PART II

Chapter 7. WATER RESOURCES MANAGEMENT

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7.1 Integrated Water Resources Management in Malawi

Water resources management which follows the principles of Integrated Water Resources Management (IWRM) has been recognized and adopted by key players who utilize water for various social and/or economic activities in a very wide cross-section of sectors. IWRM for instance has been adopted for its importance in relation to the efficient production of food crops in irrigation agriculture, for its assistance in reducing water-related health risks, and its important role in reducing the risks of floods and droughts.

The key principles in IWRM agreed in the international conference on water and the environment in DuBrin in 1992, known as "The DuBrin Principles", are as follows:

- Freshwater is a finite and vulnerable resource, essential to sustain life, development and the environment;
- Water development and management should be based on a participatory approach involving users, planners and policy makers at all levels;
- Women play a central part in the provision, management and safeguarding of water; and
- Water has an economic value in all its competing uses and should be recognized as an economic good.

Furthermore, the widely accepted Global Water Partnership's definition of IWRM is as follows:

"WRM is a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems".

7.1.1 Specific Features in Malawi Water Resources

IWRM has proven to be a flexible approach to water management that can adapt to diverse local and national contexts. The details in planning and implementation should reflect local water issues and management conditions. In order to formulate the IWRM in Malawi properly, the following features of Malawi shall be deliberated:

- There are 17 Water Resources Areas (WRAs) dividing the national territory by their drainage areas, and their areas range widely from the 3.3 km^2 of Chizumulu Island to the 18,910.6 km^2 of the Shire River Basin. Thus, there are big differences in importance from socio-economic activities and development effects to national economy so that it is not practicable to deal with them.
- Development needs in domestic water supply, hydropower generation, and agriculture, as well as flood risk, extend over the entire WRAs. Thus, IWRM shall identify the specific demands and risks of each WRA and address their issues in the process of plan formulation.

Based on the above considerations, key development issues are identified from the present situation of water resources development and management in Malawi, as shown in **Table 7.1.1.**

It is notable that the Parliament passed the Water Resources Act, which among others seeks to address the problem of water resources management on March 5, 2013. The Act stipulates the establishment of the National Water Resources Authority and the Catchment Management Committee, which closely relate to IWRM. The following are some notable points on the Authority, the Committee and the National Water Resources Master Plan stipulated in the Act, which is a great progress and back-support for the realization of IWRM.

(1) National Water Resources Authority

The National Water Resources Authority, which consists of high position people such as Principal Secretaries of related government agencies and representatives of related associations and NGOs, has the following major power and functions related to IWRM:

- To develop principles, guidelines and procedures for the allocation of water resources;
- To monitor, and from time to time reassess, the National Water Policy and the National Water Resources Master Plan;
- To manage and protect water catchment;
- To gather and maintain information on water resources and from time to time to publish forecasts, projections and information on water resources;
- To liaise with the relevant stakeholders for the better regulation and management of water resources;
- To assist the Minister in the coordination of hydrological and hydrogeological investigations;
- To coordinate the preparation, implementation and amendment of a water action plan and to recommend the water action plan to the Minister; and
- To advise the responsible Minister, as the case may require, on any dispute between agencies involved in water management that may be referred to it.

(2) Catchment Management Committee

Regarding the Catchment Management Committee, the Authority may by notice publish in the gazette, designate a defined area from which rainwater flows or drains into a watercourse, to be a catchment area for the purpose of the Act. The Authority may establish a catchment management committee for a specific catchment area after public consultations on the proposal of the community and stakeholders concerned, or the Authority may establish a catchment management committee on its own initiative. A catchment management committee 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. The committee shall advise officers of the Authority as to: (a) water resources conservation, use and allocation; (b) the grant, adjustment, cancellation or variation of any license and permit under the Act; and (c) any other matters pertinent to the proper management of water resources.

(3) National Water Resources Master Plan

The Act stipulates the following items to address in the National Water Resources Master Plan:

- Water balance for each catchment area that compares forecasted water demand with data and information regarding water availability;
- Proposed options for meeting forecasted demand for each catchment area in which forecasted water demands exceed available supply, which options may include: (a) water demand management programs; (b) necessary infrastructure construction; and (c) any other measure, including appropriate legal reforms considered necessary in achieving the objectives of the National Water Resources Master Plan;
- The protection of water resources from over-exploitation and pollution; and
- Conservation of water resources, including the recycling and re-use of wastewater, the harvesting of rainwater, and any other suitable conservation practice and technique.

7.1.2 Overall Approach for Integrated Water Resources Management

Taking the discussion in the preceding sections into consideration, the approach for proper configuration of the water resources management, which contains clarification of specific features of WRAs and their classification for easy ways to manage the basins or WRAs, shall enter at the basin analysis. The chart in **Figure 7.1.1** presents the basic approach.

Table 7.1.1 Key Development Issues in the Water Resources Management of Malawi

No	Key Development Issues	Actual Conditions	Way to Address the Issues
1	Securing food production	To increase agriculture productivity and diversification, promoting irrigation farming is one of key strategies in MGDS I & II. The Malawi Government is carrying out a national-scale project 'Green Belt Irrigation and Water Development'. But total irrigation area of 90,563 ha is equivalent to only 2.3 % of arable area of 3,994,000 ha in 2011.	To assess the water supply potential from the relevant river system and propose proper supply capacity and system to the subject area
2	Ensuring sustainable water infrastructures	To improve access to water through an integrated water management system, increasing number of people connected to piped water supply systems in both urban and rural areas. Through the continuous effort to increase the access, significant improvement shows up to 75 % to total population in service coverage of improved water supply.	To prioritize the necessary demand areas and assess the suitable water sources and supply capacity
3	Managing the water-energy relationship	To generate and distribute sufficient amount of energy to meet national socio-economic demands, construction of hydropower stations along the major river courses shall be necessary. In 2010, the access rate of electricity is still low, only 9 %.	To evaluate hydrological potential to the proposed hydropower generation plants and downstream effects in river hydrology
4	Collaboration in the management of land and water	In relation to low energy supply rate, most people rely on biomass energy produced by logged woods. As a result, forest areas have reduced for a long period. In 2010, forest-covered area remains at 35 % to the total land.	To assess the deforestation effects in hydrology, in particular increase of drought vulnerability and sediment runoff, and to propose the well-functioning collaboration between water and watershed conservation
5	Adapting to climate change	Monitoring system on climate changes is not sufficient. In particular, early warning, preparedness and response is strongly necessary for agricultural practices.	To assess the actual effects of climate changes in the typical selected model area and to demonstrate the monitoring and warning system
6	Mitigating disaster risks, floods and droughts	Habitual flooding occurs mainly along the Songwe and North Rukuru rivers in the northern region and along the Shire River in the southern region. The severe drought occurred over the country, so that agricultural products were severely damaged due to mainly relying on rainfed cultivation.	To assess the actual flooding and drought effects over the country, and to propose the appropriate countermeasures coping with natural disasters
7	Planning transboundary collaboration	Malawi is a member state of Zambezi Watercourse Commission, and future collaboration becomes much important for Nsanje World Inland Port project opening up navigable river course to the Indian Ocean.	To review the effective cooperation directions, and to propose strengthening transboundary collaboration

Source: Project Team

1. Comparative analysis of WRAs
   (1) Physical features
   - Area of WRA
   - Major rivers in the WRA

   (2) Socio-economic features
   - Population (urban and rural) in WRA
   - Major cities and towns in WRA

   (3) Major water resources development structures
   - Reservoirs for multi-purposes or single-purpose
   - Irrigation Intake

2. Classification of WRAs
   - Class A: important and socio-economically active WRAs, urgent development/management target put at these WRAs by the M/P
   - Class B: intermediate level of WRAs, long-term development/management target put at these WRAs by the M/P
   - Class C: small and socio-economically inactive WRAs

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3. Review of Legal Background for Strengthening on Water Resources Management
   - New Water Resources Act
   - Environment Management Act

4. Proposition of Proper Management Organization
   (1) Review for proper management in central government levels
   - Human resources potential
   - Budgetary back-up

   (2) Proposition of management structure

↓

WRA/Catchment Area Analysis: Class A

5. Proposition of Proper Monitoring System
   (1) Evaluation of hydrological/meteorological monitoring system
   - Monitored period
   - Monitored parameters (water level, stream flow, rainfall)
   - Representativeness of WRA

   (2) Proposition of the proper monitoring system
   - Representative hydrological/meteorological monitoring network
   - Data collecting and archiving system

6. Proposition of Water Resources Management Measures (by Class A WRAs)
   - Water resources demand (current and future) for domestic, industrial and agricultural uses
   - Water supply potential and water balance
   - Necessary measures: structural and non-structural development/management measures

Source: Project Team

Figure 7.1.1 Overall Approach to Integrated Water Resources Management

7.1.3 Water Resources Area Classification

The land area of Malawi is divided into 17 water resources areas (WRAs) based on the catchment area of the major rivers and the 1986 Master Plan formulated based on the WRAs system, which might have been established a long time ago. Each WRA consists of one river basin or in some cases consist of a number of small river basins. Furthermore, the relatively large WRAs have been sub-divided into some number of water resources units (WRUs). The following table summarizes the salient features of WRAs at present.

Table 7.1.2 Water Resources Area (WRA) and Major Indices

WRA	Region	Area[1] (km^2)	Number of WRUs	Major Rivers	Population in 2010[2] (thousand)	Major Cities and Towns[3]
1. Shire	Southern & Central	18,911	16	Shire, Liviliezi, Lisungwe, Mwanza	3,327	Blantyre, Mangochi, Balaka, Ngabu, Nsanje
2. Lake Chirwa	Southern	4,567	4	Phalombe	1,254	Zomba
3. South West Lakeshore	Southern & Central	4,998	6	Bwanje	746	Dedza
4. Linthipe	Central	8,885	6	Linthipe, Lilongwe, Diamphwe	2,496	Lilongwe, Salima
5. Bua	Central	10,658	4	Bua	1,513	Mchinji
6. Dwangwa	Northern & Central	7,751	4	Dwangwa, Mpasadzi, Rupase, Lingadzi	616	Kasungu
7. South Rukuru, North Rumphi	Northern	12,719	7	South Rukuru, Kasitu, Mzimba	925	Mzuzu, Mzimba, Rumphi
8. North Rukuru	Northern	2,088	-	North Rukuru	123	Karonga
9. Songwe, Lufira	Northern	3,730	2	Songwe, Lufira	204	-
10. South East Lakeshore	Southern	1,659	-	-	209	-
11. Lake Chiuta	Southern	2,443	-	-	317	-
12. Likoma Island	Northern	17	-	-	11 (12 & 13)	
13. Chizumulu Island	Northern	3	-	-		
14. Ruo	Southern	3,519	4		1,117	Mulanje
15. Nkhota-kota Lakeshore	Central	4,819	3	-	608	Khonbedza, Nkhotakota
16. Nkhata-Bay Lakeshore	Northern & Central	5,533	3	Luweya	308	-
17. Karonga Lakeshore	Northern	1,945	3	-	154	-

[1] Refer to Table 3.1.1 in the Part I report; [2] Refer to the report "Water Resources Investment Strategy" prepared by ATKINS, 2011; [3] Major cities and towns are highly populated areas having more than 10,000 population.
Source: Project Team

Based on the present situation, area extent and population of WRA could be divided into the following three classes. Their histograms are presented in the figure below.

Area

Large: larger than 7,000 km^2

Medium: 3,000 km^2 to 7,000 km^2

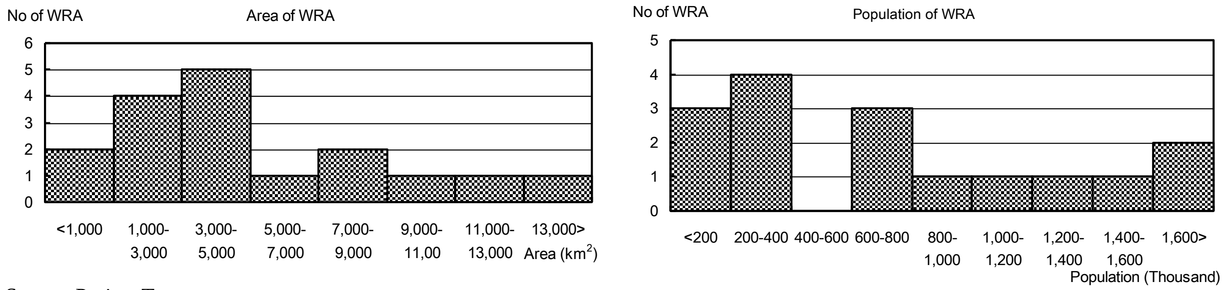
Small: smaller than 3,000 km^2

Population

Large: more than 1,000,000

Medium: 400,000 to 1,000,000

Small: less than 400,000



Source: Project Team

Figure 7.1.2 Histograms of Area and Population of WRA

Principal features of each WRA, including the above-mentioned classification of area and population, major existing and planned water resources structures, flood vulnerability and areas under trans-boundary issues are shown in **Table 7.1.3** and **Table 7.1.4**. Considering the importance of WRA and the existing and future water resources development structures, WRAs are classified into the following three classes:

(1) Class A: High national importance (8 WRAs)

(2) Class B: Medium national importance (4 WRAs)

(3) Class C: Low national importance (5 WRAs)

In Class A, the major rivers flow through the areas so that water resources management should be over the catchment area from the national level viewpoint. In Class B, the rivers are not large-scale ones so that water resources management should be concentrated in areas where water resources development structures are planned. On the other hand, in Class C, major waterworks may be limited to rural water supply. **Table 7.1.3** and **Table 7.1.4** give a list of water development facilities while **Figure 7.1.3** shows the location of WRAs and the facilities.

Table 7.1.3 Principal Features of Water Resources Area (WRA) and its Classification (1/2)

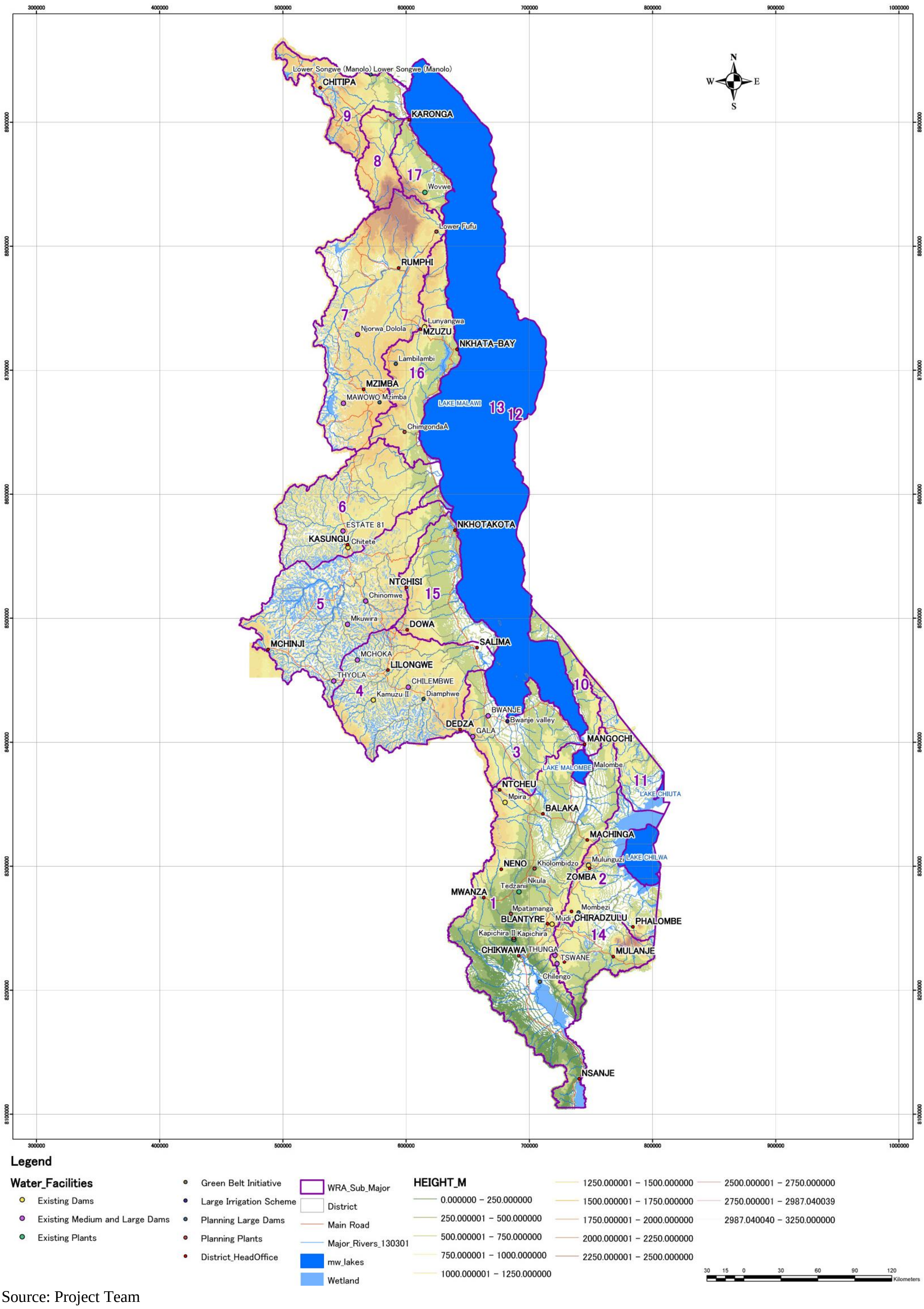
WRA / Parameter	1	2	3	4	5	6	7	8
	Shire	Lake Chirwa	South West Lakeshore	Linthipe	Bua	Dwangwa	South Rukuru/ North Rumphi	North Rukuru
Area Extent	Large	Medium	Medium	Large	Large	Large	Large	Small
Major River System	Shire	Phalombe	Many small rivers	Linthipe, Lilongwe	Bua	Dwangwa, Rupashe	South Rukuru, Mzimba	North Rukuru
Population	Large	Large	Medium	Large	Large	Large	Large	Small
Major Cities/ Towns	Blantyre, Mangochi	Zomba	Detza	Lilongwe	Mchinji	Kasungu	Mzuzu, Rumphi, Mzimba	Karonga
Irrigation Existing Medium & Large Dams	Gala in Ntcheu			Chilembwe, Mchoka, Thyola in Lilongwe	Chinomwe, Mkuwira in Dowa	Estate 81, Estate 88 in Kasungu	Mawowo, Njorwa/Dolola in Mzimba	
Large Irrigation Scheme			Bwanje Valley					
Green Belt Initiative	Malombe, Chilengo							
Urban Water Supply Existing Dams	Mpira in Ntcheu, Mudi in Blantyre	Mulunguchi in Zomba		Kamuzu I & II in Lilongwe		Chitete in Kasungu	Lunyangwa in Mzuzu	
Planning Large Dams				Diamphwe Lower (multi) in Lilongwe			Lambilambi in Muzuzu, Mzimba (multi) in Muzimba	
Hydropower Plants Existing Plants	Nkula, Tedzani, Kapichira							Wovwe
Planning Plants	Nkula A upgrade, Kholombidzo, Tezani IV, Mpatamanga, Kapichira II & III				Mbongozi, Malenga, Chasombo, Chizuma		Lower Fufu, Rumphi, Henga Valley	
Flood Vulnerability	High			High				High
Transboundary Issues	Outflow	Inflow						
Classification	**A**	**A**	**B**	**A**	**A**	**A**	**A**	**B**

Source: Project Team
Note: Medium dams are defined as dam hight of 10 m to 15 m, while large dams are defined as dam height of higher than 15 m.

Table 7.1.4 Principal Features of Water Resources Area (WRA) and its Classification (2/2)

WRA / Parameter	9	10	11	12 & 13	14	15	16	17
	Songwe, Lufira	South East Lakeshore	Lake Chiuta	Likoma Is. & Chizumulu Is.	Ruo	Nkkhota-kota Lakeshore	Nkhata-Bay Lakeshore	Karonga Lakeshore
Area Extent	Medium	Small	Small	Small	Medium	Medium	Medium	Small
Major River System	Songwe, Lufira	Many small rivers	Many small rivers	Small Islands	Ruo	Many small rivers	Many small rivers	Many small rivers
Population	Small	Small	Small	Small	Large	Medium	Small	Small
Major Cities/ Towns	-	-	-	-	Mulanje	Nkhotakota	-	-
Irrigation								
Existing Medium & Large Dams					Thunga, Tswane in Thyolo			
Large-scale Irrigation Scheme								
Green Belt Initiative	Nithola-Ilora-Ngosi							Nithola-Ilora-Ngosi
Urban Water Supply								
Existing Large Dams								
Planning Large Dams	Manolo (multi)				Mombezi in Thyolo for Blantyre			
Hydropower Plants								
Existing Plants								
Planning Plants	Bupigu, Sofwe, Manolo				Zoa Falls		Chimgonda	
Flood Vulnerability	High				High			
Transboundary Issues	Inflow	Small inflow	Outflow					
Classification	**A**	**C**	**C**	**C**	**A**	**C**	**B**	**B**

Source: Project Team
Note: Medium dams are defined as dam hight of 10 m to 15 m, while large dams are defined as dam height of higher than 15 m.



Source: Project Team

Figure 7.1.3 Location Map of WRAs and their Water Resources Development Facilities

7.2 Institutional System for Integrated Management

As described in **Subsection 7.1.1**, establishment of the National Water Resources Authority and the Catchment Management Committee will greatly contribute to the realization of IWRM in Malawi. Based on the Water Resources Act of 2012, the function of both organizations are as summarized below.

7.2.1 National Water Resources Authority

The National Water Resources Authority (NWRA) consist of representatives of the government ministries responsible for water development, health, tourism, agriculture, irrigation, land management, natural resources, environment and transport as well as representatives of catchment management committees to be established, water user associations and NGOs engaged in the water sector. This means that NWRA shall be the coordination body in cross-sectoral interests and effects on water resources development and management. Thus, the NWRA shall be the central organization to pursue the establishment of IWRM in Malawi.

Based on the power and functions stipulated by the Act as described in **Subsection 7.1.1**, the NWRA shall provide for:

(1) The collection, collation and analysis of data concerning the occurrence, flow, characteristics, quality and use of any water or waste;

(2) The systematic gauging and recording of rainfall and of the volume, flow and quality of other water or waste;

(3) The construction, operation and removal of gauging, recording and monitoring stations and investigation and monitoring boreholes; or

(4) The sampling and analysis of any water or waste.

The NWRA shall meet at least four times every year, and shall produce and publish the progress of its activities annually at the end of each financial year.

7.2.2 Catchment Management Committee

The NWRA shall at its own initiative or at the initiative of the relevant catchment management committee, formulate a catchment management strategy for the management, use, development, conservation, protection and control of water resources within each catchment area, in consultation with the relevant catchment management committee and following public consultation. In the process of formulating a catchment management strategy, the NWRA shall consult with the departments in charge of forestry and environment, respectively, and shall take into account, but shall not be bound by, any relevant prior determination made by either department pursuant to the legislation in force. It shall be the duty of the NWRA to review the catchment management strategy from time to time.

A catchment management strategy shall:

(1) Be consistent with the National Water Resources Master Plan;

(2) Prescribe the principle, objectives, and the procedures for the management, use, development, conservation and control of water resources within each catchment area;

(3) Contain water allocation plans which set out principles for allocating water; and

(4) Provide mechanisms and facilities for enabling the public and communities to participate in managing the water resources within each catchment area.

Based on the strategy, the catchment management committee, with technical assistance from NWRA, shall be under duty to promote and sensitize all users of watercourses and water bodies within the applicable water management area on the protection and management of water bodies. The committee shall also be responsible for the conservation and equitable, efficient and sustainable utilization of such watercourses and water bodies in conformity with national legislation and with regional and international water and environmental conservations.

7.2.3 Managerial Coordination of the Organizations

(1) Overview for IWRM Coordination

Based on the implication of the Water Resources Act and the IWRM policy, coordination of all relevant stakeholders centering on the NWRA and catchment management committees among them may be the great challenge in realizing the Malawi IWRM. The NWRA is an independent organization, but it is closely related to the MoAIWD, so that the NWRA shall carry out the following functions and activities on a routine basis between relevant departments of MoAIWD:

(a) Data and information monitored or planned/developed by the departments shall be shared with the NWRA, and their stored data/information shall be updated on regular basis. The data/information shall consist of monitored stream flow of water level and discharge and water quality, planned and implemented urban or rural water supply, wastewater treatment facilities, and irrigation facilities and their irrigated areas.

(b) Both organizations shall develop and maintain an identical database system that can be accessed from both sides.

(c) For a new water demand, reasonable water allocation shall be made in collaboration between both organizations through examination of water balance.

(d) For water quality management, both sides shall conduct detection of causal sources, identification of the extent of effects and implementation of remedial measures if water quality deterioration occurred in some areas.

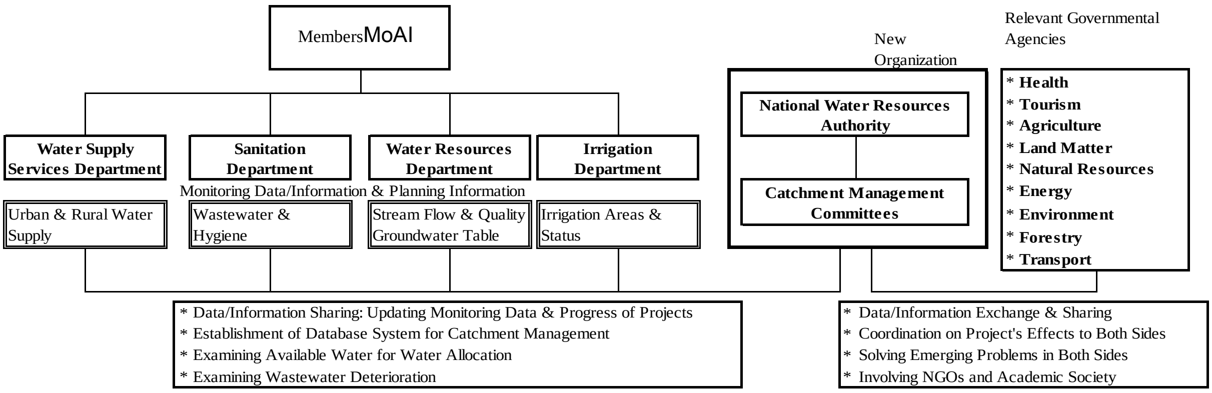
Regarding relevant governmental agencies out of MoAIWD, the NWRA shall conduct a sector-wide coordination among them. Since the NWRA is organized with the representatives from relevant governmental agencies, the following coordination shall be made in the central organization of the NWRA:

(a) Similar to the MoAIWD, data and information monitored or planned/developed by the departments shall be shared with the NWRA, and their stored data/information shall be updated on regular basis.

(b) Coordination works to mitigate adverse effects by some projects shall be necessary by both sides, if some projects with significant effects will induce to water resources or other factors operated/maintained by the relevant agencies.

(c) In case of occurrence of some problems in water resources, both sides shall collaborate for reasonable and equitable solution.

The following figure depicts the mechanism of coordination works to realize the IWRM.



Source: Study Team

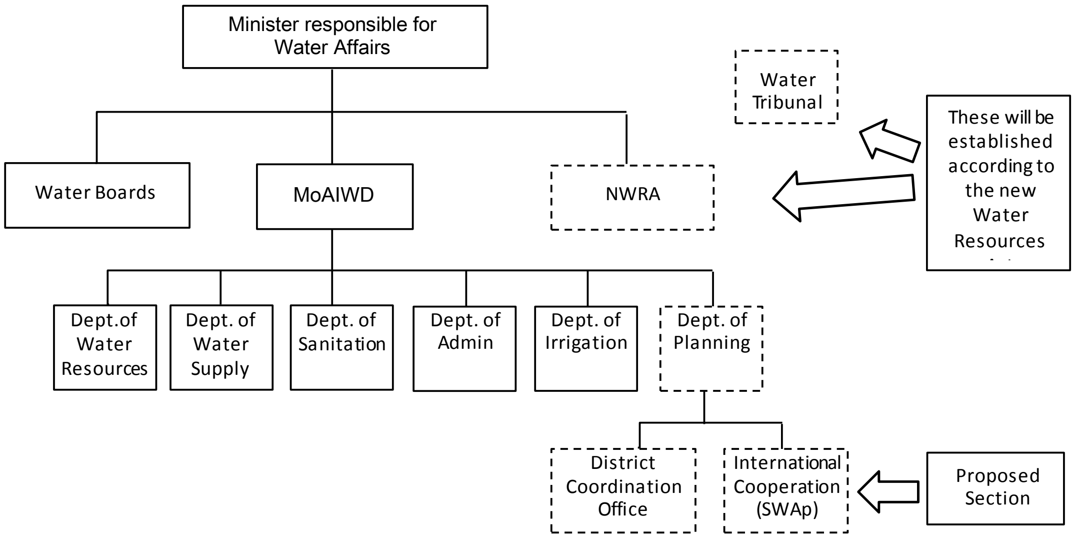
Figure 7.2.1 Organizational Relationship and Necessary Coordination Works

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

The Project Team identified the following issues which need interventions for improvement:

- The mandates of the water sector have been partly devolved to the district councils, but the process was not fully completed.
- The roles and functions of the regional offices are not well articulated. Government interventions and projects are implemented without the involvement of regional offices. The health sector, for example, has no regional office and the functions are all performed by the district councils, district offices and health institutions.
- The National Water Resources Authority was planned to be established. After the enforcement of the National Water Resources Act, an institutional structure is to be developed and implemented for this new organization to facilitate the IWRM.
- The collection rate of water licensing fees and water abstraction rentals is roughly 40%. The database is not well structured to monitor a good track record of the clients. The stakeholders within the MoAIWD are also not well sensitized about the water abstraction rentals/fees. Therefore, many boreholes and facilities are not recorded. This will make it difficult to estimate the volume of water abstraction at each catchment.
- The library does not function as a central archive of the Ministry. Information and reports are scattered and the books are not registered. The room is disorganized.
- The capacity of policy guidance and planning is weak. The Planning Section is short of human resources capacity and is heavily loaded with the SWAp coordination and M&E projects as well as the other activities.

The Integrated Water Resources Management System has become a common conceptual framework for management and utilization of water resources. In Malawi the high level government officials are well sensitized about the concept; however, the institutional structure is still in the transitional process. In the following paragraphs, proposals are made to improve the issues identified as above, for upgrading the institutional activities of the Ministry towards the IWRM, including a proposal of setting a new department with operational teams for district coordination and international cooperation activities. These new units will serve as the focal points for navigating the water sector policy, upgrading the district office activities around the country and international interventions. **Figure 7.2.2** illustrates a proposed structure of the Ministry of Water Development and Irrigation (MoAIWD) and NWRA. The sections indicated by the dotted squares are the new institutional units that are proposed in this Master Plan.



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

Figure 7.2.2 Proposed Organizational Structures of MoAIWD and NWRA

1) Institutional Framework for the National Resources Authority

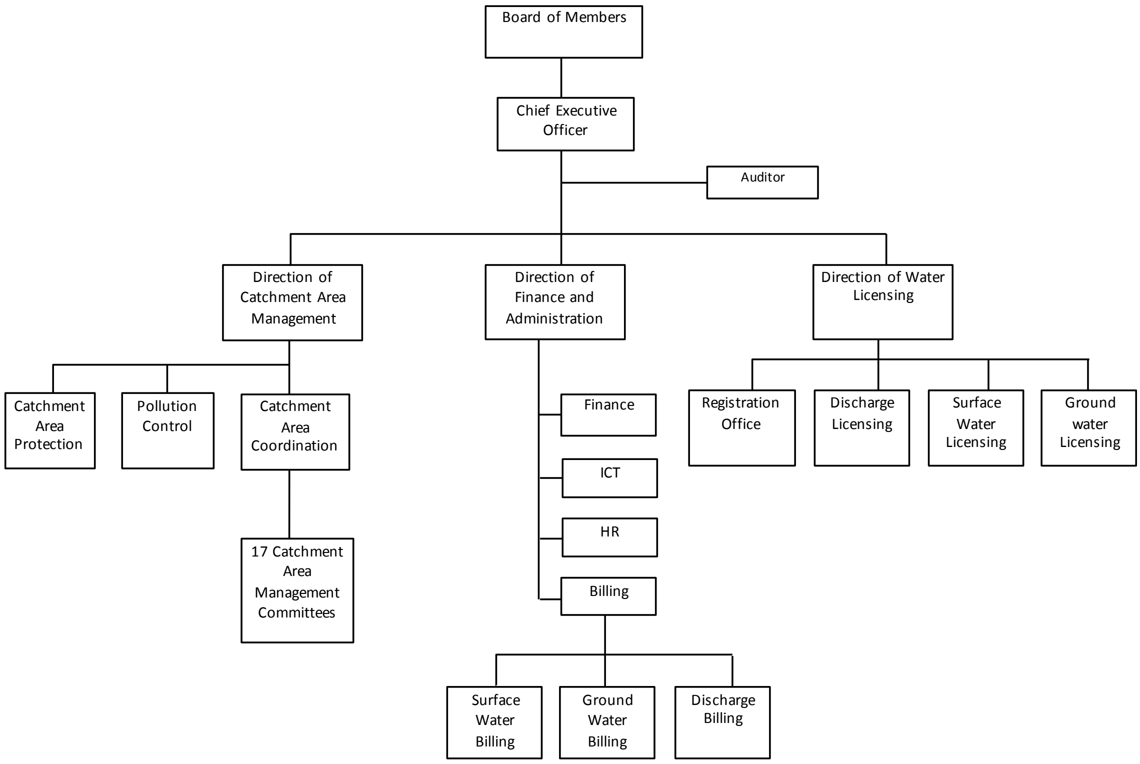
The concept of the National Water Resources Authority (NWRA) was made out of proposals to revise the institutional management of water resources towards a more integrated management for the national water resources. The management by river basin is a step towards the IWRM. The initial concepts were stipulated in the Water Resources Policy of 1995, which made the establishment of the NWRA legally binding. Thereafter the Water Resources Act drafted the concepts to establish a policy forming body that is responsible to the Parliament. The Parliament has to approve the process before the Act is thoroughly put into force. In the draft Water Resources Act, the body was suggested to be restructured from the existing Water Resources Board and to be named as the National Water Resources Board.

Further analysis was undertaken with the project "Strengthening of the Water Resources Board, January 2003", whereby the name was proposed to be "National Water Resources Authority" and a rough outline of the organizational structures was proposed.

The new Water Resources Act was enacted in 2013 in which detailed mandates of the Authority are elaborated. This gives further indications how the Authority to be established should be composed. In the same token, the public sector regulatory entities have already been operationalized for the telecommunication and energy sectors in Malawi to control public goods and resources for the benefit of the public at large. These sectors have also established similar regulatory authorities. Two regulatory authorities are taken as example to propose an organogram for the NWRA.

- Malawi Energy Regulation Authority (MERA)
- Malawi Communication Regulation Authority (MACRA)

Taking these examples of other entities as a reference as well as considering the organizations' powers and functions that the NWRA is expected to perform, an organizational structure for NWRA is illustrated in **Figure 7.2.3**. This proposed structure is an initial organogram and needs to be developed further as it requires.



Source: Project Team

Figure 7.2.3 Proposed Initial Organizational Structure of NWRA

Table 7.2.1 shows the proposed staffing plan for the NWRA. The proposal is made only for minimum core competencies. Other posts with general skills are recruited according to the requirements.

Table 7.2.1 Proposed Staffing Plan of NWRA

Post	Specialization	No. of Posts
CEO	Management/water resources	1
Auditor	Management/Finance	1
Director of Catchment Area Management	Management of Catchment Management Committee	1
Catchment Area Protection	Environmental science, water resources, civil engineering	2
Pollution Control	Water Quality, Environmental science	2
Catchment Area Coordination	Water resources/environment/forestry Hydrogeology Civil Engineering Planner	3
Director of Finance and Administration	Finance Administration Organizational Management	1
Finance	Financial Administration	2
ICT	Computer Science, Programming	1
HR	HR	1
Billing	Billing, Accounting	2
Director of Water Licensing	Hydrology, Water Resources	1
Registration Officer	Hydrology, Water resources	2
Discharge Licensing	Water Quality, Environmental Sciences	2
Surface Water Licensing	Hydrology, Water Resources	2
Groundwater Licensing	Hydrology, Groundwater	2
Principal Office Manager	Administration/Human Resources	1
Community Relations Officer	Public Relations/Media/Journalism	1
Total		27

Source: Project Team

The transitional process of establishment of the NWRA requires gradual transfer of certain mandates of which the Ministry is currently in charge. Since the NWRA is in the process of establishment with a business plan, concrete project contents have to be prepared once the organizational structure of the NWRA is set up and officers recruited. Projects that are needed for capacity building of NWRA are outlined in **Table 7.2.2**.

Table 7.2.2 Projects Recommended for Institutional Strengthening by NWRA

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

Source: Project Team, Water Resources Act

2) Catchment Management Committee

Water resources management by river basin is an effective institutional establishment for the integrated water resources management. Malawi has 17 river basins within the country. On the other hand, catchment areas are not clearly specified yet.

The Water Resources Act of 2013 stipulates the establishment of catchment management committees. Based on the law, each catchment area is to have a catchment management committee either by public consultation or by the initiative of the NWRA. However, from the viewpoint of water resources engineering, the basin-based division as a managerial unit is more rational than creating new area divisions for the Catchment Management Committee (CMC), since there may be conflicts of interest upstream and downstream. The rivers need to be coordinated as a whole in the river basin. Therefore, the Catchment Management Committee can use 17 river basins as divisional scheme for managerial purposes. Further, considering the scarcity of human resources well qualified in water resources, hydrogeology, environment and other relevant expertise, it is commendable in the first place to establish one (1) committee which will look after the 17 basins before expanding the number of committees. In the future, more committees can be established for the river basins.

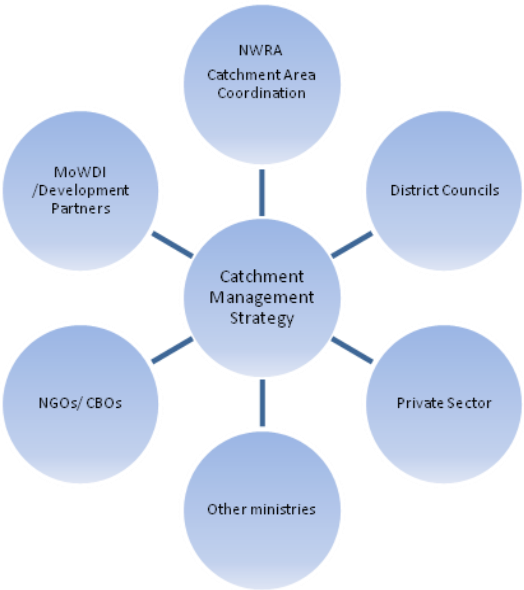
Should needs arise, sub-catchment committees can be established. The establishment of such committees has to undergo the following processes. A Secretariat that will look after all of the 17 river basins has to be placed at the headquarters of the NWRA.

Table 7.2.3 Proposal for Catchment Management Committee Establishment Process

Process	Activities
1. Selection of members	Select members
2. Establishment of Secretariat	Establish a Secretariat at each basin
3. Strategic plan for management	Draw a business management plan/management strategy either by the Authority or CMC
4. Consideration of funding sources	Draw a financial plan
5. Catchment Area Coordination	Coordinate stakeholders in relation to the catchment area management
6. Pollution Control	Monitor the data and decide actions if needed
7. Manage abstraction and discharge activities	Licensing in collaboration with the central NWRA office
8. Conduct or initiate water resources conservation activities and works	Find funding sources to undertake water resources conservation activities and works and implement the activities

Source: Project Team

The NWRA initiates the coordination or production of the catchment management strategy for the 17 basins. These plans may be implemented with support from the district councils, MoAIWD and other ministries, NGO/CBOs and private sector.

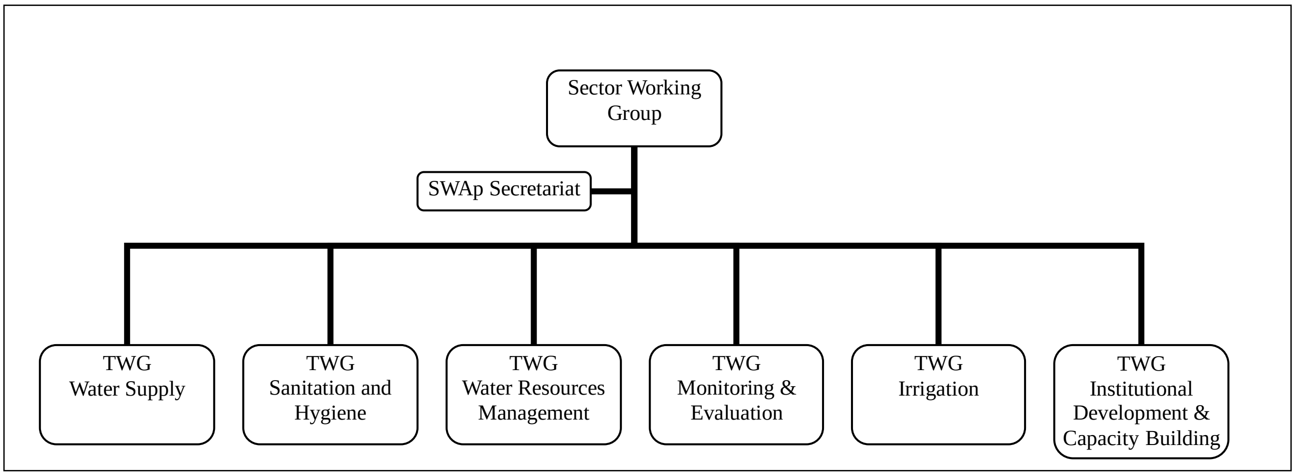


Source: Project Team

Figure 7.2.4 Potential Partners for Catchment Area Management

3) Water Sector Wide Approach

The structure of Sector-Wide Approach (SWAp) is established in order to strengthen a management system with participation of relevant stakeholders to the water sector. The management concept was sought in accordance with the guidelines from the Ministry of Finance (MoF) and the Ministry of Economic Planning and Development (MoEP&D) in 2008 and elaborated water pillars outlined in the Water Sector Investment Plan (2012). The current institutional structure is shown in **Figure 7.2.5**.



Source: Project Team, MoAIWD

Figure 7.2.5 Organizational Structure of Water Sector Technical Working Group

Challenges were identified for the progress of coordination and implementation of the SWAp structure by the SWG at the meeting on 29 May 2014 as follows:

> ‘TWG report dwelt much on detailed progress on activities that the implementing agencies in the sector are undertaking. It was difficult for the SWG to isolate strategic issues that required consideration of the Group. The Group noted that, much quarterly performance reports were required, it was important that TWG should be presenting specific recommendations on strategic issues requiring direction from the SWGs’

Source: Terms of Reference for the Water Sector Wide Approach (SWAp) Management Structures

Another challenge is the weak coordination and management capacity of the Ministry as the Secretariat of SWAp. There are various sector stakeholders in Malawi ranging from NGOs, Government, Development Partners and the Private Sector. The Ministry supports the SWAp Secretariat as the they can play an important role that functions as the focal driving force of the SWAp system.

As noted that the technical working groups are only reporting individual projects and interventions progress, the SWG is unable to identify strategic challenges, and make appropriate policy interventions and plan adequate projects or programs. Thus, there needs to be a function of synthesizing the common issues and proposing recommendations at TWG levels for policy and strategic decision making by the SWGs. The lead facilitator is currently selected among the members of TWGs. However, this facilitator should come from the departments of the Ministry as a permanent focal person to reserve constant communications with the SWG Secretariat, since the Ministry should play a managerial and leading role to facilitate this SWAp process. Therefore, for the functionality of TWGs and SWGs to be coordinated to focus more on the strategic interventions and policy formulation, the government officials of the departments from the Ministry have to be involved in the respective TWGs to coordinate, report the planning activities of TWGs and liaise with the Secretariat for the overall coordination.

Figure 7.2.6 proposes the structure of SWAp with a ministry official attached to TWGs.

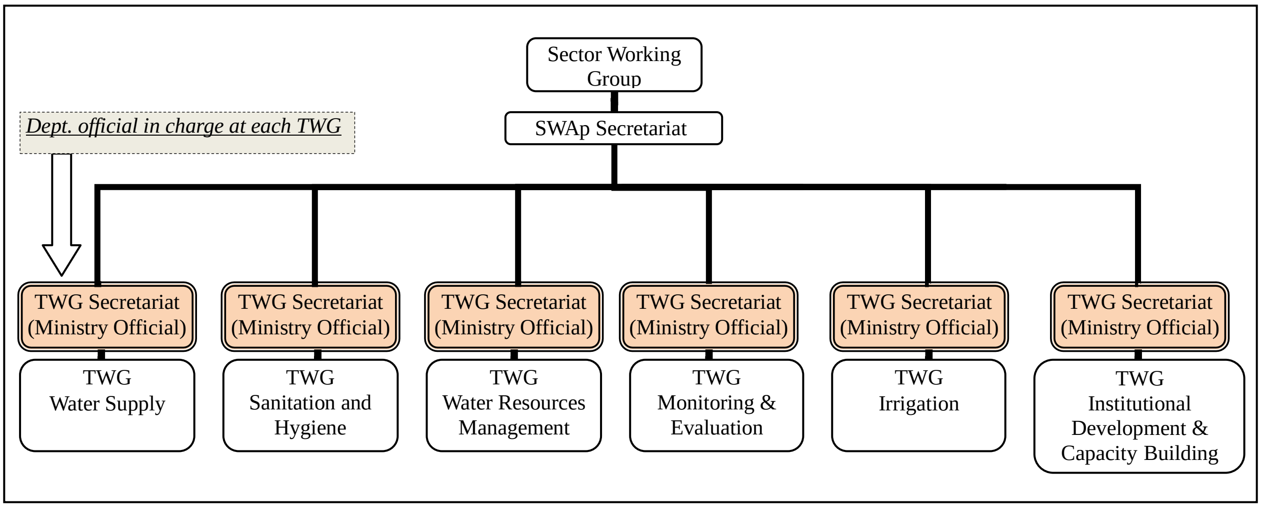


Figure 7.2.6 Proposed Organizational Structure Water Sector Technical Working Group

As for the progress of the activities in 2014 for the full institutionalization of SWAp, the following progress are monitored. The remaining activities are also identified.

Current Situation

The following are done by 2014:

- Broad Sector Policy with Clearly Defined Subsector Themes
- Sector Policy Investment Plan
- Sector Strategic Plan
- Sector Monitoring and Evaluation Framework
- SWAP Governance Structures: SWG, TWG, JSR
- Sector Medium Term Budget
- Sector Medium Term Program of Works

The following need to be done:

- Fiduciary Framework: combination of Bilateral, Multilateral, Basket funds
- SWAP Institutional Framework (full implementation)
- Program of Works implementation and supervision
- Sector Monitoring and Evaluation Implementation

Road Map

- 2015-2020: Improvement of Program of Work Implementation
  Sector M&E Implementation
- 2020: Fiduciary Framework consolidated
  SWAp Institutional Framework implemented

Table 7.2.4 Road Map of National Water Resources Authority and Sector Wide Approach

WRA / Time Frame / Program / Project / Activities	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	Responsible Organ: Main	Responsible Organ: Associate
Time Frame	Short Term 2012-2020									Middle Term 2021-2025					Long Term 2026-2035											
National Water Resources Authority																										
Business Plan/Operational Plan			■	■																					MoAIWD	MoAIWD
Financial Plan			■	■																					MoAIWD	MoAIWD
Catchment Area Management				▪	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	NWRA	ditto
Water Abstraction and Use				▪	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	NWRA	ditto
Control and Protection of Water Resources				▪	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	ditto	ditto
Prevention and Control of Water Pollution						▪	▪	▪	▪	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	ditto	ditto
Government Waterworks					▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	ditto	ditto
Dams and Flood Management								▪	▪	▪	■	■	■	■	■	■	■	■	■	■	■	■	■	■	ditto	ditto
Water Charges and Financial Provisions								▪	▪	▪	■	■	■	■	■	■	■	■	■	■	■	■	■	■	ditto	ditto
Water Trust Fund								▪	▪	▪	■	■	■	■	■	■	■	■	■	■	■	■	■	■	ditto	ditto
Associations of Water Users					■	■	■	■	■																ditto	ditto
National Water Resources Master Plan																										
Master Plan formulation	■	■	■																						MoAIWD	NWRA
Implementation of Works				■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	MoAIWD	NWRA
Master Plan update																						■	■	■	NWRA	NWRA
Sector Wide Approach																										
Fiduciary Framework				▪	▪	▪	▪	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	MoAIWD	NWRA
Institutional Framework						■	■	■	■																MoAIWD	NWRA
Sector Monitoring and Evaluation						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	MoAIWD	NWRA
Programe of works				▪	▪	▪	▪	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	MoAIWD	NWRA

Source: Project Team

(3) Development of Planning

The Ministry needs to develop its capacity to formulate a strategic policy and navigate the activities of national water resources management. The current Planning Section is placed under the Department of Administration. The capacity of this section should be enhanced to the level of the Department that can coordinate the policy proposals from different technical departments within the Ministry and play the leading role to formulate strategic planning of the water sector. Under the Department of Planning, two relevant sections are included; namely, the District Coordination Section and the International Cooperation (SWAp) Section.

1) District Coordination Section

This section will be in charge of coordinating activities of the district offices. The District coordination section in the Ministry should be able to coordinate a standardized administrative communication system and activity monitoring with all district offices throughout the country. The section will be in charge of monitoring and giving guidance to district offices in carrying out their duties, assist in data gathering and filing as well as records keeping. At present, communications are made directly through the concerned department for projects or government interventions. A standardized administration system guided by the central level will help update the district capacity and monitor the district office activities. In particular, there are projects implemented without informing the Ministry and this causes supervision and monitoring of water resources management off-handed. The District Coordination Section will thus help facilitate the functions of district offices.

Under this reform, the roles and responsibilities of the three regional offices will be integrated with those of district coordination offices and the central government, paving the way for the dissolution of regional offices.

Table 7.2.5 Proposed Mandates of District Coordination Section

Function	Activities	Purpose
To coordinate the district office activities and standardize the procedures throughout the country	• Provide districts with standardized information filing framework. • Standardized reporting of the monthly activities to the Ministry. • File and keep track records of district information.	To keep track records of policy implementation within the district • Administrative procedures • Information about development projects • Water resources • Project implementation information

Source: Project Team

2) Project Management Section

This new unit in charge of projects and interventions through international cooperation will manage the international cooperation procedures and administration concerning the projects supported by the international partners. This unit will eventually coordinate the SWAp and other projects once the SWAp is fully launched for the water sector. This setup will streamline international assistances with different approaches, either the international partners wishing to participate in the SWAp or to hold an agreement of bilateral cooperation. According to the Sector Working Group Guidelines, MoF and MEPD 2008, the following principles guide the SWAp to improve the overall sectoral performance:

- Ownership: Sectoral governance and implementation of strategies, programs and projects by the Government of Malawi
- Alignment: Support of development partners for National Policies and Procedures, National Program of Work, Sector Budget, Public Finance Management, National Monitoring and Evaluation Framework
- Harmonization: All stakeholders intervention and process in the sector
- Managing for sector results: Implementation and M&E Framework and reporting
- Mutual accountability: Review and monitor the progress of activities through Joint Sector Review (JSR)

The proposed mandate of the unit is shown in **Figure 7.2.6**.

Table 7.2.6 Human Resources Capacity Required for the Project Management Section

Competencies	Personnel	Mandate	Job Description	Tools
SWAp Secretariat	3	To coordinate related sectors	• Prepare and coordinate production of Sector Performance Review • Database control and supervision • Prepare and coordinate Joint Sector Review	• Sector strategic and investment plan • Fiduciary Framework • Program of Work • M&E Framework
International Liaison Officer	1	To coordinate international cooperation projects	• Coordinate all necessary government procedures for international cooperation works	• MoU, Record of Discussion
Procurement Officer	1	To manage procurement for projects	• Procurement administration for projects	• Budget and Procurement Plan • Terms of Reference, procurement documents
Documentation Officer	1	To maintain related documents	• Record and administer documentations	• Documentation • Database

Source: Project Team

7.3 Surface Water Management

7.3.1 Information Management Conditions

Data and information are basis of activities for water resources management, such as assessment of existing water resources and development potential, proper water allocation and water use management, water resources conservation, and examination of plan of water resources management and development. Main data characterizing water resources in the basin are rainfall, water level, discharge, groundwater level and water quality, and continuous long-term observation, monitoring and accumulation of these data enable to analyze and assess water resources in the basin with required accuracy. In Malawi, rainfall observation started in the beginning of the 1900's, water level and discharge observed from late 1940's, and groundwater monitored from 1970's in some area although they have some interruption period.

However, there are many stations of which no observation data remains even though records of installation of such stations and their operation records can be confirmed. Also, some of the remaining observation records includes low-reliable data as explained in **Part I: Chapter 5**.

Observation and monitoring data are formed by accumulating values that were recorded at each passing moment, and it is impossible to obtain values such as rainfall amount and water level at a past moment. Also, it is quite difficult to review and modify the past observation data after long time passing. Therefore, it is crucial that observers and observation equipment record data accurately and steadily at each moment and such data are timely reviewed, modified and arranged as well.

In this section, the plans for establishing and maintaining proper observation and monitoring system for rainfall, surface water, ground water and water quality are presented as below.

7.3.2 Rainfall Observation

(1) Present Condition

There have been about 800 rainfall stations in the 1980's, but it is said that there are only between 100 and 200 operational rainfall stations now in Malawi. Meteorological observation including rainfall observation is managed by the Department of Climate Change and Meteorological Services under MoNREE (Ministry of Natural Resources, Energy and Environment). Evaporation, and other climatic data, is recorded at full meteorological stations. The Department of Climate Change and Meteorological Services manages 23 full meteorological stations, which are continuously implementing high reliable observation.

In the Project, rainfall stations used for analysis are 69 stations including the above 23 stations, which are selected as the stations that have sufficient daily rainfall data. Even in this case, the covered area of one station is large at 1,000 to 2,500 km^2 and 1,400 km^2 on average. In addition, special distribution of the stations is not adequately spread evenly; for example, there are no stations in the upstream of WRA 6 and WRA 8. Further, there is no daily rainfall data available after the 1990's in almost half of the 69 stations.

Therefore, it is necessary to establish a reliable and stable rainfall observation system with higher density of stations considering proper distribution of stations.

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

(2) Road Map for Short, Middle and Long Term Plan

Rainfall data is a substantial element and base for water balance analysis and water resources assessment. It is necessary to formulate an effective and feasible plan for developing and reinforcing the present rainfall observation system in order to observe and record rainfall amount accurately as well as to collect and manage the rainfall data properly as the most important and basic activities for water resources management.

1) Short Term

A reliable and stable rainfall observation system shall be developed to ensure a steady implementation of a series of activities that accurate data is reliably recorded, the data is aggregated to the office without undue delay, and the data is reviewed, arranged and input to database, targeting at main stations operated at present.

A reliable and stable O&M structure to ensure a steady operation and maintenance of the above system shall also be developed.

Also, a framework for data sharing shall be developed in order to share the data promptly without omission from the Department of Climate Change and Meteorological Services to relevant organizations.

In addition, the observation network with well-distributed stations shall be reinforced by installing rainfall gauging stations as required to the area where there are no reliable operating stations and/or few stations in the basin, aiming at water resources management in each WRA.

2) Middle and Long Term

The reliable and stable rainfall observation system and its O&M structure shall be properly maintained and reinforced as required. Rainfall gauging stations shall be upgraded as required with the aim of improvement of reliability by ensuring substitutability of observation as well as utilization for flood forecasting and warning.

(3) Concrete Activities for Short, Middle and Long Term Plans

1) Short Term

“Observation System (Organization and Human Resources)”

In order to develop the reliable and stable rainfall observation system, the following activities shall be implemented:

- Training to assigned gauge readers, which shall consist of accurate observation data recording rule, methods for checking of observation equipment and O&M of the equipment, and so on.
- Preparation of manual for reviewing observation data, which contain confirmation of data deficit, comparison with data of neighboring stations, comparison between data of manual and automatic rainfall gauges.
- Strengthening of the structure/system of collection, input and management of the data.

In order to develop a reliable and stable O&M structure, the following activities shall be implemented:

- Setting a rule for confirming situation of gauge reader, observation station and equipment, as well as confirming and recording each station’s situation at regular interval based on the rule.
- Acquiring and keeping proper number of staff in the Department of Climate Change and Meteorological Services.

In order to develop the framework for prompt data sharing, it shall be implemented to strengthen the structure/system of collection, input and management of the data in the Department of Climate Change and Meteorological Services, and to make a rule for prompt data sharing with relevant organizations.

“Observation Network (Station and Equipment)”

Reliable gauging stations shall be increased in series aiming at development of the reliable and well-distributed observation network consisting of about 100 stations at least. Ideal condition is: (i) at least one station exists in each WRU for basin-based water resources management; and/or (ii) covered area of each station reaches to about 1,000 km^2.

Historically, there have been about 800 rainfall stations in Malawi. Therefore, installing stations for development of the network is better to be implemented prioritizing the location where observation was carried out in the past from the viewpoint of data availability. Also, attention should be paid to the security and proper O&M condition of the stations, including briefing session to inhabitants about significance of rainfall observation and importance of the station.

2) Middle and Long Term

The observation network shall be continuously reinforced by installing rainfall gauging stations as required to the area where there are no reliable operating stations and/or few stations in the basin.

Installation of automatic rainfall gauge to existing rainfall gauging stations shall be promoted as required, with the aim of: (i) ensuring substitutability of observation; (ii) ensuring data quality by confirmation and comparison of observation data; and (iii) investigating rainfall intensity.

The reliable and stable rainfall observation system and its O&M structure developed in the short term plan shall also be established and maintained to newly reinforced stations in medium and long term.

The introduction of telemeter system for stations of which observation data can be used for flood forecasting and warning in flood prone area shall be promoted as required.

(4) Action Plan

The Action Plan including prior WRA, time schedule, responsible organization and budget is shown in **Table 7.3.3**.

7.3.3 Surface Water Observation (Water Level Observation and Discharge Measurement)

(1) Present Condition

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

(2) Road Map for Short, Middle and Long Term Plans

As for water resources management, discharge data calculated from water level is a base of analysis and assessment of surface water. Since it is crucial that water level is continuously observed accurately and reliably without deficit of data, it is necessary to formulate an effective and feasible plan for developing and reinforcing the present observation system in order to observe and record water level and discharge accurately, as well as to collect and manage such data properly as the most important and basic activities for water resources management.

1) Short Term

Considering present human resources and budget of the relevant section of MoAIWD, it can be judged as difficult to make the same effort to all the stations presently opened. Therefore, prioritized stations should be targeted for activities such as improvement and rehabilitation of stations, and redevelopment of the system for proper observation and proper collection and management of the observed data.

Then, it will be aspired to establish a reliable and stable water level observation system to ensure a steady implementation of a series of activities that accurate data is reliably recorded at least by gauge reader, the data is aggregated to the office without undue delay, and the data is reviewed, arranged and input to database (HYDSTRA) in prioritized stations.

In addition, a reliable and stable O&M structure to ensure a steady operation and maintenance of the above system will be developed.

The stations shall be improved depending on the priority. Criteria for prioritization are explained in **Table 7.3.1**. Prioritized stations are shown in **Table 7.3.2** and **Figure 7.3.1**.

