
		8	Malenga	62	899	865	729	115	50	M/P	-	320	L	(1)(5)
		9	Chasombo	55	732	705	610	110	60	F/S	MG, -	170	M	(1)(5)
		10	Chizuma	50	610	607	480	37	60	F/S	MG, -	97	M	(1)(5)
7	South Rukuru	11	Rumphi	10	1076	1060	1020	39	30	M/P	-	90	L	(1)
		12	Henga Valley	28	1027	995	921	48	40	M/P	-	120	L	(1)(5)
		13	Lower Fufu	100	820	805	474	24	40	M/P	WB, IPP	200	M	(1)(5)
14	Ruo	14	Zoa Falls	37	305	305	229	21	70	M/P	-	60	M	(1)(5)
16	Dwambazi	15	Chimgonda	38~50	915	885	530	97	20	F/S	WB, IPP	178	M	(1)
9	Songwe	16	Upper Songwe (Bupigu)	16 (32**)	1240	1220	1165	70	50	F/S	AfDB, -	65	M	(3)(5)
		17	Middle Songwe (Sofwe)	79.5 (159**)	1140	1100	825	112	60	F/S	AfDB, -	170	M	(3)(5)
		18	Lower Songwe (Manolo)	74 (148**)	780	750	527	140	70	D/D	AfDB, IPP	190	M	(3)(5)
			Total	1,146										

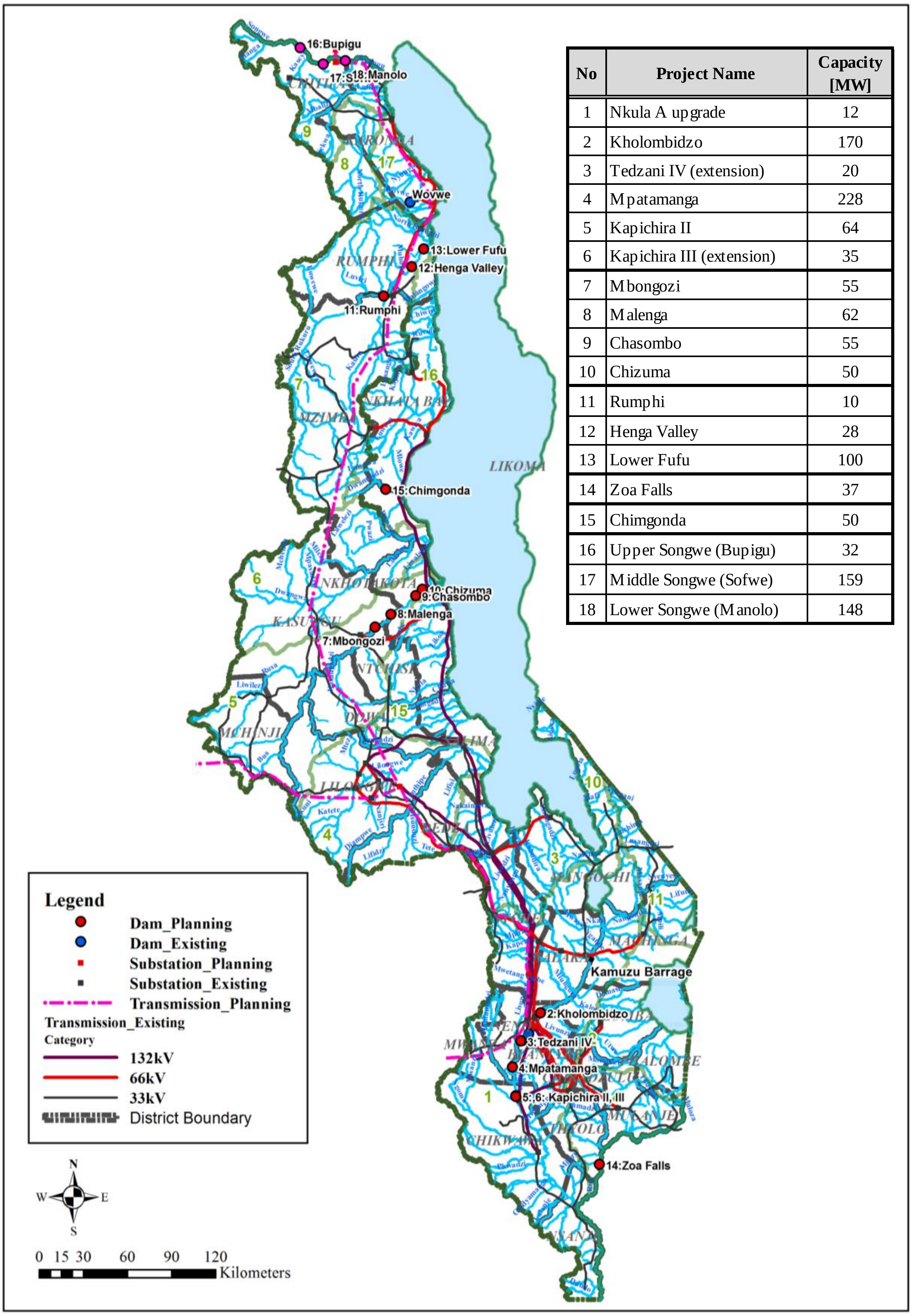
Project parameters as of September, 2013.
These parameters will be revised according to the progress of projects.

Source:
(1) WB (1998): Power System Development Study and Operation Study;
(2) Norconsult (2003): Norconsult, The Integrated Water Resources Development Plan for Lake Malawi and the Shire River System "Lake Malawi Level Control" – Stage 2, Final Feasibility Report;
(3) SRBDP (2003): NORPLAN, Feasibility Study for the Stabilisation of the Course of the Songwe River, 2003 [in the context of the Songwe River Basin Development Programme (SRBDP),
(4) JICA TOR (2013): JICA,TOR for Preparatory Study for the extension of Tedzani Hydropower Plant,
(5) JICA (2013): Report by JICA expert on electricity

Project features are based on sources described in "Source" column.
Finance source includes F/S, D/D, and construction stage (data is based on source (5)). However these parameters will be revised according to the progress of projects;

MCC: Millennium Challenge Corporation, USA, AfDB: African Development Bank, WB: World Bank, IPP: Independent Power Producer, MG: Malawi Government
Project cost is draft value based on source (1), (5) and other sources, and these values will be revised according to the progress of each project.

*Planned operation year is categorized, S, M, and L; described in Investment Term defined in MEIP (2011) and revised by JICA expert in (5) below, S: Short (0~5 years), M: Medium (5~10 years), L: Long (more than 10 years)
** Total installed capacity. Half of generated power of Songwe projects is supposed to be supplied to Malawi.



No	Project Name	Capacity [MW]
1	Nkula A upgrade	12
2	Kholombidzo	170
3	Tedzani IV (extension)	20
4	Mpatamanga	228
5	Kapichira II	64
6	Kapichira III (extension)	35
7	Mbongozi	55
8	Malenga	62
9	Chasombo	55
10	Chizuma	50
11	Rumphi	10
12	Henga Valley	28
13	Lower Fufu	100
14	Zoa Falls	37
15	Chimgonda	50
16	Upper Songwe (Bupigu)	32
17	Middle Songwe (Sofwe)	159
18	Lower Songwe (Manolo)	148

Source: Project Team, based on WB (1998) and SRBDP (2003)

Figure 4.3.1 Location Map of Hydropower Projects

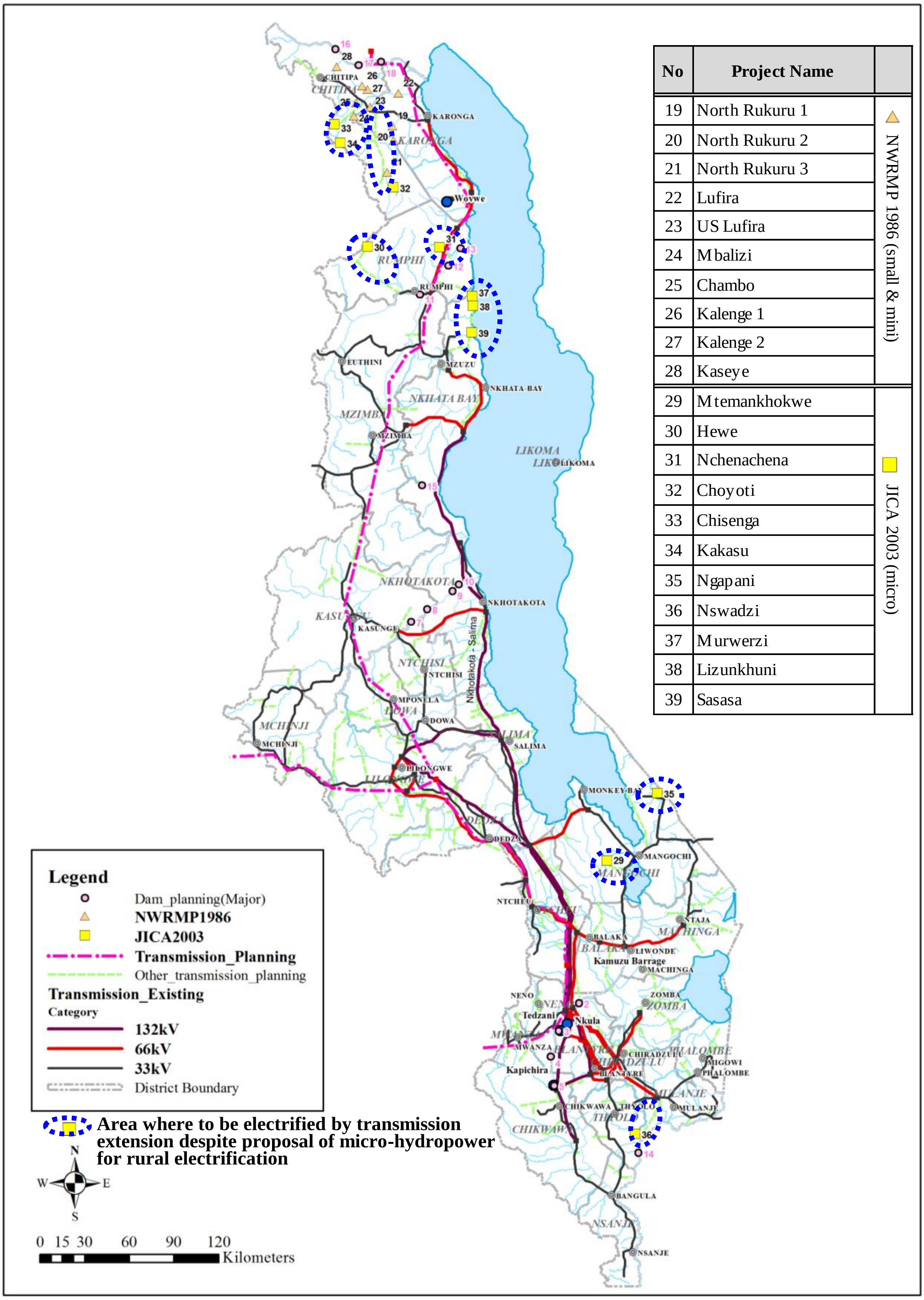
4.3.2 List of Mini and Micro Hydropower Development Projects

According to the NWRMP 1986 and the Master Plan Study for Rural Electrification by JICA in 2003, mini and micro hydropower projects were proposed for rural electrification. However, these projects have been suspended without any progress since extending transmission/distribution lines from the major electric system would entail lower cost. **Table 4.3.3** is the list of these mini and micro hydropower projects. As shown in **Figure 4.3.2**, most of the area where mini and micro hydropower planned for rural electrification, are expected to be covered by the present transmission and distribution lines. However, if the situation would change, for example, oil price would increase or Feed-in-Tariff (FIT) is set for renewable energy development, the economic efficiency of developing mini and micro hydropower for rural electrification might increase. In addition, some other small hydropower projects can be proposed by IPP, for example, in Mulanje Mountains, on tributaries of the Ruo River. Furthermore, for the purpose of the rural electrification for small villages, the hybrid method with solar power and mini-hydropower is also adopted in consideration of the hydrological conditions of mountainous area in Malawi.

Table 4.3.3 List of Mini and Micro Hydropower Development Projects in NWRMP (1986) and Rural Electrification M/P (2003)

WRA	River Name	No.	Project Name	Source	Installed Capacity [MW]	Full Supply Level [masl]	Min. Operation Level [masl]	Tail Water Level [masl]	Gross Head [m]	Dam Height [m]	Max. Plant Discharge [m^3/s]	Firm Discharge [m^3/s]	Project Status	Planned Operation Year
8	North Rukuru	19	North Rukuru	(6)	2.25	695	685	550	135	-	1.94	-	-	-
		20	North Rukuru	(6)	1.07	-	-	-	83	-	1.79	-	-	-
		21	North Rukuru	(6)	0.67	-	-	-	87	-	1	-	-	-
9	Lufira	22	Lufira	(6)	0.94	730	720	580	140	-	0.78	-	-	-
		23	US Lufira	(6)	0.13	-	-	-	70	-	0.24	-	-	-
		24	Mbalizi	(6)	0.03	-	-	-		-	0.02	-	-	-
		25	Chambo	(6)	0.006	-	-	-		-	0.008	-	-	-
		26	Kalenge 1	(6)	0.21	1130	1120	990	130	-	0.22	-	-	-
		27	Kalenge 2	(6)	0.12	985	982	915	67	-	0.22	-	-	-
	Songwe	28	Kaseye	(6)	0.15	1188	1188	1130	34	-	0.02	-	-	-
3	Naseng	29	Mtemankhok	(7)	0.025	-	-	-	20~30	-	0.1	-	-	-
7	South Rukuru	30	Hewe	(7)	0.045	-	-	-	25~30	-	0.2	-	-	-
		31	Nchenachena	(7)	0.03	-	-	-	10~30	-	0.2	-	-	-
8	North	32	Choyoti	(7)	0.06	-	-	-	30~40	-	0.2	-	-	-
9	Lufira	33	Chisenga	(7)	0.015	-	-	-	15~20	-	0.1	-	-	-
		34	Kakasu	(7)	0.015	-	-	-	10~30	-	0.1	-	-	-
11	Ngapan	35	Ngapani	(7)	0.005	-	-	-	5~15	-	0.05	-	-	-
14	Ruo	36	Nswadzi	(7)	0.075	-	-	-	5~15	-	1	-	-	-
16	Murwer	37	Murwerzi	(7)	0.005	-	-	-	10~15	-	0.05	-	-	-
	Lizunk	38	Lizunkhuni	(7)	0.05	-	-	-	50~60	-	0.15	-	-	-
	Sasasa	39	Sasasa	(7)	0.02	-	-	-	20~30	-	0.1	-	-	-

Source:
(6) NWRMP 1986: United Nations Development Programme (UNDP), National Water Resources Master Plan (NWRMP)
(7) JICA (2003), Master Plan Study on Rural Electrification in Malawi - Final Report- Technical Background Report



No	Project Name	
19	North Rukuru 1	NWRMP 1986 (small & mini)
20	North Rukuru 2	
21	North Rukuru 3	
22	Lufira	
23	US Lufira	
24	Mbalizi	
25	Chambo	
26	Kalenge 1	
27	Kalenge 2	
28	Kaseye	
29	Mtemankhokwe	JICA 2003 (micro)
30	Hewe	
31	Nchenachena	
32	Choyoti	
33	Chisenga	
34	Kakasu	
35	Ngapani	
36	Nswadzi	
37	Murwerzi	
38	Lizunkhuni	
39	Sasasa	

Source: Project Team based on NWRMP 1986 and JICA (2003)

Figure 4.3.2 Location Map of Hydropower Projects (Mini and Micro Hydropower)

4.4 Evaluation of Hydropower Development Plan

Water use sufficiency is evaluated by comparing the water demand for hydropower generation as the safety level mentioned above with the river flow volume estimated by water balance analysis. Safety levels of water use sufficiency for hydropower are set as described below to confirm the availability of power plants from the viewpoint of IWRM. In the Project, each hydropower development project is evaluated from the standpoint of water resources management. To proceed hydropower development, detailed studies should be carried out for practical hydropower development such as optimization studies of design including reservoir operation with studies of optimal peak generation hours, economic/financial analysis, geological and geotechnical studies, design studies and environment studies.

Although this preliminary evaluation study has limitations, the results shown here will be valuable for feasibility studies and detail design studies to be conducted for each project. In addition, these results can be utilized for discussion on sharing water on the relevant river basin with other stakeholders such as irrigation sector and domestic water sector as well as hydropower sector.

