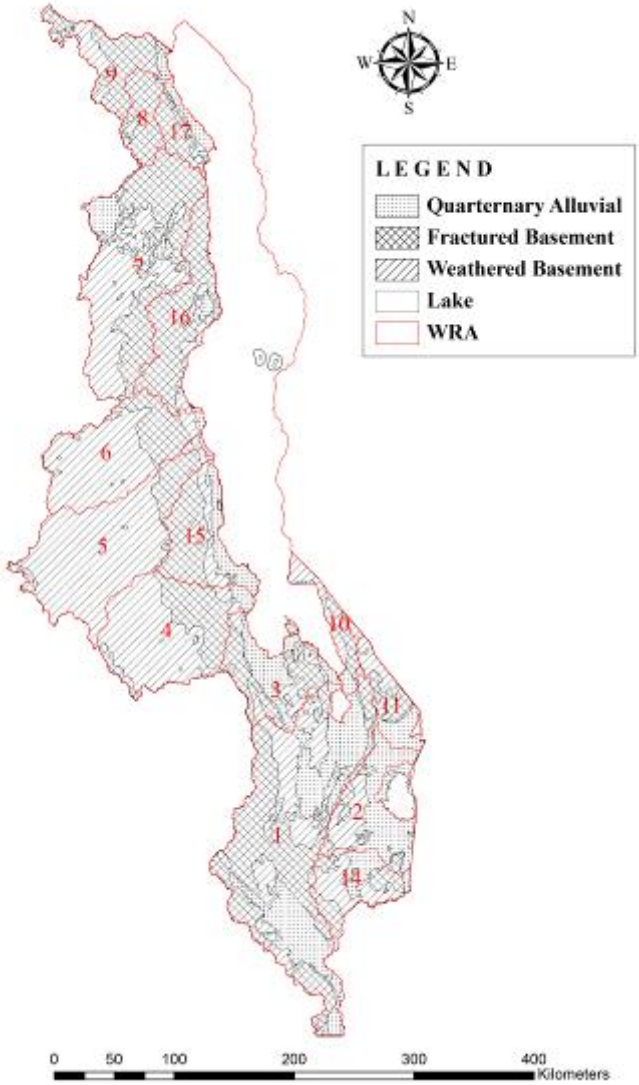
6.2 Groundwater

6.2.1 Aquifer Characteristics

(1) Aquifer Profile

The land of Malawi generally is divided into three geologic terranes, the rift valley areas overlaid by thick alluvium, the plateau area composed of weathered materials, and the mountain area exposing basement rocks. Although the aquifer structures on a micro scale have never cleared yet due to poor geological investigation, the aquifer units can be considered to correspond to the three terranes on a macro scale, and that is, the distributions of aquifers are regarded as just three aquifers, the Quaternary alluvium (AL), the weathered basement (WB) and the fractured basement rock (FB) as shown in **Figure 6.2.1.**



Source: Project Team

Figure 6.2.1 Distribution Map of Aquifers in Malawi

This report mentions the detailed geologic properties of each the aquifer in **Section 3.3, Hydrogeology**, and the macro structure of the aquifers over the whole of Malawi for evaluating the groundwater potential across the board will be explained in this chapter. The macro structure simply can be illustrated in **Figure 6.2.2**.

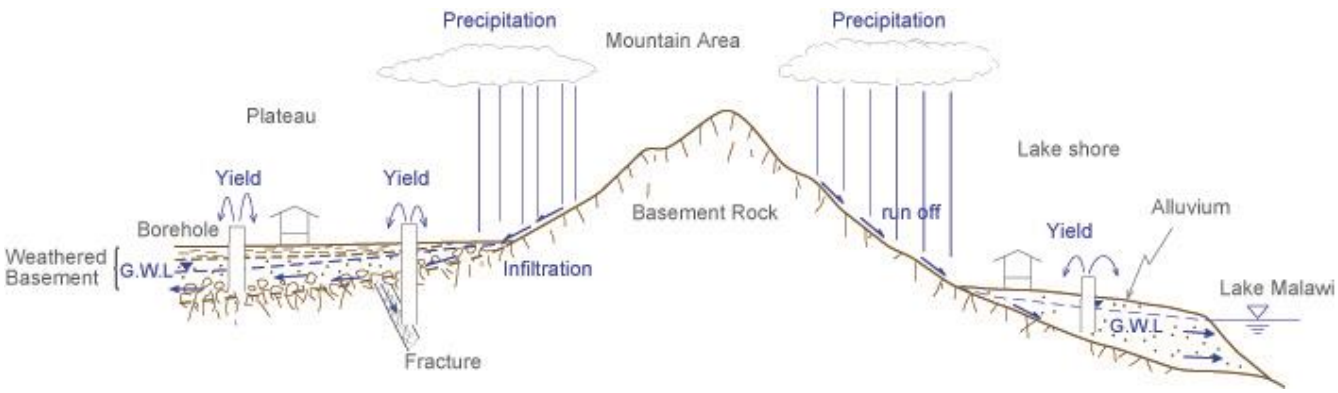
Among the three aquifers, developable aquifers are just two, the weathered basement and the alluvium. These two aquifers can be considered as permeable layers based on Darcy's theory. On the other hand, the

basement rock is basically regarded as impermeable aquifer and runoff on the surface in accordance with the following three reasons,

- ✓ Almost all of the areas exposing basement are quite poorly developed on the borehole construction.
- ✓ The infiltration does not follow the Darcy flow but groundwater flows along discontinuous planes developed at random in a rock-mass.
- ✓ Seepage paths in the basement are only joints and fractures, thus the presence of groundwater will probably be poorer than the other aquifers.

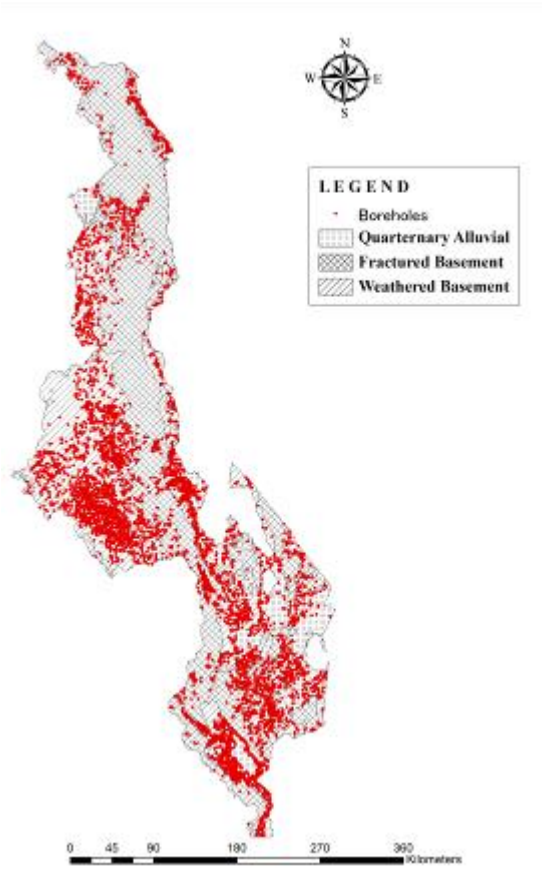
According to the existing borehole database in 1986, the borehole constructions kept out of the basement areas as shown in **Figure 6.2.3**. These areas are basically comprised of mountains and inaccessible against transporting a drilling machine and the related equipment due to steep slopes. Thus it is considered that the basement areas, in other words, mountain areas are originally not preferable to develop groundwater in viewpoint of the geomorphic feature.

Basement rocks seem not to reserve groundwater inside the intact rocks because almost all of basement rocks in Malawi consist of extremely old metamorphic or igneous stone which has high solidity. Hence the basement rocks keep groundwater only in discontinuous planes including joints and fractures. Actually, there were success boreholes remarkably producing water at the basement aquifer, however the exploration of fractures which reserve large amount of groundwater is too difficult to predict these locations owing to complicated geo-structure. It is to say that fracture expansions are very uneven distributions and the groundwater development has a sort of gambling factor. The basement rock containing within it large uncertainty is undesirable to apply the nationwide evaluation for groundwater resources.



Source: Project Team

Figure 6.2.2 Conceptual Model of Macro Aquifer Structure in Malawi



Source: Project Team

Figure 6.2.3 Relationship between Aquifer Distributions and Borehole locations

(2) Pumping Test

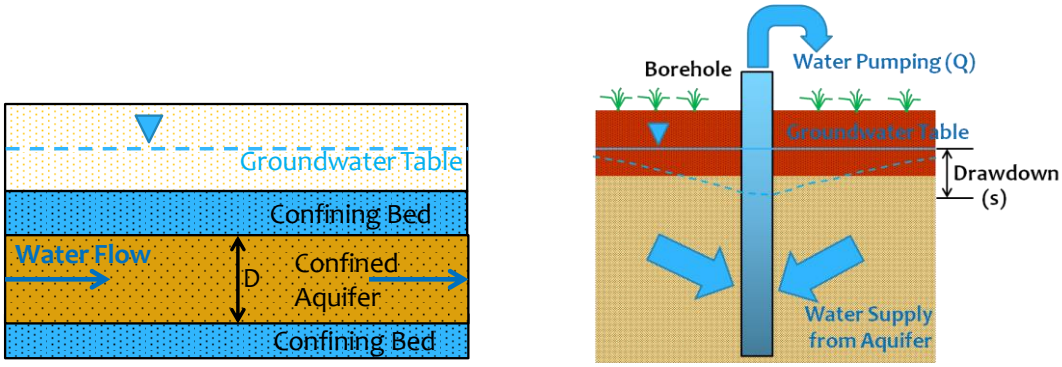
A pumping test is one of the most important investigations to know the hydraulic parameters of an aquifer such as transmissivity and storativity, and decide borehole specifications during the construction period. However, there are quite a few data recording details of pumping tests on the existing borehole records or related reports in Malawi though enormous amount of boreholes have been set until now.

Fortunately, parts of the borehole data cards unified in a program of NWRMP in 1986 offer the lowest information of pumping test results including borehole yield, drawdown and specific capacity, and these usable borehole data is contained in every WRA. The Project will make clear the aquifer properties based on a few boreholes have details of pumping test in the limited areas, and apply the relationship between the aquifer properties and the information of the cards nationwide.

A pumping test generally leads to three significant hydraulic parameters as follows:

- Specific Capacity (SC)
- Transmissivity (T)
- Storativity (S)

The basic concepts of these parameters are shown in **Figure 6.2.4** and mentioned below.



$T = k \times D$
Where, T: Transmissivity [L^2/t]
k: Permeability of Aquifer [L / t]
D: Thickness of Aquifer [L]

$SC = Q / s$
Where, SC: Specific Capacity [L^2 / t]
Q : Water yield [L^3 / t]
s : Drawdown [L]

Source: Project Team

Figure 6.2.4 Basic Concept of Groundwater Pumping
(Left: Darcy Flow Model, Right: Drawdown mechanism in extracting water from a borehole)

Specific capacity (SC), which is defined as the yield volume per unit drawdown up to the final water level in continuous pumping test, can be easily measured as an aquifer's characteristic at a borehole. This hydraulic parameter has been accumulated in abundance in the existing records.

Transmissivity (T) is defined as the flow volume through a full section of an aquifer under unit hydraulic gradient in unit time. In accordance with the Darcy's Law, it can be led by the analysis based on well hydraulics with chronological changes of drawdown on both continuous pumping and recovery after pumping. Transmissivity leads permeability by dividing it by aquifer thickness.

The past pumping tests should have set some observation wells which just measure groundwater fluctuation apart from a pumping well, in order to reject such pumping influences as well losses, surging water, fluctuations in discharge rate, and etc., but an adequate pumping test using observation wells has never been conducted even once in Malawi due to severe cost restraints. That is reason why it should be taken into consideration that the transmissivity led by analysis on the past pumping test records has no little inaccuracy.

There are several methods on the analysis using pumping test results, such as the well-known Thiem's method, Theis-type curve matching method and Jacob's linear analytical solution. The Project adopts the Jacob's method for transmissivity because it is rather easy and practical to be calculated on EXCEL spread sheets, and it can be analyzed from both continuous pumping test and recovery test. Transmissivity can be obtained by the following formulas by drawing a line on the section where groundwater drops/rises linearly in the fluctuation–ime passing curve with semi-logarithmic scale (see **Figure 6.2.6**).

$$T = \frac{0.183\,Q}{\Delta s}\log_{10}\left(\frac{t_1}{t_2}\right)$$ ..... for Continuous pumping test

$$T = \frac{0.183\,Q}{\Delta s'}\log_{10}\left(\frac{t}{t'}\right)$$ ..... for Recovery test

Where, T : Transmissivity (m^2/day)

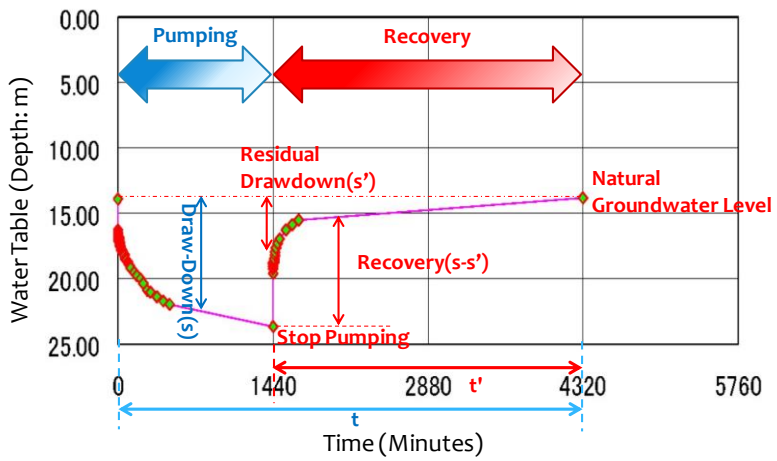
Q : Water Yield (m^3/day)

s : Drawdown (m)

s' : Residual drawdown (m)

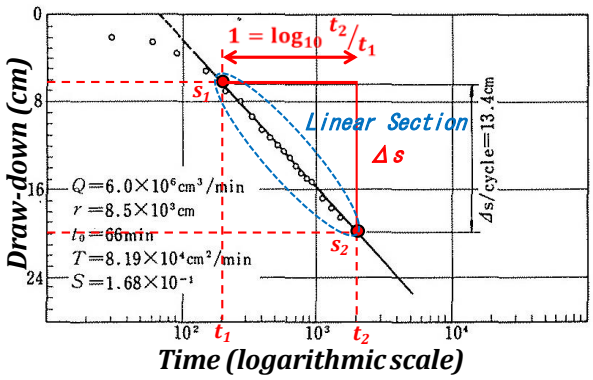
t_1, t_2 : Time since pumping began (minutes; $t_2 > t_1$)

t' : Time since pumping stopped (minutes)

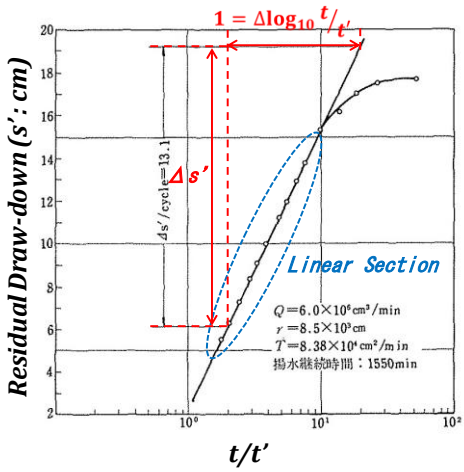


Source: Project Team

Figure 6.2.5 Chronological Changes of Groundwater Level during Continuous Pumping and Recovery



<Continuous Pumping Test>



<Recovery Test>

Source: Handbook of Groundwater Hydrology, Japan[1]

Figure 6.2.6 Examples of Jacob's Linear Analytical Solution on Continuous pumping and Recovery

Storativity (S) is defined as the volume of water which an aquifer releases from storage per unit when groundwater head changes per unit (see the right figure of **Figure 6.2.4**). One of the requirements of calculating storativity is to carry out the pumping test with several observation wells, but it has never been done in Malawi yet. Therefore the Project cannot examine the storativity from the existing pumping test results.

A past study[2] estimates storativities of weathered basement and alluvial aquifers from soil compositions, and these probably are in the range from 5×10^{-3} to 10^{-2} in the weathered basement aquifer and 10^{-2} to 5×10^{-2} in the alluvial aquifer. However these estimates have not followed precise methods based on better knowledge of the aquifers. Accumulation of the detailed studies regarding the storativity will be desired in future.

(3) Transmissivity

In Malawi, although the minimum data from the pumping tests including water yield, drawdown and specific capacity, exist on the data cards or some project reports for rural supply, most of the detailed records for evaluating transmissivity have been lost. A little data of which borehole constructions implemented by the framework of JICA's grant aid remains and can make a great contribution toward groundwater analysis. The Project extracts test pumping records from the following reports,

- ✓ The Project for Development of Groundwater in Lilongwe-Dedza, 2004 (141)[3]
- ✓ The Project for Development of Groundwater in Lilongwe West, 2007 (24)[4]
- ✓ The Project for Development of Groundwater in Mwanza and Neno, 2013 (30)[5]

Note: The figures in round brackets are the numbers of boreholes used on the evaluation.

The Project will roughly make clear the hydraulic mechanics based on the above-mentioned records though these are unevenly distributed and a little insufficient regarding the nationwide scale.

1) Groundwater Behavior in Pumping

Groundwater behaviors in the water pumping reflect a variety of circumstances of underground conditions, for example, hydraulic characteristics of an aquifer such as permeability, storativity, or geological structures, e.g. confined / unconfined layer and discontinuous planes in fresh rocks, or artificial influences including well loss, obstruction of flow by casing pipe or other accessary inside the borehole.

Groundwater usually rises by more than 30 meters at most after the first strike during the drilling in both weathered basement and alluvial aquifers. It seems that subsurface strata make a confining environment,

and most of groundwater is probably confined under impermeable lateritic soil composed of very fine particles. Thus it is appropriate to define the aquifer depths for both weathered basement and alluvial aquifers from the top of the basement rock up to the depth of the first water struck.

Two results of pumping tests are shown in **Figure 6.2.7** and **Figure 6.2.8** for reference. Groundwater among the boreholes commonly drops down to nearby the upper sealing section within the first one minute by pumping. The rapid drawdown suggests that ditchwater blocked by the seal is extracted in the casing pipe and the drawdown rate might be even more rapid than one under natural ground conditions. At LD 3-8 in **Figure 6.2.7**, the drawdown gradients (Δs) are different between the drawdown up to the depth of the first strike and up to the deepest water level. The former drawdown, which shows a lower gradient, seems to show that a confining pressure by a subsurface layer decreased. After groundwater lowered below the top of the aquifer, the aquifer changed to an unconfined condition and the water table dropped linearly because the pumping water volume exceeded the water supply from the aquifer. The boreholes having this tendency such as in LD 3-8 usually have very low transmissivity and poor groundwater potential.

LD 4-29 in **Figure 6.2.8** shows that the water table was almost stable after the first rapid drawdown in spite of the large pumping rate (172.8 m^3/day). The recovery rate was also so rapid that the water table rose up to nearby the static water level within one minute after the pumping stopped. It means that the aquifer has high transmissivity probably because of its high porosity. The sort of aquifer such as LD 4-29 seems to have high transmissivity but poor storativity; therefore, the seasonal fluctuation gaps between the dry and rainy seasons might be large due to small water retentivity.