Table 7.3.1 Criteria for Prioritization of Water Level and Discharge Gauging Stations

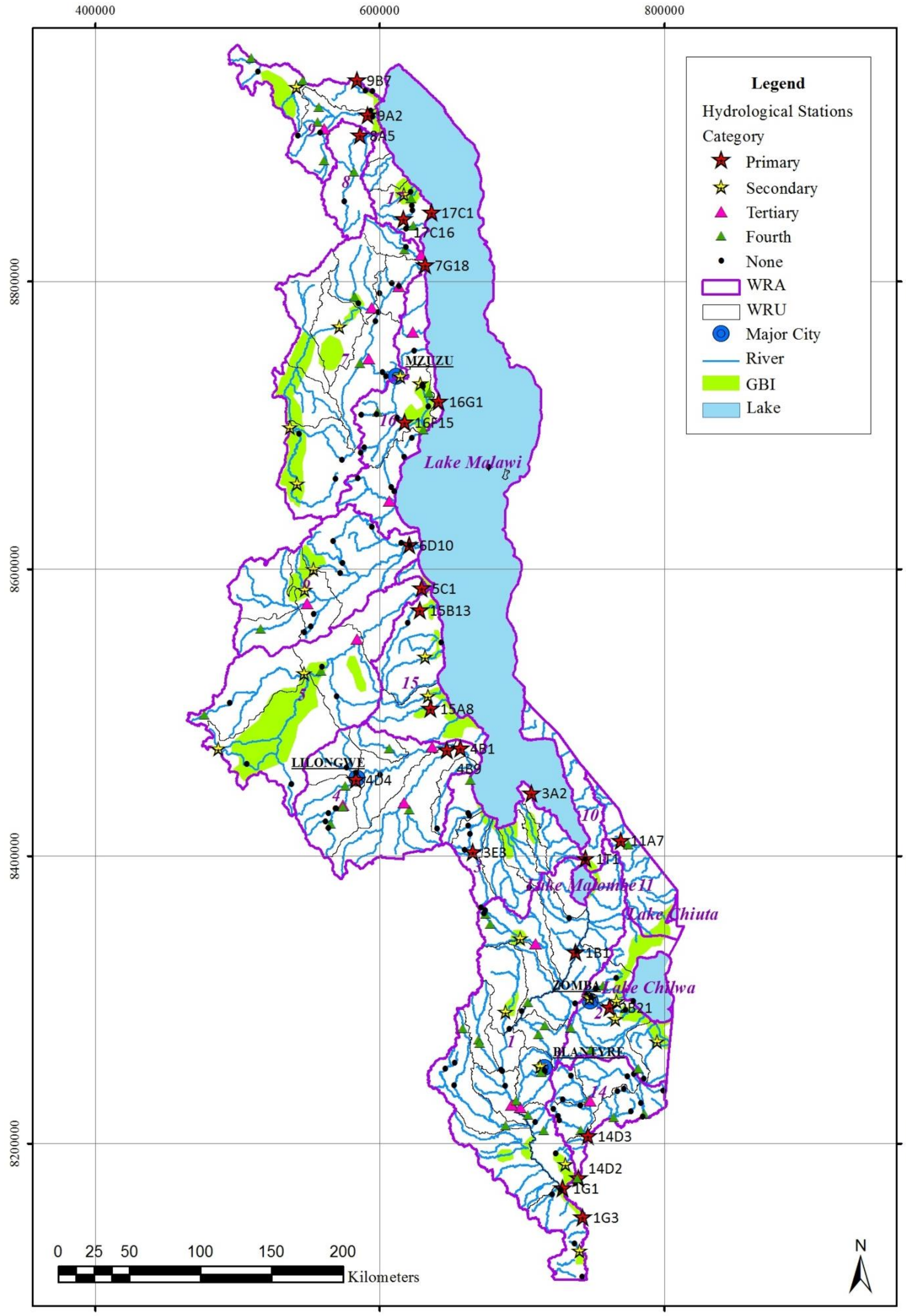
Category	Priority	Criteria
Primary	Quite High	- Stations at downstream (or middle reach) of main rivers of WRA, which can be used for assessment of water resources in WRA, or - Existing or planned automatic stations such as SADC-HYCOS stations, or - Station at just downstream of Lake Malawi (upstream of the Shire River)
Secondary	High	- Station at upstream of (or near) cities and GBI which use much amount of water
Tertiary	Middle	- Stations at upstream, middle reach or downstream of major rivers, which can be used for assessment of water resources in WRA and WRU [volume (length) of available data, physical condition and present condition of each station are also considered for selection], and - Stations assessed as “Primary Station” by MoWI in 2003.
Fourth	Low	- Stations at upstream, middle reach or downstream of major rivers, which can be used for assessment of water resources in WRA and WRU, or - Stations assessed as “Primary Station” by MoWD in 2003

Source: Project Team

Table 7.3.2 Prioritized Water Level and Discharge Gauging Stations

WRA			Existing			Category			
No	Name	Catchment Area (km^2)	Open	Closed	Total	Primary	Secondary	Tertiary	Fourth
1	Shire	18,911	25	23	48	1B1, 1G1, 1G3, 1T1	1E19, 1F2, 1G2, 1O1, 1R20	1E1, 1L12, 1R3	1C1, 1C9, 1E2, 1E4, 1F1, 1F17, 1K1, 1K3, 1M1, 1M5, 1P2, 1R18, 1R19
2	Lake Chilwa	4,568	11	9	20	2B21,	2A2, 2B8, 2B22, 2C8		2B6, 2B10, 2B11, 2B33, 2C3
3	South West Lakeshore	4,998	7	3	10	3A2, 3E3			3F1
4	Linthipe	8,885	18	2	20	4B1, 4B9, 4D4		4B4, 4C2, 4D24	4B3, 4D25, 4D27, 4D28, 4F6
5	Bua	10,658	8	3	11	5C1	5E6, 5F1	5D1	5D2, 5F3
6	Dwangwa	7,751	8	6	14	6D10	6C5, 6D1	6C1	6B2
7	South Rukuru/ North Rumphi	12,719	16	8	24	7G18	7A3, 7A9, 7D16, 7E2	7D8, 7F2, 7G14, 7H3	7D4, 7F3, 7H1
8	North Rukuru	2,088	3	1	4	8A5			8A8
9	Songwe/Lufira	3,730	9	7	16	9A2, 9B7	9B3	9A4	9A3, 9A5, 9A9, 9B4, 9B6
10	South East Lakeshore	1,659	0	0	0				
11	Lake Chiuta	2,443	1	1	2	11A7			11A6
14	Ruo	3,519	12	11	23	14D2, 14D3		14B2	14A2, 14B3, 14C2, 14C8, 14D1
15	Nkhota-kota Lakeshore	4,819	5	1	6	15A8, 15B13	15A4, 15B14		
16	Nkhata-Bay Lakeshore	5,533	9	13	22	16F15, 16G1	16F6	16E6, 16G2	16F2, 16F5, 16F21
17	Karonga Lakeshore	1,945	3	6	9	17C1, 17C16	17C9		17C6, 17C10
	Total		**136**	**94**	**230**	**25**	**22**	**16**	**47**

Source: Project Team



Source: Project Team

Figure 7.3.1 Prioritized Water Level and Discharge Gauging Stations

In parallel, development of the system which can carry out regular discharge measurement will proceed including cross sectional survey in order to develop rating curves that can accurately convert water level data to discharge data, and to confirm and update the rating curves continuously in prioritized water level stations.

Regarding the data management system, it can be said that rule for data management has been already established and its development has been accomplished at a certain level through introduction and training of HYDSTRA database and so on. Therefore, it shall be necessary to strengthen the present system to function more properly and smoothly.

2) Middle Term

Revising the priority of stations as required based on the change of local circumstances, maintenance and rehabilitation of prioritized stations, and redevelopment of the system for proper observation shall be continuously carried out in accordance with the priority so as to conduct proper observation in all of prioritized stations.

After completion of maintenance of prioritized stations (from Primary to Fourth), maintenance and rehabilitation of station as well as redevelopment of the system for proper observation shall be carried out targeting stations considered to have high necessity among stations where observation has been conducted as of 2013 and stations that operated in the past but was closed as of 2013, in consideration of the Ministry's capacity for operation and maintenance.

In case of establishing reopened stations, firstly, a staff gauge is installed at the site, and water level observation and regular cross section survey are carried out at least for one year. Then, the site is evaluated as to whether or not it is appropriate as a permanent observation point, and is determined as to whether or not observation is continued at the site.

Also, regarding automation of a station, in case that an automatic water level gauge is installed, the following may become available: (i) ensuring substitutability of observation; (ii) ensuring data quality by confirmation and comparison of observation data from manual and automatic gauges; and (iii) recording a high frequency of water level. On the other hand, burden of operation and maintenance becomes large. Therefore, it is recommended that the operation and maintenance of existing observation stations is prioritized rather than installation of new automatic gauges, and installation of automatic gauges may be done to the extent possible without undue stress from the viewpoint of operation and maintenance capacity.

In parallel, development and reinforcement of the system which can carry out proper-frequency discharge measurement to increased rehabilitated stations shall proceed. Besides, regular discharge measurement and cross sectional survey shall be continuously conducted.

3) Long Term

Developed observation systems shall be properly maintained, and observation, discharge measurement and update of the rating curve shall be continuously conducted.

Also, installation of new stations shall be done as necessary, and automation of stations shall proceed with the stations considered to have high necessity for ensuring sustainability of observation, ensuring data quality and/or recording of high frequency of water level. O&M structure corresponding to automation shall be also developed.

In addition, if necessary, introduction telemetry system for stations of which observation data can be used for flood forecasting and warning, or stations that are extremely important from water use aspect and need timely data, as well as development of a system for information collection, sharing, and dissemination corresponding to the telemetry system, shall be promoted.

(3) Concrete Activities for Short, Middle and Long Term Plans

1) Short Term

"Observation System (Organization and Human Resources)"

The following activities shall be carried out in order to develop the system for proper observation and proper collection and management of the observed data in the prioritized stations:

- To set and allocate proper remuneration to gauge readers in order to ensure their commitment and keep their motivation;
- To conduct training to gauge readers engaged in prioritized stations for accurate observation and recording and proper maintenance of observation stations;
- To strengthen district offices such as employment of necessary staff for vacant positions, training of staff, securement of transportation and increase in budget for prompt collection and management of observed data, implementation of discharge measurement, and maintenance of stations; and
- To strengthen data management system such as strengthening proper operational structure of HYDSTRA in the headquarters.

In order to develop a reliable and stable O&M structure for the above water level observation system, the following activities shall be implemented:

- Setting a rule for confirming situation of gauge reader, observation station and equipment, as well as confirming and recording each station's situation at regular interval based on the rule; and
- Acquiring and keeping proper number of staff.

In parallel, the district office system such as employment of necessary staff, training of staff and securement of transportation in order to carry out proper frequency and accurate discharge measurements and updating of rating curves continuously in prioritized water level stations shall be reinforced. When it is assumed that discharge measurement should be carried out in all prioritized stations at least with frequency of once in three months, it can be responded by maintaining the structure that each district office makes up and keeps one team of discharge measurement. Therefore, it shall be surely necessary to maintain the structure that each district can organize one discharge measurement team including securement of transportation and budget for that. At present, equipment for high flow discharge measurement are possessed in each regional office. It is recommended that regional office shall carry out discharge measurement to require those equipment and shall develop and keep the structure to organize the team for such a discharge measurement.

"Observation Network (Station and Equipment)"

Improvement and rehabilitation of stations and equipment shall be implemented for reliable and stable observation in the prioritized stations. Definitely, the following activities shall be done depending on the priority of a station:

- Confirmation of present status of a station;
- Rehabilitation and/or reinstallation of staff gauges;
- Maintenance of circumstances around stations including mowing, cutting trees and clearing and rehabilitation and/or installation of fence as required;
- Maintenance of access road to stations;
- Rehabilitation and reinstallation of facilities for high flow measurement such as a cable and a base when necessary, which are quite costly and hence stations categorized as "Primary" are targeted for only the short term plan; and

- Cross sectional survey for sections of discharge measurement;

During the short term, improvement and rehabilitation shall be finished for stations categorized from Primary to Tertiary.

Necessary equipment for discharge measurement shall be prepared in order to carry out proper discharge measurement in each district office. Fundamental equipment such as flow gauging equipment for small streams for each district office and flow gauging equipment for large rivers for each regional office have been recently provided; therefore, it seems that needs of equipment may not be serious during the short term.

"Observation Activities"

Discharge measurement shall be restarted and continuously carried out from stations where confirmation of present status and rehabilitation will be done.

Based on the results of discharge measurement, confirmation of availability of existing rating curves and those for update activity shall be conducted.

2) Middle Term

"Observation System (Organization and Human Resources)"

Same activities as the short term shall be continuously carried out for the development of reliable and stable water level observation systems so as to conduct proper observation in all prioritized stations from primary to fourth priority. The system shall be adequately maintained.

Redevelopment of the system for proper observation shall be carried out targeting stations considered to have high necessity among stations where observation is conducted as of 2013 and stations that operated in the past but was closed as of 2013, in consideration of the Ministry's capacity for operation and maintenance.

A system for proper O&M corresponding to automation of a station shall be developed. Automatic stations such as HYCOS stations are presently managed by the headquarters but in case the number of automatic stations will increase, regional offices and district offices may need to manage them. Therefore, training on how to deal with and maintain an automatic station and equipment shall be planned and implemented for staff of those offices.

In parallel, the development and reinforcement of systems that can carry out proper frequency discharge measurements for increased rehabilitated stations shall proceed.

"Observation Network (Station and Equipment)"

Same activities as the short term shall be continuously carried out for the improvement and rehabilitation of stations and equipment so as to conduct proper observation in all prioritized stations. The system shall be adequately maintained. Regarding rehabilitation and reinstallation of facilities for high flow measurement, they shall be conducted targeting the stations with high necessity.

Improvement and rehabilitation of stations and equipment shall be carried out targeting stations considered to have high necessity among stations where observation is conducted as of 2013 and stations operated in the past but were closed as of 2013, in consideration of the Ministry's capacity for operation and maintenance.

Installation of automatic water level gauges shall proceed at stations considered to have high necessity to the extent possible without undue stress from the viewpoint of operation and maintenance capacity.

"Observation Activities"

Discharge measurement shall be continuously carried out in the stations where confirmation of the present status and rehabilitation were done.

Based on the results of discharge measurement, confirmation of availability of existing rating curves and update activity shall be continuously conducted.

3) Long Term

<u>"Observation System (Organization and Human Resources)"</u>

The reliable and stable rainfall observation system and its O&M structure developed by the middle term plan shall be properly maintained.

Redevelopment of the system for proper observation shall be carried out targeting the reopened stations considered to have high necessity.

In case that installation of new stations and/or automatic stations with/without telemeter system will be promoted, the system for proper operation of those stations shall be reinforced.

<u>"Observation Network (Station and Equipment)"</u>

The stations and equipment installed or rehabilitated by the middle term plan shall be properly maintained.

Rehabilitation of a station for proper observation shall be carried out targeting the reopened stations considered to have high necessity.

Installation of a new stations and automatic water level gauging stations shall proceed as required.

In addition, if necessary, the introduction of telemeter system for stations where observation data can be used for flood forecasting and warning, or stations that are extremely important from water use aspect and need timely data shall be promoted.

7.3.4 Action Plan

The Action Plan including prior WRA, time schedule, responsible organization and budget is shown in **Table 7.3.3.**

Table 7.3.3 Action Plan of Short, Middle and Long Term Project Activities

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		
Rainfall Observation																												
	Establishment and maintenance of reliable and stable rainfall observation system in prioritized presently-operated stations	All				■	■	■	■	■	■	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	MoNREE (Dep. Meteo)	MoAIWD and others
	Reinforcement of reliable and stable rainfall observation system & network by reopen and/or newly-install of stations	6, 8				■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	ditto	ditto
	Development of framework for data sharing	All				■	■	■																			ditto	ditto
	Upgrading of stations	All										■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	ditto	ditto
Surface Water Observation																												
	Establishment and maintenance of reliable and stable water level observation system in prioritized observation stations	All				■	■	■	■	■	■	■	■	■	■	■	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	MoAIWD	NWRA
	Reinforcement of reliable and stable water level observation system & network by reopen and/or newly-install of stations	All										■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	ditto	ditto
	Establishment and maintenance of proper-frequency discharge measurement implementation system	All				■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	ditto	ditto
	Upgrading of stations	All										■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	ditto	ditto

Source: Project Team

7.3.5 Environmental Flow

Normally, environmental flow is the ensured flow for river environment in order to reduce the impact of human activities such as intake for irrigation and domestic water. Meanwhile, since the rivers in Malawi tend to dry up in the dry season, firstly, the purpose for ensuring the environmental flow, for example securing specific spices or recreation, should be clarified, and secondarily, the volume of environmental flow at control points should be determined through detailed studies and researches. Especially, when there is a large-scale water resources development, the environmental flow should be secured with compensation for environment and water users at the lower stream.

As the result of consultations with MoAIWD, the flow duration curve analysis method is applied in the Project for the estimation of environmental flow which is the 90 percentile flow (Q_{90}). **Table 7.3.4** shows the sufficiency of the environmental flow in the dry season under 5,000ha/year irrigation development scenario. As irrigation development progresses, the sufficiency of environmental flow will decrease. By modification of cropping pattern described in **Chapter 3**, it is improved to some extent. Irrigation sector is the most water consumption user; therefore, the development shall proceed carefully considering the impact of intake on river environment.

Table 7.3.4 Sufficiency of Environmental Flow under 5,000ha/year Irrigation Development Scenario

WRA	Present	Normal Cropping Pattern	Normal Cropping Pattern	Normal Cropping Pattern	Modification of Cropping Pattern	Modification of Cropping Pattern	Modification of Cropping Pattern
		2020	2025	2035	2020	2025	2035
1	92	92	92	91	92	92	92
2	70	69	68	67	87	87	85
3	93	87	68	63	96	93	92
4	61	56	56	54	87	87	85
5	69	69	62	55	92	87	83
6	57	57	57	56	72	72	71
7	95	90	58	57	95	88	87
8	96	96	96	56	97	97	66
9	66	66	60	54	79	71	65
10	46	45	46	44	74	75	72
11	54	54	54	54	83	83	81
14	85	85	85	58	88	88	67
15	88	88	88	54	91	91	69
16	98	89	89	89	97	97	97
17	88	88	63	59	96	86	83

Source: Project Team

7.4 Groundwater Management

In Malawi, groundwater resources have been exploited since the 1930's, and these have been the principal source for rural water supply. Particularly, borehole or deep well can serve safe drinking water under natural conditions all year round. The cost effectiveness is also superior to water supply facilities using surface water owing to low capital investment in rural water supply. On the other hand, groundwater is finite water resource; thus, groundwater abstraction exceeding recharge volume causes severe depletion at boreholes and saline water. Therefore, in consideration of the growing population in Malawi, groundwater development shall aim at the following two points:

- To sustain pumping volume from boreholes within groundwater recharge volume; and
- To raise effectiveness and capacity of pumping.

This section suggests rational management for future groundwater development in Malawi using hydro-geological data and theoretical methods as presented below.

7.4.1 Guideline for Groundwater Development

(1) Potential Volume of Groundwater Resources in Malawi

The groundwater potential generally corresponds to recharge volume. The recharge volume each WRA in Malawi have been roughly estimated using the Darcian flow method and the water balance method in the

Master Plan. The appropriate recharge volumes employ the lowest volume estimated in both methods based on conservative consideration. **Table 7.4.1** tabulates comparisons between the appropriate recharge intensities (mm/year), potential groundwater volumes (×1,000 m^3/year) and groundwater demands up to 2035 in WRUs. Almost all of the WRUs have sufficient groundwater available to supply water for demands by 2035 apart from WRU 5D and 5E. Only 5D and 5E watersheds including parts of Mchinji, Dowa, Nitchisi and Lilongwe districts will get into shortage of water by approx. 5 million m^3 in 2035. These water resource areas generally consist of flat lands on a series of plateau and indicate the lowest recharge (4 mm/year) in Malawi. Thus, the Malawi Government has to manage carefully to exploit groundwater resources not depending on the considerations of localized groundwater in these areas.

Table 7.4.1 Groundwater Potential and Balance of Water Demand

WRA	WRU	Area (km^2)	Recharge Intensity (mm)	Potential Groundwater Volume (×1,000 m^3/day)	Water Demands (×1,000 m^3/year) Present		2025		2035	
					Demand	Balance	Demand	Balance	Demand	Balance
1	A	1,546	30	46,386	1,609	44,777	3,261	43,125	4,456	41,930
	B	1,360		40,812	2,136	38,676	3,415	37,397	4,235	36,577
	C	735		22,056	1,119	20,937	1,575	20,481	1,789	20,267
	E	958		28,740	1,281	27,459	2,019	26,721	2,375	26,365
	F	1,185		35,559	1,690	33,869	2,989	32,570	3,756	31,803
	G	1,467		43,995	2,363	41,632	4,141	39,854	6,639	37,356
	H	2,118		63,537	2,310	61,227	4,316	59,221	7,220	56,317
	K	1,844		55,314	1,519	53,795	2,465	52,849	2,882	52,432
	L	851		25,542	1,197	24,345	2,365	23,177	3,521	22,021
	M	880		26,406	627	25,779	1,101	25,305	1,376	25,030
	N	573		17,202	565	16,637	991	16,211	1,271	15,931
	O	1,484		44,505	2,931	41,574	5,170	39,335	7,454	37,051
	P	657		19,722	705	19,017	1,275	18,447	1,760	17,962
	R	1,502		45,051	1,819	43,232	3,090	41,961	3,947	41,104
	S	1,178		35,346	1,315	34,031	2,319	33,027	3,216	32,130
	T	571		17,142	720	16,422	1,285	15,857	1,671	15,471
	Sub Total	**18,911**	-	**567,315**	**23,905**	**543,410**	**41,778**	**525,537**	**57,566**	**509,749**
2	A	943	40	37,704	1,361	36,343	2,091	35,613	2,730	34,974
	B	2,083		83,324	5,041	78,283	7,355	75,969	8,786	74,538
	C	683		27,308	1,340	25,968	2,091	25,217	2,541	24,767
	D	859		34,368	820	33,548	1,730	32,638	2,393	31,975
	Sub Total	**4,568**	-	**182,704**	**8,563**	**174,141**	**13,268**	**169,436**	**16,449**	**166,255**
3	A	910	47	42,761	1,024	41,737	1,933	40,827	2,711	40,049
	B	386		18,142	406	17,736	804	17,338	1,154	16,988
	C	784		36,853	830	36,022	1,640	35,213	2,338	34,514
	D	1,176		55,263	1,343	53,919	2,469	52,794	3,214	52,049
	E	993		46,662	1,239	45,423	2,335	44,327	2,978	43,684
	F	749		35,217	1,364	33,853	2,325	32,892	2,945	32,272
	Sub Total	**4,998**	-	**234,897**	**6,207**	**228,690**	**11,506**	**223,391**	**15,340**	**219,556**
4	A	577	16	9,227	786	8,441	1,482	7,745	1,917	7,311
	B	3,274		52,389	5,594	46,795	11,014	41,375	16,262	36,127
	C	1,615		25,835	3,759	22,076	7,589	18,246	11,895	13,940
	D	1,849		29,590	4,564	25,027	6,041	23,550	7,611	21,980
	E	953		15,251	1,462	13,789	3,044	12,208	3,937	11,314
	F	617		9,864	823	9,041	2,139	7,725	2,991	6,873
	Sub Total	**8,885**	-	**142,157**	**16,987**	**125,170**	**31,308**	**110,849**	**44,612**	**97,544**
5	C	1,439	4	5,755	831	4,925	1,944	3,811	2,735	3,020
	D	2,733		10,930	3,474	7,456	9,350	1,580	15,910	-4,979
	E	3,935		15,741	4,781	10,960	11,342	4,398	15,762	-22
	F	2,552		10,206	1,884	8,322	4,905	5,302	6,989	3,217
	Sub Total	**10,658**	-	**42,633**	**10,970**	**31,663**	**27,541**	**15,091**	**41,397**	**1,236**
6	A	1,670	5	8,352	710	7,641	2,128	6,223	3,096	5,256
	B	1,075		5,376	458	4,918	1,371	4,005	1,994	3,382
	C	1,321		6,603	912	5,691	2,077	4,526	2,441	4,162
	D	3,684		18,422	2,132	16,290	4,758	13,664	7,161	11,261
	Sub Total	**7,751**	-	**38,753**	**4,212**	**34,540**	**10,335**	**28,418**	**14,692**	**24,060**
7	A	2,944	17	50,046	1,767	48,279	3,341	46,706	4,374	45,672
	B	1,247		21,202	716	20,486	1,381	19,822	1,857	19,346
	C	1,647		27,997	574	27,423	1,065	26,933	1,424	26,574
	D	2,269		38,566	1,568	36,998	2,498	36,068	3,360	35,206
	E	1,464		24,881	694	24,187	1,321	23,560	1,774	23,107
	F	1,489		25,311	466	24,846	531	24,781	546	24,766
	G	957		16,266	189	16,077	322	15,944	425	15,841
	H	703		11,954	111	11,843	182	11,772	236	11,719
	Sub Total	**12,719**	-	**216,225**	**6,084**	**210,140**	**10,640**	**205,584**	**13,995**	**202,230**
8	A	2,088	47	98,150	740	97,410	1,346	96,804	1,717	96,433
9	A	1,746	35	61,103	1,136	59,967	2,728	58,375	5,165	55,938
	B	1,984		69,437	625	68,811	1,172	68,264	1,468	67,968
	Sub Total	**3,730**	-	**130,540**	**1,761**	**128,779**	**3,900**	**126,640**	**6,633**	**123,907**
10	A	1,659	26	43,126	1,744	41,382	3,457	39,669	4,961	38,165
11	A	2,443	15	36,641	2,621	34,019	5,368	31,272	7,939	28,701
14	A	502	51	25,612	1,506	24,106	2,418	23,195	2,841	22,771
	B	1,726		88,041	4,515	83,526	7,265	80,776	9,292	78,749
	C	1,045		53,305	2,747	50,558	4,094	49,211	5,376	47,930
	D	245		12,510	596	11,914	1,062	11,448	1,287	11,223
	Sub Total	**3,519**	-	**179,469**	**9,364**	**170,105**	**14,839**	**164,630**	**18,796**	**160,673**
15	A	2,152	24	51,648	2,701	48,947	5,747	45,901	7,986	43,662
	B	2,459		59,021	2,811	56,210	5,989	53,031	9,800	49,220
	C	208		4,992	102	4,890	220	4,772	304	4,688
	Sub Total	**4,819**	-	**115,661**	**5,614**	**110,047**	**11,957**	**103,704**	**18,090**	**97,570**
16	E	1,839	17	31,256	741	30,515	1,649	29,607	2,255	29,002
	F	2,374		40,360	716	39,644	1,743	38,617	2,372	37,988
	G	1,320		22,442	362	22,079	866	21,576	1,062	21,380
	Sub Total	**5,533**	-	**94,058**	**1,820**	**92,238**	**4,258**	**89,800**	**5,688**	**88,369**
17	A	183	90	16,434	255	16,179	301	16,133	220	16,214
	B	542		48,771	289	48,482	488	48,283	654	48,117
	C	1,221		109,854	698	109,156	1,061	108,793	1,331	108,523
	Sub Total	**1,945**	-	**175,059**	**1,242**	**173,817**	**1,850**	**173,209**	**2,204**	**172,855**
The Whole of Malawi		**94,224**	-	**2,297,385**	**101,834**	**2,195,552**	**193,352**	**2,104,033**	**270,081**	**2,027,304**

Source: Project Team

(2) Village Area

1) Conditions of Water Supply

Water supply scheme for villages is essentially not formulated uniformly and it requires deep considerations of local and social conditions including population, tradition and economy, and natural conditions including topography, geology, and ecology of each village, village group or district. However, the Master Plan has limitations to consider planning individual localized areas. Accordingly this report uniformly sets the design water use (water volume per person, day) and the general population served water premised on gaining water from boreholes as follows:

- Design water use : 36 liters/person/day
- Borehole serves : 250 people
- Supply time : 8 hours/day
- Design consumption : 0.01875 m^3/min = 18.75 liter/min

2) Borehole Placement

Required water supply is covered by individual borehole which avoids interaction of other borehole's drawdown. In this section, the most adequate distance is examined between boreholes on the conditions of the water supply mentioned above. According to the theory of Theis's Unsteady Groundwater Flow, the influence distance in which one borehole influences groundwater table of the surround by pumping up is represented theoretically as the following formula;

$$s = \frac{2.3Q}{4\pi T}\log_{10}\frac{2.25Tt}{r^2 S}\, s = \frac{2.3Q}{4\pi T}\log_{10}\frac{2.25Tt}{r^2 S} \qquad (1)$$

Where; s: drawdown

Q: discharge rate

T: transmissivity

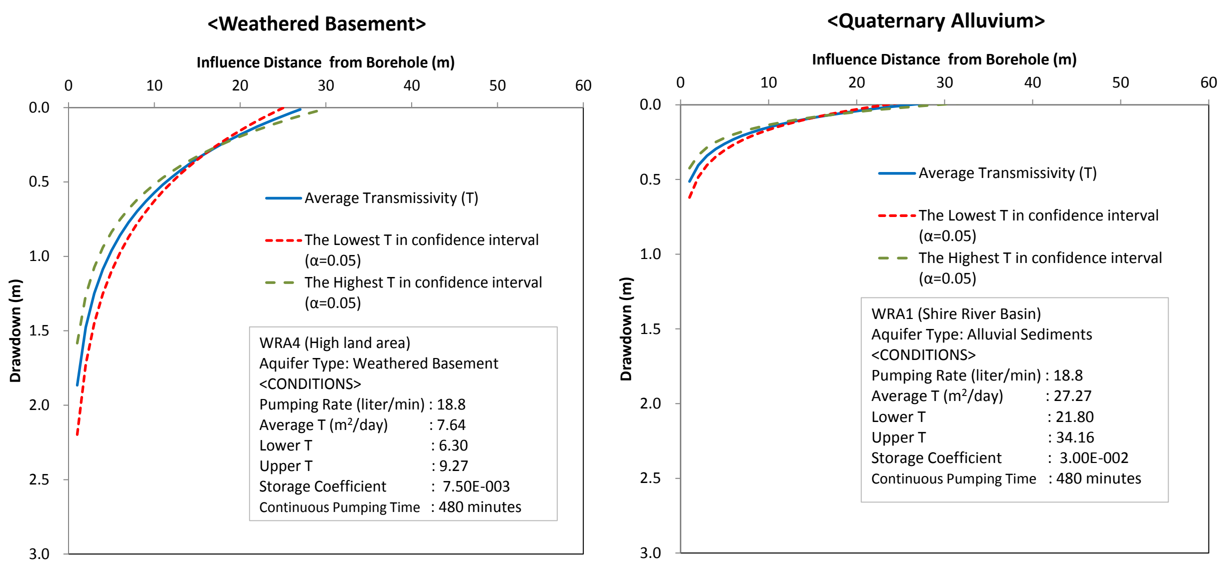
t: continuous pumping time

r: distance from borehole

S: storativity

The above formula requires aquifer constants, transmissivity and storage coefficient. Transmissivity can be calculated according to Jacob's linear analytical solution, and transmissivity indicates linear correlation to the specific capacities stored with large amount of numbers in the cardix arranged in NWRMP, 1986. Hence, approx. 3,000 values of the transmissivity converted from the specific capacities are available for the examination. On the other hand, regarding storativity defined as the water volume which an aquifer releases from storage per unit surface area per unit change in head, special pumping test using several observation wells is required. Unfortunately, it has never been carried out even once. Although there was no reliable basis for estimating storativities of aquifers in Malawi, a past study[iv] predicted storativities ranging from 0.005 to 0.01 in the weathered basement and from 0.01 to 0.05 in the Quaternary alluvium. Therefore, the storativity of 0.0075 in the weathered basement and 0.03 in the Quaternary alluvium are adopted for the examination.

The examination is the subject to WRA 1 and 4 as pilot area where the water demands are especially high and the typical aquifers, the Quaternary alluvium (AL) and the weathered basement (WB), are distributed widely. Drawdowns and influence distances are calculated on three (3) cases which vary transmissivities into the lowest, average and highest values in the confidence interval (significant level: $\alpha = 0.05$) both WRA 1 and WRA 4. The results of the examination are shown in **Figure 7.4.1**.



Source: Project Team

Figure 7.4.1 Influence Area of Drawdown by Hand Pumping

The groundwater table in the WB aquifer tends to fall deeper than in the AL aquifer due to lower transmissvity of WB aquifer, but the groundwater table does not drop below 3.0m in drawdown. There is no fluctuation of groundwater table at 30m from pumping borehole in both aquifers. Actually, pumping will not continue during 8 hours without suspensions and the drawdown and the influence distance will be smaller than the examination. Certainly the influence area will never extend over 50m from pumping borehole no matter what aquifer conditions exist as long as the fixed supply rate (18.8 liter/min) is obeyed. That is to say, sustainable water supply will be realized in 100m interval between boreholes if an aquifer has potential yield larger than the fixed supply rate (see **Figure 7.4.2**).

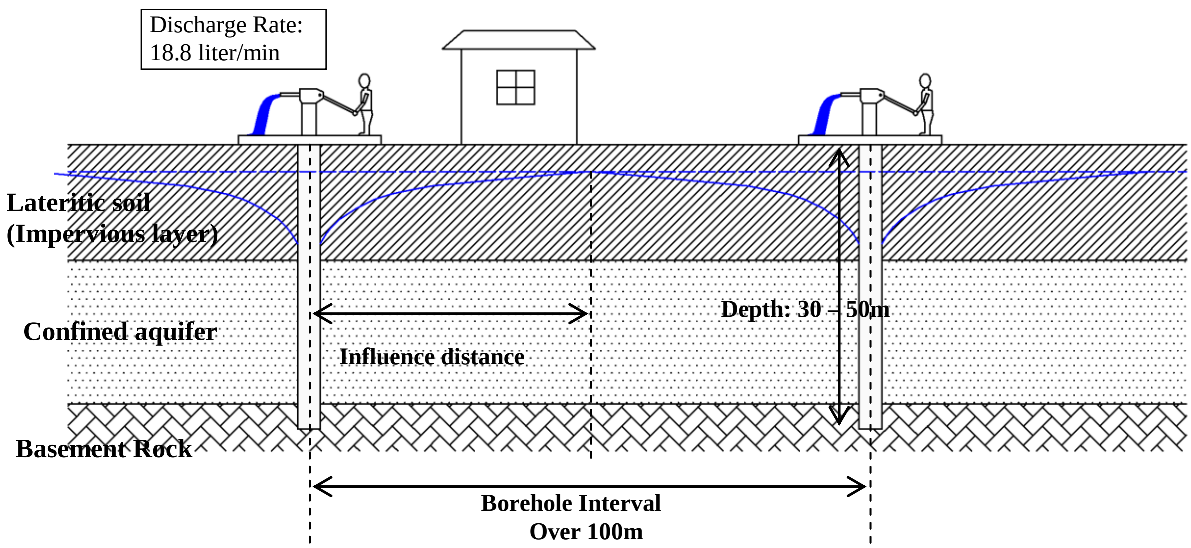


Figure 7.4.2 Adequate Borehole Placement in Village Area

(3) Guideline for Market Centers

1) Conditions of Water Supply

Market centers and trading centers play an important role because these centers work as cores of commerce for village people in Malawi. The population densities surrounding the centers are higher than in ordinary villages, but the water supply for most of these depends on boreholes, shallow wells or the neighboring rivers which are the same facilities used by ordinary villages due to lack of investment on water supply infrastructures. Therefore, people neighboring market centers are forced to labor heavily to access safe water. The water supply for relatively large demand such as market center should carried out with massive facilities which can largely reserve water and largely distribute it to consumers. In this item, required general specification of boreholes in the middle and large-scaled market centers (population: 3,000 – 25,000) is examined in a place where water supply facilities including storages and transmission systems are required. The conditions of water supply from groundwater are mentioned below:

- Design water use: 45 liter/head/day
- (50 liter/head/day, considered with 10% loss through distribution)
- Borehole(s) serves: 3,000 - 25,000
- Supply time: 12 hours/day
- Design consumption: 150 - 1,250 m^3/day

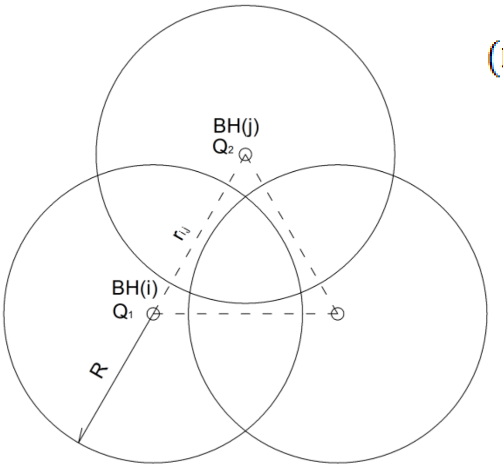
2) Borehole Placement

Boreholes for supplying water to the market centers basically apply a submergible pump and almost maximum discharge of aquifer capacity is needed in order to cover the design consumptions. Hence, an individual borehole will not fully cover the demands.

Two options can be mentioned: One is the arrangement which avoids interaction of drawdown between boreholes, and the other is where a well group of some adjoining boreholes withdraw a large amount of groundwater efficiently. The best practice taking into account aquifer characteristics is analytically examined in this item.

Water Supply using Well Group

If groundwater is abstracted from a group of wells adjoining each other set on an aquifer which extends horizontally without end, the drawdown of each well interacts with the others. The influence distance which is caused by the interactions of all wells in the group is typically shown in **Figure 7.4.3**, and the following formula is conducted based on the Thiem's Well Theory.



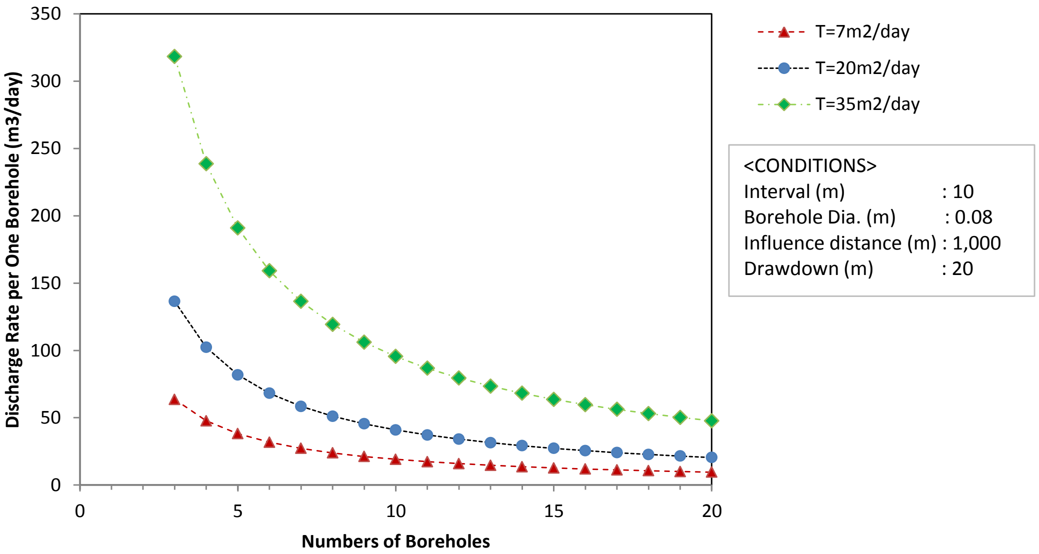
$$(\mathrm{H}-h_j)=\sum_{i=1}^{n}\frac{Q_i}{2\pi T}\log_e\frac{R}{r_i}-\sum_{i=1}^{n}\frac{Q_i}{2\pi T}\log_e\frac{r_{ij}}{r_i} \text{..... (2)}$$

Where,
- Q_i :Discharge rate each well (i = 1, 2, 3…)
- T :Transmissivity
- R :Influence distance
- r_i :Well diameter of each well
- r_{ij} :Interval between BH(i) and BH(j)
- H :G.W.L on "R" from a well
- h_j :G.W.L in BH(j) (j = 1, 2, 3…)

Source: Project Team

Figure 7.4.3 Influence Distance of a Well Group

The transmissivities substituted into Formula (2) are T=7.0 m^2/day as representative value for the weathered aquifer (WB), T=20.0 m^2/day as the lower value for the Quaternary alluvium (AL) and T=35.0 m^2/day as the higher value for the AL aquifer in accordance with the statistic tendencies. The discharge rates from a well group in case of varying well numbers with each transmissivity mentioned above are calculated under the fixed conditions that R=1,000m, ri=0.08m, rij=10m, and (H-hj) named drawdown is set to 20m. The results of the examination are shown in **Figure 7.4.4**.



Source: Project Team

Figure 7.4.4 Relationship between Discharge Rate of each Well and Well Numbers

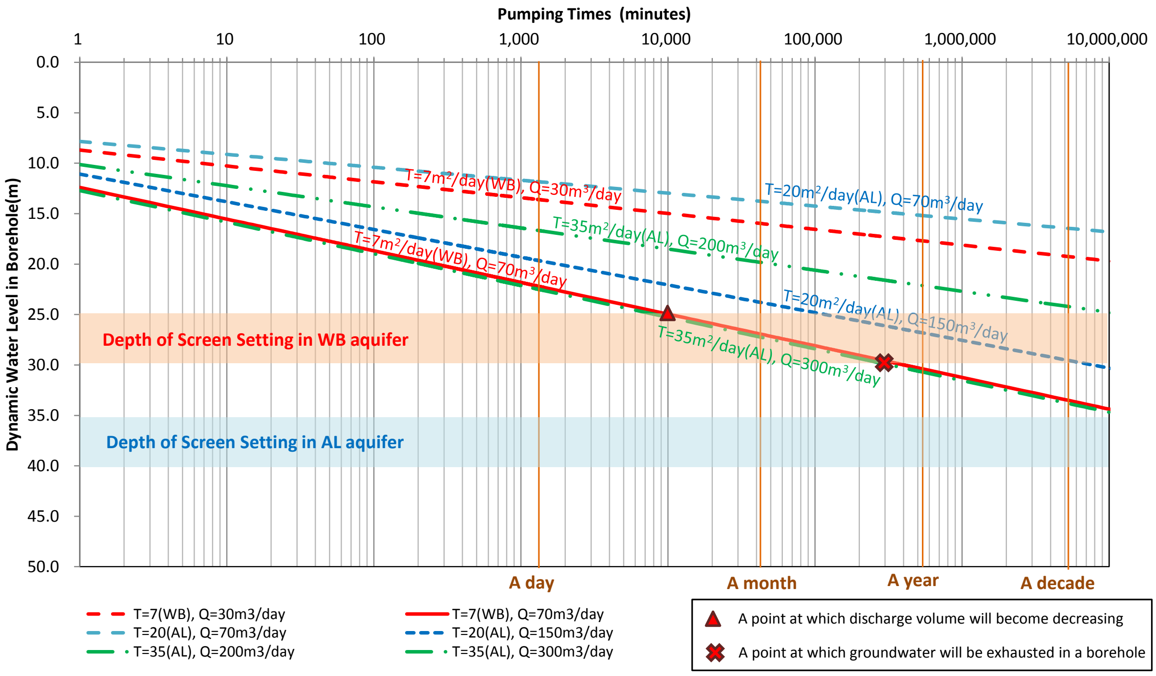
The discharge rates per one borehole in a well group tend to decrease when well numbers increase. The aquifer which has higher transmissivity yields further larger amount of groundwater. The examination result indicates that the more numbers of well will cause a decline of well productivity of each well, but the water abstraction from a well group will become more effective in the higher permeable aquifer. The appropriate numbers of well in a group will be 3 to 5 in taking cost effectiveness of well construction and O&M into consideration.

Long Term Prediction of Groundwater Fluctuation

The continuous discharge with a large amount water volume by power pump will cause a fall of groundwater table in the long term and the inadequate amount of taking water which exceeds discharge capacity of an aquifer will make dry-up in boreholes soon. Therefore, the long term conditions of groundwater should be predicted in order to sustain a constant water production. **Figure 7.4.5** shows chronological changes of groundwater drops during 20 years in case of various transmissivities of aquifers and discharge rates. For general conditions of the examination, the static water level prior to pumping is set to G.L -5m uniformly and the screen depth is set to 25-30m in depth for WB aquifer, and 35-40m in depth for AL aquifer by taking into account the construction records of the existing borehole database.

The groundwater table in the case of low transmissivity (T=7.0m^2/day) and Q=70m^3/day falls down to the upper end of the screen for WB aquifer in the brief span of several days, and the groundwater will run out within a year. In case of less than a half volume of the discharge rate (Q=30m^3/day), continuous pumping will be sustained during 20 years in spite of low transmissivity.

The high permeable AL aquifer has large capacity enough to yield groundwater for covering the demand. In case that the AL aquifer has T=35m^2/day, the drawdown by pumping water 300 m^3/day will not reach the upper end of the screen during 20 years, and the discharge rate of 200 m^3/day will still hold smaller drawdown.



Source: Project Team

Figure 7.4.5 Chronological Changes of Groundwater Drop by Continuous Pumping

3) Conceptual Development Scheme for Market Centers

Aquifer characteristics are especially important because these strongly control water discharge of boreholes if massive groundwater is required for supply to market centers. In Malawi, the Quaternary alluvial (AL) aquifers tend to have high permeability superior to the weathered basement (WB) aquifers although the transmissivities largely vary at localities, thus the Shire river basin areas or the coast areas of the Lake Malawi where the AL aquifers are distributed widely are expected to include a lot of potential sites which can realize large scaled taking of water by well groups. On the other hand, the WB aquifers prevailing in most parts of Malawi generally have poorer transmissivities and these are difficult to be provided with mass-water supply facilities. In this context, the conceptual schemes in accord with aquifer types and the scale of population are suggested as tabulated in **Table 7.4.2**.

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

Most of the WB aquifers indicate lower transmissivity and thinner thickness than the AL aquifers, thus it is anticipated that mass-scaled abstraction such as well group from groundwater which exceeds the aquifer capacity will trigger exhaustion of boreholes in a short term. In principle, single usage of borehole with relatively low discharge rate (<100m^3/day) is recommended in WB areas. In case that population exceeds 20,000 in a market center located on a WB area, alternative plans not depending on only groundwater or a combination of various water resources should be discussed.

Table 7.4.2 presents rough lodestars for groundwater development planning. The detailed plan of water supply to an individual market center requires site investigation including social conditions, topographic and geological conditions, etc., by feasibility studies.

Table 7.4.2 Conceptual Schemes of Groundwater Development for Market Centers

Aquifer	Population reserved from borehole in Market Center	Design consumption (m^3/day)	Pump Spec.	Borehole Placing Pattern	Numbers of Borehole or Group	Borehole Depth (m)	Recommended Discharge (m^3/BH/day)	Remarks
AL	< 3,000	< 150	Afridev	Single	< 15	30 - 50	10	Basically follow the groundwater development scheme for village
	5,000	250	Motive	Single	1 - 4	50	80 - 250	Target aquifer's transmissivity for 10 - 30m^2/day or more. The interval between boreholes is 100 – 150m to avoid the interaction.
	10,000	500	Motive	Single	2 - 5	50 - 70	100 - 250	Target aquifer's transmissivity for 15-30m^2/day or more. The interval between boreholes is 100 – 150m to avoid the interaction.
	20,000	1,000	Motive	Group	One group	70 - 100	350	Target aquifer's transmissivity for over 40m^2/day. A group contains 3 boreholes and the interval between boreholes in a group is 10 – 20m. Confirm none of other boreholes or shallow wells within 1km radius from a well group.
	30,000 <	1,500	Motive	Group	More than 2 groups	70 - 100	300	Target aquifer's transmissivity for over 35m^2/day. A group contains 3-5 boreholes and the interval between boreholes in a group is 10 – 20m. Confirm none of other boreholes or shallow wells within 1km radius from a well group.
WB	< 3,000	< 150	Afridev	Single	< 15	30 - 50	10	Basically follow the groundwater development scheme for village
	5,000	250	Motive	Single	5	50	50 - 60	Target aquifer's transmissivity for 8 - 10m^2/day or more. The interval between boreholes is 100m to avoid the interaction.
	10,000	500	Motive	Single	7 - 10	50 - 70	60 - 80	Target aquifer's transmissivity for 10 - 15m^2/day or more. If the good aquifers are not secured, alternative plans or combination of the various water sources should be taken up for discussion.
	20,000 <	1,000	Motive	Single	10<	50 - 70	120	Target aquifer's transmissivity for over 20m^2/day. If the good aquifers are not secured, alternative plans or combination of the various water sources should be taken up for discussion.

Source: Project Team

7.4.2 Groundwater Management

(1) Present Condition of Groundwater Management

In rural areas of Malawi, approximately 63% of the inhabitants depended on groundwater abstracted from shallow wells or boreholes. In particular, the people in plateau areas such as WRA 5 and WRA 6 where it is difficult to utilize surface water for drinking have very few choices of water source aside from groundwater. However, groundwater is a finite water resource and its utilization is limited up to the recharge volume; therefore, groundwater resources have to be sustainably developed and adequately managed in order to prevent from exhausting the resources due to growing population.

Poor data management in borehole recording is still an issue in Malawi as described in **Part I: Chapter 3 and Chapter 5**. There are several issues on the data processing of borehole construction as follows:

- The Water Resource Board, the predecessor of the present National Water Resource Authority (NWRA), had the authority to allow borehole constructions conducted by private companies or investors, but the rigorous management system in which MoAIWD manages, instructs and inspects borehole construction has not been established. Hence, MoAIWD has not grasped the real state of previously constructed boreholes.

- Construction reports from different programs are not standardized and, usually, reports have been submitted as hard copies without soft copies; thus, it requires a lot of time to import borehole records into computers by direct-input of the MoAIWD members, and most of the reports do not cover sufficient information. Consequently, these paper reports have been neglected and left out in warehouses or shelves in the MoAIWD office.
- Although there are a number of boreholes in Malawi (an estimated more than 43,000 drilled), a robust database for borehole records using information technology has not been introduced, and the manpower and techniques for building and operating data management system in MoAIWD are unsatisfactory.

Considering that parts of old boreholes have been abandoned without rehabilitation, the actual number and location of these abandoned boreholes are not known. Actual borehole conditions are required.

(2) Road Map and Activities for Groundwater Management

1) Concept

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

2) Short Term

<Road Map>

- Framework of a groundwater management system which routinize administrative procedures, data processing, maintenance, and other activities related to groundwater development will be established.
- Executive capacity of the Groundwater Division of MoAIWD will be strengthened.
- The existing boreholes will be identified using a standardized numbering system in the twelve (12) pilot districts chosen in the North, Central and South regions.

<Activities>

In order to establish the framework of the groundwater management system, the following activities shall be implemented:

- Establishment of a borehole database and managing it effectively.
- Establishment of comprehensive guideline for groundwater management system, which consists of basic/technical knowledge of groundwater and routine manual for administrative procedures, procurement, data processing, data format, maintenance of database, etc.

In order to strengthen executive capacity of the Groundwater Division of MoAIWD, the following activities shall be implemented:

- Establishment of "Groundwater Management Section" which shall specialize in data processing, analyzing and evaluating groundwater resources in the Groundwater Division.
- Capacity building and staffing of hydro-geological experts for data management, evaluation and planning groundwater development via training schemes.

In order to identify the existing boreholes, the following activities shall be implemented:

- Inventory survey for groundwater sources (boreholes and shallow wells).
- Staffing with personnel to implement the survey.

3) Middle and Long Term

<Road Map>

- All existing boreholes shall be identified in Malawi up to 2025.
- Sustainable groundwater management system via trial and error shall be set on the right track from 2025.

<Activities>

In order to operate and maintain the groundwater management system established according to activities in the short term, the following activities shall be implemented:

- Feeding back the outputs and these evaluation of activities in the short and middle terms into the guideline.
- Continuing training on management operation and maintenance (O&M).
- Keeping budget sufficient for O&M of groundwater management system every year.

(3) Outline of Groundwater Management System

Although much data regarding groundwater had accumulated, the data formats and storage media are not standardized and these generally are stored haphazardly at different storage places. Data users therefore cannot utilize groundwater information of Malawi conveniently and it takes a long time to collect and analyze the data. It seems that there have been many cases in which valuable data was buried and not used due to lack of communication between departments of the ministry and badly stored data.

The future management system for groundwater has to realize more systematic based on IT principles and a rigorous guideline. This report gives several recommendations on the framework of a sustainable management system for Malawi.

1) Organization

The specialized post regarding groundwater in the Malawi Government which corresponds to the Groundwater Division is under the direct control of MoAIWD. The Groundwater Division is further divided into two sections: the Groundwater Research Section and the Groundwater Development & Drilling Section. The present tasks of the respective sections are as follows:

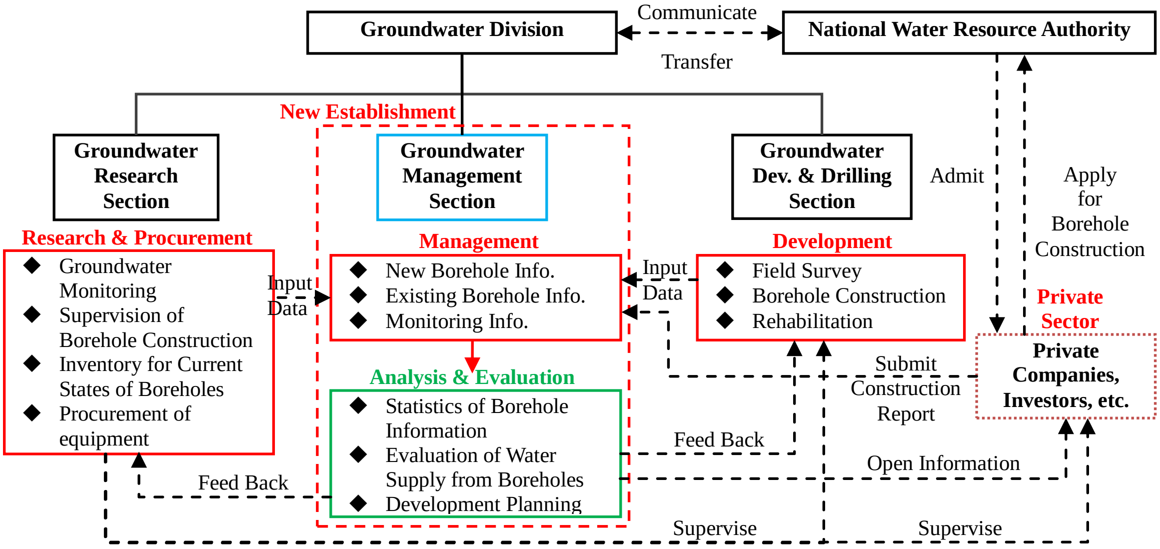
Groundwater Research Section

This section bears the responsibility of aggregating monitoring data, supervising borehole construction, and procuring various kinds of equipment needed in its staff's activity.

Groundwater Development and Drilling Section

This section bears the responsibility for investigation works, drilling and constructing boreholes, and rehabilitation and maintenance of existing boreholes. It possesses construction equipment and supplies needed for borehole construction.

In their actual activities, the responsibilities between both sections are ambiguous. In order to handle an integrated data management system, well-defined sharing of responsibility is indeed necessary and a specialized institution for groundwater management named tentatively as "Groundwater Management Section" should be required in the Groundwater Division apart from these two sections. This Section shall (a) register or archive borehole records or data, (b) store or archive groundwater monitoring data, (c) manage existing borehole data, and (d) analyze and evaluate groundwater potential i.e. giving advice on groundwater potential in the country. **Figure 7.4.6** shows the overall groundwater management system centered on the Groundwater Management Section.



Source: Project Team

Figure 7.4.6 Structure of Groundwater Management System

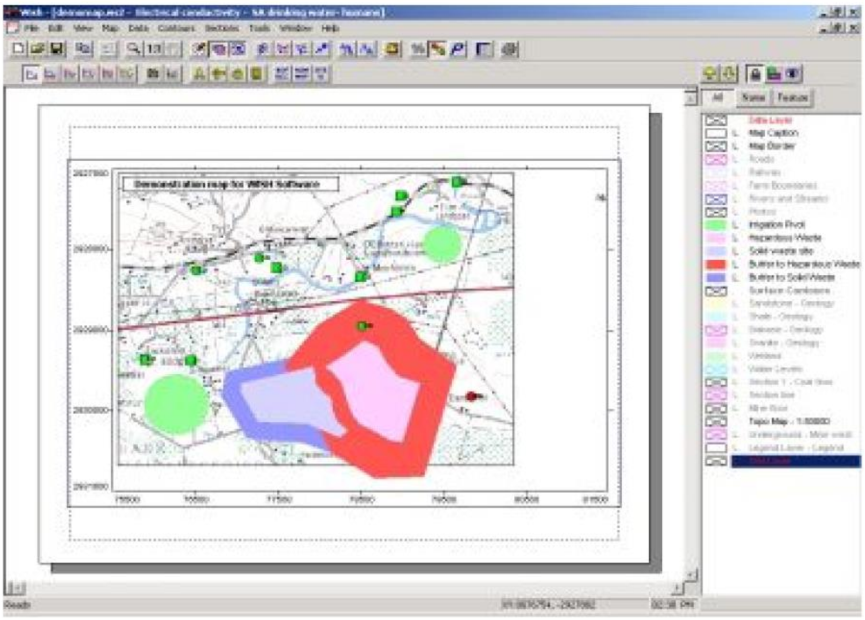
2) Borehole Database by WISH

WISH, or Windows Interpretation System for Hydro-geologists, is a computer program developed by the Institute for Groundwater Studies (IGS) and the Water Research Commission (WRC) in order to apply an assessment of groundwater environment in South Africa. The program can realize displaying thematic maps with data and graphs depicting the data in a more specialized way. Users can import map data in several formats such as Arc/Info.shp, AutoCAD.dxf, Sufer.bln and Microsoft.bmp, into an empty page in WISH, and can comprise a multi-layered map group between different map formats. The program is designed to link from Microsoft Excel/Access format to the WISH database. WISH reads information stored in the spread sheets and automatically reflects the individual locations on maps, the characteristics on graphs, and draws analyzed results on maps/graphs. The program is the specialized software for groundwater technicians or workers, and is operable by non-IT technicians, or even untrained hydro-geologists.

WISH consists of a mapping/graphing tool and link to data sets.

Map data and data sets are able to be imported into or attached to a page in WISH without limited file numbers. The data sheets to be attached to WISH have to be arranged following these rules:

- Data sets consist of 11 datasheets by default, including Basic Info, Time Chemistry, Time WL (Water Level), Time Discharge, Time Rainfall, BH Geology, BH Construction, BH Fill, BH Parameters, BH Yield and Pumping Test. If necessary, some data sheets for other parameters, such as population served, evaporation and temperature, run-off, etc., can be added in a data set.
- It is not necessary to fill in all data sheets, but at least the items Site Name, Coordinate (X, Y, Z), Site Type in “Basic Info” sheet must be filled.
- The Site Name in Basic Info links between the other sheets. If a field of the Site Name includes some numerical values in a parameter sheet, these values can be regarded as a group belonging to one field by inputting the same Site Name beside parameter cells. Thus, many rows are required for one field if time-related data such as, “Time Chemistry” or “Time WL”, are put in these sheets.



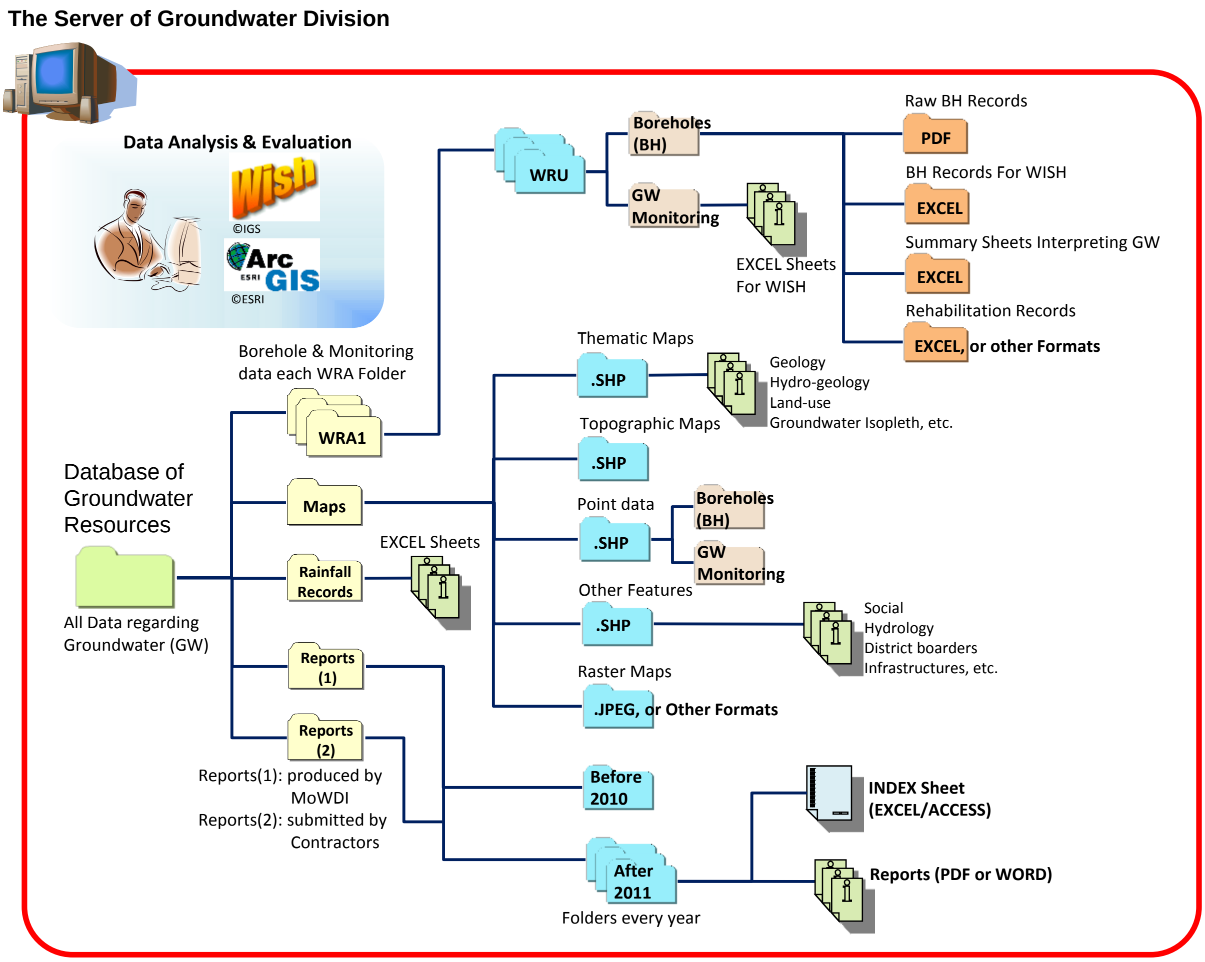
Source: Operation Manual for WISH ver.2.0 ©IGS

Figure 7.4.7 Demonstration of WISH Application

3) Design of Data Management

WISH is basically recommended for future groundwater database which is the reason why it is inexpensive but convenient software usable by non-specialists that helps user to interpret groundwater environments. On the other hand, it should be taken into consideration that the program cannot satisfy all user requirements. In particular, all the data regarding groundwater are not able to be gathered into one Excel/Access spreadsheet for data processing in WISH. The groundwater monitoring data should be prepared as an individual file, and borehole records should be divided into appropriate numbers of data files so that users can arrange and input data without mistakes. In order to maintain and check the appropriateness of analysis and evaluation in WISH, all original data must be preserved systematically, and identifications between original data and data sets for WISH have to be made clear. The database administrators in MoAIWD will need deep understanding and training of WISH to operate it adequately.