4.4.1 Study Image of Evaluating Available Water Resource

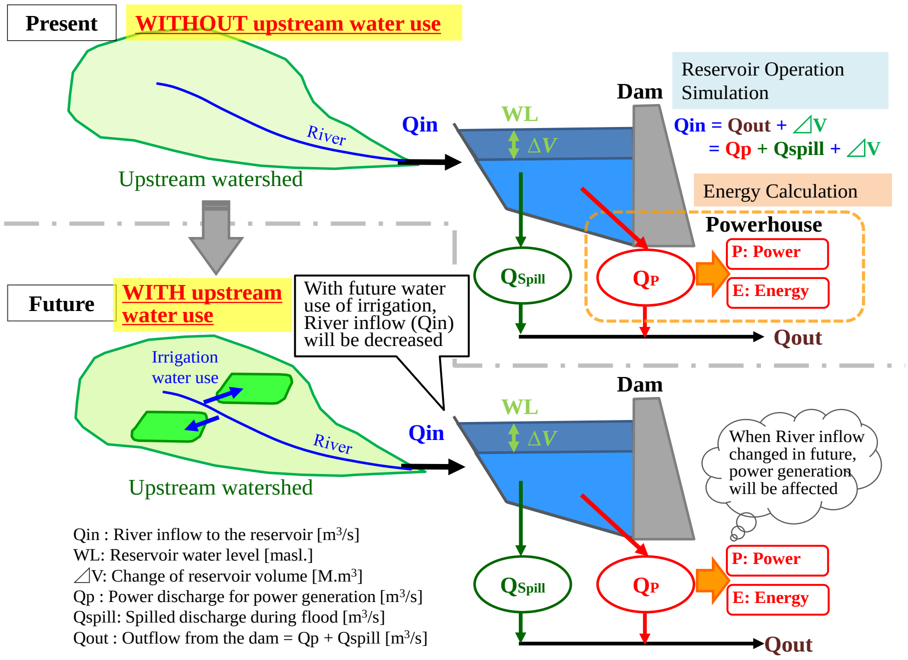
Available water resources amounts are estimated for each point of hydropower plant in each river by the water balance simulation after verification of the model based on the time-series records of observed discharge.

Available water resources for hydropower generation depend on river inflow from upper stream. If water demands in some sector (such as irrigation sector) at upper stream of the basin are to be enlarged in the future, river inflow will decrease. The advantage of this water resource master plan study is that the impacts of various sectors including agriculture and domestic water use can be simulated and examined from comprehensive viewpoints.

In the Project, two cases of water balance simulation have been conducted under the conditions of (1) “Without” upstream water demand (WITHOUT case); and (2) “With” upstream water demand such as agricultural and domestic water use (WITH case). Reservoir operation simulations and energy calculations have been conducted based on river inflow to upstream of the reservoir delivered from these water balance simulations. Energy calculations were conducted based on power discharge and water level according to the reservoir condition from relation of reservoir volume and elevation.

As shown in **Figure 4.4.1**, there is no or quite few negligible water use upstream of the hydropower reservoir at present condition (WITHOUT case in the figure). In this case, natural river flow will be supplied to hydropower reservoir. On the other hand, in consideration of future water demand upstream of the hydropower reservoir, river flow into the reservoir will be decreased by other water use such as agriculture and domestic water use upstream of the river basin (WITH case in the figure).

Hydropower plants will generate power using water stored in the reservoir. The amount of power generation depends on power discharge taken from the intake at the reservoir and water head between reservoir water level and tail water level at the powerhouse. When the river inflow from upstream is sufficient and larger than power discharge, surplus water will be stored in the reservoir until the reservoir water level reaches the Full Supply Level (FSL [masl]). When the river inflow is enough, surplus water will be spilled from spillway so that the reservoir water level will not exceed the FSL. On the other hand, when the river inflow from upstream is lower than the required power discharge, deficit volume of water will be supplied from the reservoir, and reservoir water level will be decreased in accordance with the volume of water taken from the intake at the reservoir until the reservoir water level reaches the Minimum Operation Level (MOL [masl]). In case the reservoir water level decreases, the power discharge taken from the intake will be stopped so that the reservoir water level will not be lower than MOL.



Source: Project Team

Figure 4.4.1 Study Image of Evaluation of Hydropower Projects in consideration of Integrated Water Resources Management

4.4.2 Planning Concept of Evaluating Water Use Sufficiency for Hydropower Generation

Safety levels of water use sufficiency for hydropower are set as described below to confirm the availability of power plants from the viewpoint of IWRM. Although the value of safety level is just one of the evaluation factors for the feasibility of hydropower development, the satisfaction ratio against this safety level could be utilized as not only the basic information for feasibility and detailed design studies but also as indicator to be examined as the availability for integrated water resources management in the future.

In the following sections, such items are presented as (1) setting the safety level based on load factor, which will be set as 60% against maximum water/energy demand in consideration of projection of future load factors, (2) the methodology of estimating this safety level; and (3) target values of safety level, namely annual water demand volume for hydropower for each projects.

(1) Setting Safety Level based on Electric Power Demand and Load Factor

Design safety level for each hydropower plant will be prepared based on load factor as follows.

Load factor is set based on electricity demand projection. According to **Table 4.4.1**, load factor projection will be varied from 50% to 60%. Therefore, the load factor of 60% is applied in consideration of safer side for evaluation of water use sufficiency in the Project.

Load factor is calculated by the following formula:

$$L.F\ (Load\ Factor) = \frac{Pave\ (Annual\ average\ power\ demand)[MW]}{Pmax\ (Peak\ power\ demand)[MW]}$$

Where; P_{ave} : Annual average power demand [MW]

$$= E[GWh/yr] \times 1000\ /(24[hr] \times 365\ [day])$$

E : Annual Energy Demand [GWh/yr]

$$= Pave[MW] \times (24[hr] \times 365\ [day])/1000$$

MW: Megawatt, Mega = 1,000,000
GWh: Gigawatt-hour, Giga = 1,000,000,000

Table 4.4.1 Projected Electric Power Demand and Load Factor

Item	Peak Demand [MW]			Energy Demand [GWh]			Load Factor [%]		
Case	**2020**	**2025**	**2030**	**2020**	**2025**	**2030**	**2020**	**2025**	**2030**
IAEA (reference)	1,374	2,425	4,274	6,522	11,789	20,910	54.2	55.5	55.8
IAEA (moderate)	1,257	2,141	3,622	5,743	9,871	16,616	52.2	52.6	52.4
MCC (accelerate)	660	1,234	2,166	3,093	6,058	10,441	53.5	56.0	55.0
MCC (reference)	543	950	1,532	2,680	4,981	7,931	56.3	59.9	59.1
Average of IAEA & MCC	959	1,688	2,894	4,418	7,965	13,529	52.8	54.3	53.7

Source:
IAEA 2011: International Atomic Energy Agency (IAEA), Malawi Energy Demand Assessment Report (Draft), 2011,
MCC 2011: Millennium Challenge Corporation (MCC), Malawi Power System Project Studies – Phase II, Draft

(2) Estimation Method of Sufficiency for Hydropower Generation

The safety level for hydropower to be discussed here will be evaluated based on annual river discharge volume (Unit: million m^3/year [MCM/year]) available for hydropower generation. The safety levels for hydropower generation here are set by annual power discharge volume for each hydropower plant on the following basis:

$$V_{sl} = L.F \times Qpmax \times (3600 \times 24 \times 365)/10^6$$

Where,

V_{sl}	:	Safety level of Annual discharge volume for hydropower generation [$M.m^3$/year]
Qpmax	:	Maximum Plant Discharge for the hydropower plant [m^3/s]
L.F	:	Load Factor (described in (1) above)

These volumes mean the annual water demand volume for hydropower plants. According to IAEAiii, seasonal variation of electric power demand is not significant. Therefore, the safety level expressed as discharge (m^3/s) can be estimated as "Qmax" or "L.F × Qmax" described above.

(3) Target of Water Use Sufficiency for Hydropower Generation

Water use sufficiency for hydropower generation is evaluated in consideration of safety level which is estimated by using water balance simulation. Based on the methodologies described above, target water demand and safety level for each hydropower plant are summarized below. According to these values in the following table and water resource balance in the reservoirs derived in (1) and (2) above, water use sufficiency for hydropower generation for each hydropower plant will be evaluated based on annual power discharge volume (million m^3/year). **Table 4.4.2** shows sufficiency levels of each project from the viewpoint of annual water demand for hydropower generation ($M.m^3$/yr).

Table 4.4.2 Water Demand and Safety Level for Hydropower

WRA	River Name	Plant Name	Installed Capacity [MW]	Maximum Plant Discharge [m^3/s]	Maximum Water Demand [$M.m^3/yr$]	Sufficiency Level [$M.m^3/yr$]	Condition
1	Shire	Nkula (A+B)	124	264	8,326	4,995	Existing
		Tedzani (I+II+III+IV)	110.7	325.8	10,274	6,165	I~III: Existing IV: Planning (Medium Term)
		Kapichira (I+II + III)	128.8	343.6	10,836	6,501	I: Existing II: Start operation (2013) III: Planning (Medium Term)
		Kholombidzo	170	285	8,988	5,393	Planning (Long term)
		Mpatamanga	228	418	13,182	7,909	Planning(Medium Term)
5	Bua	Mbongozi	44	50	1,577	946	Planning (Medium Term)
		Malenga	62	50	1,577	946	Planning (Medium Term)
		Chasombo	55	60	1,892	1,135	Planning (Medium Term)
		Chizuma	50	60	1,892	1,135	Planning (Medium Term)
7	South Rukuru	Rumphi	10	30	946	568	Planning (Long Term)
		Henga Valley	28	40	1,261	757	Planning (Long Term)
		Lower Fufu	100	40	1,261	757	Planning (Medium Term)
9	Songwe	Upper Songwe (Bupigu)	34	50	1,577	946	Planning (Medium Term)
		Middle Songwe (Sofwe)	159	60	1,892	1,135	Planning (Medium Term)
		Lower Songwe (Manolo)	148	70	2,208	1,325	Planning (Medium Term)
14	Ruo	Zoa Falls	37	70	2,208	1,325	Planning (Short Term)
16	Dwambazi	Chimgonda	50	20	631	378	Planning (Long Term)
17	Wovwe	Wovwe	4.35	1.017	32	19	Existing

Source: Project Team based on WB (1998), Norconsult (2003), SRBDP (2003) and JICA (2013)

4.4.3 Evaluation Results for Hydropower Development

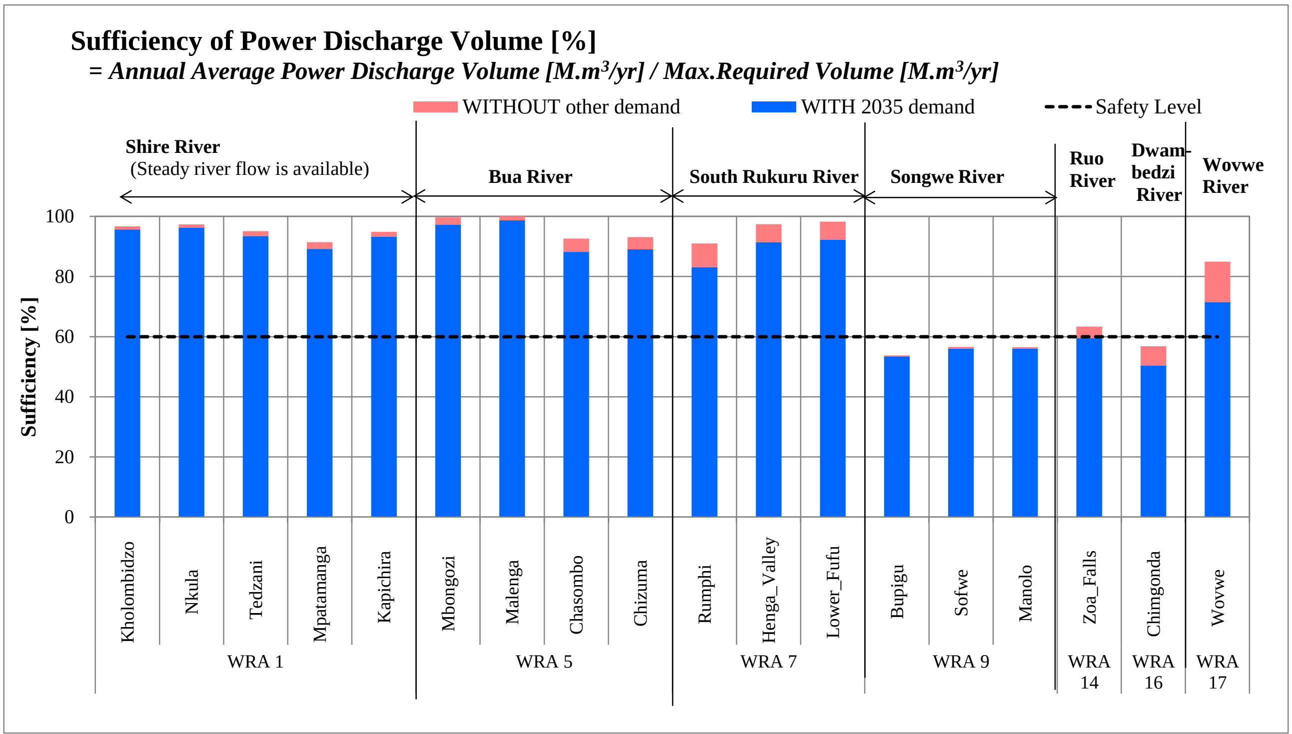
(1) Evaluation Results based on Water Demand for Hydropower Generation

Hydropower reservoir operation simulation and energy calculation were conducted for each hydropower reservoir. The results of reservoir operations are presented in **Annex 7.4.1**. Water use sufficiency for hydropower generation was evaluated in consideration of safety level on annual water demand volume for hydropower generation. **Table 4.4.3** and **Figure 4.4.2** show comparison results between “With” other water demand at upstream of the river and “Without” other water demand at upstream of the river. Since water resources development at upstream of river basin in future will affect and decrease river flows into the hydropower reservoir, the results 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” upstream water use. On the other hand, hydropower projects in WRA-9 (Songwe) and WRA-16 (Dwambezi), especially, 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 resources development as well as hydropower development.

Table 4.4.3 Evaluation Result for Hydropower Generation Water Demand

			Development Plan		Safety Level	Simulation Result (with 2035 upstream demand) — WITH 2035 demand		Simulation Result (without upstream water demand) — WITHOUT other demand	
No.	WRA	Name	Max.Plant Discharge [m³/s] (1)	Max. Required Volume [M.m³/yr] (2)	60 % of Max. Required Volume [M.m³/yr] (2)x60%	Annual Average Power Discharge Volume [M.m³/yr] (3)	Sufficiency (2035 Demand) (4) = (3)/(2)	Annual Average Power Discharge Volume [M.m³/yr] (7)	Sufficiency (Natural Condition) (8) = (7)/(2)
1	WRA 1	Kholombidzo	285.0	8,988	5,393	8,594	95.6	8,692	96.7
2		Nkula	264.0	8,326	4,995	8,016	96.3	8,105	97.3
3		Tedzani	325.8	10,274	6,165	9,604	93.5	9,768	95.1
4		Mpatamanga	418.0	13,182	7,909	11,752	89.1	12,057	91.5
5		Kapichira	343.6	10,836	6,501	10,107	93.3	10,283	94.9
6	WRA 5	Mbongozi	50.0	1,577	946	1,533	97.2	1,572	99.7
7		Malenga	50.0	1,577	946	1,556	98.7	1,578	100.1
8		Chasombo	60.0	1,892	1,135	1,669	88.2	1,752	92.6
9		Chizuma	60.0	1,892	1,135	1,684	89.0	1,762	93.1
10	WRA 7	Rumphi	30.0	946	568	787	83.1	861	91.0
11		Henga_Valley	40.0	1,261	757	1,153	91.4	1,229	97.4
12		Lower_Fufu	40.0	1,261	757	1,164	92.3	1,240	98.3
13	WRA 9	Bupigu	50.0	1,577	946	843	53.4	848	53.8
14		Sofwe	60.0	1,892	1,135	1,060	56.0	1,071	56.6
15		Manolo	70.0	2,208	1,325	1,236	56.0	1,248	56.5
16	WRA 14	Zoa_Falls	70.0	2,208	1,325	1,314	59.5	1,398	63.3
17	WRA 16	Chimgonda	20.0	631	378	317	50.3	358	56.8
18	WRA 17	Wovwe	1.017	32	19	23	71.5	27	85.0
	Total			70,559		62,412	88.5	63,849	90.5

Source: Project Team



Source: Project Team

Figure 4.4.2 Evaluation Result for Hydropower Generation Water Demand

(2) Evaluation Results based on Energy Production and Capacity Factor

In addition to the result shown in (1) above, hydropower projects were evaluated by capacity factors for energy production. Capacity factors are more practical indicators for evaluating hydropower projects both for run-of-river type and reservoir regulating type.

Load factor introduced in item (2) is an indicator from power demand side. On the other hand, capacity factor is an indicator from power supply side, derived from the formula below.

$$C.F\ (Capacity\ Factor) = \frac{Annual\ average\ eneregy\ production\ [GWh/yr]}{Installed\ Capacity[MW] \times 24\ [hr] \times 365\ [day]} \times 100\ [\%]$$

Since power generation and energy generation are based on power discharge volume, or water levels of the reservoir, the trend of the evaluation results on capacity factor presented here is almost the same as (a) valuation results on power discharge volume. Hydropower projects except for the Songwe River (WRA-9) and the Dwambezi River (WRA-16) are judged as feasible. For projects in WRA-9 and WRA-16, studies for optimizing design parameters in feasibility studies will be necessary to proceed hydropower development.