The long term behavior of boreholes in Malawi has been poorly documented. A few re-tests of pumping at the existing boreholes after their construction were carried out in a past study[2]. These results show significant deterioration of the pumping performance, specific capacity with time after construction as shown in **Table 6.2.1**. Causes of the deterioration are mentioned below,

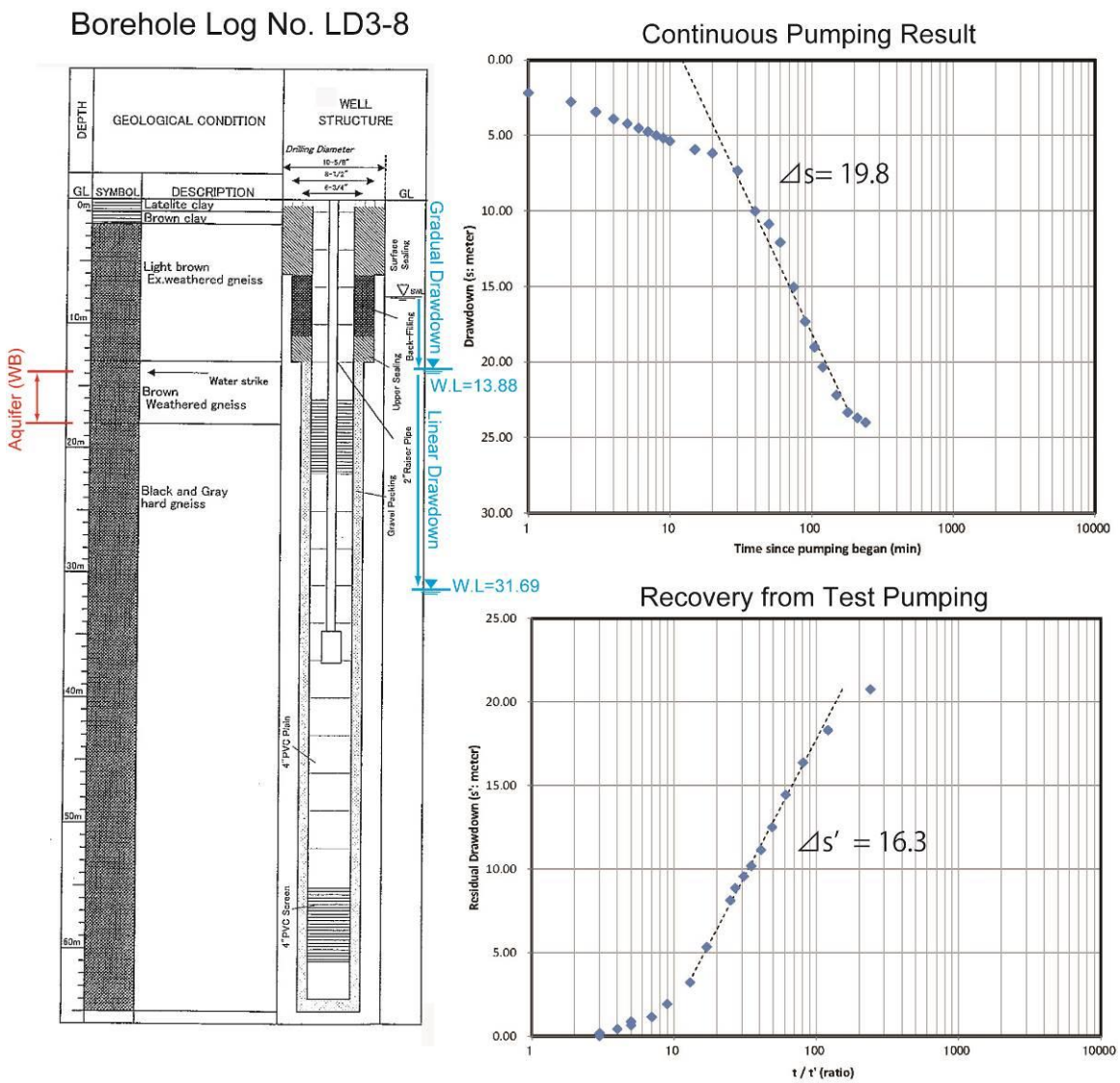
- ✓ Movement of fine material into the borehole causes infilling and a decrease in the effective section of the aquifer, alluvial areas in particular.
- ✓ Corrosion of borehole linings in areas of acidic groundwater results in further ingress of aquifer materials and triggers the collapse of sections of the borehole.
- ✓ Incrustation of the gravel pack and screen slots by iron deposits or other influent materials results decreasing aquifer's permeability.

Most of the causes of exhaustion in a borehole are not owing to a decrease of recharge but insufficient borehole structures or a lack of periodic maintenance. The above mentioned deterioration can be prevented or restored to the proper borehole condition only by using adequate construction materials and keeping regular maintenance, for instance, selection of screen installed with large size slots matching the aquifer porosity during the construction phase, and regularly washing extraneous matters sticking on screen slots with a high pressure pump during the operation phase.

Table 6.2.1 Borehole Performance for Long Term

Location	Aquifer Type	BH. No.	First Testing Date	SC (l/sec/m)	Second Testing Date	SC (l/sec/m)
Dowa	WB/FB	15A210	6-Feb-1978	0.80	12-Jul-1979	0.14
Ntcheu	WB/FB	1R129	20-Jun-1978	0.10	1-Aug-1979	0.04
Ntcheu	WB/FB	1R130	28-Jul-1978	0.28	24-Aug-1979	0.12
Chitipa	WB	9B32	21-Jun-1978	0.30	3-Jun-1982	0.29
Chiradzulu	WB	2B218	21-Aug-1978	0.06	21-Feb-1980	0.05
Balaka	AL	1R53	11-Nov-1981	0.22	21-Sep-1982	0.16
Nsanje	AL	1G32	18-May-1978	0.26	29-Apr-1982	0.97*
Nsanje	AL	1G28	20-May-1978	0.28	2-Aug-1978	0.26
Nsanje	AL	1G27	22-May-1978	0.06	31-Jul-1978	0.06
Mpemba	WB	1E1	24-May-1978	0.03	30-Mar-1980	0.03
Salima	AL	15A212	27-Jan-1978	0.83	26-Jan-1979	1.89*

Note: WB= Weathered Basement, AL= Alluvium, FB= Fractured Basement
* After development of borehole
Source: An Evaluation Report2: Groundwater Resources of Malawi, Overseas Development Administration Institute of Geological Sciences, 1983



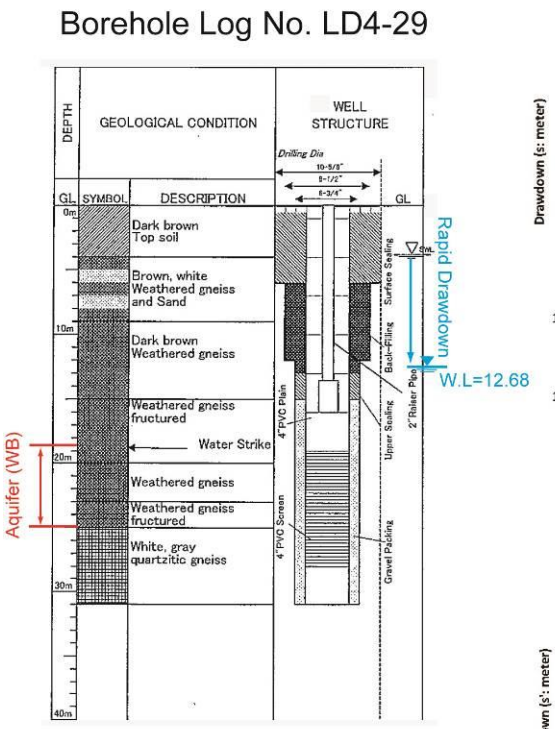
<Specifications of Test Pumping>

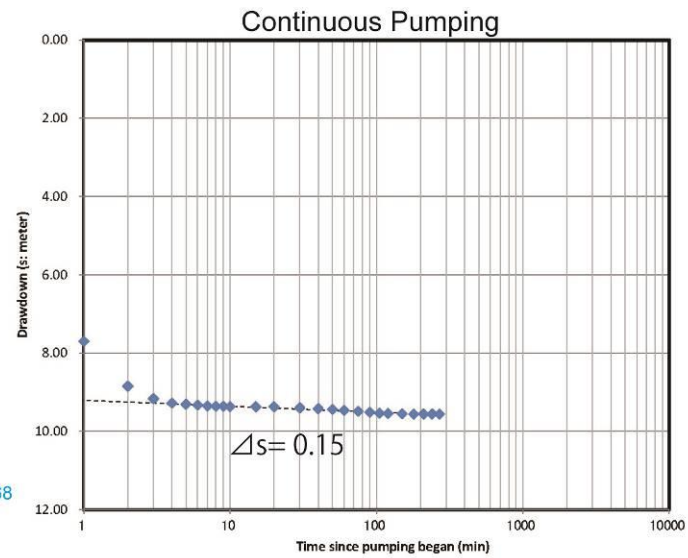
BH No.	District	Village	Drilling Date	Well Depth	Aquifer Type
LD 3-8	Lilongwe	Kumlenga	26-July-2003	64.0m	Weathered Basement

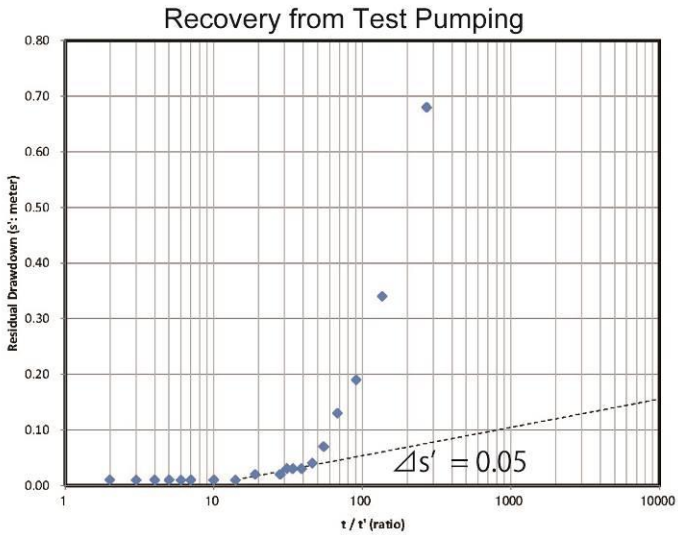
Static W.L. [m]	Drawdown W.L [m]	Discharge Volume [m^3/day]	Specific Capacity [m^2/day]	Transmissivity [m^2/day] Pumping	Recovery	Average
7.70	31.69	23.04	0.96	0.21	0.25	0.23

Source: Project Team

Figure 6.2.7 Test Result of Continuous Pumping and Recovery at LD 3-8 in Lilongwe-Dedza







<Specifications of Test Pumping>

BH No.	District	Village	Drilling Date	Well Depth	Aquifer Type
LD 4-29	Dedza	Mtende	2-May-2003	30.40m	Weathered Basement

Static W.L. [m]	Drawdown W.L [m]	Discharge Volume [m^3/day]	Specific Capacity [m^2/day]	Transmissivity [m^2/day] Pumping	Recovery	Average
3.12	12.68	172.80	18.07	206.6	620.9	413.8

Source: Project Team

Figure 6.2.8 Test Result of Continuous Pumping and Recovery at LD 4-29 in Lilongwe-Dedza

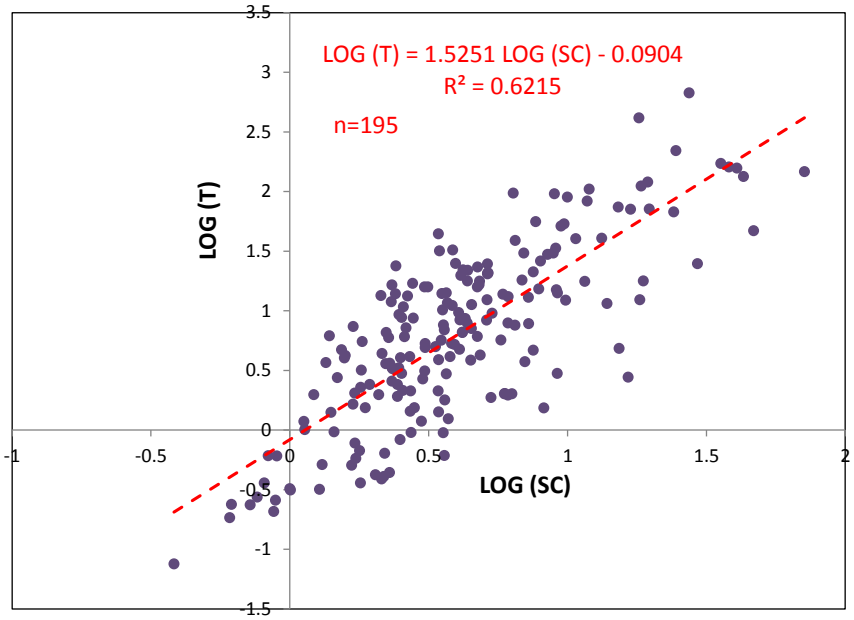
2) Relationship between Transmissivity and Specific Capacity

Specific capacity has a common dimension with transmissivity but it is not an aquifer property in the strict sense of the term because it represents just a phenomenon which shows a drawdown corresponding to a water yield at a borehole. However if so much data of specific capacity are accumulated that a statistical approach could be applied, it will become an important indicator for evaluating aquifer properties in a wide area.

Figure 6.2.9 shows a fairly linear correlation (r=0.79) between transmissivity and specific capacity, using pumping test records of the recent borehole construction in Malawi. The relationship leads a converting equation from specific capacity into transmissivity as mentioned below,

$$\text{Log (T)} = 1.5251 \text{ Log (SC)} - 0.0904 \text{ [R=0.79]}$$

Where, T: Transmissivity (m^2/day)
SC: Specific Capacity (m^2/day)



Source: Project Team

Figure 6.2.9 Relationship between Transmissivity and Specific Capacity

3) Nationwide Tendency of Transmissivity

Transmissivity values of the three main aquifers in each WRA are converted from specific capacity derived from the existing borehole database, approx. 3,000 boreholes, with the converting equation. A summary of the converted transmissivity values for the three aquifers, Alluvium (AL), Weathered Basement (WB) and Fractured Basement in each WRA is shown in **Table 6.2.2**.

Table 6.2.2 Summary of Transmissivity in Malawi

WRAs	Region	Aquifer Type	n	Transmissivity (m^2/day)							
				Range		Average	Mode	Median	Quartile (25%)	Quartile (75%)	Quartile Deviation
1	South	AL	363	0.14	- 35046.73	395.91	1.42	24.41	5.23	105.52	50.15
		WB	133	0.09	- 7374.32	147.73	166.77	16.41	4.38	63.87	29.75
		FB	122	0.02	- 16080.74	221.55	162.37	8.50	2.14	29.64	13.75
2	South	AL	34	0.11	- 737.03	58.32	-	13.97	4.88	63.10	29.11
		WB	50	0.48	- 9971.51	312.13	195.83	11.81	3.32	93.97	45.32
		FB	14	1.25	- 1005.88	123.77	-	17.90	2.64	59.06	28.21
3	Central	AL	90	0.00	- 2073.96	105.50	122.48	18.62	5.28	53.23	23.98
		WB	105	0.37	- 1353.74	64.19	6.96	9.81	4.53	32.67	14.07
		FB	16	0.09	- 209.40	21.78	6.82	2.86	1.27	6.82	2.78
4	Central	AL	16	1.28	- 31761.49	2667.61	-	43.32	5.47	252.39	123.46
		WB	453	0.01	- 8491.34	97.90	2.62	6.80	1.84	27.07	12.62
		FB	155	0.00	- 724.57	22.37	0.61	4.25	1.29	15.32	7.01
5	Central	AL	-		-						
		WB	565	0.00	- 6345.01	65.75	3.68	3.68	1.39	14.72	6.67
		FB	24	0.03	- 34.53	4.51	-	1.95	0.74	4.85	2.06
6	Central	AL	6	0.15	- 70.07	19.89	-	1.52	0.64	34.68	17.02
		WB	98	0.02	- 992.50	18.30	0.66	2.13	0.85	8.14	3.64
		FB	7	0.08	- 1.48	0.68	1.48	0.39	0.31	1.09	0.39
7	North	AL	11	0.51	- 101.08	24.97	-	9.58	3.44	35.72	16.14
		WB	203	0.03	- 16379.56	138.24	2.61	4.55	1.39	19.51	9.06
		FB	53	0.01	- 8491.34	242.61	-	4.73	1.62	18.98	8.68
8	North	AL	9	6.18	- 36462.98	4258.80	-	130.40	25.57	250.92	112.68
		WB	3	3.66	- 11.65	6.46	-	4.08	3.87	7.87	2.00
		FB	12	1.87	- 385.13	82.63	-	27.68	7.45	56.60	24.58
9	North	AL	17	0.74	- 3713.65	272.68	-	17.83	9.85	101.30	45.73
		WB	58	0.02	- 487.73	38.20	-	15.45	4.99	35.34	15.18
		FB	16	1.01	- 607.02	99.57	-	30.13	5.33	121.75	58.21
10	South	AL	1	5.83	- 5.83	5.83	-	5.83	5.83	5.83	0.00
		WB	15	3.36	- 290.21	102.46	-	53.23	16.66	195.58	89.46
		FB	1	2.73	- 2.73	2.73	-	2.73	2.73	2.73	0.00
11	South	AL	6	0.51	- 220.94	54.95	-	15.09	3.09	63.02	29.97
		WB	45	0.08	- 1990.96	73.46	-	6.11	2.12	37.65	17.77
		FB	8	0.07	- 207.53	40.55	-	8.73	0.57	37.18	18.30
14	South	AL	11	1.42	- 18883.86	1734.61	-	9.43	3.19	34.80	15.80
		WB	49	0.07	- 14219.58	311.04	-	7.36	3.56	29.22	12.83
		FB	25	0.27	- 707.72	72.97	-	6.53	1.48	19.48	9.00
15	Central	AL	43	0.25	- 4914.03	220.40	-	12.83	2.30	59.64	28.67
		WB	32	0.00	- 2921.00	137.38	-	10.55	2.34	47.10	22.38
		FB	30	0.01	- 5475.61	283.28	0.01	4.57	1.82	49.68	23.93
16	North	AL	7	0.02	- 10369.60	1483.76	-	0.51	0.06	8.06	4.00
		WB	31	0.08	- 1941.35	92.38	-	4.43	1.51	22.75	10.62
		FB	5	0.63	- 61.66	14.89	-	2.75	2.24	7.15	2.46
17	North	AL	68	1.12	- 2863.72	139.40	1.42	24.24	8.52	64.67	28.07
		WB	9	1.38	- 334.50	55.45	-	14.62	10.58	25.89	7.66
		FB	6	2.67	- 1104.10	283.52	-	21.96	6.36	417.43	205.54

Source: Project Team

There are huge deviations among transmissivity values in each WRA, ranging from approx. zero to approx. 36,000 m^2/day. The T values exceeding more than 10,000 m^2/day corresponds to high discharge rate over 100 m^3/day in spite of such a slight drawdown of less than one meter. These too high values are very suspicious to be mis-readings of drawdown or discharge volume in past testing. However, these detailed pumping records have already run out somewhere hence nobody can verify the appropriateness of such high transmissivity.