All data regarding groundwater are desired to be accessible from anywhere in MoAIWD using a local network, but this idea is difficult to realize at the present due to poor network infrastructure. The first step is to realize a future data management system, which is recommended to build a hierarchical database cumulated in a data server. **Figure 7.4.8** shows a structure of the database for reference.



Source: Project Team

Figure 7.4.8 Hierarchical Database System for Groundwater Management

4) Standardized Information Format for Borehole Construction

Numerous borehole reports of varying age have been stored haphazardly in the Groundwater Division. These reports were written in a variety of formats for every project, and most of the records were incomplete or suspected to be unreliable. In NWRMP, 1986, the borehole data cardex was introduced as the first standardized form for easy reference to basic borehole information. However, the cardex system had never been updated although the number of borehole constructions had rapidly increased during the 1990's and 2000's.

Databases comprised of hard copies do not offer efficient data management any longer, and all borehole data are now required to be stored as electronic data. Thus the serial procedure of borehole construction has to become more systematic for efficient data processing in an established database. However, the borehole reports submitted by contractors have been made in their original formats and mostly as hard copies. More terribly, there is no information on the construction of a project. Consistent rules for borehole construction are required to ensure reliable information and realize a computerized database in MoAIWD.

The minimum required rules are mentioned below for reference:

- Any corporation or organization (hereinafter "the developers") which desire to construct boreholes in Malawi shall apply to the National Water Resource Authority which has the water rights.
- The developer shall submit an inception report which mentions detailed construction plans to MoAIWD. The inception report should not be obsessed with a fixed format, but the report shall

include the following information: project name, reasons for exploiting groundwater, framework of construction and environment conservation, number of boreholes, approximate borehole locations planned for construction, and rough estimate of potential yield.

- Borehole I.D. shall be in accordance with the numbering system defined by MoAIWD, and the developer shall make inquiry about the proper number to MoAIWD to avoid duplication with existing borehole numbers.
- The developer or the engineering contractor shall conduct the construction following the authoritative specification related to borehole construction, and submit several reports formatted to the specification to MoAIWD and the local communities (or stakeholders) every time a borehole is completed in order to clarify the properness of the construction.
- All borehole constructions shall be inspected by MoAIWD staff who supervises the constructions.
- Final report shall include an executive summary regarding the project, the whole construction schedule, total cost, borehole design, site photos, and all record sheets. The report shall be submitted as both hard and soft copies to MoAIWD. In particular, the construction records such as drilling information, civil works and pump installation, borehole log and pumping tests shall be provided in Excel format for immediate conversion into the groundwater database.

These rules about detail procedure of borehole construction in MoAIWD shall be further discussed and be systematized in an authoritative guideline comprehending general groundwater management.

5) Inventory for Groundwater Resources

In order to establish a competent database for groundwater resources, the current status of existing boreholes and other water supply facilities relevant to groundwater in the whole of Malawi has to be grasped.

In these past few years, general investigations for positioning all water abstraction points were conducted in specific districts such as, Chitipa, Mchinji, Salima, Dowa, Mangochi, Mzimba, Mwanza and Blantyre. The results of the investigation were edited and published as “Rural Water Atlas” with UNICEF’s support. However, most of the spreadsheets and point data for GIS were unfortunately lost because the computer stored with the database crushed due to computer virus. Consequently, MoAIWD is now in a situation where the staff must investigate all water points in the whole of Malawi again.

Malawi has not had a standardized numbering system required to manage database of groundwater for a long period. The borehole numbering rules varied with each developer or drilling contractor. In 1983, the first trial of a standardized numbering system was suggested by an overseas consulting agency. The numbering rule was based on a combination of Water Resource Area (WRA), sub-catchment area (WRU) and the order of borehole construction in a time series; for example, 5F148 is the 148th borehole constructed in sub-catchment area F (Rusa), of WRA 5 (Bua River). According to the numbering system, approximately 5,800 boreholes were numbered and their basic information was put together into the cardex in NWRMP, 1986. However, this system became extinct in the 1990’s.

The Water Resources Board designed a new numbering system, enhancing the old system and bringing together all sorts of water abstraction points in 2006[v]. This new system is based on a combination of WRA, WRU, type of water abstraction point, numbers in chronological order, for example, 5F-BH-148 means the 148th borehole in sub-catchment area F, of WRA 5. **Figure 7.4.4** shows the types of water abstraction point and their associated codes.

Table 7.4.3 Water Point Type Codes

Water Point Type	Code
Borehole	BH
Motorized Borehole	MBH
Shallow Well	SH
Rural Communal Tap	TP
Dam	DM
Effluent Discharge Point	ED
River Abstraction Point	WA
Gauging Station	GS
Water Quality Monitoring Station	WQ
Monitoring Well	MW

Source: Water Point Numbering System Implementation Guide, MoAIWD

The new trial numbering system was applied to the inventory of water supply facilities in "Integrated Rural Water Supply and Sanitation Project for Ntchisi and Mzimba District, 2007", but several years have passed since the project, more inconsistencies with the boreholes and shallow wells between the numbers of the inventory table and the actual ones have occurred due to disorderly construction of boreholes and vandalism in the both districts.

The second trial of the standardized numbering activities based on the new numbering system was started in the Shire River Basin areas with support from "Shire River Basin Management Program (SRBMP)". The numbering project directed by the Groundwater Division of MoAIWD has been ongoing in Balaka, Chikuwawa, Mwanza,Neno, and Nsanje districts.

The final goal is to inventory all of the water points relative to groundwater resources in accordance with a standardized numbering system over the whole of Malawi, but it is still a long and arduous task to achieve this goal. Many borehole constructions will proceed in parallel to the inventory survey. The identification number of new boreholes should be tentatively numbered by another rule separate from the standardized numbering system in the district where the inventory is not completed. This report proposes a sub-rule of the numbering system for temporarily numbering new boreholes until completion of the water point inventory, as follows:

1A(WRA+WRU) – BH(Water Point Type) – IRWSS(Abbreviation or Identification Code of Project Name or Location) - 20XX(construction year) – XXXX(Number of chronological order)

For example, 4D-BH-LW-2007-0015 is the 15th borehole constructed in "Groundwater Development Project for Lilongwe West", 2007, in sub-catchment D of WRA 4. If the numbering of water points is completed thoroughly in a sub-catchment area, tentative numbers of borehole constructed before the completion of the inventory only have to be transferred to the formal numbers without duplicating numbers of existing boreholes. (e.g., 4D-BH-LW-2007-15 → 4D-BH-2087)

A numbering system is very necessary to manage the utilization of groundwater resources. Besides updating water point numbers regularly, MoAIWD should have firm control over all borehole constructions by the private sector at all times for sustainable data management.

7.4.3 Groundwater Monitoring

(1) Present Conditions of Groundwater Monitoring

Monitoring groundwater is the only method to understand how groundwater behaves in response to several environmental changes such as climate patterns, increment of borehole construction, expansion and diversification of land-use, etc. However, the groundwater monitoring system of Malawi has stayed at such a poor level that it cannot achieve comprehensive understandings of the groundwater environment. The report mentions several issues on the groundwater monitoring as follows:

- A total of 35 monitoring wells were built in Malawi during 2009 to 2010. The monitoring has not satisfied the basic data of groundwater evaluation.

- Five (5) monitoring wells were vandalized and have been abandoned because most of monitored wells were not protected with a locking steel lid. Hence 30 out of 35 wells are available.
- Parts of monitoring wells are far from the water offices so that measurement personnel work at officer's houses and the budget of fuel for commuting to these monitoring points is not enough. Therefore, the data deficits are occasionally shown more or less on the monitoring records.
- Aquifer's characteristics of all monitoring wells are not known due to lack of construction records and geological logs.
- Parts of monitoring wells yield turbid water and include a large amount of faecal coliforms and high BOD values shown by water quality analysis. These mean that surface water polluted on ground directly flows into the wells due to inadequate seepage control at the wells.

(2) Road Map and Activities for Groundwater Monitoring

1) Concept

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

This report shows several road-maps and activities for realizing sustainable groundwater monitoring in the short, middle and long term as follows:

2) Short Term

<Road Map>

- Routine works of the automatic leveling will be strengthened to a more competent regime.
- Monitoring wells will be added up to approx. 90 wells in total.

<Activities>

In order to strengthen routine works of the automatic leveling, the following activities shall be implemented:

- Preparation of manual for collecting data from data loggers, tidying up data in computer, extracting data error, and maintaining data loggers.
- Staffing officers who collect monitoring data at sites.
- Keeping budget sufficient for expenditure of regular site-visits and consumables every year.

In order to construct new monitoring wells, the following activities shall be implemented:

- Feasibility study each site
- Well construction

3) Middle & Long Term

<Road Map>

- Existing monitoring wells shall be renewed if necessary.

<Activities>

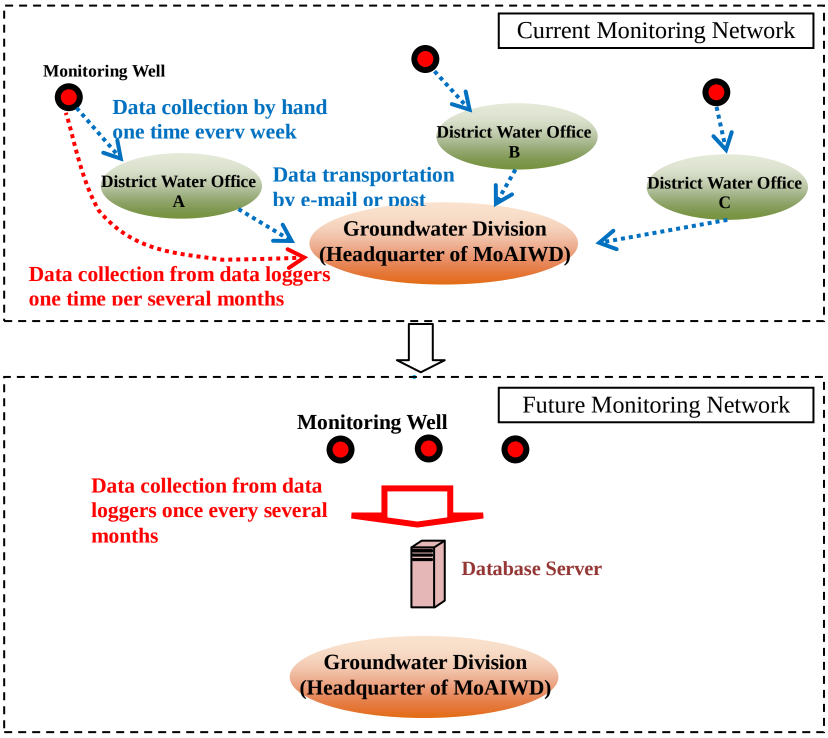
In order to renew the existing wells, the following activities shall be implemented:

- Regularly confirming conditions of monitoring well and data logger.
- Keeping budget sufficient for expenditure of parts replacement of data logger and the relevant equipment every year.

(3) Groundwater Monitoring Network

1) Monitoring Regime

The groundwater monitoring of each point has been carried out using hand-leveling by local officials since the establishment of 35 monitoring wells during 2009 to 2010. The monitoring with automatic leveling started with the project, "Establishment of Water Resources Monitoring System" on September, 2013. Two modes of monitoring, conventional measuring by hand and the advanced automatic measuring by a data logger, have coexisted in the trial period because of the cross-checking accuracy of measurements between both modes. In the future, the automatic monitoring will run by itself. **Figure 7.4.9** shows both the current monitoring network for groundwater and the network aimed for the future.



Source: Project Team

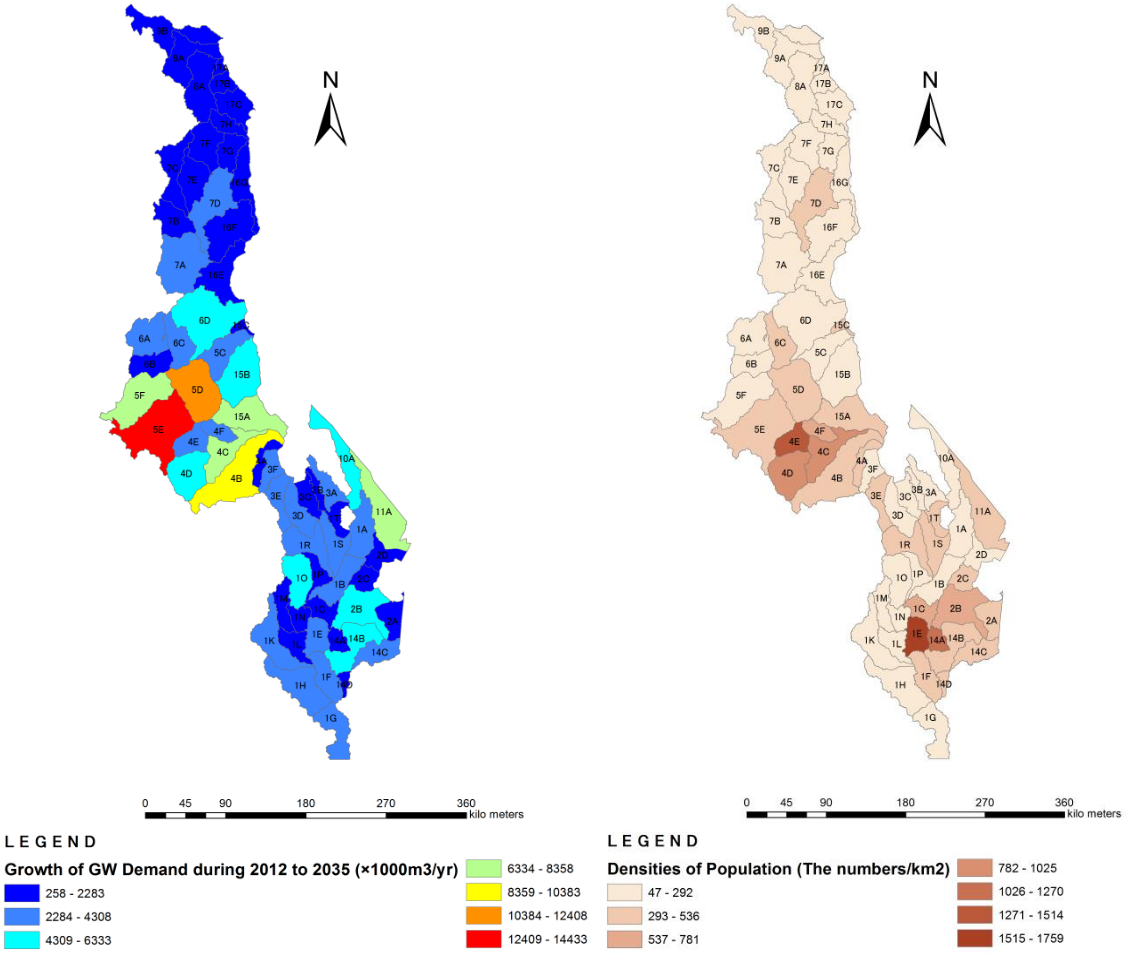
Figure 7.4.9 Groundwater Monitoring Network in Malawi

2) Construction of New Monitoring Wells

Thirty (30) monitoring wells which were not vandalized have been protected with a lockable lid and installed with a data logger since September 2013. The conventional monitoring by hand measurement was switched to automatic monitoring, and the groundwater monitoring network was drastically improved. However, 30 monitoring wells are still insufficient to evaluate the groundwater environment in the whole of Malawi. Therefore, this report offers a proposal for newly recommended locations of the monitoring well based on population and groundwater demand forecasting in 2035.

In a large demand area of groundwater resources, monitoring is carried out to evaluate areal groundwater fluctuation caused by periodically long environmental changes, and to obtain basic information in advance of new groundwater development. Hereupon, it is most important for the result of monitoring to correlate with intensities of precipitation. Monitoring well(s) should be set closer to a rainfall gauging station. The groundwater level to be recorded should exclude artificial influences such as motorized pumping for water supply, irrigation and industrial use, because it is useless to capture the local fluctuation in a wide area.

Figure 7.4.10 shows estimates of growth volume of groundwater demand during 2012 to 2035 and densities of population in 2035. The demands in 2035 will increase approximately twice at least as the present, and tend to respond to increasing of population. In particular, the demands in plateau areas of WRA4 and 5 except the urban area (Lilongwe) are far larger compared to the south region. The south region in Shire River Basin has high geomorphic diversity and there are a lot of choices of taking water apart from borehole and shallow well. On the other hand, in the plateau areas, it is generally difficult to intake and transmit water by gravity from streams in mountain areas because these water points are too far from the consumption centers. Unfortunately rivers across the plateau areas, even major rivers such as Bua River, have too remarkably lower discharge volumes or being dried up in dry season. Therefore, there is generally no choice except groundwater resources as the water point in which inhabitants can gain safe water easily and sustainably during a year especially in rural areas. The increment of groundwater demand in the plateau areas is a natural consequence.

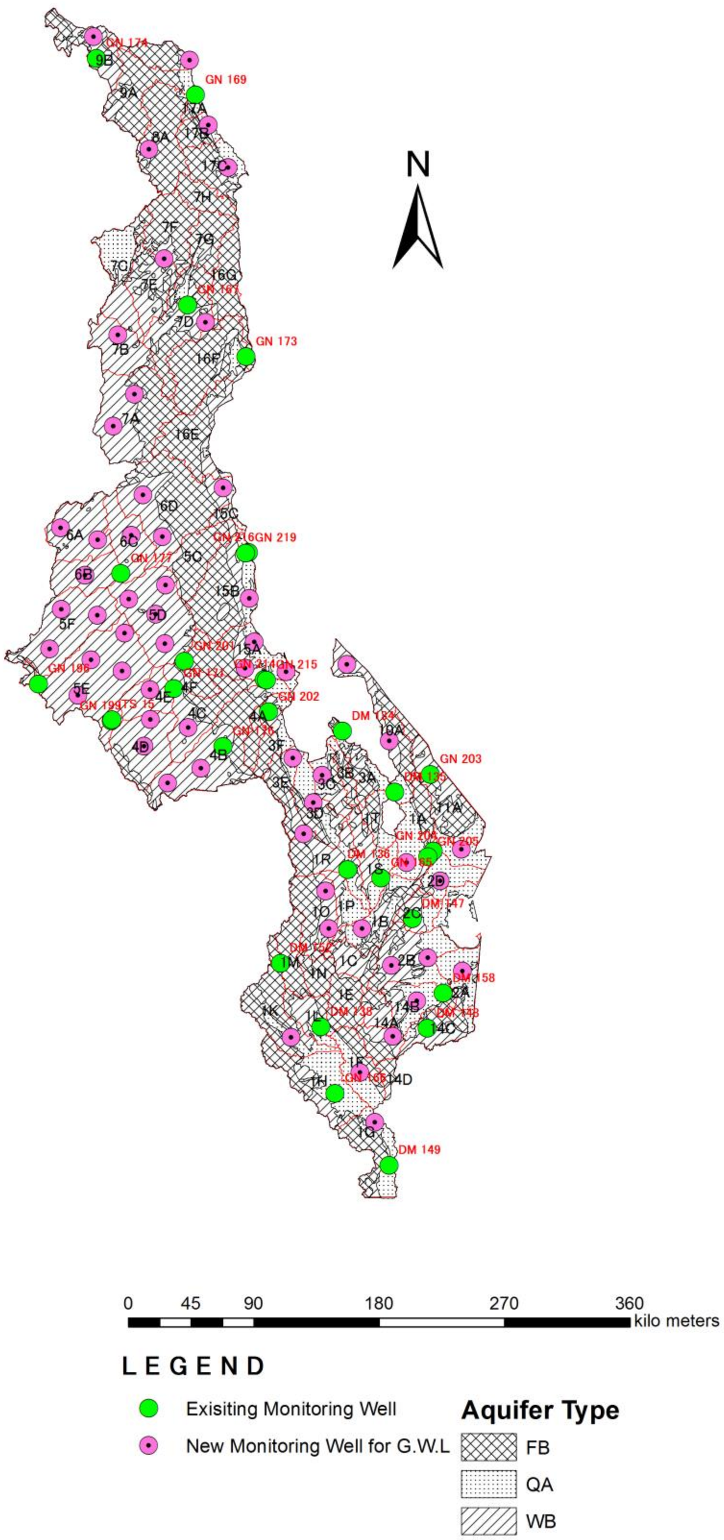


Source: Project Team

Figure 7.4.10 Growth Volume of Groundwater Demand and Density of Population in each WRU (Left: Growth of Demand during 2013 to 2035; Right: Density of Population in 2035)

The monitoring wells for areal groundwater fluctuation are preferable to be set at a larger number, but the number for sustainable monitoring is at least 100 wells in the whole of Malawi taking current manpower in MoAIWD into consideration. Therefore, the construction of monitoring wells should be a priority on the judgment from several factors such as clearance between other wells, groundwater demand, locations of rainfall gauging station, geologic composition, and accessibility. The fixed well locations should be carefully chosen after feasibility studies of both desktop study and site reconnaissance.

This report suggests an arrangement of additional groundwater monitoring wells as shown in **Figure 7.4.11** and **Table 7.4.4** for reference. Parts of WRA 4 and WRA 5 correspond to the largest groundwater demand as shown in **Figure 7.4.10**; whereas, the recharge volume in these areas is the lowest in Malawi. Thus, WRA 4 and WRA 5 have to be ranked as especially important areas under surveillance. In these important sub-catchment areas, the monitoring wells should be evenly established at more than 3 wells per WRU. The other WRUs in which groundwater demand is relatively low should set one well, at least, per WRU apart from mountain areas.



Source: Project Team

Figure 7.4.11 Distribution of Newly Recommended Monitoring Wells

Table 7.4.4 List of Recommended Monitoring Wells to be Newly Constructed

No.	ID.	WRA	WRU	District / Location	Region	Aquifer Type
1	MH-01-01	1	1A	MACHINGA	South	Quaternary Alluvium
2	MH-01-02	1	1B	ZOMBA	South	Quaternary Alluvium
3	MH-01-03	1	1F	CHIKWAWA	South	Quaternary Alluvium
4	MH-01-04	1	1G	NSANJE	South	Quaternary Alluvium
5	MH-01-05	1	1K	CHIKWAWA	South	Quaternary Alluvium
6	MH-01-06	1	1O	NENO	South	Weathered Basement
7	MH-01-07	1	1O	NTCHEU	Central	Weathered Basement
8	MH-01-08	1	1R	NTCHEU	Central	Weathered Basement
9	MH-02-01	2	2A	PHALOMBE	South	Quaternary Alluvium
10	MH-02-02	2	2B	ZOMBA	South	Weathered Basement
11	MH-02-03	2	2B	ZOMBA	South	Quaternary Alluvium
12	MH-02-04	2	2D	MACHINGA	South	Quaternary Alluvium
13	MH-03-01	3	3C	MANGOCHI	South	Quaternary Alluvium
14	MH-03-02	3	3D	NTCHEU	Central	Quaternary Alluvium
15	MH-03-03	3	3E	DEDZA	Central	Quaternary Alluvium
16	MH-04-01	4	4B	DEDZA	Central	Weathered Basement
17	MH-04-02	4	4B	DEDZA	Central	Weathered Basement
18	MH-04-03	4	4C	LILONGWE	Central	Weathered Basement
19	MH-04-04	4	4D	LILONGWE	Central	Weathered Basement
20	MH-04-05	4	4D	LILONGWE	Central	Weathered Basement
21	MH-04-06	4	4E	LILONGWE	Central	Weathered Basement
22	MH-05-01	5	5D	DOWA	Central	Weathered Basement
23	MH-05-02	5	5D	DOWA	Central	Weathered Basement
24	MH-05-03	5	5D	KASUNGU	Central	Weathered Basement
25	MH-05-04	5	5D	KASUNGU	Central	Weathered Basement
26	MH-05-05	5	5E	MCHINJI	Central	Weathered Basement
27	MH-05-06	5	5E	LILONGWE	Central	Weathered Basement
28	MH-05-07	5	5E	MCHINJI	Central	Weathered Basement
29	MH-05-08	5	5E	DOWA	Central	Weathered Basement
30	MH-05-09	5	5F	MCHINJI	Central	Weathered Basement
31	MH-05-10	5	5F	KASUNGU	Central	Weathered Basement
32	MH-05-11	5	5F	KASUNGU	Central	Weathered Basement
33	MH-06-01	6	6A	KASUNGU	Central	Weathered Basement
34	MH-06-02	6	6A	KASUNGU	Central	Weathered Basement
35	MH-06-03	6	6B	KASUNGU	Central	Weathered Basement
36	MH-06-04	6	6C	KASUNGU	Central	Weathered Basement
37	MH-06-05	6	6D	KASUNGU	Central	Weathered Basement
38	MH-06-06	6	6D	MZIMBA	North	Weathered Basement
39	MH-06-07	6	6D	NKHOTAKOTA	Central	Weathered Basement
40	MH-07-01	7	7A	MZIMBA	North	Weathered Basement
41	MH-07-02	7	7A	MZIMBA	North	Weathered Basement
42	MH-07-03	7	7B	MZIMBA	North	Weathered Basement
43	MH-07-04	7	7D	MZIMBA	North	Weathered Basement
44	MH-07-05	7	7E	RUMPHI	North	Weathered Basement
45	MH-08-01	8	8A	CHITIPA	North	Weathered Basement
46	MH-09-01	9	9B	KARONGA	North	Quaternary Alluvium
47	MH-09-02	9	9B	CHITIPA	North	Weathered Basement
48	MH-10-01	10	10A	MANGOCHI	South	Weathered Basement
49	MH-10-02	10	10A	MANGOCHI	South	Weathered Basement
50	MH-11-01	11	11A	MACHINGA	South	Quaternary Alluvium
51	MH-14-01	14	14B	THYOLO	South	Weathered Basement
52	MH-14-02	14	14B	MULANJE	South	Quaternary Alluvium
53	MH-15-01	15	15A	SALIMA	Central	Quaternary Alluvium
54	MH-15-02	15	15A	SALIMA	Central	Weathered Basement
55	MH-15-03	15	15A	SALIMA	Central	Quaternary Alluvium
56	MH-15-04	15	15B	NKHOTAKOTA	Central	Quaternary Alluvium
57	MH-17-01	17	17B	KARONGA	North	Quaternary Alluvium
58	MH-17-02	17	17C	KARONGA	North	Weathered Basement

Source: Project Team

3) Design of Monitoring Wells

Newly constructed monitoring wells, as well as procedures and codes of ordinary borehole drillings, have to be recorded. Well logs including geological profile, well structures and pumping test records are also essential to interpret the hydro-geological environment. In addition, some advance investigations such as extracting soil/rock samples, soil laboratory test (soil or rock physical and mechanical properties), detailed pumping tests with several observation wells, etc., should be done as well. Monitoring generally aims to observe and record scientific phenomena. **Table 7.4.5** tabulates the recommended investigation menu for monitoring well construction.

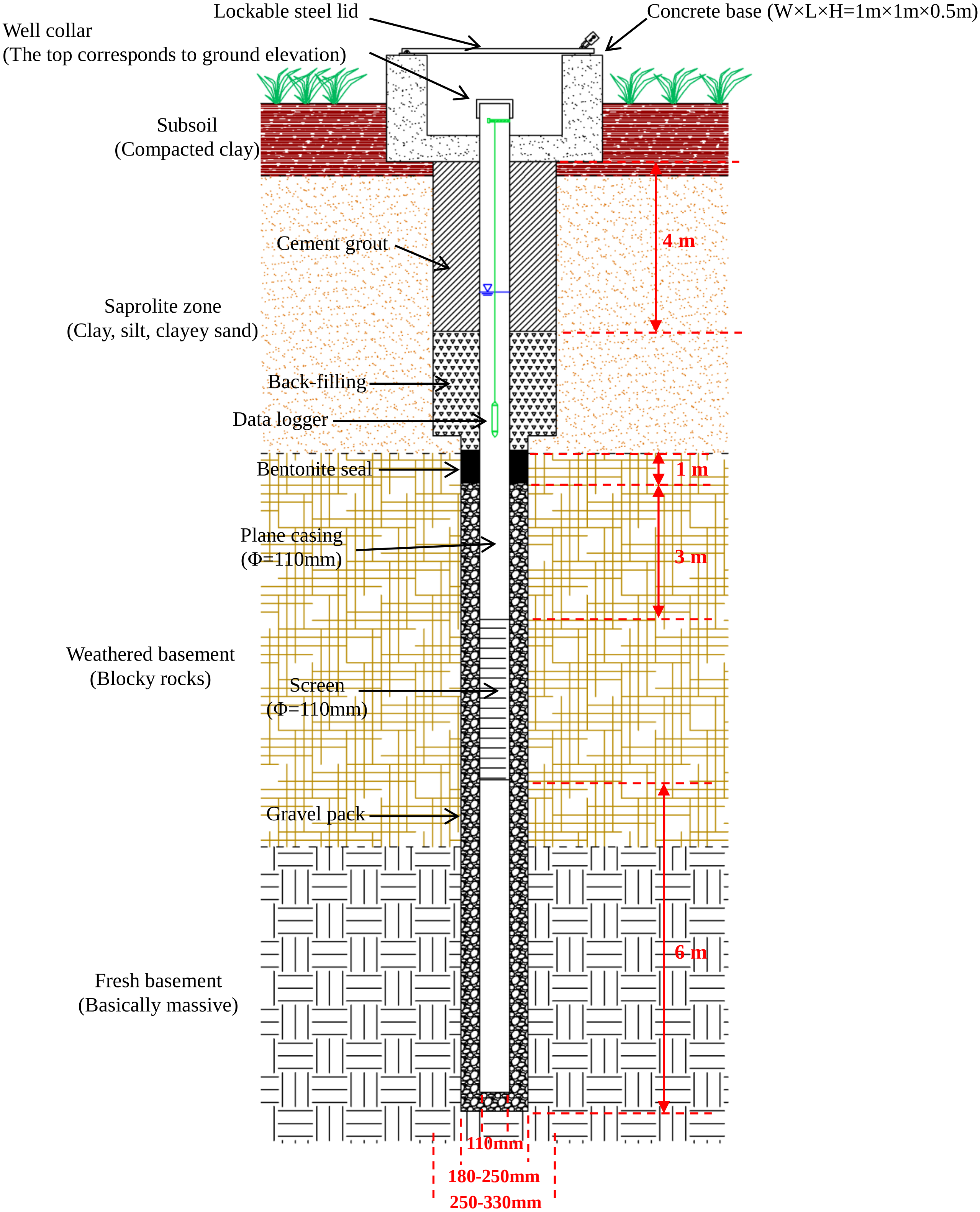
Table 7.4.5 Recommended Investigations for Monitoring Well Construction

Phase	Recommended Investigations	Priority	Specification / Standard
Feasibility Study	- Desktop Study ➢ Aerial geology and topography, land-use, population, etc.	A	-
	- Site Reconnaissance ➢ Checking geology, topography, land-use, etc., in places	A	-
	- Geophysical Prospecting ➢ Electrical resistivity surveys (Wenner array, or other arrays) ➢ Electrical resistivity 2D-profiling	B	Applied Geophysics in Hydrogeological and Engineering Practice, W.E. Kelly & S. Mares, Elsevier Science, 1993
Well Construction	- Observations and records during Drilling ➢ Geological compositions ➢ Depth at which water struck / yield volume ➢ Groundwater level ➢ Well structure	A	Design and Technical Specification for the Construction of Water Supply Facilities in Rural Areas, MoAIWD, Malawi
	- Sample Extractions ➢ Disturbed soil samples ➢ Undisturbed soil / rock samples	B (C)	ASTM D1452 ASTM D4220-83
	- Pumping test ➢ using a production well only ➢ using several observation wells	A (B)	ASTM D6034-96
	- Borehole Logging ➢ Electric resistivity log ➢ Electric induction log ➢ National gamma log ➢ Ultrasonic acoustic log ➢ Thermal profiling log	B (C)	ASTM D6726-01 ASTM D6274 – 10 ASTM D6760 – 08 ASTM D6727 - 01
	- Soil laboratory test ➢ Particle size gradation ➢ Atterberg Limit ➢ Moisture ➢ Specific gravity ➢ Density ➢ Porosity	B	ASTM D421,422-63 ASTM D4318-84 ASTM D2216-83 ASTM D854-83 ASTM D9254-83
	- Rock laboratory test ➢ Water absorption ➢ Unconfined compressive strength	C	ASTM D6473 ASTM D2166-06

Note: Priority A: done definitely; B: done as much as possible; C: done if necessary
Source: Project Team

According to the latest water quality monitoring, most of the present monitoring wells are contaminated by facial organisms to one degree or another. It implies that surface water may directly flow into these wells due to the failure of well structure. Actually, some monitoring wells indicate unnatural fluctuation of groundwater tables, which is suspected to be caused by direct inflow. To grasp the correct groundwater dynamics and characteristics under natural conditions, monitoring wells have to be carefully designed to absolutely cut-off direct inflow. Although the final design will be determined after carefully taking geological compositions into consideration based on several detailed investigations, this report suggests a standard design of monitoring wells, as mentioned below:

- To insert a plane casing pipe down to bottom of well 6m beneath the end of the lowest screen.
- Screen is inserted at an aquifer horizon recognized by an experienced hydro-geologist. If more than two aquifers are recognized in a well, plural screens should be set to aquifers.
- The diameter of the plane casing and screen pipes will determine the size of yield pump to be installed.
- The slot-size of the screen should be chosen based on the particle size gradation of the aquifer. The rule-of-thumb screen specification is that minimum slot-size is 0.79mm and open area is at least 10%. The slot size never exceeds particle size of gravel pack.
- Gravel pack to be inserted around casing pipe within screen section(s), extending 3m above the end of the highest screen. The gravel must be sieved to a size larger than 0.75mm.
- Bentonite seal or other impervious materials, about 1m thick, are filled upon the gravel pack.
- For avoiding contamination of surface water, cement grout is injected around casing from ground surface to at least 4m in depth. The space between grout section and impervious section is filled with the well cuttings (back-filling).
- A concrete block (1m W × 1m L × 0.5m H) is to be installed at the well collar. The top of collar shall correspond to the ground elevation for easy groundwater measurement.
- The standard monitoring well design is shown in **Figure 7.4.12.**

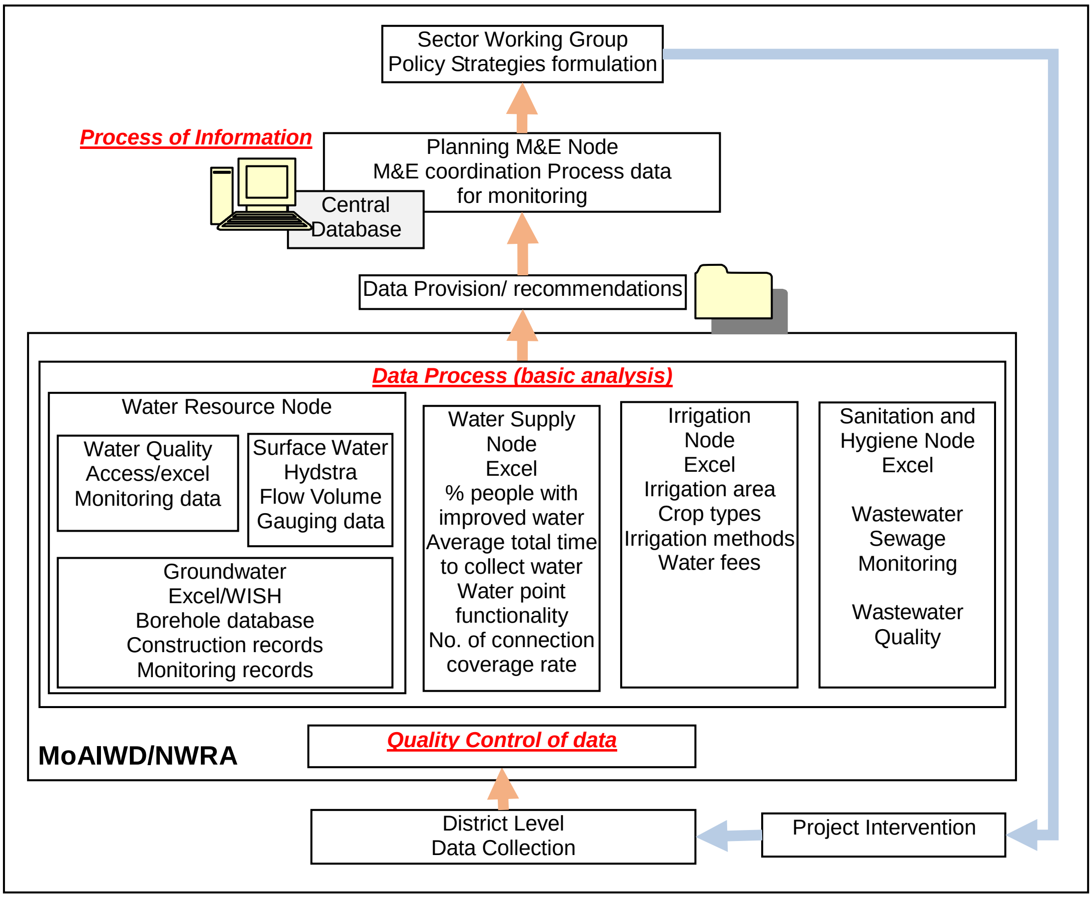


Source: Project Team

Figure 7.4.12 Standard Design of Monitoring Well

7.5 Monitoring and Information System

The progress of the Project made it clear that the hydrological data sets are fragmented and inconsistent in MoAIWD. In addition, there is no proper system to manage data quality and data process for hydrological information. At present, two projects named as "Strengthening Water Sector Monitoring and Evaluation Project" and "Establishment of Water Resources Monitoring System" through NWDP-II were implemented to improve the data collection system and data quality. As a result, MoAIWD is aware how important to establish information management system. In the system, every department in MoAIWD provides information to the central databank. Then, the central databank can process the information so as to be used for policy decision making. In near future, NWRA will monitor the hydrological data including surface water, groundwater and water quality, and will manage them. A schematic system of the information management is shown in **Figure 7.5.1**.



Source: Project Team

Figure 7.5.1 Schematic Flow of Data Management

A situation analysis revealed, however, that the capacity for data collection, recording, data tracking and processing is not sufficient to provide reliable data to the central databank which will be installed at the Department of Planning. For the Water Resources Management to be more tuned as the Integrated Water Resources Management, the data collection, recording, monitoring, processing and analyzing functions have to be strengthened. Each section should strengthen its data processing capacity and skills and comprehend the usage of data for planning of interventions and policymaking.

In particular, the database at each division of the Department of Water Resources needs to be well established and archived. The information should not be personalized at the Ministry and treated as a public utility asset. The archival activity needs to be enhanced by organizing documents and database well sorted at each division and library.

Consistency is required in policy formulation and implementation of undertakings to attain tangible achievements of short-term and long-term objectives for the water resources management including the water supply sector. Such undertakings and projects need to be planned based on analytical results of data directed by long-term policy guidance. It is vital to reflect scientific data into planning of undertakings and policy formulation so as to be physically, economically and environmentally viable, sustainable and manageable. In this section, project recommendations are outlined for capacity development to facilitate logically viable strategic policies formulation as well as project undertakings based on scientific data. The areas of recommendations include surface water, groundwater and water resources management.

A challenge at the institutional level is to make use of monitoring data of water to plan undertakings and formulate policy. A systematic review and incorporation of real time water resources data into the planning process will be of a great use for projects and policy formulation.

At the Department of Planning of the Ministry, a project was implemented to strengthen capacity of water sector monitoring system, Strengthening Water Sector Monitoring and Evaluation (SWSMEP). This project was a two-year project and was financially supported by the African Water Facility (AWF) and the Government of Malawi. The SWSMEP was completed in December 2013. The project collected data from three districts on a pilot basis. Through this SWSMEP, a central database for monitoring and information system (MIS) was installed at the MoAIWD.

However, the database is not fully operationalized. Further interventions are necessary in the form of training and technical assistance to make use of the system and the information stored in the database. **Table 7.5.1** summarizes the current progress of the training undertaken with regard to the monitoring and information system at different divisional nodes.

Table 7.5.1 Monitoring and Information System Capacity Development Needs

Nodal Division	Capacity Development Needs for MIS system	Current Situation (2014)
Water supply		
Urban Water	Training on testing and demonstration of the system	Need to be facilitated
Rural Water	Training on data collection and demonstration of the system	*EWB and WaterAid rolled out at 3 districts
Irrigation	Training on database development and usage	JICA assisted in 11 districts
Water Resources		
Water Quality	Water quality monitoring data collection Access database establishment	5 WBs trained under NWDPII
Surface Water	Training on testing and demonstration of the system Hydstra database	Need to be facilitated
Groundwater	Training on testing and demonstration of the system WISH database	Need to be facilitated
Sanitation and Hygiene	Training on database wastewater monitoring, wastewater quality	Need to be facilitated

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

Table 7.5.2 Monitoring and Information System Capacity Development Needs

Project Theme and Background	Project Components	Target Stakeholders
1. Technical assistance for database control and operation		
The central database has been developed and installed however, the database is not in operation due to lack of knowledge on operation of the system.	・ Assistance to the planning division to acquire full knowledge on the operation of the system ・ Training sessions ・ Input: Engagement of technical experts for a year (possibly part-time basis)	Department of Planning
2. Roll out of database operation		
Some districts have been included in the project as pilot sites to use the database; however, there is need for all districts to have been trained on the already developed and provided with the necessary equipment.	・ Training on data collection and demonstration of the system ・ Training sessions on the collection of data and usage of database ・ Input: Engagement of technical experts	District Councils NWRA officials Dept. of Irrigation

7.5.1 Surface Water

The section to be in charge of surface water management will be responsible from hydrometric data collection to catchment area management, quantity and quality monitoring of water resources as well as conservation. Apart from data management, institutional strengthening is also a key to improve management of surface water resources in Malawi. The following needs are identified to formulate an institutional framework on surface water management. **Table 7.5.3** summarizes the capacity needs in relation to monitoring data management for personnel at different institutional levels.

Table 7.5.3 Surface Water Monitoring Data Utilization in Projects and Policy Formulation

Institutional Levels	Short-Term Targets	Mid-Term Targets	Long-Term Targets
Policy level	- Plan governmental undertakings using surface water data ・ Water supply ・ Irrigation ・ Water resources conservation and management ・ Draught/flood control protocols	-Plan and formulate policy and undertakings based on monitored data and analysis results -Formulate policy and regulations to protect and conserve surface water	-Review and plan the Sector Performance Review. -Formulate Long-Term Plan such as Master Plan of Water Resources Management.
Engineers level	-Properly check information and data quality -Proper storage of collected surface water data into database -Develop and maintain a flood warning system	-Identify and report the data analysis results that are relevant to policies -Plan and develop catchment areas -Publish year books	-Produce optional recommendations for surface water usage to policy makers for discussion.
District and monitoring station level	- Properly record and report collected data -Properly read monitoring gauges at hydrometric stations -Properly maintain and rehabilitate gauzing stations	-Consolidate reporting system from monitoring points to the database system - Properly conduct discharge measuring	-Sustainable technical transfer to new personnel.

7.5.2 Groundwater

Projects have been carried out to improve the data collection, recording, processing and monitoring. These projects organized training on database system, use of database software, and measurement among others. The activities have to be carried out continuously to ensure a reliable data management. The collected data are entered into Excel files. WISH program was introduced for basic processing for information of water quality. The main challenge is to collect and record the data throughout the country continuously and make use of the data in policy formulation effectively.

To ensure that the data is well secured for use, at least the following work procedures should be undertaken as the daily-based activities. The collected data should be sent to the Ministry and entered onto the database. It is not an absolute necessity that the central government personnel always go to the field to collect data by themselves. It is costly and time consuming. Data management has to be done continuously and harmonized. The information has to be a common property of the section and not personalized to make the information available all the time when it is needed. The section will be responsible from hydrogeological data collection, assessment of aquifers and quality of groundwater as well as conservation. **Table 7.5.4** summarizes the capacity needs for personnel at different institutional levels.

Table 7.5.4 Groundwater Monitoring Data Utilization in Projects and Policy Formulation

Institutional Levels	Short-Term Targets	Mid-Term Targets	Long-Term Targets
Policy Level	Plan governmental undertakings using surface water data · Water supply : · Irrigation · Water resources conservation and management · Draught/flood control protocols	Plan and formulate policy and undertakings based on monitored data and analysis results. Formulate policy and regulations to protect and conserve surface water	Review and plan the Sector Performance Review. Formulate Long-term Plan such as Master Plan on surface water
Engineers Level	Properly record collected surface water data into database. Develop and maintain a flood warning system	Identify and report the data analysis results that are relevant to policies. Plan and develop catchment areas	Produce optional recommendations for surface water usage to policy makers for discussion
District and Monitoring Station Level	Record and report collected data. Properly read monitoring gauges at hydrometric stations	Consolidate reporting system from monitoring points to the database system	Sustainable technical transfer to new personnel

Source: Project Team

Table 7.5.5 Steps Needed for Groundwater Data Management

Phase	Activities
Data Collection	Collection of data from district levels, all catchment areas; Coordination of data collection activities with relevant stakeholders such as district offices
Data Entry	Data entry has to be done with care. Any unconvincing data should be noted and its credibility checked out.
Data Processing	Data cleaning, simple processing
Data Analysis	Analyze the data according to the needs.
Monitoring	Maintain database in good condition and always keep a back-up.
Information Production	Produce presentation material and provide information, processed analysis and policy recommendations to project planners, and policy-makers

Source: Project Team

7.5.3 Water Quality

To improve the capacity of the water quality section, various capacity development projects have been carried out to improve the data collection, recording, processing and monitoring. These projects organized training on database system, use of database software, and measurement among others. In addition, the database software “Access” is proposed to replace “D-base III” that is currently applied. The monitoring activities have to be carried out continuously to ensure a reliable data management.

Table 7.5.6 Data Required for Water Quality Monitoring

Database System	Purpose
Access	·Keep records of water quality monitoring data ·Conduct data analysis

Source: Project Team

This section is also providing water quality tests and analysis services for private customers. The data that are collected through such assignments can also be stored in the database and utilized as useful information sources. However, the background of the data collection needs to be noted. The section with regard to water quality management will be responsible from water quality monitoring pollution control and analytical services. **Table 7.5.7** summarizes the capacity needs for personnel at different institutional levels.

Table 7.5.7 Water Quality Monitoring Data Utilization in Projects and Policy Formulation

Institutional Levels	Short-term targets	Mid-term targets	Long-term targets
Policy Level	Promote water quality standards and monitor compliance Improve laboratory services in Northern, Southern and Central Regions	Develop, in collaboration with MBS and others, national water quality standards and monitor compliance. Develop and maintain modern laboratory management	Maintain sustainable and quality laboratory services
Engineers Level	Maintain the water quality database in a good condition. Produce report on water quality and pollution. Maintain laboratorial equipment in a good condition and keep an inventory list	Provide paid analytical services to stakeholders who need water quality assessment	Identify and report constraints affecting water resources development. Identify and report impacts of proposed development projects

Source: Project Team

7.5.4 Water Resources Board Database System

The WRB is using a database system for water resources abstraction called “Permit Processing and Tracking System, Version 1.3.0”. All water abstraction activities have to be registered at the Water Resources Board. The system is an effective tool for the tracking records of registration and a rough estimate of water abstraction volume. Data collection activities throughout the country can be conducted by the local district officials to cover all the water abstraction activities.

Water licensing is an effective strategic tool to control and monitor abstraction of raw water which affects greatly the water resources management in the conceptual framework of the IWRM. Improvement of the current registration rates of water abstraction activities is to be a prerequisite for a sustainable water resources management. The volume and areas where water is abstracted will be monitored throughout the country. The use of water resources has to be well regulated before the economic activities boost where the volume of water abstraction increases. The water balance has to be well monitored and regulated so that disastrous consequences of over-exploitation of water resources will be avoided.

Improvement of the database system at the WRB is a stepping stone for the establishment of the National Water Resources Authority. All the water abstraction activities have to be registered and given a license number. License fees should be paid by the clients.

The WRB has to keep the backup file of the database regularly updated to secure the database from any loss of the databank, virus contamination and/or any other disturbances such as theft.

7.5.5 Library

The library activities need a significant upgrading so as to be functional as the national water sector archive. Very important documents, materials, past plans, designs, and project documents are scattered, personalized and often lost in the Ministry. This makes policy formulation and intervention programming more laborious than necessary. The library is in charge of collecting documents, reports, annual reports and technical data. All stored materials have to be numbered and entered into the archive database. Upgrading of the library activities and transforming it to the “National Water Resources Information Center” will help the country’s information management on the national water resources management.

The steps have to be taken step by step for the officer in charge to get familiarized with the standard librarian activities and upgrade from the library the information center archival function.

Table 7.5.8 Upgrading of the Library by Phase

Institutional Levels	Short-Term Targets	Mid-Term Targets	Long-Term Targets
Policy Level	Library becomes a useful information source	The quality of the library as a data source	The Ministry's relevant information is centrally managed and kept well.
Practical Level	-All books and documents are on the shelves; -A database is created for all the materials in the library; -All the materials are entered in the database; -Clean the library and keep a usable database; -The materials and information are easy to find.	-Lending and returning regulations are set; -Users' guide is established (days of lending, penalties if not returned, etc.); -The criteria on which materials to collect are set; -The new materials are collected and archived; -Users know how to lend the library materials; -The library materials are properly traceable as to where about; -The kind of information stored at the library is clear;	-A modernized data search system is installed, preferably a web-based system; -The information is also available on the web where possible; -Data search system is well established.

Table 7.5.9 Data System Required for the Library

Database System	Purpose
Excel	Keep records of: ･Title ･Media of information ･Publishing year ･Author ･Summary ･Any other information that are in line with the standard library registration

Source: Project Team

7.5.6 ICT Office

The databank needs a constant and professional support by a computer specialist. This office is a new unit and should be placed under the Department of Administration at the Ministry where there will be personnel who can look after the computer equipment and the databank. The ICT office personnel can work on the databank maintenance. Once the system is networked, the ICT office is responsible for the networking system and server.

Table 7.5.10 Requirement of ICT Office Personnel

Post	Specialization
ICT Specialist	-Knowledge of electronic equipment, network system, computer hardware and software, including applications and programming -Data back-up

Source: Project Team

7.5.7 District Water Office

As described in **Part I: Subsection 3.4.4(2)(a)**, the district water offices have responsibility for water level measurement and discharge measurement at monitoring stations as well as water quality. However, only two offices have just one hydrologist and most offices have two or three staff members of the hydrological team as of September 2013 (see **Part I: Subsection 3.4.4**). In addition, remuneration to gauge readers is not enough to ensure their commitment; thus, many stations are not being properly maintained and many gauges are now not even being read because of low remuneration to gauge reader. Furthermore, maintenance by district staff is also constrained by unavailability of staff, vehicles or fuel. As a result, about 70 stations are estimated to need reinstall or replacement of gauge plates among 136 present operational stations managed by MoAIWD.

The role of each office level is summarized in **Table 7.5.12**. The main role of district offices is about supervision of observation of each station, and of regional office is about supervision and coordination of district offices, and of headquarters is about the supervision and coordination of regional offices and storing, utilizing and supervision of data for their decision-making. Definitely, quality control to find erroneous data should be carried out at each office level. At present, it is carried out based on experience using graphs, visually. District offices check whether the data is observed and collected properly, regional offices and the head office check data from the hydrological aspect.

Data input is carried out in the head office at present because there are few people who can operate HYDSTRA and few licenses. Ideally, data input is carried out in regional offices, and the head office compiles data from them, manages quality, retrieves and discloses data. The regional offices make planning of observation station network in own district and the head office manages these planning from the national point of view. At present, the boundaries of hydrometric districts to which the responsible area of water offices are assigned based on WRA are different of basin boundaries. Therefore, the responsible areas of water offices should be reorganized in order to match them when planning of observation station network is assigned to regional offices.

The staff status of each office is shown in **Table 7.5.12**. There is only 1 staff in Thyolo District and the Northern Regional Office respectively while there are two personnel in each of the 8 offices, because it is difficult to maintain gauging stations, accessibility and discharge measurements due to budgetary issues.

The ideal staffing of district offices is that all posts such as two hydrologists and a hydrological team of five staff members of two assistant hydrological officers, one hydrological assistant and two gauging assistants is filled to undertake comprehensive maintenance of stations and access roads, flow measurement including high and low flow for rating curve and payment of gauge readers. The ideal staffing of regional offices shall include a hydrologist and a manager assigned for planning of observation station network in own district. However, even in the head office, there is not enough number of staff. Therefore, organization for observation is developed by stages. First, the number of staff and capacity of the head office are enhanced, then those of regional and district offices are enhanced by staff of the head office.

Appropriate remuneration to gauge readers is needed because the observation would not be carried out if wages are not paid. There are some suggestions about increasing remuneration. One is 5,000 MK/month in cities and 3,000MK/month in rural areas and the other is 6,000 to 8,000 MK/month. Before increasing remuneration, it is recommended that gauge readers are trained on observation techniques and simple hydrological analysis. For gauge readers who travel a long time or distance to an observation station located at a remote area, bicycle allowance should be reintroduced as awarded to them in the past. Before that, the importance of observation station is evaluated and the bicycle allowance should be given considering importance and distance. At the same time, capacity development of gauge readers is needed for observing properly. Gauge readers may not speak English. Therefore, the training is held by office staff. Definitely, capacity development of office staff is also needed (see **Table 7.5.3**).

At present, drivers are shared among some offices. For proper and effective management of observation, at least one driver is needed for each office. This is useful for the management of stations, transmission of data and so on.

Also, lack of promotion and long term position is a challenging issue. When one person stays in the same position for a long term, and if he or she leaves the office, no one possesses the previously accumulated knowledge. Therefore, appropriate promotion or rotation of positions is needed for providing motivation of staff to perform well and for knowledge inheritance.

Table 7.5.11 Role of Each Office Level

	District Office	Regional Office	Headquarters
Responsibility (At Present)	-Sending of data to regional office -Maintenance of gauging stations -Maintenance of access routes to the stations -Discharge measurement (routine measurement of flows and measurement of high flow) -Payment of and communication with gauge readers (data collection from gauge readers) -Quality Control	-Sending of data to the head office -Supervision and assistance to district offices -Quality Control	-Quality control -Data processing -Storage of data -Retrieval and disclosure of data -Assistance to regional offices -Field work -Management of automatic recorders
Responsibility (Proposed)	-The same as described above	-The same as described above -Management of data -Planning of observation network in districts	-The same as described above -Decision making and planning in whole country with respect to hydrology

Source: Project Team

Table 7.5.12 Staff Status on Hydrological Services in the Head Office and the Regional and District Water Offices (as of October 2013)

Water Office	Principal Hydrologist	Hydrologist	Senior Assistant Hydrological Officer	Assistant Hydrological Officer	Hydrological Assistant	Head Gauging Assistant	Gauging Assistant
Headquarter	Vacant	2	2	1	Vacant	Vacant	Vacant
Southern Region	Vacant	Vacant	Vacant	Vacant	1	Vacant	1
Blantyre District	Vacant	Vacant	Vacant	2	Vacant	Vacant	1 (Senior)
Zomba District	Vacant	Vacant	Vacant	1	Vacant	Vacant	1
Thyolo District	Vacant	Vacant	Vacant	Vacant	Vacant	Vacant	1 (Senior)
Ngabu District	Vacant	Vacant	Vacant	1	1	Vacant	Vacant
Central Region	Vacant	1	Vacant	Vacant	1	Vacant	2
Ntcheu District	Vacant	1 (Senior)	1	1	1	Vacant	Vacant
Lilongwe District	Vacant	1 (Senior)	1	Vacant	Vacant	Vacant	1
Nkhotakhota District	Vacant	1 (Senior)	Vacant	1	Vacant	Vacant	1 (Senior)
Kasungu District	Vacant	Vacant	Vacant	1	1	Vacant	1
Northern Region	Vacant	Vacant	1 (same person as in Mzuzu District)	Vacant	Vacant	Vacant	Vacant
Karonga District	Vacant	1	Vacant	Vacant	Vacant	Vacant	1
Chitipa District	Vacant	Vacant	Vacant	Vacant	1	Vacant	1
Rumphi District	Vacant	Vacant	Vacant	1	Vacant	Vacant	1
Mzuzu District	Vacant	Vacant	1	Vacant	2	1	Vacant

Source: Project Team

There is currently little sharing of data among other institutions such as the water boards at Blantyre, Zomba, Lilongwe and Mzuzu. It is needed for filling the network, improving quality of data and assurance of supply, etc. It is also needed for making coordination for drought.

7.6 Water Quality Conservation

7.6.1 Present Conditions of Water Quality Management

The extension of high water resource development shall accompany the integrity of water quality; however, it seems that mitigation measures for aqueous environment lag behind whereas development precedes in Malawi. Sustainable development is impossible without environmental conservation and protection. The Malawi Government should take into serious consideration solutions of the following problems:

(1) Quality Conservation of Natural Water Resources

Although more than 80% of urbanites can utilize purified water through pipelines from water treatment plants, more than 80% of the inhabitants of rural areas do not have any options except to utilize raw water for drinking such as borehole, shallow dug well, and river intake. Quality of the untreated water is easily degraded by environmental changes. Actually, victims of watery diarrhea always increase every rainy season because the flooding rivers are dirty, and the overflow from latrine pollutes groundwater in boreholes.

In urban areas, sewage treatment plants tend to be abandoned due to lack of financial sources. Hence, sewage water overflows into the nearest river or stream from the broken conduits and it degrades the water. In addition, illegal disposal to rivers goes on. The negligence in improving these degradations will cause serious infectious diseases.

Heavy industrial factories or mining activities will release harmful substances such as mercury, cadmium, lead, radioactive substances, etc., into aqueous environments and cause serious health problems to the people and ecosystem as many advanced countries used to experience.

In the current situations mentioned above, any guidelines and standards for conservation of aqueous environment are not established, and water quality monitoring necessary to confirm the conditions is also not done.

(2) Poor Management

The Water Quality Service Division belongs to MoAIWD. This division is the only agency conducting water quality analysis in Malawi, and has a total of three laboratories in the south, central and north regions. However, the south and north laboratories have almost stopped due to severe budget and staffing constraints. The central water laboratory had covered a part of its budget through commercial analysis for private companies in addition to the budget from the Malawi Government. In the past years, some foreign consultants recommended MoAIWD to conduct water quality monitoring at approx. 300 locations in the whole of Malawi, but monitoring was not yet realized due to insufficient operating capital. The budgetary problems of operating laboratories often result in inferior data of water quality because of lack of necessary maintenance.

The results of analysis are entered into a computerized database named Dbase III which run on a DOS machine. This database system has been applied in the central laboratory since the middle of 1980’s. The Dbase III allows its users to enter the water quality records into boxes with fixed 18 chemical parameters, but does not allow change of definition of the parameter in each box and add new parameter boxes. The Dbase III is now outdated and cannot deal with new sorts of pollution such as pesticide, heavy industrial effluent and radioactivity.

Most data stored in Dbase III are the results of once-off commercial analysis and detailed information on water samples except chemical compositions which are not recorded. Therefore, the current database is almost useless to outsiders.