Table 4.4.4 Evaluation Result for Hydropower (Energy Production and Capacity Factor)

Capacity Factor (C.F.) [%] — WITH 2035 demand — WITHOUT other demand

No.	WRA	Name	Developemt Plan: Installed Capacity [MW]	Developemt Plan: Annual Energy [GWh/yr]	Developemt Plan: C.F [%]	Simulation Result (with 2035 upstream demand): Annual Average Energy [GWh/yr]		Simulation Result (with 2035 upstream demand): Capacity Factor (2035 Demand) [%]	Simulation Result (without upstream water demand): Annual Average Energy [GWh/yr]		Simulation Result (without upstream water demand): Capacity Factor (Natural Condition) [%]
			(1)	(2)	(3)	(4)		(5) = (4)/Σ(1) **	(6)		(7) = (6)/Σ(1)**
1	WRA 1	Kholombidzo	170	1,415	95.0	1,414.8	*	95.0	1433.5		96.3
2	WRA 1	Nkula	130	1,086	95.4	1,041.1	*	91.4	1055.8	*	92.7
3	WRA 1	Tedzani	110.7	949	97.9	863.8	*	89.1	881.0	*	90.8
4	WRA 1	Mpatamanga	228	1,156	57.9	1,634.4		81.8	1701.6		85.2
5	WRA 1	Kapichira	163.8	1,326	92.4	1,268.1	*	88.4	1315.6	*	91.7
6	WRA 5	Mbongozi	55	176	36.5	438.5		91.0	463.7		96.2
7	WRA 5	Malenga	62	152	28.0	487.0		89.7	541.2		99.7
8	WRA 5	Chasombo	55	159	33.0	332.5		69.0	357.0		74.1
9	WRA 5	Chizuma	50	122	27.9	389.1		88.8	407.5		93.0
10	WRA 7	Rumphi	10	36	41.1	61.4		70.1	69.3		79.1
11	WRA 7	Henga_Valley	28	137	55.9	199.9		81.5	223.7		91.2
12	WRA 7	Lower_Fufu	100	530	60.5	801.2		91.5	859.9		98.2
13	WRA 9	Bupigu	32	110	39.2	117.9		42.1	118.6		42.3
14	WRA 9	Sofwe	159	634	45.5	711.3		51.1	719.2		51.6
15	WRA 9	Manolo	148	596	46.0	661.4		51.0	668.0		51.5
16	WRA 14	Zoa_Falls	37	125	38.6	192.9		59.5	205.2		63.3
17	WRA 16	Chimgonda	50	191	43.6	210.2		48.0	237.0		54.1
18	WRA 17	Wovwe	4.35	38	100.0	27.2	*	71.3	32.3	*	84.7
	Total		1,592.9	8,938.0	64.1	10,852.9		77.8	11,290.2		

* : Simulated annual average energy is lower than the planned value

**** Capacity Factor (C.F.) = Annual Average Energy [GWh/yr] / (Installed Capacity [MW] x 24[hr] x 365[day] /1000) x 100 [%]**

Annual Average Energy [GWh/yr] = Σ {E (t) [GWh/day] x 365 [day]} / 30 [year]

Energy: E (t) [GWh/day] = P (t) [MW] x 24 [hr/day]

P (t) = 9.8 x C x Hg (t) x Qp (t) / 1000 [MW]

Hg (t) : Gross head [masl.] = "Reservoir Water Level (changes daily)" - "Tail Water Level (constant)"

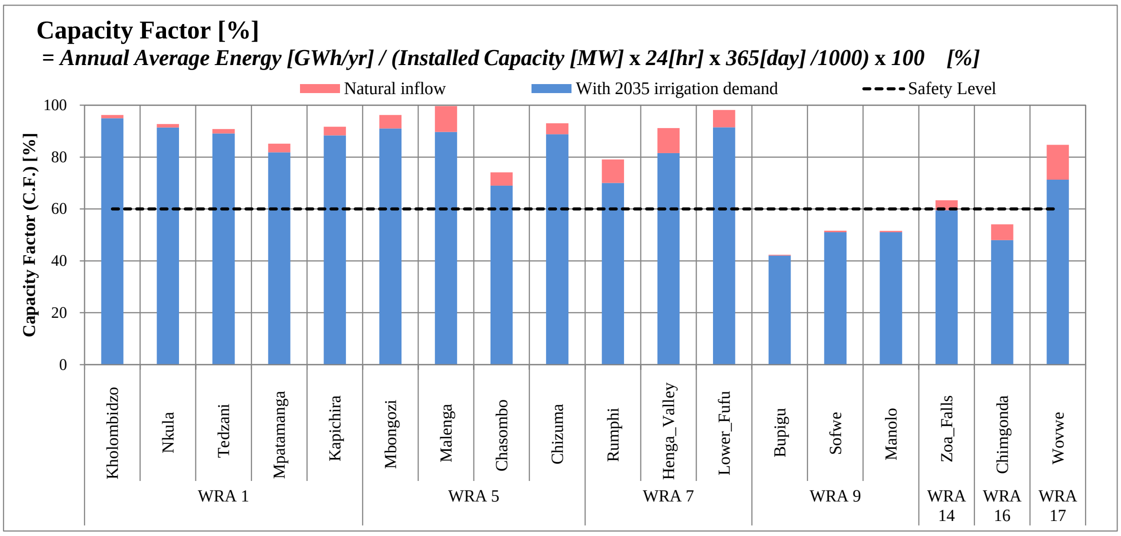
Qp : Power discharge [m3/s]

C : Combined effeciency in consideration of Head loss

C = Pmax / 9.8 / Hg / Qmax x 1000 = Pmax / 9.8 / (FSL - TWL) / Qmax x 1000, <--- Pmax = 9.8 x C x Hg x Qmax / 1000

FSL: Full Supply Level [masl.], TWL: Tail Water Level [masl.], Qmax: Maximum Plant Discharge [m3/s]

Source: Project Team



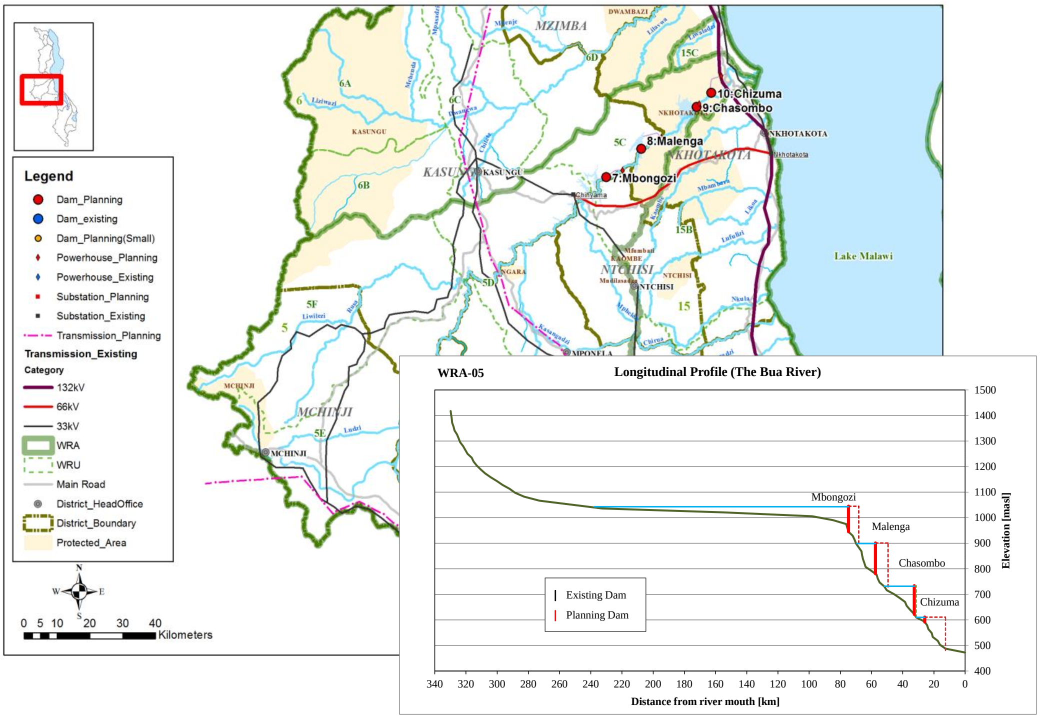
Source: Project Team

Figure 4.4.3 Simulation Result (Inflow, Outflow, Power Generation) in the Shire River

4.4.4 Conclusion for Evaluation Results for Hydropower Development

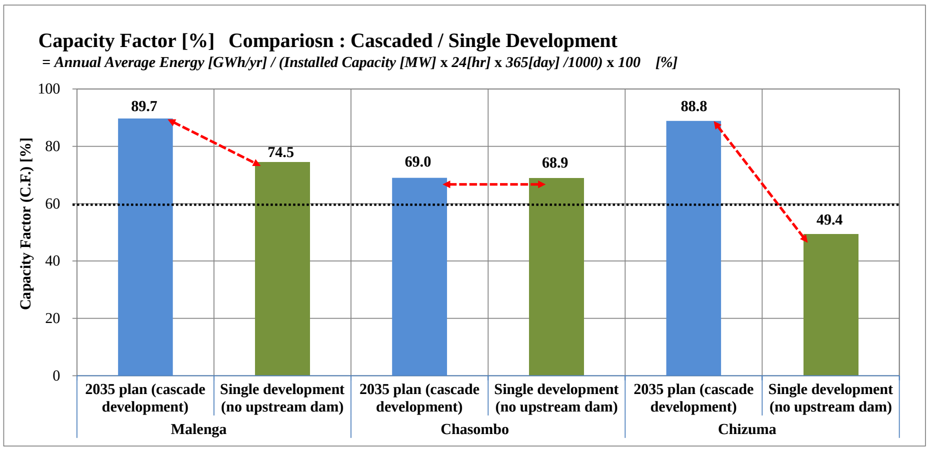
Table 4.4.4 and **Figure 4.4.3** were carried out with the assumption that all of the hydropower development projects have been completed. For the purpose of assessment of hydropower development plans, one of other development options is assumed. For example, there are 4 hydropower plants (Mbongozi, Malenga, Chasombo and Chizuma) at the Bua River as a cascaded hydropower development. The cascaded hydropower development has an advantage that river flow of the downstream hydropower plants will be steady because string reservoirs strongly regulate river discharge. For the purpose of discussion of hydropower development here, single development cases are assumed; namely, only Malenga (without Mbongozi at upstream of the reservoir), only Chasombo (no reservoir at upstream, without Mbongozi nor Malenga), and only Chizuma (no reservoir at upstream) is to be developed. As shown in **Figure 4.4.5**, although Chizuma hydropower project seems to be not feasible in case of single development, it will be feasible in case of cascaded development. Other projects are feasible in both single and cascaded development. **Figure 4.4.6** shows the comparison results on flow regimes for both single development case and cascaded development case. As shown in this figure, water use for power discharge will be available more steadily in cascaded development case than in single development case.

The comparison result shown below shows that cascaded development is more efficient than single development. For hydropower development, these points of view are to be considered in feasibility studies for the next development step.



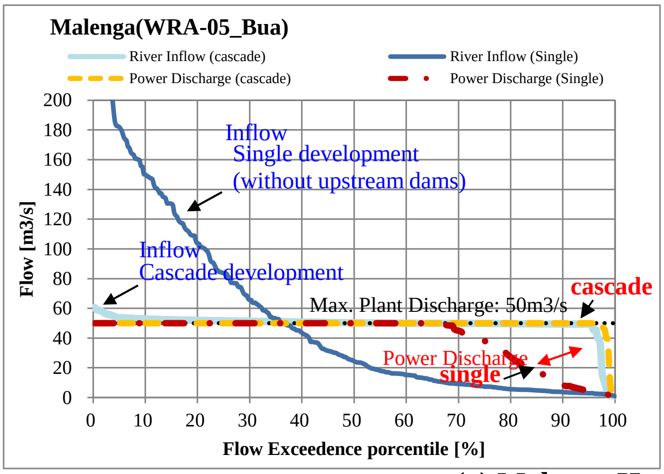
Source: Project Team

Figure 4.4.4 Example of Cascaded Hydropower Projects on the Bua River



Source: Project Team

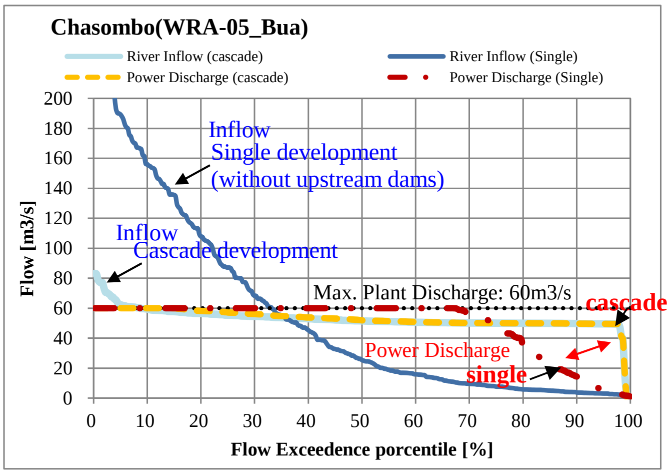
Figure 4.4.5 Comparison of Capacity Factor between Cascaded and Single Hydropower Development on the Bua River



Malenga	Single * Development	2035 Cascade Development
Plant Discharge	50.0 m^3/s	50.0 m^3/s
Inflow [%]	36.7 %	58.3 %
Plant Discharge [%]	66.7 %	97.2 %
50% flow	24.4 m^3/s	50.3 m^3/s
75% flow	7.4 m^3/s	49.8 m^3/s
95% flow	2.9 m^3/s	49.4 m^3/s

*** Without upstream dams (Mbongozi)**

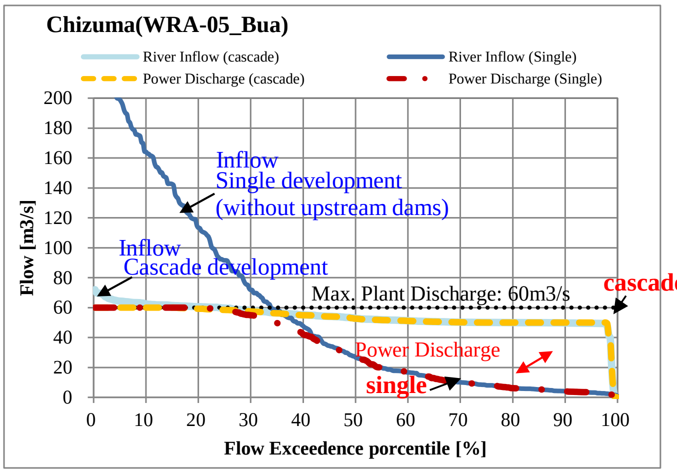
(a) Malenga Hydropower Project



Chasombo	Single * Development	2035 Cascade Development
Plant Discharge	60.0 m^3/s	60.0 m^3/s
Inflow [%]	33.3 %	8.9 %
Plant Discharge [%]	67.2 %	15.0 %
50% flow	25.4 m^3/s	51.6 m^3/s
75% flow	7.7 m^3/s	50.0 m^3/s
95% flow	3.1 m^3/s	49.6 m^3/s

*** Without upstream dams (Mbongozi, Malenga)**

(b) Chasombo Hydropower Project



Chizuma	Single * Development	2035 Cascade Development
Plant Discharge	60.0 m^3/s	60.0 m^3/s
Inflow [%]	33.9 %	15.6 %
Plant Discharge [%]	21.4 %	19.7 %
50% flow	26.7 m^3/s	52.9 m^3/s
75% flow	8.1 m^3/s	50.1 m^3/s
95% flow	3.2 m^3/s	49.5 m^3/s

*** Without upstream dams (Mbongozi, Malenga, Chasombo)**

(c) Chizumao Hydropower Project

Source: Project Team

Figure 4.4.6 Comparison of Flow Duration Curves between Cascaded and Single Hydropower Development on the Bua River

4.4.5 Summary and Conclusion for Evaluation Results for Hydropower Development

According to the results and discussion above, hydropower projects in Malawi are feasible from the standpoint of water resources. Furthermore, cascaded development proposed in the master plan level study of WB1998 is more beneficial than single development. Therefore, as MoNREE proceeds with the projects, feasibility studies and further design studies are recommended for practical hydropower development.

4.5 Proposal for Capacity Development

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 sometimes face difficulties. Furthermore, in consideration of increasing of water demand for irrigation or urban use, necessity for developing multipurpose dam including hydropower will rise up. Furthermore, developing the 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 sharing development of the watershed will be very important. From the viewpoints above, cooperation with MoNREE and MoAIWD will be very important.

As for hydropower development in Malawi, a number of IPPs are recently energetically starting pre-feasibility studies and proposing hydropower potential sites to be developed. Therefore, as a regulatory authority, DoE of MoNREE should possess the ability to evaluate proposals for hydropower development. At present, a JICA expert on electricity works is supporting DoE. However, it is said that DoE staff's capability at present is not enough for evaluating hydropower. Therefore, technical assistance and capacity development for hydropower development are essential for DoE.