Average values of transmissivity in each aquifer or WRA are relatively high due to a few terribly high T values, but 90% of the values lie below the ninetieth percentile on which the average value stands each aquifer as shown in **Figure 6.2.9**, and it means that most of the values lean to the smaller side than the average value. The values summarized in each WRA also show that the average values are too high against the tendency in which smaller values account for large proportions as shown in

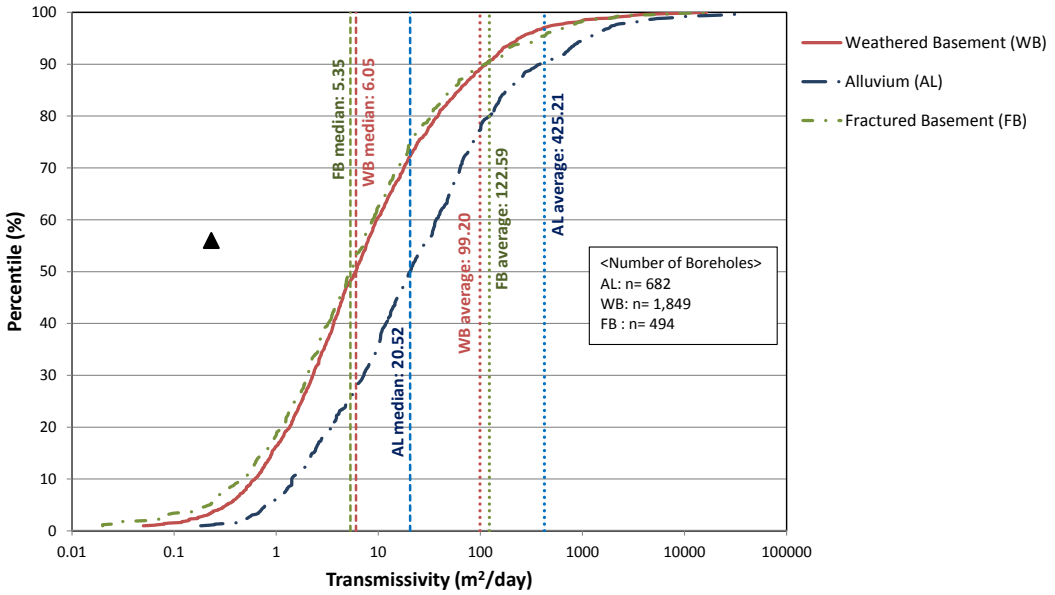
Figure 6.2.10. Therefore, it seems that the average value of transmissivity is not preferable as a representative for aquifers, or each WRA, but the median values are rather acceptable in statistics. Therefore the Project will adopt the median values as representative transmissivity for aquifers in each WRA.

Figure 6.2.9 shows that transmissivity values of the alluvial aquifer are the highest of the three aquifers so that the median value is 20.52 m^2/day, approximately three times as high as those of the other aquifers in the whole of Malawi. The transmissivity of both weathered basement and the fractured basement are almost same each other. The local tendencies of transmissivity each aquifer are summarized as **Figure 6.2.11**. The plateau area including WRA 4 to 6 which correspond to Kasungu through Lilongwe and Dedza, has relatively low transmissivity as the median value ranging from 2.13 to 12.28 m^2/day in the weathered basement aquifers. These data are believable because of much accumulation of pumping test results in these areas.

Transmissivity values of the alluvial aquifer are too many with the watershed of the Shire River (WRA1) in the southern Malawi. Nsanje district located in the farthest downstream of the Shire River has 66.25 m^2/day which is the highest transmissivity value in the alluvial aquifer. The alluvium in Balaka district located on the midstream of the Shire River tends to be also high after the southernmost area. The transmissivity values in the west lakeshore of Lake Malawi (corresponding to WRA 3, 4, 6, 15 and 16) generally tend to be poorer than the watershed of the Shire River, except Salima lakeshore area located in WRA 4, but the data in these areas is very few in the first place. Hence the actual transmissivity of the west lakeshore areas would be better because the tendency in the lakeshore of the northern Malawi (WRA 8, 9 and 17) shows the high values ranging 17.83 to 130.4m^2/day.

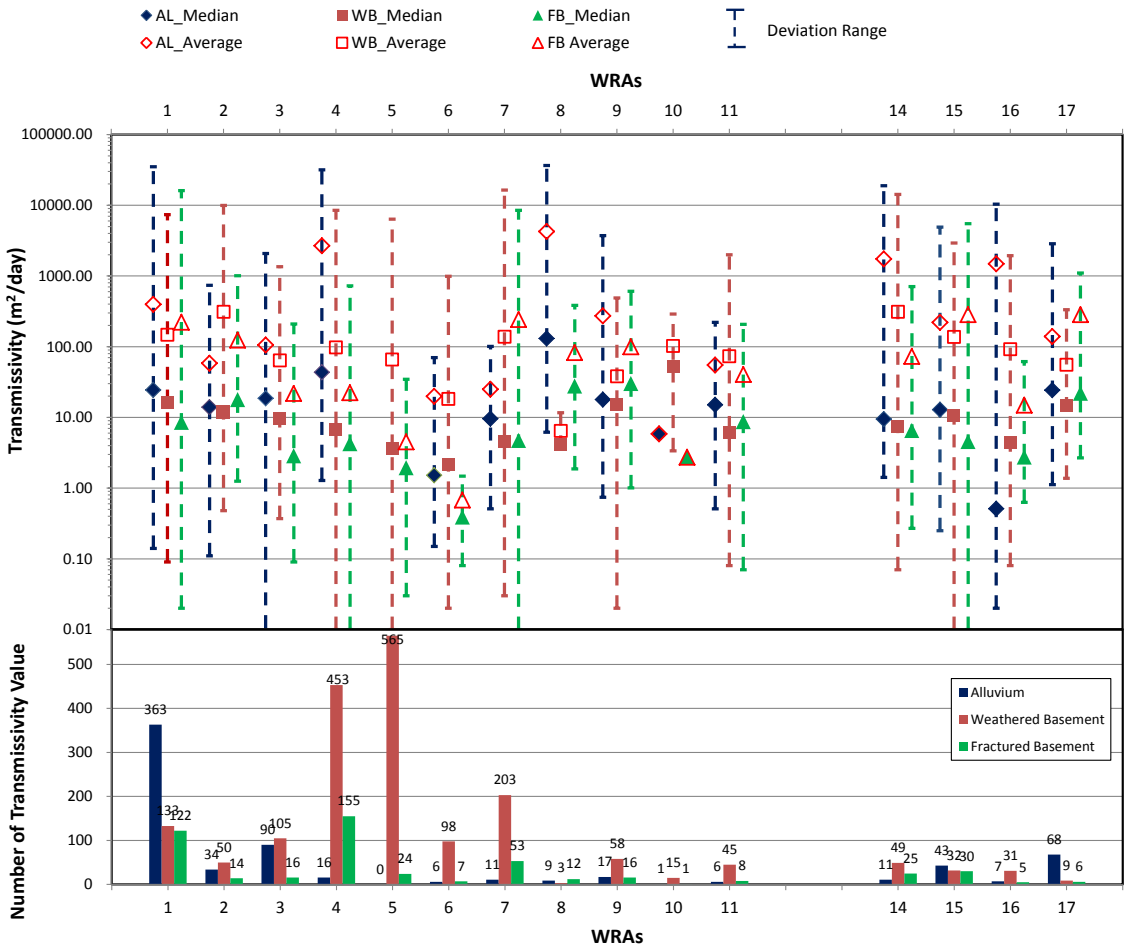
The alluvium in the Lake Chilwa basin (WRA 2) in somewhat different from the other alluvial areas in that it is not in the bottom of the rift valley. There are very few boreholes and poor lithological records, pumping test records. According to two past exploratory drillings for the National and Shire Irrigation Study (1980)[6], thick clay successions have been dominated and these clayey aquifers produce very little amount of water, thus the two boreholes were finally abandoned. The actual transmissivity value of the fine sediments surrounding Lake Chilwa would be poorer than results of the examination in the Project.

Transmissivity values of the fracture basement (FB) calculated by Jacob's linear analytical solution are just apparent transmissivity because the groundwater inside rocks generally does not follow laminar flow but random flow. The statistic values of FB are the lowest of the three aquifers in spite of small differences between FB and WB in the whole of Malawi as shown in **Figure 6.2.9**. The WRAs which have the data of FB enough to do statistical processing indicate the lowest value compared with the other aquifers. Though in parts of WRAs the transmissivity values between WB or AL and FB are reversed, but the higher transmissivity values of FB may not be plausible due to very few usable data (see **Figure 6.2.10**). The Project judges that the FB aquifer generally has the lowest transmissivity according to the statistic tendencies, and excludes the transmissivity of FB on evaluating groundwater recharge, the reason why groundwater development in rocks is generally difficult in Malawi due to the complicated seepage paths, the low potential of groundwater presence and the severe access for transporting a drilling machine.



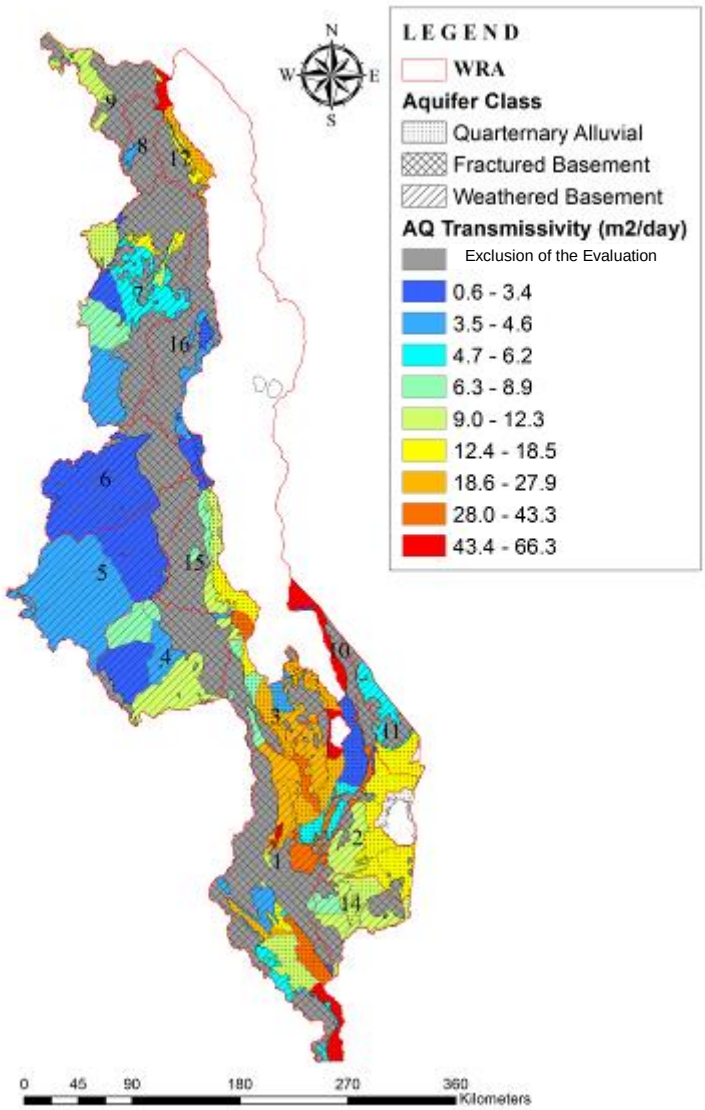
Source: Project Team

Figure 6.2.10 Relative Cumulative Frequency Curves for the Aquifers



Source: Project Team

Figure 6.2.11 Bar Chart of Transmissivity Deviation for Aquifers in each WRA



Source: Project Team

Figure 6.2.12 Distribution Map of Transmissivity in Malawi

6.2.2 Groundwater Distributions

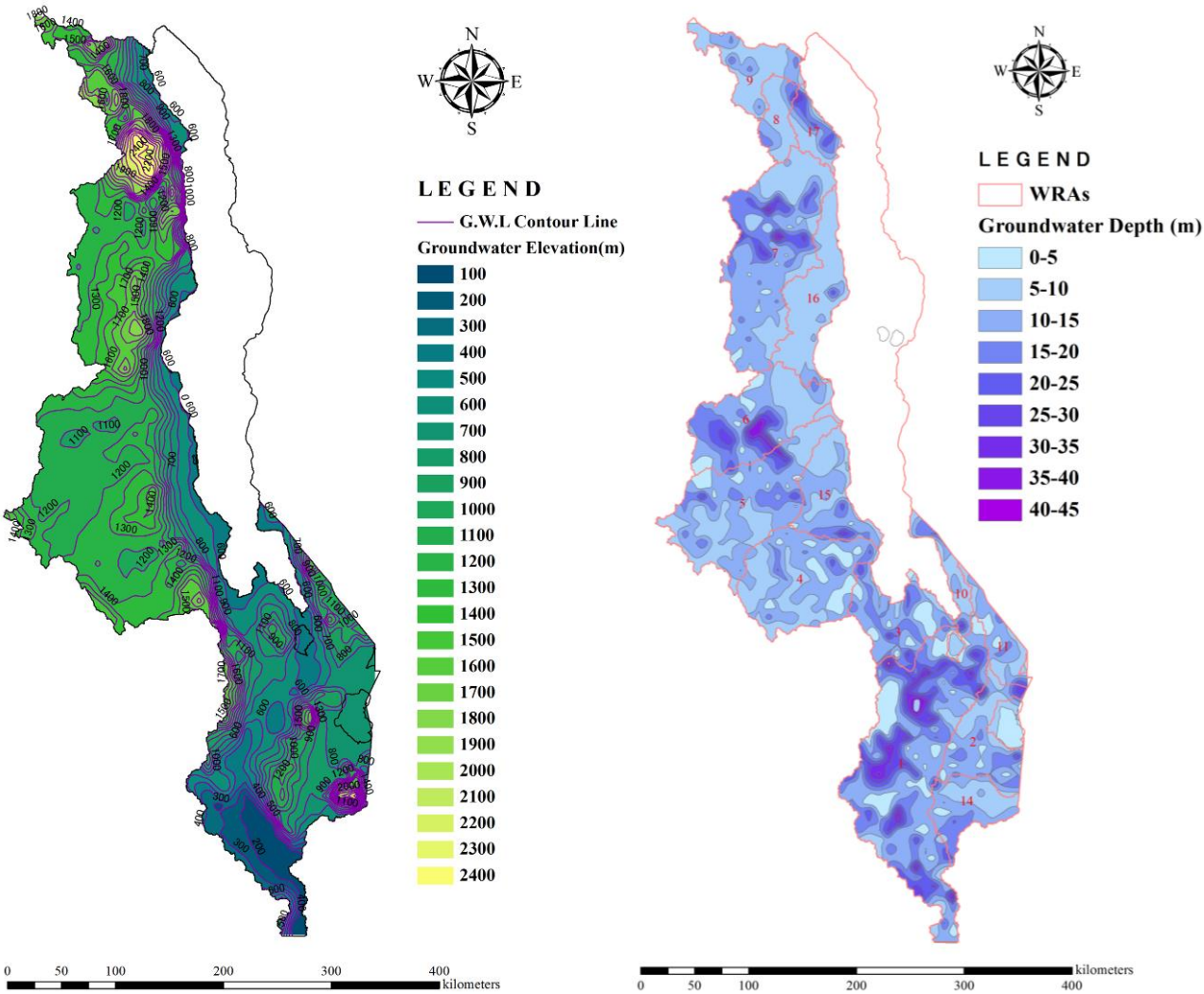
In Malawi, an enormous amount of borehole logs had been cumulated as borehole data cards from the 1930's to 1985. These data include groundwater levels that were measured at borehole construction or rehabilitation; hence, presence of groundwater resources can be known by drawing groundwater distribution maps (i.e., groundwater contour map and groundwater depth map). The Project will prepare these maps by spatial and statistical processing based on the following borehole logs:

- Borehole Cardex Records[7] (1930s to 1985) in the whole of Malawi: 5,822 logs.
- Borehole construction records in Thyolo District[8]: 129 logs
- Borehole construction records in Lilongwe–Dedza District[2] 141 logs
- Borehole construction records in Lilongwe West[3]: 23 logs
- Current groundwater monitoring records: 18 logs

Groundwater usually flows almost in parallel with the ground surface. The hydraulic gradients in the highland area of WRA 4, 5 and 6 are very gentle, ranging from 0.001 to 0.01 as shown in **Figure 6.2.13**, which means that it would take a long time to discharge groundwater to other watersheds. On the other hand, mountain areas

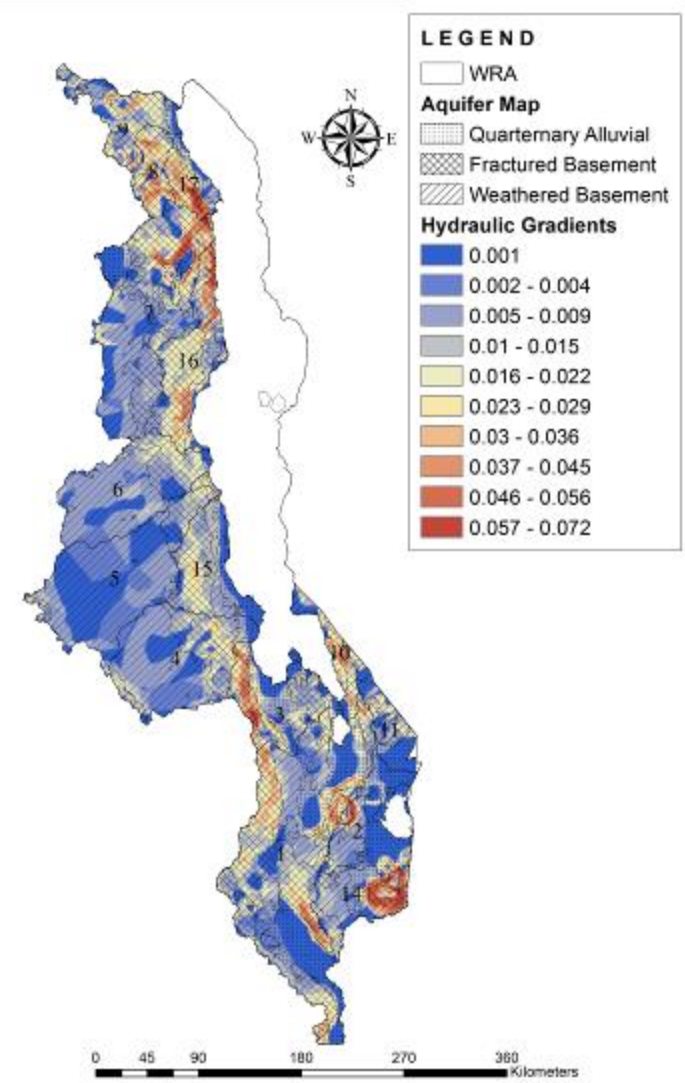
such as Niyaka Plateau in Northern WRA7, has high hydraulic gradients so that groundwater infiltrated on top of the mountains rapidly discharges into Lake Malawi.

Depths to the groundwater in the highland areas of WRA4 and WRA5 are generally shallower than 15m below ground level, but the groundwater tends to be slightly deeper 15 to 25m below ground level in the area adjacent to foot of mountains (WRA6 and 7, for example). Depth to groundwater in the alluvial sediments tends to be shallower with distance from Lake Malawi, Salima and Nkhotakota district at WRA15 for example. The groundwater level is normally less than 10m below ground surface, but the lakeshore groundwater levels located in the northern region are relatively deep levels ranging from 10 to 20m in depth. The groundwater depths in parts of the watershed of the Shire River (WRA1) tend to sink into deep parts (30m or more below ground level).