7.6.2 Road Map and Activities for Water Quality Management

(1) Concept

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

(2) Short & Middle Term

<Road Map>

- Capacity enhancement for members of the technical working group for water quality management
- Water quality database will be renewed from Dbase III by 2018
- The functions of three (3) existing water laboratories including the Central, North and South labs will be strengthened in upgrading facilities, staffing and capacity building of lab staff, and securing financial sources for their activities. Each laboratory will be able to execute monitoring every year and deal with high-tech analytical instruments by 2025
- Environmental water quality standard and guideline will be established by the NWRA for Water Quality by 2025

<Activities>

- Coordinating committee members between the relevant institutes and NWRA
- Establishment of an administrative office for the committee and staffing clerks
- Building a system of prompt data sharing between the committee members

In order to upgrade Dbase III to new database, the following activities shall be implemented;

- Drawing the basic design of new database system
- Training for O&M of the new database to the laboratory staff

In order to strengthen water laboratory’s functions, the following activities shall be implemented;

- Preparation of manual for routine works such as the sampling procedure, tidying up data in computer, etc.
- Procurement of analytical and measurement instruments for pesticide, organic solvent and heavy metals, such as Gas Chromatograph & Mass Spectrometer (GC/MS), Inductively Coupled Plasma Mass Spectrometry (ICP-MS), etc.
- Capacity building for O&M of the analytical and measurement instruments, data management and logical interpretation of analysis outputs
- Keeping budget sufficient for expenditure of O&M in each laboratory every year

In order to establish environmental water quality standard and guideline, the following activities shall be implemented;

- Inventory survey of water abstraction points except groundwater resources and the neighboring land-uses in the whole of Malawi
- Water quality analysis on conventional constituents analyzed in the Center Water Laboratory (26 parameters) at pilot points chosen from the water abstraction points
- Assigning the watershed class for environmental conservation to all rivers, marshes and lakes in Malawi

(3) Long Term

<Road Map>

- Water quality monitoring scheme via trial and error will be set on the right track from 2025

<Activities>

In order to operate and maintain the water quality monitoring scheme established according to activities in the short term, the following activities shakkll be implemented;

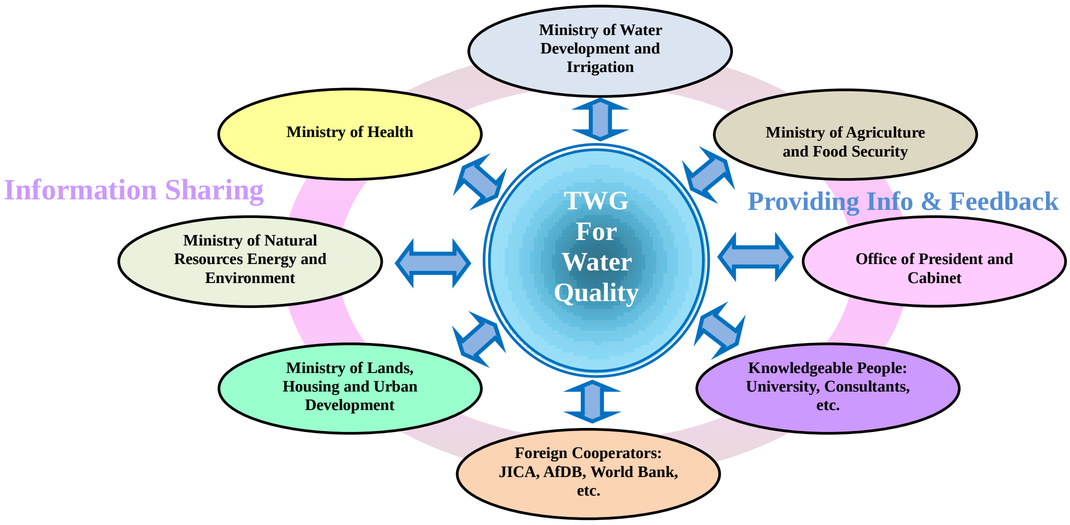
- Feeding back the outputs and these evaluation of activities in the short and middle terms into the environmental water quality standards and guidelines
- Continuing training of O&M in each water laboratory

7.6.3 Regime for Water Quality Conservation

(1) Organization

The Water Quality Service Division in MoAIWD has a Water Quality Sector as a subordinate organization. Its working foothold is mainly the central laboratory and almost all staff members are performing experiments in the laboratory. The Water Quality Sector submits a report on annual activities to the head office of MoAIWD, but the lab staff offers only raw data gained from water quality analysis, and besides they never can brainstorm to initiate useful suggestions through high interpretation of the analysis results. Indeed, nobody makes rigorous standards and guidelines for environmental water quality or systematic plans of water quality monitoring in Malawi.

The problems relevant to water quality generally involve interdisciplinary studies. There are many chemical compounds which have unknown effects in the ecosystem or human health. The pollution issues in aqueous environments include a variety of factors. Harmful substances, pollution sources and paths, latency period in human body, etc., are extremely convoluted and beyond an individual's understanding. Thus, in order to improve the environment and the monitoring schemes, the technical working group (TWG) for water quality monitoring involving several ministries, foreign cooperators and outer knowledgeable people should be done with supporting of NWRA (see **Figure 7.6.1**).



Source: Project Team

Figure 7.6.1 Structure of future TWG for Water Quality

(2) Environmental Water Quality Standards and Guidelines

In Malawi, there is a large difference in water usage between urban areas and rural areas. Most of the rural inhabitants cannot use the treated water which city dwellers are blessed with. The Malawi Government has an obligation to supply safe water for everyone. However, the government cannot uniformly build the infrastructures for water supply in the rural areas at the same level as those in the urban areas. Therefore, the government has to make sure of the safety on water points, which have remained untreated, and improve the water quality if the water points exist where the drinking water possibly can be harmful to human health. In addition, aqueous environments give places of fishery, laundry, bathing, recreation and relaxation for people and these blessings of nature must be sustained. Environmental standards for water quality shall aim for the conservation of all aqueous environments. The improved TWG for water quality should formulate the environmental standards based on the latest scientific grounds, monitor the implementation of environmental conservation, and update the standards and the relevant guidelines. This report suggests the concepts of the environmental standards and the draft thresholds of water quality as follows:

1) Water Quality Standard for Human Health

This standard follows the existing standards for drinking water (MS214), borehole and shallow well (MS733) designated by the Malawi Bureau of Standards (MBS) in principle. The thresholds for organic solvents should be formulated in the future. This standard shall be applied to any water point for drinking water in Malawi.

Table 7.6.1 Water Quality Guidelines for Drinking Water

Constituents	Unit	Thresholds of the Draft Environmental Standards
pH	pH	6.0 – 9.5
Electrical Conductivity	μs/cm	3,500
Total Dissolved Solids	mg/l	2,000
Turbidity	NTU	25
Calcium (Ca)	mg/l	250
Magnesium (Mg)	mg/l	200
Chloride (Cl)	mg/l	750
Aluminium (Al)	mg/l	0.5
Copper (Cu)	mg/l	2.0
Hardness ($CaCO_3$)	mg/l	800
Colour	TCU	50
Sodium (Na)	mg/l	500
Iron (Fe)	mg/l	3.0
Manganese (Mn)	mg/l	1.5
Sulphate (SO_4^{2-})	mg/l	800
Zinc (Zn)	mg/l	15
Antimony (Sb)	mg/l	10
Chromium (Cr)	mg/l	100
Mercury (Hg)	mg/l	2.0
Nickel as Ni	mg/l	150
Arsenic (As)	mg/l	0.05
Cadmium (Cd)	mg/l	0.01
Cyanide (CN)	mg/l	0.07
Lead (Pb)	mg/l	0.05
Nitrate (NO_3)	mg/l	50
Selenium (Se)	mg/l	0.01
Faecal Coliform	Number/100ml	0
Faecal Steptococci	Number/100ml	0

Source: Project Team

2) Water Quality Standard for Conservation of Aqueous Environments

The improvement targets for water quality should be decided in accordance with several grades of watershed which correspond to the water usage or degrees of water pollution. The grade classification of watershed is established for the target to improve water quality in a specified area, and these areas do not necessarily need to correspond to the water resource areas (WRAs) or the sub-catchment areas (WRUs). The water usages according to grade of watershed are tabulated in **Table 7.6.2**.

Table 7.6.2 Categories of Water usages for Water Quality Target

Category of Water Usage		Terms of Water Usage
Water Supply	I	It is available for drinking by simple treatment such as boiling or chlorination
	II	For drinking, it is needed to be treated by sedimentation and chlorination
	III	For drinking, it is needed to be treated by highly technical processing.
Industrial	I	It is needed to be treated by normal sedimentation.
	II	It is needed to be treated by highly technical processing such as throw of chemical agent.
	III	It is needed to be treated by special technical processing.
Others	Bathing	
	Irrigation	
	Relaxation	The neighboring residents do not feel uncomfortable against odor, etc.
	Ecosystem	It is habitable for any aquatic creature.

Source: Project Team

The grades of watershed for water quality targets should be assigned as "Watershed Class" to any water points of surface water such as river, marsh and lake by taking into consideration the topics below.

- Watershed in which the environmental pollution related to water degradation is proceeding, or will proceed.
- Current water usages or those in the future.
- Improvement over the current status.
- Milestones to achieve the improvement target.

The draft thresholds of water quality for each grade are shown in **Table 7.6.3**. The actual standard should be formulated by the improved TWG based on wide-area monitoring of water quality and water usages at water points.

Table 7.6.3 Draft Environmental Standard for Conservation of Aqueous Environments

Watershed Class	Water usages	Threshold of Draft Environmental Standard						
		pH	BOD	DO	SS	Coliform	Total Nitrogen	Total Phospho-rus
		pH	mg/l	mg/l	mg/l	Number/ 100ml	mg/l	mg/l
AA	- Water Supply (I) - Ecosystem conservation	6.0 – 9.5	<2.0	>7.5	<25	<50	<0.1	<0.005
A	- Water Supply (II) - Bathing		<3.0			<1,000	<0.2	<0.01
B	- Water Supply (III)		<5.0	>5.0		<5,000		
C	- Industrial (I)		<8.0		<50	No limit	<1.0	<0.1
D	- Industrial (II) - Irrigation	5.5 – 9.5	<10	>2.0	<100			
E	- Industrial (III) - Relaxation		<20		No limit though none of floating rubbish			

Source: Project Team

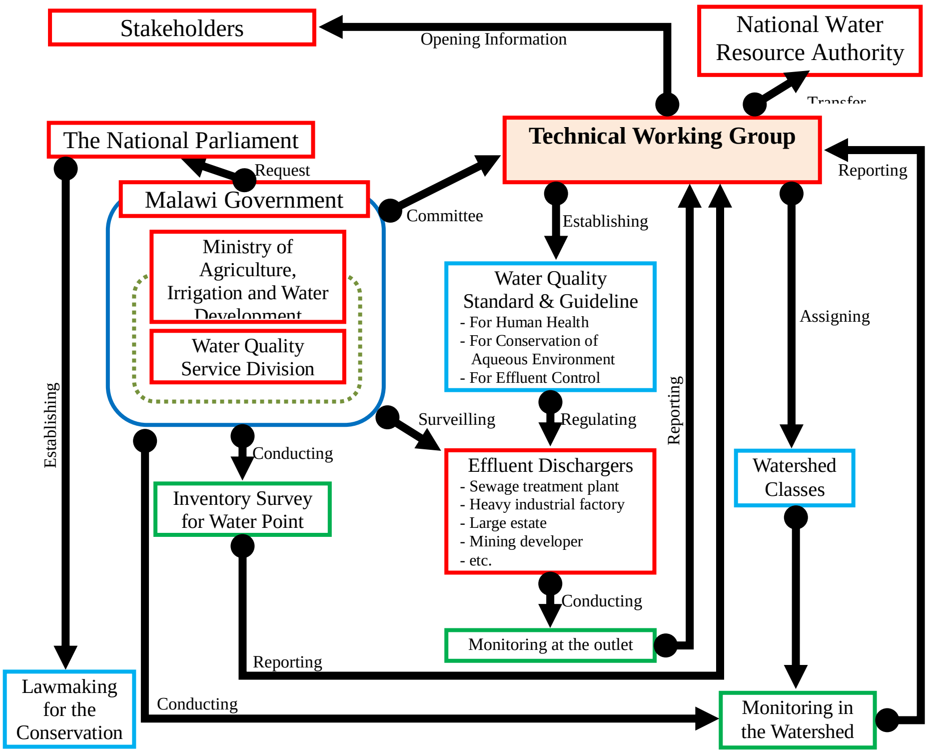
3) Water Quality Standard for Effluent Control

Any sort of harmful substance at hot spots of effluent discharges depends on the source. For example, the pollution by pesticides comes under agricultural activities, or the pollution by heavy metals comes from heavy industrial factories or mining sites. The water quality standard for effluent control should be established at every sort of pollution source with reference to the past case studies.

(3) Monitoring Scheme

The Malawi Government and effluent dischargers (private companies or municipal corporations) have a strict responsibility to ensure the safety of public water resources and certify the fact to the people. In order to implement conservation of human health and aqueous environments, according to the rigorous standards and guidelines, the validation by water quality monitoring is indeed necessary. The water quality monitoring has two aspects, namely; the monitoring for pollution sources and the monitoring with the changing times in wide areas. All effluent dischargers shall be in charge of the former monitoring with own burden under the government surveillance. Any exception for reasons of constrained budget on the monitoring shall not be acceptable. Laws which force effluent dischargers to implement water quality monitoring and environmental conservation will be needed. Periodical monitoring in wide areas shall be the government's responsibility. Due to the fact that improvement targets for water quality vary in the water usage of each watershed, the government should inventory the actual conditions of water usage in the whole of Malawi according to the numbering system designed by the Water Resource Board.

The technical working group (TWG) has to be strengthened and watershed classes assigned to all rivers, marshes and lakes based on the actual water usages, and establish a water quality monitoring program in each watershed. For the next step, the Water Quality Division of MoAIWD will execute the monitoring activities according to the program. The TWG will integrate these monitoring results to an annual report and open the information to stakeholders in Malawi. In the future, the TWG will transfer the information and skills to the National Water Resources Authorities. **Figure 7.6.2** sows a series of water quality monitoring schemes.



Source: Project Team

Figure 7.6.2 Flow Chart of the Water Quality Monitoring Scheme

(4) Data Management

The existing database of the Water Quality Service Division, Dbase III, is now outdated and the historical data stored in an old computer are exposed to sudden loss by machine crushing, hence it is urgently necessary to replace Dbase III with another new database. The new database integrated together with other hydrological data named "HYDSTRA" is recommended in the project "Establishment of Water Resources Monitoring System" on September, 2013. The HYDSTRA database is compatible with other monitoring systems used in the wider region (SADC) and available to facilitate data exchange with the countries which belong to SADC. However, the Water Quality Service Division based in the central water laboratory cannot access the intra-server installed with HYDSTRA in the head office of MoAIWD, and also in future. Therefore, HYDSTRA is uneasy for the Water Quality Service Division to handle database, and a simpler database with easier processing is desired instead of HYDSTRA.

(5) Strengthening Laboratory Implementation

Three official water laboratories exist in the south, central and north regions of Malawi, but the south and north water laboratories could not be used for analysis due to severe budget and staffing constraints. In order to conduct water quality monitoring in the whole of Malawi all at once, sufficient funding for the monitoring activities of the two laboratories is requisite and the monitoring works in the three regions shall be divided. In addition, all laboratories lack the required analytical and measurement instruments for pesticides, organic solvents, parts of heavy metals and radioactivity, and the operation skills. The expenses of these monitoring activities and maintaining lab facilities of the Water Quality Service Division are far from insignificant.

The budget for strengthening water laboratories such as monitoring activities, maintaining lab facilities and capacity building of lab staff should be applied from parts of the charges of water abstraction and effluent discharge, or the Water Resources Trust Funds.

7.6.4 Action Plan

Action plan including prior WRA, time schedule, responsible organization and budget is shown in **Table 7.6.4**.

Table 7.6.4 Action Plan of Building Water Resources Monitoring Systems by 2035

Program / Project / Activities	Prior WRA	Time Frame: Short Term 2012-2020, Middle Term 2021-2025, Long Term 2026-2035 (12–35)	Responsible Organ: Main	Responsible Organ: Associate
Groundwater Management System				
Establishment of guideline for groundwater management	All	solid 15–17; dashed 18–25	MoAIWD	NWRA
Capacity building for data management, evaluation and planning of groundwater development	All	solid 15–20; dashed 21–35	ditto	ditto
Inventory survey for groundwater resources	All	solid 15–25; dashed 26–35	ditto	ditto
Implementation and Maintenance of groundwater management system	All	solid 21–35	ditto	ditto
Groundwater Monitoring				
Reinforcement and maintenance of automatic groundwater leveling	All	solid 15–35	MoAIWD	NWRA
Establishment of new monitoring wells	4, 5	solid 15–20	ditto	ditto
Upgrading of monitoring wells	All	solid 21–35	ditto	ditto
Water Quality Conservation				
Establishment of steering committee for water quality	All	solid 15–16; dashed 17–35	OPC	NWRA
Establishment of environmental water quality standard and guideline	All	solid 17–25; dashed 26–35	NWRA	MoAIWD
Establishment of water quality database	All	solid 15–17	MoAIWD	NWRA
Strengthening of water laboratory functions	All	solid 15–25; dashed 26–35	ditto	ditto
Implementation of water quality monitoring scheme	All	solid 26–35	NWRA	MoAIWD

Source: Project Team

7.7 Sanitation

7.7.1 General

Sanitation refers to the act of preventing human contact with wastes through the treatment and proper disposal of the sewage wastewater.

Domestic wastewater is one of the sources of pollution of surface and groundwater. Domestic wastewater in Malawi is mainly disposed by means of flush toilets with septic tanks and pit latrines. The nation faces serious health threats from the inadequate sanitary facilities. According to the Welfare Monitoring Survey of 2009 (National Statistical Office), ten (10) percent of households used flush toilet, one (1) percent used ventilated improved pit latrine, eighty three (83) percent use traditional pit latrines and six (6) percent had no facility.

In the urban areas of the country, one may find the following types of sewage disposal: (1) sewerage; (2) septic tank; (3) improved pit latrine; (4) pit latrine; and (5) no facility (open defecation).

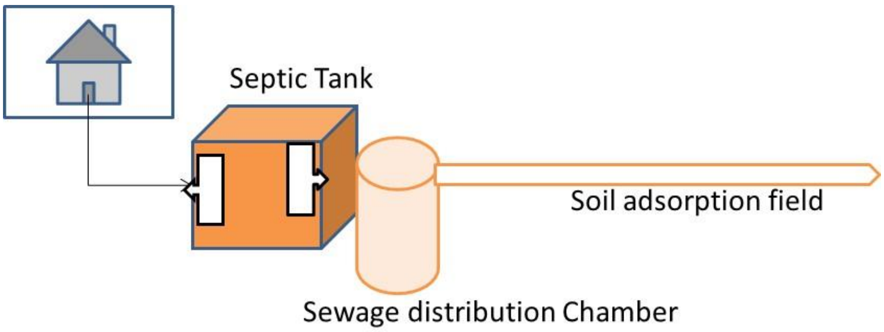
As for rural areas of the country, the most used type is the pit latrine or open defecation.

It is opportune to mention that city councils headed by the Chief Executive have currently the responsibility of dealing with sewage management in the urban areas. As for rural areas, the District Council headed by the District Commissioner has the responsibility of promoting safe sewage disposal conjointly with the Ministry of Health.

In the Project, on-site sewage management system means that sewage is treated locally inside the premises of the generator generally by using septic tanks. On the other hand, off-site sewage management system refers to the system that collects sewage from households, institutions, industries and entities through a centralized sewerage network for its transport to the treatment plant outside the premises of the generator building for final treatment and disposal.

7.7.2 On-Site Sewage Management System

Majority of the population in Malawi including households, commercial and institutional premises use on-site system to dispose their sewage. The common on-site facilities used in Malawi are pit latrine, improved pit latrine and flush toilet with septic tank and soil adsorption field. The last type of facility is shown in **Figure 7.7.1**.



Source: Project Team

Figure 7.7.1 Outline of Flush Toilet with Septic Tank and Soil Adsorption Field

Those who use septic tanks get emptying services from City Councils. A few private emptying companies take the sludge to the city sewage treatment works. However, in many cases to avoid the payment of discharge fee or the long distance to the treatment works, the sludge is disposed anywhere resulting in a public health risk and pollution of water bodies. This kind of practice happens due to the scarce control of the authorities.

A considerable number of urban and rural dwellers in many parts of the country still use the open defecation or direct disposal into watercourses. On the other hand, a number of institutions in Malawi exists (public and private) that generates a considerable amount of wastewater which are disposed and treated in big septic tanks at their own premises which are considered as on-site management system in the Project. **Figure 7.7.2 to Table 7.7.6** present a list of these entities including their names, location, treatment system and operational current status.

(1) Institution in Charge of Promotion

The promotion of on-site sewage treatment such as the construction of pit latrines, septic tanks, etc., is made by the District Council(s) conjointly with the Ministry of Health and MoAIWD (Sanitation and Hygiene Department).

(2) Field Observation of Facilities

The JICA Project Team conjointly with officers of MWDI made a joint observation of one on-site facility in Lilongwe City in order to check its current condition as follows:

Likuni Girls Secondary School

- Treatment system: septic tank
- There are more than ten (10) septic tanks distributed in different points in the compound of the School. Some of them needed maintenance works.

7.7.3 Off-Site Sewage Management System

In Malawi, currently, very few cities are being partially served with centralized sewerage system with wastewater treatment plant such as Lilongwe, Blantyre, Zomba and Machinga. However, there are many institutions (public and private) that treat their sewage by off-site system utilizing mainly stabilization lagoons. **Table 7.7.7** and **Table 7.7.8** present a list of the facilities including their name, location, treatment system and current operational status.

(1) Institution in Charge of the Service

Currently, the city councils are the providers of the service in the urban areas of cities for centralized sewage collection, transportation, treatment and disposal. However, the Water Policy (2005) and the Sanitation Policy (2008) stipulate that water utility companies are responsible for the service; consequently, there is a need of definition and decision by the Malawian authorities on this issue.

(2) Field Observation of Facilities

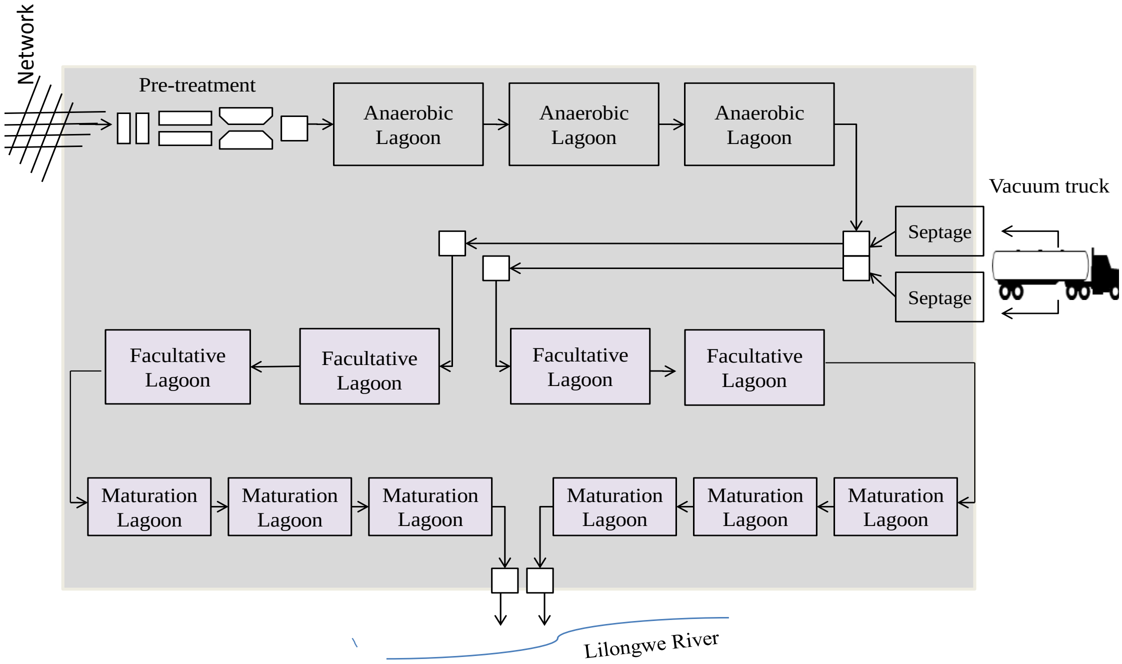
In order to check the current condition of the facilities, the JICA Project Team conjointly with officials of MoAIWD and the Lilongwe City Council, made a joint site observation of some sewage treatment plants that serve Lilongwe City; namely, Kauma, Lumbadzi and Kamuzu Barraks. The treatment plant that serves Chipasula Secondary School was also observed.

Additionally, the JICA Project Team conjointly with officers of MoAIWD also observed some sewage treatment plants that serve Liwonde Town (Liwonde Sewage Treatment Plant) and Blantyre City (Soche Sewage Treatment Plant; Chirimba Sewage Treatment Plant).

The results of the observation are presented below.

1) Kauma Sewage Treatment Plant (Lilongwe City)

Figure 7.7.2 shows a schematic distribution of the facilities.



Source: Project Team

Figure 7.7.2 Kauma Sewage Treatment Plant in Lilongwe City

Major findings were:

1) The construction started in 1994 and was completed in 1997, and became operational from 1998.

2) Treatment is by use of stabilization lagoons system composed of pre-treatment facilities for solid waste and sand removal with partial flume for discharge measurement, three anaerobic lagoons, four facultative lagoons, six maturation lagoons, and two septage lagoons which receive sewage from vacuum trucks.

3) Design capacity is 6,100 m^3/d (daily average). Likewise, the Plant was designed to have outlet quality of the following values: BOD = 20 mg/l, SS= 30 mg/l and F. coliform= 1 x 10^3 MPN/ml. No data is available on the current quantity of the influent to the Plant.

4) The tariff for sewage is as follows: for households MK 5,500/month (not collected currently); for commercial MK 25,000/month (not collected currently); for industrial there was no charge; for vacuum trucks (big) Mk 2,500/each discharge, and for vacuum trucks (small) Mk 1,000/each discharge.

5) It was observed that the lagoons needed maintenance.

6) According to officials of Lilongwe City Council, many houses are not connected to the sewerage since their locations are far from the main sewers. They need secondary sewers near their houses to be connected to the system.

7) The Central Laboratory of MoAIWD made an analysis of the two outlets of the maturations lagoons on 27 June 2011 and the results are shown in **Table 7.7.1**

Table 7.7.1 Kauma Sewage Treatment Plant - Quality of the Effluent

Parameter	Unit	Maturation Lagoon (Final-Set I)	Maturation Lagoon (Final-Set II)	Discharge Standard MS 691:2005
pH		8.47	8.64	6.5-9.0
EC	μ/cm	650	710	
TDS	mg/l	423	462	500
SS	mg/l	22	47	30
Turbidity	NTU	20	20	25
NO3	mg/l	0.084	0.110	50
PO4	mg/l	4.16	4.20	0.15
BOD	mg/l	102	76	20
COD	mg/l	277	189	70
Zn	mg/l	0.142	0.031	5
Cd	mg/l	0.025	0.059	0.01
F. coliform	Count/100cc	1,150	1,310	
F. streptococci	Count/100cc	40	84	

Source: Central Water Quality Laboratory, MoAIWD

8) According to the laboratory results, the effluent of this Plant does not fulfill the standard (MS 691:2005) discharge into watercourses. This fact could be attributable to the lack of maintenance of the facilities.

2) Lumbadzi Sewage Treatment Plant (Lilongwe City)

Major findings were:

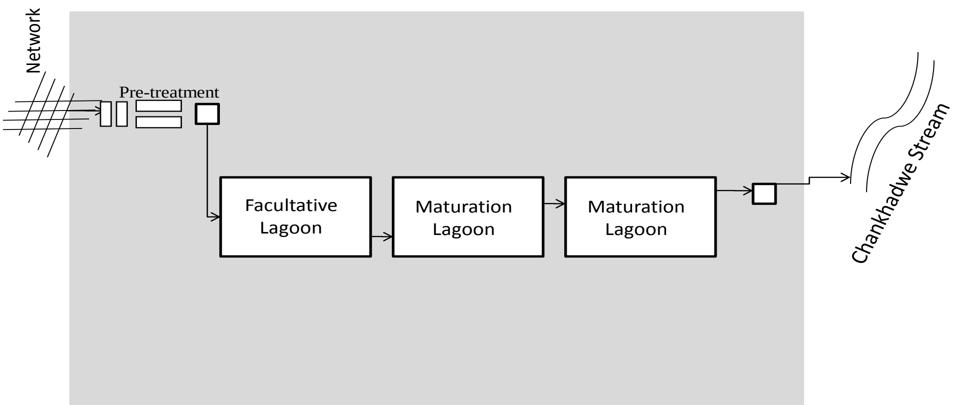
1) The plant was constructed in 1982 and became operational in 1984 until 1994 when it completely stopped operating up to date. The design capacity is 112 m^3/day.

2) The plant was constructed by the Malawi Housing Corporation to serve airport staff houses located in Area 53.

3) Treatment is by use of stabilization lagoons system (facultative and maturation lagoons). At this moment, the plant is not receiving any wastewater since the sewers that connect the houses to the treatment plant have been broken and vandalized. It was also observed that some parts of the raw sewage was diverted from a manhole into agricultural lands for irrigation and other portions to Lumbadzi River.

4) Rehabilitation of this Plant is necessary and the replacement of 1.5 km of sewers to connect the main trunks to the treatment Plant.

Figure 7.7.3 below shows a schematic distribution of the facilities.



Source: Project Team

Figure 7.7.3 Lumbadzi Sewage Treatment Plant in Lilongwe City

3) Kamuzu Barraks (Lilongwe City)

Major findings were:

1) Treatment is by the stabilization lagoons system composed by pre-treatment facilities for solid waste and sand removal, two (2) facultative lagoons, and one (1) maturation lagoon.
2) The plant is not fenced and any person may enter. Broken sewers observed before entering the pre-treatment basin lead to pollution of the nearby water courses. The plant needs maintenance works.

4) Chipasula Secondary School (Lilongwe City)

Major findings were:

1) Treatment is by the stabilization lagoons system composed by one (1) anaerobic lagoon, one (1) facultative lagoon, and two (2) maturation lagoons.
2) Current operation status: this plant is not fenced and the presences of many children were noted playing inside the premises. The plant is surrounded by many dwelling houses. The plant that serves about 1,200 students looked abandoned and needs urgent maintenance works.

5) Liwonde Sewage Treatment (Liwonde Town)

Major findings were:

1) The Plant is located next to the Shire River and the operator is the Liwonde Town Council.
2) Outline of the treatment plant: bars for grid and solid waste removal, one (1) facultative lagoon, and three (3) maturation lagoons.
3) No information exists on the capacity of the plant. Receiving water body is Shire River. There was no outflow from the plant attributable to seepage of the lagoons and minimum inflow of sewage due to broken sewers in the collection system. Lagoons are overloaded and needs maintenance. The treatment plant also receives industrial wastewater.
4) Within the Town, broken pipes were observed and the sewage diverted to irrigate crops

6) Soche Sewage Treatment (Blantyre City)

Major findings were:

1) The plant is composed of bars for grid and solid waste removal, sand removal basin, settlers, trickling filter, digesters for sludge and drying beds. The operator is the Blantyre City Council.
2) This plant was completed in 1959 with a capacity of 5,500 m^3/day to treat domestic sewage. Some minor repairs were made in 1997. Presently, the plant needs a complete overhaul since many parts are not working properly (digesters, trickling filter, settlers, drying beds, etc.). Receiving water body is the Napiri River which discharges to Mudi River.
3) Training of personnel is another necessity that must accompany the repairs and maintenance of this treatment facility.

7.7.4 Recommendations on Sanitation of the Present WRMP

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

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

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

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

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

(3) Improvement of Sanitation in the Country

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

Table 7.7.2 On-Site Sewage Treatment System by Public and Private Institutions in Malawi (1/5)

No.	Location	Liquid Waste Type	Treatment System	Current Status
	Central Region			
1	**Lilongwe City**			
	Urban Area			
1.1	Likuni Girls Secondary School	D	ST	Operational. Various septic tanks are distributed in the compound, some of them need maintenance works
1.2	Chinsampo Sec. School	D	ST	Operational
1.3	Lilongwe Girl Sec. School	D	ST	Operational with problems (spillage)
1.4	Malawi Institute of Management	D	ST	Operational
1.5	St. Johns Sec. School	D	ST	Operational
1.6	Bwaila Sec. School	D	ST	Operational
1.7	Don Bosco Technical School	D	ST	Operational
1.8	Lilongwe Technical School	D	ST	Operational
1.9	Capital City Motel	D	ST	Operational
1.10	Lilongwe Hotel	D	ST	Operational with problems (spillage)
1.11	Cross Road Hotel	D	ST	Operational with problems (spillage)
1.12	Area 30 Police Headquarters	D	ST	Operational with problems (spillage)
1.13	SOS Premises	D	ST	Operational
1.14	Dzenza Sec. School	D	ST	Operational
1.15	African Bible College Premises	D	ST	Operational
1.16	Police Mobile Force Premises	D	ST	Operational with problems (spillage)
1.17	Likuni Mission Hospital	D	ST	Operational
1.18	Capital Hill Government Offices	D	ST	Operational with problems (spillage)
	Rural Area			
1.19	Mitundu Sec. School	D	ST	Operational
1.20	Namitete Sec. School	D	ST	Operational
1.21	Chitedze Research Station	D	ST	Operational
1.22	Dzuka Private Sec. School	D	ST	Operational
1.23	Double Vision Sec. School	D	ST	Operational
1.24	Matindi Sec. School Girls Academy	D	ST	Operational
1.25	Matindi Boys Sec. School Academy	D	ST	Operational
2	**Kasungu District**			
2.1	Kasungu Inn	D	ST	Operational with problems (spillage)
2.2	Kasungu Sec. School	D	ST	Operational with problems (spillage)
2.3	Chikho Hotel	D	ST	Operational
3	**Salima District**			
3.1	Livingstonia Beach Hotel	D	ST	Operational
3.2	Kambiri Point Cottage	D	ST	Operational
3.3	Salima Sec. School	D	ST	Operational
3.4	Chipoka Sec. School	D	ST	Operational
3.5	Chipoka Jetty	D	ST	Operational with problems (spillage)
4	**Nkhotakota District**			
4.1	Prison Premises	D	ST	Operational with problems (spillage)
4.2	Police Premises	D	ST	Operational with problems (spillage)
4.3	Nkhotakota Sec. School	D	ST	Operational
5	**Ntchisi District**			
5.1	Ntchsi Sec. School	D	ST	Operational with problems (spillage)
5.2	Prison Premises	D	ST	Operational with problems (spillage)
6	**Mchinji District**			
6.1	Magawa Sec. School	D	ST	Operational with problems (spillage)
6.2	Mkanda Sec. School	D	ST	Operational with problems (spillage)
6.3	Walilanji CDSS	D	ST	Operational with problems (spillage)
6.4	Kochilira Health Centre	D	ST	Operational with problems (spillage)
6.5	Ludzi Girls Sec. School	D	ST	Operational with problems (spillage)
7	**Dowa District**			
7.1	District Hospital	D	ST	Operational
7.2	MEDI at Mponela	D	ST	Operational
7.3	Kongwe Sec. School	D	ST	Operational with problems (spillage)

D: domestic; ST: septic tank; St: Settlement tanks; NAI: no available information

Table 7.7.3 On-Site Sewage Treatment System by Public and Private Institutions in Malawi (2/5)

No.	Location	Liquid Waste Type	Treatment System	Current Status
7.4	Madisi Sec. School	D	ST	Operational
7.5	Madisi Mission Hospital	D	ST	Operational
8	**Dedza District**			
8.1	District Hospital	D	ST	Operational with problems (spillage)
8.2	Bembeke Teachers Training College	D	ST	Operational with problems (spillage)
8.3	Dedza Sec. School	D	ST	Operational with problems (spillage)
8.4	Umbwi Sec. School	D	ST	Operational
8.5	Mtemdere Sec. School	D	ST	Operational
8.6	Mtendere Sec. School	D	ST	Operational with problems (spillage)
8.7	Chongoni College of Forestry	D	ST	Operational with problems (spillage)
9	**Ntcheu District**			
9.1	Ntcheu Prison Premises	D	ST	Operational with problems (spillage)
9.2	Ntcheu Sec. School	D	ST	Operational with problems (spillage)
9.3	District Hospital	D	ST	Operational with problems (spillage)
9.4	New Era Boys Sec. School	D	ST	Operational with problems (spillage)
9.5	New Era Girls Sec. School	D	ST	Operational with problems (spillage)
9.6	Kings Foundation Sec. School	D	ST	Operational with problems (spillage)
9.7	Lake View University	D	ST	Operational
9.8	Nkhande ADD	D	ST	Operational
9.9	Bilira CDSS	D	ST	Operational
	Southern Region			
1	**Blantyre City**			
	Urban Area			
1.1	Seventh Day Adventist Hospital	D	ST	NAI
1.2	Kachere Rehabilitation Centre	D	ST	NAI
	Rural Area			
1.3	Mlambe Hospital	D	ST	NAI
1.4	Lunzu Sec. School	D	ST	Operational
1.5	Kaphuka Private Sec. School	D	ST	NAI
1.6	Chileka Airport	D	ST	Operational with problems
1.7	Mdeka Sec. School	D	ST	Operational
1.8	Mpemba Staff Training Centre	D	ST	Operational with problems
1.9	Chazunda Islamic Centre	D	ST	Operational with problems
1.10	Army Sec. School	D	ST	Operational with problems
1.11	Matindi Private Sec. School	D	ST	Operational with problems
2	**Zomba City**			
	Urban Area			
2.1	Mlunguzi Sec. School	D	ST	Operational
2.2	Zomba Catholic Sec. School	D	ST	Operational
2.3	Police Sec. School	D	ST	Operational with problems (spillage)
2.4	Cobbe Barracks	D	ST	Operational with problems
2.5	District Hospital	D	ST	Operational
2.6	Masongola Sec. School	D	ST	Operational with problems
2.7	Works Training Centre	D	ST	Operational
2.8	Malawian Defense Force Air Wing	D	ST	Operational
2.9	Kuchawe Inn	D	ST	Operational
2.10	Hotel Masongola	D	ST	Operational
2.11	Zomba Agriculture Development Div.	D	ST	Operational
2.12	Annie’s Lodge	D	ST	Operational
2.13	St. Mary’s Sec. School	D	ST	Operational with problems
2.14	Mental Hospital	D	ST	Operational with problems (spillage)
2.15	Mikuyu Prison Premises	D	ST	Operational with problems (spillage)
	Rural Area			
2.16	Malosa Hospital	D	ST	Operational
2.17	Malosa Sec. School	D	ST	Operational
3	**Chikhwawa District**			
3.1	Chikhwawa Sec. School	D	ST	Operational
3.2	St. Lawrence Girls Sec. School	D	ST	Operational

D: domestic; ST: septic tank; NAI: no available information

Table 7.7.4 On-site Sewage Treatment System by Public and Private Institutions in Malawi (3/5)

No.	Location	Liquid Waste Type	Treatment System	Current Status
3.3	Chikhwawa Hospital	D	ST	Operational
3.4	Ngabu Rural Hospital	D	ST	Operational
3.5	St. Montfort Mission Hospital	D	ST	Operational
3.6	Chikhwawa Boma (Housing, Police, Prison, etc.)	D	ST	Operational with problems (spillage)
3.7	Ngabu Agricultural Development Div.	D	ST	Operational
4	**Machinga District**			
4.1	Hippo View Lodges	D	ST	Operational with problems (spillage)
4.2	Sun Village Lodges	D	ST	Operational
4.3	District Hospital	D	ST	Operational with problems (spillage)
4.4	Machinga Teachers Training College	D	ST	Operational
4.5	Liwonde Day Sec. School	D	ST	Operational
4.6	Liwonde Community Day Sec. School	D	ST	Operational
5	**Chiradzulu District**			
5.1	Chiradzulu Sec. School	D	ST	Operational
5.2	St. Joseph College of Nursing	D	ST	Operational
5.3	Magomero Community Training College	D	ST	Operational
5.4	Nansawa Technical School	D	ST	Operational with problems (spillage)
6	**Mwanza District**			
6.1	Mwanza Sec. School	D	ST	Operational with problems (overflows)
6.2	Prison Premises	D	ST	Operational with problems (spillage)
6.3	Mwanza Border Post	D	ST	Operational
7	**Neno District**			
7.1	Neno District Hospital	D	ST	Operational
7.2	Neno Community Day Sec. School	D	ST	Operational
7.3	Matandani Mission Sec. School	D	ST	Operational
8	**Mangochi District**			
8.1	Mangochi Sec. School	D	ST	Operational with problems (spillage)
8.2	Nkopola Lodge	D	ST	Operational
8.3	Sun &Sand Holiday Resort	D	ST	Operational with problems (spillage)
8.4	Club Makokola Hotel	D	ST	Operational
8.5	Chigweje (Namwera) Training Centre	D	ST	Operational
8.6	Mulangeni Holiday Resort	D	ST	Operational with problems (spillage)
8.7	Andrews Motel	D	ST	Operational with problems (spillage)
8.8	Malindi Sec. School	D	ST	Operational
8.9	District Hospital	D	ST	Operational
8.10	Fisheries Research Centre	D	ST	Operational
8.11	MDF Marine Centre	D	ST	Operational with problems (spillage)
8.12	Monkey Bay Harbour/Jetty	D	ST	Operational with problems (spillage)
9	**Thyolo District**			
9.1	Thyolo Sec. School	D	ST	Operational with problems (spillage)
9.2	Luchenza Sec. School	D	ST	Operational with problems (spillage)
9.3	Bvumbwe Research Station	D	ST	Operational with problems (spillage)
9.4	Makwasa Mission Hospital	D	ST	Operational with problems (spillage)
9.5	Lichenza Sec. School	D	ST	Operational with problems (spillage)
10	**Mulanje District**			
10.1	Mulanje Sec. School	D	ST	Operational with problems (spillage)
10.2	Providence Sec. School	D	ST	Operational with problems (spillage)
10.3	Gawani Sec. School	D	ST	Operational
10.4	Mulanje Motel	D	ST	Operational
10.5	Prison Premises	D	ST	Operational with problems (spillage)
10.6	Police Premises	D	ST	Operational with problems (spillage)
10.7	Mloza Sec. School	D	ST	Operational
11	**Phalombe District**			
11.1	Phalombe Sec. School	D	ST	Operational
11.2	Holly Family Hospital	D	ST	Operational
12	**Balaka District**			

D: domestic; ST: septic tank; NAI: no available information

Table 7.7.5 On-Site Sewage Treatment System by Public and Private Institutions in Malawi (4/5)

No.	Location	Liquid Waste Type	Treatment System	Current Status
12.1	Balaka Sec. School	D	ST	Operational with problems (spillage)
12.2	District Hospital	D	ST	NAI
12.3	Police Premises	D	ST	Operational with problems (spillage)
13	**Nsanje District**			
13.1	Nsanje Sec. School	D	ST	Operational
13.2	District Hospital	D	ST	Operational
13.3	Prison Premises	D	ST	Operational with problems (spillage)
13.4	Police Premises	D	ST	Operational with problems (overflows)
	Northern Region			
1	**Rumphi District**			
1.1	District Hospital	D	ST	Operational with problems (spillage)
1.2	Prison Premises	D	ST	Operational with problems (spillage)
1.3	Rumphi Sec. School	D	ST	Operational with problems (spillage)
1.4	Livingstonia University	D	ST	Operational
1.5	Phwezi Boys Sec. School	D	ST	Operational with problems (spillage)
1.6	Phwezi Girls Sec. School	D	ST	Operational with problems (spillage)
1.7	Phwezi Technical College	D	ST	Operational
2	**Nkhata Bay District**			
2.1	Jetty	D	ST	Operational with problems (spillage)
2.2	Chintheche Inn	D	ST	Operational
2.3	District Hospital	D	ST	Operational with problems (spillage)
2.4	Police Premises	D	ST	Operational with problems (spillage)
2.5	Bandawe Sec. School	D	ST	Operational with problems (spillage)
2.6	Chintheche Hospital	D	ST	Operational with problems (spillage)
2.7	NkhataBay Prison	D	ST	Operational with problems (spillage)
2.8	NkhataBay Sec. School	D	ST	Operational
3	**Mzimba District**			
3.1	Mzimba Sec. School	D	ST	Operational with problems (spillage)
3.2	Prison Premises	D	ST	Operational with problems (spillage)
3.3	Raiply Company	D	ST	Operational
4	**Mzuzu City**			
4.1	Mzuzu Hotel	D	ST	Operational
4.2	Mzuzu City Council	D	ST	Operational with problems (spillage)
4.3	Police Premises	D	ST	Operational with problems (spillage)
4.4	St. Johns Hospital	D	ST	Operational
4.5	Ekwendeni Hospital	D	ST	Operational
4.6	Mzuzu Prison	D	ST	Operational with problems (spillage)
4.7	Mzuzu Govt.Sec. School	D	ST	Operational with problems (spillage)
4.8	District Hospital	D	ST	Operational with problems (spillage)
4.9	Ekwendeni College of Nursing	D	ST	Operational with problems (spillage)
4.10	Ekwendeni Sec. School	D	ST	Operational with problems (spillage)
4.11	Kaka Motel	D	ST	Operational with problems (spillage)
4.12	Mzuzu Tourism Lodge	D	ST	Operational
4.13	Katoto Sec. School	D	ST	Operational
4.14	Ilala Lodge	D	ST	Operational
4.15	Mzuzu Technical College	D	ST	Operational
4.16	Mzuzu City Stadium	D	ST	Operational with problems (spillage)
4.17	St Johns of God	D	ST	Operational
4.18	St. Johns Nursing School	D	ST	Operational
4.19	Viphya Private Sec. School	D	ST	Operational
4.20	Ukani Sec. Private School	D	ST	Operational
4.21	Hilltop Private Sec. School	D	ST	Operational
4.22	Royo Private Sec. School	D	ST	Operational
4.23	St. Peters Primary School	D	ST	Operational
5	**Karonga District**			
5.1	District Hospital	D	ST	Operational with problems (overflows)
5.2	Karonga Teachers Training College	D	ST	Operational with problems (overflows)
5.3	Chaminadi Secondary School	D	ST	Operational

D: domestic; ST: septic tank; AL: aerated lagoon; NAI: no available information

Table 7.7.6 On-Site Sewage Treatment System by Public and Private Institutions in Malawi (5/5)

No.	Location	Liquid Waste Type	Treatment System	Current Status
5.4	Malawi Defence Force (Chilumba Barracks)	D	ST	Operational
5.5	Songwe Border Post	D	ST	Operational
5.6	Karonga Police Premises	D	ST	Operational with problems (spillage)
5.7	Karonga Secondary School	D	ST	Operational with problems (overflows)
5.8	Karonga Prison Premises	D	ST	Operational with problems (overflows)
5.9	Chilumba Jetty	D	ST	Operational with problems
6	**Chitipa District**			
6.1	District Hospital	D	ST	Operational with problems (overflows)
6.2	Chitipa Secondary School	D	ST	Operational with problems (overflows)
6.3	Chitipa Inn	D	ST	Operational
6.4	Nthalire Secondary School	D	ST	Operational
6.5	Nthalire Health Centre	D	ST	Operational
6.6	Misuku CDSS	D	ST	Operational
6.7	Chitipa Police	D	ST	Operational with problems (overflows)
6.8	Chitipa Prison Premises	D	ST	Operational with problems (overflows)

D: domestic; ST: septic tank; NAI: no available information

Source: MoAIWD

Table 7.7.7 Off-Site Sewage Treatment System by Public and Private Institutions in Malawi (1/2)

No.	Location	Liquid Waste Type	Treatment System	Current status
	Central Region			
1	**Lilongwe City**			
1.1	Kauma Sewage Works	D	SL	Operational. Lagoons needs urgent maintenance works
1.2	Kanengo Sewage Works	D+I	SL	
1.3	Lumbadzi Sewage Works	D	SL	Non-operational. Needs rehabilitation of sewers to the treatment plant
1.4	Cold Storage Sewage Works	D+I	SL	Operational. Inlet works needs maintenance
1.5	Kamuzu International Airport (KIA) Sewage Works	D+I	SL	Operational with scum in the ponds
1.6	Natural Resources College	D	SL	Operational with problems (Spillage)
1.7	Lilongwe Teachers Training College	D	SL	Not operational
1.8	Chipasula Secondary School + Staff quarters	D	SL	Operational. Lagoons needs urgent maintenance works
1.9	Malawi Defence Force (Kamuzu Barracks)	D	SL	Operational. Broken sewers. Pre-treatment needs urgent maintenance
	Rural Area			
1.10	Nkhoma Hospital	D	SL	Operational with problems (Spillage)
1.11	Bunda College of Agriculture	D	SL	Operational
2	**Kasungu District**			
2.1	District Hospital	D	SL	Operational with problems (lots of blockages due to weeds in the lagoons)
2.2	Kasungu Agriculture Development Division	D	SL	Operational with problems (little inflow due to blockages)
2.3	Kasungu Teachers Training College	D	SL	Operational with problems (Spillage)
2.4	Chayamba Secondary School	D	SL	Operational with problems (little inflow due to blockages)
2.5	Kamuzu School Academy	D	SL	Operational with problems (lots of weeds in the lagoons)
3	**Salima District**			
3.1	District Hospital	D	SL	Not operational
3.2	Malawi Armed Forces College (MAFCO)	D	SL	Operational with problems (spillage)
4	**Mchinji District**			
4.1	District Hospital	D	SL	Operational with problems like vandalism
4.2	Mchinji Secondary School	D	SL	Operational with problems (lots of blockages)
5	**Ntchisi District**			
5.1	District Hospital	D	SL	Operational with problems (some blockages)
6	**Dowa District**			
6.1	Malawi Defence Force (Mvera Support Batallion)	D	SL	Operational with problems (cracks on the embankments)
	Southern Region			
1	**Blantyre City**			
1.1	Chirimba Sewage Works	D+I	TF	Non operational and vandalized. This Plant was abandoned long time ago
1.2	Soche Sewage Works	D	TF	Operational. The Plant needs a complete overhaul since many parts of it are not working properly. Some parts needs urgent reparation and others needs urgent maintenance
1.3	Blantyre Sewage Works	D+I	AS + SL	Operational with problems
1.4	Limbe Sewage Works	D+I	SL	Non operational. Needs to replace vandalised sewer pipelines to connect the line to the plant. Currently, sewage spilling over the open manhole to the ground and nearby stream
1.5	Maone Sewage Works	D	St	Non operational and vandalised
2	**Thyolo District**			
2.1	District Hospital	D	SL	Operational with problems (Spillage)

D: domestic; I: industrial; TF: Trickling Filter; AS: Activated sludge; SL: Stabilization lagoon; St: Settlement tanks

Table 7.7.8 Off-Site Sewage Treatment System by Public and Private Institutions in Malawi (2/2)

No.	Location	Liquid Waste Type	Treatment System	Current status
3	**Chiradzulu District**			
3.1	District Hospital	D	SL	Operational with problems (scum in almost all the lagoons)
4	**Zomba City**			
4.1	Zomba City Council Sewage Works	D+I	TF + SL	Operational with lots of weeds in all lagoons
4.2	Chancellor College	D	SL	Operational with problems (no outflow from the final pond)
	Rural Area			
4.3	Domasi Teachers Training College	D	SL	Operational with problems
4.4	Domasi Institute of Management	D	SL	Operational with problems
4.5	Domasi Prison Premises	D	SL	Operational with problems
5	**Chikhwawa District**			
5.1	Nchalo(12 settlements in Illovo Sugar Estate)	D	SL	Not operational. Composed of 12 individual system
5.2	Ngabu Sec. School	D	SL	Operational
6	**Machinga District**			
6.1	Liwonde Town Council Sewage Works	D+I	SL	Operational. No outflow from the last pond. Observed deliberate breaking of sewer network for irrigation of crops
7	**Chiradzulu District**			
7.1	District Hospital	D	SL	Operational with problems (Spillage)
8	**Mwanza District**			
8.1	District Hospital	D	SL	Operational with problems (some blockages)
9	**Mulanje District**			
9.1	District Hospital	D	SL	Operational
9.2	Mulanje Mission Hospital	D	SL	Operational
	Northern Region			
1	**Mzuzu City**			
1.1	Malawi Defence Force (Moyale Barracks)	D	SL	Operational with problems (lots of cracks on the embankments of some lagoons)
1.2	General Hospital	D	SL	Operational with problems (Spillage)
1.3	Mzuzu University Sewage Works	D	SL	Operational with problems (Spillage)
1.4	Luwinga Sewage Works	D+I	SL	Operational
2	**Mzimba District**			
2.1	District Hospital	D	SL	Operational with problems (some blockages)

D: domestic; I: industrial; TF: Trickling Filter; AS: Activated sludge; SL: Stabilization lagoon; St: Settlement tanks
Source: MoAIWD
Compiled by JICA Survey Team

7.8 Improvement of Management Plan for Water Development Facilities

7.8.1 Waterworks Facility for Domestic Water Supply

The management for the water supply facility influences the safety and stability of drinking water, hence it shall be carried out adequately, effectively and rationally. Following items should be considered for the operation and maintenance of the water supply schemes:

Table 7.8.1 Points for Management of Domestic Water Supply

Classification	Facilities	Required O&M points
Urban and Towns	Intake (Weir, Pump), Borehole/Power Pump, Treatment Plant, Storage tank, Transmission/Distribution pipe and dam	- Preparation/Upgrading of Manual for Operation, Monitoring, Risk Management - Capacity Development of Operator - Effective Outsourcing - Rehabilitation/Expansion
Market Center	Intake (Weir, Pump), Borehole/Power Pump, Treatment Plant, Storage tank, Transmission/Distribution pipe and dam	- Preparation/Upgrading of Manual for Operation, Monitoring, Risk Management - Capacity Development of Operator - Effective Outsourcing - Rehabilitation/Expansion
Community (Gravity-fed Water Supply)	-Water Supply Facilities -Intake (Weir, Pump), Treatment Plant, Storage tank, Transmission/Distribution pipe	- Preparation/Upgrading of Manual for Operation, Monitoring, Risk Management - Quantity & Quality Control - Capacity Development of Water Users Association - Rehabilitation & Expansion
Community (Borehole)	-Borehole and Hand-pump	- Capacity Development of Water Committee - Manpower Training for Area Mechanic - Sales points of Spare-parts of Hand-pump

The management for waterworks facility is generally classified in two: operation management and maintenance engineering. The roadmap concerning the operation and maintenance of waterworks facility is formulated from these two respects, and it shall be performed.

(1) Operation Management

1) Short Term

- Examination and preparation of recording system for operation and control management, recording of job and operating diary.
- Preparation of operation management manual for water boards. (In this manual, the normal and aberrant values of the operation data, the normal and abnormal operating procedures, the accident response, restoration and its structure, etc., shall be described.)
- Procurement of necessary equipment for operations.
- Investigation of aging facilities and stocks of spare parts.
- Capacity development for responsible organizations and personnel.

2) Middle and Long Terms

- Recording of operation and control management; Recording of job and operating diary.
- Database architecture (for the routine work, the information management, the water supply control and management, the facilities management, the equipment inspection and rehabilitation archival record, the asset management, etc.)
- Water quantity and pressure control (for the integrated management from intake facility to feeder pipe end, the appropriate control regulation, the promotion of efficiency of energy use, the effective leakage prevention, etc.)
- Water quality control (for the target water quality, the appropriate sampling and monitoring, the planning and recording of water quality inspection, etc.)

(2) Maintenance Engineering

1) Short Term

- Preparation of maintenance manuals
- Encouragement of compliance to manual
- Procurement of necessary machineries to maintain waterworks facilities
- Investigation of aging facilities
- Establishment of short, middle and long term maintenance plan
- Capacity development for responsible organizations and personnel

2) Middle and Long Terms

- Maintenance operation (for the inspection, maintenance, repair) and Functional advancement (for the functional assessment of waterworks facility, the rebuilding or update or life-extension diagnostics)
- Preventive and corrective maintenance
- Reliability risk evaluation for facilities
- Database architecture to record maintenance and results and revise the maintenance plan

7.8.2 Irrigation Facilities

For the proper operation and management of the irrigation facilities, a total organization to maintain the facilities should be necessary.

The details of irrigation control system vary depending on the scale of the project, the composition of the facilities and level of function of the operation and control facilities. The irrigation system, however, is usually controlled by hierarchical control which takes responsibility for control function according to the channel diversion from the water source to the end. Thus totality on the control of overall system and the flexibility in response to individual demand of water supply are achieved.

On the assumption of organizing the Water Users Association, the association has a responsibility of the irrigation system working together with government irrigation officers. Normally there are three levels to maintain and control the irrigation system in the project area: (1) Central control office, (2) Local or diversion block control office, and (3) On-farm control office.

(1) Central Control Office

It is the core organization of the entire irrigation scheme. It divides the course of the main line and branches which lead to diversion blocks.

- Adjusting water supply in relation to other water supply schemes, if any;
- Collecting, exchanging, and adjusting of information from local control offices;
- Decision making for proper distribution of water; and
- Controlling of the water intake and distribution facilities.

(2) Local or Diversion Block Control Office

It takes responsibility for distribution of water from diversion blocks to lower farm ponds. It plays a part of the central control office in middle-sized area.

- Collecting, exchanging, and adjusting of information from on-farm control offices;
- Adjusting of water consumption in the area or in diversion blocks; and
- Controlling the water distribution facilities.

(3) Principle of Operation and Management of On-Farm Facilities

It is necessary to clarify the characteristics and the operation policy of the facilities and explain it explicitly to the beneficiaries or the farmers in order to ensure smooth operation and management of the irrigation facilities in accordance with the design and the purposes of establishment. Such positive attitude will foster the farmers' sense that the facilities are the common property of the community.

The principle of operation of the on-farm facilities is as follows:

- Major facilities including the water source facilities, water distribution channels, the water diversion facilities and operation and control facilities should be managed by a reasonable number of personnel or a designated number of operators for clarifying the area of responsibilities.
- The date and time of water supply should be based on the planned rotation schedule. Any change of schedule requires the consent of related farmers and approval of responsible personnel.
- Rotational irrigation is employed, in principle. In the rotation block, the capacity of the on-farm facilities is shared by a number of farmers. Unless the capacity of water supply is designed specifically large, arbitrary use of water is not allowed.
- For the effective use of the facilities, joint operation in the field maintenance and intensive cultivation of crops are desired. If block is small, of if a number of crops are grown in the same field, careful distribution of crops in the field is necessary in order to avoid crops from contaminating adjacent crops by chemicals.
- Operational cost is desirable to be divided among farmers according to the volume of water used. However, in practice, because of the reasons for providing measuring devices and complicated calculation of the share of water charge for each farmer, it is often divided depending on the size of benefitted area. Thus fair and orderly share of water supply among the farmers is essential in general, and the timely operation of insect control and its period of application should be equally distributed, in particular.

In the irrigation facilities, examination of the following items of control should be conducted in order to protect the system from defective operation and maintenance. The structure and arrangement of the water supply facilities and the function of operation and maintenance facilities are taken into consideration for proper operation in general.

(a) Monitoring water source and planning water supply

- Designed seasonal water use, effective rainfall, and necessary water supply
- Changes of water source conditions, and possible water supply

(b) Operating water intake and distribution

- The demand of water supply and its formalities for use (on-farm to center), irrigation time required, and communication network
- Operation of water intake and distribution (center to on-farm), and allocated time and its conditions

(c) Emergency handling

- Emergency operation (spots of operation and countermeasures)
- Communication with related persons and organizations (communication and instruction network)

(d) Inspection and maintenance facilities

- Inspection, operation and maintenance of water supply facilities
- Operation and maintenance of control facilities, equipment and devices
- Inspection and adjustment of electric facilities and power supply
- Repair, maintenance and property administration of various ancillary facilities

(e) Collecting, arranging and analyzing water control data

- Range of collected data, purpose and method of data arrangement, and analysis method and its applications
- Storage of records

(f) Public relations

- Communication with related organizations, and adjustment with other related projects

Road Map and Activities for Irrigation Management

As described above, irrigation management is strongly and closely related to the irrigation development schemes. In each irrigation development scheme, WUA (Water Users Association) shall be established. Simultaneously, Central Control Office shall be established there as well. The structure of the control office depends on the scale of irrigation development.

1) Short Term

<Road Map>

- Water Users Association (WUA) is established among the beneficial farmers in each irrigation area in parallel with the progress of the irrigation development project by 2020.
- Central Control Office (CCO) is established in each irrigation area, and necessary offices are also established depending on the project scale by 2020.

<Activities>

- Collecting of on-farm information, and forming the communication and information sharing passage among the project sites, the Irrigation Service Division (ISD), and the Central Government (DOI).
- Gaining the operation and maintenance experiences at the project sites through controlling the irrigation facilities.
- Implementation of capacity development for proper operation and maintenance of the irrigation facilities by the ISD.

2) Middle and Long Term

<Road Map>

- Continuously establishing the WUAs and CCOs in parallel with the progress of irrigation development project until 2035.
- Formulating a strong network of irrigation information and human resources from the project sites to the DOI until 2035.

<Activities>

- Continuously gaining operation and maintenance experiences at the project sites through controlling the irrigation facilities.
- Implementation of capacity development for proper operation and maintenance of the irrigation facilities by the ISD

[iv] Overseas Development Administration Institute of Geological Sciences, “Groundwater Resources of Malawi” Department of Lands, Valuation and Water, Malawi, 1983

[iv] Water Point Numbering System Implementation Guide, Ministry of Irrigation and Water Development, 2006

PART II

Chapter 8. PROJECT IMPLEMENTATION PROGRAM

CHAPTER 8. PROJECT IMPLEMENTATION PROGRAM

8.1 Cost Estimation

8.1.1 Condition of Cost Estimation

(1) Constitution of Cost Estimation

Project cost consists of construction costs for the contractors, land acquisition costs, physical contingencies, costs for engineering services for the preliminary and detailed design, construction supervision, and administration costs for owner's management. The main items which constitute the project costs are as follows:

Construction Cost

- Land Acquisition Cost
- Physical Contingency
- Engineering Service Cost
- Administration Cost

(2) Construction Cost

Construction costs for the facilities proposed in this Master Plan are calculated based on the approximate bill of quantities and unit costs applied to the related project work items.