4.6 Challenges to Facility Management

4.6.1 Sediment Management

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

At present, sedimentation in the existing hydropower reservoirs such as Nkula, Tedzani and Kapichira is serious. Most of the sediment comes from the tributaries downstream of the Kamuzu Barrage at Liwonde according to ESCOM (Electricity Supply Corporation of Malawi Limited). Since the river bank of tributaries are not protected, soil from the croplands adjacent to rivers flow into the rivers when flood occurs.

As for countermeasures, dredging/excavation and scouring are applied. Since 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 sediment. Therefore, dredging is the main countermeasure at present. According to ESCOM, the dredger in the Nkula reservoir operates 16 hours a day for the whole year. The removed sediment are fertile and can be utilized as fertilizer for agriculture.

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

4.6.2 Weed Management

Weeds flowing into intakes are also a problem to hydropower generation. ESCOM is occupied with the removal of weeds from the intakes. Some of the weeds come by passing through the Kamuzu Barrage at Liwonde, and the others from the tributaries. As for countermeasures, removing the weeds at the upstream point of Liwonde has been effective, and the volume passing through Liwonde has decreased. However, weeds flowing together with sediment from the tributaries have been increasing because of soil erosion at the tributaries, similar to the above-mentioned sedimentation. Therefore, as mentioned above, protecting the river bank to prevent soil erosion will be important for this countermeasure. Furthermore, it will be effective to restrict cropland use along the river.

4.7 Conflict Management

As mentioned above, water demand for irrigation at the upstream will have impacts on hydropower generation because water used for irrigation never flows 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 the 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 among them the amount to be developed to meet water demand. As for the opportunity to discuss the conflicts, activities and organizations such as the Sector Wide Approach (SWAp), or the River Basin Authority (RBA) could play important roles for solving conflicts. The Shire River Basin Management Project (SRBMP) supported by the World Bank plays important roles on conflict management as well as facilities management.

4.8 Summary and Consideration on Hydropower Development

The project on hydropower presents hydropower potential in whole Malawi, and also presents preliminary evaluation results from the standpoint of water resource management. These results can be utilized for discussion between stakeholders of water use on the river basin as well as for further studies on hydropower development.

In the Project, present conditions of hydropower were summarized. At first, existing hydropower facilities were summarized and present issues/problems of facility management were also summarized. Then, hydropower potentials were summarized based on the World Bank's master plan study on electricity power development in 1998 together with the updating of available latest study reports and information provided by DoE and ESCOM. Finally, these hydropower projects including existing facilities and planning projects were evaluated from the viewpoints of Integrated Water Resources Management (IWRM). From the standpoint of IWRM, water resource conditions of present condition and future condition (namely with irrigation withdrawal) are considered to evaluate hydropower projects.

In this evaluation study, cascaded hydropower developments are considered. Therefore, as one of discussions, comparative study for the Bua River between cascaded hydropower development and single development is conducted for example as a preliminary case study. This case study of comparison study for the Bua River shows the advantages of cascaded hydropower development. The reservoir with a huge volume will contribute to decrease flood peaks and increase low waters to provide steady inflow to the downstream hydropower reservoirs which help these downstream hydropower plants to generate power stably.

According to the results of evaluating hydropower projects, future water demand for irrigation upstream of hydropower projects will give impacts on hydropower generation, decreasing power generation due to decreasing river inflow to the hydropower reservoir by withdrawal for irrigation upstream of the river.

These results will present information for discussion among multi-stakeholders for water use on the river basin.

However, the evaluation results on hydropower developments presented here are preliminary results only from the standpoint of water resources without considering other points for hydropower development. Therefore, it is necessary to conduct a study for the respective projects from the viewpoint of comprehensive evaluation in feasibility studies and further studies for actual hydropower development.

In the Project, planning parameters are assumed almost based on the master plan level study without optimizing these parameters by economic/financial studies, power generation planning studies, and design and planning optimization studies. Power generation and energy production in the Project are evaluated merely based on river inflow, supplementary water from storage water in the reservoir, and power generation calculation based on power discharge and hydraulic heads (hydraulic head between reservoir water level and tail water level at the powerhouse) for power generation assuming 24 hours continuous power generation without considering peak/off-peak generation. Reservoir storage capacity curves for planning projects adopted here are mostly based on 1/50,000 topographic maps and data provided in master plan level studies. Therefore, planning parameters including operating water levels, optimum designs, and reservoir storage capacity should be studied based on topographic maps to be prepared in feasibility studies.

Furthermore, for practical hydropower development, detailed conditions should be studied in feasibility studies including reviewing electricity demand study, cost/benefit study, and optimization study of power generation planning in consideration of roles of each hydropower plant (for example, to supply electricity to satisfy peak demand or to supply for base demand).

References

[i] Ministry of Natural Resources, Energy and Environment (MoNREE), Malawi Electricity Investment Plan, 2011
[ii] World Bank (WB), Power System Development Study and Operation Study, Appendix Volume PM01, 1998
[iii] IAEA, International Atomic Energy Agency (IAEA), Malawi Energy Demand Assessment Report, 2011

PART II

Chapter 5. WATER RELATED DISASTER

CHAPTER 5. WATER RELATED DISASTER

5.1 Background of Disaster Related to Water

5.1.1 General Disaster Conditions

(1) Major Water Related Disaster in Malawi

Overall, records as to disaster damage provided by DoDMA and the Prevention Web (by UNISDR: The United Nations Office for Disaster Risk Reduction) give critical information related to human and economic losses resulting from the disasters that have occurred in Malawi during this three decades. More than 47 natural disasters were recorded in the period and these disasters range from droughts, earthquakes, epidemics, floods and storms. In these natural disasters, a total of 2,775 people were killed with an average of 90 people killed per year. Most of these (60%) died due to epidemics. In terms of people affected with the disasters, a total of over 20 million people were affected with an average affected population of over 700,000 per annum. Among them, floods have the highest frequency followed by droughts while storms were the least in occurrence.

(2) Flood and Drought Conditions

The 1991 flood recorded the second highest economic damage following the damage by earthquake 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. The top 5 economic damage and affected people by floods and droughts are summarized in **Table 5.1.1**.

In addition, in the year 2008, it was recorded by DoDMA (2008) that Nsanje District had the highest number of households affected by floods (16,341). This was followed by Chikhwawa District with 5,678 households affected. As overall for the year 2008, 27,758 households were affected, 9,851 had their households damaged while a total of 10,080 hectares of crops were damaged by natural disasters.

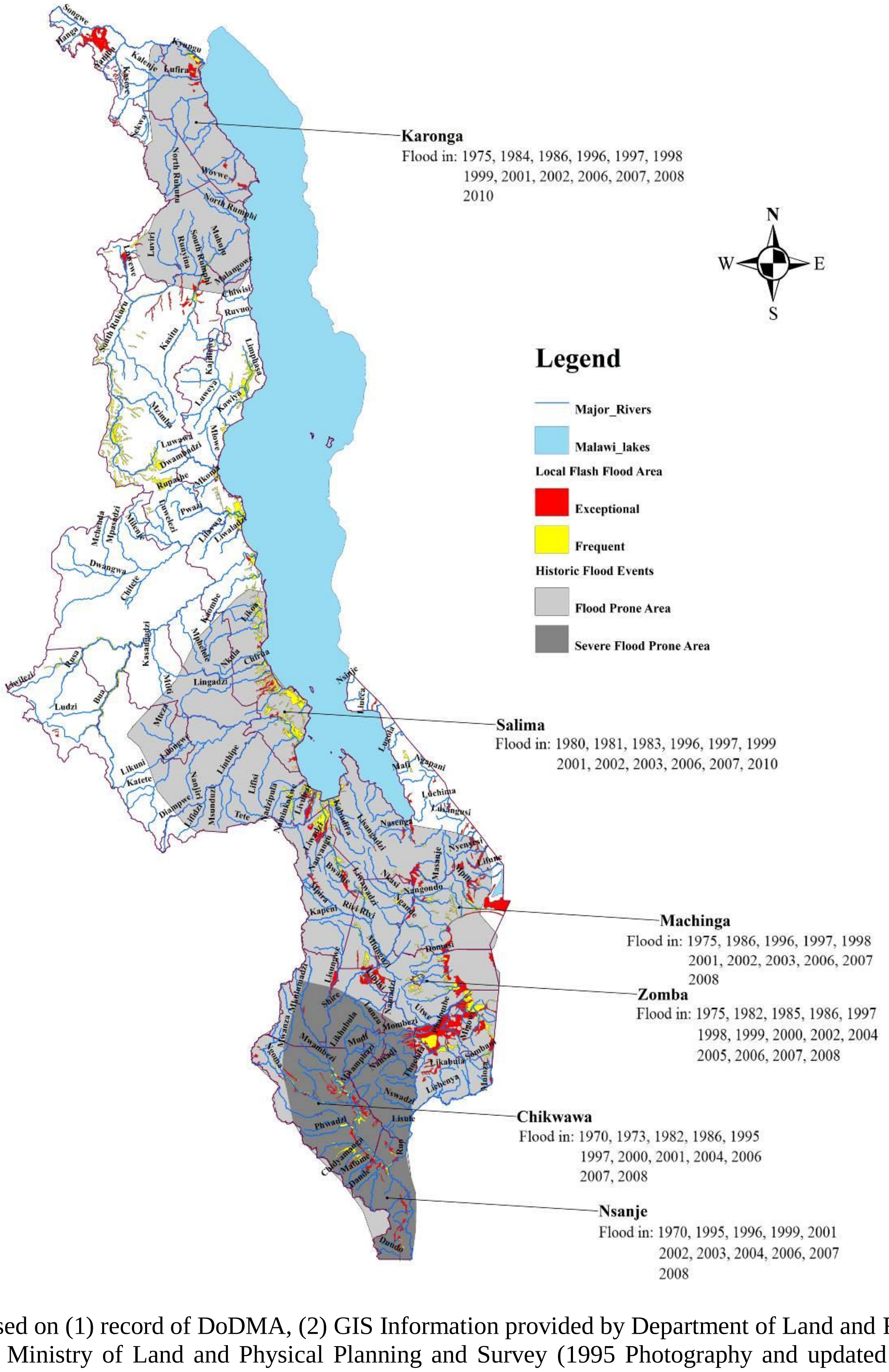
Table 5.1.1 Top Five Economic Damages (Left) and People Affected by Major Droughts and Floods (Right)

Order	Disaster Events	Year	Damage (1,000USD)
1	Earthquake	1989	28,000
2	Flood	1991	24,000
3	Flood	2001	6,700
4	Flood	2000	1,000
5	Flood	1998	89

Year	People Affected (Drought)	Year	People Affected (Flood)
1987	1,429,267	1991	268,000
1990	2,800,000	1997	400,000
1992	7,000,000	2001	500,000
2002	2,829,435	2002	246,340
2005	5,100,000	2003	81,604
2007	520,000	2007	180,246

Source: EMDAT and Prevention Web

According to the report "Malawi and Southern Africa: Climatic Variability and Economic Performance (2003, WB)", 6 districts; namely, Karonga, Salima, Machinga, Zomba, Chikwawa and Nsanje, are vulnerable to flood and drought events. In addition, areas remarkable and vulnerable to flood and drought are illustrated in **Figure 5.1.1** which also indicates flood occurrence years and probable flood areas based on DoDMA's disaster record and **Figure 3.5.1** in **Part I: Chapter 3**, respectively.



Based on (1) record of DoDMA, (2) GIS Information provided by Department of Land and Resources in the Ministry of Land and Physical Planning and Survey (1995 Photography and updated using 2012 Satellite Images) and (3) Linthipe and Lingadzi River System Study (GIZ, 2012)

Figure 5.1.1 Major Areas Vulnerable to Flood and Drought Damage

5.1.2 Policy and Legislations for Disaster Management

(1) Disaster Risk Management

The Disaster Risk Management (DRM) should be strengthened by the spiral-up process under a series of activities for mitigation and preparation works in the precaution stage and for response and recovery works after occurrence of disasters. The spiral-up process will create a virtuous cycle to adapt to prevention and mitigation works against disaster damages. The cycle described above is called as “Disaster Management Cycle”.

However, in Malawi, activities for DRM is just started for the first step of the cycle based on the “National Disaster Risk Management Policy (2013-2017)” which is aligned to “Hyogo Framework for Action (HFA 2005-2015)” adopted by the United Nations World Conference on Disaster Reduction in 2005 of which the Malawi Government is a signatory. The 6 linked legislations and strategies to the policy are summarized in the table below.

Table 5.1.2 Linked Legislations and Strategies

No.	Legislations and Strategies	Year of Enactment
1	The Forestry Act	1996
2	The Irrigation Act	2001
3	The Local Government Act	1998
4	The Town and Country Planning Act	1988
5	The Water Resources Act	1696
6	The Malawi Growth and Development Strategy 2012-2017	
7	The Malawi Constitution.	

The Policy consists of 6 priority areas toward achievement of the policy goal and ensuring that it meets commitments of HFA, the Africa Regional Strategy for Disaster Risk Reduction, MDGs and MGDS. The priority areas are as itemized below.

- Mainstreaming disaster risk management into sustainable development
- Establishment of a comprehensive system for disaster risk identification, assessment and monitoring
- Development and streaming of a people-centered early warning system
- Promotion of a culture of safety, and adoption of resilience enhancing interventions
- Strengthening preparedness capacity for effective response and recovery

(2) Flood Risk Management Strategy

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

5.2 Integrated Flood Management (IFM)

5.2.1 Objectives and Policy of Flood Control

Flood disaster should be prevented and mitigated in consideration of activities for other disasters to effectively utilize systems, functions, human resources, budget related agencies as to DRM. In addition, the Malawi Government states that all stakeholders in the country shall 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 also be integrated with the National DRM and countermeasures should be done involving all stakeholders from government units and civilian groups. In this context, an integrated flood management (IFM) in Malawi should be recommended and supposed by strategies explained in item (2).

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 scattered to manage. Efficiency of large-scale structural measures that aim to deal with floods in Malawi may be very low because the flood damaged areas are less developed and less populated. Therefore, appropriate flood management made of the best mix of structural and non-structural measures should be applied to build a society resilient to floods.

5.2.2 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 flood damage in habitual flood areas. The measures should consist of structural and non-structural measures in consideration of climate change impacts and cost-benefit. The characteristics of habitual flood areas is described below.

The major flood prone districts in Malawi are the Karonga, Salima and Nsanje districts. For instance, flood disasters in Karonga District are due to swollen rivers, rising of water level in the lake, water stagnation in low lying areas and ground saturation especially on wetlands (Karonga Contingency Plan 2010), whereas in Salima and Nsanje, floods are reported to be due to the swelling of rivers and come from upland areas in the interview survey of the Project. The frequency of flood is presented in **Figure 4.3.1**.

Most of the floods that have caused damage are the flash floods which normally come along with no alert message and even cause severe damage when experienced at night. In Karonga, floods tend to occur more often in the northern and southern parts of the district while floods that are experienced in Salima are due to the swelling of the Linthipe and Lifidzi rivers. On the other hand, floods experienced in Nsanje are either due to over-topping of the Ruo or Shire rivers in the junction.

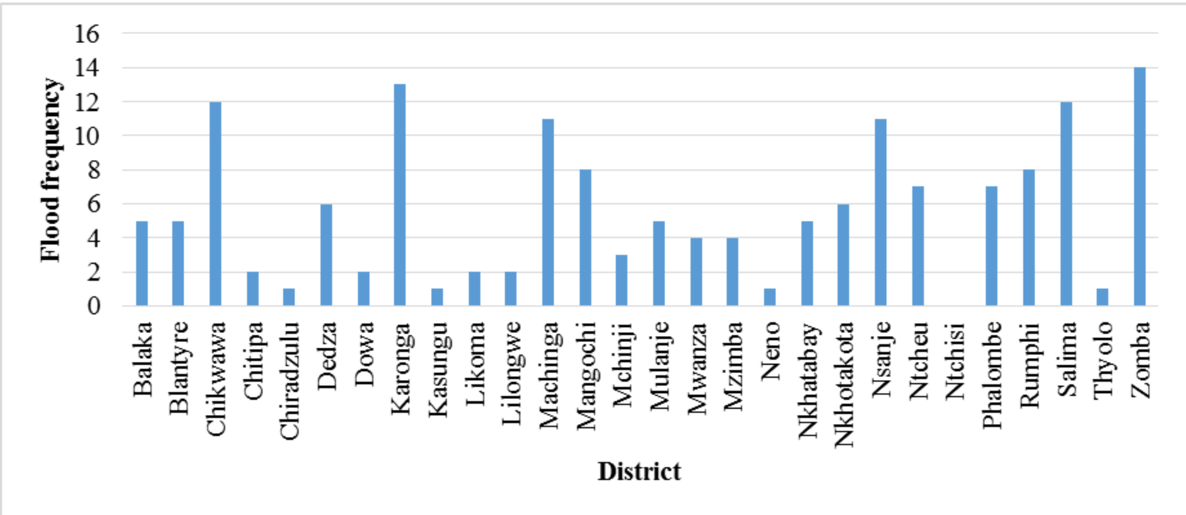


Figure 5.2.1 Flood Frequency of Over 40-Year Return Period in Districts

Flood disaster damages and frequency have increased in the recent years due to effects of human activity, catchment destruction and river-line cultivation. The frequency is shown in **Figure 5.2.1**. Average return period in such floodplains has been reported to have decreased to almost less than half in the past three decades; for example, according to the hydrological observation data of MoAIWD, the Songwe River has decreased from 5-year in the 1980's to 2-year in the recent years. Discharges in these rivers have also tremendously increased in recent years; for example, Songwe River which increased from 500 cubic meters per second in 1986 to 2000 cubic meters in 2006.