Source: Project Team

Figure 6.2.13 Groundwater Isopleth
(Left: Groundwater Contour Map, Right: Depth of Groundwater Table)



Source: Project Team

Figure 6.2.14 Distributions of Hydraulic Gradient in Malawi

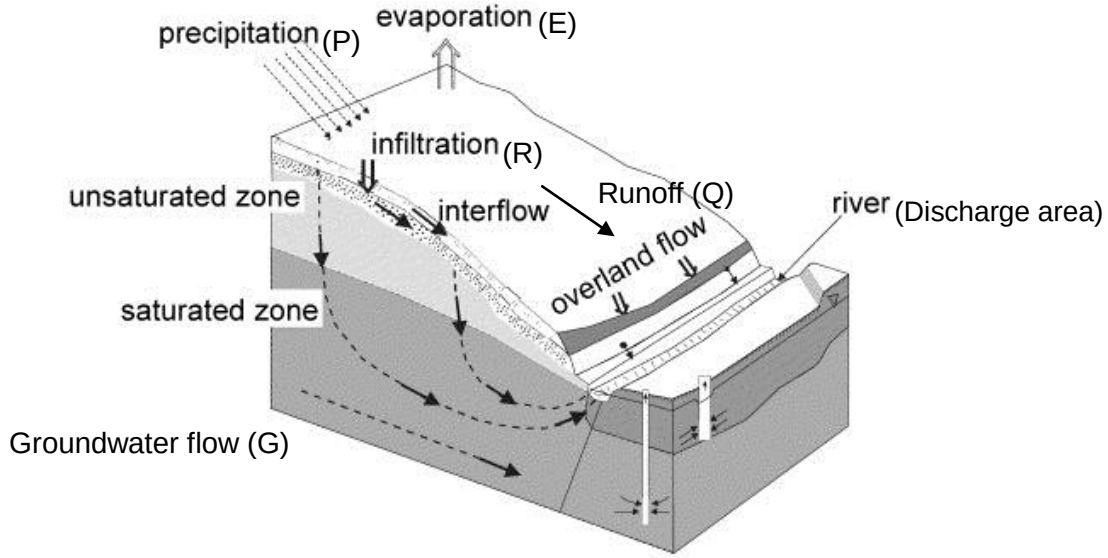
Note: A hydraulic gradient in each 1 km^2 mesh is calculated based on the groundwater contour map

6.2.3 Concepts of Groundwater Analysis

The recharge can be considered as potential groundwater resources, the reason why groundwater is roughly balanced with precipitation in the long run. Estimates of recharge to the weathered basement and alluvial aquifers have been made by the analysis of Water Balance and Darcian Flow mentioned as below. The fractured basement is not considered to estimate the recharge because the basement do not perform as an aquifer.

(1) Water Balance

Recharge is mainly from direct infiltration of part of the water from precipitation. The tendency of groundwater fluctuation shows consistent periodic cycles and it strongly depends on precipitation in common of Malawi in accordance with current groundwater monitoring activities (see **Subsection 3.4.3**). Recharge sources also correspond to dam reservoirs, irrigated areas and other water storage on the surface with the exception of precipitation, but in Malawi it is not doubted that the most important recharge method must be precipitation. Recharge from precipitation is generally modeled as shown in **Figure 6.2.15.**



Source: Project Team

Figure 6.2.15 General Water Balance

Assuming a sufficiently long period of analysis in surface and groundwater storage, a soil moisture deficit (interflow in **Figure 6.2.15**) can be considered to be negligible if the water balance is carried out over years. Recharge from precipitation can be simplistically calculated with basic hydrological parameters such as the following formula:

$$R = P - Q - E$$

Where, R : Recharge,

P : Precipitation,

Q : Surface runoff,

E : Evaporation

The approach considered with water cycle will be conducted in the analysis process of MIKE-SHE.

(2) Darcian Flow

The annual groundwater discharge is considered to be balanced by recharge if the groundwater is in a steady state groundwater flow assuming that a sufficiently long period of groundwater storage is considered to be negligible. In that case, recharge can be calculated in accordance with Darcy's Law. According to geological conditions of the ground surface of Malawi, three categories of aquifer have been broadly identified as Weathered Basement (WB), Fractured Basement (FB) and Quaternary Alluvial (AL). Darcian flow can transmit into particle spaces of WB and AL but cannot transmit into basement rocks which are basically considered to be impermeable. Recharge considered with Darcy's theory can be calculated by the following formula:

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

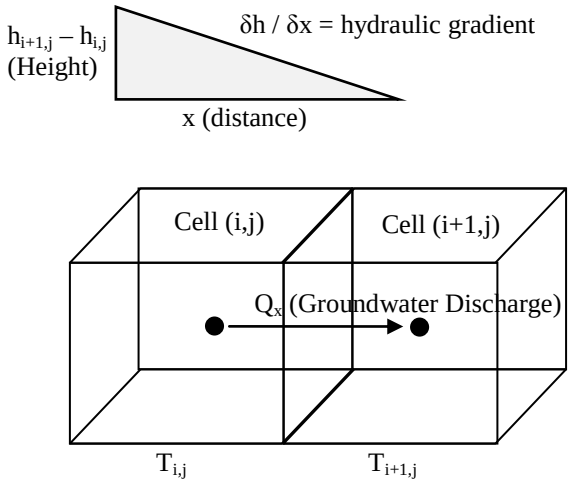
Where, Q : Groundwater Discharge

T : Transmissivity

i : Hydraulic Gradient

W : Area width throughout groundwater flows

The transmissivity values are variable between different WRAs; hydraulic gradients are also variable depending on localities. Therefore, the spatial analysis by GIS is the appreciated tool to calculate the Darcian flow in spatial data variation. The analysis scheme by GIS is as illustrated in **Figure 6.2.16**.



$$Q_x = T_{i+1/2,\,j} \times \delta h / \delta x$$

Where, Q_x : Groundwater discharge
$T_{i,j}$: Transmissivity at cell(i,j)
$h_{i,j}$: Groundwater Level at cell(i,j)
x : Distance between cells

Source: Project Team

Figure 6.2.16 Concept of Darcian Flow Analysis by GIS

In general, there are few reliable data on each component for estimating accurate recharge in any approach, and these approaches have both merits and demerits according to natural conditions. Thus the Project will examine accuracy of the data of each component comprising these approaches and carry out a comparative study of Water Balance and Darcian Flow.

6.2.4 Groundwater Potential in Malawi

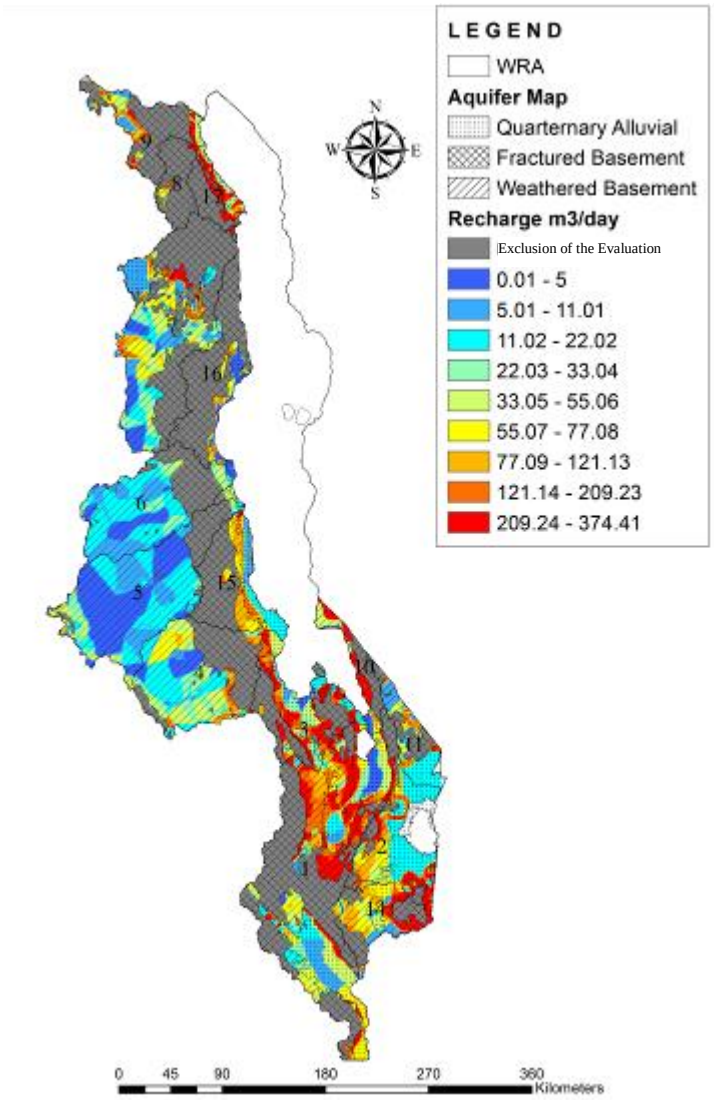
(1) Recharge Estimates

Groundwater recharges in the whole of Malawi are roughly estimated in accordance with the analysis scheme of Darcy Flow. The intensities of the recharge in each WRA are summarized in **Table 6.2.3** and **Figure 6.2.17**.

Table 6.2.3 Summary of Recharge Estimates by Darcian Flow Method

WRAs	Area of Aquifer (km^2)		Recharge (mm/year) in AL Aquifer Area		Recharge (mm/year) in WB Aquifer Area		Whole Recharge (mm/year)	Groundwater Potential Volume (×1,000 m^3/year)		
	AL	WB	Range	Average	Range	Average		AL	WB	Total
1	6,106	4,846	1 - 983	49	1 - 750	77	61	298,000	375,000	673,000
2	2,714	1,204	4 - 500	35	4 - 739	50	40	95,000	60,000	155,000
3	1,768	1,250	1 - 382	50	1 - 383	90	67	88,000	113,000	201,000
4	282	5,738	6 - 207	51	1 - 208	14	16	14,000	83,000	97,000
5	-	9,229			1 - 47	4	4	0	38,000	38,000
6	105	5,657	0 - 8	2	0 - 26	5	5	0	27,000	27,000
7	933	5,837	3 - 125	15	1 - 348	18	17	14,000	104,000	118,000
8	31	136	72 - 180	124	1 - 84	31	48	4,000	4,000	8,000
9	240	1,027	4 - 412	88	4 - 265	33	43	21,000	34,000	55,000
10	246	746	1 - 59	15	2 - 1,025	261	201	4,000	195,000	199,000
11	801	807	2 - 111	13	2 - 96	18	15	10,000	14,000	24,000
14	876	1,507	3 - 391	61	1 - 324	45	51	53,000	68,000	121,000
15	1,276	972	1 - 207	19	1 - 151	31	24	24,000	30,000	54,000
16	230	758	0 - 34	2	1 - 80	21	17	1,000	16,000	17,000
17	575	272	5 - 593	82	5 - 586	152	104	47,000	41,000	88,000
Total								***670,000***	***1,200,000***	***1,870,000***

Source: Project Team



Source: Project Team

Figure 6.2.17 Recharge Intensities calculated by Darcian Flow Method

The estimates of groundwater recharge derived using Darcian Flow method take the range of 4 to 201mm/year in case that an average value in each WRA is regarded as the representative recharge amount. Distributions of the recharge intensity as shown in **Figure 6.2.17** indicate that the recharge intensities are dominated by hydraulic gradients rather than quantities of transmissivity, i.e., the recharge intensity clearly tend to be higher than 100mm/year at the feet of mountain areas, such as the surroundings Zomba Mountain and Mulanje Mountain, hills in Blantyre, Ntcheu, Balaka and Mangochi district in the southern region, whereas the plateau plane including Lilongwe, Mchinji and Kasungu district in the central region shows small amount of recharge less than 20mm/year owing to very gentle geomorphic surfaces and low transmissivities in the weathered basement aquifers. According to the tendency of maximum annual rainfall as shown in **Figure 3.4.5**, it seems that the correlation between the tendency of groundwater recharge and rainfall intensity is fairly good because rainfalls tend to intensify at adjacent mountains and foot of the escarpment in the rift valley; whereas, amounts of rainfall tend to be relatively small in the plateau area similar to groundwater recharge.

In WRA5 which shows the lowest recharge intensity, 4mm/year in the weathered aquifer, the recharge accounts for minus 1% of the rainfall intensity using 825mm/year which averaged the data of Madisi rainfall station during 1959 through 1988. One of the reasons of such a too small recharge against the rainfall in the plateau area is considered that thick clayey layers in the unsaturated zone on such as dambo

areas may prevent the infiltration to the aquifer from precipitation. On these dambo areas, the recharge may normally occur for several years or several decades because surface water which stagnate leaks very slowly into underground through the fine materials.

(2) Issues of Groundwater Analysis

Groundwater recharge generally can be considered as the upper limit of utilized groundwater resources, and there are some approaches to estimate it. This report has roughly estimated the recharge in Malawi using the Darcian Flow scheme, but this approach should be considered on evaluating groundwater potential as follows;

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

Precipitation is the most important source of groundwater recharge in Malawi, and more preferable recharge intensity has to be required with comparative study on both Darcian Flow and Water Balance method. Furthermore, the appropriateness of the recharge intensity have to be cross-checked with actual utilization of boreholes.

6.3 Projection of Population

The projected country population to 2050 is mentioned in the Population Projection in Malawi. Only the projected district population up to 2030 is mentioned in it. The populations of each district between 2031 and 2035 are calculated by using same tendency of growth ratio. **Table 6.3.1** shows the projected district population in target year.

The future population projections in whole of Malawi of Census 2008 had been produced through the cohort component method. (It involves calculating the future size of cohorts, taking into account the effects of the population components: mortality, fertility and international migration.) Using the assumed projection level and trends in mortality, fertility and internal net migration, the population of each district and city was projected.

On the other hand, the population projections at 4 cities (Lilongwe, Blantyre, Mzuzu, Zomba) had been studied by past several reports concerning the water supply. The population projections of Census 2008 and the population projections of water supply projects in the future of four cities that are currently underway are shown in **Table 6.3.2**. Although the calculation method of the future population for census 2008 is shown as above-mentioned, the scenario of population projections that was assumed in the WB's projects in progress are also shown in **Table 6.3.2**.

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

Table 6.3.1 Projected District Population in Target Year

Region/District	2008	2012	2015	2020	2025	2030	2035
Malawi	13,077,160	14,844,821	16,310,430	19,104,274	22,358,190	26,090,974	30,296,833
Northern Region	1,708,930	1,955,528	2,161,786	2,553,758	3,003,745	3,519,245	4,090,391
CHITIPA	178,904	200,061	216,912	247,196	279,464	314,475	350,640
KARONGA	269,890	307,216	337,448	393,957	458,965	532,326	614,304
NKHATABAY	215,789	244,537	269,069	316,018	368,111	426,327	488,997
RUMPHI	172,034	192,307	208,616	237,914	269,205	308,845	353,936
MZIMBA	727,931	819,297	895,550	1,041,885	1,212,687	1,404,351	1,620,621
LIKOMA	10,414	10,420	10,451	10,523	10,593	10,595	10,553
MZUZU	133,968	181,690	223,740	306,265	404,720	522,326	651,341
Central Region	5,510,195	6,364,357	7,065,859	8,399,989	9,952,421	11,758,945	13,795,971
KASUNGU	627,467	735,836	826,285	1,001,534	1,210,969	1,460,386	1,753,924
NKHOTAKOTA	303,659	345,495	379,474	444,408	520,895	608,647	709,682
NTCHISI	224,872	258,499	285,892	337,459	397,770	469,653	553,251
DOWA	558,470	671,075	764,414	938,620	1,136,353	1,365,292	1,617,871
SALIMA	337,895	383,421	419,448	486,166	562,730	649,836	748,611
LILONGWE	1,230,834	1,356,289	1,455,501	1,643,430	1,863,679	2,118,163	2,408,351
LILONGWE CITY	674,448	868,800	1,037,294	1,365,724	1,749,564	2,200,362	2,691,599
MCHINJI	456,516	530,218	589,572	703,150	836,977	995,210	1,179,324
DEDZA	624,445	686,636	735,411	825,925	929,275	1,044,224	1,172,664
NTCHEU	471,589	528,088	572,568	653,573	744,209	847,172	960,693
Southern Region	5,858,035	6,524,936	7,082,785	8,150,527	9,402,024	10,812,784	12,410,471
MANGOCHI	797,061	916,274	1,017,070	1,215,905	1,458,256	1,743,037	2,080,315
MACHINGA	490,579	554,840	608,182	712,540	839,493	986,893	1,161,573
ZOMBA	579,639	625,580	660,896	725,344	797,153	871,224	949,634
ZOMBA CITY	88,314	115,013	138,583	184,724	239,629	304,495	376,356
CHIRADZULO	288,546	305,692	318,323	340,614	364,437	388,137	411,813
BLANTYRE	340,728	372,843	398,835	447,177	500,572	557,234	617,415
BLANTYRE CITY	661,256	783,296	884,497	1,072,684	1,286,866	1,531,012	1,800,470
MWANZA	92,947	99,434	104,153	112,131	119,837	127,018	133,369
THYOLO	587,053	612,676	643,836	705,136	777,109	853,353	937,835
MULANJE	521,391	550,721	572,305	612,153	657,156	703,162	751,680
PHALOMBE	313,129	346,639	373,587	426,572	491,965	564,536	649,781
CHIKWAWA	434,648	489,030	533,714	619,645	720,209	834,723	965,775
NSANJE	238,103	262,035	281,552	319,635	365,028	418,051	480,341
BALAKA	317,324	360,252	396,411	466,518	549,911	645,830	756,913
NENO	107,317	130,611	150,841	189,749	234,403	284,079	337,202

Source: Census 2008, Population Projection in Malawi and Project Team

Table 6.3.2 Scenarios of Population Projections in 4 cities

City Name		Lilongwe			Blantyre			Mzuzu			Zomba			Remarks
Report Name		Census	Rate (Sogreah=1)	Sogreah	Census	Rate (Sogreah=1)	Sogreah	Census	Rate (Sogreah=1)	Sogreah	Census	Rate (SSI=1)	SSI	
Population projections concerning 4 cities	2015	1,037,294	1.07	972,000	884,497	1.18	747,462	223,740	1.32	169,006	138,583	1.30	106,721	
	2020	1,365,724	1.18	1,160,000	1,072,684	1.32	809,643	306,265	1.49	205,622	184,724	1.50	123,120	
	2025	1,749,564	1.28	1,370,000	1,286,866	1.48	869,106	404,720	1.62	250,171	239,629	1.69	142,038	
	2030	2,200,362	1.39	1,580,000	1,531,012	1.66	923,915	522,326	1.75	298,563	304,495	1.86	163,863	
	2035	(2,691,599)	1.48	1,824,151	(1,800,470)	1.85	971,677	(651,341)	1.85	351,186	(376,356)	1.99	189,042	
Base year		2008	-	2008	2008	-	2008	2008	-	2008	2008	-	2008	
Assumption for projections		Population projection to 2030 is based on the JICA study (The Study on Urban Development Master Plan for Lilongwe in the Republic of Malawi; Nippon Koei Co., Ltd.). In this study created two scenarios. Scenario 1 is based on the UN urbanization and national population projection. Scenario 2 is based on the implication that urbanization rate of Lilongwe would be less than that predicted in Scenario 1. The difference of population projections between the two scenarios would be 0.439 million in 2030. Scenario 1 is projected in a way that the City primacy rate (share of Lilongwe in total urban population) would continuously be the same in the future as its present rate of 26 %. On the other hand, in Scenario 2, urbanization of the City would modestly increase from 4.9% in 2008 to 6.1% in 2030. Although its primacy rate is expected to decrease from 26% in 2008 to 20% in 2030, the difference of such rates would be absorbed into the suburban area.			The three scenarios (high, middle, low) were prepared for future population projections. Given that the NSO projections at 1998 were overestimated the population at 2008, it has been assumed that the NSO projections were still valid, but it represented the upper limit of growth rates, and hence were used in the high scenario. The actual growth rate from the two last censuses was selected for the low scenario since the growth rates were low (2.33% for 2007-2008) and there was no global geographical constraint to reduce development below the current trend. The medium scenario was defined as the average between the high and low scenarios.			The Sogreah held meetings with senior officers of the Physical Planning Department (Mzuzu) and of the M'mbelwa District Assembly (Mzimba). They all expressed the view that the economic activity will remain at a high level during the next 10 to 15 years. Mzuzu will most likely be positively impacted by the establishment of Kayerekera uranium mine (close to the town of Karonga) which will boost the economy of the Northern Region. Once water supply to the town will be improved, Mzimba will be able to receive some industries on its territory (like wood processing industries which previously abandoned their project due to the lack of water). For the long term, beyond 2025, it seems reasonable to forecast a reduction of the population growth of Mzuzu and Mzimba which would experience growth rates similar to those currently observed in Blantyre and Zomba.			The population of Zomba City has been growing in the past and in the 2008 census it has been estimated at 87,366 having grown from the population figure of 65,915 in 1998. The growth rate is thus 2.9% which is marginally higher than the National average of 2.8%, Southern Region (2.4%) and that of the district (2.0%) for 2008. Zomba's 2008 population represents 5.7% of the urban population in Malawi. However the percentage urban share of the population growth has been reducing since 1966 and this has mainly been due to the shifting of the capital from Zomba to Lilongwe. The population growth rate is slowing down compared to that of Blantyre and Lilongwe. Although the town is no longer the national capital, it has been experiencing growth in the population and water demand and has recently been declared a City.			
Adopted scenario		In this study proposes Scenario 2 as the likely population framework of Lilongwe.			From the comparison of past studies (Niras, BKS) and the approval with BWB, the middle scenario was recognized as reality-based projection.			On above bases, the growth rates used by the Sogreah in agreement with NRWB, over the entire planning period covered by this study, are summarized. (Growth rate: 4.0-3.0%)			From above reason, the SSI assumed that the population growth until 2020 is same as the growth rate from 1998 to 2008. (Growth rate: 2.9%)			

Note. Census 2008 predicted the population until 2030. Sogreah predicted the population until 2035 (2040) for Lilongwe and Blantyre cities (Mzuzu city). SSI predicted the population until 2020.