Construction costs for the various components of the proposed measures are basically estimated as the product of unit cost and the corresponding work quantity, as follows:

Construction Cost ＝ Σ (Unit Cost × Work Quantity)

In case it is judged not appropriate to estimate construction costs with unit cost for a proposed measure, the construction cost is estimated by other methods, such as formula of approximated curve or full set of construction cost. The details about setting of unit cost and the like are described in a later part of this section.

(3) Land Acquisition Cost

Land acquisition costs are not considered for the proposed projects in this Master Plan except for the part of Water Supply for the four (4) cities. Especially, the facilities for rural water supply are generally constructed in public lands; if private lands are used, such usage require agreement among the WUA and the local community members.

(4) Physical Contingency

Physical contingencies are provided to cater for the costs involved due to unpredictable physical conditions during the implementation of urgent and important components of the projects. Physical contingencies are estimated at 12% of the total sum of construction costs and land acquisition costs.

(5) Engineering Service Cost

Engineering service cost for the consultant is composed of the costs for the preliminary design, detailed design and construction supervision services for the construction works in the project implementation. The service costs are estimated at 10% of the total sum of construction costs, land acquisition costs and physical contingencies.

(6) Administration Cost

Administration costs are reserved for the activities of the government personnel as the administration expenses, which are estimated at 4% of the total sum of construction costs, land acquisition costs, physical contingencies and engineering service costs.

(7) Conditions of Cost Estimation

The conditions of cost estimation are summarized as follows.

Table 8.1.1 Conditions of Cost Estimation

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

Source: Project Team

(8) Other Preconditions

1) Time of Cost Estimation

The costs for the Master Plan (M/P) is estimated in US dollars (USD) based on the currency exchange rate as of December 2012; namely, USD 1.00 = MK 329 = EURO 0.77.

When the construction costs for recent similar projects described in existing reports are made as reference, it is necessary to convert them into the present value of 2012 as the base year. In the M/P, construction costs and unit costs are estimated by converting them into the present value of 2012 by means of the GDP deflator from the World Bank database.

Inflation as measured by the annual growth rate of the GDP implicit deflator shows the rate of price change in the economy as a whole. The GDP implicit deflator is the ratio of GDP in current local currency to GDP in constant local currency.

Construction costs and unit costs at the base year (2012) are estimated by using the following formula with correction coefficient.

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

Table 8.1.2 Inflation, GDP Deflator and Correction Coefficient

Years	Inflation, GDP deflator (annual %)	Correction Coefficient	
2001	25.6225	0.17234	
2002	62.1647	0.27947	
2003	9.5617	0.30619	
2004	15.4088	0.35337	
2005	10.9726	0.39215	
2006	27.3153	0.49926	
2007	9.9914	0.54915	
2008	8.6549	0.59668	
2009	8.3739	0.64664	
2010	26.4482	0.81767	
2011	3.9061	0.84960	
2012	17.7018	1.00000	→ Basic Year

Source: Project Team based on World Bank database

2) Breakdown of Foreign and Local Currency Cost

The investments are broken down into foreign and local currency costs on the basis of the assumptions presented in **Table 8.1.3**.

Table 8.1.3 Breakdown of Foreign and Local Currency Costs

Sector	Facilities	Foreign	Local
Integrated Project	Barrage	10%	90%
Water Supply for 4 Cities	Dams and Intake	10%	90%
	Pipelines	60%	40%
	Pumping Stations	60%	40%
	Water Treatment Plants	40%	60%
	Tanks	30%	70%
	Borehole with Motor Pump	40%	60%
	Electric Lines	70%	30%
	Land Compensation Costs	0%	100%
	Engineering Service	100%	0%
Towns & Rural Water Supply	Towns and Market Center	40%	60%
	Gravity-fed WS System	20%	80%
	Deep Well with Hand Pump	20%	80%
	Engineering Service	0%	100%
Agriculture & Irrigation	Dams	10%	90%
	Irrigation Development	10%	90%
	Engineering Service	0%	100%

Source: SOGREAH Report

3) Service Life of Project Components

The service life expectancies for elements comprising the scheme in this study are as follows:

Table 8.1.4 Service life Expectancies for each Element Comprising the Scheme in this Study

Element	Economic Life Expectancy
Dams	>50 years
Civil Structures	50 years
Pipelines	40 years
Towns & Rural Water Supply Structures	40 years
Irrigation Structures	40 years
Electrical - Mechanical Equipment	15 years in regular operation

Source: SOGREAH report

8.1.2 Basis for Setting Unit Cost and Construction Cost for the Project

(1) Integrated Project

1) Upgraded Kamuzu Barrage

The construction cost of the upgraded Kamuzu barrage at Liwonde was estimated at 27.96 MUSD according to the Final Feasibility Study Report on The Integrated Water Resources Development Plan for Lake Malawi and Shire River System “Lake Malawi Level Control” – Stage 2 (Norconsult, 2003), with conversion into the present value in 2012.

(2) Water Supply for Four Cities

1) New Water Source Development

As for the new water source development project for Lilongwe, Blantyre, Mzuzu City, the feasibility study has been implemented by Sogreah in 2009-2010 and the validity of the respective projects have been verified by the World Bank in 2012 and the projects for the three cities are currently ongoing.

The construction costs were estimated on the basis of the costs estimated in the respective reports. As for the cost of heightening the Mulunguzi Dam at Zomba City, the project cost is estimated at 10.20 mil USD with reference to the estimated project cost of heightening the Kamuzu Dam being planned in Lilongwe City.

(i) Other Improvement Projects

(a) Network Expansion

As for the construction costs of network expansion, it is estimated as the product of the served population for expansion water supply area and the unit price for distribution pipe of 176 USD/capita which is estimated by the unit price for distribution pipe works per meter and the pipe length per capita of Lilongwe City in 2008. The unit price for distribution pipe works per meter is estimated by multiplying the length of pipeline with each diameter and the unit cost of pipeline with each diameter listed in **Table 8.1.5**. The following unit costs include supply cost and laying cost. The supply costs include the pipes, the fittings and valves and transport to the site. Steel pipes are used for all pipeline cost estimates. Pipe laying costs include trench excavation, pipe installation, backfilling of both loose soil and rocky soil, and pipeline flushing and testing.

Table 8.1.5 Unit Costs of Pipeline

Diameter	Pressure class	Unit Cost
mm	bars	USD/m
50	21	32
75	21	48
100	21	65
150	21	97
200	21	129
250	21	152
300	21	170
350	21	187
400	21	210
500	21	302
800	21	564

Source: Project Team based on SOGREAH report

(ii) Others

As for the construction costs of the other improvement projects such as the development of new groundwater borehole, extension of WTP, network improvement and rehabilitation, etc., they are estimated as project costs with reference to the reports of the Future Investment Plan, etc., of each city.

(3) Water Supply for Towns and Rural Water Supply

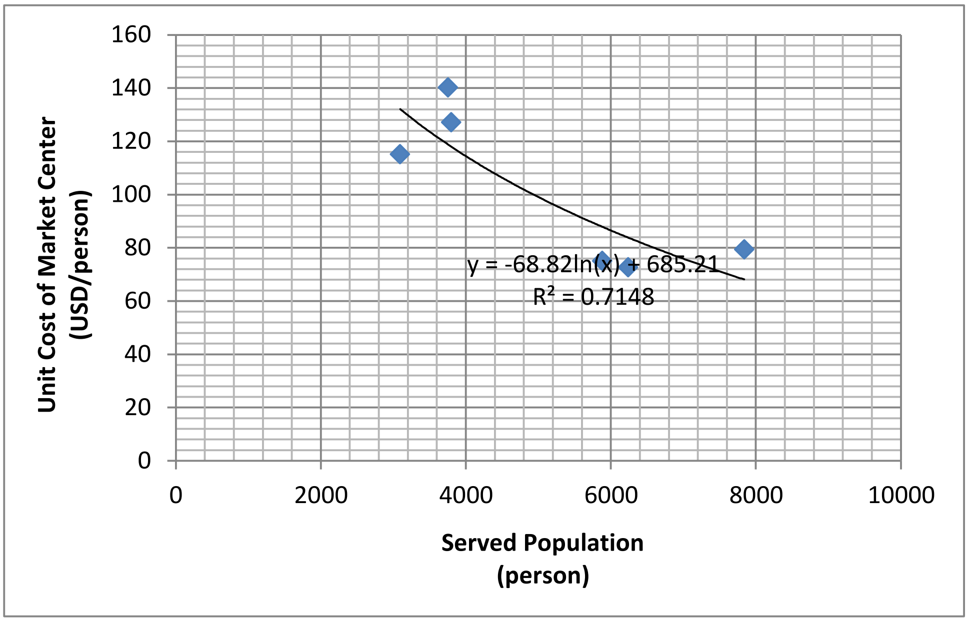
1) Towns and Market Center

(i) Case of Groundwater for Water Source

Towns utilize groundwater and surface water as water source in the water supply scheme. Also, the Market Center generally utilizes groundwater sources which are abstracted by means of boreholes equipped with submersible motor pumps, also raw water for groundwater is safe for human consumption. Therefore, water supply facility consists of submersible pumps for groundwater, transmission pipelines, elevated tank (including chlorination), distribution systems and public taps, with groundwater for water source.

The construction costs of water supply facilities utilizing groundwater are estimated by using the formula of the approximated curve which made served population the variable of this formula based on the unit costs of the similar projects and existing reports.

The figure of the approximated curve which shows the relation between unit cost per person and served population is shown as follows. However, the unit costs are set at 140 USD/person as upper limit and 40 USD/person as lower limit.



Source: Project Team based on existing reports

Figure 8.1.1 Approximated Curve between Unit Cost of MC and Served Population (Case of Groundwater for Water Source)

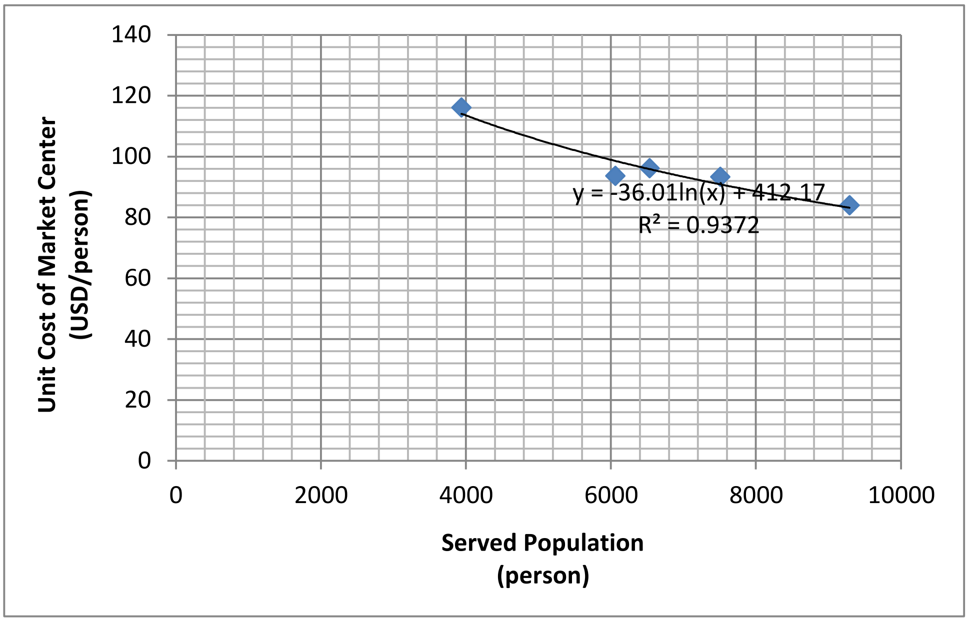
(ii) Case of Surface Water for Water Source

Concerning the investment costs for the water source of the towns and the market center, it becomes generally more expensive to adopt surface water than groundwater. However, when a good well cannot be hydrologically developed near the market center, there is no choice but to depend on surface water such as abstracting from river. When surface water as the water source is adopted, such as river, filtration treatment is generally necessary as the water-purifying process. In this Study, the water-purifying process in case surface water is the water source is set as the coagulation/sedimentation and rapid sand filtration process in consideration of safety.

Therefore, the water supply facility for the market center consists of intake weir, transmission pipelines, coagulation/sedimentation tank, rapid sand filters, service reservoir, distribution systems and public taps, with surface water as the water source.

The construction costs of water supply facilities for the market center utilizing surface water are estimated by using the formula of the approximated curve which made the served population the variable of this formula based on the unit costs of similar projects in the existing reports.

The figure of the approximated curve which shows the relation between unit cost per person and served population is shown as follows. However, the unit costs are set at 140 USD/person as the upper limit and 60 USD/person as the lower limit.



Source: Project Team, based on existing reports

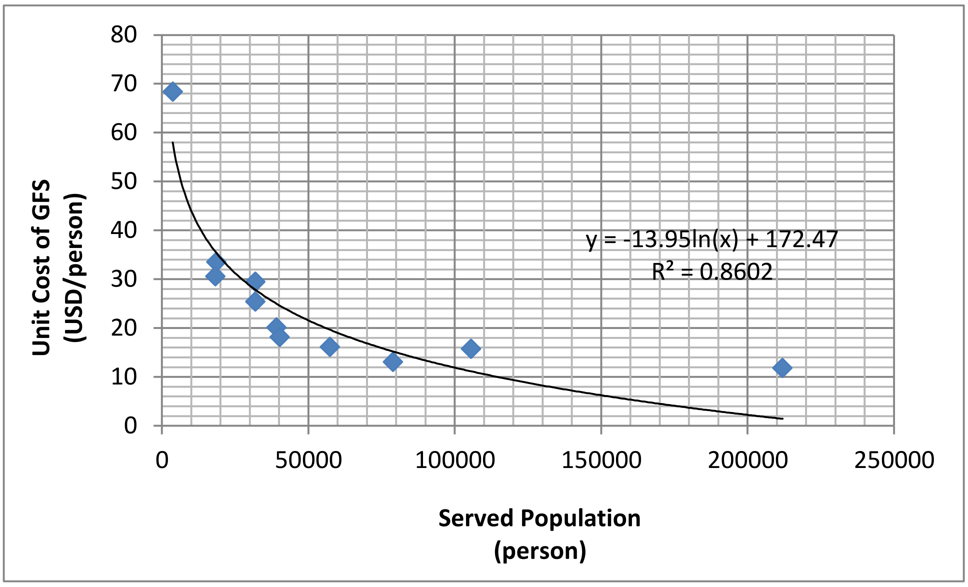
Figure 8.1.2 Approximated Curve between Unit Cost of MC and Served Population (Case of Surface Water as Water Source)

2) Community by Gravity-Fed Piped Water Supply

Gravity-fed WS generally utilizes surface water sources which are abstracted from river/mountain stream. It is recommended that roughening filters and slow sand filters are adopted as treatment process for the raw water, turbidity removal and bacteriological treatment. Water supply facilities for the Gravity-fed System shall be comprised of intake weir, transmission pipelines, roughening filters, slow sand filters, service reservoir, distribution systems and public taps.

The construction costs of water supply facilities for the gravity-fed system are estimated by using the formula of the approximated curve which made served population the variable of this formula based on the unit costs of similar projects and existing reports on the rehabilitation of existing water supply facilities.

The figure of the approximated curve which shows the relation between unit cost per person and served population is shown as follows. However, the unit costs are set at 40 USD/person as the upper limit and 10 USD/person as the lower limit.



Source: Project Team based on existing reports

Figure 8.1.3 Approximated Curve between Unit Cost of Gravity-Fed Piped WS and the Served Population

3) Community by Borehole Water Supply (Deep Well with Hand Pump)

The costs of deep well with hand pump (Afridev pump) are estimated on the basis of similar projects under the condition that one deep well serves 250 people. The unit cost is estimated at 4,500 USD/deep well, which include site works, drilling, pump installation and ancillary works and water quality analysis.

(4) Agriculture & Irrigation

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 as shown below are considered applicable for irrigation development.

Table 8.1.6 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 based on existing project costs from DoI and GBI

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

Table 8.1.7 Applicability Criteria for Structural Measures in Irrigation Development

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

2) Unit Cost of Structural Measures for Irrigation Development

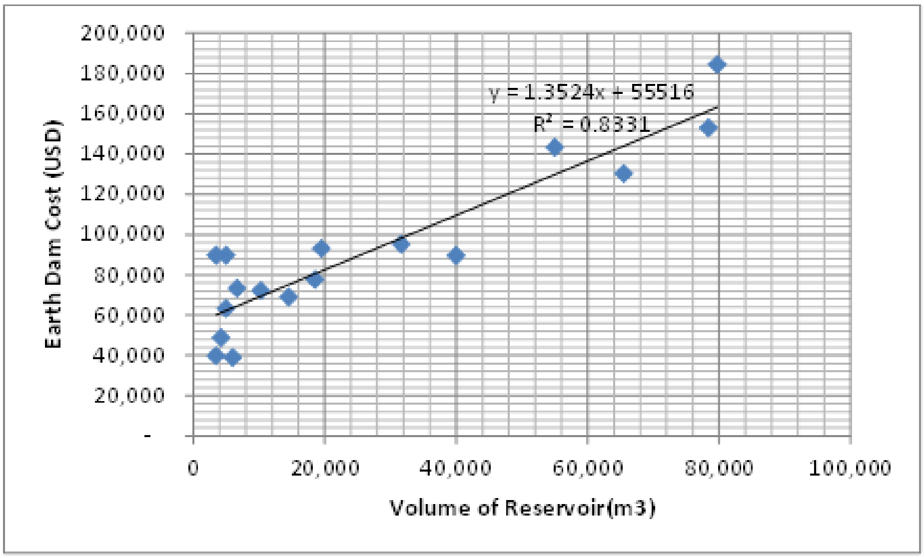
Irrigation development costs are worked out by multiplying the irrigation area with the unit cost (USD/ha) obtained from similar project costs and data from the relevant reports. Unit costs are shown in the following table based on the above-mentioned applicability criteria.

Table 8.1.8 Unit Cost for Structural Measures

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

Source: Project Team

In order to meet the water deficit, a water storage facility is necessary. The costs of irrigation reservoir of earth dam are calculated by using the formula derived from the past and ongoing 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 8.1.4 Relation between Cost of Earth Dam and Reservoir Volume

8.1.3 Summary of Project Cost

(1) Summary of Project Cost

In this Master Plan, the proposed projects are classified into four sectors; namely, Integrated Project, Water Supply for Four Cities, Water Supply for Towns and Rural Water Supply; and Water Supply for Agriculture and Irrigation. The summary of project cost and breakdown for each term of the proposed projects are shown in **Table 8.1.9**.

Table 8.1.9 Summary of Project Cost in this Master Plan (1/3)

Unit: Million USD

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

Source: Project Team

Table 8.1.10 Summary of Project Cost in this Master Plan (2/3)

Unit: Million USD

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

Source: Project Team

Table 8.1.11 Summary of Project Cost in this Master Plan (3/3)

Unit: Million USD

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

Source: Project Team

(2) Water Supply for Four Cities

1) Breakdown of Project Cost

Breakdown of project cost of Water Supply for the four Cities is shown below.

Table 8.1.12 Summary of Project Cost for New Water Resource Development of Water Supply for the Four Cities

Unit: Million USD

City	Description	Total	Time Frame		
			Short Term	Middle Term	Long Term
			2012 - 2020	2021 - 2025	2026 - 2035
Lilongwe	Construction cost				
	Dam	41.00	41.00	0.00	0.00
	New Water treatment plant	43.00	15.00	15.00	0.00
	Pipelines	90.00	18.00	36.00	0.00
	Balancing tanks	2.00	0.50	0.50	0.00
	Pumping stations	10.00	4.00	4.00	0.00
	Electric lines	0.40	0.20	0.20	0.00
	Resettlement / Compensation Irrigation	14.00	14.00	0.00	0.00
	Fisheries	0.11	0.08	0.03	0.00
	Development Irrigation	4.00	2.00	2.00	0.00
	Sub-total	204.51	94.78	57.73	0.00
	Land acquisition cost	0.02	0.01	0.00	0.00
	Physical contingency	24.54	11.37	6.93	0.00
	Engineering service	22.91	12.84	4.24	0.00
	Administration cost	10.08	4.77	2.75	0.00
	Total	**262.06**	**123.77**	**71.65**	**0.00**
Blantyre	Construction cost				
	River intake	2.22	2.22	0.00	0.00
	Water treatment plant	25.30	12.65	0.00	0.00
	Pipelines	62.85	35.24	0.00	0.00
	Reservoirs	17.52	11.12	0.00	0.00
	Pumping stations	18.72	10.23	0.00	0.00
	Electric lines	0.32	0.32	0.00	0.00
	Sub-total	126.93	71.78	0.00	0.00
	Land acquisition cost	0.00	0.00	0.00	0.00
	Physical contingency	15.23	8.61	0.00	0.00
	Engineering service	14.22	8.04	2.48	0.00
	Administration cost	6.26	3.54	0.10	0.00
	Total	**162.64**	**91.97**	**2.58**	**0.00**
Mzuzu	Construction cost				
	Dam	36.61	18.00	0.00	0.00
	Transmission system to WTP	30.77	15.07	0.00	0.00
	Water treatment plant	21.59	12.95	0.00	0.00
	Treated water tank	3.04	1.52	0.00	0.00
	Transmission system from WTP to service reservoirs	3.03	3.03	0.00	0.00
	Electric lines	0.65	0.03	0.00	0.00
	Sub-total	95.69	50.60	0.00	0.00
	Land acquisition cost	18.20	5.70	0.00	0.00
	Physical contingency	13.67	6.76	0.00	0.00
	Engineering service	12.76	6.31	0.00	0.00
	Administration cost	5.61	2.77	0.00	0.00
	Total	**145.93**	**72.14**	**0.00**	**0.00**
Zomba	Construction cost				
	Raising of Mulunguzi dam	7.96	0.00	0.00	0.00
	Sub-total	7.96	0.00	0.00	0.00
	Land acquisition cost	0.00	0.00	0.00	0.00
	Physical contingency	0.96	0.00	0.00	0.00
	Engineering service	0.89	0.00	0.22	0.00
	Administration cost	0.39	0.00	0.01	0.00
	Total	**10.20**	**0.00**	**0.23**	**0.00**

Source: Project Team

Table 8.1.13 Summary of Project Cost for Other Improvement Projects of Water Supply for the Four Cities (1/2)

City	Description	Total	Time Frame		
			Short Term	Middle Term	Long Term
			2012 - 2020	2021 - 2025	2026 - 2035
Lilongwe	Construction cost				
	Development new groundwater borehole (+10,000m3/d)	4.06	4.06	0.00	0.00
	Sub-total	4.06	4.06	0.00	0.00
	Land acquisition cost	0.00	0.00	0.00	0.00
	Physical contingency	0.49	0.49	0.00	0.00
	Engineering service	0.45	0.45	0.00	0.00
	Administration cost	0.20	0.20	0.00	0.00
	Total	**5.20**	**5.20**	**0.00**	**0.00**
	Construction cost				
	Extension Existing TWII (purification plant: +30,000m3/d)	3.90	3.90	0.00	0.00
	Sub-total	3.90	3.90	0.00	0.00
	Land acquisition cost	0.00	0.00	0.00	0.00
	Physical contingency	0.47	0.47	0.00	0.00
	Engineering service	0.44	0.44	0.00	0.00
	Administration cost	0.19	0.19	0.00	0.00
	Total	**5.00**	**5.00**	**0.00**	**0.00**
	Construction cost				
	Raising Kamuzu dam I and associated rehabilitation works (+30,000m3/d)	3.97	3.97	0.00	0.00
	Sub-total	3.97	3.97	0.00	0.00
	Land acquisition cost	0.00	0.00	0.00	0.00
	Physical contingency	0.48	0.48	0.00	0.00
	Engineering service	0.45	0.45	0.00	0.00
	Administration cost	0.20	0.20	0.00	0.00
	Total	**5.10**	**5.10**	**0.00**	**0.00**
	Construction cost				
	Extension Existing TWII(2nd) (purification plant: +30,000m3/d) and Technical Assistance	7.57	7.57	0.00	0.00
	Sub-total	7.57	7.57	0.00	0.00
	Land acquisition cost	0.00	0.00	0.00	0.00
	Physical contingency	0.91	0.91	0.00	0.00
	Engineering service	0.85	0.85	0.00	0.00
	Administration cost	0.37	0.37	0.00	0.00
	Total	**9.70**	**9.70**	**0.00**	**0.00**
	Construction cost				
	Network improvement	0.15	0.15	0.00	0.00
	Sub-total	0.15	0.15	0.00	0.00
	Land acquisition cost	0.00	0.00	0.00	0.00
	Physical contingency	0.02	0.02	0.00	0.00
	Engineering service	0.02	0.02	0.00	0.00
	Administration cost	0.01	0.01	0.00	0.00
	Total	**0.20**	**0.20**	**0.00**	**0.00**
	Construction cost				
	Rehabilitation of Existing TWII	3.12	2.08	1.04	0.00
	Sub-total	3.12	2.08	1.04	0.00
	Land acquisition cost	0.00	0.00	0.00	0.00
	Physical contingency	0.37	0.24	0.13	0.00
	Engineering service	0.35	0.24	0.11	0.00
	Administration cost	0.15	0.10	0.05	0.00
	Total	**4.00**	**2.66**	**1.34**	**0.00**
	Construction cost				
	Network expansion	176.23	33.03	55.05	88.15
	Sub-total	176.23	33.03	55.05	88.15
	Land acquisition cost	0.00	0.00	0.00	0.00
	Physical contingency	21.15	3.96	6.60	10.59
	Engineering service	19.74	3.69	6.15	9.90
	Administration cost	8.68	1.62	2.70	4.36
	Total	**225.80**	**42.30**	**70.50**	**113.00**

Source: Project Team

Table 8.1.14 Summary of Project Cost for Other Improvement Projects of Water Supply for the Four Cities (2/2)

Unit: Million USD

City	Description	Total	Time Frame		
			Short Term	Middle Term	Long Term
			2012 - 2020	2021 - 2025	2026 - 2035
Blantyre	Construction cost				
	Network improvement	7.02	7.02	0.00	0.00
	Sub-total	7.02	7.02	0.00	0.00
	Land acquisition cost	0.00	0.00	0.00	0.00
	Physical contingency	0.84	0.84	0.00	0.00
	Engineering service	0.79	0.79	0.00	0.00
	Administration cost	0.35	0.35	0.00	0.00
	Total	**9.00**	**9.00**	**0.00**	**0.00**
	Construction cost				
	Network expansion	101.30	18.99	31.65	50.66
	Sub-total	101.30	18.99	31.65	50.66
	Land acquisition cost	0.00	0.00	0.00	0.00
	Physical contingency	12.16	2.28	3.80	6.08
	Engineering service	11.35	2.13	3.55	5.67
	Administration cost	4.99	0.93	1.55	2.51
	Total	**129.80**	**24.33**	**40.55**	**64.92**
	Construction cost				
	Poverty program (Kiosk and Toilet development)	10.93	2.73	8.20	0.00
	Sub-total	10.93	2.73	8.20	0.00
	Land acquisition cost	0.00	0.00	0.00	0.00
	Physical contingency	1.31	0.33	0.98	0.00
	Engineering service	1.22	0.31	0.91	0.00
	Administration cost	0.54	0.13	0.41	0.00
	Total	**14.00**	**3.50**	**10.50**	**0.00**
Mzuzu	Construction cost				
	Network improvement	1.40	0.56	0.84	0.00
	Sub-total	1.40	0.56	0.84	0.00
	Land acquisition cost	0.00	0.00	0.00	0.00
	Physical contingency	0.17	0.06	0.11	0.00
	Engineering service	0.16	0.06	0.10	0.00
	Administration cost	0.07	0.02	0.05	0.00
	Total	**1.80**	**0.70**	**1.10**	**0.00**
	Construction cost				
	Network expansion	63.06	14.84	18.55	29.67
	Sub-total	63.06	14.84	18.55	29.67
	Land acquisition cost	0.00	0.00	0.00	0.00
	Physical contingency	7.57	1.80	2.25	3.52
	Engineering service	7.06	1.68	2.10	3.28
	Administration cost	3.11	0.72	0.90	1.49
	Total	**80.80**	**19.04**	**23.80**	**37.96**
Zomba	Construction cost				
	Expansion existing TW (18,200m3/d to 30,000m3/d)	6.36	6.36	0.00	0.00
	Sub-total	6.36	6.36	0.00	0.00
	Land acquisition cost	0.00	0.00	0.00	0.00
	Physical contingency	0.76	0.76	0.00	0.00
	Engineering service	0.71	0.71	0.00	0.00
	Administration cost	0.31	0.31	0.00	0.00
	Total	**8.14**	**8.14**	**0.00**	**0.00**
	Construction cost				
	Network improvement	2.81	2.24	0.57	0.00
	Sub-total	2.81	2.24	0.57	0.00
	Land acquisition cost	0.00	0.00	0.00	0.00
	Physical contingency	0.34	0.28	0.06	0.00
	Engineering service	0.31	0.24	0.07	0.00
	Administration cost	0.14	0.12	0.02	0.00
	Total	**3.60**	**2.88**	**0.72**	**0.00**
	Construction cost				
	Network expansion	5.70	0.76	1.90	3.04
	Sub-total	5.70	0.76	1.90	3.04
	Land acquisition cost	0.00	0.00	0.00	0.00
	Physical contingency	0.68	0.10	0.25	0.33
	Engineering service	0.64	0.08	0.20	0.36
	Administration cost	0.28	0.04	0.10	0.14
	Total	**7.30**	**0.98**	**2.45**	**3.87**

Source: Project Team

(3) Water Supply for Towns and Rural Water Supply

2) Breakdown of Project Cost

Breakdown of project cost of Water Supply for Towns and Rural Water Supply is shown below.

Table 8.1.15 Summary of Project Cost of Water Supply for Towns and Rural Water Supply

Unit: Million US$

Classification	Description	Total	Time Frame		
			Short Term	Middle Term	Long Term
			2012 - 2020	2021 - 2025	2026 - 2035
Towns	Construction cost				
	Northern region	22.95	11.26	8.47	3.22
	Central region	37.85	19.21	9.48	9.16
	Southern region	51.03	20.31	30.09	0.63
	Sub-total	111.83	50.78	48.04	13.01
	Land acquisition cost	0.00	0.00	0.00	0.00
	Physical contingency	13.41	6.09	5.76	1.56
	Engineering service	12.53	5.69	5.38	1.46
	Administration cost	5.51	2.50	2.37	0.64
	Total	**143.28**	**65.06**	**61.55**	**16.67**
Market Center	Construction cost				
	Northern region	22.10	14.07	5.96	2.07
	Central region	37.83	25.88	7.51	4.44
	Southern region	36.25	20.55	5.93	9.77
	Sub-total	96.18	60.50	19.40	16.28
	Land acquisition cost	0.00	0.00	0.00	0.00
	Physical contingency	11.54	7.26	2.33	1.95
	Engineering service	10.77	6.78	2.17	1.82
	Administration cost	4.74	2.98	0.96	0.80
	Total	**123.23**	**77.52**	**24.86**	**20.85**
Community by Gravity-fed WS	Construction cost				
	Northern region	23.90	6.77	13.07	4.06
	Central region	24.75	12.43	10.62	1.70
	Southern region	58.13	38.21	11.03	8.89
	Sub-total	106.78	57.41	34.72	14.65
	Land acquisition cost	0.00	0.00	0.00	0.00
	Physical contingency	12.82	6.89	4.17	1.76
	Engineering service	11.96	6.43	3.89	1.64
	Administration cost	5.26	2.83	1.71	0.72
	Total	**136.82**	**73.56**	**44.49**	**18.77**
Community by Borehole WS	Construction cost				
	Northern region	21.02	5.26	5.26	10.50
	Central region	124.19	31.05	31.05	62.09
	Southern region	79.13	19.80	19.80	39.53
	Sub-total	224.34	56.11	56.11	112.12
	Land acquisition cost	0.00	0.00	0.00	0.00
	Physical contingency	26.91	6.73	6.73	13.45
	Engineering service	25.12	6.28	6.28	12.56
	Administration cost	11.05	2.76	2.76	5.53
	Total	**287.42**	**71.88**	**71.88**	**143.66**

Source: Project Team

3) Estimation of Construction Cost

The basis of construction cost estimation is as follows.

Table 8.1.16 Construction Cost of Water Supply for Towns

Region	District	Water Scheme	Population in 2012	Type of Water Source	Population in 2035	Water Demand (m3/day)		Priority	Unit Cost (USD/cpt)	Construction Cost (mil USD)	Short Term 2012-2020 (mil USD)	Middle Term 2021-2025 (mil USD)	Long Term 2026-2035 (mil USD)
						2,012	2,035						
Northern	Chitipa	CHITIPA Boma	23,313	Borehole	75,918	1,237	10,431	A	40	3.04	3.04		
	Karonga	KARONGA Boma	45,368	Lake	97,696	3,628	14,143	B	60	5.86		5.86	
		CHILUMBA	21,732	Lake	43,455	1,552	6,598	B	60	2.61		2.61	
	Nkhata Bay	NKHATABAY	24,334	Lake	36,632	1,802	5,794	C	60	2.20			2.20
		CHINTHECHE	7,933	Lake	15,863	876	2,552	C	64	1.02			1.02
	Rumphi	RUMPHI	44,122	River	73,354	2,361	10,522	A	60	4.40	4.40		
	Mzimba	MZIMBA	27,824	River	63,672	2,566	9,359	A	60	3.82	3.82		
	Total				406,588	14,024	59,400			22.95	11.26	8.47	3.22
Central	Kasungu	KASUNGU	66,117	Dam	143,321	3,034	20,390	A	60	8.60	8.60		
	Nkhotakota	NKHOTAKOTA	32,729	Borehole	55,923	1,735	8,352	A	40	2.24	2.24		
		DWANGWA	12,662	Borehole	26,009	459	3,599	B	40	1.04		1.04	
	Ntchisi	NTCHISI	18,404	Borehole	38,483	828	5,379	B	40	1.54		1.54	
	Dowa	DOWA	16,298	Borehole & River	39,293	636	5,540	C	40	1.57			1.57
		MPONELA	20,745	Borehole	50,013	719	6,963	A	40	2.00	2.00		
		MADISI	10,507	Borehole	25,331	357	3,561	B	40	1.01		1.01	
	Salima	SALIMA	42,838	Borehole	89,575	2,274	13,041	B	40	3.58		3.58	
		SENGA-BAY	2,929	Borehole	5,718	240	807	C	90	0.51			0.51
		CHIPOKA	3,371	Lake	6,582	303	1,136	C	96	0.63			0.63
		PARACHUTTE BATTALLION	1,346	Borehole	1,346	623	777	B	140	0.19		0.19	
		MAFCO	5,457	Lake	5,457	2,910	3,547	C	102	0.56			0.56
	Lilongwe Rural	LIKUNI	52,160	Borehole	92,620	2,802	14,042	A	40	3.70	3.70		
		BUNDA	27,109	Dam	48,137	502	6,881	C	60	2.89			2.89
	Mchinji	MCHINJI	17,288	Borehole & River	39,737	1,586	5,933	B	40	1.59		1.59	
		KOCHILIRA	4,515	Borehole	10,043	410	1,932	C	51	0.51			0.51
	Dedza	DEDZA	36,747	Borehole	66,850	1,573	9,080	A	40	2.67	2.67		
		BEMBEKE	1,937	River	3,308	89	509	C	120	0.40			0.40
		DEDZA SECONDARY SCHOOL	2,982	River	5,093	381	1,222	B	105	0.53		0.53	
	Ntcheu	NTCHEU	14,953	Borehole & River	34,915	879	4,835	C	60	2.09			2.09
	Total				787,754	22,338	117,526			37.85	19.21	9.48	9.16
Southern	Mangochi	MANGOCHI	34,944	River	80,322	2,895	11,618	B	60	4.82		4.82	
		MONKEYBAY	14,300	Lake	32,467	1,824	5,806	B	60	1.95		1.95	
		NAMWERA	7,626	Borehole	17,314	398	2,458	A	40	0.69	0.69		
	Machinga	MACHINGA	3,909	River	8,184	914	2,132	B	88	0.72		0.72	
		LIWONDE	26,977	River	61,593	2,028	8,337	A	60	3.70	3.70		
	Balaka	BALAKA	31,340	Dam	78,360	1,907	10,646	A	60	4.70	4.70		
	Zomba rural	DOMASI	144,186	River	284,564	569	1,675	B	60	17.07		17.07	
		CHAWE	8,065	River	12,243	566	1,040	A	73	0.89	0.89		
	Chiradzulu	CHIRADZULU	2,426	River	3,683	234	695	B	116	0.43		0.43	
		NAMADZI Trading Center	3,182	River	4,287	217	541	C	111	0.48			0.48
	Mwanza	MWANZA	2,835	River	3,819	1,100	10,218	B	115	0.44		0.44	
	Thyolo	THYOLO	29,305	River	74,947	1,094	3,396	A	60	4.50	4.50		
	Thyolo	LUCHENZA	9,501	Borehole & River	20,595	924	3,771	A	40	0.82	0.82		
		MIKOLONGWE	15,356	Borehole & River	24,827	62	177	A	40	0.99	0.99		
	Mulanje	MULANJE	684	River	1,047	2,097	5,144	C	140	0.15			0.15
		MULOZA Trading Center	20,685	Borehole	28,233	408	1,504	B	40	1.13		1.13	
	Phalombe	PHALOMBE	7,826	River	10,682	453	3,662	B	78	0.83		0.83	
	Chikwawa	CHIKWAWA	7,865	Borehole	25,737	1,407	5,562	A	40	1.03	1.03		
		NGABU Trading Center	18,674	Borehole	36,879	783	4,339	B	40	1.48		1.48	
		NCHALO Trading Center	15,453	Borehole	30,518	613	4,857	B	40	1.22		1.22	
	Nsanje	NSANJE	17,821	Borehole	35,194	883	5,841	A	40	1.41	1.41		
		BANGULA	21,928	Borehole	39,433	442	2,502	A	40	1.58	1.58		
	Total				914,926	21,817	95,921			51.03	20.31	30.09	0.63
Grand Total					2,109,269	58,179	272,847			111.83	50.78	48.04	13.01

Source: Project Team

Table 8.1.17 Construction Cost for Market Center in Northern Region

Region	District	Water Scheme	Population in 2012	Population in 2025	Population in 2035	Proposed water source	Priority	Unit Cost (USD/cpt)	Construction Cost (mil USD)	Short Term 2012-2020 (mil USD)	Middle Term 2021-2025 (mil USD)	Long Term 2026-2035 (mil USD)
Northern	Chitipa	Nthalire	5,400	8,133	11,021	Groundwater	A	45	0.50	0.50		
		Misuku	6,000	9,037	12,245	River	A	73	0.89	0.89		
		Kameme	4,598	6,925	9,384	Groundwater	B	56	0.53		0.53	
	Karonga	Songwe	4,000	6,144	8,367	Groundwater	A	64	0.54	0.54		
		Chilumba	7,039	10,813	14,724	Lake	A	67	0.99	0.99		
		Nyungwe	2,573	3,952	5,382	Groundwater	B	94	0.51		0.51	
		Chitimba	3,957	6,078	8,277	Groundwater	B	64	0.53		0.53	
		Kaporo	4,218	6,479	8,823	Groundwater	B	60	0.53		0.53	
		Mulare	3,716	5,674	7,726	Groundwater	B	69	0.53		0.53	
	Nkhata-Bay	Mzenga	8,705	12,160	15,256	Groundwater	A	40	0.61	0.61		
		Usisya	6,341	8,857	11,113	River	A	77	0.86	0.86		
		Kande	1,078	1,506	1,889	Groundwater	C	140	0.26			0.26
		Mpamba	9,220	12,880	16,160	Groundwater	A	40	0.65	0.65		
		Chintheche	4,205	5,874	7,370	Lake	B	91	0.67		0.67	
		Chikwina	4,535	6,334	7,948	River	A	89	0.71	0.71		
	Likoma	Likoma	7,683	10,755	14,140	Lake	A	68	0.96	0.96		
	Rumphi	Katowo	3,718	5,554	7,434	River	A	91	0.68	0.68		
		Nchenachena	6,691	9,995	13,379	River	A	70	0.94	0.94		
		Livingstonia	9,321	13,925	18,638	River	A	60	1.12	1.12		
		Mphompha	4,887	7,301	9,773	Groundwater	B	53	0.52		0.52	
		Bolero	8,046	12,020	16,088	River	A	63	1.01	1.01		
		Chiweta	5,314	7,939	10,626	Groundwater	A	47	0.50	0.50		
	Mzimba	Euthini	5,699	8,579	11,396	Groundwater	A	42	0.48	0.48		
		Emfeni	1,925	2,898	3,849	Groundwater	C	117	0.45			0.45
		Ekwendeni	13,695	20,616	27,386	River	A	60	1.64	1.64		
		Mbalachanda	3,750	5,645	7,499	Groundwater	B	71	0.53		0.53	
		Bulala	2,984	4,492	5,967	Groundwater	B	87	0.52		0.52	
		Edingeni	5,503	8,284	11,004	Groundwater	A	45	0.50	0.50		
		Chikangawa	2,751	4,141	5,501	River	B	102	0.56		0.56	
		Embangweni	5,489	8,263	10,976	Groundwater	A	45	0.49	0.49		
		Champhira	1,875	2,823	3,749	River	C	116	0.43			0.43
		Kafukule	2,500	3,763	4,999	Groundwater	C	99	0.49			0.49
		Manyamula	1,832	2,758	3,663	Groundwater	C	120	0.44			0.44
		Jenda	3,089	4,650	6,177	Groundwater	B	85	0.53		0.53	
	Total	**34**	**172,337**	**255,247**	**337,932**				**22.10**	**14.07**	**5.96**	**2.07**

Source: Project Team

Table 8.1.18 Construction Cost for Market Center in Central Region

Region	District	Water Scheme	Population in 2012	Population in 2025	Population in 2035	Proposed water source	Priority	Unit Cost (USD/cpt)	Construction Cost (mil USD)	Short Term 2012-2020 (mil USD)	Middle Term 2021-2025 (mil USD)	Long Term 2026-2035 (mil USD)
Central	Kasungu	Nkhamenya	6,990	15,569	25,057	River	A	60	1.50	1.50		
		Chisemphere	3,540	7,885	12,691	River	A	72	0.91	0.91		
		Chamama	7,400	16,484	26,528	River	A	60	1.59	1.59		
		Santhe	6,286	14,002	22,535	River	A	60	1.35	1.35		
	Nkhotakota	Msenjere	3,730	5,833	8,085	Groundwater	A	66	0.53	0.53		
		Dwambazi	8,000	12,510	17,342	River	A	61	1.06	1.06		
		Dwangwa	12,662	19,801	27,448	Groundwater	A	40	1.10	1.10		
		Mwasambo	6,400	10,008	13,873	Groundwater	A	40	0.55	0.55		
		Benga	4,130	6,458	8,953	Groundwater	B	59	0.53		0.53	
		Bua	2,190	3,425	4,747	Groundwater	C	103	0.49			0.49
		Liwalazi	1,980	3,096	4,292	Groundwater	C	110	0.47			0.47
		Kasitu	2,100	3,284	4,552	Groundwater	C	106	0.48			0.48
		Ngala	2,430	3,800	5,267	Groundwater	B	95	0.50		0.50	
	Ntchisi	Malomo	4,200	5,185	5,741	Groundwater	A	90	0.52	0.52		
		Khuwi	1,908	2,355	2,608	Groundwater	C	140	0.37			0.37
	Dowa	Madisi	10,500	15,831	21,568	Groundwater	A	40	0.86	0.86		
		Nambuma	4,870	7,342	10,003	Groundwater	A	51	0.51	0.51		
		Bowe	3,400	5,126	6,984	Groundwater	B	76	0.53		0.53	
		Mvera	3,968	5,982	8,151	Groundwater	B	65	0.53		0.53	
		Mponela	4,300	6,483	8,833	Groundwater	A	60	0.53	0.53		
		Lumbazi	4,500	6,785	9,243	Groundwater	A	57	0.53	0.53		
	Salima	Thavite	1,460	2,247	3,125	Groundwater	C	131	0.41			0.41
		Chagunda	1,800	2,770	3,852	Groundwater	C	117	0.45			0.45
		Khombedza	2,800	4,309	5,993	Groundwater	B	87	0.52		0.52	
		Chipoka	7,640	11,756	16,351	River	A	63	1.03	1.03		
		Kaphatenga	2,400	3,693	5,137	Groundwater	A	97	0.50	0.50		
	Lilongwe	Kasiya	3,915	6,630	9,439	Groundwater	A	55	0.52	0.52		
		Nkhoma	5,320	9,009	12,826	Groundwater	A	40	0.51	0.51		
		Nsaru	2,620	4,436	6,316	Groundwater	A	83	0.52	0.52		
		Namitete	6,891	11,669	16,613	Groundwater	A	40	0.66	0.66		
		Sinyala	2,400	4,064	5,786	Groundwater	B	89	0.51		0.51	
		Mitundu	6,872	11,637	16,568	Groundwater	A	40	0.66	0.66		
		Nathenje	5,645	9,559	13,609	River	A	69	0.94	0.94		
		Chimutu	2,800	4,741	6,750	Groundwater	B	78	0.53		0.53	
		Lumbadzi	7,400	12,531	17,840	Groundwater	A	40	0.71	0.71		
		Kabudula	2,130	3,607	5,135	Groundwater	B	97	0.50		0.50	
		Mpingu	1,980	3,353	4,774	Groundwater	C	102	0.49			0.49
	Mchinji	Mkanda	8,750	12,023	15,537	Groundwater	A	40	0.62	0.62		
		Kapiri	5,645	7,757	10,024	Groundwater	A	51	0.51	0.51		
		Kamwendo	10,110	13,893	17,953	Groundwater	A	40	0.72	0.72		
		Kochirira	1,780	2,446	3,161	Groundwater	C	131	0.41			0.41
		Nthema	1,850	2,542	3,285	Groundwater	C	128	0.42			0.42
	Dedza	Mtakataka	6,369	12,826	19,732	Groundwater	A	40	0.79	0.79		
		Mayani	5,039	10,147	15,611	Groundwater	A	40	0.62	0.62		
		Linthipe	3,886	7,825	12,038	Groundwater	A	40	0.48	0.48		
		Lobi	9,905	19,947	30,687	Groundwater	A	40	1.23	1.23		
		Golomoti	6,400	12,888	19,828	Groundwater	A	40	0.79	0.79		
		Chimbiya	1,750	3,524	5,422	Groundwater	B	93	0.50		0.50	
		Bembeke	2,500	5,034	7,745	River	A	90	0.70	0.70		
	Ntcheu	Lizulu	4,696	7,412	10,444	River	A	79	0.83	0.83		
		Senzani	5,333	8,419	11,863	Groundwater	A	40	0.47	0.47		
		Bwanje	4,137	6,531	9,202	Groundwater	B	57	0.52		0.52	
		Bilila	3,665	5,786	8,153	Groundwater	B	65	0.53		0.53	
		Tsangano	2,659	4,198	5,915	River	B	99	0.59		0.59	
		Manjawira	3,000	4,736	6,673	River	B	95	0.63		0.63	
		Chingeni	2,700	4,262	6,005	River	B	99	0.59		0.59	
		Mlangeni	3,000	4,736	6,673	Groundwater	A	79	0.53	0.53		
		Kampepuza	1,800	2,841	4,004	River	C	113	0.45			0.45
	Total	**58**	**264,532**	**443,027**	**634,567**				**37.83**	**25.88**	**7.51**	**4.44**

Source: Project Team

Table 8.1.19 Construction Cost for Market Center in Southern Region

Region	District	Water Scheme	Population in 2012	Population in 2025	Population in 2035	Proposed water source	Priority	Unit Cost (USD/cpt)	Construction Cost (mil USD)	Short Term 2012-2020 (mil USD)	Middle Term 2021-2025 (mil USD)	Long Term 2026-2035 (mil USD)
Southern	Mangochi	Makanjira	5,800	8,174	10,551	Groundwater	A	48	0.51	0.51		
		Malindi	6,800	9,583	12,371	Groundwater	A	40	0.49	0.49		
		Namwera	6,500	9,160	11,825	Groundwater	A	40	0.47	0.47		
		Nankumba	1,200	1,691	2,183	Groundwater	C	140	0.31			0.31
		Chilipa	2,108	2,971	3,835	Groundwater	C	117	0.45			0.45
		Maldeco	5,400	7,781	10,271	Lake	A	80	0.82	0.82		
		Namiyasi	3,450	4,971	6,562	Lake	A	96	0.63	0.63		
		Monkey Bay	6,300	9,078	11,983	Lake	A	74	0.89	0.89		
		Cape Maclear	3,200	4,611	6,086	Lake	A	98	0.60	0.60		
	Balaka	Phalula	7,293	10,740	14,402	River	A	67	0.96	0.96		
		Ulongwe	5,311	7,821	10,488	Groundwater	A	48	0.50	0.50		
		Mangochi Turn off	3,100	4,565	6,122	Groundwater	A	85	0.52	0.52		
		Kachenga	2,170	3,196	4,285	Groundwater	C	110	0.47			0.47
	Machinga	Nayuchi	3,200	4,611	6,086	Groundwater	A	86	0.52	0.52		
		Ngokwe	1,800	2,594	3,424	Groundwater	C	125	0.43			0.43
		Chikweo	1,740	2,507	3,309	Groundwater	C	127	0.42			0.42
		Nsanama	2,175	3,134	4,137	River	C	112	0.46			0.46
		Ntaja	2,181	3,143	4,149	River	C	112	0.46			0.46
	Zomba	Namwera T/Off	1,800	2,865	4,087	River	C	113	0.46			0.46
		Turn Off (Malosa)	1,202	1,913	2,729	River	C	127	0.35			0.35
		Chinseu	2,700	4,297	6,130	River	A	98	0.60	0.60		
		Jali	3,240	5,156	7,356	River	B	92	0.68		0.68	
		Kachulu	1,348	2,145	3,061	Groundwater	C	133	0.41			0.41
		Mayaka	3,400	5,411	7,719	Groundwater	B	69	0.53		0.53	
		Chingale	3,600	5,729	8,173	River	B	88	0.72		0.72	
		Malosa	2,145	3,414	4,870	River	C	106	0.52			0.52
		Thondwe	4,115	6,549	9,343	Groundwater	A	56	0.52	0.52		
	Chiradzulu	Namadzi	2,944	4,454	6,163	River	B	98	0.60		0.60	
		Namitambo	1,500	2,270	3,140	Groundwater	C	131	0.41			0.41
		Mbulumbuzi	3,100	4,690	6,490	Groundwater	B	81	0.53		0.53	
		Mbulumbuzi	3,120	4,721	6,532	Groundwater	A	81	0.53	0.53		
		Nguludi	2,150	3,253	4,501	Groundwater	C	106	0.48			0.48
		Milepa	2,130	3,223	4,459	Groundwater	C	107	0.48			0.48
	Blantyre	Lirange Nkula	7,620	15,876	24,935	Groundwater	A	40	1.00	1.00		
		Linjidzi	3,194	6,654	10,451	Groundwater	A	48	0.50	0.50		
		Chikuli	1,460	3,042	4,778	Groundwater	C	102	0.49			0.49
	Mwanza	Thambani	4,200	5,639	6,955	Groundwater	A	76	0.53	0.53		
		Kunenekude	3,800	5,102	6,293	Groundwater	B	83	0.52		0.52	
	Neno	Neno	2,281	3,177	4,181	Groundwater	C	111	0.46			0.46
		Lisungwi	2,350	3,274	4,308	Groundwater	C	109	0.47			0.47
	Thyolo	Thekerani	4,087	6,714	9,394	Groundwater	B	56	0.53		0.53	
		Goliati	6,804	11,178	15,640	Groundwater	A	40	0.63	0.63		
		Bvumbwe	8,800	14,457	20,228	Groundwater	A	40	0.81	0.81		
		Luchenza	16,901	27,766	38,848	River	A	60	2.33	2.33		
		Masamanjati	2,800	4,600	6,436	Groundwater	B	82	0.53		0.53	
	Mulanje	Muloza	5,248	6,325	7,039	Groundwater	A	76	0.53	0.53		
		Chinyama	1,347	1,623	1,807	River	C	140	0.25			0.25
		Nkando	1,375	1,657	1,844	River	C	140	0.26			0.26
		Mkando	5,285	6,369	7,089	Groundwater	A	75	0.53	0.53		
		Kamwendo	4,855	5,851	6,512	River	A	96	0.63	0.63		
	Phalombe	Migowi	2,456	3,115	3,759	River	C	116	0.44			0.44
		Chitekesa	1,895	2,404	2,901	River	C	125	0.36			0.36
		Sombani	6,120	7,763	9,368	River	B	83	0.78		0.78	
		Mulomba	2,125	2,695	3,253	Groundwater	C	129	0.42			0.42
		Chiringa	3,120	3,957	4,776	River	C	107	0.51			0.51
		Phaloni	4,180	5,302	6,398	River	A	97	0.62	0.62		
	Chikwawa	Chapananga	6,027	7,192	8,227	River	A	88	0.72	0.72		
		Ngabu	15,889	18,959	21,687	Groundwater	A	40	0.87	0.87		
		Nchalo	18,323	21,865	25,010	Groundwater	A	40	1.00	1.00		
	Nsanje	Bangula	10,147	14,401	19,020	Groundwater	A	40	0.76	0.76		
		Miseu Folo	4,250	6,032	7,967	Groundwater	A	67	0.53	0.53		
		Marka	3,032	4,303	5,683	Groundwater	B	90	0.51		0.51	
	Total	**62**	**268,191**	**387,714**	**511,605**				**36.25**	**20.55**	**5.93**	**9.77**
All Malawi		**154**	**705,059**	**1,085,987**	**1,484,104**				**96.18**	**60.50**	**19.40**	**16.28**

Source: Project Team

Table 8.1.20 Construction Cost for Communities with Gravity-Fed WS in Northern and Central Regions

No.	Region	District	Gravity scheme	Original Schemes			Planned Population			Priority	Unit Cost (USD/cpt)	Construction Cost (mil USD)	Short Term 2012-2020 (mil USD)	Middle Term 2021-2025 (mil USD)	Long Term 2026-2035 (mil USD)
				Designed Population	Design flow (m^3/day)	Year completed	2,015	2,025	2,035						
1		MZIMBA	Champhira South	32,000	1334.88	1987	78,553	107,467	142,759	**B**	**10**	**1.43**		**1.43**	
2		MZIMBA	Champhira North	24,000	1367.28	1984	65,131	89,105	118,366	**B**	**10**	**1.18**		**1.18**	
3		MZIMBA	Luwazi	8,000	466.56	1981	24,001	32,835	43,618	**C**	**23**	**1.00**			**1.00**
4		MZIMBA	Luzi	8,000	330.48	1975	29,332	40,129	53,308	**B**	**21**	**1.12**		**1.12**	
5		MZIMBA	Msaka	3,000	311.04	1986	7,615	10,418	13,839	**C**	**39**	**0.54**			**0.54**
6		MZIMBA	Khosolo	10,356	900.72	1983	29,059	39,756	52,812	**B**	**21**	**1.11**		**1.11**	
7		RUMPHI	Nkhamanga	12,000	1088.64	1978	34,960	47,549	63,643	**A**	**18**	**1.15**	**1.15**		
8		RUMPHI	Hewe	8,000	388.8	1977	24,006	32,651	43,701	**A**	**23**	**1.01**	**1.01**		
9		RUMPHI	Ng'onga	2,000	311.04	1972	6,957	9,463	12,665	**A**	**40**	**0.51**	**0.51**		
10		RUMPHI	Livingstonia	3,000	136.08	1984	7,320	9,955	13,325	**A**	**40**	**0.53**	**0.53**		
11		RUMPHI	Muhuju	1,000	395.28	1973	3,377	4,594	6,148	**A**	**40**	**0.25**	**0.25**		
12		RUMPHI	Ntchenachena	3,200	790.56	2002	4,586	6,238	8,349	**A**	**40**	**0.33**	**0.33**		
13		RUMPHI	Chitimba	950	414.72	1997	1,578	2,147	2,873	**A**	**40**	**0.11**	**0.11**		
14		RUMPHI	Bale	4,800	233.28	1994	8,714	11,852	15,864	**B**	**38**	**0.60**		**0.60**	
15	Northern	NKATA BAY	Lifutazi	11,000	414.72	1987	23,139	29,812	37,405	**B**	**26**	**0.97**		**0.97**	
16		NKATA BAY	Msese	7,560	207.36	1991	14,240	18,346	23,019	**B**	**32**	**0.74**		**0.74**	
17		NKATA BAY	Luwawa	8,880	479.52	1999	13,411	17,278	21,678	**B**	**33**	**0.72**		**0.72**	
18		NKATA BAY	Usisya	14880	803.52	1997	23,748	30,596	38,389	**A**	**25**	**0.96**	**0.96**		
19		NKATA BAY	Ruarwe	1008	77.76	1995	1,700	2,190	2,748	**C**	**40**	**0.11**			**0.11**
20		KARONGA	Lufira/Karonga	30,000	1620	1983	84,576	117,516	160,028	**B**	**10**	**1.60**		**1.60**	
21		KARONGA	Chilumba	4,000	239.76	1975	14,735	20,474	27,880	**C**	**30**	**0.84**			**0.84**
22		KARONGA	Ighembe	4,000	233.28	1983	11,277	15,669	21,337	**C**	**33**	**0.70**			**0.70**
23		KARONGA	Iponga	5,600	239.76	1983	15,787	21,936	29,872	**C**	**29**	**0.87**			**0.87**
24		CHITIPA	Chisenga/Chitipa	2,800	1321.92	1986	7,270	9,966	13,505	**B**	**40**	**0.54**		**0.54**	
25		CHITIPA	Misuku	8760	473.04	1984	24,366	33,401	45,260	**A**	**23**	**1.04**	**1.04**		
26		CHITIPA	Nthalire	6120	330.48	1983	17,619	24,151	32,727	**A**	**27**	**0.88**	**0.88**		
27		CHITIPA	Sekwa	10200	550.8	1997	18,141	24,867	33,697	**B**	**27**	**0.91**		**0.91**	
28		CHITIPA	Chinunkha	4200	226.8	1975	15,922	21,825	29,575	**B**	**29**	**0.86**		**0.86**	
29		CHITIPA	Ifumbo	3600	194.4	1982	10,727	14,704	19,925	**B**	**34**	**0.68**		**0.68**	
30		CHITIPA	Chintekwa	5160	278.64	1998	8,867	12,154	16,470	**B**	**37**	**0.61**		**0.61**	
Total				**248,074**			**630,714**	**859,046**	**1,144,786**			**23.90**	**6.77**	**13.07**	**4.06**
31		NTCHEU	Mpira Balaka	222000		1992	394,629	560,229	789,378	**A**	**10**	**7.89**	**7.89**		
32		NTCHEU	Dombole	22,000	946.08	1984	47,649	67,644	95,312	**B**	**13**	**1.24**		**1.24**	
33		NTCHEU	Ntonda	25,000	706.32	1980	59,767	84,847	119,552	**A**	**10**	**1.20**	**1.20**		
34		NTCHEU	Sanjike	12,000	259.2	1980	28,688	40,727	57,385	**B**	**20**	**1.15**		**1.15**	
35		NTCHEU	Kasinje	14,000	615.6	1983	31,080	44,122	62,169	**B**	**18**	**1.12**		**1.12**	
36		NTCHEU	Nanyangu	20,000	764.64	1983	44,400	63,031	88,813	**B**	**14**	**1.24**		**1.24**	
37		NTCHEU	Kalitsiro	1,000	84.24	1977	2,575	3,655	5,150	**A**	**40**	**0.21**	**0.21**		
38		NTCHEU	Chilobwe	1,200	90.72	1975	3,246	4,608	6,493	**A**	**40**	**0.26**	**0.26**		
39		NTCHEU	Lizulu	6,000	220.32	1978	15,070	21,394	30,145	**A**	**29**	**0.87**	**0.87**		
40	Central	MCHINJI	Mchinji	20,000	680.4	1976	71,549	91,614	118,389	**B**	**10**	**1.18**		**1.18**	
41		DEDZA	Ngwere	4200	226.8	1976	12,314	20,769	31,952	**A**	**28**	**0.89**	**0.89**		
42		DEDZA	Mongwera	1,400	64.8	1983	3,430	5,784	8,899	**C**	**40**	**0.36**			**0.36**
43		DEDZA	Mvula	8760	473.04	1983	21,459	36,194	55,683	**A**	**20**	**1.11**	**1.11**		
44		DEDZA	Ngodzi	19800	1069.2	2006	26,877	45,333	69,742	**B**	**17**	**1.19**		**1.19**	
45		NKHOTAKOTA	Mwansambo/ Kasakula	25,000	1542.24	1984	60,057	84,592	117,261	**B**	**10**	**1.17**		**1.17**	
46		NKHOTAKOTA	Mwansambo/ Mwadzama	18,000	648	1983	44,495	62,673	86,876	**B**	**14**	**1.22**		**1.22**	
47		NKHOTAKOTA	Dwambazi	20000	1620	2004	27,124	38,204	52,958	**B**	**21**	**1.11**		**1.11**	
48		SALIMA	Chipoka	10080	544.32	1991	20,931	29,122	40,506	**C**	**24**	**0.97**			**0.97**
49		NTCHISI	Mpamira	1680	90.72	1983	4,316	6,326	9,162	**C**	**40**	**0.37**			**0.37**
Total				**452,120**			**919,655**	**1,310,868**	**1,845,824**			**24.75**	**12.43**	**10.62**	**1.70**