(2) Creation of Flood Resilience Land Use

Disorderly land development in flood prone areas increase the 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 stakeholders meeting held in September 2014, there were recommendations from stakeholders to regulate cultivation in the riverine areas so as not to increase sedimentation which results in the malfunction of river facilities and occurrence of overflow 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 does 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 silt in places close to where it joins Linthipe River. There is no trace of river course since any drop of water that finds its way into the river spreads and floods into villages and fields that lie below it.

In addition, people living in flood prone areas are also a problem to protect 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 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 be introduced with technical assistance by WB in the Shire River Basin. Similar activities and projects should be implemented in the flood habitual areas.

5.2.3 Objectives and Roadmap for IMF

The objective of the 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 in the "Flood Risk Management Strategy (2010)"; however, the strategy was formulated before DoDMA started the DRM activities by 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.

5.2.4 Action Plans for IMF Roadmap

Based on the conditions described in items (1) to (3), action plans proposed for the IMF are given in **Table 5.2.1** and explained thereafter.

Table 5.2.1 Action Plan for the IMF

Program	Project / Activities (WRA / Time Frame / Organ/Budget)	Prior WRA	Short Term 2012-2020: 12	13	14	15	16	17	18	19	20	Middle Term 2021-2025: 21	22	23	24	25	Long Term 2026-2035: 26	27	28	29	30	31	32	33	34	35	Responsible Organ: Main	Major Associate
Policy and Strategy																												
F-1	Establishment of Flood Disaster Management Cycle	All	━	━	━	━	━	━																			MoAIWD and DoDMA	DRM members
F-2	Formulation of River zoning , code and protocols	All				━	━	━	━	━	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	ditto	ditto
Preparation & Studies																												
F-2	Risk Assessment for Malawi	All	━	━	━																						DoDMA	DRM members
F-3	Strenghening of information management system	All				━	━	━	━	━	━	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	MoAIWD	RBA
F-4	Feasibility Study for major vulnerable areas	1, 15, 17				━	━	━	━																		MoAIWD	RBA and DoDMA
F-5	Investigation for flash flood damage for tributaries of main rivers	All							━	━	━	━	━	■	■	■	■	■	■	■	■	■	■	■	■	■	MoAIWD	RBA and DoDMA
F-6	Preparation of technical guidelines for flood protection works	All				━	━	━	━	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	MoAIWD	RBA
F-7	Capacity building for flood protection works and plannning	All				━	━	━	━	━	━	━	━														MoAIWD	DoDMA and RBA
Implementation of Flood Mitigation Works																												
F-9	Implementation of flood warning system	All			━	━	━	━	■	━	━	━	━	■	■	■	■	■	■	■	■	■	■	■	■	■	MoAIWD and DoDMA	-
F-10	Implementation of flood protection works	1, 15, 17								━	━	━	━	■	■	■	■	■	■	■	■	■	■	■	■	■	MoAIWD	DoDMA and LG
F-11	Implementation of community-based flood protection	All											━	━	━	━	━	■	■	■	■	■	■	■	■	■	DoDMA and LG	MoAIWD
Response and Recovery																												
F-11	The response and recovery should be done by line ministries in accordance with DRM	All																									DoDMA	MoAIWD and RBA

RBA:River Basin Authority, LG: Local government

Source: Project Team (modified the schedule and action plans proposed in the Flood Risk Management Strategy by UNDP, 2011)

(1) Improvement of Strategy in consideration of DRM Preparation (F-1)

The flood risk strategy by UNDP should be rearranged and modified to harmonize with recent activities related to DRM because the Strategy was formulated before DoDMA started the DRM activities and the enactment of the Water Bill, and occurrence of the largest flood (2011). The flood is one of disaster risks which should be effectively managed by integrated approach using limited human resources, budget and functions of related agencies.

(2) Formulation of River Zoning, Hazard Maps and Protocols (F-2)

Zoning and regulations in the rivers and flood prone areas are essential for prevention of disorderly development activities which will cause increment of flood damage. Especially, river areas should be confirmed, regulated and managed by government agencies. It is better to define the river area in consultation with MoAIWD and the River Basin Authority. In addition, authorization and gazette of the area by the Malawi Government are necessary through the formal protocol by the line ministries headed by the Ministry of Land and Physical Planning and Survey.

After the confirmation of river area, line ministries and local governments should refer to the river area to make flood maps/hazard maps which are information to examine the flood countermeasures and make flood management plans. In addition, all the environmentally and ecologically important and sensitive areas such as protected areas, wetlands, water catchment areas, wildlife corridors and so on should be considered and demarcated when the flood mitigation and prevention plans are formulated.

Flood hazard maps which graphically indicate information on inundation areas as well as on evacuation areas are useful to reduce loss of people’s property and help smooth evacuation from home to relief areas before the occurrence of flood. Recently, the flood inundation area in the Shire River Basin has been analyzed. More detailed analyses and studies regarding the hazard areas are necessary to facilitate the smooth evacuation and regulation of land use in and around local areas vulnerable to flood damage. As a result of the activities, the flood hazard maps will be elaborated including the information for their use not only for recording flood inundation but also for raising flood-awareness of people, land use planning and evacuation activities.

(3) Risk Assessment (F-3)

Flood risk assessments have been conducted by DoDMA based on exposure data and assumptions of damage. The results should be utilized to select priority areas and formulate flood mitigation plans in the future.

(4) Strengthening of Information Management System (F-4)

To make flood mitigation plans and hazard maps, the hydro-meteorological information is essential as well as flood damage information. Currently, former information is managed by MoAIWD (hydrological data) and MoNREE (meteorological data), while the latter one is recorded by DoDMA. These information should be arranged properly and shared among related agencies. In the future, the River Basin Authority may be a platform to share and manage the information; however, the ministries should have a proper management system individually to smoothly furnish the information to the authority and related agencies or water users for the purpose of integrated water resources management. A program to enhance capacities on information management is also suggested to introduce a proper information management system.

(5) Feasibility Study for Major Vulnerable Area (F-5)

At present, flood prevention works such a construction of dikes or piling of sandbags are carried out based on requests from the local government. DoDMA and MoAIWD dispatch engineers to assists the local government or NGOs which directly conduct the works. However, MoAIWD should conduct feasibility studies to clarify necessary measures and interventions in the vulnerable areas classified in the Project before flood mitigation works are implemented ad hoc by the local governments.

(6) Investigation for Flash Flood Conditions (F-6)

Several studies and analysis have been carried out by the Ministry of Land and Physical Planning and Survey (MoLPPS), DoDMA and development partners to outline and classify the flood conditions. However, implementation of detailed investigation is necessary to build plans to mitigate flood damages in the local areas. Local governments should be involved from the planning stage to enable them understand the flood conditions and countermeasures to be conducted in future. Many flashflood damaged areas can be seen in **Figure 5.1.1**.

(7) Preparation of Technical Guidelines for Flood Protection Works (F-7)

MoAIWD is responsible for flood forecasting and warning systems, and flood mitigation and protection works such as river training, dams, levees and dykes. However, technical guidelines and manuals, and design standards are not prepared in the Ministry. The guidelines and manuals should be arranged and distributed in MoAIWD to implement flood protection and mitigation works and maintain river structures properly.

So far, flood protection works and design of structures are conducted by the local government as local development funds permit with the assistance of MoAIWD or traditional authority and village civil protection committees with the assistance of NGOs and DoDMA. However, the river structures for prevention of floods such as a small dike are easily flushed away or collapsed partially in the next flood due to the lack of proper guidance and directions for planning, designing and maintenance.

(8) Capacity Building for Flood Protection and Mitigation Activities (F-8)

MoAIWD, DoDMA and local government agencies are responsible for the security of the people at the national and local level. Actually, they shoulder activities of flood warning/forecasting, evacuation, flood fighting and rescue during floods. Moreover, they should be involved in land use planning to clarify the flood hazard area and river area. Therefore, strengthening of the capacity of the MoAIWD, DoDMA and local government agencies is a key for building flood-resilient communities. Implementation of capacity building programs for flood protection and mitigation are proposed in terms of: (a) Information management and sharing (especially, hydro-meteorological information and disaster information);

(b) Arrangement of technical guidelines; (c) Flood hazard maps with flood evacuation drills; (d) Flood forecasting and warning; (e) Flood evacuation system: (f) Construction works; and (g) Definition of river area and regulation of land use in the area.

(9) Implementation of Flood Warning System (F-9 and F-11)

Under the DRM Policy, DoDMA has initiatives to conduct preparation and planning to establish community based early warning system and national early warning roadmap with line ministries in the process of the policy priority area No. 2. After the preparation, early warning systems and forecasting systems should be installed in the major vulnerable area and local flash flood areas based on the result of "F-5" and "F-6". Simultaneously, MoAIWD should rehabilitate and strengthen the hydrological monitoring system and information management system and the result of activities of "F-4".

At the same time, the project "Shire Basin Operational Decision Support System (ODSS) through Enhanced Hydro-Meteorological Service" starts to install a real-time forecasting modelling framework and early warning system with automated alert system. Learnings from the project should be disseminated and utilized in case of the implementation of warning and forecasting systems in other areas.

(10) Implementation of Flood Protection Works (F-10)

Flood prevention and mitigation works should be done in the selected area based on the result of "F-7". Scales and durability of structural measures to prevent and mitigate the flood damage should be planned and designed based on the hydrological information which is rehabilitated in "F-4" as well as cost-benefit conditions. The guidelines, manuals and standards, which are prepared in "F-6", should be utilized to plan, design, maintain and operate river structures.

(11) Response and Recovery (F-12)

In accordance with the DRM cycle, activities for response and recovery shall be executed in the future in case of the occurrences of flood disaster and learnings from the response and recovery works will be utilized to renew the plans formulated in "F-5" and "F-6". The cycle should be spiraled up to improve the quality of all activities from "F-1" to "F-9".

PART II

Chapter 6. SOIL EROSION MEASURES AND WATERSHED CONSERVATION PLAN

CHAPTER 6. SOIL EROSION MEASURES AND WATERSHED CONSERVATION PLAN

6.1 Introduction

Deforestation and forest degradation have rapidly proceeded in Malawi mainly due to augmentation of agricultural land and logging for charcoal production and utilization as firewood. The reasons are low electrification rate, high population growth, poverty and low literacy. Insufficient management of agricultural land also causes soil erosion and results in deterioration of crop yields. Sediment runoff to rivers impacts on structures such as dam. In the Shire river basin, sedimentation in hydropower dams has occurred (see photos below) due to cutting of trees for firewood with population increase in Blantyre resulting in the deterioration of storage capacity of reservoirs, instability of and decrease in power generation and degradation of structures such as intake facilities.

Sedimentation in rivers, furthermore, causes aggradation of river bed level and deterioration of flow capacity. The lowering of water retention capacity of land due to deforestation increases peak flow and rapid runoff of water resources. In the Songwe River floodplain, there is siltation problem blocking tributaries and causing flood damage to crops and houses. The Ruo River also has siltation problems at the confluence with the Shire River where the Ruo River has a steep slope and the Shire River has a gentle slope. This confluence is located downstream of the Elephant Marsh, and the sediment is thought to affect the river channel and floodplain of the Shire River.

There are many malfunctioning irrigation ponds due to sediment inflow. The Bwanje Valley Irrigation System was damaged by the flood in 2001 and sedimentation caused the problem of maintenance. Proper management is, therefore, necessary for sustainable utilization of irrigation ponds.

At the wetlands which are valuable water resources for irrigation as well as habitat for a variety of species, sedimentation causes change in wetland environment.

The load to water treatment plants increases sediment inflow to rivers. Sedimentation at intake results in failure of intakes and damage of facilities.

Vegetation outflows together with soil erosion cause a problem for reservoirs. ESCOM which manages hydropower dams on the Shire River suffers from removing vegetation which flows from tributaries among others.

Based on the above-mentioned situations, there is strong relationship between soil erosion and water resources, etc. The issue of soil erosion is sector-wide and watershed conservation is necessary for securement of water resources.

Source: ESCOM

Sediment deposition near the intake (March 2010)

Source: ESCOM

Sediment deposition in the reservoir (March 2010)

6.2 Present Condition

6.2.1 Existing Results of Study

There are existing results of study about soil erosion risks such as the 1986 soil erosion hazard map and risk of sediment ingress to watercourses shown in **Figure 6.2.1** and **Figure 6.2.3**. The risk of sediment deposition at watercourses was studied in the Water Resources Investment Strategy and the risk for each WRA and WRU were estimated by considering land cover, rainfall, slope, soil erosion and distance from watercourse.

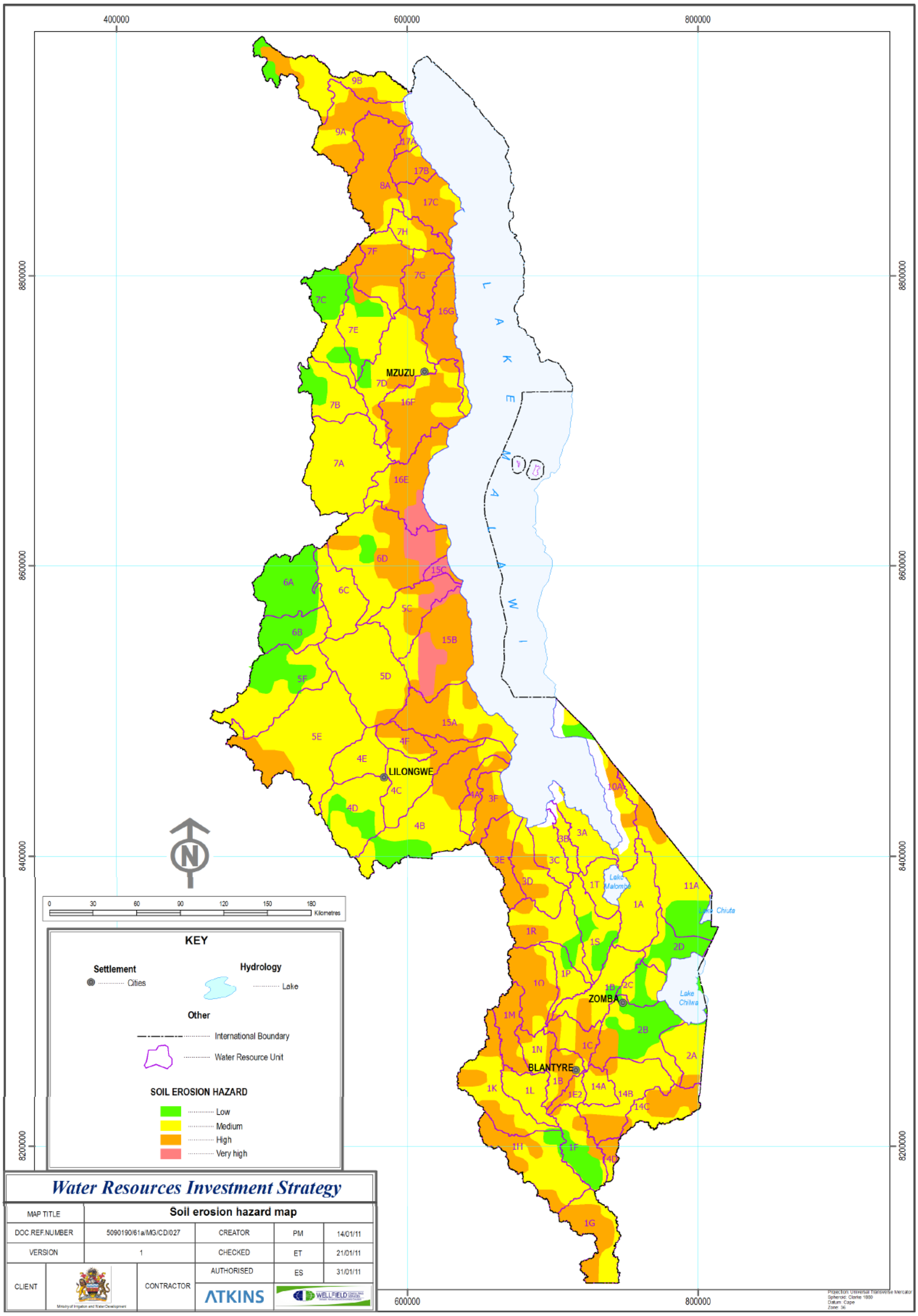
JICA implemented the project for community vitalization and afforestation in Middle Shire (COVAMS) from 2007 to 2012 with the Department of Forestry to control soil erosion through community forestry. As of the present, the project for promoting catchment management activities in Middle Shire is being conducted to expand the approach developed by COVAMS to other areas of Middle Shire Catchment.