Source: Sogreah and SSI reports (2010) each city and Project Team

6.4 Water Demand

6.4.1 Domestic and Industrial Water

(1) Approach to Estimate Water Demand

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

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

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

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

Table 6.4.1 shows the sources of information for the estimation of population in each service category.

Table 6.4.1 Approach to Estimate Population

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

Water demand of cities and towns is estimated by each city/town population. Population In rural area is estimated in district-wise by decreasing the urban population. Water for the industry, commercial and institute is estimated based on data of the Water Boards.

(2) Population

1) Lilongwe, Blantyre, Mzuzu and Zomba Cities

Table 6.4.2 shows the growth rates between 1966 and 1987, and from 1987 to 2008 at the four major cities in Malawi. In these four major cities, the rapid growth rate of population is remarkable.

Table 6.4.2 Population, Rank and Growth Rates of Four Major Cities

Urban Area (City)	Rank of City/Town			Population of City/Town			Growth Rate (%)		2008/1966 Rate
	2008	1987	1966	2008	1987	1966	1987-2008	1966-1987	
Lilongwe	1	2	2	674,448	233,978	45,380	9.0	9.0	14.9
Blantyre	2	1	1	661,256	331,588	109,461	4.7	4.2	6.0
Mzuzu	3	3	5	133,968	44,238	8,490	9.7	10.6	15.8
Zomba	4	4	3	88,314	42,878	19,666	5.0	5.9	4.5

Source: Spatial distribution and urbanization report, 2008 Census, NSO

However, it is hard to think that the rapid increase of population as in the past two decades will occur. According to the WB's projects, the future population of the four cities from 2008 are predicted to rise gently. Therefore, for the long term, it seems reasonable to forecast a reduction of the population growth rate of the four cities.

Table 6.4.3 shows the Projected Population of the four cities. In the water supply zone/scheme of three cities except Zomba City, the surrounding areas such as rural area are added to the city's area.

Table 6.4.3 Projected Population in the 4 Cities

City Name	Item	2008	2012	2015	2020	2025	2030	2035	Remarks
Lilongwe city	Lilongwe City	689,231	850,813	972,000	1,160,000	1,370,000	1,580,000	1,824,151	
	Other area (Rural)	60,500	64,889	68,182	73,668	79,155	84,642	90,129	
	Total (Planned Population)	749,731	915,703	1,040,182	1,233,668	1,449,155	1,664,642	1,914,280	
Blantyre city	Blantyre City	661,444	710,020	747,462	809,643	869,106	923,915	971,677	
	Other area (Rural)	96,662	115,026	153,647	246,802	349,141	462,295	605,531	
	Total (Planned Population)	758,106	825,045	901,108	1,056,445	1,218,247	1,386,210	1,577,208	
Mzuzu city	Mzuzu City	128,431	150,246	169,006	205,622	250,171	298,563	351,186	
	Other area (Ekwendeni town)	10,600	12,047	13,241	15,424	17,881	20,729	24,030	
	Total (Planned Population)	139,031	162,293	182,247	221,046	268,052	319,291	375,216	
Zomba city	Zomba City	87,366	97,950	106,721	123,120	142,038	163,863	189,042	
	Total (Planned Population)	87,366	97,950	106,721	123,120	142,038	163,863	189,042	

Sources: SOGREAH Report (2010), SSI Report (2010)

2) Other urban areas (town/boma) served by the Regional Water Boards

The population of towns/bomas served by three regional water boards is estimated based on the Census 2008. Increase rate is applied the rate of each District.

Table 6.4.4 shows the Projected Population for the Regional Water Boards in 2015-2035, except those of the Mzuzu and Zomba cities.

Table 6.4.4 Projected Population in the Regional Water Boards

Year	2008	2012	2015	2020	2025	2030	2035
Northern Region	121,455	137,244	150,167	174,303	201,523	232,482	266,772
Central Region	289,796	329,332	361,256	421,600	491,913	573,442	666,704
Southern Region	221,549	291,551	314,962	360,233	413,899	474,919	545,312
Total	632,800	758,126	826,384	956,137	1,107,335	1,280,843	1,478,788

Source: Project Team

3) Rural area

Table 6.4.5 shows the Projected Population of the rural area in 2015 - 2035. Increase rate is applied the rate of each District.

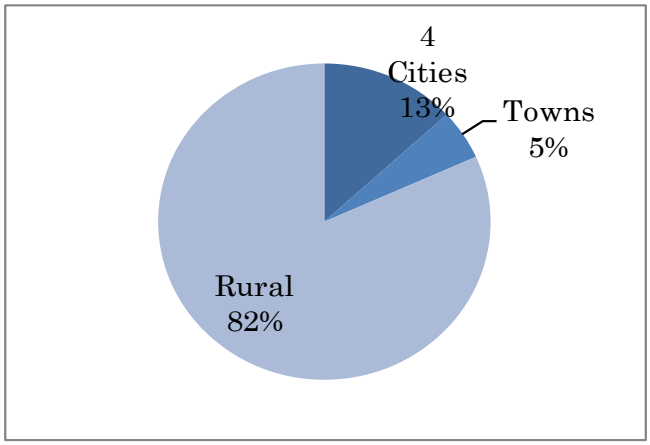
Table 6.4.5 Projected Population in the Rural Area

Year	2008	2012	2015	2020	2025	2030	2035
Northern Region	1,453,507	1,636,594	1,787,879	2,073,190	2,397,502	2,764,437	3,172,278
Central Region	4,545,951	5,166,225	5,667,309	6,612,665	7,710,944	8,985,141	10,437,668
Southern Region	4,886,916	5,335,076	5,744,743	6,532,886	7,461,630	8,502,358	9,688,333
Rural Total	10,886,374	12,137,896	13,199,932	15,218,740	17,570,076	20,251,936	23,298,279

Source: Project Team

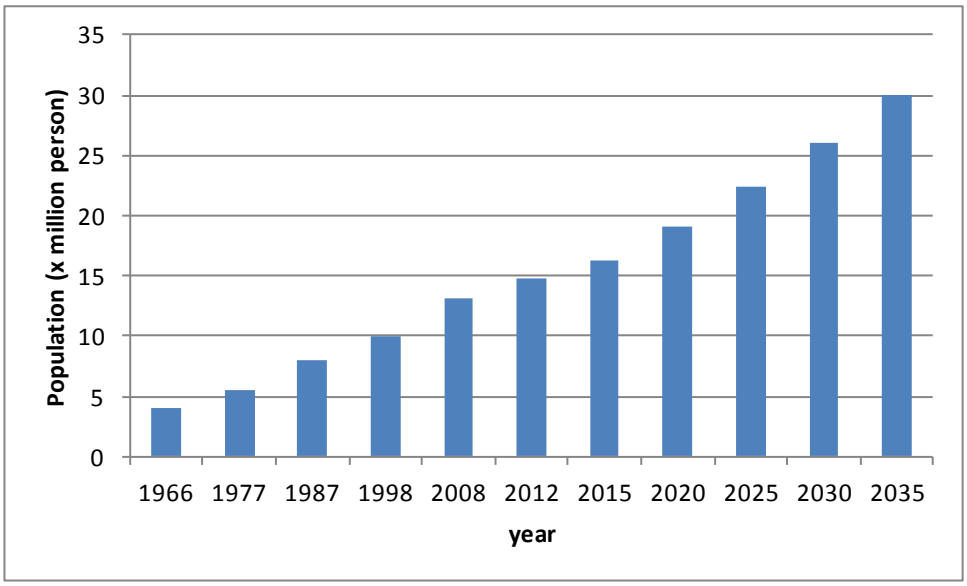
4) Total Population

Total population of Malawi is discussed in Subsection 2.4.2. Total population in 2008 based on the National Census is 13 million. This value is predicted to increase to around 15 million in 2012, and 30 million in 2035 with increase rate of 2-4%. **Figure 6.4.1** shows the ratio of 4 cities, other towns and rural area in 2012. Almost 82% of the population live in rural areas.



Source: Project Team

Figure 6.4.1 Ratio of the Population in 2012



Source: Project Team

Figure 6.4.2 Total Population of Malawi in 1966-2035

(3) Basic Factors for the Projection

1) Target of Water Coverage Rate

According to the Malawi Sector Performance Report in 2011, water coverage rate was analyzed as the Headline indicators. Coverage rate is 92% in urban area, 77% in rural area and 79% in National level. Target of coverage rate in 2015 is shown below for MDG and MDG II.

Table 6.4.6 Target of Water Coverage Rate

Policy Paper	Water Coverage Rate
MDG	Urban: 95% by 2015 Rural: 67% by 2015
MGD II:	Urban: 80% for urban and peri-urban inhabitants by 2016 Rural: 75% rural, town & market center by 2016

Source: Project Team

In the "Malawi Water Sector Investment Plan", World Bank in 2012 April, the proposed long-term target is to provide access to improved water supply to 98% of the population by 2025 as shown in **Table 6.4.7**.

Table 6.4.7 Recommended Water Supply Target

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

Source: Project Team

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

2) Water Consumption per Capita

In order to analyze water consumption per capita for the demand projection, Malawi's standard, useful information of the other past studies, water sales of the Regional Water Boards in 2012 and experience of the surrounding countries were reviewed.

(i) Malawi's Standard

The Draft Handbook of "Indicators Concepts and Definitions for Irrigation, Water and Sanitation" in 2012 was submitted by MoIWD to bring harmony on the various technical terms, concepts and indicators on this Sector. The "Design Engineer's Manual for Gravity Fed Rural Piped Water Schemes", published in 1990's, has been the basic design criteria for water supply facilities.

Table 6.4.7 shows the basic units for water supply. Basically daily water supply per capita is considered 27L per capita per day as minimum value applied for rural water supply and communal water point of urban water supply.

Table 6.4.8 Basic Unit of the Water Supply

Items	Indicators Concept & definitions	Design Engineer's Manual
Water consumption per capita per day	27 L	36 L (minimum 27 L)
Minimal flow from all taps open simultaneously	0.076 L/sec 0.25 L/sec	0.076 L/sec
Continuous service hours of Gravity-fed rural water supply	-	16 hours
Max. distance to the taps	500 m in rural areas 200 m in urban areas	500 m
Number of persons per tap	-	120

Source: Project Team

(ii) Other Past Studies

Two Reports were reviewed. One was the Feasibility Study for 16 water schemes of urban areas in 1999. The other was the Feasibility Study for Lilongwe and Blantyre in 2010.

a) Sixteen New Water Supply Schemes Feasibility Study Report

According to the "16 New Water Supply Schemes Feasibility Study Report", 1999, Metaferia Consulting Engineers, water demand projection was given under the following condition.

<u>Consumption by Demand Categories</u>

Daily water supply per capita apply the following values by the type of housing area. Low density area can be considered for houses with high living standards (see **Table 6.4.9**).

- Traditional Houses Areas (THA): 25 L/p/d
- High Density Housing Areas (HDHA): 75 L/p/d
- Medium Density Housing Areas (MDHA): 125 L/p/d
- Low Density Housing Areas (LDHA): 200 L/p/d

Growth Rate of Water Demand

Growth rate is given as 1%. Water consumption will increase when people acquire better education and higher living standards. However, demand of traditional housing areas using public taps will not grow because the distance to the water point will disturb taking more water.

Table 6.4.9 Projected Water Demand per Capita by Demand Category

Unit: l/p/d

Demand Category	Year			
	2000	Growth Rate (%)	2010	2020
THA	25	1.0	28	30
HDHA	75	1.0	82	90
MDHA	125	1.0	138	150
LDHA	200	1.0	220	240

Source: 16 New Water Supply Schemes Feasibility Study Report

b) Feasibility Study for Lilongwe and Blantyre

According to the “Feasibility Study and Preliminary Design for Lilongwe's New Water Source” and the “Feasibility Study and Preliminary Design for Blantyre's New Raw Water Source and Other Purposes”, August 2010 (SOGREAH), the following water consumption per capita are applied.

Water consumption per capita is classified into only one category. In the case of Lilongwe, Water consumption per capita is 108 L/p/d in 2015, and increased tto 135 L/p/d in 2025. Water consumption of public taps is fixed at the flat rate of 25 L/p/d. Industrial water consumption increases 1% annually, and commercial use is 3-4% annually (See **Table 6.4.10**).

Blantyre Water Board has a smaller water consumption per capita, 69 L/p/d in 2015, and this value increases to 135 L/p/d in 2025. Water use of the public tap is the same at 25 L/p/d (see **Table 6.4.11**).

Table 6.4.10 Projected Water Demand per Capita by Demand Category (Lilongwe)

Unit: l/p/d

Demand Category	Year					
	2008	Growth Rate (%)	2015	2020	2025	2035
Residential	81	1.0	108	127	135	135
Kiosk	25	1.0	25	25	25	25
Industrial	–	1.0	–	–	–	–
Commercial	–	3-4%	–	–	–	–

Source: Feasibility Study and Preliminary Design for Lilongwe's new water source, 2010

Table 6.4.11 Projected Water Demand per Capita by Demand Category (Blantyre)

Unit: l/p/d

Demand Category	Year					
	2008	Growth Rate (%)	2015	2020	2025	2035
Residential	65	1.0	69	78	90	90
Kiosk	17	1.0	25	25	25	25
Industrial	–	–	–	–	–	–
Commercial	–	–	–	–	–	–

Source: Feasibility Study and Preliminary Design for Lilongwe's new water source, 2010

(iii) Water Sales of the Regional Water Boards

Daily water consumption per capita can be estimated from water sales and number of connection of the Water Boards (see **Table 6.4.12 to Table 6.4.14**).

Category is classified as Residential, Communal water points, Institutions and Commercial. Only the Northern Regional Water Board supplied the residential category of high, middle and low density.

Average water consumption per capita of residential in NRWB is 70.6 L/p/d, varying from 101.3 L/p/d in low density area to 52.5 L/p/d in high density area. Other average water consumption is 88 L/p/d in CRWB and 101 L/p/d in SRWB. In the case of communal water point, the number of people for one tap is not clear; therefore, it is difficult to estimate consumption per capita.

Table 6.4.12 Water Consumption of NRWB in 2010/2011

Category	No. of Customers	Water Sales (m^3/year)	Water Sales (m^3/day)	Water Sale/Connection (m^3/day)	Water Consumption per Capita (L/p/d)
Residential(LD)	6,819	1,261,022	3,455	0.51	101.3
Residential(MD)	15,132	1,698,465	4,653	0.31	61.5
Residential(HD)	3,991	382,458	1,048	0.26	52.5
Residential total	25,942		9,156	0.35	70.6
CWP	433	206,565	566	1.31	26.2
Institutions	676	1,926,239	5,277	7.80	1.5
Commercial	1,362	713,641	1,955	1.44	0.7

Source: Northern Region Water Board

Table 6.4.13 Water Consumption of CRWB in 2009

Category	No. of Customers	Water Sales (m^3/year)	Water Sales (m^3/day)	Water Sale/Connection (m^3/day)	Water Consumption per Capita (L/p/d)
Residential	12,549	2,023,999	5,545	0.44	88.4
CWP	221	161,664	443	2.00	8.0
Institutions	674	2,308,000	6,323	9.38	-
Commercial	963	422,926	1,159	1.20	-

Source: Central Region Water Board Annual Report in 2009

Table 6.4.14 Water Consumption of SRWB in 2009

Category	No. of Customers	Water Sales (m^3/day)	Water Sale/connection (m^3/day)	Water Consumption per Capita (L/p/d)
Residential	19,391	9,800	0.51	101.1
CWP	322	1,926	5.98	24.0
Institutions	1,115	11,335		-
Commercial	1,045	1,577		-

Source: Central Region Water Board Annual Report in 2011/2012

(iv) Water Consumption per Capita in Surrounding Country

Table 6.4.15 shows the water consumption per capita of some cities of Kenya in 2008/09. This record is made by the Water Service Regulator Board of Kenya, and value of water consumption varies from 6 to 151 L/c/d. The average national consumption per capita including NRW is 116 L/c/d, and if excluded is 57 l/c/d.

Table 6.4.15 Water Consumption in Kenya, 2008/09

Name of the City	Population Served	Daily Production (x 1,000 m3/day)	NRW (%)	Consumption per Capita (L/c/d) without NRW
Nairobi	2,157,826	154,000	40	118
Mombasa	618,594	16,240	35	47
Kisumu	153,083	6,200	62	42
Embu	67,549	3,726	57	65

Source: A Performance Report of Kenya's Water Service Sub-Sector, Water Service Regulatory Board, 2010

(v) Water Consumption per Capita for Water Demand Projection

Considering the above reviews, water consumption per capita for Water Demand Projection apply the following conditions (see **Table 6.4.16**).

In the case of the four cities, Lilongwe, Blantyre, Mzuzu and Zomba, water consumption per capital adopt the values in the Feasibility Study Report by SOGREAH in 2010, because the Project will be realized by this plan, and detailed analysis of Demand and Supply have been conducted.

In the case of the other towns, water consumption per capita is assumed at 93 L/c/d to 115 L/c/d in 2012-2035 for household connections, and 36-50 L/c/d for communal points in 2012-2035.

Water consumption in 3 Regional Water Boards were set at the same value by following assumption of the service category, proportion and consumption in **Table 6.4.18**.

Table 6.4.16 Water Consumption of Towns applied to Water Demand Projection

Service Category	2012-2020		2025-2035	
	Proportion (%)	Consumption (L/c/d)	Proportion (%)	Consumption (L/c/d)
Communal water point	20	36	20	50
HD: yard tap	40	75	30	100
MD: house connection	30	120	40	150
LD: house connection	10	200	15	200
Average Consumption(L/c/p)	93		130	

Source: Project Team

Water consumption per capita for Market Center is assumed at 45 L/c/d in 2012-2020 and 50 L/c/d in 2025-2035 by following the assumption in **Table 6.4.17**.

Table 6.4.17 Water Consumption of Market Center applied to Water Demand Projection

Service Category	2012-2020		2025-2035	
	Proportion (%)	Consumption (L/c/d)	Proportion (%)	Consumption (L/c/d)
Communal water point	75	36	60	36
HD: yard tap	20	50	25	50
MD: house connection	5	80	15	80
LD: house connection	0	120	0	120
Average Consumption(L/c/p)	41		46	
With 10% of water loss(L/c/p)	45		50	

Source: Project Team

For communal faucets with gravity-fed piped water supply, water consumption is set as 40 L/p/d, and for boreholes it is 36 L/c/d.

Water demand can be set on the situation of water sources, management of customer service and operation & maintenance of water schemes. The objective of this water demand projection is to discuss water resources management, then mentioned simple assumption of water consumption can be applied.