Source: Project Team

Table 8.1.21 Construction Cost for Communities with Gravity-Fed WS in Southern Region

No.	Region	District	Gravity scheme	Original Schemes			Planned Population			Priority	Unit Cost (USD/cpt)	Construction Cost (mil USD)	Short Term 2012-2020 (mil USD)	Middle Term 2021-2025 (mil USD)	Long Term 2026-2035 (mil USD)
				Designed Population	Design flow (m^3/day)	Year completed	2,015	2,025	2,035						
50		MANGOCHI	Lingamasa	12,000	1360.8	1981	28,934	37,608	48,548	C	22	1.07			1.07
51		BALAKA	Mpira-Balaka	222000	11988	1983	457,977	618,008	828,726	A	10	8.29	8.29		
52		MACHINGA	Kawinga	70,000	3240	1983	169,183	224,581	296,443	A	10	2.96	2.96		
53		MACHINGA	Liwonde	23,000	1522.8	1983	55,589	73,791	97,403	A	12	1.17	1.17		
54		MACHINGA	Naungu	1800	97.2	2001	2,600	3,452	4,557	A	40	0.18	0.18		
55		MACHINGA	Nkala	1080	58.32	2002	1,516	2,013	2,657	A	40	0.11	0.11		
56		MACHINGA	Chagwa	7,000	1490.4	1976	20,666	27,434	36,212	A	26	0.94	0.94		
57		MACHINGA	Chinkwenzule	2,000	58.32	1983	4,834	6,417	8,470	A	40	0.34	0.34		
58		MACHINGA	Lifani	20,000	978.48	1977	57,383	76,172	100,546	A	12	1.21	1.21		
59		MACHINGA	Zumulu	23,500	272.16	2001	33,951	45,068	59,489	A	19	1.13	1.13		
60		MACHINGA	Chanyungu	7800	421.2	2000	11,596	15,392	20,318	A	34	0.69	0.69		
61		MACHINGA	Chanyungu 2	1320	71.28	1983	3,190	4,235	5,590	A	40	0.22	0.22		
62		MACHINGA	Machinga	1200	64.8	1983	2,900	3,850	5,082	A	40	0.20	0.20		
63		MACHINGA	Doza	1320	71.28	2003	1,801	2,391	3,156	A	40	0.13	0.13		
64		MACHINGA	Mirala	13,000	946.08	1985	29,674	39,390	51,994	A	21	1.09	1.09		
65		MACHINGA	Mangale	1320	71.28	1983	3,190	4,235	5,590	A	40	0.22	0.22		
66		ZOMBA	Zomba East-Domasi	100,000	5520.96	1981	132,820	190,435	271,671	A	10	2.72	2.72		
67		ZOMBA	Zomba west	60,000	2371.68	1986	77,344	110,894	158,199	A	10	1.58	1.58		
68		ZOMBA	Makwawa south	8040	434.16	1986	10,364	14,860	21,199	A	34	0.72	0.72		
69		ZOMBA	Makwawa North	16,000	382.32	1986	20,625	29,572	42,186	A	24	1.01	1.01		
70		ZOMBA	Chingale	5,000	388.8	1968	7,178	10,292	14,682	A	39	0.57	0.57		
71		MULANJE	Namitambo	60,000	2799.36	1979	118,439	136,274	151,662	A	10	1.52	1.52		
72		MULANJE	Mulanje West	90,000	2579.04	1975	192,303	221,261	246,246	A	10	2.46	2.46		
73		MULANJE	Mulanje SW	24,000	1172.88	1989	38,864	44,717	49,766	A	22	1.09	1.09		
74		MULANJE	Lichenya	46,000	3726	1982	85,566	98,451	109,568	A	11	1.21	1.21		
75		MULANJE	Muloza East	32,000	576.72	1983	58,357	67,145	74,726	A	16	1.20	1.20		
76	Southern	MULANJE	Nalipiri	9,000	356.4	1983	16,413	18,884	21,017	A	34	0.71	0.71		
77		MULANJE	Chambe	28,000	2980.8	1979	55,271	63,594	70,776	B	17	1.20		1.20	
78		MULANJE	Muloza crater	15,000	648	1983	27,355	31,474	35,028	C	26	0.91			0.91
79		MULANJE	Nalipili	25920	1399.68	1983	47,269	54,387	60,528	B	19	1.15		1.15	
80		MULANJE	Phwera	32000	298.08	1983	58,357	67,145	74,726	A	16	1.20	1.20		
81		MULANJE	Nansato school	3000	45.36	1983	5,471	6,295	7,006	C	40	0.28			0.28
82		MULANJE	Mbewa VH	7272	116.64	1983	13,262	15,259	16,982	C	37	0.63			0.63
83		PHALOMBE	Phalombe Major	145,000	5877.36	2005	183,006	220,887	266,573	B	10	2.67		2.67	
84		PHALOMBE	Sombani	54,400	1944	1979	151,852	183,285	221,193	B	10	2.21		2.21	
85		PHALOMBE	Phalombe Minor	46000	648	2005	58,057	70,075	84,568	B	14	1.18		1.18	
86		PHALOMBE	Sakanena(Action aid)	4920	265.68	2007	5,842	7,051	8,509	C	40	0.34			0.34
87		PHALOMBE	Migowi	9,420	583.2	1971	33,569	40,518	48,898	C	22	1.08			1.08
88		PHALOMBE	Chiringa	3,200	265.68	1972	11,061	13,350	16,111	C	37	0.60			0.60
89		THYOLO	Didi	12,000	239.76	2005	15,714	22,863	31,988	B	28	0.90		0.90	
90		THYOLO	Sankhulani	15,000	1172.88	2005	19,643	28,579	39,985	A	25	1.00	1.00		
91		THYOLO	Limphagwi	8000	550.8	1983	18,036	26,240	36,713	B	26	0.95		0.95	
92		THYOLO	Mvumoni	9,000	550.8	2005	11,786	17,147	23,991	B	32	0.77		0.77	
93		THYOLO	Mdala	1920	103.68	2005	2,514	3,658	5,118	C	40	0.20			0.20
94		THYOLO	Kalintulo	1440	77.76	1983	3,246	4,723	6,608	C	40	0.26			0.26
95		CHIKWAWA	Mwanza/ chapananga	60000	3240	1983	108,556	124,650	142,580	A	10	1.43	1.43		
96		CHIKWAWA	East Bank	18720	1010.88	1997	25,669	29,474	33,714	A	27	0.91	0.91		
97		MWANZA	Thabwani	4900	181.44	1983	16,147	20,265	24,996	C	31	0.77			0.77
98		MWANZA	Kukhoma	3500	97.2	1983	11,533	14,475	17,854	C	36	0.64			0.64
99		MWANZA	Nsupe	4080	220.32	1999	7,069	8,872	10,943	C	40	0.44			0.44
100		MWANZA	Mpeni	9189	304.56	1983	30,280	38,004	46,875	C	22	1.03			1.03
101		NSANJE	Mapelela	1200	64.8	2001	1,592	2,097	2,769	C	40	0.11			0.11
102		NSANJE	Chididi	3120	168.48	1972	7,563	9,959	13,154	C	40	0.53			0.53
Total				1,384,581	35,472		2,572,975	3,251,148	4,083,885			58.13	38.21	11.03	8.89
Grand Total				2,084,775	35,472		4,123,343	5,421,062	7,074,496			106.78	57.41	34.72	14.65

Source: Project Team

Table 8.1.22 Construction Cost of Communities by Borehole WS

Region/District	Population served by Borehole = Community total - Gravity-fed Project List						Number of Borehole in 2035	Construction Cost (mil USD)	Short Term 2012-2020 (mil USD)	Middle Term 2021-2025 (mil USD)	Long Term 2026-2035 (mil USD)
	2012	2015	2020	2025	2030	2035					
All Malawi	**6,943,720**	**7,671,946**	**8,136,271**	**9,359,849**	**10,799,382**	**12,460,386**	**49,852**	**224.34**	**56.11**	**56.11**	**112.12**
Northern Region	**704,457**	**757,422**	**763,589**	**879,149**	**1,011,729**	**1,167,486**	**4,672**	**21.02**	**5.26**	**5.26**	**10.50**
CHITIPA	54,510	56,260	47,703	44,629	38,303	29,160	**117**	**0.53**	**0.13**	**0.13**	**0.27**
KARONGA	79,731	85,547	80,682	91,579	104,259	118,745	**475**	**2.14**	**0.54**	**0.54**	**1.06**
NKHATABAY	93,131	99,079	105,678	131,879	161,403	196,007	**785**	**3.53**	**0.88**	**0.88**	**1.77**
RUMPHI	33,386	14,972	5,858	3,805	0	224	**1**	**0.00**	**0.00**	**0.00**	**0.00**
MZIMBA	443,699	501,565	523,668	607,258	707,764	823,350	**3,294**	**14.82**	**3.71**	**3.71**	**7.40**
LIKOMA											
MZUZU city											
Central Region	**3,593,786**	**4,033,581**	**4,365,902**	**5,082,553**	**5,918,437**	**6,897,779**	**27,595**	**124.19**	**31.05**	**31.05**	**62.09**
KASUNGU	560,900	639,899	712,061	860,328	1,037,961	1,251,415	**5,006**	**22.53**	**5.63**	**5.63**	**11.27**
NKHOTAKOTA	108,702	119,997	116,311	134,870	157,524	184,773	**740**	**3.33**	**0.83**	**0.83**	**1.67**
NTCHISI	207,108	228,920	252,034	297,226	350,060	413,097	**1,653**	**7.44**	**1.86**	**1.86**	**3.72**
DOWA	503,908	588,885	669,683	824,563	1,000,275	1,203,770	**4,816**	**21.67**	**5.42**	**5.42**	**10.83**
SALIMA	262,192	288,743	312,748	361,951	417,967	480,963	**1,924**	**8.66**	**2.17**	**2.17**	**4.32**
LILONGWE Rural	1,115,143	1,222,375	1,303,335	1,466,145	1,657,155	1,878,710	**7,515**	**33.82**	**8.46**	**8.46**	**16.90**
LILONGWE CITY	0	0	0	0	0	0					
MCHINJI	331,894	406,673	450,152	543,213	653,385	784,597	**3,139**	**14.13**	**3.53**	**3.53**	**7.07**
DEDZA	503,938	538,089	549,578	594,257	644,110	700,455	**2,802**	**12.61**	**3.15**	**3.15**	**6.31**
NTCHEU	0	0	0	0	0	0	**0**	**0.00**	**0.00**	**0.00**	**0.00**
Southern Region	**2,645,478**	**2,880,943**	**3,006,780**	**3,398,146**	**3,869,215**	**4,395,121**	**17,585**	**79.13**	**19.80**	**19.80**	**39.53**
MANGOCHI	688,267	793,109	877,599	1,052,787	1,267,862	1,521,792	**6,088**	**27.40**	**6.85**	**6.85**	**13.70**
MACHINGA	87,144	113,836	101,696	126,415	163,458	208,956	**836**	**3.76**	**0.94**	**0.94**	**1.88**
ZOMBA Rural	327,363	340,617	321,682	319,647	313,399	295,208	**1,181**	**5.31**	**1.33**	**1.33**	**2.65**
ZOMBA CITY	0	0	0	0	0	0					
CHIRADZULO	268,739	286,998	298,144	318,618	340,552	362,281	**1,450**	**6.53**	**1.63**	**1.63**	**3.27**
BLANTYRE rural	231,563	241,626	234,472	243,990	253,045	258,717	**1,035**	**4.66**	**1.17**	**1.17**	**2.32**
BLANTYRE CITY	0	0	0	0	0	0					
MWANZA	9,605	0	0	0	0	0	**0**	**0.00**	**0.00**	**0.00**	**0.00**
THYOLO	460,784	469,061	473,024	501,872	536,858	572,131	**2,289**	**10.30**	**2.58**	**2.58**	**5.14**
MULANJE	0	0	0	0	0	0	**0**	**0.00**	**0.00**	**0.00**	**0.00**
PHALOMBE	0	0	0	0	0	0	**0**	**0.00**	**0.00**	**0.00**	**0.00**
CHIKWAWA	273,929	296,595	326,750	392,506	471,094	561,533	**2,247**	**10.11**	**2.53**	**2.53**	**5.05**
NSANJE	195,398	213,466	228,221	259,014	295,933	338,913	**1,356**	**6.10**	**1.53**	**1.53**	**3.04**
BALAKA	0	0	0	0	0	0	**0**	**0.00**	**0.00**	**0.00**	**0.00**
NENO	102,686	125,635	145,192	183,298	227,015	275,590	**1,103**	**4.96**	**1.24**	**1.24**	**2.48**

Source: Project Team

(2) Agriculture and Irrigation

1) Breakdown of Project Cost

The breakdown of project cost for Agriculture and Irrigation is shown as follows in 2,500ha/year and 5,000ha/year respectively.

Table 8.1.23 Project Cost of Irrigation Development (2,500ha/year)

WRA	WRU	Irrigation Area (ha)	Construction Cost (mil USD)	Physical contingency (mil USD)	Engineering service (mil USD)	Administration cost (mil USD)	Total cost (mil USD)
		2500ha/year	2500ha/year	2500ha/year	2500ha/year	2500ha/year	2500ha/year
1	A	587	2.81	0.34	0.32	0.14	3.61
	B	712	3.41	0.41	0.38	0.17	4.37
	C	769	3.67	0.44	0.41	0.18	4.70
	E	517	2.47	0.30	0.28	0.12	3.17
	F	264	1.29	0.15	0.14	0.06	1.64
	G	679	3.25	0.39	0.36	0.16	4.16
	K	826	3.95	0.47	0.44	0.19	5.05
	L	580	2.77	0.33	0.31	0.14	3.55
	M	628	3.00	0.36	0.34	0.15	3.85
	N	274	1.31	0.16	0.15	0.06	1.68
	O	764	3.65	0.44	0.41	0.18	4.68
	P	589	2.82	0.34	0.32	0.14	3.62
	R	1,056	5.05	0.61	0.57	0.25	6.48
	S	734	3.51	0.42	0.39	0.17	4.49
	T	90	0.43	0.05	0.05	0.02	0.55
2	A	21	0.49	0.06	0.06	0.02	0.63
	B	60	0.29	0.03	0.03	0.01	0.36
	C	14	0.07	0.01	0.01	0.00	0.09
	D	7	0.20	0.02	0.02	0.01	0.25
3	A	533	2.55	0.31	0.29	0.13	3.28
	B	483	2.31	0.28	0.26	0.11	2.96
	C	1,024	4.90	0.59	0.55	0.24	6.28
	D	564	2.70	0.32	0.30	0.13	3.45
	E	733	3.50	0.42	0.39	0.17	4.48
	F	211	1.01	0.12	0.11	0.05	1.29
4	A	15	0.08	0.01	0.01	0.00	0.10
	B	300	1.44	0.17	0.16	0.07	1.84
	C	68	0.33	0.04	0.04	0.02	0.43
	D	188	0.90	0.11	0.10	0.04	1.15
	E	100	0.48	0.06	0.05	0.02	0.61
	F	19	0.10	0.01	0.01	0.00	0.12
5	C	466	1.78	0.21	0.20	0.09	2.28
	D	400	1.95	0.23	0.22	0.10	2.50
	E	1,549	7.56	0.91	0.85	0.37	9.69
	F	1,213	5.92	0.71	0.66	0.29	7.58
7	A	2,238	10.70	1.28	1.20	0.53	13.71
	B	934	4.47	0.54	0.50	0.22	5.73
	C	1,034	4.94	0.59	0.55	0.24	6.32
	D	2,737	13.09	1.57	1.47	0.65	16.78
	E	406	1.94	0.23	0.22	0.10	2.49
	F	867	4.14	0.50	0.46	0.20	5.30
	G	559	2.67	0.32	0.30	0.13	3.42
	H	293	1.40	0.17	0.16	0.07	1.80
8	A	3,742	17.89	2.15	2.00	0.88	22.92
9	A	209	1.00	0.12	0.11	0.05	1.28
	B	257	1.23	0.15	0.14	0.06	1.58
14	B	95	2.52	0.30	0.28	0.12	3.22
	C	8,973	49.59	5.95	5.55	2.44	63.53
15	A	3,106	14.85	1.78	1.66	0.73	19.02
	B	5,003	27.61	3.31	3.09	1.36	35.37
	C	611	3.37	0.40	0.38	0.17	4.32
16	E	3,387	16.20	1.94	1.81	0.80	20.75
	F	3,800	18.17	2.18	2.04	0.90	23.29
	G	1,881	8.99	1.08	1.01	0.44	11.52
17	A	16	0.08	0.01	0.01	0.00	0.10
	B	974	4.66	0.56	0.52	0.23	5.97
	C	1,843	8.81	1.06	0.99	0.43	11.29
Total		**60,000**	**300.27**	**36.02**	**33.64**	**14.75**	**384.68**

Source: Project Team

Table 8.1.24 Project Cost of Irrigation Development (5,000ha/year)

WRA	WRU	Irrigation Area (ha)	Construction Cost (mil USD)	Physical contingency (mil USD)	Engineering service (mil USD)	Administration cost (mil USD)	Total cost (mil USD)
		5000ha/year	5000ha/year	5000ha/year	5000ha/year	5000ha/year	5000ha/year
1	A	1,173	5.62	0.67	0.63	0.28	**7.20**
	B	1,425	6.83	0.82	0.77	0.34	**8.76**
	C	1,537	7.36	0.88	0.82	0.36	**9.42**
	E	1,034	4.95	0.59	0.55	0.24	**6.33**
	F	528	2.58	0.31	0.29	0.13	**3.31**
	G	1,358	6.51	0.78	0.73	0.32	**8.34**
	K	1,652	7.92	0.95	0.89	0.39	**10.15**
	L	1,160	5.56	0.67	0.62	0.27	**7.12**
	M	1,256	6.02	0.72	0.67	0.30	**7.71**
	N	548	2.62	0.31	0.29	0.13	**3.35**
	O	1,528	7.32	0.88	0.82	0.36	**9.38**
	P	1,178	5.64	0.68	0.63	0.28	**7.23**
	R	2,111	10.11	1.21	1.13	0.50	**12.95**
	S	1,467	7.03	0.84	0.79	0.35	**9.01**
	T	180	0.86	0.10	0.10	0.04	**1.10**
2	A	42	0.63	0.08	0.07	0.03	**0.81**
	B	120	0.58	0.07	0.07	0.03	**0.75**
	C	29	0.14	0.02	0.02	0.01	**0.19**
	D	13	0.25	0.03	0.03	0.01	**0.32**
3	A	1,065	5.10	0.61	0.57	0.25	**6.53**
	B	966	4.63	0.56	0.52	0.23	**5.94**
	C	2,048	9.81	1.18	1.10	0.48	**12.57**
	D	1,127	6.23	0.75	0.70	0.31	**7.99**
	E	1,465	7.02	0.84	0.79	0.35	**9.00**
	F	423	2.03	0.24	0.23	0.10	**2.60**
4	A	30	0.16	0.02	0.02	0.01	**0.21**
	B	601	2.88	0.35	0.32	0.14	**3.69**
	C	135	0.66	0.08	0.07	0.03	**0.84**
	D	376	1.80	0.22	0.20	0.09	**2.31**
	E	200	0.95	0.11	0.11	0.05	**1.22**
	F	39	0.18	0.02	0.02	0.01	**0.23**
5	C	932	5.21	0.63	0.58	0.26	**6.68**
	D	800	3.92	0.47	0.44	0.19	**5.02**
	E	3,097	15.15	1.82	1.70	0.75	**19.42**
	F	2,427	11.88	1.43	1.33	0.59	**15.23**
7	A	4,476	21.44	2.57	2.40	1.06	**27.47**
	B	1,868	8.95	1.07	1.00	0.44	**11.46**
	C	2,068	9.91	1.19	1.11	0.49	**12.70**
	D	5,475	26.23	3.15	2.94	1.29	**33.61**
	E	813	3.89	0.47	0.44	0.19	**4.99**
	F	1,734	8.47	1.02	0.95	0.42	**10.86**
	G	1,118	5.46	0.66	0.61	0.27	**7.00**
	H	586	2.81	0.34	0.32	0.14	**3.61**
8	A	7,485	44.40	5.33	4.97	2.19	**56.89**
9	A	419	2.06	0.25	0.23	0.10	**2.64**
	B	514	2.54	0.30	0.28	0.12	**3.24**
14	B	190	3.16	0.38	0.35	0.16	**4.05**
	C	17,946	120.04	14.40	13.44	5.92	**153.80**
15	A	6,212	34.35	4.12	3.85	1.69	**44.01**
	B	10,005	55.33	6.64	6.20	2.73	**70.90**
	C	1,221	6.75	0.81	0.76	0.33	**8.65**
16	E	6,774	32.45	3.89	3.63	1.60	**41.57**
	F	7,601	36.41	4.37	4.08	1.79	**46.65**
	G	3,761	18.02	2.16	2.02	0.89	**23.09**
17	A	32	0.20	0.02	0.02	0.01	**0.25**
	B	1,947	9.33	1.12	1.05	0.46	**11.96**
	C	3,686	19.13	2.30	2.14	0.94	**24.51**
Total		**120,000**	**637.47**	**76.50**	**71.41**	**31.44**	**816.82**

Source: Project Team

2) Estimation of Construction Cost

The basis of construction cost estimation is presented in **Tables 3.5.3** to **3.5.11**.

8.1.4 Disbursement Schedule

The disbursement schedules for the overall project to the target year 2035 are set by classifying them into the following four sectors:

- Integrated Project
- Water Supply for the Four (4) Cities
- Water Supply for Towns & Rural Areas
- Agriculture and Irrigation

The disbursement schedules are estimated by classifying them into three (3) terms (short, middle, long term), in accordance with the priority of the studied action plans for each sector.

Regarding the implementation year of scheme of each sector, the Integrated Project is expected to be four (4) years from 2015. Water Supply for the four (4) Cities are as shown the implementation schedule of the action plan. Water supply for Towns and Rural Areas are set as short, middle and long term for each priority ABC respectively. Agriculture and Irrigation are set based on the ranking criteria and scores that have been studied in the action plan as shown in **Table 8.1.34**, the implementation period of scheme of each WRU can be classified into three types according to their irrigation development area as shown in the following table.

Table 8.1.25 Classification of Implementation Period by Irrigation Development Areas

Implementation Period	Case of 2,500ha/year	Case of 5,000ha/year
2 year	under 500ha	under 1,000ha
3 year	500 - 1000ha	1,000 - 2,000ha
4 year	beyond 1,000ha	beyond 2,000ha

Source: Project Team

The disbursement schedules for the target year of each sector have been estimated as shown in **Table 8.1.26** to **Table 8.1.46.**

(1) Integrated Project

Table 8.1.26 Disbursement Schedule for Upgraded Kamuzu Barrage

Unit: Million USD

Project	Description	Total	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
Upgraded Kamuzu Barrage	Construction cost																									
	Civil works	13.68					6.84	6.84																		
	Mechanical/hydraulic steelworks	12.84						6.42	6.42																	
	Eelectircal works	1.44						0.72	0.72																	
	Sub-total	27.96	0.00	0.00	0.00	0.00	6.84	13.98	7.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Land acquisition cost	0.00																								
	Physical contingency	3.36					0.82	1.68	0.86																	
	Engineering service	3.13				0.78	0.78	0.78	0.79																	
	Administration cost	1.38				0.03	0.34	0.66	0.35																	
	Total	**35.83**	**0.00**	**0.00**	**0.00**	**0.81**	**8.78**	**17.10**	**9.14**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Source: Project Team

1) Water Supply for Four Cities

Table 8.1.27 Summary of Disbursement Schedule for Water Supply for 4 Cities

Unit: Million USD

City	Description	Total	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
Lilongwe	Construction cost	403.51	0.00	0.00	3.98	9.14	5.15	15.05	24.68	32.71	58.83	51.78	29.01	11.01	11.01	11.01	11.01	37.01	37.01	11.01	11.01	11.01	11.01	11.08	0.00	0.00
	Land acquisition cost	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Physical contingency	48.43	0.00	0.00	0.47	1.11	0.63	1.80	2.96	3.92	7.05	6.22	3.48	1.32	1.32	1.32	1.32	4.44	4.44	1.32	1.32	1.32	1.32	1.35	0.00	0.00
	Engineering service	45.21	0.00	0.00	0.56	3.13	2.68	2.26	3.37	3.49	3.49	3.48	3.33	1.23	1.23	1.23	3.17	3.17	3.18	1.23	1.23	1.23	1.23	1.29	0.00	0.00
	Administration cost	19.88	0.00	0.00	0.20	0.53	0.33	0.79	1.24	1.60	2.77	2.46	1.42	0.54	0.54	0.54	0.62	1.78	1.78	0.54	0.54	0.54	0.54	0.58	0.00	0.00
	Total	**517.06**	**0.00**	**0.00**	**5.21**	**13.91**	**8.79**	**19.90**	**32.25**	**41.73**	**72.14**	**63.95**	**37.24**	**14.10**	**14.10**	**14.10**	**16.13**	**46.40**	**46.41**	**14.10**	**14.10**	**14.10**	**14.10**	**14.30**	**0.00**	**0.00**
Blantyre	Construction cost	246.18	0.00	0.00	0.00	1.40	1.40	1.40	19.48	38.89	37.95	9.06	9.06	9.07	6.33	6.33	15.53	29.31	29.30	6.33	6.33	6.33	6.33	6.35	0.00	0.00
	Land acquisition cost	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Physical contingency	29.54	0.00	0.00	0.00	0.17	0.17	0.17	2.34	4.66	4.55	1.09	1.09	1.08	0.76	0.76	1.86	3.52	3.52	0.76	0.76	0.76	0.76	0.76	0.00	0.00
	Engineering service	27.58	0.00	0.00	0.00	0.16	1.77	1.77	2.48	2.47	2.62	1.02	1.02	1.00	1.95	1.95	1.95	1.95	1.93	0.71	0.71	0.71	0.71	0.70	0.00	0.00
	Administration cost	12.14	0.00	0.00	0.00	0.07	0.13	0.13	0.97	1.84	1.81	0.44	0.44	0.46	0.36	0.36	0.77	1.39	1.39	0.31	0.31	0.31	0.31	0.34	0.00	0.00
	Total	**315.44**	**0.00**	**0.00**	**0.00**	**1.80**	**3.47**	**3.47**	**25.27**	**47.86**	**46.93**	**11.61**	**11.61**	**11.61**	**9.40**	**9.40**	**20.11**	**36.17**	**36.14**	**8.11**	**8.11**	**8.11**	**8.11**	**8.15**	**0.00**	**0.00**
Mzuzu	Construction cost	160.15	0.00	0.00	0.00	0.00	6.00	26.03	25.99	3.99	3.99	3.99	3.99	3.99	3.71	3.71	3.71	14.99	14.99	18.08	11.87	3.71	3.71	3.70	0.00	0.00
	Land acquisition cost	18.20	0.00	0.00	0.00	0.00	2.85	2.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.25	6.25	0.00	0.00	0.00	0.00	0.00	0.00
	Physical contingency	21.41	0.00	0.00	0.00	0.00	1.06	3.47	3.13	0.48	0.48	0.48	0.48	0.50	0.45	0.45	0.45	1.80	2.55	2.92	1.44	0.45	0.45	0.37	0.00	0.00
	Engineering service	19.98	0.00	0.00	0.00	1.58	1.58	2.00	1.99	0.45	0.45	0.45	0.45	0.46	0.42	0.42	1.71	1.71	1.71	1.71	1.71	0.42	0.42	0.34	0.00	0.00
	Administration cost	8.79	0.00	0.00	0.00	0.06	0.46	1.37	1.24	0.19	0.19	0.19	0.19	0.21	0.18	0.18	0.23	0.74	1.02	1.16	0.59	0.18	0.18	0.23	0.00	0.00
	Total	**228.53**	**0.00**	**0.00**	**0.00**	**1.64**	**11.95**	**35.72**	**32.35**	**5.11**	**5.11**	**5.11**	**5.11**	**5.16**	**4.76**	**4.76**	**6.10**	**19.24**	**26.52**	**30.12**	**15.61**	**4.76**	**4.76**	**4.64**	**0.00**	**0.00**
Zomba	Construction cost	22.83	0.00	0.00	3.18	3.18	0.00	0.56	0.56	0.94	0.94	0.95	0.38	0.38	0.38	0.38	3.03	3.03	3.04	0.38	0.38	0.38	0.38	0.38	0.00	0.00
	Land acquisition cost	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Physical contingency	2.74	0.00	0.00	0.38	0.38	0.00	0.07	0.07	0.12	0.12	0.11	0.05	0.05	0.05	0.05	0.37	0.37	0.37	0.05	0.05	0.03	0.03	0.02	0.00	0.00
	Engineering service	2.55	0.00	0.00	0.36	0.35	0.00	0.06	0.06	0.10	0.10	0.11	0.04	0.04	0.04	0.26	0.26	0.26	0.27	0.04	0.04	0.05	0.05	0.06	0.00	0.00
	Administration cost	1.12	0.00	0.00	0.16	0.15	0.00	0.03	0.03	0.05	0.05	0.04	0.02	0.02	0.02	0.03	0.15	0.15	0.14	0.02	0.02	0.01	0.01	0.02	0.00	0.00
	Total	**29.24**	**0.00**	**0.00**	**4.08**	**4.06**	**0.00**	**0.72**	**0.72**	**1.21**	**1.21**	**1.21**	**0.49**	**0.49**	**0.49**	**0.72**	**3.81**	**3.81**	**3.82**	**0.49**	**0.49**	**0.47**	**0.47**	**0.48**	**0.00**	**0.00**

Source: Project Team

Table 8.1.28 Disbursement Schedule for New Water Resource Development of Water Supply for 4 Cities

Unit: Million USD

City	Description	Total	Phase1	Phase2	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
Lilongwe	Construction cost																											
	Dam	41.00	41.00	0.00						13.67	13.67	13.66																
	New Water treatment plant	43.00	30.00	13.00									15.00	15.00						6.50	6.50							
	Pipelines	90.00	54.00	36.00									18.00	18.00	18.00					18.00	18.00							
	Balancing tanks	2.00	1.00	1.00									0.50	0.50						0.50	0.50							
	Pumping stations	10.00	8.00	2.00									4.00	4.00						1.00	1.00							
	Electric lines	0.40	0.40	0.00									0.20	0.20														
	Resettlement / Compensation Irrigation	14.00	14.00	0.00								7.00	7.00															
	Fisheries	0.11	0.11	0.00									0.08	0.03														
	Development Irrigation	4.00	4.00	0.00									2.00	2.00														
	Sub-total	204.51	152.51	52.00	0.00	0.00	0.00	0.00	0.00	13.67	13.67	20.66	46.78	39.73	18.00	0.00	0.00	0.00	0.00	26.00	26.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Land acquisition cost	0.02	0.01	0.01								0.01							0.01									
	Physical contingency	24.54	18.30	6.24						1.64	1.64	2.48	5.61	4.77	2.16				0.00	3.12	3.12							
	Engineering service	22.91	17.08	5.83				2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.10				1.94	1.94	1.95							
	Administration cost	10.08	7.52	2.56				0.09	0.09	0.70	0.70	1.01	2.18	1.87	0.88				0.08	1.24	1.24							
	Total	**262.06**	**195.42**	**66.64**	**0.00**	**0.00**	**0.00**	**2.23**	**2.23**	**18.15**	**18.15**	**26.30**	**56.71**	**48.51**	**23.14**	**0.00**	**0.00**	**0.00**	**2.03**	**32.30**	**32.31**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Blantyre	Construction cost																											
	River intake	2.22	2.22	0.00								2.22																
	Water treatment plant	25.30	12.65	12.65								6.33	6.32							6.33	6.32							
	Pipelines	62.85	35.24	27.61							11.75	11.75	11.74						9.20	9.20	9.21							
	Reservoirs	17.52	11.12	6.40								5.56	5.56							3.2	3.2							
	Pumping stations	18.72	10.23	8.49								5.12	5.11							4.25	4.24							
	Electric lines	0.32	0.32	0.00								0.16	0.16															
	Sub-total	126.93	71.78	55.15	0.00	0.00	0.00	0.00	0.00	0.00	11.75	31.14	28.89	0.00	0.00	0.00	0.00	0.00	9.20	22.98	22.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Land acquisition cost	0.00	0.00	0.00																								
	Physical contingency	15.23	8.61	6.62							1.41	3.74	3.46						1.10	2.76	2.76							
	Engineering service	14.22	8.04	6.18					1.61	1.61	1.61	1.61	1.60				1.24	1.24	1.24	1.24	1.22							
	Administration cost	6.26	3.54	2.72					0.06	0.06	0.59	1.46	1.37				0.05	0.05	0.46	1.08	1.08							
	Total	**162.64**	**91.97**	**70.67**	**0.00**	**0.00**	**0.00**	**0.00**	**1.67**	**1.67**	**15.36**	**37.95**	**35.32**	**0.00**	**0.00**	**0.00**	**1.29**	**1.29**	**12.00**	**28.06**	**28.03**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Mzuzu	Construction cost																											
	Dam	36.61	18.00	18.61					6.00	6.00	6.00									6.20	6.20	6.21						
	Transmission system to WTP	30.77	15.07	15.70						7.54	7.53											7.85	7.85					
	Water treatment plant	21.59	12.95	8.64						6.48	6.47									4.32	4.32							
	Treated water tank	3.04	1.52	1.52						0.76	0.76									0.76	0.76							
	Transmission system from WTP to service reservoirs	3.03	3.03	0.00						1.52	1.51																	
	Electric lines	0.65	0.03	0.62						0.02	0.01											0.31	0.31					
	Sub-total	95.69	50.60	45.09	0.00	0.00	0.00	0.00	6.00	22.32	22.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.28	11.28	14.37	8.16	0.00	0.00	0.00	0.00	0.00
	Land acquisition cost	18.20	5.70	12.50					2.85	2.85											6.25	6.25						
	Physical contingency	13.67	6.76	6.91					1.06	3.02	2.68									1.35	2.10	2.47	0.99					
	Engineering service	12.76	6.31	6.45				1.58	1.58	1.58	1.57								1.29	1.29	1.29	1.29	1.29					
	Administration cost	5.61	2.77	2.84				0.06	0.46	1.19	1.06								0.05	0.56	0.84	0.98	0.41					
	Total	**145.93**	**72.14**	**73.79**	**0.00**	**0.00**	**0.00**	**1.64**	**11.95**	**30.96**	**27.59**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**1.34**	**14.48**	**21.76**	**25.36**	**10.85**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Zomba	Construction cost																											
	Raising of Mulunguzi dam	7.96	7.96	0.00															2.65	2.65	2.66							
	Sub-total	7.96	7.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.65	2.65	2.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Land acquisition cost	0.00	0.00	0.00																								
	Physical contingency	0.96	0.96	0.00															0.32	0.32	0.32							
	Engineering service	0.89	0.89	0.00														0.22	0.22	0.22	0.23							
	Administration cost	0.39	0.39	0.00														0.01	0.13	0.13	0.12							
	Total	**10.20**	**10.20**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.23**	**3.32**	**3.32**	**3.33**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Source: Project Team

Table 8.1.29 Disbursement Schedule for Other Improvement Project of Water Supply for 4 Cities (1/2)

Unit: Million USD

City	Description	Total	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
Lilongwe	Construction cost																									
	Development new groundwater borehole (+10,000m3/d)	4.06			2.03	2.03																				
	Sub-total	4.06	0.00	0.00	2.03	2.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Land acquisition cost	0.00																								
	Physical contingency	0.49			0.24	0.25																				
	Engineering service	0.45			0.23	0.22																				
	Administration cost	0.20			0.10	0.10																				
	Total	**5.20**	**0.00**	**0.00**	**2.60**	**2.60**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	Construction cost																									
	Extension of Existing TWII (purification plant: +30,000m3/d)	3.90			1.95	1.95																				
	Sub-total	3.90	0.00	0.00	1.95	1.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Land acquisition cost	0.00																								
	Physical contingency	0.47			0.23	0.24																				
	Engineering service	0.44			0.22	0.22																				
	Administration cost	0.19			0.10	0.09																				
	Total	**5.00**	**0.00**	**0.00**	**2.50**	**2.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	Construction cost																									
	Raising Kamuzu dam I and associated rehabilitation works (+30,000m3/d)	3.97				1.32	1.32	1.33																		
	Sub-total	3.97	0.00	0.00	0.00	1.32	1.32	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Land acquisition cost	0.00																								
	Physical contingency	0.48				0.16	0.16	0.16																		
	Engineering service	0.45			0.11	0.11	0.11	0.12																		
	Administration cost	0.20			0.00	0.06	0.06	0.08																		
	Total	**5.10**	**0.00**	**0.00**	**0.11**	**1.65**	**1.65**	**1.69**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	Construction cost																									
	Extension of Existing TWII(2nd) (purification plant: +30,000m3/d) and Technical Assistance	7.57				3.79	3.78																			
	Sub-total	7.57	0.00	0.00	0.00	3.79	3.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Land acquisition cost	0.00																								
	Physical contingency	0.91				0.45	0.46																			
	Engineering service	0.85				0.43	0.42																			
	Administration cost	0.37				0.19	0.18																			
	Total	**9.70**	**0.00**	**0.00**	**0.00**	**4.86**	**4.84**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	Construction cost																									
	Network improvement	0.15				0.05	0.05	0.05																		
	Sub-total	0.15	0.00	0.00	0.00	0.05	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Land acquisition cost	0.00																								
	Physical contingency	0.02				0.01	0.01	0.00																		
	Engineering service	0.02				0.01	0.01	0.00																		
	Administration cost	0.01				0.00	0.00	0.01																		
	Total	**0.20**	**0.00**	**0.00**	**0.00**	**0.07**	**0.07**	**0.06**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	Construction cost																									
	Rehabilitation of Existing TWII	3.12								1.04	1.04	1.04														
	Sub-total	3.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.04	1.04	1.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Land acquisition cost	0.00																								
	Physical contingency	0.37								0.12	0.12	0.13														
	Engineering service	0.35								0.12	0.12	0.11														
	Administration cost	0.15								0.05	0.05	0.05														
	Total	**4.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**1.33**	**1.33**	**1.34**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	Construction cost																									
	Network expansion	176.23							11.01	11.01	11.01	11.01	11.01	11.01	11.01	11.01	11.01	11.01	11.01	11.01	11.01	11.01	11.01	11.08		
	Sub-total	176.23	0.00	0.00	0.00	0.00	0.00	0.00	11.01	11.01	11.01	11.01	11.01	11.01	11.01	11.01	11.01	11.01	11.01	11.01	11.01	11.01	11.01	11.08	0.00	0.00
	Land acquisition cost	0.00																								
	Physical contingency	21.15							1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.35		
	Engineering service	19.74							1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.29		
	Administration cost	8.68							0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.58		
	Total	**225.80**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**14.10**	**14.10**	**14.10**	**14.10**	**14.10**	**14.10**	**14.10**	**14.10**	**14.10**	**14.10**	**14.10**	**14.10**	**14.10**	**14.10**	**14.10**	**14.30**	**0.00**	**0.00**
Blantyre	Construction cost																									
	Network improvement	7.02				1.40	1.40	1.40	1.40	1.42																
	Sub-total	7.02	0.00	0.00	0.00	1.40	1.40	1.40	1.40	1.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Land acquisition cost	0.00																								
	Physical contingency	0.84				0.17	0.17	0.17	0.17	0.16																
	Engineering service	0.79				0.16	0.16	0.16	0.16	0.15																
	Administration cost	0.35				0.07	0.07	0.07	0.07	0.07																
	Total	**9.00**	**0.00**	**0.00**	**0.00**	**1.80**	**1.80**	**1.80**	**1.80**	**1.80**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Source: Project Team

Table 8.1.30 Disbursement Schedule for Other Improvement Project of Water Supply for 4 Cities (2/2)

Unit: Million USD

City	Description	Total	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
Blantyre	Construction cost																									
	Network expansion	101.30							6.33	6.33	6.33	6.33	6.33	6.33	6.33	6.33	6.33	6.33	6.33	6.33	6.33	6.33	6.33	6.35		
	Sub-total	101.30	0.00	0.00	0.00	0.00	0.00	0.00	6.33	6.33	6.33	6.33	6.33	6.33	6.33	6.33	6.33	6.33	6.33	6.33	6.33	6.33	6.33	6.35	0.00	0.00
	Land acquisition cost	0.00																								
	Physical contingency	12.16							0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76		
	Engineering service	11.35							0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.7		
	Administration cost	4.99							0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.34		
	Total	**129.80**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**8.11**	**8.11**	**8.11**	**8.11**	**8.11**	**8.11**	**8.11**	**8.11**	**8.11**	**8.11**	**8.11**	**8.11**	**8.11**	**8.11**	**8.11**	**8.15**	**0.00**	**0.00**
	Construction cost																									
	Poverty program (Kiosk and Toilet development)	10.93									2.73	2.73	2.73	2.74												
	Sub-total	10.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.73	2.73	2.73	2.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Land acquisition cost	0.00																								
	Physical contingency	1.31									0.33	0.33	0.33	0.32												
	Engineering service	1.22									0.31	0.31	0.31	0.29												
	Administration cost	0.54									0.13	0.13	0.13	0.15												
	Total	**14.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**3.50**	**3.50**	**3.50**	**3.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Mzuzu	Construction cost																									
	Network improvement	1.40								0.28	0.28	0.28	0.28	0.28												
	Sub-total	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	0.28	0.28	0.28	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Land acquisition cost	0.00																								
	Physical contingency	0.17								0.03	0.03	0.03	0.03	0.05												
	Engineering service	0.16								0.03	0.03	0.03	0.03	0.04												
	Administration cost	0.07								0.01	0.01	0.01	0.01	0.03												
	Total	**1.80**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.35**	**0.35**	**0.35**	**0.35**	**0.40**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	Construction cost																									
	Network expansion	63.06						3.71	3.71	3.71	3.71	3.71	3.71	3.71	3.71	3.71	3.71	3.71	3.71	3.71	3.71	3.71	3.71	3.70		
	Sub-total	63.06	0.00	0.00	0.00	0.00	0.00	3.71	3.71	3.71	3.71	3.71	3.71	3.71	3.71	3.71	3.71	3.71	3.71	3.71	3.71	3.71	3.71	3.70	0.00	0.00
	Land acquisition cost	0.00																								
	Physical contingency	7.57						0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.37		
	Engineering service	7.06						0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.34		
	Administration cost	3.11						0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.23		
	Total	**80.80**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**4.76**	**4.76**	**4.76**	**4.76**	**4.76**	**4.76**	**4.76**	**4.76**	**4.76**	**4.76**	**4.76**	**4.76**	**4.76**	**4.76**	**4.76**	**4.76**	**4.64**	**0.00**	**0.00**
Zomba	Construction cost																									
	Expansion existing TW (18,200m3/d to 30,000m3/d)	6.36			3.18	3.18																				
	Sub-total	6.36	0.00	0.00	3.18	3.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Land acquisition cost	0.00																								
	Physical contingency	0.76			0.38	0.38																				
	Engineering service	0.71			0.36	0.35																				
	Administration cost	0.31			0.16	0.15																				
	Total	**8.14**	**0.00**	**0.00**	**4.08**	**4.06**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	Construction cost																									
	Network improvement	2.81						0.56	0.56	0.56	0.56	0.57														
	Sub-total	2.81	0.00	0.00	0.00	0.00	0.00	0.56	0.56	0.56	0.56	0.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Land acquisition cost	0.00																								
	Physical contingency	0.34						0.07	0.07	0.07	0.07	0.06														
	Engineering service	0.31						0.06	0.06	0.06	0.06	0.07														
	Administration cost	0.14						0.03	0.03	0.03	0.03	0.02														
	Total	**3.60**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.72**	**0.72**	**0.72**	**0.72**	**0.72**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	Construction cost																									
	Network expansion	5.70								0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38		
	Sub-total	5.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.00	0.00
	Land acquisition cost	0.00																								
	Physical contingency	0.68								0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.03	0.03	0.02		
	Engineering service	0.64								0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.06		
	Administration cost	0.28						0.00	0.00	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.02		
	Total	**7.30**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.49**	**0.49**	**0.49**	**0.49**	**0.49**	**0.49**	**0.49**	**0.49**	**0.49**	**0.49**	**0.49**	**0.49**	**0.47**	**0.47**	**0.48**	**0.00**	**0.00**

Source: Project Team

2) Water Supply for Towns & Rural Areas

Table 8.1.31 Disbursement Schedule for Water Supply for Towns and Rural Areas

Unit: Million USD

Classification	Description	Total	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
Towns	Construction cost																									
	Northern region	22.95					2.25	2.25	2.25	2.25	2.26	1.69	1.69	1.69	1.69	1.71	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.34
	Central region	37.85					3.84	3.84	3.84	3.84	3.85	1.90	1.90	1.90	1.90	1.88	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.88
	Southern region	51.03					4.06	4.06	4.06	4.06	4.07	6.02	6.02	6.02	6.02	6.01	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.09
	Sub-total	111.83	0.00	0.00	0.00	0.00	10.15	10.15	10.15	10.15	10.18	9.61	9.61	9.61	9.61	9.60	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.31
	Land acquisition cost	0.00					0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Physical contingency	13.41					1.22	1.22	1.22	1.22	1.21	1.15	1.15	1.15	1.15	1.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.12
	Engineering service	12.53					1.14	1.14	1.14	1.14	1.13	1.08	1.08	1.08	1.08	1.06	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.11
	Administration cost	5.51					0.50	0.50	0.50	0.50	0.50	0.47	0.47	0.47	0.47	0.49	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.10
	Total	**143.28**	**0.00**	**0.00**	**0.00**	**0.00**	**13.01**	**13.01**	**13.01**	**13.01**	**13.02**	**12.31**	**12.31**	**12.31**	**12.31**	**12.31**	**1.67**	**1.67**	**1.67**	**1.67**	**1.67**	**1.67**	**1.67**	**1.67**	**1.67**	**1.64**
Market Center	Construction cost																									
	Northern region	22.10					2.81	2.81	2.81	2.81	2.83	1.19	1.19	1.19	1.19	1.20	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.18
	Central region	37.83					5.18	5.18	5.18	5.18	5.16	1.50	1.50	1.50	1.50	1.51	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.48
	Southern region	36.25					4.11	4.11	4.11	4.11	4.11	1.19	1.19	1.19	1.19	1.17	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.95
	Sub-total	96.18	0.00	0.00	0.00	0.00	12.10	12.10	12.10	12.10	12.10	3.88	3.88	3.88	3.88	3.88	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.61
	Land acquisition cost	0.00					0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Physical contingency	11.54					1.45	1.45	1.45	1.45	1.46	0.47	0.47	0.47	0.47	0.45	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.15
	Engineering service	10.77					1.36	1.36	1.36	1.36	1.34	0.43	0.43	0.43	0.43	0.45	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.20
	Administration cost	4.74					0.60	0.60	0.60	0.60	0.58	0.19	0.19	0.19	0.19	0.20	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
	Total	**123.23**	**0.00**	**0.00**	**0.00**	**0.00**	**15.51**	**15.51**	**15.51**	**15.51**	**15.48**	**4.97**	**4.97**	**4.97**	**4.97**	**4.98**	**2.09**	**2.09**	**2.09**	**2.09**	**2.09**	**2.09**	**2.09**	**2.09**	**2.09**	**2.04**
Community by Gravity-fed WS	Construction cost																									
	Northern region	23.90					1.35	1.35	1.35	1.35	1.37	2.61	2.61	2.61	2.61	2.63	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.37
	Central region	24.75					2.49	2.49	2.49	2.49	2.47	2.12	2.12	2.12	2.12	2.14	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
	Southern region	58.13					7.64	7.64	7.64	7.64	7.65	2.21	2.21	2.21	2.21	2.19	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.88
	Sub-total	106.78	0.00	0.00	0.00	0.00	11.48	11.48	11.48	11.48	11.49	6.94	6.94	6.94	6.94	6.96	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.42
	Land acquisition cost	0.00					0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Physical contingency	12.82					1.38	1.38	1.38	1.38	1.37	0.83	0.83	0.83	0.83	0.85	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.14
	Engineering service	11.96					1.29	1.29	1.29	1.29	1.27	0.78	0.78	0.78	0.78	0.77	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.20
	Administration cost	5.26					0.57	0.57	0.57	0.57	0.55	0.34	0.34	0.34	0.34	0.35	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.09
	Total	**136.82**	**0.00**	**0.00**	**0.00**	**0.00**	**14.72**	**14.72**	**14.72**	**14.72**	**14.68**	**8.89**	**8.89**	**8.89**	**8.89**	**8.93**	**1.88**	**1.88**	**1.88**	**1.88**	**1.88**	**1.88**	**1.88**	**1.88**	**1.88**	**1.85**
Community by Borehole WS	Construction cost																									
	Northern region	21.02					1.05	1.05	1.05	1.05	1.06	1.05	1.05	1.05	1.05	1.06	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05
	Central region	124.19					6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.20
	Southern region	79.13					3.96	3.96	3.96	3.96	3.96	3.96	3.96	3.96	3.96	3.96	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.98
	Sub-total	224.34	0.00	0.00	0.00	0.00	11.22	11.22	11.22	11.22	11.23	11.22	11.22	11.22	11.22	11.23	11.21	11.21	11.21	11.21	11.21	11.21	11.21	11.21	11.21	11.23
	Land acquisition cost	0.00					0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Physical contingency	26.91					1.35	1.35	1.35	1.35	1.33	1.35	1.35	1.35	1.35	1.33	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.30
	Engineering service	25.12					1.26	1.26	1.26	1.26	1.24	1.26	1.26	1.26	1.26	1.24	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.22
	Administration cost	11.05					0.55	0.55	0.55	0.55	0.56	0.55	0.55	0.55	0.55	0.56	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.58
	Total	**287.42**	**0.00**	**0.00**	**0.00**	**0.00**	**14.38**	**14.38**	**14.38**	**14.38**	**14.36**	**14.38**	**14.38**	**14.38**	**14.38**	**14.36**	**14.37**	**14.37**	**14.37**	**14.37**	**14.37**	**14.37**	**14.37**	**14.37**	**14.37**	**14.33**

Source: Project Team

Table 8.1.32 Summary of Disbursement Schedule for Irrigation Development (2,500ha/year)

Unit: Million USD

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					1.20	1.20	1.20																	
	B	710	4.37	6,155	3	7					1.46	1.46	1.46																	
	C	766	4.70	6,136	3	7					1.57	1.57	1.57																	
	E	515	3.33	6,466	3	1	1.11	1.11	1.11																					
	F	263	1.64	6,236	2	13							0.82	0.82																
	G	677	4.25	6,278	3	1	1.42	1.42	1.42																					
	K	823	5.05	6,136	3	7					1.68	1.68	1.68																	
	L	578	3.55	6,142	3	7				1.18	1.18	1.18																		
	M	626	3.85	6,150	3	32													1.28	1.28	1.28									
	N	273	1.68	6,154	2	44																0.84	0.84							
	O	761	4.68	6,150	3	32														1.56	1.56	1.56								
	P	587	3.62	6,167	3	32																1.21	1.21	1.21						
	R	1,051	6.48	6,166	4	1	1.62	1.62	1.62	1.62																				
	S	731	4.5	6,142	3	7					1.50	1.50	1.50																	
	T	90	0.55	6,111	2	13							0.28	0.28																
2	A	21	0.6	30,000	2	44																0.32	0.32							
	B	60	0.4	5,982	2	13								0.18	0.18															
	C	14	0.09	6,278	2	13							0.05	0.05																
	D	7	0.25	37,774	2	44																0.13	0.13							
3	A	530	3.28	6,189	3	32															1.09	1.09	1.09							
	B	481	2.96	6,154	2	44																1.48	1.48							
	C	1,020	6.28	6,157	4	13							1.57	1.57	1.57	1.57														
	D	562	3.45	6,139	3	32												1.15	1.15	1.15										
	E	730	4.48	6,137	3	32																1.49	1.49	1.49						
	F	211	1.29	6,114	2	32																0.65	0.65							
4	A	15	0.10	6,761	2	32																0.05	0.05							
	B	299	1.84	6,154	2	13								0.92	0.92															
	C	67	0.43	6,418	2	13						0.22	0.22																	
	D	187	1.15	6,150	2	13							0.58	0.58																
	E	100	0.61	6,102	2	13							0.31	0.31																
	F	19	0.12	6,192	2	13							0.06	0.06																
5	C	464	2.28	4,914	2	44															1.14	1.14								
	D	399	2.50	6,266	2	44																1.25	1.25							
	E	1,543	9.69	6,280	4	13									2.42	2.42	2.42	2.42												
	F	1,209	7.58	6,270	4	13								1.90	1.90	1.90	1.90													
7	A	2,229	13.71	6,151	4	13					3.43	3.43	3.43	3.43																
	B	930	5.73	6,161	3	32													1.91	1.91	1.91									
	C	1,030	6.32	6,136	4	13								1.58	1.58	1.58	1.58													
	D	2,727	16.78	6,153	4	13									4.20	4.20	4.20	4.20												
	E	405	2.49	6,148	2	44																			1.25	1.25				
	F	864	5.30	6,134	3	32																1.77	1.77	1.77						
	G	557	3.42	6,140	3	32																1.14	1.14	1.14						
	H	292	1.80	6,164	2	13						0.90	0.90																	
8	A	3,728	22.92	6,148	4	13												5.73	5.73	5.73	5.73									
9	A	209	1.28	6,124	2	44																			0.64	0.64				
	B	256	1.58	6,172	2	44																			0.79	0.79				
14	B	95	3.22	33,853	2	57																			1.61	1.61				
	C	8,974	63.53	7,079	4	44																					15.88	15.88	15.88	15.88
15	A	3,094	19.02	6,147	4	13								4.76	4.76	4.76	4.76													
	B	4,983	35.37	7,098	4	44																	8.84	8.84	8.84	8.84				
	C	608	4.32	7,105	3	56																		1.44	1.44	1.44				
16	E	3,374	20.75	6,150	4	1	5.19	5.19	5.19	5.19																				
	F	3,785	23.29	6,153	4	1	5.82	5.82	5.82	5.82																				
	G	1,873	11.52	6,151	4	1			2.88	2.88	2.88	2.88																		
17	A	16	0.10	6,314	2	44																		0.05	0.05					
	B	970	5.97	6,155	3	32													1.99	1.99	1.99									
	C	1,836	11.29	6,149	4	13												2.82	2.82	2.82	2.82									
Total		59,808	384.93				15.16	15.16	18.04	16.69	14.90	16.01	15.60	16.41	17.52	16.42	14.85	16.32	14.89	16.45	17.53	14.11	20.25	15.94	14.62	14.57	15.88	15.88	15.88	15.88
Accumulated Investment Cost							15.16	30.31	48.35	65.04	79.94	95.95	111.55	127.96	145.48	161.90	176.74	193.06	207.95	224.39	241.92	256.03	276.28	292.22	306.83	321.40	337.28	353.17	369.05	384.93

Source: Project Team

Table 8.1.33 Summary of Disbursement Schedule for Irrigation Development (5,000ha/year)

Unit: Million USD

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					2.40	2.40	2.40																	
	B	1,422	8.93	6,280	3	5					2.98	2.98	2.98																	
	C	1,534	9.63	6,278	3	5					3.21	3.21	3.21																	
	E	1,032	6.82	6,609	3	5				2.27	2.27	2.27																		
	F	527	3.31	6,281	2	12							1.66	1.66																
	G	1,356	8.77	6,468	3	1	2.92	2.92	2.92																					
	K	1,649	10.36	6,283	3	5					3.45	3.45	3.45																	
	L	1,158	7.27	6,278	3	5				2.42	2.42	2.42																		
	M	1,254	7.87	6,276	3	28									2.62	2.62	2.62													
	N	547	3.43	6,271	2	41												1.72	1.72											
	O	1,525	9.61	6,302	3	28												3.20	3.20	3.20										
	P	1,176	7.39	6,284	3	28												2.46	2.46	2.46										
	R	2,107	15.81	7,504	4	28	3.95	3.95	3.95	3.95																				
	S	1,464	9.2	6,270	3	5					3.06	3.06	3.06																	
	T	180	1.10	6,111	2	12							0.55	0.55																
2	A	41	0.8	19,756	2	41													0.41	0.41										
	B	120	0.8	6,231	2	12								0.38	0.38															
	C	29	0.19	6,627	2	28									0.10	0.10														
	D	13	0.32	24,175	2	41													0.16	0.16										
3	A	1,063	6.53	6,143	3	28												2.18	2.18	2.18										
	B	964	5.94	6,162	2	41												2.97	2.97											
	C	2,044	12.57	6,150	4	12					3.14	3.14	3.14	3.14																
	D	1,125	7.99	7,102	3	53															2.66	2.66	2.66							
	E	1,462	9.00	6,156	3	28									3.00	3.00	3.00													
	F	422	2.60	6,161	2	28									1.30	1.30														
4	A	30	0.21	7,099	2	41													0.11	0.11										
	B	600	3.69	6,150	2	12					1.85	1.85																		
	C	135	0.84	6,215	2	12								0.42	0.42															
	D	376	2.31	6,144	2	12					1.16	1.16																		
	E	200	1.22	6,102	2	12							0.61	0.61																
	F	39	0.23	5,934	2	12							0.12	0.12																
5	C	930	6.68	7,183	2	55															3.34	3.34								
	D	799	5.02	6,283	2	41												2.51	2.51											
	E	3,091	19.42	6,283	4	12							4.86	4.86	4.86	4.86														
	F	2,422	15.23	6,288	4	12								3.81	3.81	3.81	3.81													
7	A	4,467	27.47	6,150	4	12					6.87	6.87	6.87	6.87																
	B	1,864	11.46	6,148	3	28												3.82	3.82	3.82										
	C	2,064	12.70	6,153	4	12								3.18	3.18	3.18	3.18													
	D	5,464	33.61	6,151	4	12								8.40	8.40	8.40	8.40													
	E	811	4.99	6,153	2	41													2.50	2.50										
	F	1,730	10.86	6,277	3	28											3.62	3.62	3.62											
	G	1,115	7.00	6,278	3	28												2.33	2.33	2.33										
	H	584	3.61	6,182	2	12						1.81	1.81																	
8	A	7,470	56.89	7,616	4	41														14.22	14.22	14.22	14.22							
9	A	418	2.64	6,316	2	41														1.32	1.32									
	B	515	3.24	6,291	2	41													1.62	1.62										
14	B	190	4.05	21,289	2	55															2.03	2.03								
	C	17,911	153.80	8,587	4	41																					38.45	38.45	38.45	38.45
15	A	8,200	44.01	5,367	4	12															11.00	11.00	11.00	11.00						
	B	9,986	70.90	7,100	4	41																	17.73	17.73	17.73	17.73				
	C	1,219	8.65	7,096	3	53																		2.88	2.88	2.88				
16	E	6,761	41.57	6,148	4	1	10.39	10.39	10.39	10.39																				
	F	7,586	46.65	6,149	4	1	11.66	11.66	11.66	11.66																				
	G	3,754	23.09	6,151	4	1	5.77	5.77	5.77	5.77																				
17	A	32	0.25	7,892	2	55																		0.13	0.13					
	B	1,943	11.96	6,155	3	28											3.99	3.99	3.99											
	C	3,679	24.51	6,662	4	28									6.13	6.13	6.13	6.13												
Total		121,770	822.14				34.70	34.70	34.70	36.48	32.81	34.61	34.70	33.98	34.18	33.39	34.74	34.93	33.58	34.32	34.57	33.25	45.61	31.74	20.73	20.61	38.45	38.45	38.45	38.45
Accumulated Investment Cost							34.70	69.41	104.11	140.59	173.39	208.01	242.71	276.68	310.86	344.25	378.99	413.92	447.50	481.82	516.40	549.65	595.26	627.00	647.73	668.34	706.79	745.24	783.69	822.14