The Shire River Basin Management Program (SRBMP) was carried out by the World Bank to construct the framework for managing the Shire river basin and watershed conservation in order to recover forest resources and prevent soil degradation, etc. There are three components; namely, Shire Basin Planning (Component A), Catchment Management (Component B), and Water Related Infrastructure (Component C). Under each component, there are three or four sub-components. Soil and water conservation is under Component B. **Table 6.2.1** shows soil loss of priority sub-catchment areas for the Component B project which are selected by consideration of reducing sedimentation impact on hydropower plants at lower stream and site characteristics. **Figure 6.2.5** shows the location of the priority sub-catchment areas.

Table 6.2.1 Overview of Priority Sub-Catchment for Project Component B of SRBMP

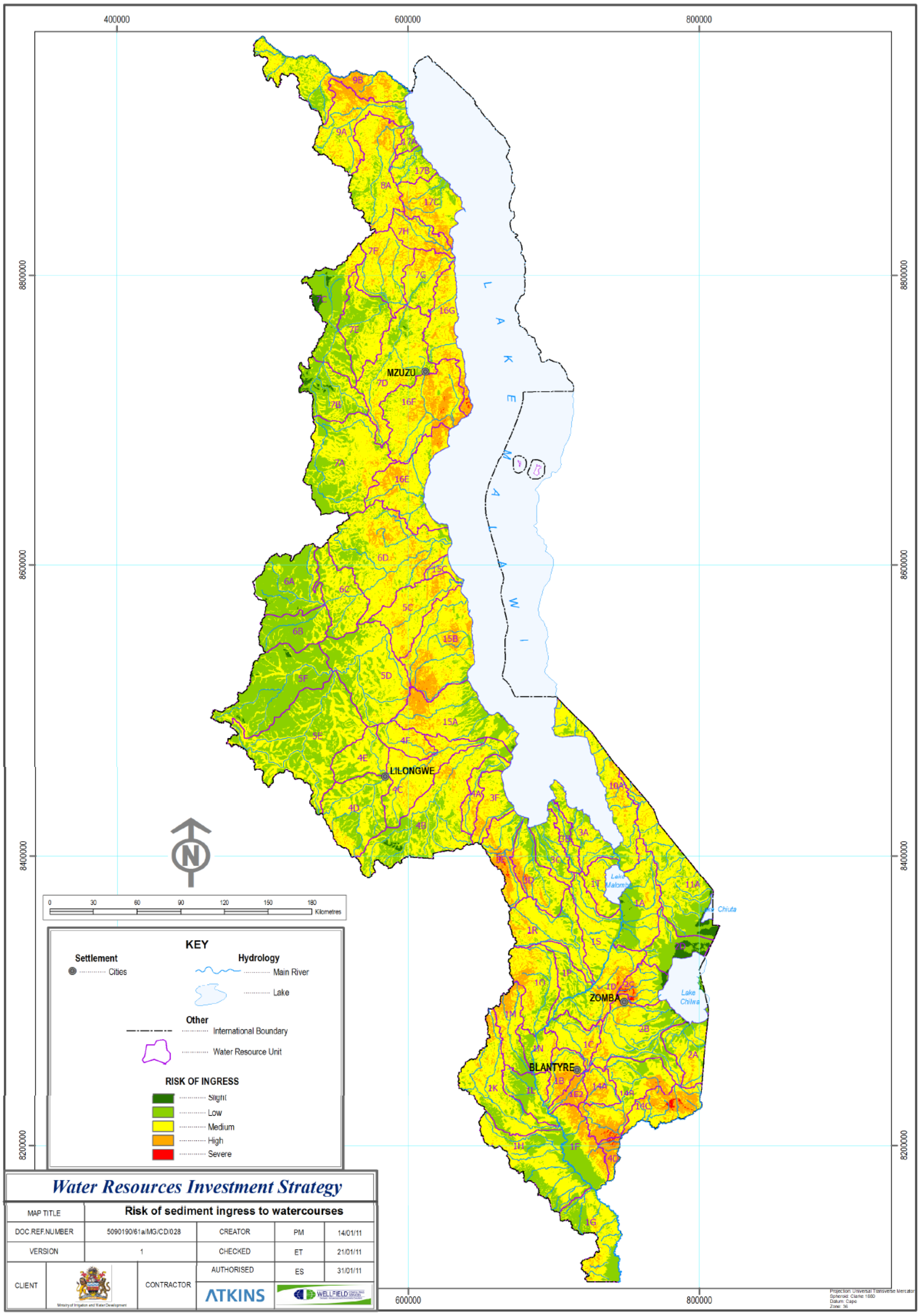
Sub-catchment Code	No of GV	No. of HH	Area (ha)	High Soil Loss (ha)	High Soil Loss (%)	Area/GVH (ha)	Ha/HH
Catchment 1 - Upper Lisungwe							
48	3	7,424	16,075	9,803	61.0	5,358	2.2
47	1	2,334	9,706	3,917	40.4	9,706	4.2
Sub-total	4	9,758	25,781	13,720	53.2	6,445	2.6
Catchment 2 - Upper Wamkulumadzu							
53	1	1,273	15,913	6,760	42.5	15,913	12.5
51	2	4,089	7,703	3,551	46.1	3,852	1.9
52	2	1,955	9,641	5,159	53.5	4,821	4.9
Sub-total	5	7,317	33,257	15,470	46.5	6,651	4.5
Catchment 3 - Escarpment Upstream from Kapichira Falls (Blantyre District)							
70	5	6,269	20,130	13,402	66.6	4,026	3.2
79	3	4,923	12,996	7,362	56.6	4,332	2.6
Sub-Total	8	11,192	33,126	20,764	62.7	4,141	3.0
Catchment 4 - Chingale							
39	6	9,600	17,578	7,700	43.8	2,930	1.8
40	4	5,110	9,829	3,321	33.8	2,457	1.9
42	1	2,618	13,345	5,138	38.5	13,345	5.1
Sub-Total	11	17,328	40,752	16,159	39.7	3,705	2.4
Total	**28**	**45,595**	**132,916**	**66,113**	**49.7**	**4,747**	**2.9**

GV: Group Village, HH: Households
Source: The World Bank



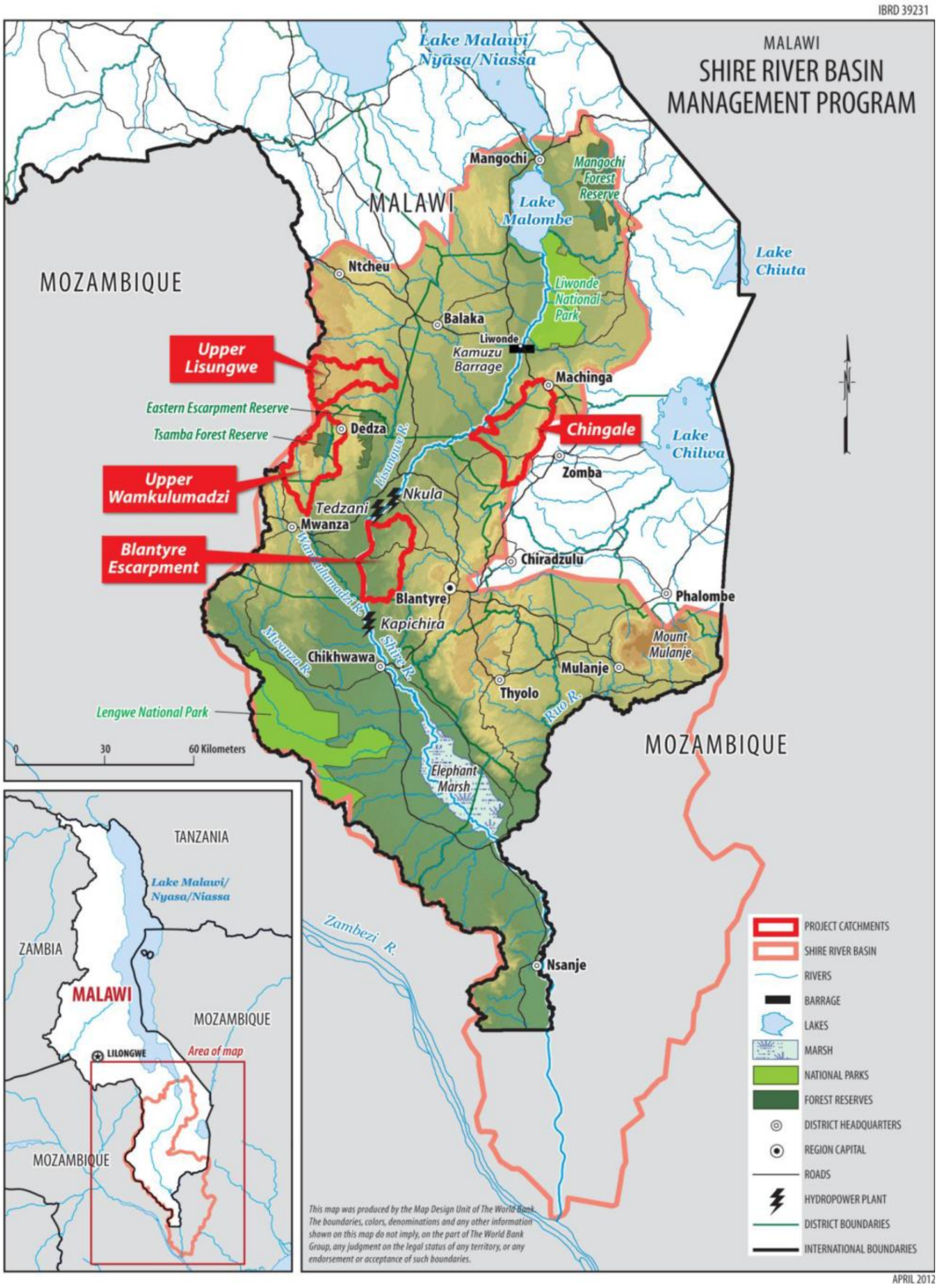
Source: WRIS

Figure 6.2.1 Soil Erosion Hazard Map, 1986



Source: WRIS

Figure 6.2.2 Risk of Sediment Ingress to Watercourses



Source: World Bank

Figure 6.2.3 Location Map of Project Component B of SRBMP

6.2.2 Malawi Policy

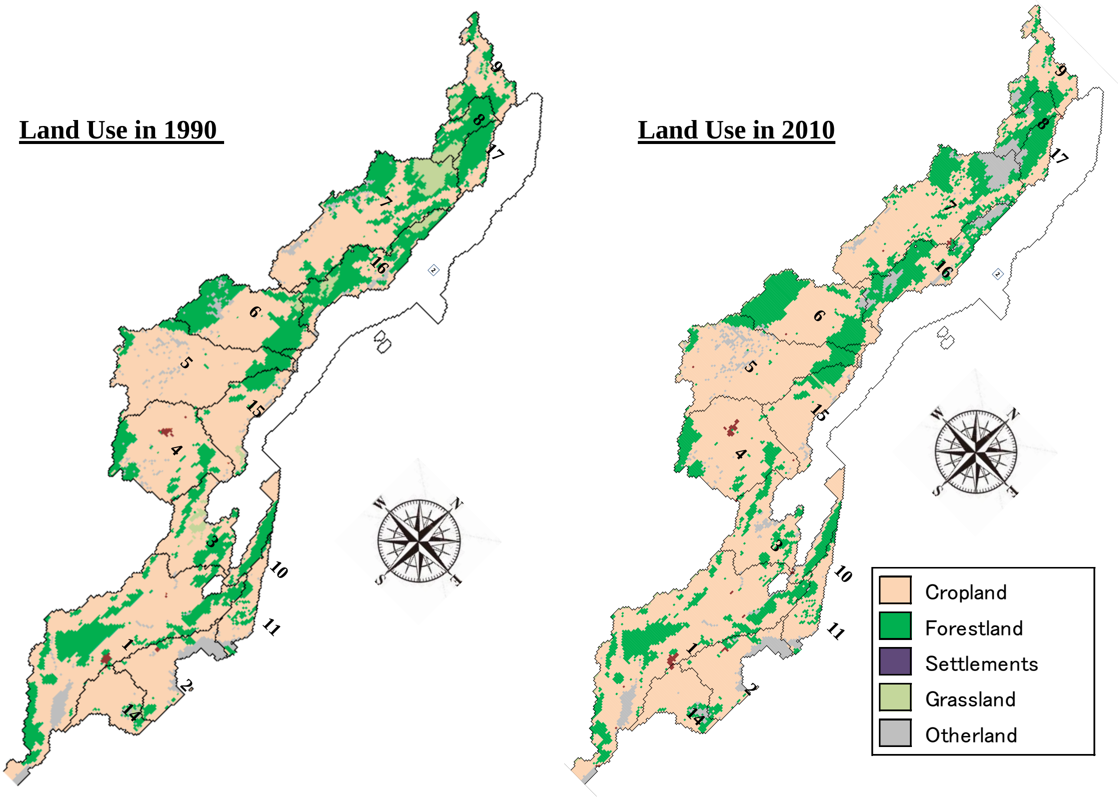
The guiding principles 5.2 (a) and (b) of the National Environmental Policy shows that deforestation is an important contributing factor to soil erosion, siltation of lakes, rivers, and reservoirs and other water bodies, loss of biodiversity and climate change and the participation of the private sector, NGOs and local communities in forestry is essential for sustainable management, conservation and utilization of forest resources. They also describe the promotion of plantation, monitoring and development forest management plan that incorporates the conservation and sustainable management of resources such as water and wildlife.

The guiding principles 5.5 (b) and (j) of the National Environmental Policy show that all programs related to water should be implemented in such a manner that mitigates environmental degradation and at the same time promote enjoyment of the asset by all beneficiaries, and the construction of small dams and diversion of water in rivers for development of irrigation shall take into account catchment protection measures.

In line with this, the water resources development should consider the watershed's conservation for sustainable development to prevent catchment degradation. Forest is important for watershed conservation and it should be managed with the participation of communities.

6.2.3 Land Cover

Comparing land use in 1990 and 2010, the deforestation occurs in the northern region, along Lake Malawi and the Shire river basin. Forest land decreased from 28 percent to 26 percent in twenty years. On the other hand, cropland increased from 61percent to 63 percent. Most of the land in Malawi is cropland and forest land is not large. With consideration of land use condition and deforestation, it is important to conserve forest land.

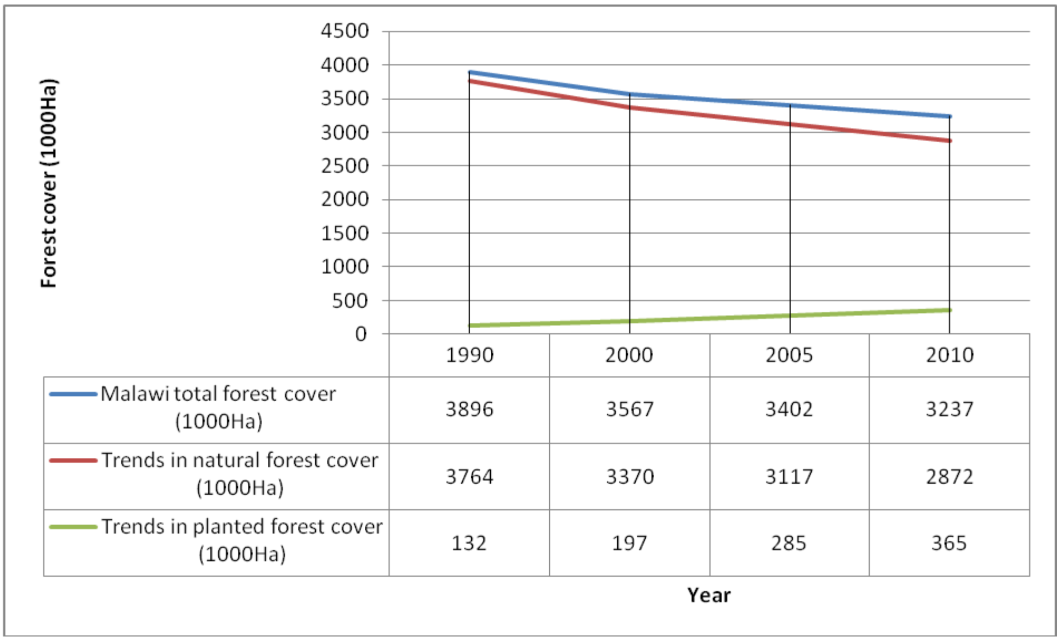


Source: Project Team

Figure 6.2.4 Land Use Change from 1990 to 2010

6.2.4 Assessment of Forest Reserves

Figure 6.2.5 shows that there has been a consistent depletion of forest cover in Malawi which has not been significantly addressed in recent years. Nevertheless, it indicates that there have been some notable efforts to build the forest cover although presumably not proportionate. The main keys contributing to the forest cover loss include poverty, population growth, low literacy levels and agricultural expansion. Some of the forests where depletion is very eminent include the Michiru mountain forest reserve in Blantyre, the Marabvi forest reserve in Chiradzulu, the Chimaliro forest reserve in Kasungu District and the Thyolo forest reserve in Thyolo District.