Daily water consumption in urban and rural area is summarized in **Table 6.4.18.**

Table 6.4.18 Daily Water Consumption per Capita adopted to Water Demand Projection

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

Source: Project Team

(4) Water Demand for Four Cities (Lilongwe, Blantyre, Zomba and Mzuzu)

Urbanization by the rural-urban drift gives some issues to urban infrastructure:

- Growing demand of infrastructure at all levels including water and environment.
- Emergence of infrastructure gap due to densification and peri-urbanization in metropolises. etc.

If there is abundant supply into the national budget, the solution might be easy, but, in reality, flexible and drastic investment into infrastructure is difficult, infrastructure gap between urban and peri-urban cannot be solved. As result, squatter slum in peri-urban is formed, and people who do not have access to safe water/sanitation will increase. In these cities, demand gap is greater, there is a change of up to 744 liters from 12 liters per capita per day in the case of the city of Blantyre.

Hence, the projection of these urban water demands shall be handled carefully. The projection of previous project reports that had studied the situation methodically should be taken into account.

The referenced reports are as follows;

- Feasibility Study and Preliminary Design for Lilongwe's New Water Source, April 2010 (SOGREAH Consultants)
- Feasibility Study and Preliminary Design for Blantyre's New Raw Water Source and Other Purposes, August 2010 (SOGREAH Consultants)
- Feasibility Study and Preliminary Design of Multi-Purpose Water Source Development for Mzuzu & Mzimba and Surrounds, September 2010 (SOGREAH Consultants)
- Preliminary and Detailed Design and Construction Supervision for Zomba and Mangochi Water Supplies, June 2010 (SSI Engineers Environmental Consultants)

The projected water demands for the four major cities are shown in **Table 6.4.19**, **Table 6.4.20**, **Table 6.4.21** and **Table 6.4.22**.

Table 6.4.19 Estimated Water Consumption at Lilongwe Water Board

Description	Unit	2008	2012	2015	2020	2025	2030	2035
		Census						
Population and Household		669,021						
Population	inh.	749,731	915,703	1,040,182	1,233,668	1,449,155	1,664,642	**1,914,280**
Lilongwe City	inh.	**689,231**	850,813	**972,000**	**1,160,000**	1,370,000	**1,580,000**	**1,824,151**
Projected Extended Areas	inh.	40,500	43,438	45,642	49,315	52,988	56,661	**60,334**
Along future conveyance system	inh.	20,000	21,451	22,539	24,353	26,167	27,981	**29,795**
Population annual growth rate								
Lilongwe City	%	4.27%	4.98%	4.34%	3.35%	3.16%	2.73%	2.75%
Projected Extended Areas	%		1.72%	1.64%	1.51%	1.41%	1.31%	1.23%
Along future conveyance system	%		1.72%	1.64%	1.51%	1.41%	1.31%	1.23%
				MDG95%	National Policy 100%			
Service Coverage of Lilongwe city	%	**60%**	78%	**95%**	98%	**100%**	100%	**100%**
Individual connection (IC)	%	**44%**	48%	**52%**	57%	**61%**	65%	**69%**
Kiosk	%	**16%**	30%	**43%**	41%	**39%**	35%	**31%**
Service Coverage except Lilongwe city:	%	**0%**	50%	**100%**	100%	**100%**	100%	**100%**
Individual connection (IC)	%	**0%**	25%	50%	50%	**50%**	50%	**50%**
Kiosk	%	**0%**	25%	**50%**	50%	**50%**	50%	**50%**
Service Coverage of all LWB	%	55%	76%	95%	98%	100%	100%	100%
Individual connection (IC)	%	40%	46%	52%	56%	60%	64%	68%
Kiosk	%	15%	29%	43%	42%	40%	36%	32%
Number of Connection								
Residential Connection	Nos	**30,620**	42,920	55,220	75,720	96,220	116,720	137,220
Kiosk	Nos	**453**	1,053	1,653	1,803	1,953	2,103	2,253
Per capita consumption	l/c/d							
Residential	l/c/d	81	93	106	127	135	135	135
Kiosk	l/c/d	25	25	25	25	25	25	25
Domestic / IC	m^3/d	24,564	38,809	54,883	84,955	114,883	141,111	172,546
Lilongwe City	m^3/d	24,564	38,169	53,538	83,034	112,820	138,645	169,920
Projected Extended Areas	m^3/d	0	429	**901**	1,286	**1,381**	1,651	**1,758**
Along future conveyance system	m^3/d	0	212	**445**	635	**682**	815	**868**
Domestic / Kiosk	m^3/d	2,757	6,680	11,301	12,811	14,347	14,883	15,264
Lilongwe City	m^3/d	2,757	6,275	10,449	11,890	13,358	13,825	14,137
Projected Extended Areas	m^3/d	0	271	571	616	662	708	754
Along future conveyance system	m^3/d	0	134	282	304	327	350	372
Domestic / Total	m^3/d	27,321	45,489	66,185	97,766	129,230	155,995	187,810
Lilongwe City	m^3/d	27,321	44,444	63,987	94,924	126,177	152,470	184,057
Projected Extended Areas	m^3/d	0	700	1,471	1,902	2,044	2,359	2,512
Along future conveyance system	m^3/d	0	346	727	939	1,009	1,165	1,241
Institutional demand	m^3/d	**8,613**	8,874	9,143	9,610	10,100	10,615	11,156
Commercial/Industrial	m^3/d	**8,165**	9,878	**11,950**	12,349	**12,761**	15,076	**17,811**
Bunda College	m^3/d	**437**	477	**510**	568	**632**	681	733
Total water demand	m^3/d	44,537	64,719	87,788	120,292	152,723	182,366	217,510
Lilongwe City	m^3/d	44,100	63,196	**85,080**	116,883	**149,038**	178,161	**213,024**
Surrounding areas	m^3/d	0	1,046	**2,198**	2,841	**3,053**	3,525	**3,753**
Bunda College	m^3/d	437	477	**510**	568	**632**	681	**733**
Non Revenue Water								
Unbilled	%	**30%**	28%	**25%**	22.5%	**20%**	20%	20%
Distribution loss	%							
Sub-Total	%	30%	28%	25%	23%	20%	20%	20%
Production Loss	%	**8%**	6.8%	**5%**	5%	5%	5%	5%
Water Average Production	m^3/d	63,624	89,888	117,051	155,215	190,904	227,958	271,888
Lilongwe City	m^3/d	62,999	87,772	113,440	150,816	186,297	222,701	266,280
Surrounding areas	m^3/d	0	1,453	2,931	3,666	3,816	4,406	4,691
Bunda College	m^3/d	624	663	680	733	790	851	917
Water Average Abstraction	m^3/d	69,156	96,446	123,211	163,384	200,951	239,960	286,206
Lilongwe City	m^3/d	68,478	94,176	119,410	158,754	196,103	234,422	280,295
Surrounding areas	m^3/d	0	1,559	3,085	3,859	4,017	4,638	4,938
Bunda College	m^3/d	679	711	716	771	832	900	973
Losses in distribution system	m^3/d	19,087	25,169	29,263	34,923	38,181	45,592	54,378
Losses in all water supply system	m^3/d	24,620	31,727	35,423	43,093	48,228	57,593	68,696
WTP exisiting Capacity - average	m^3/d	97,000	97,000	97,000	97,000	97,000	97,000	97,000
Peak Production Required	m^3/d	80,913	112,842	144,157	191,160	235,113	280,753	334,861

Source: Project Team, SOGREAH report (2010)

Table 6.4.20 Estimated Water Consumption at Blantyre Water Board

Description	Unit	2008	2012	2015	2020	2025	2030	2035
		Census						
Population and Household								
Population								
Blantyre City	inh.	661,444	710,020	747,462	809,643	869,106	923,915	971,677
Blantyre Rural (part)	inh.	96,662	115,026	153,647	246,802	349,141	462,295	605,531
BWB area	inh.	758,106	825,045	901,108	1,056,445	1,218,247	1,386,210	1,577,208
Population annual growth rate								
Blantyre City	%	2.8%	1.8%	1.7%	1.5%	1.3%	1.1%	0.9%
Blantyre Rural (part)	%	1.0%	6.7%	10.9%	9.2%	5.8%	5.8%	5.4%
BWB area	%	2.5%	2.4%	3.2%	3.2%	2.6%	2.6%	2.6%
Households								
Blantyre City	hh.	154,782	167,057	176,138	191,257	205,751	219,118	230,767
Blantyre Rural (part)	hh.	26,255	31,245	41,696	66,918	94,634	125,282	164,081
BWB area	hh.	181,037	198,302	217,834	258,175	300,385	344,400	394,848
Population density								
Blantyre City	inh./ha	36	38	40	44	47	50	52
Blantyre Rural (part)	inh./ha	3	4	5	8	12	16	20
BWB area	inh./ha	16	17	19	22	25	29	33
Individual connections (Stand pipe and In-house conn		53.3%	60.8%	63.6%	63.6%	63.7%	65.0%	69.0%
Population connected to an individual connection		53.3%	60.8%	63.6%	63.6%	63.7%	65.0%	69.0%
BWB area	Inh.	403,800	501,707	572,847	671,788	776,371	900,610	1,088,273
Resindential Customers (numbers of connections)								
New Individual Connections	Conn.		3,852	1,764	2,156	2,051	3,802	3,945
BWB area	Conn.	32,361	42,802	50,523	60,561	71,257	83,988	103,424
Per capita consumption							10.7	10.5
BWB area	lpcd	65	67	69	73	78	84	90
Volume sold								
BWB area	m^3/d	26,185	33,445	39,524	49,244	60,702	75,651	97,945
KIOSKS								
Number of service kiosks								
New Kiosk Installations	Conn.		76	31	110	110	-	-
BWB area	Conn.	350	561	706	958	1,509	1,942	1,956
Population connected to Kiosks		11.5%	17.0%	19.6%	22.7%	31.0%	35.0%	31.0%
BWB area	inh.	87,415	140,152	176,482	239,488	377,229	485,600	488,934
Per capita consumption								
BWB area	lpcd	17	25	25	25	25	25	25
Volume sold at Kiosks								
BWB area	m^3/d	1,467	3,504	4,412	5,987	9,431	12,140	12,223
Total Residential water demand								
Population connected	%	64.8%	77.8%	83.2%	86.3%	94.7%	100.0%	100.0%
BWB area	Inh.	491,215	641,859	749,329	911,276	1,153,600	1,386,210	1,577,208
Water demand			9%	4%	5%	5%	6%	5%
BWB area	m^3/d	27,652	36,949	43,936	55,231	70,133	87,791	110,168
Instituitional demand		1.9%	1.0%	1.1%	1.1%	0.9%	0.8%	0.7%
BWB area	m^3/d	6,138	6,741	6,968	7,357	7,711	8,033	8,333
		6,132						
Commercial and Industrial demand		1.9%	2.2%	2.6%	2.6%	2.2%	2.1%	2.0%
BWB area	m^3/d	11,778	13,531	14,569	16,552	18,597	20,675	22,909
		11,766						
Total Net demand for BWB			6%	4%	4%	4%	5%	4%
BWB area	m^3/d	45,568	57,221	65,473	79,140	96,441	116,499	141,410
Losses in distribution system (NRW)	m^3/d							
Non Revenue Water Rate (Total)	%	53%	30%	27.1%	25.5%	25%	25%	25%
Non Revenue Water Rate (Total)	m^3/d	51,189	24,523	24,285	27,041	32,147	38,833	47,137
Water losses rate in production system (WTP + Transmission mains)	%	5%	5%	5%	5%	5%	5%	5%
Losses in all system (NRW)	m^3/d	56,281	28,826	29,009	32,630	38,915	47,008	57,060
Total average productions			-23%	3%	4%	4%	5%	4%
BWB area	m^3/d	96,757	81,744	89,758	106,181	128,588	155,332	188,547
BWB area	$Mm^3/year$	35.32	29.84	32.76	38.76	46.93	56.70	68.82
Total Raw water required								
BWB area	m^3/d	101,849	86,047	94,482	111,770	135,355	163,508	198,470
BWB area	$Mm^3/year$	37.18	31.41	34.49	40.80	49.40	59.68	72.44
Capacity at Walker F. + Mudi	m^3/d	82,264	95,132	108,000	108,000	108,000	108,000	108,000
Additional Production required	m^3/d	14,493	-13,388	-18,242	-1,819	20,588	47,332	80,547
Addtional Raw water required	m^3/d	15,256	-14,092	-19,202	-1,914	21,671	49,823	84,786
Addtional Raw water required	$Mm^3/year$	5.57	-5.14	-7.01	-0.70	7.91	18.19	30.95

Source: Project Team, SOGREAH report (2010)

Table 6.4.21 Estimated Water Consumption at Mzuzu city of Northern Region Water Board

Description		Unit	2008	2012	2015	2016	2020	2025	2030	2035
			Consult.'Ekw)							
Population			Census (Mzu)							
	Mzuzu	No	128,431	150,246	169,006	175,767	205,622	250,171	298,563	351,186
	Ekwendeni & Villages	No	10,600	12,047	13,241	13,651	15,424	17,881	20,729	24,030
	Total Population (TP)	No	139,031	162,293	182,247	189,418	221,046	268,052	319,291	375,216
Annual growth rate										
	Mzuzu	%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	3.6%	3.3%
	Ekwendeni	%		3.2%	3.2%	3.1%	3.1%	3.0%	3.0%	3.0%
Breakdown of population										
	Low density areas	% of TP	13%	14%	14%	14%	15%	16%	16%	17%
		No	18,632	22,247	25,820	27,127	33,012	42,086	52,578	64,663
	Medium density areas	% of TP	21%	21%	22%	22%	22%	23%	24%	24%
		No	29,093	34,401	39,374	41,180	49,257	61,552	75,486	91,256
	High density areas	% of TP	66%	65%	64%	64%	63%	61%	60%	58%
		No	91,306	105,644	117,053	121,111	138,777	164,414	191,227	219,297
Population served										
	Low density areas, LDA	% of LDA	86%	94%	100%	100%	100%	100%	100%	100%
		No	16,077	20,912	25,820	27,127	33,012	42,086	52,578	64,663
	Medium density areas, MDA	% of MDA	100%	100%	100%	100%	100%	100%	100%	100%
		No	28,991	34,401	39,374	41,180	49,257	61,552	75,486	91,256
	High density areas, HDA (H. Connections)	% of HDA	19%	24%	28%	29%	34%	40%	47%	53%
		No	17,790	25,777	32,775	35,364	47,184	65,765	89,239	116,958
	High density areas, HDA (CWP)	% of HDA	32%	38%	43%	45%	51%	60%	53%	47%
	(CWP: Communal Water Point)	No	29,070	40,497	50,333	54,015	70,776	98,648	101,988	102,339
Population not served		% of TP	34%	25%	19%	17%	9%	0%	0%	0%
		No	47,103	40,705	33,945	31,731	20,817	0	0	0
Number of connections required										
	Low density areas, LDA	No	2,923	3,802	4,695	4,932	6,002	7,652	9,560	11,757
	Medium density areas, MDA	No	5,271	6,255	7,159	7,487	8,956	11,191	13,725	16,592
	High density areas, HDA	No	1,779	2,578	3,277	3,536	4,718	6,577	8,924	11,696
	Total	No	9,973	12,635	15,131	15,956	19,676	25,420	32,208	40,045
Additional connections required per month		No		62	73	69	83	105	123	141
Number of CWP required		No	171	238	296	318	416	580	600	602
Additional CWP required per year		No		18	19	22	27	36	3	-0
Per capita demand										
	Low density areas, LDA	l/c/d	115	130	145	150	170	190	190	190
	Medium density areas, MDA	l/c/d	70	87	105	111	135	150	150	150
	High density areas, HDA (H.Connections)	l/c/d	38	55	70	74	90	100	100	100
	High density areas, HDA (CWP)	l/c/d	10	19	25	26	30	36	36	36
Domestic demand										
	Low density areas, LDA	m^3/day	1,843	2,719	3,744	4,069	5,612	7,996	9,990	12,286
	Medium density areas, MDA	m^3/day	2,033	2,993	4,134	4,571	6,650	9,233	11,323	13,688
	High density areas, HDA (H.Connections)	m^3/day	678	1,418	2,294	2,617	4,247	6,577	8,924	11,696
	High density areas, HDA (CWP)	m^3/day	279	769	1,258	1,404	2,123	3,551	3,672	3,684
	Total	m^3/day	4,833	7,899	11,431	12,661	18,632	27,357	33,908	41,354
Other demands										
	Institutional demand	% of TND	36.8%	29.4%	24.0%	23.0%	19.0%	16.0%	15.5%	15%
		m^3/day	3,459	3,949	4,253	4,446	5,094	6,037	7,300	8,580
	Commercial demand	% of TND	11.9%	10.2%	9.0%	8.8%	8.0%	7.5%	8%	8%
		m^3/day	1,118	1,370	1,595	1,701	2,145	2,830	3,768	4,576
	Industrial demand	% of TND	0%	1.6%	2.5%	2.7%	3.5%	4.0%	4.5%	4.7%
		m^3/day	0	215	443	522	938	1,509	2,119	2,688
Total average net demand (TND)		m^3/day	9,410	13,433	17,722	19,330	26,808	37,734	47,095	57,198
Losses in distribution system		% of TGD	33%	28%	25%	25%	23%	21%	20%	20%
		m^3/day	4,568	5,224	5,907	6,307	8,008	10,031	11,774	14,300
Total average gross demand (TGD)		m^3/day	13,978	18,657	23,629	25,637	34,816	47,764	58,868	71,498
Losses in transmission & treatment system		% of RWD	5%	5%	5%	5%	5%	5%	5%	5%
		m^3/day	736	982	1,244	1,349	1,832	2,514	3,098	3,763
Raw water demand (RWD)		m^3/day	14,714	19,639	24,873	26,986	36,648	50,278	61,967	75,261
		Mm^3/year	5.4	7.2	9.1	9.9	13.4	18.4	22.6	27.5

Source: Project Team, SOGREAH report (2010)

Table 6.4.22 Estimated Water Consumption at Zomba city of Southern Region Water Board

Description	Unit	2008	2012	2015	2020	2025	2030	2035
		Census						
Population	inh.	87,366	97,950	106,721	123,120	142,038	163,863	189,042
Growth rate	%	2.9%	2.9%	2.9%	2.9%	2.9%	2.9%	2.9%
% of Popuation served								
Low Density housing (LDHA)	%	5.0%	7.1%	8.7%	8.7%	8.7%	8.7%	8.7%
Medium Density housing (MDHA)	%	8.0%	9.6%	10.8%	10.8%	10.8%	10.8%	10.8%
High Density Permanent housing (HDHPA)	%	15.0%	17.8%	19.9%	19.9%	19.9%	19.9%	19.9%
High Density Traditional housing (HDHTA)	%	45.0%	53.9%	60.6%	60.6%	60.6%	60.6%	60.6%
Total	%	73.0%	88.4%	100.0%	100.0%	100.0%	100.0%	100.0%
Popuation served								
LDHA	inh.	4,368	6,968	9,285	10,757	12,410	14,317	16,517
MDHA	inh.	6,989	9,403	11,526	13,254	15,291	17,640	20,351
HDHPA	inh.	13,105	17,435	21,237	24,469	28,229	32,566	37,570
HDHTA	inh.	39,315	52,809	64,673	74,640	86,109	99,340	114,604
Total	inh.	63,777	86,616	106,721	123,120	142,038	163,863	189,042
Population not served	%	27.0%	11.6%	0.0%	0.0%	0.0%	0.0%	0.0%
	inh.	23,589	11,334	0	0	0	0	0
Per capita demand								
Low Density housing (LDHA)	l/c/d	190	190	190	190	190	190	190
Medium Density housing (MDHA)	l/c/d	150	150	150	150	150	150	150
High Density Permanent housing (HDHPA)	l/c/d	100	100	100	100	100	100	100
High Density Traditional housing (HDHTA)	l/c/d	80	80	80	80	80	80	80
Water Availability		44%	61%	76%	95%	100%	100%	100%
Low Density housing (LDHA)	%	70%	77%	82%	95%	100%	100%	100%
Medium Density housing (MDHA)	%	60%	69%	75%	95%	100%	100%	100%
High Density Permanent housing (HDHPA)	%	60%	69%	75%	95%	100%	100%	100%
High Density Traditional housing (HDHTA)	%	60%	69%	75%	95%	100%	100%	100%
Domestic demand								
Low Density housing (LDHA)	m^3/day	581	1,018	1,447	1,942	2,358	2,720	3,138
Medium Density housing (MDHA)	m^3/day	629	967	1,297	1,889	2,294	2,646	3,053
High Density Permanent housing (HDHPA)	m^3/day	786	1,196	1,593	2,325	2,823	3,257	3,757
High Density Traditional housing (HDHTA)	m^3/day	1,887	2,897	3,880	5,673	6,889	7,947	9,168
Total (Td)		3,883	6,077	8,216	11,827	14,363	16,570	19,116
Public demand								
Instituional, Commercial, Administrational & Industrial								
Annual groeth rate	%	95% of Td		1.8%	1.8%	1.8%	1.8%	1.8%
	m^3/day	3,983	6,262	6,607	7,223	7,897	8,634	9,439
Total average net demand (Tn)	m^3/day	7,866	12,340	14,823	19,051	22,260	25,204	28,555
Losses in distribution System	% of Tn	30%	24%	20%	20%	20%	20%	20%
	m^3/day	2,360	2,997	2,965	3,810	4,452	5,041	5,711
Total average gross demand (Tg)	m^3/day	10,226	15,337	17,788	22,861	26,712	30,245	34,267
Losses in production System	% of Tr	5%	5%	5%	5%	5%	5%	5%
Raw water average demand (Tr)	m^3/day	10,765	16,144	18,724	24,064	28,118	31,836	36,070
	Mm^3/year	3.9	5.9	6.8	8.8	10.3	11.6	13.2
Seasonal Peak Factor		1.30	1.30	1.30	1.30	1.30	1.30	1.30
Raw water peak demand	m^3/day	13,294	19,937	23,124	29,719	34,726	39,318	44,547
(=WTW required)	Mm^3/year	4.9	7.3	8.4	10.8	12.7	14.4	16.3

Sources: Project Team and the SSI Report (2010)

Table 6.4.23 Water Demand Projection in the Four cities in 2012-2035

Unit: m^3/day

Name of City	2012	2015	2020	2025	2030	2035
Mzuzu City	19,639	24,873	36,648	50,278	61,967	75,261
Zomba City	15,976	20,902	29,995	35,491	39,837	44,750
Lilongue City	96,446	123,211	163,384	200,951	239,960	286,206
Blantyre City	119,259	129,880	144,505	160,289	179,474	212,964
total	251,320	298,866	374,533	447,009	521,267	619,181

Source: Project Team

(5) Other Urban Area (Town/Boma) served by Three Regional Water Boards

Water demand projection of the other urban area covered by three Regional Water Boards is estimated by following assumptions.