Source: Project Team

Table 8.1.34 Ranking Criteria and Scores for Irrigation Development

WRA	WRU	Irrigation Area (ha)		Total cost (mil USD)		Unit Cost (USD/ha)		Water Supply Potential (m3/ha)	Ranking Criteria									
									2500ha/year					5000ha/year				
		2500ha/year	5000ha/year	2500ha/year	5000ha/year	2500ha/year	5000ha/year		Cost Efficiency	Development Effect	Water Supply Potential	Final Score	Ranking	Cost Efficiency	Development Effect	Water Supply Potential	Final Score	Ranking
1	A	587	1,173	3.61	7.20	6,154	6,136	34	3	2	2	**12**	**7**	3	2	2	**12**	**7**
	B	712	1,425	4.37	8.76	6,134	6,148	28	3	2	2	**12**	**7**	3	2	2	**12**	**7**
	C	769	1,537	4.70	9.42	6,115	6,128	20	3	2	2	**12**	**7**	3	2	2	**12**	**7**
	E	517	1,034	3.17	6.33	6,132	6,123	42	3	2	3	**18**	**1**	3	2	3	**18**	**1**
	F	264	528	1.64	3.31	6,218	6,275	52	3	1	3	**9**	**13**	3	1	3	**9**	**13**
	G	679	1,358	4.16	8.34	6,126	6,140	44	3	2	3	**18**	**1**	3	2	3	**18**	**1**
	K	826	1,652	5.05	10.15	6,112	6,143	27	3	2	2	**12**	**7**	3	2	2	**12**	**7**
	L	580	1,160	3.55	7.12	6,120	6,137	29	3	2	2	**12**	**7**	3	2	2	**12**	**7**
	M	628	1,256	3.85	7.71	6,129	6,137	17	3	2	1	**6**	**32**	3	2	1	**6**	**28**
	N	274	548	1.68	3.35	6,135	6,117	18	3	1	1	**3**	**44**	3	1	1	**3**	**40**
	O	764	1,528	4.68	9.38	6,124	6,137	18	3	2	1	**6**	**32**	3	2	1	**6**	**28**
	P	589	1,178	3.62	7.23	6,146	6,137	18	3	2	1	**6**	**32**	3	2	1	**6**	**28**
	R	1,056	2,111	6.48	12.95	6,139	6,134	20	3	3	2	**18**	**1**	3	3	2	**18**	**1**
	S	734	1,467	4.49	9.01	6,121	6,141	22	3	2	2	**12**	**7**	3	2	2	**12**	**7**
	T	90	180	0.55	1.10	6,116	6,116	45	3	1	3	**9**	**13**	3	1	3	**9**	**13**
2	A	21	42	0.63	0.81	30,348	19,509	85	1	1	3	**3**	**44**	1	1	3	**3**	**40**
	B	60	120	0.36	0.75	5,982	6,231	89	3	1	3	**9**	**13**	3	1	3	**9**	**13**
	C	14	29	0.09	0.19	6,278	6,627	97	3	1	3	**9**	**13**	2	1	3	**6**	**28**
	D	7	13	0.25	0.32	37,774	24,175	113	1	1	3	**3**	**44**	1	1	3	**3**	**40**
3	A	533	1,065	3.28	6.53	6,159	6,131	16	3	2	1	**6**	**32**	3	2	1	**6**	**28**
	B	483	966	2.96	5.94	6,129	6,150	16	3	1	1	**3**	**44**	3	1	1	**3**	**40**
	C	1,024	2,048	6.28	12.57	6,133	6,138	17	3	3	1	**9**	**13**	3	3	1	**9**	**13**
	D	564	1,127	3.45	7.99	6,121	7,087	17	3	2	1	**6**	**32**	1	2	1	**2**	**53**
	E	733	1,465	4.48	9.00	6,116	6,143	20	3	2	1	**6**	**32**	3	2	1	**6**	**28**
	F	211	423	1.29	2.60	6,103	6,151	21	3	1	2	**6**	**32**	3	1	2	**6**	**28**
4	A	15	30	0.10	0.21	6,761	7,099	66	2	1	3	**6**	**32**	1	1	3	**3**	**40**
	B	300	601	1.84	3.69	6,125	6,141	66	3	1	3	**9**	**13**	3	1	3	**9**	**13**
	C	68	135	0.43	0.84	6,363	6,215	52	3	1	3	**9**	**13**	3	1	3	**9**	**13**
	D	188	376	1.15	2.31	6,113	6,139	52	3	1	3	**9**	**13**	3	1	3	**9**	**13**
	E	100	200	0.61	1.22	6,102	6,102	52	3	1	3	**9**	**13**	3	1	3	**9**	**13**
	F	19	39	0.12	0.23	6,192	5,934	52	3	1	3	**9**	**13**	3	1	3	**9**	**13**
5	C	466	932	2.28	6.68	4,894	7,169	17	3	1	1	**3**	**44**	1	1	1	**1**	**55**
	D	400	800	2.50	5.02	6,247	6,272	17	3	1	1	**3**	**44**	3	1	1	**3**	**40**
	E	1,549	3,097	9.69	19.42	6,258	6,270	17	3	3	1	**9**	**13**	3	3	1	**9**	**13**
	F	1,213	2,427	7.58	15.23	6,247	6,276	17	3	3	1	**9**	**13**	3	3	1	**9**	**13**
7	A	2,238	4,476	13.71	27.47	6,127	6,138	11	3	3	1	**9**	**13**	3	3	1	**9**	**13**
	B	934	1,868	5.73	11.46	6,135	6,135	10	3	2	1	**6**	**32**	3	2	1	**6**	**28**
	C	1,034	2,068	6.32	12.70	6,111	6,140	11	3	3	1	**9**	**13**	3	3	1	**9**	**13**
	D	2,737	5,475	16.78	33.61	6,130	6,139	11	3	3	1	**9**	**13**	3	3	1	**9**	**13**
	E	406	813	2.49	4.99	6,128	6,141	10	3	1	1	**3**	**44**	3	1	1	**3**	**40**
	F	867	1,734	5.30	10.86	6,114	6,264	12	3	2	1	**6**	**32**	3	2	1	**6**	**28**
	G	559	1,118	3.42	7.00	6,121	6,264	11	3	2	1	**6**	**32**	3	2	1	**6**	**28**
	H	293	586	1.80	3.61	6,148	6,165	110	3	1	3	**9**	**13**	3	1	3	**9**	**13**
8	A	3,742	7,485	22.92	56.89	6,125	7,601	10	3	3	1	**9**	**13**	1	3	1	**3**	**40**
9	A	209	419	1.28	2.64	6,110	6,301	15	3	1	1	**3**	**44**	3	1	1	**3**	**40**
	B	257	514	1.58	3.24	6,147	6,303	15	3	1	1	**3**	**44**	3	1	1	**3**	**40**
14	B	95	190	3.22	4.05	33,853	21,289	8	1	1	1	**1**	**57**	1	1	1	**1**	**55**
	C	8,973	17,946	63.53	153.80	7,080	8,570	8	1	3	1	**3**	**44**	1	3	1	**3**	**40**
15	A	3,106	6,212	19.02	44.01	6,124	7,085	7	3	3	1	**9**	**13**	1	3	1	**3**	**40**
	B	5,003	10,005	35.37	70.90	7,070	7,086	5	1	3	1	**3**	**44**	1	3	1	**3**	**40**
	C	611	1,221	4.32	8.65	7,076	7,084	5	1	2	1	**2**	**56**	1	2	1	**2**	**53**
16	E	3,387	6,774	20.75	41.57	6,126	6,136	39	3	3	2	**18**	**1**	3	3	2	**18**	**1**
	F	3,800	7,601	23.29	46.65	6,128	6,138	35	3	3	2	**18**	**1**	3	3	2	**18**	**1**
	G	1,881	3,761	11.52	23.09	6,126	6,139	39	3	3	2	**18**	**1**	3	3	2	**18**	**1**
17	A	16	32	0.10	0.25	6,314	7,892	17	3	1	1	**3**	**44**	1	1	1	**1**	**55**
	B	974	1,947	5.97	11.96	6,132	6,142	17	3	2	1	**6**	**32**	3	2	1	**6**	**28**
	C	1,843	3,686	11.29	24.51	6,126	6,649	16	3	3	1	**9**	**13**	2	3	1	**6**	**28**
Total		**60,000**	**120,000**	**384.68**	**816.82**													

Source: Project Team

Table 8.1.35 Disbursement Schedule for Irrigation Development (2,500ha/year) (1/6)

Unit: Million USD

WRA	WRU	Descriptiion	Total	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	Construction cost	2.81	0.94	0.94	0.94																					
		Physical contingency	0.34	0.11	0.11	0.11																					
		Engineering service	0.32	0.11	0.11	0.11																					
		Administration cost	0.14	0.05	0.05	0.05																					
		Total	3.61	1.20	1.20	1.20																					
	B	Construction cost	3.41	1.14	1.14	1.14																					
		Physical contingency	0.41	0.14	0.14	0.14																					
		Engineering service	0.38	0.13	0.13	0.13																					
		Administration cost	0.17	0.06	0.06	0.06																					
		Total	4.37	1.46	1.46	1.46																					
	C	Construction cost	3.67	1.22	1.22	1.22																					
		Physical contingency	0.44	0.15	0.15	0.15																					
		Engineering service	0.41	0.14	0.14	0.14																					
		Administration cost	0.18	0.06	0.06	0.06																					
		Total	4.70	1.57	1.57	1.57																					
	E	Construction cost	2.60	0.87	0.87	0.87																					
		Physical contingency	0.31	0.10	0.10	0.10																					
		Engineering service	0.29	0.10	0.10	0.10																					
		Administration cost	0.13	0.04	0.04	0.04																					
		Total	3.33	1.11	1.11	1.11																					
	F	Construction cost	1.29						0.65	0.65																	
		Physical contingency	0.15						0.08	0.08																	
		Engineering service	0.14						0.07	0.07																	
		Administration cost	0.06						0.03	0.03																	
		Total	1.64						0.82	0.82																	
	G	Construction cost	3.32	1.11	1.11	1.11																					
		Physical contingency	0.40	0.13	0.13	0.13																					
		Engineering service	0.37	0.12	0.12	0.12																					
		Administration cost	0.16	0.05	0.05	0.05																					
		Total	4.25	1.42	1.42	1.42																					
	K	Construction cost	3.95	1.32	1.32	1.32																					
		Physical contingency	0.47	0.16	0.16	0.16																					
		Engineering service	0.44	0.15	0.15	0.15																					
		Administration cost	0.19	0.06	0.06	0.06																					
		Total	5.05	1.68	1.68	1.68																					
	L	Construction cost	2.77	0.92	0.92	0.92																					
		Physical contingency	0.33	0.11	0.11	0.11																					
		Engineering service	0.31	0.10	0.10	0.10																					
		Administration cost	0.14	0.05	0.05	0.05																					
		Total	3.55	1.18	1.18	1.18																					
	M	Construction cost	3.00			1.00	1.00	1.00																			
		Physical contingency	0.36			0.12	0.12	0.12																			
		Engineering service	0.34			0.11	0.11	0.11																			
		Administration cost	0.15			0.05	0.05	0.05																			
		Total	3.85			1.28	1.28	1.28																			
	N	Construction cost	1.31												0.66	0.66											
		Physical contingency	0.16												0.08	0.08											
		Engineering service	0.15												0.08	0.08											
		Administration cost	0.06												0.03	0.03											
		Total	1.68												0.84	0.84											

Source: Project Team

Table 8.1.36 Disbursement Schedule for Irrigation Development (2,500ha/year) (2/6)

Unit: Million USD

WRA	WRU	Descriptiion	Total	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	O	Construction cost	3.65												1.22	1.22	1.22										
		Physical contingency	0.44												0.15	0.15	0.15										
		Engineering service	0.41												0.14	0.14	0.14										
		Administration cost	0.18												0.06	0.06	0.06										
		Total	4.68												1.56	1.56	1.56										
	P	Construction cost	2.82			0.94	0.94	0.94																			
		Physical contingency	0.34			0.11	0.11	0.11																			
		Engineering service	0.32			0.11	0.11	0.11																			
		Administration cost	0.14			0.05	0.05	0.05																			
		Total	3.62			1.21	1.21	1.21																			
	R	Construction cost	5.05	1.26	1.26	1.26	1.26																				
		Physical contingency	0.61	0.15	0.15	0.15	0.15																				
		Engineering service	0.57	0.14	0.14	0.14	0.14																				
		Administration cost	0.25	0.06	0.06	0.06	0.06																				
		Total	6.48	1.62	1.62	1.62	1.62																				
	S	Construction cost	3.51	1.17	1.17	1.17																					
		Physical contingency	0.42	0.14	0.14	0.14																					
		Engineering service	0.39	0.13	0.13	0.13																					
		Administration cost	0.17	0.06	0.06	0.06																					
		Total	4.49	1.50	1.50	1.50																					
	T	Construction cost	0.43						0.22	0.22																	
		Physical contingency	0.05						0.03	0.03																	
		Engineering service	0.05						0.03	0.03																	
		Administration cost	0.02						0.01	0.01																	
		Total	0.55						0.28	0.28																	
2	A	Construction cost	0.49																			0.25	0.25				
		Physical contingency	0.06																			0.03	0.03				
		Engineering service	0.06																			0.03	0.03				
		Administration cost	0.02																			0.01	0.01				
		Total	0.63																			0.32	0.32				
	B	Construction cost	0.29								0.15	0.15															
		Physical contingency	0.03								0.02	0.02															
		Engineering service	0.03								0.02	0.02															
		Administration cost	0.01								0.01	0.01															
		Total	0.36								0.18	0.18															
	C	Construction cost	0.07	0.04	0.04																						
		Physical contingency	0.01	0.01	0.01																						
		Engineering service	0.01	0.01	0.01																						
		Administration cost	0.00	0.00	0.00																						
		Total	0.09	0.05	0.05																						
	D	Construction cost	0.20																			0.10	0.10				
		Physical contingency	0.02																			0.01	0.01				
		Engineering service	0.01																			0.01	0.01				
		Administration cost	0.01																			0.01	0.01				
		Total	0.25																			0.13	0.13				

Source: Project Team

Table 8.1.37 Disbursement Schedule for Irrigation Development (2,500ha/year) (3/6)

Unit: Million USD

WRA	WRU	Descriptiion	Total	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
3	A	Construction cost	2.55																			0.85	0.85	0.85			
		Physical contingency	0.31																			0.10	0.10	0.10			
		Engineering service	0.29																			0.10	0.10	0.10			
		Administration cost	0.13																			0.04	0.04	0.04			
		Total	3.28																			1.09	1.09	1.09			
	B	Construction cost	2.31																							1.16	1.16
		Physical contingency	0.28																							0.14	0.14
		Engineering service	0.26																							0.13	0.13
		Administration cost	0.11																							0.06	0.06
		Total	2.96																							1.48	1.48
	C	Construction cost	4.90												1.23	1.23	1.23	1.23									
		Physical contingency	0.59												0.15	0.15	0.15	0.15									
		Engineering service	0.55												0.14	0.14	0.14	0.14									
		Administration cost	0.24												0.06	0.06	0.06	0.06									
		Total	6.28												1.57	1.57	1.57	1.57									
	D	Construction cost	2.70																					0.90	0.90	0.90	
		Physical contingency	0.32																					0.11	0.11	0.11	
		Engineering service	0.30																					0.10	0.10	0.10	
		Administration cost	0.13																					0.04	0.04	0.04	
		Total	3.45																					1.15	1.15	1.15	
	E	Construction cost	3.50																						1.17	1.17	1.17
		Physical contingency	0.42																						0.14	0.14	0.14
		Engineering service	0.39																						0.13	0.13	0.13
		Administration cost	0.17																						0.06	0.06	0.06
		Total	4.48																						1.49	1.49	1.49
	F	Construction cost	1.01																						0.51	0.51	
		Physical contingency	0.12																						0.06	0.06	
		Engineering service	0.11																						0.06	0.06	
		Administration cost	0.05																						0.03	0.03	
		Total	1.29																						0.65	0.65	
4	A	Construction cost	0.08																			0.04	0.04				
		Physical contingency	0.01																			0.01	0.01				
		Engineering service	0.01																			0.01	0.01				
		Administration cost	0.00																			0.00	0.00				
		Total	0.10																			0.05	0.05				
	B	Construction cost	1.44								0.72	0.72															
		Physical contingency	0.17								0.09	0.09															
		Engineering service	0.16								0.08	0.08															
		Administration cost	0.07								0.04	0.04															
		Total	1.84								0.92	0.92															
	C	Construction cost	0.33			0.17	0.17																				
		Physical contingency	0.04			0.02	0.02																				
		Engineering service	0.04			0.02	0.02																				
		Administration cost	0.02			0.01	0.01																				
		Total	0.43			0.22	0.22																				

Source: Project Team

Table 8.1.38 Disbursement Schedule for Irrigation Development (2,500ha/year) (4/6)

Unit: Million USD

WRA	WRU	Descriptiion	Total	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
		Construction cost	0.90	0.45	0.45																						
		Physical contingency	0.11	0.06	0.06																						
	D	Engineering service	0.10	0.05	0.05																						
		Administration cost	0.04	0.02	0.02																						
		Total	1.15	0.58	0.58																						
		Construction cost	0.48	0.24	0.24																						
		Physical contingency	0.06	0.03	0.03																						
4	E	Engineering service	0.05	0.03	0.03																						
		Administration cost	0.02	0.01	0.01																						
		Total	0.61	0.31	0.31																						
		Construction cost	0.10	0.05	0.05																						
		Physical contingency	0.01	0.01	0.01																						
	F	Engineering service	0.01	0.01	0.01																						
		Administration cost	0.00	0.00	0.00																						
		Total	0.12	0.06	0.06																						
		Construction cost	1.78																				0.89	0.89			
		Physical contingency	0.21																				0.11	0.11			
	C	Engineering service	0.20																				0.10	0.10			
		Administration cost	0.09																				0.05	0.05			
		Total	2.28																				1.14	1.14			
		Construction cost	1.95																			0.98	0.98				
		Physical contingency	0.23																			0.12	0.12				
	D	Engineering service	0.22																			0.11	0.11				
		Administration cost	0.10																			0.05	0.05				
		Total	2.50																			1.25	1.25				
5		Construction cost	7.56				1.89	1.89	1.89	1.89																	
		Physical contingency	0.91				0.23	0.23	0.23	0.23																	
	E	Engineering service	0.85				0.21	0.21	0.21	0.21																	
		Administration cost	0.37				0.09	0.09	0.09	0.09																	
		Total	9.69				2.42	2.42	2.42	2.42																	
		Construction cost	5.92				1.48	1.48	1.48	1.48																	
		Physical contingency	0.71				0.18	0.18	0.18	0.18																	
	F	Engineering service	0.66				0.17	0.17	0.17	0.17																	
		Administration cost	0.29				0.07	0.07	0.07	0.07																	
		Total	7.58				1.90	1.90	1.90	1.90																	
		Construction cost	10.70				2.68	2.68	2.68	2.68																	
		Physical contingency	1.28				0.32	0.32	0.32	0.32																	
	A	Engineering service	1.20				0.30	0.30	0.30	0.30																	
		Administration cost	0.53				0.13	0.13	0.13	0.13																	
		Total	13.71				3.43	3.43	3.43	3.43																	
		Construction cost	4.47												1.49	1.49	1.49										
		Physical contingency	0.54												0.18	0.18	0.18										
7	B	Engineering service	0.50												0.17	0.17	0.17										
		Administration cost	0.22												0.07	0.07	0.07										
		Total	5.73												1.91	1.91	1.91										
		Construction cost	4.94				1.24	1.24	1.24	1.24																	
		Physical contingency	0.59				0.15	0.15	0.15	0.15																	
	C	Engineering service	0.55				0.14	0.14	0.14	0.14																	
		Administration cost	0.24				0.06	0.06	0.06	0.06																	
		Total	6.32				1.58	1.58	1.58	1.58																	

Source: Project Team

Table 8.1.39 Disbursement Schedule for Irrigation Development (2,500ha/year) (5/6)

Unit: Million USD

WRA	WRU	Descriptiion	Total	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
7	D	Construction cost	13.09				3.27	3.27	3.27	3.27																	
		Physical contingency	1.57				0.39	0.39	0.39	0.39																	
		Engineering service	1.47				0.37	0.37	0.37	0.37																	
		Administration cost	0.65				0.16	0.16	0.16	0.16																	
		Total	16.78				4.20	4.20	4.20	4.20																	
	E	Construction cost	1.94																				0.97	0.97			
		Physical contingency	0.23																				0.12	0.12			
		Engineering service	0.22																				0.11	0.11			
		Administration cost	0.10																				0.05	0.05			
		Total	2.49																				1.25	1.25			
	F	Construction cost	4.14												1.38	1.38	1.38										
		Physical contingency	0.50												0.17	0.17	0.17										
		Engineering service	0.46												0.15	0.15	0.15										
		Administration cost	0.20												0.07	0.07	0.07										
		Total	5.30												1.77	1.77	1.77										
	G	Construction cost	2.67												0.89	0.89	0.89										
		Physical contingency	0.32												0.11	0.11	0.11										
		Engineering service	0.30												0.10	0.10	0.10										
		Administration cost	0.13												0.04	0.04	0.04										
		Total	3.42												1.14	1.14	1.14										
	H	Construction cost	1.40						0.70	0.70																	
		Physical contingency	0.17						0.09	0.09																	
		Engineering service	0.16						0.08	0.08																	
		Administration cost	0.07						0.04	0.04																	
		Total	1.80						0.90	0.90																	
8	A	Construction cost	17.89								4.47	4.47	4.47	4.47													
		Physical contingency	2.15								0.54	0.54	0.54	0.54													
		Engineering service	2.00								0.50	0.50	0.50	0.50													
		Administration cost	0.88								0.22	0.22	0.22	0.22													
		Total	22.92								5.73	5.73	5.73	5.73													
9	A	Construction cost	1.00																				0.50	0.50			
		Physical contingency	0.12																				0.06	0.06			
		Engineering service	0.11																				0.06	0.06			
		Administration cost	0.05																				0.03	0.03			
		Total	1.28																				0.64	0.64			
	B	Construction cost	1.23												0.62	0.62											
		Physical contingency	0.15												0.08	0.08											
		Engineering service	0.14												0.07	0.07											
		Administration cost	0.06												0.03	0.03											
		Total	1.58												0.79	0.79											
14	B	Construction cost	2.52																				1.26	1.26			
		Physical contingency	0.30																				0.15	0.15			
		Engineering service	0.28																				0.14	0.14			
		Administration cost	0.12																				0.06	0.06			
		Total	3.22																				1.61	1.61			
	C	Construction cost	49.59																12.40	12.40	12.40	12.40					
		Physical contingency	5.95																1.49	1.49	1.49	1.49					
		Engineering service	5.55																1.39	1.39	1.39	1.39					
		Administration cost	2.44																0.61	0.61	0.61	0.61					
		Total	63.53																15.88	15.88	15.88	15.88					

Source: Project Team

Table 8.1.40 Disbursement Schedule for Irrigation Development (2,500ha/year) (6/6)

Unit: Million USD

WRA	WRU	Descriptiion	Total	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
15	A	Construction cost	14.85															3.71	3.71	3.71	3.71						
		Physical contingency	1.78															0.45	0.45	0.45	0.45						
		Engineering service	1.66															0.42	0.42	0.42	0.42						
		Administration cost	0.73															0.18	0.18	0.18	0.18						
		Total	19.02															4.76	4.76	4.76	4.76						
	B	Construction cost	27.61																				6.90	6.90	6.90	6.90	
		Physical contingency	3.31																				0.83	0.83	0.83	0.83	
		Engineering service	3.09																				0.77	0.77	0.77	0.77	
		Administration cost	1.36																				0.34	0.34	0.34	0.34	
		Total	35.37																				8.84	8.84	8.84	8.84	
	C	Construction cost	3.37																						1.12	1.12	1.12
		Physical contingency	0.40																						0.13	0.13	0.13
		Engineering service	0.38																						0.13	0.13	0.13
		Administration cost	0.17																						0.06	0.06	0.06
		Total	4.32																						1.44	1.44	1.44
16	E	Construction cost	16.20								4.05	4.05	4.05	4.05													
		Physical contingency	1.94								0.49	0.49	0.49	0.49													
		Engineering service	1.81								0.45	0.45	0.45	0.45													
		Administration cost	0.80								0.20	0.20	0.20	0.20													
		Total	20.75								5.19	5.19	5.19	5.19													
	F	Construction cost	18.17												4.54	4.54	4.54	4.54									
		Physical contingency	2.18												0.55	0.55	0.55	0.55									
		Engineering service	2.04												0.51	0.51	0.51	0.51									
		Administration cost	0.90												0.23	0.23	0.23	0.23									
		Total	23.29												5.82	5.82	5.82	5.82									
	G	Construction cost	8.99								2.25	2.25	2.25	2.25													
		Physical contingency	1.08								0.27	0.27	0.27	0.27													
		Engineering service	1.01								0.25	0.25	0.25	0.25													
		Administration cost	0.44								0.11	0.11	0.11	0.11													
		Total	11.52								2.88	2.88	2.88	2.88													
17	A	Construction cost	0.08																							0.04	0.04
		Physical contingency	0.01																							0.01	0.01
		Engineering service	0.01																							0.01	0.01
		Administration cost	0.00																							0.00	0.00
		Total	0.10																							0.05	0.05
	B	Construction cost	4.66																						1.55	1.55	1.55
		Physical contingency	0.56																						0.19	0.19	0.19
		Engineering service	0.52																						0.17	0.17	0.17
		Administration cost	0.23																						0.08	0.08	0.08
		Total	5.97																						1.99	1.99	1.99
	C	Construction cost	8.81												2.20	2.20	2.20	2.20									
		Physical contingency	1.06												0.27	0.27	0.27	0.27									
		Engineering service	0.99												0.25	0.25	0.25	0.25									
		Administration cost	0.43												0.11	0.11	0.11	0.11									
		Total	11.29												2.82	2.82	2.82	2.82									
Total		Construction cost	300.47	10.72	10.72	12.05	13.92	12.49	12.11	12.11	11.64	11.64	10.77	10.77	14.22	14.22	12.95	11.68	16.11	16.11	16.11	14.61	12.73	12.27	12.15	13.35	5.04
		Physical contingency	36.04	1.29	1.29	1.45	1.67	1.50	1.45	1.45	1.39	1.39	1.29	1.29	1.71	1.71	1.56	1.40	1.93	1.93	1.93	1.75	1.52	1.47	1.45	1.60	0.61
		Engineering service	33.65	1.20	1.20	1.35	1.57	1.40	1.36	1.36	1.30	1.30	1.21	1.21	1.60	1.60	1.45	1.31	1.80	1.80	1.80	1.63	1.42	1.37	1.36	1.49	0.57
		Administration cost	14.76	0.52	0.52	0.60	0.69	0.62	0.60	0.60	0.57	0.57	0.53	0.53	0.70	0.70	0.64	0.58	0.79	0.79	0.79	0.72	0.63	0.61	0.60	0.65	0.25
		Total	384.92	13.72	13.72	15.44	17.85	16.01	15.52	15.52	14.90	14.90	13.80	13.80	18.22	18.22	16.59	14.97	20.64	20.64	20.64	18.71	16.31	15.72	15.56	17.09	6.45
Accumulated Investment Cost				13.72	27.44	42.89	60.73	76.74	92.26	107.77	122.67	137.57	151.36	165.16	183.38	201.60	218.20	233.17	253.80	274.44	295.08	313.79	330.09	345.82	361.38	378.47	384.92

Source: Project Team

Table 8.1.41 Disbursement Schedule for Irrigation Development (5,000ha/year) (1/6)

Unit: Million USD

WRA	WRU	Descriptiion	Total	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	Construction cost	5.62	1.87	1.87	1.87																					
		Physical contingency	0.67	0.22	0.22	0.22																					
		Engineering service	0.63	0.21	0.21	0.21																					
		Administration cost	0.28	0.09	0.09	0.09																					
		Total	7.20	2.40	2.40	2.40																					
	B	Construction cost	6.97	2.32	2.32	2.32																					
		Physical contingency	0.84	0.28	0.28	0.28																					
		Engineering service	0.78	0.26	0.26	0.26																					
		Administration cost	0.34	0.11	0.11	0.11																					
		Total	8.93	2.98	2.98	2.98																					
	C	Construction cost	7.52	2.51	2.51	2.51																					
		Physical contingency	0.90	0.30	0.30	0.30																					
		Engineering service	0.84	0.28	0.28	0.28																					
		Administration cost	0.37	0.12	0.12	0.12																					
		Total	9.63	3.21	3.21	3.21																					
	E	Construction cost	5.32	1.77	1.77	1.77																					
		Physical contingency	0.64	0.21	0.21	0.21																					
		Engineering service	0.60	0.20	0.20	0.20																					
		Administration cost	0.26	0.09	0.09	0.09																					
		Total	6.82	2.27	2.27	2.27																					
	F	Construction cost	2.58						1.29	1.29																	
		Physical contingency	0.31						0.16	0.16																	
		Engineering service	0.29						0.15	0.15																	
		Administration cost	0.13						0.07	0.07																	
		Total	3.31						1.66	1.66																	
	G	Construction cost	6.84	2.28	2.28	2.28																					
		Physical contingency	0.82	0.27	0.27	0.27																					
		Engineering service	0.77	0.26	0.26	0.26																					
		Administration cost	0.34	0.11	0.11	0.11																					
		Total	8.77	2.92	2.92	2.92																					
	K	Construction cost	8.08	2.69	2.69	2.69																					
		Physical contingency	0.97	0.32	0.32	0.32																					
		Engineering service	0.91	0.30	0.30	0.30																					
		Administration cost	0.40	0.13	0.13	0.13																					
		Total	10.36	3.45	3.45	3.45																					
	L	Construction cost	5.67	1.89	1.89	1.89																					
		Physical contingency	0.68	0.23	0.23	0.23																					
		Engineering service	0.64	0.21	0.21	0.21																					
		Administration cost	0.28	0.09	0.09	0.09																					
		Total	7.27	2.42	2.42	2.42																					
	M	Construction cost	6.14			2.05	2.05	2.05																			
		Physical contingency	0.74			0.25	0.25	0.25																			
		Engineering service	0.69			0.23	0.23	0.23																			
		Administration cost	0.30			0.10	0.10	0.10																			
		Total	7.87			2.62	2.62	2.62																			
	N	Construction cost	2.68												1.34	1.34											
		Physical contingency	0.32												0.16	0.16											
		Engineering service	0.30												0.15	0.15											
		Administration cost	0.13												0.07	0.07											
		Total	3.43												1.72	1.72											

Source: Project Team

Table 8.1.42 Disbursement Schedule for Irrigation Development (5,000ha/year) (2/6)

Unit: Million USD

WRA	WRU	Descriptiion	Total	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	O	Construction cost	7.50								2.50	2.50	2.50														
		Physical contingency	0.90								0.30	0.30	0.30														
		Engineering service	0.84								0.28	0.28	0.28														
		Administration cost	0.37								0.12	0.12	0.12														
		Total	9.61								3.20	3.20	3.20														
	P	Construction cost	5.77			1.92	1.92	1.92																			
		Physical contingency	0.69			0.23	0.23	0.23																			
		Engineering service	0.65			0.22	0.22	0.22																			
		Administration cost	0.28			0.09	0.09	0.09																			
		Total	7.39			2.46	2.46	2.46																			
	R	Construction cost	12.34	3.09	3.09	3.09	3.09																				
		Physical contingency	1.48	0.37	0.37	0.37	0.37																				
		Engineering service	1.38	0.35	0.35	0.35	0.35																				
		Administration cost	0.61	0.15	0.15	0.15	0.15																				
		Total	15.81	3.95	3.95	3.95	3.95																				
	S	Construction cost	7.17	2.39	2.39	2.39																					
		Physical contingency	0.86	0.29	0.29	0.29																					
		Engineering service	0.80	0.27	0.27	0.27																					
		Administration cost	0.35	0.12	0.12	0.12																					
		Total	9.18	3.06	3.06	3.06																					
	T	Construction cost	0.86						0.43	0.43																	
		Physical contingency	0.10						0.05	0.05																	
		Engineering service	0.10						0.05	0.05																	
		Administration cost	0.04						0.02	0.02																	
		Total	1.10						0.55	0.55																	
2	A	Construction cost	0.63																			0.32	0.32				
		Physical contingency	0.08																			0.04	0.04				
		Engineering service	0.07																			0.04	0.04				
		Administration cost	0.03																			0.02	0.02				
		Total	0.81																			0.41	0.41				
	B	Construction cost	0.58								0.29	0.29															
		Physical contingency	0.07								0.04	0.04															
		Engineering service	0.07								0.04	0.04															
		Administration cost	0.03								0.02	0.02															
		Total	0.75								0.38	0.38															
	C	Construction cost	0.14						0.07	0.07																	
		Physical contingency	0.02						0.01	0.01																	
		Engineering service	0.02						0.01	0.01																	
		Administration cost	0.01						0.01	0.01																	
		Total	0.19						0.10	0.10																	
	D	Construction cost	0.25																			0.13	0.13				
		Physical contingency	0.03																			0.02	0.02				
		Engineering service	0.03																			0.02	0.02				
		Administration cost	0.01																			0.01	0.01				
		Total	0.32																			0.16	0.16				

Source: Project Team

Table 8.1.43 Disbursement Schedule for Irrigation Development (5,000ha/year) (3/6)

Unit: Million USD

WRA	WRU	Descriptiion	Total	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
3	A	Construction cost	5.10																			1.70	1.70	1.70			
		Physical contingency	0.61																			0.20	0.20	0.20			
		Engineering service	0.57																			0.19	0.19	0.19			
		Administration cost	0.25																			0.08	0.08	0.08			
		Total	6.53																			2.18	2.18	2.18			
	B	Construction cost	4.63																							2.32	2.32
		Physical contingency	0.56																							0.28	0.28
		Engineering service	0.52																							0.26	0.26
		Administration cost	0.23																							0.12	0.12
		Total	5.94																							2.97	2.97
	C	Construction cost	9.81												2.45	2.45	2.45	2.45									
		Physical contingency	1.18												0.30	0.30	0.30	0.30									
		Engineering service	1.10												0.28	0.28	0.28	0.28									
		Administration cost	0.48												0.12	0.12	0.12	0.12									
		Total	12.57												3.14	3.14	3.14	3.14									
	D	Construction cost	6.23																					2.08	2.08	2.08	
		Physical contingency	0.75																					0.25	0.25	0.25	
		Engineering service	0.70																					0.23	0.23	0.23	
		Administration cost	0.31																					0.10	0.10	0.10	
		Total	7.99																					2.66	2.66	2.66	
	E	Construction cost	7.02																						2.34	2.34	2.34
		Physical contingency	0.84																						0.28	0.28	0.28
		Engineering service	0.79																						0.26	0.26	0.26
		Administration cost	0.35																						0.12	0.12	0.12
		Total	9.00																						3.00	3.00	3.00
	F	Construction cost	2.03																						1.02	1.02	
		Physical contingency	0.24																						0.12	0.12	
		Engineering service	0.23																						0.12	0.12	
		Administration cost	0.10																						0.05	0.05	
		Total	2.60																						1.30	1.30	
4	A	Construction cost	0.16																			0.08	0.08				
		Physical contingency	0.02																			0.01	0.01				
		Engineering service	0.02																			0.01	0.01				
		Administration cost	0.01																			0.01	0.01				
		Total	0.21																			0.11	0.11				
	B	Construction cost	2.88								1.44	1.44															
		Physical contingency	0.35								0.18	0.18															
		Engineering service	0.32								0.16	0.16															
		Administration cost	0.14								0.07	0.07															
		Total	3.69								1.85	1.85															
	C	Construction cost	0.66			0.33	0.33																				
		Physical contingency	0.08			0.04	0.04																				
		Engineering service	0.07			0.04	0.04																				
		Administration cost	0.03			0.02	0.02																				
		Total	0.84			0.42	0.42																				

Source: Project Team

Table 8.1.44 Disbursement Schedule for Irrigation Development (5,000ha/year) (4/6)

Unit: Million USD

WRA	WRU	Descriptiion	Total	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
4	D	Construction cost	1.80	0.90	0.90																						
		Physical contingency	0.22	0.11	0.11																						
		Engineering service	0.20	0.10	0.10																						
		Administration cost	0.09	0.05	0.05																						
		Total	2.31	1.16	1.16																						
	E	Construction cost	0.95	0.48	0.48																						
		Physical contingency	0.11	0.06	0.06																						
		Engineering service	0.11	0.06	0.06																						
		Administration cost	0.05	0.03	0.03																						
		Total	1.22	0.61	0.61																						
	F	Construction cost	0.18	0.09	0.09																						
		Physical contingency	0.02	0.01	0.01																						
		Engineering service	0.02	0.01	0.01																						
		Administration cost	0.01	0.01	0.01																						
		Total	0.23	0.12	0.12																						
5	C	Construction cost	5.21																				2.61	2.61			
		Physical contingency	0.63																				0.32	0.32			
		Engineering service	0.58																				0.29	0.29			
		Administration cost	0.26																				0.13	0.13			
		Total	6.68																				3.34	3.34			
	D	Construction cost	3.92																			1.96	1.96				
		Physical contingency	0.47																			0.24	0.24				
		Engineering service	0.44																			0.22	0.22				
		Administration cost	0.19																			0.10	0.10				
		Total	5.02																			2.51	2.51				
	E	Construction cost	15.15				3.79	3.79	3.79	3.79																	
		Physical contingency	1.82				0.46	0.46	0.46	0.46																	
		Engineering service	1.70				0.43	0.43	0.43	0.43																	
		Administration cost	0.75				0.19	0.19	0.19	0.19																	
		Total	19.42				4.86	4.86	4.86	4.86																	
	F	Construction cost	11.88				2.97	2.97	2.97	2.97																	
		Physical contingency	1.43				0.36	0.36	0.36	0.36																	
		Engineering service	1.33				0.33	0.33	0.33	0.33																	
		Administration cost	0.59				0.15	0.15	0.15	0.15																	
		Total	15.23				3.81	3.81	3.81	3.81																	
7	A	Construction cost	21.44				5.36	5.36	5.36	5.36																	
		Physical contingency	2.57				0.64	0.64	0.64	0.64																	
		Engineering service	2.40				0.60	0.60	0.60	0.60																	
		Administration cost	1.06				0.27	0.27	0.27	0.27																	
		Total	27.47				6.87	6.87	6.87	6.87																	
	B	Construction cost	8.95								2.98	2.98	2.98														
		Physical contingency	1.07								0.36	0.36	0.36														
		Engineering service	1.00								0.33	0.33	0.33														
		Administration cost	0.44								0.15	0.15	0.15														
		Total	11.46								3.82	3.82	3.82														
	C	Construction cost	9.91				2.48	2.48	2.48	2.48																	
		Physical contingency	1.19				0.30	0.30	0.30	0.30																	
		Engineering service	1.11				0.28	0.28	0.28	0.28																	
		Administration cost	0.49				0.12	0.12	0.12	0.12																	
		Total	12.70				3.18	3.18	3.18	3.18																	

Source: Project Team

Table 8.1.45 Disbursement Schedule for Irrigation Development (5,000ha/year) (5/6)

Unit: Million USD

WRA	WRU	Descriptiion	Total	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
		Construction cost	26.23				6.56	6.56	6.56	6.56																	
		Physical contingency	3.15				0.79	0.79	0.79	0.79																	
	D	Engineering service	2.94				0.74	0.74	0.74	0.74																	
		Administration cost	1.29				0.32	0.32	0.32	0.32																	
		Total	33.61				8.40	8.40	8.40	8.40																	
		Construction cost	3.89																				1.95	1.95			
		Physical contingency	0.47																				0.24	0.24			
	E	Engineering service	0.44																				0.22	0.22			
		Administration cost	0.19																				0.10	0.10			
		Total	4.99																				2.50	2.50			
		Construction cost	8.47								2.82	2.82	2.82														
		Physical contingency	1.02								0.34	0.34	0.34														
7	F	Engineering service	0.95								0.32	0.32	0.32														
		Administration cost	0.42								0.14	0.14	0.14														
		Total	10.86								3.62	3.62	3.62														
		Construction cost	5.46								1.82	1.82	1.82														
		Physical contingency	0.66								0.22	0.22	0.22														
	G	Engineering service	0.61								0.20	0.20	0.20														
		Administration cost	0.27								0.09	0.09	0.09														
		Total	7.00								2.33	2.33	2.33														
		Construction cost	2.81						1.41	1.41																	
		Physical contingency	0.34						0.17	0.17																	
	H	Engineering service	0.32						0.16	0.16																	
		Administration cost	0.14						0.07	0.07																	
		Total	3.61						1.81	1.81																	
		Construction cost	44.40												11.10	11.10	11.10	11.10									
		Physical contingency	5.33												1.33	1.33	1.33	1.33									
8	A	Engineering service	4.97												1.24	1.24	1.24	1.24									
		Administration cost	2.19												0.55	0.55	0.55	0.55									
		Total	56.89												14.22	14.22	14.22	14.22									
		Construction cost	2.06																				1.03	1.03			
		Physical contingency	0.25																				0.13	0.13			
	A	Engineering service	0.23																				0.12	0.12			
		Administration cost	0.10																				0.05	0.05			
9		Total	2.64																				1.32	1.32			
		Construction cost	2.54												1.27	1.27											
		Physical contingency	0.30												0.15	0.15											
	B	Engineering service	0.28												0.14	0.14											
		Administration cost	0.12												0.06	0.06											
		Total	3.24												1.62	1.62											
		Construction cost	3.16																							1.58	1.58
		Physical contingency	0.38																							0.19	0.19
	B	Engineering service	0.35																							0.18	0.18
		Administration cost	0.16																							0.08	0.08
14		Total	4.05																							2.03	2.03
		Construction cost	120.04																30.01	30.01	30.01	30.01					
		Physical contingency	14.40																3.60	3.60	3.60	3.60					
	C	Engineering service	13.44																3.36	3.36	3.36	3.36					
		Administration cost	5.92																1.48	1.48	1.48	1.48					
		Total	153.80																38.45	38.45	38.45	38.45					

Source: Project Team

Table 8.1.46 Disbursement Schedule for Irrigation Development (5,000ha/year) (6/6)

Unit: Million USD

WRA	WRU	Descriptiion	Total	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
		Construction cost	34.35															8.59	8.59	8.59	8.59						
		Physical contingency	4.12															1.03	1.03	1.03	1.03						
	A	Engineering service	3.85															0.96	0.96	0.96	0.96						
		Administration cost	1.69															0.42	0.42	0.42	0.42						
		Total	44.01															11.00	11.00	11.00	11.00						
		Construction cost	55.33																				13.83	13.83	13.83	13.83	
		Physical contingency	6.64																				1.66	1.66	1.66	1.66	
15	B	Engineering service	6.20																				1.55	1.55	1.55	1.55	
		Administration cost	2.73																				0.68	0.68	0.68	0.68	
		Total	70.90																				17.73	17.73	17.73	17.73	
		Construction cost	6.75																						2.25	2.25	2.25
		Physical contingency	0.81																						0.27	0.27	0.27
	C	Engineering service	0.76																						0.25	0.25	0.25
		Administration cost	0.33																						0.11	0.11	0.11
		Total	8.65																						2.88	2.88	2.88
		Construction cost	32.45								8.11	8.11	8.11	8.11													
		Physical contingency	3.89								0.97	0.97	0.97	0.97													
	E	Engineering service	3.63								0.91	0.91	0.91	0.91													
		Administration cost	1.60								0.40	0.40	0.40	0.40													
		Total	41.57								10.39	10.39	10.39	10.39													
		Construction cost	36.41											9.10	9.10	9.10	9.10										
		Physical contingency	4.37											1.09	1.09	1.09	1.09										
16	F	Engineering service	4.08											1.02	1.02	1.02	1.02										
		Administration cost	1.79											0.45	0.45	0.45	0.45										
		Total	46.65											11.66	11.66	11.66	11.66										
		Construction cost	18.02								4.51	4.51	4.51	4.51													
		Physical contingency	2.16								0.54	0.54	0.54	0.54													
	G	Engineering service	2.02								0.51	0.51	0.51	0.51													
		Administration cost	0.89								0.22	0.22	0.22	0.22													
		Total	23.09								5.77	5.77	5.77	5.77													
		Construction cost	0.20																							0.10	0.10
		Physical contingency	0.02																							0.01	0.01
	A	Engineering service	0.02																							0.01	0.01
		Administration cost	0.01																							0.01	0.01
		Total	0.25																							0.13	0.13
		Construction cost	9.33																						3.11	3.11	3.11
		Physical contingency	1.12																						0.37	0.37	0.37
17	B	Engineering service	1.05																						0.35	0.35	0.35
		Administration cost	0.46																						0.15	0.15	0.15
		Total	11.96																						3.99	3.99	3.99
		Construction cost	19.13												4.78	4.78	4.78	4.78									
		Physical contingency	2.30												0.58	0.58	0.58	0.58									
	C	Engineering service	2.14												0.54	0.54	0.54	0.54									
		Administration cost	0.94												0.24	0.24	0.24	0.24									
		Total	24.51												6.13	6.13	6.13	6.13									
		Construction cost	641.60	22.28	22.28	25.12	28.54	25.12	24.35	24.35	24.47	24.47	22.74	21.72	30.05	30.05	27.44	26.92	38.60	38.60	38.60	34.19	23.59	23.19	24.62	28.62	11.70
		Physical contingency	77.01	2.67	2.67	3.01	3.43	3.02	2.93	2.93	2.94	2.94	2.73	2.61	3.61	3.61	3.30	3.23	4.63	4.63	4.63	4.10	2.84	2.79	2.95	3.43	1.40
Total		Engineering service	71.90	2.50	2.50	2.82	3.20	2.82	2.74	2.74	2.74	2.74	2.55	2.43	3.36	3.36	3.07	3.02	4.32	4.32	4.32	3.83	2.65	2.60	2.77	3.21	1.31
		Administration cost	31.63	1.10	1.10	1.23	1.41	1.24	1.21	1.21	1.21	1.21	1.12	1.07	1.48	1.48	1.35	1.33	1.90	1.90	1.90	1.68	1.16	1.14	1.22	1.42	0.58
		Total	822.14	28.55	28.55	32.18	36.57	32.19	31.21	31.21	31.36	31.36	29.14	27.83	38.49	38.49	35.16	34.50	49.45	49.45	49.45	43.81	30.24	29.72	31.56	36.68	14.99
Accumulated Investment Cost				28.55	57.11	89.28	125.85	158.05	189.26	220.47	251.83	283.19	312.34	340.16	378.65	417.14	452.30	486.79	536.25	585.70	635.15	678.96	709.19	738.91	770.47	807.15	822.14

Source: Project Team

8.2 Economic Evaluation of Projects

8.2.1 Methodology

(1) General

The main objective of the economic evaluation here is to examine the investment efficiency of the project components of the Master Plan from the viewpoint of national economy using cost-benefit analysis in cases where it can be applied. Market prices have been converted to economic ones where the influence of market distortion is removed (the so-called shadow prices). Opportunity costs are used for the costs of goods and services whose markets do not exist. Willingness-to-pay is used for benefits whose markets do not exist. Internal Rate of Return (IRR) is used here as the indicator of the efficiency of a project investment. IRR is defined as the discount rate which makes the present value of the flow of costs incurred in the project the same as that of benefit, or which makes the Net Present Value (NPV) 0 (zero), showing what percentage of profit the investment will be paid back. IRR used in economic evaluation is called Economic Internal Rate of Return (EIRR).

(2) Precondition

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

1) With-Project and Without-Project

"Without-project” is the case where the water resources are managed by the currently existing systems. “With-project” is the case where the project is implemented into the currently existing systems. By comparing the with-project and the without-project situations, costs and benefits are estimated to calculate EIRR.

2) Evaluation Period

The evaluation period is 2012 to 2060.

3) Standard Conversion Factor (SCF)

SCF is the ratio of the economic price value of all goods in an economy at their border price equivalent values to their domestic market price value. Prices of goods and services procured domestically are converted to economic ones by the SCF. This project employs an SCF of 1.0 (one point zero), which is the value employed in Ministry of Water Development (2003), "The Integrated Water Resources Development Plan for Lake Malawi and Shire River System."

4) Other Preconditions

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

(3) Costs

Additional costs of projects are included in the evaluation by comparing the with-project and the without-project situations. The additional costs are calculated in the form of cash flow of each year during the evaluation period. The following cost items are calculated:

1) Investment Cost

Investment cost includes costs of construction of the facility, equipment, and consulting services. Economic evaluation excludes price escalation but includes physical contingencies.

2) Operation and Maintenance (O&M) Cost

O&M costs for each year are included. Price escalation is not included.

3) Depreciation

Since the money allocated and subject to depreciation is not actually spent at that time, it is not included in the cost items.

(4) Benefits

Additional benefits are included in the evaluation by comparing with-project and without-project. The benefits are calculated in the form of cash flow in each year during the evaluation period. Since each component has different effects, their benefits should be identified for each component. Contents, expected effects and the benefits of components are summarized in the following table.

Table 8.2.1 Expected Effects, and Benefit of Components

Component	Expected Effect	Benefit
• Domestic and Industrial Water Supply	To increase water supply in urban and Rural Water Supply	Living condition of the people improves.
• Irrigation	To increase agricultural productions	Income of farmers increases.
• Navigation	To improve the water transportation	Transportation cost decreases.
• Hydropower Generation	To increase the electric power generation	GDP increases. Living condition of the people improves.
• Water Quality Conservation	To conserve the water quality	Living environment of the residents improves.

Source: Project Team

8.2.2 Cost-Benefit Analysis of Projects

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

(1) Project Cost

The following items are included in the cost calculation:

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

These cost items are converted to economic ones as mentioned above, but they are the same figures since 1.0 is employed for SCF. Details on the project costs are mentioned in **Section 8.1, Cost Estimation**.

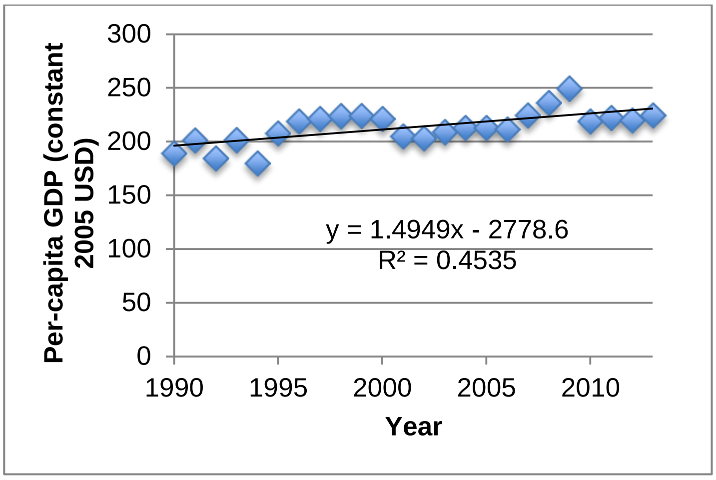
(2) Project Benefit

1) Domestic and Industrial Water Supply

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

<u>Per-capita GDP Growth Rate</u>

WTP is assumed to increase in accordance with the per-capita GDP Growth rate. Per-capita GDP in the future is projected with utilizing a result of the regression analysis of the World Bank data. The result of the regression analysis of past per-capita GDP data of the World Bank is presented below.



Source: Project Team based on the World Bank data

Figure 8.2.1 Regression Analysis of Per-capita GDP

$y = 1.4949x - 2778.6$

$R^2 = 0.45348$

Where;

x: year

y: per-capita GDP (constant 2005 USD) in year x

R^2: determination coefficient

By using this result, future per-capita GDP and its real growth rates are projected as follows:

Table 8.2.2 Future Projections of Per-capita GDP and Real Growth Rate

	2012	2015	2020	2025	2030	2035
Per-capita GDP (constant 2005 USD)	229.14	233.62	240.10	248.57	256.05	263.52
Growth Rate	0.66%	0.64%	0.62%	0.61%	0.59%	0.57%

Source: Project Team based on the World Bank data

Willingness-to-Pay (WTP)

According to JICA (2002), "Study on Economic Evaluation Methodology for Development Study, Part 9. Water Supply " (Japanese), various research results of WTP for supplied water by using the Contingent Valuation Method (CVM) fall in the range of 3-5% of disposable income. Thus, the Project employs 5% of disposable income.

The Project uses consumption data of The National Statistics Office (NSO), "Integrated Household Survey 2010 - 2011" instead of disposal income due to availability of data.

Table 8.2.3 Average Per-capita Consumption in 2011

	MK	USD	Applied To
Lilongwe City	106,735	681.9	Four Cities
Blantyre City	152,907	976.9	
Mzuzu City	98,302	628.1	
Zomba City	115,604	738.6	
Nortern Region	46,160	294.9	Towns
Central Region	57,455	367.1	
Southern Region	54,269	346.7	
Rural North	39,366	251.5	Market Centers
Rural Center	48,320	308.7	
Rural South	39,101	249.8	

Source: NSO, "Integrated Household Survey 2010-2011" and Project Team

The calculation result of WTP for the urban water supply is shown below:

Table 8.2.4 Calculation Result of WTP for Urban Water Supply (Four Cities)

Region	Calculation Item	2012	2015	2020	2025	2030	2035
Lilongwe	Increase in Water Supply by Project (m^3/day)	0	28,211	60,000	105,951	144,960	191,206
	Servded Population (pers.)	0	104,997	318,084	562,571	778,058	1,027,696
	Per-capita Consumption (l/c/day)	93	106	127	135	135	135
	WTP for Water Supply (USD/c/year)	40.4	41.2	42.5	43.8	45.1	46.5
	WTP for Water Supply (USD/m^3/day)	1.18	1.07	0.92	0.89	0.92	0.94
	Total WTP (USD/year)	0	10,969,501	20,129,884	34,393,179	48,470,707	65,800,750
Blantiyre	Increase in Water Supply by Project (m^3/day)	0	0	16,638	40,223	68,376	103,338
	Servded Population (pers.)	0	0	161,947	404,271	636,881	827,879
	Per-capita Consumption (l/c/day)	67	69	73	78	84	90
	WTP for Water Supply (USD/c/year)	57.9	59.0	60.9	62.8	64.7	66.6
	WTP for Water Supply (USD/m^3/day)	2.37	2.34	2.29	2.21	2.11	2.03
	Total WTP (USD/year)	0	0	13,878,211	32,374,598	52,639,185	76,418,985
Mzuzu	Increase in Water Supply by Project (m^3/day)	0	8,773	20,548	34,178	45,867	59,161
	Servded Population (pers.)	0	0	51,928	119,750	170,990	226,914
	Per-capita Consumption (l/c/day)	65	77	93	102	106	110
	WTP for Water Supply (USD/c/year)	37.2	37.9	39.1	40.4	41.6	42.8
	WTP for Water Supply (USD/m^3/day)	1.57	1.35	1.15	1.08	1.07	1.06
	Total WTP (USD/year)	0	0	8,644,588	13,516,189	17,955,695	22,967,472
Zomba	Increase in Water Supply by Project (m^3/day)	0	524	5,864	9,918	13,636	17,870
	Servded Population (pers.)	0	7,008	23,407	42,325	64,150	89,329
	Per-capita Consumption (l/c/day)	100	101	101	101	101	101
	WTP for Water Supply (USD/c/year)	43.8	44.6	46.0	47.5	48.9	50.3
	WTP for Water Supply (USD/m^3/day)	1.19	1.21	1.25	1.29	1.32	1.36
	Total WTP (USD/year)	0	231,185	2,669,657	4,655,301	6,593,129	8,892,286

Note: USD is converted to 2012 level.
Source: Project Team based on the World Bank data

Table 8.2.5 Calculation Result of WTP for Urban Water Supply (Towns)

Region	Calculation Item	2012	2015	2020	2025	2030	2035
Northern	Increase in Water Supply by Project (m^3/day)	0	0	9,330	18,613	33,207	48,799
	Served Population (pers.)	0	0	85,028	138,171	212,658	302,228
	Per-capita Consumption (l/c/day)	93	93	93	130	130	130
	WTP for Water Supply (USD/c/year)	17.5	17.8	18.4	19.0	19.5	20.1
	WTP for Water Supply (USD/m^3/day)	0.51	0.52	0.54	0.40	0.41	0.42
	Total WTP (USD/year)	0	0	1,844,251	2,713,516	4,986,622	7,542,050
Central	Increase in Water Supply by Project (m^3/day)	0	0	17,170	33,145	63,720	99,885
	Served Population (pers.)	0	0	142,726	231,929	406,815	626,719
	Per-capita Consumption (l/c/day)	93	93	93	130	130	130
	WTP for Water Supply (USD/c/year)	21.7	22.2	22.9	23.6	24.3	25.0
	WTP for Water Supply (USD/m^3/day)	0.64	0.65	0.67	0.50	0.51	0.53
	Total WTP (USD/year)	0	0	4,224,182	6,014,457	11,910,293	19,214,947
Southern	Increase in Water Supply by Project (m^3/day)	0	0	15,450	29,142	53,353	80,617
	Served Population (pers.)	0	0	125,314	203,635	334,522	495,982
	Per-capita Consumption (l/c/day)	93	93	93	130	130	130
	WTP for Water Supply (USD/c/year)	20.5	20.9	21.6	22.3	23.0	23.6
	WTP for Water Supply (USD/m^3/day)	0.61	0.62	0.64	0.47	0.48	0.50
	Total WTP (USD/year)	0	0	3,590,215	4,994,893	9,419,405	14,648,516

Note: USD is converted to 2012 level.
Source: Project Team based on the World Bank data

The calculation result of WTP for the rural water supply is shown below:

Table 8.2.6 Calculation Result of WTP for Rural Water Supply (Market Centers)

Region	Calculation Item	2012	2015	2020	2025	2030	2035
Northern	Increase in Water Supply by Project (m^3/day)	0	0	5,262	11,133	13,743	15,858
	Served Population (pers.)	0	0	49,232	112,196	150,926	193,228
	Per-capita Consumption (l/c/day)	41.0	41.0	41.0	46.0	46.0	46.0
	WTP for Water Supply (USD/c/year)	14.9	15.2	15.7	16.2	16.6	17.1
	WTP for Water Supply (USD/m^3/day)	1.00	1.02	1.05	0.96	0.99	1.02
	Total WTP (USD/year)	0	0	954,704	1,898,827	2,320,377	2,655,238
Central	Increase in Water Supply by Project (m^3/day)	0	0	6,436	15,820	21,691	26,595
	Served Population (pers.)	0	0	93,014	215,467	305,102	403,177
	Per-capita Consumption (l/c/day)	41.0	41.0	41.0	46.0	46.0	46.0
	WTP for Water Supply (USD/c/year)	18.3	18.6	19.2	19.8	20.4	21.0
	WTP for Water Supply (USD/m^3/day)	1.22	1.25	1.29	1.18	1.22	1.25
	Total WTP (USD/year)	0	0	3,020,652	6,822,907	9,636,417	12,159,809
Southern	Increase in Water Supply by Project (m^3/day)	0	0	5,744	12,652	18,612	21,823
	Served Population (pers.)	0	0	72,758	167,116	224,306	288,529
	Per-capita Consumption (l/c/day)	41.0	41.0	41.0	46.0	46.0	46.0
	WTP for Water Supply (USD/c/year)	14.8	15.1	15.6	16.1	16.5	17.0
	WTP for Water Supply (USD/m^3/day)	0.99	1.01	1.04	0.96	0.98	1.01
	Total WTP (USD/year)	0	0	2,181,493	4,415,592	6,690,698	8,074,086

Note: USD is converted to 2012 level.
Source: Project Team based on the World Bank data

The calculation result of WTP for the urban water supply is shown below:

Table 8.2.7 Calculation Result of WTP for Urban Water Supply (Four Cities)

Region	Calculation Item	2012	2015	2020	2025	2030	2035
Lilongwe	Increase in Water Supply by Project (m^3/day)	0	28,211	60,000	105,951	144,960	191,206
	Per-capita Consumption (l/c/day)	93	106	127	135	135	135
	WTP for Water Supply (USD/c/year)	40.4	41.2	42.5	43.8	45.1	46.5
	WTP for Water Supply (USD/m^3/day)	1.18	1.07	0.92	0.89	0.92	0.94
	Total WTP (USD/year)	0	10,969,501	20,129,884	34,393,179	48,470,707	65,800,750
Blantiyre	Increase in Water Supply by Project (m^3/day)	0	0	16,638	40,223	68,376	103,338
	Per-capita Consumption (l/c/day)	67	69	73	78	84	90
	WTP for Water Supply (USD/c/year)	57.9	59.0	60.9	62.8	64.7	66.6
	WTP for Water Supply (USD/m^3/day)	2.37	2.34	2.29	2.21	2.11	2.03
	Total WTP (USD/year)	0	0	13,878,211	32,374,598	52,639,185	76,418,985
Mzuzu	Increase in Water Supply by Project (m^3/day)	0	8,773	20,548	34,178	45,867	59,161
	Per-capita Consumption (l/c/day)	65	77	93	102	106	110
	WTP for Water Supply (USD/c/year)	37.2	37.9	39.1	40.4	41.6	42.8
	WTP for Water Supply (USD/m^3/day)	1.57	1.35	1.15	1.08	1.07	1.06
	Total WTP (USD/year)	0	0	8,644,588	13,516,189	17,955,695	22,967,472
Zomba	Increase in Water Supply by Project (m^3/day)	0	524	5,864	9,918	13,636	17,870
	Per-capita Consumption (l/c/day)	100	101	101	101	101	101
	WTP for Water Supply (USD/c/year)	43.8	44.6	46.0	47.5	48.9	50.3
	WTP for Water Supply (USD/m^3/day)	1.19	1.21	1.25	1.29	1.32	1.36
	Total WTP (US/year)	0	231,185	2,669,657	4,655,301	6,593,129	8,892,286

Note: USD is converted to 2012 level.
Source: Project Team based on the World Bank data

Table 8.2.8 Calculation Result of WTP for Urban Water Supply (Towns)

Region	Calculation Item	2012	2015	2020	2025	2030	2035
Northern	Increase in Water Supply by Project (m^3/day)	0	0	9,330	18,613	33,207	48,799
	Per-capita Consumption (l/c/day)	93	93	93	130	130	130
	WTP for Water Supply (USD/c/year)	17.5	17.8	18.4	19.0	19.5	20.1
	WTP for Water Supply (USD/m^3/day)	0.51	0.52	0.54	0.40	0.41	0.42
	Total WTP (USD/year)	0	0	1,844,251	2,713,516	4,986,622	7,542,050
Central	Increase in Water Supply by Project (m^3/day)	0	0	17,170	33,145	63,720	99,885
	Per-capita Consumption (l/c/day)	93	93	93	130	130	130
	WTP for Water Supply (USD/c/year)	21.7	22.2	22.9	23.6	24.3	25.0
	WTP for Water Supply (USD/m^3/day)	0.64	0.65	0.67	0.50	0.51	0.53
	Total WTP (USD/year)	0	0	4,224,182	6,014,457	11,910,293	19,214,947
Southern	Increase in Water Supply by Project (m^3/day)	0	0	15,450	29,142	53,353	80,617
	Per-capita Consumption (l/c/day)	93	93	93	130	130	130
	WTP for Water Supply (USD/c/year)	20.5	20.9	21.6	22.3	23.0	23.6
	WTP for Water Supply (USD/m^3/day)	0.61	0.62	0.64	0.47	0.48	0.50
	Total WTP (USD/year)	0	0	3,590,215	4,994,893	9,419,405	14,648,516

Note: USD is converted to 2012 level.
Source: Project Team based on the World Bank data

The calculation result of WTP for the rural water supply is shown below:

Table 8.2.9 Calculation Result of WTP for Rural Water Supply (Market Centers)

Region	Calculation Item	2012	2015	2020	2025	2030	2035
Northern	Increase in Water Supply by Project (m^3/day)	0	0	5,262	11,133	13,743	15,858
	Per-capita Consumption (l/c/day)	41.0	41.0	41.0	46.0	46.0	46.0
	WTP for Water Supply (USD/c/year)	14.9	15.2	15.7	16.2	16.6	17.1
	WTP for Water Supply (USD/m^3/day)	1.00	1.02	1.05	0.96	0.99	1.02
	Total WTP (USD/year)	0	0	954,704	1,898,827	2,320,377	2,655,238
Central	Increase in Water Supply by Project (m^3/day)	0	0	6,436	15,820	21,691	26,595
	Per-capita Consumption (l/c/day)	41.0	41.0	41.0	46.0	46.0	46.0
	WTP for Water Supply (USD/c/year)	18.3	18.6	19.2	19.8	20.4	21.0
	WTP for Water Supply (USD/m^3/day)	1.22	1.25	1.29	1.18	1.22	1.25
	Total WTP (USD/year)	0	0	3,020,652	6,822,907	9,636,417	12,159,809
Southern	Increase in Water Supply by Project (m^3/day)	0	0	5,744	12,652	18,612	21,823
	Per-capita Consumption (l/c/day)	41.0	41.0	41.0	46.0	46.0	46.0
	WTP for Water Supply (USD/c/year)	14.8	15.1	15.6	16.1	16.5	17.0
	WTP for Water Supply (USD/m^3/day)	0.99	1.01	1.04	0.96	0.98	1.01
	Total WTP (USD/year)	0	0	2,181,493	4,415,592	6,690,698	8,074,086

Note: USD is converted to 2012 level.
Source: Project Team based on the World Bank data

2) Irrigation

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

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

Table 8.2.10 International Prices of Crops

	Maize		Rice		Exchange Rate
	(USD/Ton)	(MK/Ton)	(USD/Ton)	(MK/Ton)	(MK/USD)
2009	169.42	583.48	23,917	82,368	141.17
2010	195.26	520.00	29,384	78,253	150.49
2011	289.25	566.24	45,272	88,625	156.52
2012	270.42	590.39	88,968	194,238	329.00
2013	243.81	532.67	88,846	194,109	364.41

Note: Current price
Source: FAO and the World Bank

Table 8.2.11 Economic Prices of Crops

Unit: MK/kg

	Maize	Rice
2009/10	26.65	80.31
2010/11	37.33	83.44
2011/12	67.12	141.43
2012/13	88.91	194.17

Note 1: Arithmetic mean of the 2 years
Note 2: Current price
Source: Project Team based on the FAO data

Increase in income is calculated by the gross margin (USD/ha) times increase in irrigation area (ha). Gross margin of maize and rice are shown as follows:

Table 8.2.12 Gross Margin of Maize Production

Unit: MK/ha

	2009/10	2010/11	2011/12	2012/13
Revenue	61,296	75,253	201,360	284,503
Production Cost				
Inputs				
Seed	7,500	8,750	9,750	15500
Fertilizer (basal dressing)	11,400	11,000	15,000	28000
Fertilizer (top dressing)	17,850	16,500	22,500	42000
Pesticides	2,280	2,400	2,400	6400
Inputs Total	39,030	38,650	49,650	91,900
Labor				
Land clearing	3,900	3,000	4,000	4,000
Ridging	4,500	4,500	5,000	10,000
Planting	1,500	1,500	2,000	5,000
Fertilizer application	1,500	1,500	2,000	3,000
Thinning	450	450	600	1,200
Banking	2,400	2,400	3,200	10,000
Stooking	1,500	1,500	2,000	4,000
Harvesting	1,500	1,500	2,000	12,000
Shelling	1,500	750	1,000	5,000
Winnowing	450	450	600	800
Bagging	150	150	200	200
Post harvest treating	750	750	1,000	1,000
Loading	600	600	800	1,600
Labor Total	20,700	19,050	24,400	57,800
Post Harvest Costs				
Transport	3,000	3,000	6,000	12800
Bagging material	4,600	9,200	6,000	12000
Post Harvest Costs Total	7,600	12,200	12,000	24,800
Production Cost Total	67,330	69,900	86,050	174,500
Gross Margin	-6,034	5,353	115,310	110,003

Note: Current price
Source: Project Team based on the MoAFS data

Table 8.2.13 Gross Margin of Rice Production

Unit: MK/ha

	2009/10	2010/11	2011/12	2012/13
Revenue	185,517	192,745	353,580	485,434
Production Cost				
Inputs				
Seed	5,625	5,625	5,625	15,000
Fertilizer - 23:21:0+4S	11,400	11,000	11,000	28,000
Fertilizer - Urea	17,850	16,500	16,500	40,500
Inputs Transport	0	0	0	600
Inputs Total	34,875	33,125	33,125	84,100
Labor				
Clearing	4,500	4,500	6,000	5,000
Puddling	2,250	2,250	3,000	6,000
Nursery preparation & management	750	750	1,000	2,000
Transplanting	6,900	6,900	9,200	9,200
First weeding	9,000	9,000	12,000	16,000
Second weeding	5,250	5,250	7,000	8,000
Harvesting	4,500	4,500	6,000	12,000
Threshing	3,750	3,750	5,000	6,000
Drying	600	600	800	1,200
Winnowing/Grading	300	300	400	800
Packaging	450	450	600	1,200
Loading	300	300	400	800
Labor Total	38,550	38,550	51,400	68,200
Post Harvest Costs				
Transport	3,000	3,000	5,000	5,000
Packaging materials	4,700	4,700	5,000	5,000
Post Harvest Costs Total	7,700	7,700	10,000	10,000
Production Cost Total	81,125	79,375	94,525	162,300
Gross Margin	104,392	113,370	259,055	323,134

Note: Current price
Source: Project Team based on the MoAFS data

According to the above data, the average values of the gross margins of maize and rice are calculated with consideration of adjustment to 2012 price level as follows:

Table 8.2.14 Adjusted Gross Margin of Maize and Rice

	2009/10	2010/11	2011/12	2012/13	Average
Correction Coefficient*	0.65893	0.75529	0.83527	1.0000	–
Adjusted Gross Margin					
Maize (MK/ha)	-9,158	7,088	138,051	110,003	45,327
Rice (MK/ha)	158,427	150,100	310,144	323,134	206,224
Maize (USD/ha)	-27.84	21.54	419.61	334.36	186.92
Rice (USD/ha)	481.54	456.23	942.69	982.17	715.66

Note: 2012 price
*: Geometric mean of the two years' correction coefficients
Source: Project Team based on the World Bank and MoAFS data

Increase in irrigation area by the project is shown below. Ratio of cropping areas between maize and rice is set in accordance with that in 2011.