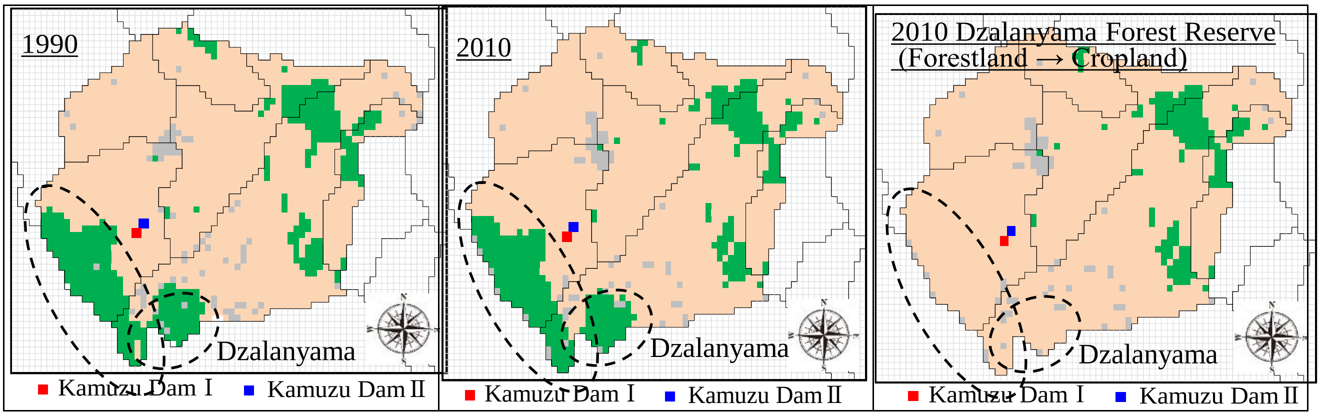
	1990	2000	2005	2010
Malawi total forest cover (1000Ha)	3896	3567	3402	3237
Trends in natural forest cover (1000Ha)	3764	3370	3117	2872
Trends in planted forest cover (1000Ha)	132	197	285	365

Source: Malawi Environmental Profile (2011)

Figure 6.2.5 Trends on Forest Cover from 1990 to 2010

6.2.5 Impact of Land Cover Change on Water Resources

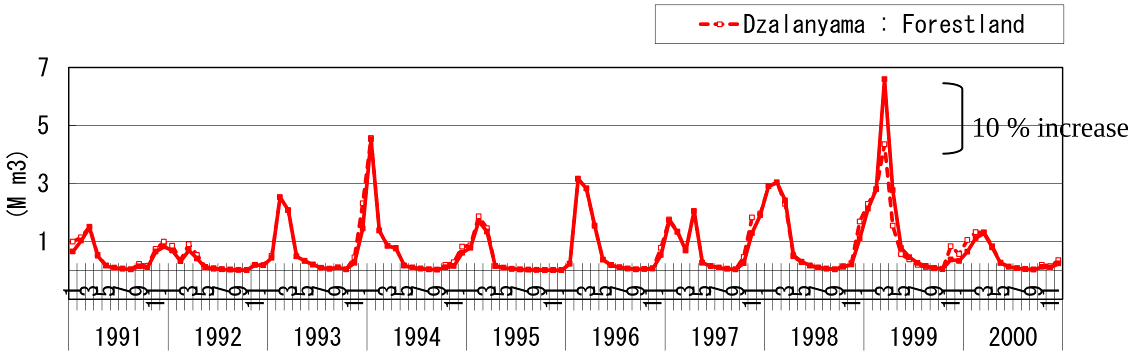
There is the Dzalanyama forest reserve upstream of the Kamuzu Dam which supplies water to Lilongwe City. The area of the Dzalanyama forest reserve is 989 km^2 and it spreads to Lilongwe, Dedza, Mchinji. The impact on water resources especially flow at the Kamuzu Dam has been studied in case of land cover change from forest land to cropland at the Dzalanyama forest reserve shown in **Figure 6.2.6.** The ratio of change is about ten percent decrease of forest land when the Dzalanyama forest reserve changes to cropland.



Source: Project Team

Figure 6.2.6 Land Use Change at the Dzalanyama Forest Reserve

Using the MIKE-SHE model developed in **Part I: Chapter 6**, the flow at the Kamuzu Dam is calculated to find the impact of deforestation on water resources. **Figure 6.2.7** shows the comparison of the flow in case of forest land and cropland at the Dzalanyama forest reserve. The peak flow at the dam has increased in this case by approximately ten percent. It is because of increasing direct flow during flood. It means that the water in rainy season runs off in a short time and it is lost water resources because surplus water at reservoir flows out if there is full storage capacity although the result is roughly estimated. Therefore, it is necessary to make a further detailed study to ensure the impact of deforestation on water resources.



Source: Project Team

Figure 6.2.7 Inflow at Kamuzu Dam II (Monthly Maximum)

6.2.6 Sediment Survey in Pilot Basin

Present condition and issues on sediment runoff are investigated through survey and analysis targeting some pilot basins.

(1) Methodology of Survey

In the Project, sediment runoff survey was carried out in the following manner:

Objective: To investigate sediment runoff condition in selected target basins with various forest coverage ratio.

Survey Method: Actual sediment runoff volume is measured at the lower stream ends of several basins with various ratio of forest coverage, and the results are compared in order to confirm effect on forest coverage to sediment runoff. The survey is carried out in the following procedure: (a) sampling river water in both rain and dry seasons at sites located at the lower stream ends in the selected target basins; (b) estimating volume of wash load and suspended sediment by analyzing SS (suspended solid) of samples; (c) measuring river discharge at the same time as sampling; (d) investigating relationship between sediment concentration and river discharge; and (e) comparing forest coverage with sediment concentration and river discharge.

Selecting target basins and sampling sites: The target basins were selected comparing forest coverage shown in **Figure 6.2.4**. Considering the deforestation and forest degradation, the target basins are narrowed down to the central region of WRA-3, 4, 5 and 6. In addition, sampling and discharge measurements are carried out at the sites, which are the existing operational gauging stations as well as water quality monitoring points, considering availability of existing data and repeatability of survey. Consequently, they are set as a prerequisite for selecting target basins where proper gauging station exists in and around lower stream end of relevant basins. Further, the following are also considered for selection: (a) existence of past discharge data; (b) existence of rating curve developed in recent years; and (c) availability of discharge measurement in both low and high flows. Finally, three stations (4E1, 5F1 and 6C1) and related basins are selected for investigating effects on forest coverage ratio to sediment runoff as shown in **Table 6.2.2**.

Moreover, an additional station of 4D21 is also selected as a survey site since future detailed investigation including historical change of forest coverage may be available by cooperation with ongoing forest project by JICA. The upper stream area of 4D21 is a target area of the forest project and 4D21 also fits into most of the above-mentioned condition for the selection.

Table 6.2.2 Sampling Sites (Stations) and Target Basins

Station	Target Area: Catchment Area (km^2)	Target Area: Coverage Ratio of Forest	Represented WRU
4E1	943	0%	4E
5F1	2,347	18%	5F
6C1	2,866	67%	6A & 6B
4D21	180	64%	(4D)

Source: Project Team

(2) Result of Survey

The survey result is summarized in **Table 6.2.3**. From the result below, it can be said that volume of suspended sediment is inversely proportional to forest coverage ratio and its volume is bigger in rainy season than in dry season. In case that the above-mentioned finding is converted into annual soil erosion rate though the result only includes suspended sediment, converted soil erosion rate is very small in the order of 10-3 to 10-5 mm/year.

Table 6.2.3 Survey Result on Suspended Sediment

Target Area			Represented WRU	Survey Result			
Station	Catchment Area (km^2)	Coverage Ratio of Forest		Suspended Sediment (mg/l)	Discharge (m^3/sec.)	Estimated Volume of SS (g/sec/km^2)	Season/Date
4E1	943	0%	4E	32	4.92	0.167	Rain/8Mar2013
				30	0.64	0.020	Dry/12Jun2013
5F1	2,347	18%	5F	1	18.75	0.008	Rain/13Mar2013
				<0.10	0.89	N.A.	Dry/11 Jun2013
6C1	2,866	67%	6A & 6B	11	0.77	0.003	Rain/13Mar2013
				(4.7)	0	N.A.	Dry/11Jun2013
4D21	180	64%	4D	To be measured	ditto	To be estimated	Rain/2014
				<0.10	0.35	N.A.	Dry/12Jun2013

Source: Project Team

(3) Comparison with Past Survey

The survey regarding sediment runoff was conducted in the Feasibility Study for the Stabilization of the Course of the Songwe River, 2003. In the survey, suspended sediment and discharge that are the same items as the survey in the Project were measured in five sites in the Songwe river basin. One site is in the upper stream of the Songwe River, three sites are in the lower stream of the Songwe River, and one site is in the Kyungu River, a tributary of Songwe River. The measurement was conducted once or twice a month from December 2002 to June 2003.

From the above survey, the result of Mwandenga site, which is located in the lower stream of the Songwe River and is a site of existing gauging station of 9B7 with catchment area of 3,864km2 including area in Tanzania, is summarized in **Table 6.2.4**.

Table 6.2.4 Result of Suspended Sediment Survey in Past Study

Target Area		Represented WRU	Survey Result			
Station	Catchment Area (km^2)		Suspended Sediment (mg/l)	Discharge (m^3/sec.)	Estimated Volume of SS (g/sec/km^2)	Date
9B7	3,864	(9B)	2,855	68.5	50.613	31Dec2002
			2,650	165.1	113.229	14Feb2003
			1,089	37.7	10.625	28Mar2003
			3,670	57.7	54.803	10Apr2003
			346	32.7	2.928	24Apr2003
			94	24.1	0.586	21May2003
			235	28.5	1.733	24May2003

Source:The Project Team, based on the information of NORPLAN, Feasibility Study for the Stabilization of the Course of the Songwe River, 2003

Forest coverage ratio in WRU-9B is 18% though this value is assessed using only area in Malawi side. This ratio is almost at the same level as 5F1, but the volume of suspended sediment in **Table 6.2.4** is far more than 5F1 as well as the other target areas in the survey carried out in the Project. However, an order of annual soil erosion rate converting the volume is 10-3 to 100 mm/year and is judged to be within normal range that corresponds to the value of grassland/wood land to agricultural land in general.

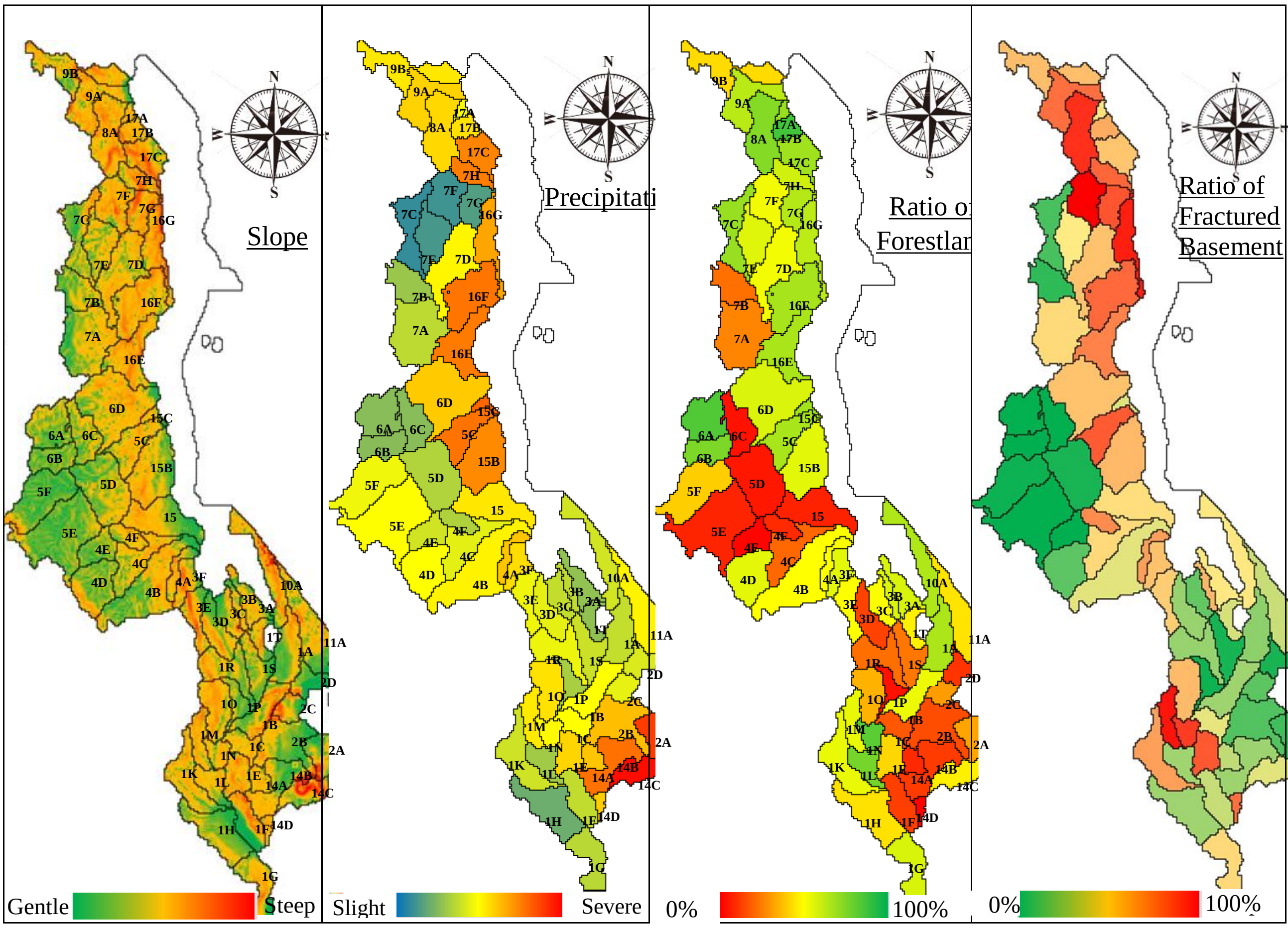
(4) Findings

As investigated above, 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.

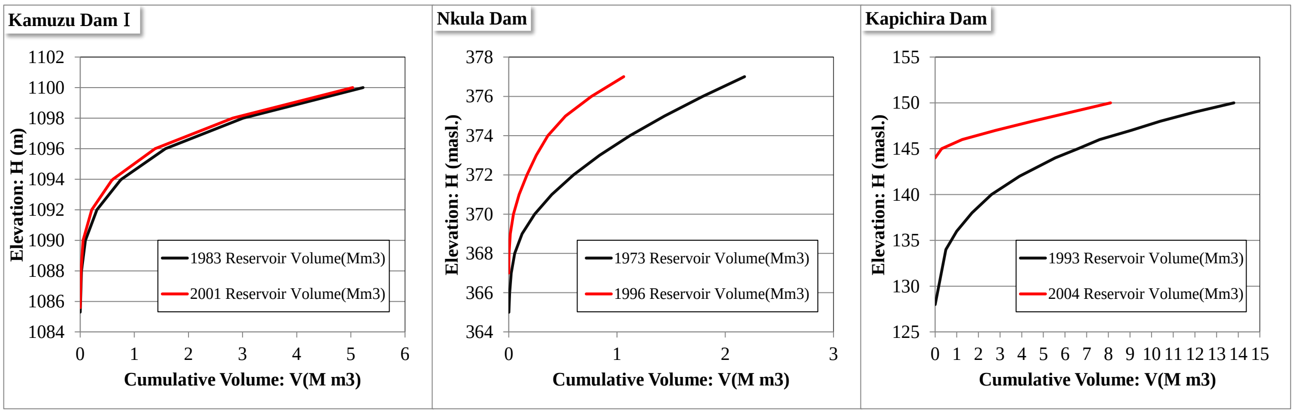
6.2.7 Assessment of Sediment Volume

The sediment volume is estimated by desktop analysis considering slope, slope length, precipitation, land use and soil which seem to be related to produce sediment volume. **Figure 6.2.8** shows slope, precipitation, ratio of forest land and fractured basement in Malawi. Slope is estimated from using SRTM DEM data. Precipitation data is one which is used in hydrological analysis. Ratio of forest land is estimated by land use in 2010 shown in **Figure 6.2.4** as the land use factor. Rate of fractured basement is estimated from geological map as soil factor. Slope length is not considered because it is estimated from the slope and there is similar feature with slope factor. The analysis is conducted by 2 km^2 mesh. Elevation-volume curves at the Kamuzu Dam I, the Nkura Dam and the Kapichira Dam were collected and shown in **Figure 6.2.9** and the sediment volume is estimated from these data and existing survey. There is some degree of correlation between sediment volume and other factors shown in **Figure 6.2.10**. Considering the correlation, the sediment yield in Malawi is estimated by WRU and shown in **Figure 6.2.11**. There are relatively severe sediment volumes in the northern and southern regions and along Lake Malawi because of steep slope and severe precipitation. On the other hand, there are relatively slight sediment volumes in the central region because there is a gentle slope and sediment is considered to be caught by dambos. Among the factors related to sediment volume, only the ratio of forest is changed by mainly human activities. Therefore, forest land should be conserved to control sediment in watershed. However, since this is only desktop analysis under the limited data, a field survey is required for more appropriate findings.