1) Population of the Service Area

Population of the service area is the population of the Town/ Boma. Base population is the Census population in 2008. Population growth rate of the Town/Boma adopts the District's growth rate.

2) Population served by the Water Board

Population served by the Water Board is the result of the Water Supply Survey by the Study Team shown in Chapter 5.

3) Served Population in Future (2015, 2020, 2025, 2030, 2035)

Served population in future is calculated by the target coverage rate shown below.

- 2012: 92%
- 2015: 95%
- 2020: 96%
- 2025: 98%
- 2030: 98%

Maximum coverage rate is 98%, i.e., 2% will remain without access to improved water. In the process until 98%, the population that is not serviced by the Water Board is considered to be taking water from boreholes or protected shallow wells.

4) Water Consumption per Capita and Other Consumptions

Water consumption per capita from **Table 6.4.18** is applied. Daily Water Consumption per capita adopted to water demand projection of water consumption for Institute used the survey results in 2012, and this value is increased with 1% of growth rate. Water consumption for commercial is also the same but used 3% of growth rate. These increase rates are the same rates applied to the SOGREAH's Study for Lilongwe and Blantyre Cities.

Table 6.4.24 to **Table 6.4.26** show the assumed basic factors adopted for water demand projection in other towns served by three regional water boards.

Table 6.4.24 Basic Factors of Water Demand Projection for the NRWB

Item	Unit	2012	2015	2020	2025	2030	2035
Water consumption per capita for connection	L/c/d	93	93	93	115	130	130
Water consumption per capita for communal faucet	L/c/d	36	36	36	50	50	50
Institute 1% incr/year	m^3/day	5,277	5,437	5,714	6,006	6,312	6,634
Commercial & industrial 3% incr/year	m^3/day	1,955	2,136	2,245	2,360	2,480	2,607
NRW	%	32	25	22	20	20	20

Source: Project Team

Table 6.4.25 Basic Factors of the Water Demand Projection for the CRWB

Item	Unit	2008	2015	2020	2025	2030	2035
Water consumption per capita for connection	L/c/d	93	93	93	115	130	130
Water consumption per capita for communal faucet	L/c/d	36	36	36	50	50	50
Institute, 1% incr/year	m^3/day	6,323	6,779	7,125	7,488	7,870	8,272
Commercial & Industrial 3% incr/year	m^3/day	1,159	1,425	1,652	1,916	2,221	2,574
NRW	%	25	25	22	20	20	20

Source: Project Team

Table 6.4.26 Basic Factors of the Water Demand Projection for the SRWB

Item	Unit	2012	2015	2020	2025	2030	2035
Water consumption per capita for connection	L/c/d	93	93	93	115	130	130
Water consumption per capita for communal faucet	L/c/d	36	36	36	50	50	50
Institute 1% incr/year	m^3/day	11,335	11,678	12,274	12,900	13,558	14,250
Commercial & industrial 3% incr/year	m^3/day	1,577	1,723	1,811	1,904	2,001	2,103
NRW	%	31	25	22	20	20	20

Source: Project Team

5) Water Demand Projection in 2012-2035

Table 6.4.27 shows the water demand projection of the towns/bomas served by 3 regional water boards in 2012-2035. This projection is made as rough estimation for the evaluation of water resources management. Detailed consideration is necessary if project planning will proceed on the basic factors mentioned and the increase rate of population of the service area.

Table 6.4.27 Water demand of three Regional Water Boards in 2012-2035

Unit: m^3/day

Name of City/ Town	2012	2015	2020	2025	2030	2035
Northern RWB	14,024	15,859	19,931	29,214	43,807	59,400
Central RWB	22,338	27,320	34,811	50,786	81,362	117,526
Southern RWB	21,817	24,814	30,753	44,446	68,656	95,921

Source: Project Team

(6) Rural Area

Water demand of rural area is estimated under the following assumptions in order to simplify the estimation procedure.

1) Population

Population of rural area used the population of districts in Census 2008, and the population in urban area served by three Regional Water Boards are decreased. Growth rate used the District's rate.

Population of the rural area is composed of those of the Market Center, the Area served by gravity-fed piped water supply, the Area served by Borehole, and the Area without improved water source.

Population of the Market Center and the area with gravity-fed piped water supply is estimated from the lists in **Table 5.1.39** and **Table 5.1.44** of Chapter 5.

Population of the Borehole area and the no improved water source is estimated by the total population in Rural Area decreased by the populations of the Market Center and the Area served by gravity-fed system.

2) Population Served by the Target Rate

Population Served by the target rate is calculated by following rate.

Table 6.4.28 Water Coverage Rates, 2012-2035

Item	Unit	2012	2015	2020	2025	2030	2035
Water coverage rate	%	92	95	96	98	98	98

Source: Project Team

3) Type of Water Sources

Population by water source is estimated by the Water Source Survey in the Census 2008.

Water sources are classified as follows:

- Community standpipe
- Protected well/borehole
- Un-improved water include unprotected well, spring, river/stream, pond/lake, dam, rainwater, tanker truck/bower, others.

Data of dry season from Census 2008 is used for this water demand projection because the necessity of water is more severe in the dry season.

Share of community standpipe, protected well/borehole and un-improved water in 2008 is assumed as shown in **Table 6.4.29**. Coverage rate of the access to safe water in rural area is almost the same in 2008 and 2012; therefore, this share rate in 2012 is applied from 2008.

Un-improved source needs to be decreased until 2% in 2025. Share point of the un-improved source is assumed at 22% in 2015 and 15% in 2020. Assumption of the water source instead of un-improved water was borehole/protected shallow well, because the water points of rural area are wholly distributed, and availability of surface water is uncertain.

Table 6.4.29 Share of Water Sources in 2008

Region	District	Community stand pipe	Protected well/borehole	Unimproved source
Northern	Chitipa	0.14	0.49	0.37
	Karonga	0.08	0.72	0.20
	Nkhata Bay	0.09	0.44	0.46
	Rumphi	0.28	0.42	0.30
	Mzimba	0.07	0.65	0.27
	Likoma	0.09	0.65	0.26
	Mzuzu City	0.54	0.23	0.24
Central	Kasungu	0.04	0.46	0.50
	Nkhotakota	0.08	0.57	0.35
	Ntchisi	0.04	0.63	0.33
	Dowa	0.02	0.51	0.48
	Salima	0.03	0.77	0.19
	Lilongwe	0.01	0.62	0.37
	Lilongwe City	0.66	0.23	0.11
	Mchinji	0.07	0.55	0.38
	Dedza	0.02	0.63	0.35
	Ntcheu	0.15	0.61	0.24
Southern	Mangochi	0.06	0.70	0.24
	Machinga	0.11	0.56	0.33
	Zomba	0.09	0.72	0.19
	Chiradzulu	0.01	0.86	0.13
	Blantyre	0.07	0.72	0.22
	Mwanza	0.04	0.67	0.28
	Thyolo	0.05	0.60	0.35
	Mulanje	0.18	0.60	0.22
	Phalombe	0.38	0.47	0.14
	Chikwawa	0.08	0.65	0.26
	Nsanje	0.02	0.79	0.19
	Balaka	0.20	0.63	0.17
	Neno	0.01	0.66	0.33
	Zomba City	0.76	0.18	0.06
	Blantyre City	0.75	0.16	0.08

Source: Project Team

Table 6.4.30 Water Demand of Rural Area in 2012-2035

Unit: m^3/day

Year		2012	2015	2020	2025	2030	2035
North	CHITIPA	5,641	6,238	6,883	8,018	8,851	8,797
	KARONGA	7,850	8,447	9,548	11,638	13,525	14,249
	NKHATA BAY	6,797	7,637	8,681	10,780	12,605	14,482
	RUMPHI	5,720	5,575	6,248	7,630	8,676	7,915
	MZIMBA	24,497	27,427	30,898	37,413	43,491	48,893
Central	KASUNGU	18,853	22,966	26,695	33,772	40,971	45,793
	NKHOTAKOTA	9,516	10,723	12,166	15,048	17,714	22,317
	NTCHISI	7,273	8,176	9,337	11,442	13,496	15,739
	DOWA	17,434	21,380	25,100	32,012	38,728	48,230
	SALIMA	10,391	11,234	12,686	15,310	17,738	20,535
	LILONGWE	38,648	43,565	48,268	56,693	64,368	76,766
	MCHINJI	14,385	17,576	20,143	24,964	29,679	33,555
	DEDZA	20,008	22,204	24,579	28,866	32,590	40,946
	NTCHEU	16,049	17,887	20,003	23,796	27,092	26,973
South	MANGOCHI	25,892	29,466	33,715	41,821	50,115	56,728
	MACHINGA	15,688	17,969	20,328	24,671	29,032	28,974
	ZOMBA	20,144	21,133	23,067	26,364	29,023	29,367
	CHIRADZULU	9,924	10,219	10,974	12,198	13,056	14,391
	BLANTYRE	8,504	8,839	9,082	10,102	10,776	12,441
	MWANZA	2,726	2,463	2,535	2,633	2,572	2,987
	THYOLO	19,164	20,358	22,076	25,268	27,888	31,505
	MULANJE	17,589	18,083	19,421	21,602	23,186	19,744
	PHALOMBE	11,210	11,861	13,213	15,620	17,943	11,147
	CHIKWAWA	13,964	14,889	16,782	20,186	23,453	24,194
	NSANJE	7,335	7,841	8,692	10,251	11,716	13,776
	BALAKA	10,591	11,487	13,014	15,886	18,648	17,571
	NENO	3,606	4,446	5,292	6,898	8,513	10,581

Source: Project Team

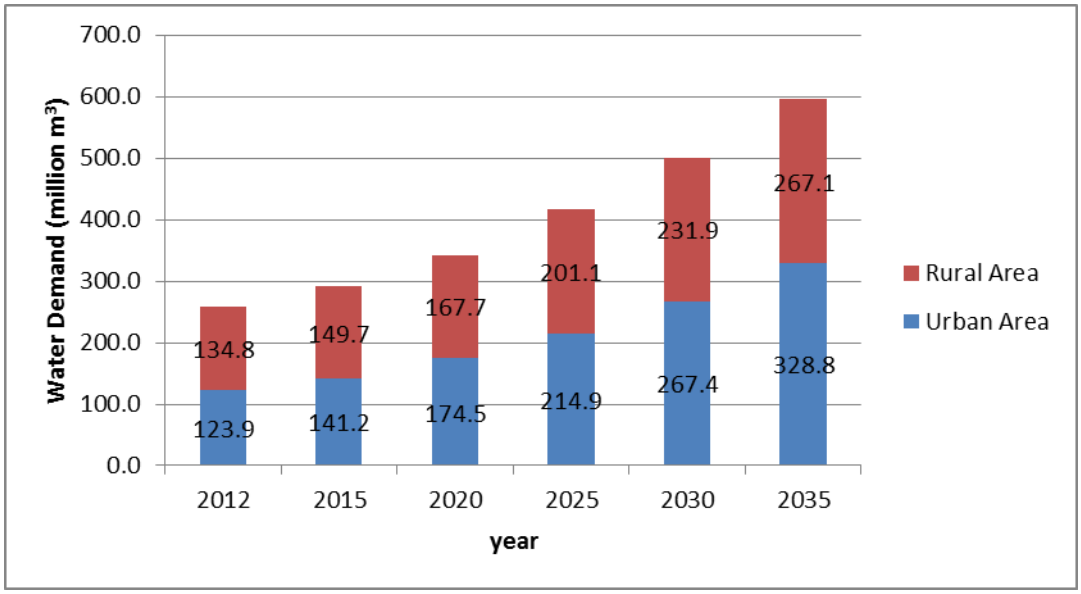
(7) Results of Water Demand Projection

Table 6.4.31 and **Figure 6.4.3** show results of water demand projection. Approximately 239 million m^3/year will increase by around 2.5 times higher to 580 m^3/year. Since water consumption per capita of the urban area is larger than that of the rural area, when the population in urban area will constantly increase, the demand for drinking water will increase more rapidly than the relation of linearity.

Table 6.4.31 Results of Water Demand Projection

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

Source: Project Team



Source: Project Team

Figure 6.4.3 Water Demand Projection for 2012-2035

(8) Distribution on WRA and WRU

Estimated water demand is distributed to WRA and WRU.

In case the water served by the water boards is from the intake points, the location almost corresponds to the location of water schemes. However, when water source is from dam, the location shall be selected carefully at the dam site. **Table 6.4.32** shows the water demand of WRA in 2012-2035. Values of WRA 1 and WRA 4 are bigger than those of the other areas because these areas have water sources for Lilongwe and Blantyre.

Table 6.4.32 Water Demand on WRA in 2012-2035

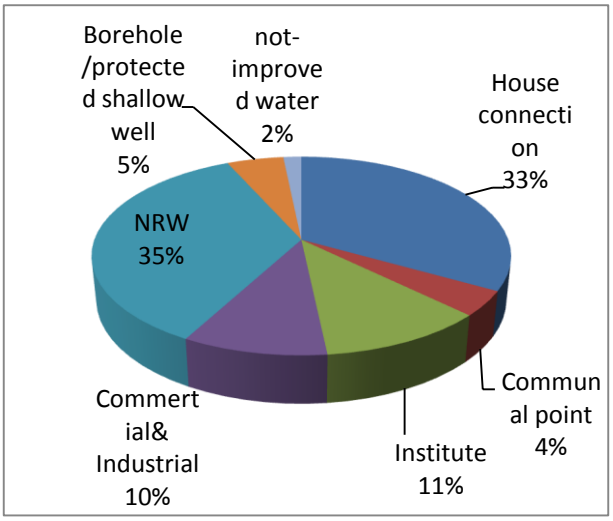
Unit: million m³/year

WRA	2012	2015	2020	2025	2030	2035
1	80.3	87.0	97.5	113.6	133.1	159.5
2	19.9	22.5	27.5	32.2	36.3	40.7
3	10.3	11.6	13.2	16.4	19.9	23.8
4	61.6	71.5	88.7	108.7	131.4	155.3
5	18.0	21.4	24.9	31.4	38.8	47.6
6	8.3	9.9	11.6	14.9	19.5	24.9
7	18.8	21.6	27.5	35.8	43.8	52.8
8	1.2	1.3	1.5	1.7	1.9	2.2
9	2.6	3.0	3.5	4.6	5.9	7.5
10	2.4	2.8	3.2	3.9	4.7	5.6
11	3.9	4.5	5.1	6.3	7.7	9.3
12&13	0.0	0.0	0.0	0.0	0.0	0.0
14	15.0	15.7	17.1	19.8	22.7	25.7
15	7.8	8.8	10.2	13.0	16.0	19.5
16	4.6	4.9	5.6	7.1	8.6	10.3
17	3.6	3.9	4.5	5.9	8.0	10.2
Total	258.4	290.5	341.7	415.2	498.4	594.9

Source: Project Team

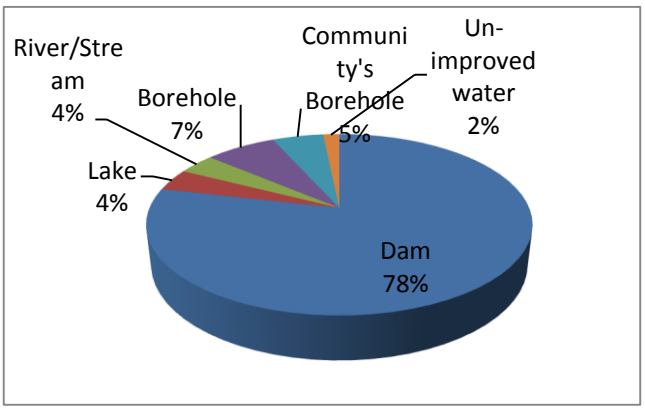
(9) Share of Water Sources

Based on the data of 2012, existing water sources in urban area is analyzed as follows. **Figure 6.4.4** shows the share of water consumption of urban area. Water for house connection, communal point, institute, commercial & industry is served by the Water Boards, some is served by borehole/protected shallow well, and others still have no access to improved water source. Water schemes managed by the Water Boards have their own water source such as dam, lake, river, and borehole as described in Chapter 5. **Figure 6.4.5** shows the share of water sources of the urban area. Almost 78% is shared by Dam, because the 4 big cities, Lilongwe, Blantyre, Mzuzu and Zomba, utilize water from Dam. **Figure 6.4.6** shows the share of water sources of rural area. Gravity-fed by river and stream water is around 8%, and Borehole/protected shallow well is 62%.