Table 8.2.15 Increase in Irrigation Area by Crop (2,500ha case)

Unit: ha

WRA	Crop	2012	2015	2020	2025	2030	2035
1	Total	0	2,243	6,788	6,788	9,035	9,035
	Maize	0	2,170	6,567	6,567	8,741	8,741
	Rice	0	73	221	221	294	294
2	Total	0	0	75	75	102	102
	Maize	0	0	69	69	95	95
	Rice	0	0	5	5	7	7
3	Total	0	0	0	1,582	3,534	3,534
	Maize	0	0	0	1,542	3,446	3,446
	Rice	0	0	0	40	88	88
4	Total	0	0	672	672	687	687
	Maize	0	0	663	663	677	677
	Rice	0	0	10	10	10	10
5	Total	0	0	0	2,752	3,615	3,615
	Maize	0	0	0	2,665	3,500	3,500
	Rice	0	0	0	87	115	115
6	Total	0	0	0	0	0	0
	Maize	0	0	0	0	0	0
	Rice	0	0	0	0	0	0
7	Total	0	0	2,521	6,278	8,629	9,034
	Maize	0	0	2,518	6,271	8,620	9,024
	Rice	0	0	3	7	9	10
8	Total	0	0	0	0	3,728	3,728
	Maize	0	0	0	0	3,352	3,352
	Rice	0	0	0	0	376	376
9	Total	0	0	0	0	0	465
	Maize	0	0	0	0	0	402
	Rice	0	0	0	0	0	63
14	Total	0	0	0	0	0	9,069
	Maize	0	0	0	0	0	8,716
	Rice	0	0	0	0	0	353
15	Total	0	0	0	3,094	3,094	8,685
	Maize	0	0	0	2,921	2,921	8,199
	Rice	0	0	0	173	173	486
16	Total	0	7,159	9,032	9,032	9,032	9,032
	Maize	0	6,201	7,823	7,823	7,823	7,823
	Rice	0	958	1,209	1,209	1,209	1,209
17	Total	0	0	0	0	2,822	2,822
	Maize	0	0	0	0	2,040	2,040
	Rice	0	0	0	0	781	781

Source: Project Team based on the World Bank and MoAFS data

Table 8.2.16 Increase in Irrigation Area by Crop (5,000ha case)

Unit: ha

WRA	Crop	2012	2015	2020	2025	2030	2035
1	Total	0	1,356	11,493	15,995	18,102	18,102
	Maize	0	1,312	11,119	15,474	17,512	17,512
	Rice	0	44	374	521	590	590
2	Total	0	0	120	203	203	203
	Maize	0	0	112	189	189	189
	Rice	0	0	9	14	14	14
3	Total	0	0	2,044	5,955	7,080	7,080
	Maize	0	0	1,993	5,806	6,903	6,903
	Rice	0	0	51	149	177	177
4	Total	0	0	1,350	1,379	1,379	1,379
	Maize	0	0	1,331	1,360	1,360	1,360
	Rice	0	0	19	20	20	20
5	Total	0	0	0	6,312	7,242	7,242
	Maize	0	0	0	6,112	7,012	7,012
	Rice	0	0	0	200	230	230
6	Total	0	0	0	0	0	0
	Maize	0	0	0	0	0	0
	Rice	0	0	0	0	0	0
7	Total	0	0	5,051	18,099	18,099	18,099
	Maize	0	0	5,046	18,079	18,079	18,079
	Rice	0	0	5	20	20	20
8	Total	0	0	0	0	7,470	7,470
	Maize	0	0	0	0	6,716	6,716
	Rice	0	0	0	0	754	754
9	Total	0	0	0	515	933	933
	Maize	0	0	0	445	807	807
	Rice	0	0	0	70	126	126
14	Total	0	0	0	0	190	18,101
	Maize	0	0	0	0	183	17,397
	Rice	0	0	0	0	7	704
15	Total	0	0	0	0	8,200	19,405
	Maize	0	0	0	0	7,741	18,318
	Rice	0	0	0	0	459	1,087
16	Total	0	18,101	18,101	18,101	18,101	18,101
	Maize	0	15,678	15,678	15,678	15,678	15,678
	Rice	0	2,423	2,423	2,423	2,423	2,423
17	Total	0	0	0	5,622	5,654	5,654
	Maize	0	0	0	4,065	4,088	4,088
	Rice	0	0	0	1,557	1,566	1,566

Source: Project Team based on the World Bank and MoAFS data

Multiplier Effect

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

(3) Calculation Results

1) Domestic and Industrial Water Supply

The calculation results are shown in the following table.

Table 8.2.17 Calculation Results of Domestic and Industrial Water Supply

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

Source: Project Team

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

2) Irrigation

The calculation results are shown below.

Table 8.2.18 Calculation Results of Irrigation

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

Source: Project Team

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

3) Cash Flow Tables

(i) Domestic and Industrial Water Supply

Table 8.2.19 Cash Flow Table of Urban Water Supply (Lilongwe City)

Unit: Million USD

Year	Benefit	Cost								Net Benefit
		Construction	Land Acquisition	Physical Contingency	Engineering Service	Admin.	O&M	Replacement	Cost Total	
2012	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2013	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2014	0.00	3.98	0.00	0.47	0.56	0.20	0.00	0.00	5.21	-5.21
2015	10.97	9.14	0.00	1.11	3.13	0.53	0.13	0.00	14.04	-3.07
2016	11.30	5.15	0.00	0.63	2.68	0.33	0.18	0.00	8.97	2.32
2017	15.93	15.05	0.00	1.80	2.26	0.79	0.33	0.00	20.23	-4.30
2018	18.27	24.68	0.00	2.96	3.37	1.24	0.58	0.00	32.83	-14.56
2019	20.61	32.71	0.01	3.92	3.49	1.60	0.91	0.00	42.64	-22.03
2020	20.13	58.83	0.00	7.05	3.49	2.77	1.50	0.00	73.64	-53.51
2021	25.44	51.78	0.00	6.22	3.48	2.46	2.01	0.00	65.96	-40.51
2022	27.95	29.01	0.00	3.48	3.33	1.42	2.30	0.00	39.54	-11.59
2023	30.06	11.01	0.00	1.32	1.23	0.54	2.41	0.00	16.51	13.55
2024	32.21	11.01	0.00	1.32	1.23	0.54	2.52	0.00	16.62	15.58
2025	34.39	11.01	0.00	1.32	1.23	0.54	2.63	0.00	16.73	17.66
2026	37.15	11.01	0.01	1.32	3.17	0.62	2.74	0.00	18.87	18.28
2027	39.88	37.01	0.00	4.44	3.17	1.78	3.11	0.00	49.51	-9.64
2028	42.67	37.01	0.00	4.44	3.18	1.78	3.48	0.00	49.89	-7.22
2029	45.54	11.01	0.00	1.32	1.23	0.54	3.59	0.00	17.69	27.84
2030	48.47	11.01	0.00	1.32	1.23	0.54	3.70	0.00	17.80	30.67
2031	51.77	11.01	0.00	1.32	1.23	0.54	3.81	0.00	17.91	33.86
2032	55.15	11.01	0.00	1.32	1.23	0.54	3.92	0.00	18.02	37.13
2033	58.62	11.08	0.00	1.35	1.29	0.58	4.04	0.00	18.34	40.28
2034	62.17	0.00	0.00	0.00	0.00	0.00	4.04	0.00	4.04	58.13
2035	65.80	0.00	0.00	0.00	0.00	0.00	4.04	0.00	4.04	61.77
2036	65.80						4.04	0.00	4.04	61.77
2037	65.80						4.04	0.00	4.04	61.77
2038	65.80						4.04	0.00	4.04	61.77
2039	65.80						4.04	0.00	4.04	61.77
2040	65.80						4.04	0.00	4.04	61.77
2041	65.80						4.04	0.00	4.04	61.77
2042	65.80						4.04	0.00	4.04	61.77
2043	65.80						4.04	0.00	4.04	61.77
2044	65.80						4.04	0.00	4.04	61.77
2045	65.80						4.04	36.57	40.60	25.20
2046	65.80						4.04	0.00	4.04	61.77
2047	65.80						4.04	0.00	4.04	61.77
2048	65.80						4.04	0.00	4.04	61.77
2049	65.80						4.04	0.00	4.04	61.77
2050	65.80						4.04	0.00	4.04	61.77
2051	65.80						4.04	0.00	4.04	61.77
2052	65.80						4.04	0.00	4.04	61.77
2053	65.80						4.04	0.00	4.04	61.77
2054	65.80						4.04	0.00	4.04	61.77
2055	65.80						4.04	0.00	4.04	61.77
2056	65.80						4.04	0.00	4.04	61.77
2057	65.80						4.04	0.00	4.04	61.77
2058	65.80						4.04	0.00	4.04	61.77
2059	65.80						4.04	0.00	4.04	61.77
2060	65.80						4.04	0.00	4.04	61.77
	Total	403.51	0.02	48.43	45.21	19.88				

Source: Project Team

EIRR 13.21%

Table 8.2.20 Cash Flow Table of Urban Water Supply (Blantyre City)

Unit: Million USD

Year	Benefit	Cost								Net Benefit
		Construction	Land Acquisition	Physical Contingency	Engineering Service	Admin.	O&M	Replacement	Cost Total	
2012	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2013	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2014	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2015	0.00	1.40	0.00	0.17	0.16	0.07	0.00	0.00	1.80	-1.80
2016	1.79	1.40	0.00	0.17	1.77	0.13	0.03	0.00	3.50	-1.71
2017	4.36	1.40	0.00	0.17	1.77	0.13	0.04	0.00	3.51	0.85
2018	7.25	19.48	0.00	2.34	2.48	0.97	0.24	0.00	25.51	-18.26
2019	10.23	38.89	0.00	4.66	2.47	1.84	0.63	0.00	48.49	-38.25
2020	13.88	37.95	0.00	4.55	2.62	1.81	1.01	0.00	47.94	-34.06
2021	17.58	9.06	0.00	1.09	1.02	0.44	1.10	0.00	12.71	4.87
2022	21.32	9.06	0.00	1.09	1.02	0.44	1.19	0.00	12.80	8.53
2023	25.08	9.07	0.00	1.08	1.00	0.46	1.28	0.00	12.89	12.19
2024	28.82	6.33	0.00	0.76	1.95	0.36	1.34	0.00	10.74	18.08
2025	32.37	6.33	0.00	0.76	1.95	0.36	1.40	0.00	10.80	21.57
2026	36.15	15.53	0.00	1.86	1.95	0.77	1.56	0.00	21.67	14.48
2027	40.01	29.31	0.00	3.52	1.95	1.39	1.85	0.00	38.02	1.99
2028	43.96	29.30	0.00	3.52	1.93	1.39	2.15	0.00	38.29	5.68
2029	48.01	6.33	0.00	0.76	0.71	0.31	2.21	0.00	10.32	37.70
2030	52.64	6.33	0.00	0.76	0.71	0.31	2.27	0.00	10.38	42.26
2031	57.23	6.33	0.00	0.76	0.71	0.31	2.34	0.00	10.45	46.78
2032	61.87	6.33	0.00	0.76	0.71	0.31	2.40	0.00	10.51	51.36
2033	66.57	6.35	0.00	0.76	0.70	0.34	2.46	0.00	10.61	55.96
2034	71.32	0.00	0.00	0.00	0.00	0.00	2.46	0.00	2.46	68.86
2035	76.42	0.00	0.00	0.00	0.00	0.00	2.46	0.00	2.46	73.96
2036	76.42						2.46	0.00	2.46	73.96
2037	76.42						2.46	0.00	2.46	73.96
2038	76.42						2.46	0.00	2.46	73.96
2039	76.42						2.46	0.00	2.46	73.96
2040	76.42						2.46	0.00	2.46	73.96
2041	76.42						2.46	0.00	2.46	73.96
2042	76.42						2.46	0.00	2.46	73.96
2043	76.42						2.46	0.00	2.46	73.96
2044	76.42						2.46	0.00	2.46	73.96
2045	76.42						2.46	27.15	29.61	46.81
2046	76.42						2.46	0.00	2.46	73.96
2047	76.42						2.46	0.00	2.46	73.96
2048	76.42						2.46	0.00	2.46	73.96
2049	76.42						2.46	0.00	2.46	73.96
2050	76.42						2.46	0.00	2.46	73.96
2051	76.42						2.46	0.00	2.46	73.96
2052	76.42						2.46	0.00	2.46	73.96
2053	76.42						2.46	0.00	2.46	73.96
2054	76.42						2.46	0.00	2.46	73.96
2055	76.42						2.46	0.00	2.46	73.96
2056	76.42						2.46	0.00	2.46	73.96
2057	76.42						2.46	0.00	2.46	73.96
2058	76.42						2.46	0.00	2.46	73.96
2059	76.42						2.46	0.00	2.46	73.96
2060	76.42						2.46	0.00	2.46	73.96
	Total	246.18	0.00	29.54	27.58	12.14				
									EIRR	19.39%

Source: Project Team

Table 8.2.21 Cash Flow Table of Urban Water Supply (Mzuzu City)

Unit: Million USD

Year	Benefit	Cost								Net Benefit
		Construction	Land Acquisition	Physical Contingency	Engineering Service	Admin.	O&M	Replacement	Cost Total	
2012	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2013	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2014	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2015	0.00	0.00	0.00	0.00	1.58	0.06	0.00	0.00	1.64	-1.64
2016	5.18	6.00	2.85	1.06	1.58	0.46	0.06	0.00	12.01	-6.83
2017	6.03	26.03	2.85	3.47	2.00	1.37	0.32	0.00	36.04	-30.01
2018	6.90	25.99	0.00	3.13	1.99	1.24	0.58	0.00	32.93	-26.03
2019	7.77	3.99	0.00	0.48	0.45	0.19	0.62	0.00	5.73	2.04
2020	8.64	3.99	0.00	0.48	0.45	0.19	0.66	0.00	5.77	2.87
2021	9.55	3.99	0.00	0.48	0.45	0.19	0.70	0.00	5.81	3.74
2022	10.49	3.99	0.00	0.48	0.45	0.19	0.74	0.00	5.85	4.64
2023	11.46	3.99	0.00	0.50	0.46	0.21	0.78	0.00	5.94	5.52
2024	12.47	3.71	0.00	0.45	0.42	0.18	0.82	0.00	5.58	6.90
2025	13.52	3.71	0.00	0.45	0.42	0.18	0.85	0.00	5.61	7.90
2026	14.34	3.71	0.00	0.45	1.71	0.23	0.89	0.00	6.99	7.35
2027	15.19	14.99	0.00	1.80	1.71	0.74	1.04	0.00	20.28	-5.09
2028	16.08	14.99	6.25	2.55	1.71	1.02	1.19	0.00	27.71	-11.63
2029	17.00	18.08	6.25	2.92	1.71	1.16	1.37	0.00	31.49	-14.49
2030	17.96	11.87	0.00	1.44	1.71	0.59	1.49	0.00	17.10	0.86
2031	18.89	3.71	0.00	0.45	0.42	0.18	1.53	0.00	6.29	12.60
2032	19.85	3.71	0.00	0.45	0.42	0.18	1.56	0.00	6.32	13.53
2033	20.86	3.70	0.00	0.37	0.34	0.23	1.60	0.00	6.24	14.61
2034	21.89	0.00	0.00	0.00	0.00	0.00	1.60	0.00	1.60	20.29
2035	22.97	0.00	0.00	0.00	0.00	0.00	1.60	0.00	1.60	21.37
2036	22.97						1.60	0.00	1.60	21.37
2037	22.97						1.60	0.00	1.60	21.37
2038	22.97						1.60	0.00	1.60	21.37
2039	22.97						1.60	0.00	1.60	21.37
2040	22.97						1.60	0.00	1.60	21.37
2041	22.97						1.60	0.00	1.60	21.37
2042	22.97						1.60	0.00	1.60	21.37
2043	22.97						1.60	0.00	1.60	21.37
2044	22.97						1.60	0.00	1.60	21.37
2045	22.97						1.60	13.86	15.46	7.51
2046	22.97						1.60	0.00	1.60	21.37
2047	22.97						1.60	0.00	1.60	21.37
2048	22.97						1.60	0.00	1.60	21.37
2049	22.97						1.60	0.00	1.60	21.37
2050	22.97						1.60	0.00	1.60	21.37
2051	22.97						1.60	0.00	1.60	21.37
2052	22.97						1.60	0.00	1.60	21.37
2053	22.97						1.60	0.00	1.60	21.37
2054	22.97						1.60	0.00	1.60	21.37
2055	22.97						1.60	0.00	1.60	21.37
2056	22.97						1.60	0.00	1.60	21.37
2057	22.97						1.60	0.00	1.60	21.37
2058	22.97						1.60	0.00	1.60	21.37
2059	22.97						1.60	0.00	1.60	21.37
2060	22.97						1.60	0.00	1.60	21.37
	Total	160.15	18.20	21.41	19.98	8.79				

Source: Project Team

EIRR	10.06%

Table 8.2.22 Cash Flow Table of Urban Water Supply (Zomba City)

Unit: Million USD

Year	Benefit	Cost								Net Benefit
		Construction	Land Acquisition	Physical Contingency	Engineering Service	Admin.	O&M	Replacement	Cost Total	
2012	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2013	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2014	0.00	3.18	0.00	0.38	0.36	0.16	0.00	0.00	4.08	-4.08
2015	0.23	3.18	0.00	0.38	0.35	0.15	0.06	0.00	4.12	-3.89
2016	0.67	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.06	0.60
2017	1.13	0.56	0.00	0.07	0.06	0.03	0.07	0.00	0.79	0.34
2018	1.62	0.56	0.00	0.07	0.06	0.03	0.07	0.00	0.79	0.82
2019	2.13	0.94	0.00	0.12	0.10	0.05	0.08	0.00	1.29	0.83
2020	2.67	0.94	0.00	0.12	0.10	0.05	0.09	0.00	1.30	1.37
2021	3.03	0.95	0.00	0.11	0.11	0.04	0.10	0.00	1.31	1.72
2022	3.41	0.38	0.00	0.05	0.04	0.02	0.11	0.00	0.60	2.82
2023	3.81	0.38	0.00	0.05	0.04	0.02	0.11	0.00	0.60	3.21
2024	4.22	0.38	0.00	0.05	0.04	0.02	0.11	0.00	0.60	3.62
2025	4.66	0.38	0.00	0.05	0.26	0.03	0.12	0.00	0.84	3.82
2026	5.02	3.03	0.00	0.37	0.26	0.15	0.15	0.00	3.96	1.06
2027	5.39	3.03	0.00	0.37	0.26	0.15	0.18	0.00	3.99	1.40
2028	5.78	3.04	0.00	0.37	0.27	0.14	0.21	0.00	4.03	1.75
2029	6.18	0.38	0.00	0.05	0.04	0.02	0.21	0.00	0.70	5.48
2030	6.59	0.38	0.00	0.05	0.04	0.02	0.22	0.00	0.71	5.89
2031	7.02	0.38	0.00	0.03	0.05	0.01	0.22	0.00	0.69	6.33
2032	7.47	0.38	0.00	0.03	0.05	0.01	0.22	0.00	0.69	6.77
2033	7.93	0.38	0.00	0.02	0.06	0.02	0.23	0.00	0.71	7.22
2034	8.40	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.23	8.17
2035	8.89	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.23	8.66
2036	8.89						0.23	0.00	0.23	8.66
2037	8.89						0.23	0.00	0.23	8.66
2038	8.89						0.23	0.00	0.23	8.66
2039	8.89						0.23	0.00	0.23	8.66
2040	8.89						0.23	0.00	0.23	8.66
2041	8.89						0.23	0.00	0.23	8.66
2042	8.89						0.23	0.00	0.23	8.66
2043	8.89						0.23	0.00	0.23	8.66
2044	8.89						0.23	0.00	0.23	8.66
2045	8.89						0.23	3.34	3.57	5.32
2046	8.89						0.23	0.00	0.23	8.66
2047	8.89						0.23	0.00	0.23	8.66
2048	8.89						0.23	0.00	0.23	8.66
2049	8.89						0.23	0.00	0.23	8.66
2050	8.89						0.23	0.00	0.23	8.66
2051	8.89						0.23	0.00	0.23	8.66
2052	8.89						0.23	0.00	0.23	8.66
2053	8.89						0.23	0.00	0.23	8.66
2054	8.89						0.23	0.00	0.23	8.66
2055	8.89						0.23	0.00	0.23	8.66
2056	8.89						0.23	0.00	0.23	8.66
2057	8.89						0.23	0.00	0.23	8.66
2058	8.89						0.23	0.00	0.23	8.66
2059	8.89						0.23	0.00	0.23	8.66
2060	8.89						0.23	0.00	0.23	8.66
	Total	22.83	0.00	2.74	2.55	1.12				

Source: Project Team

EIRR	20.67%

Table 8.2.23 Cash Flow Table of Urban Water Supply (Towns)

Unit: Million USD

Year	Benefit	Cost								Net Benefit
		Construction	Land Acquisition	Physical Contingency	Engineering Service	Admin.	O&M	Replacement	Cost Total	
2012	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2013	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2014	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2016	1.88	10.15	0.00	1.22	1.14	0.50	0.10	0.00	13.11	-11.23
2017	3.79	10.15	0.00	1.22	1.14	0.50	0.20	0.00	13.21	-9.42
2018	5.72	10.15	0.00	1.22	1.14	0.50	0.30	0.00	13.31	-7.59
2019	7.68	10.15	0.00	1.22	1.14	0.50	0.41	0.00	13.42	-5.74
2020	9.66	10.18	0.00	1.21	1.13	0.50	0.51	0.00	13.53	-3.87
2021	8.24	9.61	0.00	1.15	1.08	0.47	0.60	0.00	12.91	-4.67
2022	9.36	9.61	0.00	1.15	1.08	0.47	0.70	0.00	13.01	-3.65
2023	10.40	9.61	0.00	1.15	1.08	0.47	0.80	0.00	13.11	-2.71
2024	11.39	9.61	0.00	1.15	1.08	0.47	0.89	0.00	13.20	-1.81
2025	13.72	9.60	0.00	1.16	1.06	0.49	0.99	0.00	13.30	0.42
2026	16.18	1.30	0.00	0.16	0.15	0.06	1.00	0.00	2.67	13.51
2027	18.67	1.30	0.00	0.16	0.15	0.06	1.01	0.00	2.68	15.99
2028	21.19	1.30	0.00	0.16	0.15	0.06	1.03	0.00	2.70	18.50
2029	23.74	1.30	0.00	0.16	0.15	0.06	1.04	0.00	2.71	21.03
2030	26.32	1.30	0.00	0.16	0.15	0.06	1.05	0.00	2.72	23.59
2031	29.27	1.30	0.00	0.16	0.15	0.06	1.07	0.00	2.74	26.53
2032	32.25	1.30	0.00	0.16	0.15	0.06	1.08	0.00	2.75	29.51
2033	35.27	1.30	0.00	0.16	0.15	0.06	1.09	0.00	2.76	32.51
2034	38.32	1.30	0.00	0.16	0.15	0.06	1.11	0.00	2.78	35.55
2035	41.41	1.31	0.00	0.12	0.11	0.10	1.12	0.00	2.76	38.65
2036	41.41						1.12	0.00	1.12	40.29
2037	41.41						1.12	0.00	1.12	40.29
2038	41.41						1.12	0.00	1.12	40.29
2039	41.41						1.12	0.00	1.12	40.29
2040	41.41						1.12	0.00	1.12	40.29
2041	41.41						1.12	0.00	1.12	40.29
2042	41.41						1.12	0.00	1.12	40.29
2043	41.41						1.12	0.00	1.12	40.29
2044	41.41						1.12	0.00	1.12	40.29
2045	41.41						1.12	0.00	1.12	40.29
2046	41.41						1.12	0.00	1.12	40.29
2047	41.41						1.12	0.00	1.12	40.29
2048	41.41						1.12	0.00	1.12	40.29
2049	41.41						1.12	0.00	1.12	40.29
2050	41.41						1.12	0.00	1.12	40.29
2051	41.41						1.12	0.00	1.12	40.29
2052	41.41						1.12	0.00	1.12	40.29
2053	41.41						1.12	0.00	1.12	40.29
2054	41.41						1.12	0.00	1.12	40.29
2055	41.41						1.12	0.00	1.12	40.29
2056	41.41						1.12	0.00	1.12	40.29
2057	41.41						1.12	0.00	1.12	40.29
2058	41.41						1.12	0.00	1.12	40.29
2059	41.41						1.12	0.00	1.12	40.29
2060	41.41						1.12	0.00	1.12	40.29
	Total	111.83	0.00	13.41	12.53	5.51				

Source: Project Team

EIRR	17.30%

Table 8.2.24 Cash Flow Table of Rural Water Supply (Market Center)

Unit: Million USD

Year	Benefit	Cost								Net Benefit
		Construction	Land Acquisition	Physical Contingency	Engineering Service	Admin.	O&M	Replacement	Cost Total	
2012	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2013	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2014	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2016	1.41	12.10	0.00	1.45	1.36	0.60	0.12	0.00	15.63	-14.22
2017	2.83	12.10	0.00	1.45	1.36	0.60	0.24	0.00	15.75	-12.92
2018	4.27	12.10	0.00	1.45	1.36	0.60	0.36	0.00	15.87	-11.60
2019	5.74	12.10	0.00	1.45	1.36	0.60	0.48	0.00	15.99	-10.26
2020	7.21	12.10	0.00	1.46	1.34	0.58	0.61	0.00	16.09	-8.87
2021	8.13	3.88	0.00	0.47	0.43	0.19	0.64	0.00	5.61	2.52
2022	9.86	3.88	0.00	0.47	0.43	0.19	0.68	0.00	5.65	4.20
2023	11.60	3.88	0.00	0.47	0.43	0.19	0.72	0.00	5.69	5.91
2024	13.37	3.88	0.00	0.47	0.43	0.19	0.76	0.00	5.73	7.63
2025	15.15	3.88	0.00	0.45	0.45	0.20	0.80	0.00	5.78	9.37
2026	16.35	1.63	0.00	0.20	0.18	0.08	0.82	0.00	2.91	13.45
2027	17.57	1.63	0.00	0.20	0.18	0.08	0.83	0.00	2.92	14.65
2028	18.80	1.63	0.00	0.20	0.18	0.08	0.85	0.00	2.94	15.86
2029	20.04	1.63	0.00	0.20	0.18	0.08	0.86	0.00	2.95	17.09
2030	21.30	1.63	0.00	0.20	0.18	0.08	0.88	0.00	2.97	18.33
2031	22.25	1.63	0.00	0.20	0.18	0.08	0.90	0.00	2.99	19.26
2032	23.44	1.63	0.00	0.20	0.18	0.08	0.91	0.00	3.00	20.44
2033	24.88	1.63	0.00	0.20	0.18	0.08	0.93	0.00	3.02	21.86
2034	26.57	1.63	0.00	0.20	0.18	0.08	0.95	0.00	3.04	23.54
2035	26.14	1.61	0.00	0.15	0.20	0.08	0.96	0.00	3.00	23.14
2036	26.14						0.96	0.00	0.96	25.18
2037	26.14						0.96	0.00	0.96	25.18
2038	26.14						0.96	0.00	0.96	25.18
2039	26.14						0.96	0.00	0.96	25.18
2040	26.14						0.96	0.00	0.96	25.18
2041	26.14						0.96	0.00	0.96	25.18
2042	26.14						0.96	0.00	0.96	25.18
2043	26.14						0.96	0.00	0.96	25.18
2044	26.14						0.96	0.00	0.96	25.18
2045	26.14						0.96	0.00	0.96	25.18
2046	26.14						0.96	0.00	0.96	25.18
2047	26.14						0.96	0.00	0.96	25.18
2048	26.14						0.96	0.00	0.96	25.18
2049	26.14						0.96	0.00	0.96	25.18
2050	26.14						0.96	0.00	0.96	25.18
2051	26.14						0.96	0.00	0.96	25.18
2052	26.14						0.96	0.00	0.96	25.18
2053	26.14						0.96	0.00	0.96	25.18
2054	26.14						0.96	0.00	0.96	25.18
2055	26.14						0.96	0.00	0.96	25.18
2056	26.14						0.96	0.00	0.96	25.18
2057	26.14						0.96	0.00	0.96	25.18
2058	26.14						0.96	0.00	0.96	25.18
2059	26.14						0.96	0.00	0.96	25.18
2060	26.14						0.96	0.00	0.96	25.18
	Total	96.18	0.00	11.54	10.77	4.74				
									EIRR	15.14%

Source: Project Team

(ii) Irrigation

Table 8.2.25 Cash Flow Table of Irrigation (2,500ha Case)

Unit: Million USD

Year	Benefit	Cost								Net Benefit
		Construction	Land Acquisition	Physical Contingency	Engineering Service	Admin.	O&M	Replacement	Cost Total	
2012	0.00	10.72	0.00	1.29	1.20	0.52	0.00	0.00	13.72	-13.72
2013	0.00	10.72	0.00	1.29	1.20	0.52	0.00	0.00	13.72	-13.72
2014	0.33	12.05	0.00	1.45	1.35	0.60	0.17	0.00	15.61	-15.27
2015	2.64	13.92	0.00	1.67	1.57	0.69	0.24	0.00	18.08	-15.45
2016	2.64	12.49	0.00	1.50	1.40	0.62	0.30	0.00	16.31	-13.67
2017	3.32	12.11	0.00	1.45	1.36	0.60	0.36	0.00	15.88	-12.55
2018	4.44	12.11	0.00	1.45	1.36	0.60	0.42	0.00	15.94	-11.50
2019	5.25	11.64	0.00	1.39	1.30	0.57	0.48	0.00	15.38	-10.13
2020	5.35	11.64	0.00	1.39	1.30	0.57	0.54	0.00	15.43	-10.08
2021	5.64	10.77	0.00	1.29	1.21	0.53	0.59	0.00	14.39	-8.75
2022	7.13	10.77	0.00	1.29	1.21	0.53	0.64	0.00	14.44	-7.31
2023	8.33	14.22	0.00	1.71	1.60	0.70	0.72	0.00	18.94	-10.61
2024	8.33	14.22	0.00	1.71	1.60	0.70	0.79	0.00	19.01	-10.68
2025	8.49	12.95	0.00	1.56	1.45	0.64	0.85	0.00	17.44	-8.96
2026	10.76	11.68	0.00	1.40	1.31	0.58	0.91	0.00	15.88	-5.12
2027	11.10	16.11	0.00	1.93	1.80	0.79	0.99	0.00	21.63	-10.53
2028	11.64	16.11	0.00	1.93	1.80	0.79	1.07	0.00	21.71	-10.07
2029	12.41	16.11	0.00	1.93	1.80	0.79	1.15	0.00	21.79	-9.38
2030	12.41	14.61	0.00	1.75	1.63	0.72	1.22	0.00	19.94	-7.52
2031	14.25	12.73	0.00	1.52	1.42	0.63	1.29	0.00	17.59	-3.34
2032	14.25	12.27	0.00	1.47	1.37	0.61	1.35	0.00	17.07	-2.82
2033	14.25	12.15	0.00	1.45	1.36	0.60	1.41	0.00	16.97	-2.72
2034	14.25	13.35	0.00	1.60	1.49	0.65	1.48	0.00	18.57	-4.32
2035	16.77	5.04	0.00	0.61	0.57	0.25	1.50	0.00	7.96	8.81
2036	16.77						1.50	0.00	1.50	15.27
2037	16.77						1.50	0.00	1.50	15.27
2038	16.77						1.50	0.00	1.50	15.27
2039	16.77						1.50	0.00	1.50	15.27
2040	16.77						1.50	0.00	1.50	15.27
2041	16.77						1.50	0.00	1.50	15.27
2042	16.77						1.50	0.00	1.50	15.27
2043	16.77						1.50	0.00	1.50	15.27
2044	16.77						1.50	0.00	1.50	15.27
2045	16.77						1.50	0.00	1.50	15.27
2046	16.77						1.50	0.00	1.50	15.27
2047	16.77						1.50	0.00	1.50	15.27
2048	16.77						1.50	0.00	1.50	15.27
2049	16.77						1.50	0.00	1.50	15.27
2050	16.77						1.50	0.00	1.50	15.27
2051	16.77						1.50	0.00	1.50	15.27
2052	16.77						1.50	0.00	1.50	15.27
2053	16.77						1.50	0.00	1.50	15.27
2054	16.77						1.50	0.00	1.50	15.27
2055	16.77						1.50	0.00	1.50	15.27
2056	16.77						1.50	0.00	1.50	15.27
2057	16.77						1.50	0.00	1.50	15.27
2058	16.77						1.50	0.00	1.50	15.27
2059	16.77						1.50	0.00	1.50	15.27
2060	16.77						1.50	0.00	1.50	15.27
	Total	300.47	0.00	36.04	33.65	14.76				
									EIRR	2.19%

Source: Project Team

Table 8.2.26 Cash Flow Table of Irrigation (5,000ha Case)

Unit: Million USD

Year	Benefit	Cost								Net Benefit
		Construction	Land Acquisition	Physical Contingency	Engineering Service	Admin.	O&M	Replacement	Cost Total	
2012	0.00	22.28	0.00	2.67	2.50	1.10	0.00	0.00	28.55	-28.55
2013	0.00	22.28	0.00	2.67	2.50	1.10	0.00	0.00	28.55	-28.55
2014	0.42	25.12	0.00	3.01	2.82	1.23	0.35	0.00	32.53	-32.11
2015	7.41	28.54	0.00	3.43	3.20	1.41	0.49	0.00	37.06	-29.65
2016	7.41	25.12	0.00	3.02	2.82	1.24	0.62	0.00	32.81	-25.40
2017	8.37	24.35	0.00	2.93	2.74	1.21	0.74	0.00	31.95	-23.58
2018	10.75	24.35	0.00	2.93	2.74	1.21	0.86	0.00	32.07	-21.32
2019	12.90	24.47	0.00	2.94	2.74	1.21	0.98	0.00	32.34	-19.44
2020	12.98	24.47	0.00	2.94	2.74	1.21	1.10	0.00	32.47	-19.48
2021	14.07	22.74	0.00	2.73	2.55	1.12	1.22	0.00	30.36	-16.29
2022	17.75	21.72	0.00	2.61	2.43	1.07	1.33	0.00	29.15	-11.41
2023	19.59	30.05	0.00	3.61	3.36	1.48	1.48	0.00	39.97	-20.38
2024	21.74	30.05	0.00	3.61	3.36	1.48	1.63	0.00	40.12	-18.37
2025	24.18	27.44	0.00	3.30	3.07	1.35	1.76	0.00	36.92	-12.74
2026	24.99	26.92	0.00	3.23	3.02	1.33	1.90	0.00	36.39	-11.40
2027	25.33	38.60	0.00	4.63	4.32	1.90	2.09	0.00	51.54	-26.21
2028	28.36	38.60	0.00	4.63	4.32	1.90	2.29	0.00	51.74	-23.37
2029	31.03	38.60	0.00	4.63	4.32	1.90	2.48	0.00	51.93	-20.90
2030	31.04	34.19	0.00	4.10	3.83	1.68	2.65	0.00	46.46	-15.41
2031	34.68	23.59	0.00	2.84	2.65	1.16	2.77	0.00	33.00	1.68
2032	34.68	23.19	0.00	2.79	2.60	1.14	2.88	0.00	32.60	2.08
2033	34.68	24.62	0.00	2.95	2.77	1.22	3.01	0.00	34.56	0.12
2034	34.68	28.62	0.00	3.43	3.21	1.42	3.15	0.00	39.83	-5.15
2035	40.26	11.70	0.00	1.40	1.31	0.58	3.21	0.00	18.20	22.06
2036	40.26						3.21	0.00	3.21	37.05
2037	40.26						3.21	0.00	3.21	37.05
2038	40.26						3.21	0.00	3.21	37.05
2039	40.26						3.21	0.00	3.21	37.05
2040	40.26						3.21	0.00	3.21	37.05
2041	40.26						3.21	0.00	3.21	37.05
2042	40.26						3.21	0.00	3.21	37.05
2043	40.26						3.21	0.00	3.21	37.05
2044	40.26						3.21	0.00	3.21	37.05
2045	40.26						3.21	0.00	3.21	37.05
2046	40.26						3.21	0.00	3.21	37.05
2047	40.26						3.21	0.00	3.21	37.05
2048	40.26						3.21	0.00	3.21	37.05
2049	40.26						3.21	0.00	3.21	37.05
2050	40.26						3.21	0.00	3.21	37.05
2051	40.26						3.21	0.00	3.21	37.05
2052	40.26						3.21	0.00	3.21	37.05
2053	40.26						3.21	0.00	3.21	37.05
2054	40.26						3.21	0.00	3.21	37.05
2055	40.26						3.21	0.00	3.21	37.05
2056	40.26						3.21	0.00	3.21	37.05
2057	40.26						3.21	0.00	3.21	37.05
2058	40.26						3.21	0.00	3.21	37.05
2059	40.26						3.21	0.00	3.21	37.05
2060	40.26						3.21	0.00	3.21	37.05
	Total	641.60	0.00	77.01	71.90	31.63				

Source: Project Team

EIRR	3.16%

8.3 Evaluation from Social and Environmental Aspects

8.3.1 Objectives of Evaluation from Social and Environmental Aspects

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

8.3.2 Methodology on Evaluation of Environmental and Social Aspects

The projects proposed in the M/P shall be evaluated through the execution of the Initial Environmental Examination (IEE). The terms of reference for IEE is presented in **Annex 8.3.2-1**.

8.3.3 Evaluation through IEE

(1) Natural and Social-Environmental Condition of the Study Area

Since the present M/P study is at country level, an initial assessment of the current state of the environment in the country considering relevant environmental components to this M/P study was made and presented in the following table.

Table 8.3.1 Initial Assessment of Natural and Social-Environmental Condition in Malawi

Component	Assessment
Surface water quality	Many river basins in the country are under severe pressures due to deforestation, unsustainable agriculture, settlements, mining, industry, commerce, tourism and climate change. These activities have influenced changes in water quality especially due to sediment loads, domestic and industrial wastes, chemicals from agricultural lands. The proliferation of aquatic vegetation also is a concern in some dams
Groundwater quality	Generally good except for the presence of sulphur, fluoride, iron and other such minerals in some localities and pollution introduced by human activities.
Water Pollution	In Malawi, the treatment of wastewater is poorly managed and most of them reach watercourses without any treatment causing water pollution. Sources of pollution are domestic, industrial, solid waste and agricultural lands.
Fauna and Flora	Malawi is rich in fauna and flora. Faunal resources include about 192 species of mammals (8 endangered), 648 species of birds, more than 1,000 species of fish, etc. Floral resources include about 6,000 species of plants (261 threatened). New research must be conducted to update the above figures.
Vegetation	Malawi has varied topography and rainfall regimes and as a result is reach in vegetation types. Major vegetation types include the miombo woodland, deciduous forests and thickets, evergreen and semi-evergreen forests, and Afromontane grassland.
Fisheries	Main species that can be found in major water bodies of Malawi are as follows: Lake Malawi (28 species): among them we can cite Chambo, Chisawasawa, Samwamowa, Utaka, Kambuzi, Binga, Saguga, Mzomba, Dimba, Mbaba, etc. Lake Malombe (5 species): Chambo, Utaka, Mlamba, Kampango, Ntchira Lake Chilwa (3 species): Makumba, Mlamba, Matemba Lake Chiuta (2 species): Kampango, Ntchira Lower Shire (12 species): Ntcheni, Nchenka, Nghenka, Matemba, Njole, Tsimbu; Mlamba, Chikanu, Nkhonokono, Dande, Mphende, Mkokafodya.
Protected Areas	In Malawi exists five (5) national parks, four (4) wildlife reserves, three (3) nature sanctuaries and eighty-eight (88) Gazetted Forest Reserves that are considered as protected areas. Illegal cutting of trees and poaching are the major threat of protected areas.
Socio-economy	Population and Settlement: Malawi has a population of 13,077,160 (2008 census). The density is 139 persons/km^2 and the average number of persons per household is 4.6. The population growth is estimated at 2.9% and the migration from rural to urban areas is growing. Low income areas such as Ntopwa in Blantyre, Chinsapo, Mgona, and Mtandire in Lilongwe and Mchengautuwa in Mzuzu are growing at unprecedented rates. The 2008 Crude Birth Rate (CBR) was about 39.5 births per thousand population. The peoples belong to many ethnic groups like Chewa, Tumbuka, Nyanja, Yao, Lomwe, Sena and communication is made using different languages namely, Chichewa, Chinyanja, Chiyao, Chilomwe, and many more. Population in poverty account for 65% of the total population and population in absolute poverty account for 29% of the total population (census 2008). Employment: Agriculture alone accounts for 90% of export earnings as well as employing nearly half of those in employment. In Malawi a large proportion of the population (86%) is rural and largely dependent on subsistence agriculture with nearly 60% cultivating less than 1 hectare of arable land. People living in the rural parts of Malawi are also engaged in making various types of hard wood carvings.
Water related diseases	Among the four water related diseases reported by Ministry of Health for 2011 year, at Country and District levels the malaria occupies the highest level followed by diarrhea, schistosomiasis and cholera. At district level, the highest cases of malaria and diarrhea were reported in Lilongwe, as for schistosomiasis, Mangochi ranked the highest place, while for cholera few districts suffered from this disease and Dedza reported the highest number of cases. The diarrheal diseases may be attributable to poor or inadequate sanitary facilities and hygienic practices. In Malawi, the sewerage sector is not well developed yet in important cities, permitting the contamination of water sources with untreated sewage. On the other hand, the high rate of Malawian people suffering from malaria negatively impacts on the social and economic development of communities.

Source: Project Team

(2) Project Description

Projects were classified into same type of projects by Sector, i.e., Sector Dams, Sector Water Supply and so on. In addition projects were classified according to its current status of implementation (e.g. ongoing projects and planning projects). Ongoing projects are those that are under construction or under detailed design study, however, planning projects are those that are under master plan or feasibility studies.

The list of projects is composed of four sectors including 31 ongoing and 75 planning projects as listed below. The complete list of the projects with a brief description of the main activities is given in **Annex 8.3.3-3** for Dams Sector; **Annex 8.3.3-4** for Water Supply Sector; **Annex 8.3.3-5** for Irrigation Sector; and **Annex 8.3.3-6** for Water Resources Management.

Table 8.3.2 Number of Projects under Water Resources Master Plan

Sector	Ongoing Projects	Planning Projects*	Total
1. Dams	2	19	21
2. Water Supply	29	36	65
3. Irrigation	-	17	17
4. Water Resources Management	-	3	3
Total	31	75	106

Source: Project Team

It is opportune to mention here that for IEE purposes the Sector Water Supply included projects using surface water and groundwater through the construction of boreholes.

(3) Categorization of Projects

This categorization (screening) was made on on-going and planning projects following Malawian EIA guidelines. The procedure for categorization is presented below:

- Screening by list of prescribed projects for which EIA is required (Category I)
- Screening by list of prescribed projects for which a EIA may be required (Category II)
- Screening by list of not prescribed projects for which EIA is not required, specifically those which only involve preparation of studies, environmental awareness programs, institutional development, etc. (Category III)

The screening of projects was made based on the Categories List stipulated in the Malawian Guidelines for Environmental Impact Assessment, 1997. Categories List is shown in **Annexes 8.3.3-1** and **8.3.3-2**.

The result of the screening is shown in **Annex 8.3.3-3** to **Annex 8.3.3-6** and summarized in the following Table.

Table 8.3.3 Categorization of Projects in M/P subjected to IEE/EIA Study

Prescribed Project	EIA Category	Description	Documents Required For Application to EIA Division	Projects affected	
				Sector	Number
Prescribed Project (List A)	1	EIA is required	Submission of Project Brief	Dams	21
				Water Supply	33
				Irrigation	17
				WRM	0
				Total Category 1	71
Prescribed Project (List B)	2	EIA may be required	Submission of Project Brief	Dams	0
				Water Supply	20
				Irrigation	0
				WRM	0
				Total Category 2	20
No Prescribed Project	3	Not require EIA	Application letter for EIS	Dams	0
				Water Supply	12
				Irrigation	0
				WRM	3
				Total Category 3	15
	Total Projects in the Master Plan				106

Source: Project Team

Projects in Category 3 such as capacity development, awareness creation, development of studies, etc., do not require EIA; therefore, these projects are not scoped for IEE.

From the above table, 71 projects in Category I and 20 projects in Category II are subject to scoping at IEE study level (total=91) in four (4) Sectors (Dams, Water Supply, Irrigation and WRM). This is in compliance with the Guidelines for EIA and the JICA guidelines for environmental and social considerations.

(4) Identification of Impacts and its Significance

For projects that have been scoped for IEE study as shown in the **Annex 8.3.3-3** to **Annex 8.3.3-6**, the identification of impacts and its significance were made based on the scoping matrix. To realize this, each Sector of projects was divided into several groups that might have similar scoping outcome. The criteria applied for this grouping is as follows:

Table 8.3.4 Grouping of Projects subject to IEE Study

Sector	Criteria	Group	Nº Projects
Dams	Group 1: Hydropower dams with TH more than 20 m or firm flow=100 m3/sec; or Multipurpose dam (area >100 ha; high=4.5 m or higher; TH>20 or firm flow=100 m3/sec); or Construction or expansion of dams with high=4.5 m or higher for WS	1	11
	Group 2: Hydropower or multipurpose dams located in protected area or vicinity	2	10
Water Supply Scheme	Water supply scheme for > 10,000 people	1	15
	Water supply scheme for < 10,000 people	2	3
	Groundwater utilization > 15 liters/second or well>=60m	3	5
	Groundwater utilization < 15 liters/second or well < 60m	4	9
	Rehabilitation, improvement or maintenance of water system (big scale activities)	R1	13
	Rehabilitation, improvement or maintenance of water system (small scale activities)	R2	8
Irrigation Scheme	Irrigation Scheme with area more than 10 has	1	17
	Irrigation Scheme with area less than 10 has	2	0
	Irrigation Scheme with area located in Protected Area	3	0

Source: Project Team

The summary results of identification of impacts and its significance are presented in the following tables.

Table 8.3.5 Summary of Matrix for Scoping (Sector Dams and Water Supply)

Environmental Component	Nº	Likely Impact Items	Overall Rating							
			Sector Dams		Sector Water Supply					
			Dams - Group 1	Dams - Group 2	WS with Capacity to serve >10,000 people- Group 1	WS with Capacity to serve <10,000 people- Group 2	Groundwater utilization > than 15 l/sec or serving > 10,000 persons- Group 3	Groundwater utilization < 15 l/sec or serving < 10,000 persons- Group 4	Rehabilitation of Facilities with big scale of activities- Group R1	Rehabilitation of Facilities with smale scale of activities- Group R2
Social Environment	1	Involuntary resettlement	A-	-	-	-	-	-	-	-
	2	Local Economy such as Employment & Livelihood, etc.	A+	A+	A+	B+	B+	-	A+	B+
	3	Land use and utilization of local resources	A-	A-	B-	B-	-	-	-	-
	4	Social institutions such as social infrastructure and local decision-making institutions	C-	C-	-	-	C-	-	-	-
	5	Existing social infrastructure & Services such as Traffic/Public Facilities	A-	A-	A-	B-	-	-	A-	B-
	6	The poor, indigenous and ethnic people	C-	-	-	-	-	-	-	-
	7	Inequality between beneficiaries and project-affected peoples	-	-	-	-	-	-	-	-
	8	Cultural heritage	C-	C-	-	-	-	-	-	-
	9	Local conflict of interests	C-	A-	C-	-	-	-	-	-
	10	Water use right and common land use right	C-	C-	-	-	-	-	-	-
	11	Water supply and/or Irrigation with Potential Power generation	A+	A+	A+	A+	A+	A+	-	-
	12	Vector of diseases	A-	A-	-	-	-	-	-	-
	13	Disaster (natural risk) and infectious diseases such as HIV/AIDS	A-	A-	B-	B-	B-	B-	B-	B-
Natural Environment	14	Topography and geographical features	B-	B-	-	-	-	-	-	-
	15	Accumulation of sediment into Dams	B-	B-	-	-	-	-	-	-
	16	Protected Area	-	A-	C-/C+	C-/C+	C-/C+	-	-	-
	17	Ground water	C-/C+	C-/C+	-	-	-	-	-	-
	18	Soil erosion	B-	B-	B-	B-	-	-	-	-
	19	Hydrological situation (flow regime)	B-	B-	B-	B-	C-	-	-	-
	20	Coastal zone	-	-	C-	C-	-	-	-	-
	21	Flora, Fauna and Biodiversity	A-	A-	B-	B-	-	-	-	-
	22	Meteorology	-	-	-	-	-	-	-	-
	23	Landscape	-	-	-	-	-	-	-	-
	24	Global warming	-	-	-	-	-	-	-	-
Pollution	25	Air pollution	B-	B-	B-	B-	B-	B-	B-	B-
	26	Water pollution	B-	B-	B-	B-	B-	B-	B-	B-
	27	Soil pollution	-	-	-	-	-	-	-	
	28	Waste	B-	B-	B-	B-	B-	B-	B-	B-
	29	Noise and vibration	B-	B-	B-	B-	B-	B-	B-	B-
	30	Ground subsidence	-	-	-	-	-	-	-	-
	31	Offensive odor	-	-	-	-	-	-	-	-
	32	Bottom sediment	C-	C-	B-	B-	-	-	-	-
	33	Accident	C-	C-	C-	C-	C-	C-	C-	C-

Rating Criteria

A+/-: Significant positive/negative impact is expected.

B+/-: Some positive/negative impact is expected.

C+/-: Extent of positive/negative impact is unknown. (A further examination is required in the further project formulation)

・-: No impact is expected.

Source: Project Team

Table 8.3.6 Summary of Matrix for Scoping (Sector Irrigation)

Environmental Component	Nº	Likely Impact Items	Overall Rating: Sector Irrigation — Irrigation Schemes with Area > 10 ha - Group 1	Overall Rating: Sector Irrigation — Irrigation Schemes with Area < 10 ha - Group 2
Social Environment	1	Involuntary resettlement	A-	B-
	2	Local Economy such as Employment & Livelihood, etc.	A+	B+
	3	Land use and utilization of local resources	A-	B-
	4	Social institutions such as social infrastructure and local decision-making institutions	-	-
	5	Existing social infrastructure & Services such as Traffic/Public Facilities	A-	B-
	6	The poor, indigenous and ethnic people	C-	C-
	7	Inequality between beneficiaries and project-affected peoples	-	-
	8	Cultural heritage	-	-
	9	Local conflict of interests	C-	C-
	10	Water use right and common land use right	B-	B-
	11	Water supply and/or Irrigation with Potential Power generation	-	-
	12	Vector of diseases	A-	B-
	13	Disaster (natural risk) and infectious diseases such as HIV/AIDS	B-	B-
Natural Environment	14	Topography and geographical features	-	-
	15	Accumulation of sediment into Dams	-	-
	16	Protected Area	-	-
	17	Ground water	-	-
	18	Soil erosion	B-	B-
	19	Hydrological situation (flow regime)	B-	B-
	20	Coastal zone	-	-
	21	Flora, Fauna and Biodiversity	A-	B-
	22	Meteorology	-	-
	23	Landscape	-	-
	24	Global warming	-	-
Pollution	25	Air pollution	B-	B-
	26	Water pollution	A-	B-
	27	Soil pollution	B-	B-
	28	Waste	B-	B-
	29	Noise and vibration	B-	B-
	30	Ground subsidence	-	-
	31	Offensive odor	-	-
	32	Bottom sediment	B-	B-
	33	Accident	C-	C-

Rating Criteria
A+/-: Significant positive/negative impact is expected.
B+/-: Some positive/negative impact is expected.
C+/-: Extent of positive/negative impact is unknown. (A further examination is required in the further p
・-: No negative impact is expected.

Source: Project Team

(5) Description of Mitigation Measures against Adverse Impacts

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

1) Sector Dams

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

Table 8.3.7 Potential Negative Impacts and Mitigation Measures (Sector Dam)

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

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

2) Sector Water Supply

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

Table 8.3.8 Potential Negative Impacts and Mitigation Measures for Projects using Surface Water as Water Source (Sector Water Supply)

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

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

Table 8.3.9 Potential Negative Impacts and Mitigation Measures for Projects using Groundwater as Water Source (Sector Water Supply)

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

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

3) Sector Irrigation

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

Table 8.3.10 Potential Negative Impacts and Mitigation Measures (Sector Irrigation)

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

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

(6) Conclusion and Recommendations

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

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