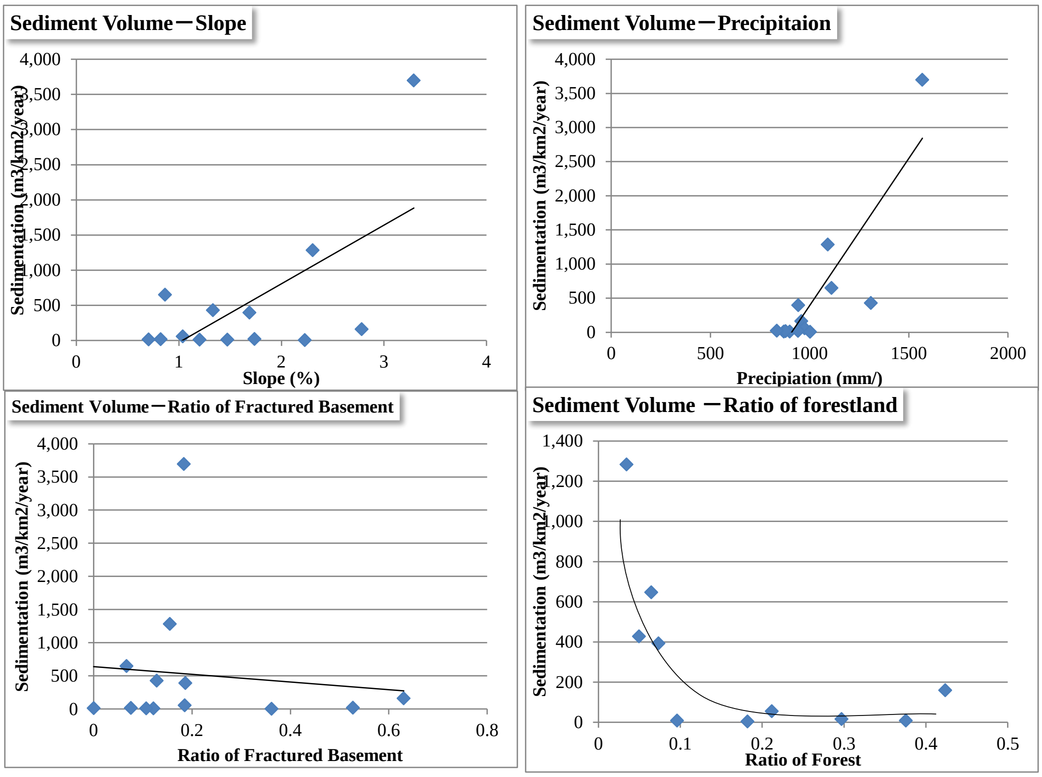
Source: Project Team

Figure 6.2.8 Slope, Precipitation and Ratio of Forest Land and Fractured Basement



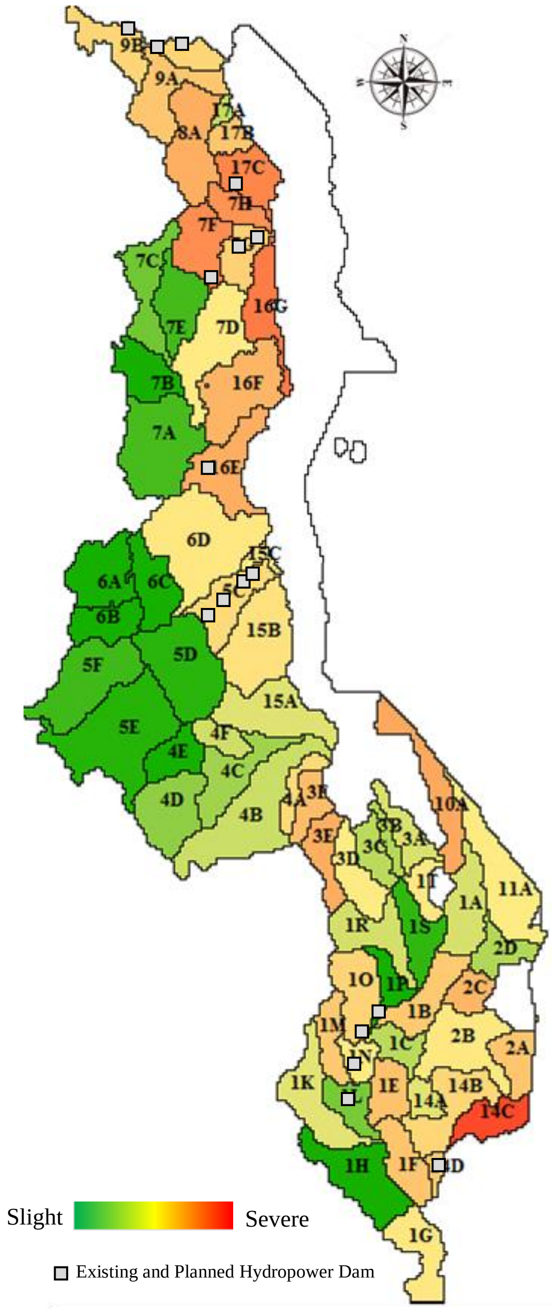
Source: Project Team

Figure 6.2.9 Elevation-Volume Curve at Kamuzu I, Nkula, Kapichira Dam



Source: Project Team

Figure 6.2.10 Relationship between Factors and Sediment Volume



Source: Project Team

Figure 6.2.11 Estimated Sediment Yields in Malawi

6.2.8 Sediment and Weed Management at the Hydropower Dams on the Shire River

The three hydropower dams on the Shire River, the Nkula Dam, the Tedzani Dam, the Kapichira Dam, have siltation problems which cause the reduction of storage capacity. To resolve these problems, scouring is conducted at all three dams. However, scouring is not effective because it removes only sediment in main river channel. Among the hydropower dams at the Shire River, the Nkula Dam is most affected by sediment deposition. At the Nkula Dam, dredging and pumping are conducted as measures against sediment deposition. Pumping is done at 16 hours per day intermittently by pumping up sediment from the reservoir and storage at the land of lower stream. On the other hand, the removal of weeds is conducted by human labor. The flow of weeds and plants from the Shire River had decreased because plants at upper stream are removed at the Kamuzu Barrage. However, the problem is the flow of weeds from the tributaries. (See picture below.)

The Kapichira Dam has four low level gates for flushing operations conducted regularly on monthly basis to prevent sediment deposition from damage of turbines and reduction of power generation. At the downstream of the Kapichira Dam, there are intake facilities for agricultural use. Sediment from the Kapichira Dam has caused problems with these facilities.

Source: Project Team

Sediment Suction Machine at the Nkura Reservoir

Source: Project Team

Place to Discharge Sediment Suction

Source: Project Team

Dust Remover at Intake Point

Source: Project Team

Removal of Plants

Source: Project Team

Removed Plants

6.3 Road Map for Short, Middle and Long Term Plans

6.3.1 Concept

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 to watershed conservation. The major key to solve the challenges is how to secure energy under the population growth and poverty. The reliance from 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 and, at the same time, electricity is increased from 2.3% to 40%. Presently in Malawi, 94% of electricity is generated by hydropower and hydropower generation will still 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 sediment deposition in the hydropower reservoirs, 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. Non-structural and structural measures, institution and legal framework, capacity building and monitoring and evaluation shown in **Table 6.3.1** are the actions for soil erosion measures and watershed conservation to tackle the challenges. These actions should be implemented collaboratively to get synergistic effects.

Table 6.3.1 Challenges and Actions for Soil Erosion and Watershed Conservation

<table>
<tr><th>Challenges</th><th>Impacts on Water Resources</th><th>Actions</th></tr>
<tr><td rowspan="2"><Natural Condition>
-Deforestation due to low electrification rate, etc.
-Expansion of cropland</td><td rowspan="5">-Sedimentation in dams and ponds
-Reduction of hydropower generation
-Reduction of crop yields
-Reduction of water resources
-Increase of flood peak and reduction of flow capacity of rivers
-Increase of loads on water treatment plant
-Effect on water quality
-Impact on environment, flora and fauna
-Outflow of weeds which affect reservoir management</td><td><Non-Structural Measures>
-Establishment of conservation and co-management plans
-Utilization of effective fuel and electricity
-Promotion of afforestation, village forest area and agroforestry
-Contour farming for existing farm
-Setting of restricted zoning on settlement and farms</td></tr>
<tr><td><Structural Measures>
-Structural measures (sedimentation tank, riprap, etc.)</td></tr>
<tr><td rowspan="2"><Social Condition>
-Population growth
-Poverty
-Low literacy</td><td><Institution and Legal Framework>
-Establishment of catchment management committees
-Participation of community
-Co-management agreements with surrounding communities
-Cooperation between sectors and relevant agencies
-Intensified forest patrols and penalties
-Topping up of water tariff and introduction of licenses for logging</td></tr>
<tr><td><Capacity Building>
-Capacity building</td></tr>
<tr><td><Monitoring and Evaluation Condition>
-Insufficient observation</td><td><Monitoring and Evaluation>
-Strengthening of monitoring
-Field Examination to find the effect of afforestation</td></tr>
</table>

Source: Project Team

6.3.2 Road Map

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 are implemented from the priority WRUs.

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

6.4 Concrete Activities for Short, Middle and Long-Term Plan

6.4.1 Non-Structural Measures

(1) Establishment of Conservation and Co-Management Plans

The soil and forest conservation and co-management plan for watershed should be established at the priority WRUs. The soil conservation plan needs a comprehensive viewpoint from the whole watershed. Some forest reserves such as Kaning'ina forest reserve in Nkhatabay District already have conservation plans with the District Council and the Department of Forestry. Referring to proceeded plans, the plans of the priority WRUs are developed. The soil conservation plan is necessary to be developed in consultation with relevant institutions and communities. It ensures their ownership as well.

(2) Utilization of Effective Fuel and Electricity

Intensifying the rural electrification program and making electricity affordable is described in the Malawi Vision 2020. The utilization of more effective fuel such as briquette is considered instead of firewood to get energy more effectively. This reduces the demand pressure on logging and also reduces deforestation. The electricity rate is increased by 40 percent up to 2020 as set in the National Energy Policy. This is promoted to attain electrification and reduce pressure of deforestation.

(3) Promotion of Afforestation, Village Forest Area and Agroforestry

For sustainable utilization of forest resources, after cutting trees, it is better to plant more trees. There are notable forest reserves where plantations have deliberately been established such as Jembya forest reserve in Chitipa District. Referring to the proceeded planting actions, it is introduced at the priority WRUs at first and then spread to other WRUs. Community participation is important for the promotion of planting and it results in sustainable and effective impacts. It is recommended that village forest areas (VFAs) should be established, more especially on forest reserves where forest cover is more critical. VFAs are areas created by and for the communities to reduce pressure on the forest reserves. One good example is the VFAs that have been created around Karonga South Escarpment in Karonga District and Masenjere forest reserve in Nsanje District. There are currently 19 VFAs around Karonga South Escarpment forest reserve. It was reported that these forest reserves have significantly and sustainably eased pressure on the forest reserve by supporting the communities around the reserve.

Promotion of agroforestry which is a land use management with trees and crops for sustainable land use and prevention of degradation of watershed is also important. Commercial forest ownership and forestry industries are promoted as well.

(4) Contour Farming for Existing Farm

Contour farming is one of methods to prevent soil erosion from farms. It does not promote the expansion of farm to mountainous forest area, but it is applied to existing farm to reduce soil erosion from farm. This method is spread to farmers utilizing lead farmers system. Lead farmers are the responsible people who are selected in villages. They learn the knowledge of contour farming from extension officers and after that they become teachers for village people to spread the knowledge which they get from extension officers. It is an effective way for agricultural extension service to spread contour farming and knowledge to reduce soil erosion for watershed conservation. It is introduced at the priority WRUs at first and then spread to other WRUs.

(5) Setting of Restricted Zoning on Settlement and Farm

In consultation with relevant institutions, restricted zoning on settlement and farm should be set to prevent expansion of unregulated development and destruction of forest land and watershed. Likewise, river bank cultivation should be restricted to prevent soil loss and outflow of weeds from river bank.

6.4.2 Structural Measures (Sedimentation Tank, Riprap, etc.)

To prevent soil erosion from watersheds by structural measures, construction of sedimentation tank is promoted on community basis. In addition, construction of riprap is proposed to prevent sediment flow from rivers and stabilization of riverbanks and riverbeds where there are problems. Appropriate maintenance and management of structures are important for keeping their functions.

6.4.3 Institution and Legal Framework

The Catchment Management Committee (CMC) is established for water resources conservation, coordination of stakeholders, monitoring, etc., under the National Water Resources Authority (NWRA) to contribute to the realization of IWRM in Malawi pursuant to the new Water Resources Bill of 2013. CMC shall consist of the representatives of government agencies related to water resources in the catchment area and representatives of various stakeholders within the catchment area concerned.

Participation of communities, co-management agreements with surrounding communities and cooperation between sectors and relevant agencies are promoted for watershed conservation to prevent deforestation and soil erosion from watershed. It ensures ownership of forest through co-management communities and sustainable use of forest resource. Cooperation between sectors and relevant agencies is important in case that the scouring of hydropower dam on the Shire River impact on agricultural uses downstream.

Intensified forest patrols and penalties are effective ways to conserve forest. Eighty percent of the district forest0020offices indicated to have plans to intensify forest patrols in the next annual action plans.

Topping up of water tariff and introduction of licenses for logging should be considered for the protection of water source forests such as the Dzalanyama forest reserve upstream of the Kamuzu Dam which supplies water to Lilongwe City.

6.4.4 Capacity Building

Low literacy level for forest management, population growth and poverty promote deforestation and depletion of watershed. Therefore, capacity building for village people is important for watershed conservation and creation of public awareness. Likewise, capacity building of ministries and departments related to watershed management are necessary.

6.4.5 Monitoring and Evaluation

Monitoring and evaluation should be conducted from the viewpoint of the whole watershed. To estimate the amount of soil erosion, sediment runoff and sediment deposition in the reservoir should be observed. However, it needs a great deal of effort to observe them in the whole country.

Therefore, the observation should focus on areas where there is a problem and possibility for them to occur, including the existing and planned reservoirs. For understanding the condition of a watershed, it is also important to know the change of land use. A land use survey should be carried out regularly.

A database is needed to be developed for the storage and utilization of observation data. Capacity development on the observation and operation of the database should be conducted to ensure accuracy and proper management of observation data.

6.5 Action Plan

The Action Plan including prior WRA, time schedule and responsible organization is shown in **Table 6.5.1**. The prior WRA is selected by considering sediment yield and existing and planning structures.

Table 6.5.1 Action Plan for Soil Erosion Measures and Watershed Conservation by 2035

Program / Project / Activities (WRA / Time Frame / Organ/Budget)	Prior WRA	Time Frame																								Responsible Organ	
		Short Term									Middle Term					Long Term											
		2012-2020									2021-2025					2026-2035										Main	Associate
		12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35		
Soil Erosion and Watershed Conservation																											
Non-Structural Measures																											
Establishment of conservation and co-management plans	1, 7, 9, 14, 16, 17	■	■	■	■	■																				MoNREE (Dep. Forestry)	MoAIWD and others
Utilization of effective fuel and electricity	All					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	ditto	ditto
Promotion of afforestation, village forest area and agroforestry	1, 7, 9, 14, 16, 17	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	ditto	ditto
Contour farming for existing farm	1, 7, 9, 14, 16, 17	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	ditto	ditto
Setting of restricted zoning on settlement and farm	All					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	ditto	ditto
Structural Measures																											
Structural measures (sedimentation tank, riprap, etc.)	All										■	■	■	■	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	MoAIWD, MoNREE (Dep. Forestry) and others	DoDMA
Institution and Legal Framework																											
Establishment of catchment management committees	All				▪	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	NWRA	MoAIWD
Participation of community	All	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	MoNREE (Dep. Forestry)	MoAIWD and others
Co-management agreements with surrounding communities	All	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	ditto	ditto
Cooperation between sectors and relevant agencies	All	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	ditto	ditto
Intensified forest patrols and penalties	All	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	ditto	ditto
Topping up of water tariff and introduction of licenses for logging	All					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	MoAIWD and MoNREE (Dep. Forestry)	-
Capacity Building																											
Capacity building	All					■	■	■	■	■																MoNREE (Dep. Forestry)	MoAIWD and others
Monitoring and Evaluation																											
Strengthening of monitoring	1, 7, 9, 14, 16, 17					■	■	■	■	■																MoNREE (Dep. Forestry)	MoAIWD and others
Field Examination to find the effect of afforestation	All					■	■	■	■	■																ditto	ditto

Source: Project Team