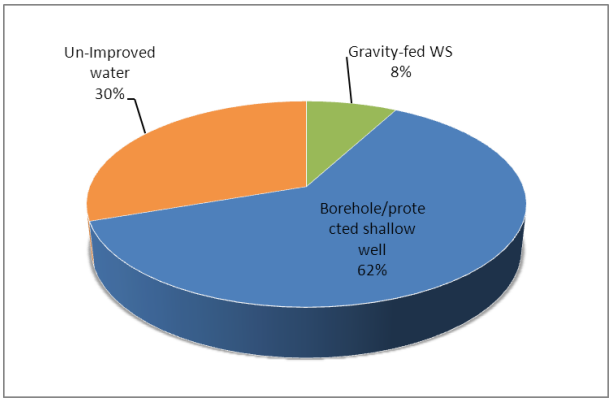
Source: Project Team

Figure 6.4.4 Share of Water Uses in Urban Area in 2012



Source: Project Team

Figure 6.4.5 Share of Water Sources in Urban Area (2012)



Source: Project Team

Figure 6.4.6 Share of Water Sources in Rural Area (2012)

6.4.2 Agriculture

Agricultural production comprises two main sectors: the small-scale farming sector (subsistence farming of food crops and smallholder cash cropping) and the commercial sector dominated by large sugar, tobacco, tea and coffee estates. Smallholder cropping patterns are dominated by maize mostly grown under rain-fed conditions. Other important smallholder subsistence crops include rice, groundnuts and potatoes. Tobacco, cotton and sugar are grown as cash crops on a much smaller scale than the estates.

Land on which water is used primarily for the purpose of agricultural production is generally referred to as "water managed areas". Irrigated land refers to water managed areas or wetlands that are equipped with hydraulic structures (full or partial control irrigation), or valley bottoms and areas equipped for spate irrigation, whereby seasonal floods of rivers, streams, ponds and lakes are used to fill water storage canals for irrigation. For the purposes of this assessment, irrigation demand has been calculated for all areas considered as irrigated land.

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

Step 1: Determine irrigated area for selected crops;

- Crop area estimations
- Irrigated area estimation

Step 2: Determine crop water and irrigation requirements; and

Step 3: Determine irrigation demand

(1) Demand Calculation for Irrigation Water

1) Assessment Parameters on Irrigation Water Demand

(i) Unit area for assessment

Irrigation water demand is assessed on WRA and WRU basis, the same as that of the domestic and industrial water.

(ii) Base Year Irrigated Area

The national irrigated area on the base year (2011) is determined mainly based on the DOI data as shown in the following **Table 6.4.33**. Ninety thousand (90,000) ha is adopted as the base year irrigated area.

Table 6.4.33 Base Year Irrigated Area

	Irrigation area (ha)	Data source
(1) Small holder	42,181	DOI, Annual report 2010/11
(2) Estate	48,382	DOI, Annual report 2010/11
(3) Sub-total	90,563	(1)+(2)
Final figure	90,000	Rounded, Base year 2011

Source: Project Team

(iii) Available data for assessment

In Malawi, nationwide records/materials for water requirement and intake volume of water for irrigation are very limited. In addition, the registered number of water rights for irrigation are also limited. Therefore, these would not be used for assessment.

Much of the data used for demand estimation such as economic data, population and crop area are available at the administrative district level rather than the WRA level. Using Geographic Information System (GIS), district to WRA ratios were calculated and used to apportion district level data to WRAs.

The Economic Survey Department of the Ministry of Agriculture, Irrigation and Water Development (MoAIWD) provided the district-level estimate of national smallholder and estate crop production and crop areas as shown in **Table 6.4.35 to Table 6.4.38.** The crop production/areas of 2010/11 third round for major crops such as maize, rice, tobacco, cotton, wheat, coffee, sugarcane and tea are adopted for the assessment. Estate crop production/areas are supplemented through each crop production association and the Estate Survey conducted by the Project Team.

(iv) Conversion of district crop area data to WRU level data

The district level crop area data (**Table 6.4.35 to Table 6.4.38**) is then scaled to the WRU level data using the crop area's ratio, as shown in **Table 6.4.39 to Table 6.4.45**. This ratio is derived from GIS (Land Use Map, 2010, Dept. of Forestry).

(v) Spatial allocation of base year irrigated area across WRAs

The spatial allocation of base year irrigated area across WRAs was determined using available data on smallholder and estate irrigation development and estimates of irrigated area derived from the 2002 FAO global irrigation map (Siebert et al., 2007). The proportion of each WAR's irrigation area is shown in **Table 6.4.34**. The GIS (Land use map, 2010, Dept. of Forestry) has no information on irrigation area.

Table 6.4.34 Proportion of each WAR's Irrigation Area

WRA	% of total Irrigation Area
1	29.69%
2	2.28%
3	0.18%
4	0.99%
5	2.19%
6	9.19%
7	1.15%
8	0.06%
9	0.66%
10	0.04%
11	0.36%
12&13	0.00%
14	38.71%
15	2.15%
16	11.96%
17	0.39%
Total	100.00

Source: WRIS (Water Resources Investment Strategy)

Table 6.4.35 Crop Production/Area Estimates (1/4)

Dist	Maize						Rice					
	Sum.		Est.		Win.		Sum.		Est.		Win.	
	ha	Mt	ha	Mt	ha	Mt	ha	Mt	ha	Mt	ha	Mt
Chitipa	26,018	80,761	-	-	2,025	6,024	581	716	-	-	-	-
Karonga	22,942	56,817	-	-	5,083	13,793	9,899	25,116	-	-	1,234	5,274
Rumphi	14,067	40,479	328	1,020	2,198	6,812	105	135	-	-	-	-
Mzimba	122,602	272,711	2,887	9,023	7,635	23,603	45	37	-	-	-	-
Nkhata Bay	14,439	43,925	-	-	1,614	5,362	2,391	5,611	-	-	332	1,326
Likoma	154	331	-	-	29	72	3	4	-	-	-	-
Kasungu	102,058	272,002	19,780	69,743	6,408	18,516	22,227	23,632	-	-	-	-
Mchinji	86,489	205,727	20,257	68,337	22,274	68,344	642	683	-	-	-	-
Dowa	80,633	203,640	6,462	20,469	10,583	32,855	5	4	-	-	-	-
Ntchisi	39,715	95,502	3,075	10,090	7,306	24,841	-	-	-	-	-	-
Lilongwe	168,216	457,588	762	3,586	27,776	98,674	435	595	-	-	-	-
Dedza	88,083	169,186	639	2,287	11,993	32,632	3,246	8,623	-	-	785	4,001
Ntcheu	90,591	159,668	4	20	5,591	15,096	866	741	-	-	-	-
Nkhotakota	21,446	65,174	429	1,609	3,620	8,682	5,286	12,600	-	-	432	1,522
Salima	38,286	90,649	282	848	4,240	8,902	1,872	1,977	-	-	126	375
Mangochi	97,269	133,162	521	1,485	4,307	8,520	3,194	2,085	-	-	-	-
Machinga	49,902	70,887	-	-	3,133	5,988	10,112	14,564	-	-	361	1,522
Zomba	83,114	130,732	252	892	5,594	14,094	4,497	6,014	-	-	120	604
Balaka	59,833	59,324	128	380	633	1,092	385	254	-	-	-	-
Blantyre	43,750	87,207	124	664	2,671	12,162	200	212	-	-	-	-
Thyolo	46,524	122,023	210	1,111	2,142	9,186	-	-	-	-	-	-
Chiradzulu	29,247	47,963	38	140	723	3,111	25	24	-	-	-	-
Phalombe	39,120	78,316	272	1,532	5,120	23,464	4,973	8,272	-	-	-	-
Mulanje	57,342	145,023	-	-	2,442	9,921	4,236	5,958	-	-	-	-
Mwanza	15,625	29,801	22	66	1,055	4,974	40	23	-	-	-	-
Neno	23,055	31,877	20	68	1,172	5,017	-	-	-	-	-	-
Chikwawa	30,701	18,531	-	-	14,970	22,161	3,012	6,358	-	-	312	626
Nsanje	11,405	10,063	-	-	10,451	21,562	1,401	1,770	-	-	192	450
Total	①	②	56,492	193,369	172,788	505,460	79,678	23,734,421	0	0	3,894	15,700

Note:①=1,502,626, ②=3,179,068, Dist. = District, Sum. = Summer Crop, Win. = Winter Crop, Est. = Estate Crop
Source: MoAFS and Estate Survey by Project Team

Table 6.4.36 Crop Production/Area Estimates (2/4)

Dist	Tobacco						Cotton					
	Sum.		Est.		Win.		Sum.		Est.		Win.	
	ha	kg	ha	kg	ha	kg	ha	Mt	ha	Mt	ha	Mt
Chitipa	282	262,917	20	18,800	-	-	-	-	-	-	-	-
Karonga	47	51,083	3	3,000	-	-	1,745	1,989	-	-	-	-
Rumphi	7,098	5,105,398	1,620	914,715	-	-	-	-	-	-	-	-
Mzimba	4,272	4,590,821	3,397	2,358,324	-	-	13	8	-	-	-	-
Nkhata Bay	99	163,700	108	96,600	-	-	-	-	-	-	-	-
Likoma	1	1,300	2	1,500	-	-	-	-	-	-	-	-
Kasungu	15,527	4,686,368	25,738	8,015,252	-	-	-	-	-	-	-	-
Mchinji	3,661	3,113,139	4,373	3,514,667	-	-	-	-	-	-	-	-
Dowa	7,849	6,014,291	9,887	4,286,521	-	-	322	321	-	-	-	-
Ntchisi	585	631,700	1,936	623,175	-	-	315	211	-	-	-	-
Lilongwe	25,737	17,064,057	17,087	②	-	-	-	-	-	-	-	-
Dedza	999	946,424	124	86,300	-	-	1,896	2,083	-	-	-	-
Ntcheu	968	920,073	41	17,800	-	-	2,430	1,817	-	-	-	-
Nkhotakota	473	357,777	803	642,387	-	-	801	783	-	-	-	-
Salima	2,371	273,085	274	247,523	-	-	4,700	6,114	-	-	-	-
Mangochi	1,164	1,311,766	296	322,815	-	-	2,654	1,906	-	-	-	-
Machinga	571	499,150	196	129,687	-	-	858	529	-	-	-	-
Zomba	2,328	2,471,407	418	719,909	-	-	2,053	1,404	-	-	-	-
Balaka	111	140,499	-	-	-	-	10,181	6,730	10	8	-	-
Blantyre	104	97,126	12	15,000	-	-	486	602	-	-	-	-
Thyolo	99	91,433	65	155,000	-	-	54	48	-	-	-	-
Chiradzulu	419	391,126	13	9,800	-	-	33	22	-	-	-	-
Phalombe	546	598,949	10	5,000	-	-	-	-	-	-	-	-
Mulanje	210	164,854	-	-	-	-	52	40	-	-	-	-
Mwanza	1	1,300	8	11,500	-	-	48	35	-	-	-	-
Neno	-	-	-	-	-	-	1,652	2,439	-	-	-	-
Chikwawa	4	1,300	12	1,500	-	-	26,973	23,753	-	-	-	-
Nsanje	-	-	-	-	-	-	2,351	1,759	-	-	-	-
Total	75,528	①	66,443	③	0	0	59,617	52,593	10	8	0	0

Note : ①= 49,951,043, ②= 10,024,112, ③= 32,220,887

Source: MoAFS and Estate Survey by Project Team

Table 6.4.37 Crop Production/Area Estimates (3/4)

Dist	Wheat						Coffee					
	Sum.		Est.		Win.		Sum.		Est.		Win.	
	ha	Mt	ha	Mt	ha	Mt	ha	Mt	ha	Mt	ha	Mt
Chitipa	17	46	-	-	-	-	4,008	2,025	-	-	-	-
Karonga	-	-	-	-	-	-	-	-	-	-	-	-
Rumphi	17	30	-	-	-	-	813	730	-	-	-	-
Mzimba	8	22	-	-	-	-	433	433	-	-	-	-
Nkhata Bay	17	46	-	-	-	-	224	227	-	-	-	-
Likoma	-	-	-	-	-	-	-	-	-	-	-	-
Kasungu	-	-	-	-	-	-	-	-	-	-	-	-
Mchinji	-	-	-	-	-	-	-	-	-	-	-	-
Dowa	7	13	-	-	-	-	-	-	-	-	-	-
Ntchisi	17	40	-	-	-	-	4	3	-	-	-	-
Lilongwe	-	-	-	-	-	-	-	-	-	-	-	-
Dedza	12	15	-	-	-	-	-	-	-	-	-	-
Ntcheu	-	-	-	-	187	195	-	-	-	-	-	-
Nkhotakota	-	-	-	-	-	-	-	-	-	-	-	-
Salima	-	-	-	-	-	-	-	-	-	-	-	-
Mangochi	5	5	-	-	-	-	-	-	1,000	900	-	-
Machinga	-	-	-	-	-	-	-	-	-	-	-	-
Zomba	-	-	-	-	-	-	-	-	60	75	-	-
Balaka	-	-	-	-	-	-	-	-	-	-	-	-
Blantyre	-	-	-	-	-	-	-	-	-	-	-	-
Thyolo	-	-	-	-	-	-	-	-	470	460	-	-
Chiradzulu	-	-	-	-	-	-	-	-	100	150	-	-
Phalombe	7	6	-	-	-	-	-	-	-	-	-	-
Mulanje	-	-	-	-	-	-	-	-	-	-	-	-
Mwanza	4	3	-	-	-	-	-	-	-	-	-	-
Neno	930	1,447	-	-	-	-	-	-	-	-	-	-
Chikwawa	-	-	-	-	-	-	-	-	-	-	-	-
Nsanje	-	-	-	-	-	-	-	-	-	-	-	-
Total	1,041	1,673	0	0	187	195	5,482	3,418	1,630	1,585	0	0

Source: MoAFS and Estate Survey by Project Team

Table 6.4.38 Crop Production/Area Estimates (4/4)

Dist	Sugarcane				Tea			
	Sum.		Est.		Sum.		Est.	
	ha	Mt	ha	Mt	ha	Mt	ha	Mt
Chitipa	-	-	-	-	-	-	-	-
Karonga	-	-	-	-	-	-	-	-
Rumphi	-	-	-	-	-	-	-	-
Mzimba	-	-	-	-	-	-	-	-
Nkhata Bay	-	-	-	-	122	250	642	2,355
Likoma	-	-	-	-	-	-	-	-
Kasungu	-	-	-	-	-	-	-	-
Mchinji	-	-	-	-	-	-	-	-
Dowa	-	-	-	-	-	-	-	-
Ntchisi	-	-	-	-	-	-	-	-
Lilongwe	-	-	-	-	-	-	-	-
Dedza	-	-	-	-	-	-	-	-
Ntcheu	-	-	-	-	-	-	-	-
Nkhotakota	-	-	8,010	750,000	-	-	-	-
Salima	-	-	-	-	-	-	-	-
Mangochi	-	-	-	-	-	-	-	-
Machinga	-	-	-	-	-	-	-	-
Zomba	-	-	-	-	-	-	-	-
Balaka	-	-	-	-	-	-	-	-
Blantyre	-	-	-	-	-	-	-	-
Thyolo	-	-	-	-	1,664	3,410	8,735	17,828
Chiradzulu	-	-	-	-	-	-	-	-
Phalombe	-	-	-	-	-	-	-	-
Mulanje	-	-	-	-	1,194	2,447	6,270	18,428
Mwanza	-	-	-	-	-	-	-	-
Neno	-	-	-	-	-	-	-	-
Chikwawa	-	-	22,905	2,140,000	-	-	-	-
Nsanje	-	-	840	78,000	-	-	-	-
Total	0	0	31,755	2,968,000	2,980	6,106	15,647	38,611

Source: MoAFS and Estate Survey by Project Team

Table 6.4.39 District-Crop Area Ratio in WRU (1-A~1-M) (1/7)

Unit/km^2

	WRA	1																			
	WRU	A		B		C		E		F		G		H		K		L		M	
		C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio
Region/District																					
North	CHITIPA																				
	KARONGA																				
	NKHATABAY																				
	RUMPHI																				
	MZIMBA*																				
	LIKOMA																				
Central	KASUNGU																				
	NKHOTAKOTA																				
	NTCHISI																				
	DOWA																				
	SALIMA																				
	LILONGWE																				
	MCHINJI																				
	DEDZA																				
	NTCHEU																				
South	MANGOCHI	347.659	0.088																		
	MACHINGA	397.122	0.210	260.251	0.138																
	ZOMBA			449.637	0.232	14.759	0.008														
	CHIRADZULO					82.306	0.115														
	BLANTYRE			246.583	0.169	566.509	0.388	486.879	0.334									6.302	0.004		
	MWANZA															345.478	0.637	14.914	0.027	182.288	0.336
	THYOLO							151.970	0.095	341.356	0.214										
	MULANJE																				
	PHALOMBE																				
	CHIKWAWA							54.133	0.018	189.207	0.064			1,522.107	0.517	925.750	0.314	253.539	0.086		
	NSANJE									164.248	0.158	749.351	0.721	82.847	0.080						
	BALAKA	0.000	0.000	0.114	0.000																
	NENO			0.561	0.000	0.259	0.000													441.071	0.393
Total		744.782		957.146		663.833		692.982		694.811		749.351		1,604.955		1,271.228		274.755		623.359	

Note:* = MUZUZU is included in MZIMBA

Table 6.4.40 District-Crop Area Ratio in WRU (1-N~2-D) (2/7)

Unit/km^2

WRA		1												2							
WRU		N		O		P		R		S		T		A		B		C		D	
		C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio
Region/District																					
North	CHITIPA																				
	KARONGA																				
	NKHATABAY																				
	RUMPHI																				
	MZIMBA*																				
	LIKOMA																				
Central	KASUNGU																				
	NKHOTAKOTA																				
	NTCHISI																				
	DOWA																				
	SALIMA																				
	LILONGWE																				
	MCHINJI																				
	DEDZA																				
	NTCHEU			606.279	0.220	77.510	0.028	812.416	0.295												
South	MANGOCHI							45.569	0.012	180.100	0.045	320.446	0.081								
	MACHINGA									3.642	0.002							104.415	0.055	281.969	0.149
	ZOMBA									0.003	0.000			3.551	0.002	1,117.426	0.576	355.657	0.183		
	CHIRADZULO															291.398	0.408				
	BLANTYRE	100.767	0.069	0.006	0.000	0.088	0.000									8.517	0.006				
	MWANZA																				
	THYOLO																				
	MULANJE													1.299	0.001	174.821	0.122				
	PHALOMBE													689.993	0.649	249.154	0.235				
	CHIKWAWA	1.403	0.000																		
	NSANJE																				
	BALAKA			97.118	0.049	464.260	0.234	455.382	0.230	851.273	0.430	113.323	0.057								
	NENO	53.709	0.048	548.847	0.489	78.511	0.070														
Total		155.880		1,252.249		620.369		1,313.367		1,035.018		433.769		694.842		1,841.317		460.073		281.969	

Note:* = MUZUZU is included in MZIMBA

Table 6.4.41 District-Crop Area Ratio in WRU (3-A~4-D) (3/7)

Unit/km^2

WRA		3												4							
WRU		A		B		C		D		E		F		A		B		C		D	
		C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio
Region/District																					
North	CHITIPA																				
	KARONGA																				
	NKHATABAY																				
	RUMPHI																				
	MZIMBA*																				
	LIKOMA																				
Central	KASUNGU																				
	NKHOTAKOTA																				
	NTCHISI																				
	DOWA																	175.126	0.065		
	SALIMA											183.403	0.103	134.744	0.076	329.604	0.186	57.930	0.033		
	LILONGWE															417.768	0.096	1,145.159	0.263	995.139	0.228
	MCHINJI																				
	DEDZA					8.608	0.004	75.394	0.031	327.091	0.136	329.983	0.138	283.531	0.118	1,373.530	0.573				
	NTCHEU					42.205	0.015	795.773	0.289	421.936	0.153										
South	MANGOCHI	562.396	0.142	257.070	0.065	489.679	0.124	98.092	0.025												
	MACHINGA																				
	ZOMBA																				
	CHIRADZULO																				
	BLANTYRE																				
	MWANZA																				
	THYOLO																				
	MULANJE																				
	PHALOMBE																				
	CHIKWAWA																				
	NSANJE																				
	BALAKA																				
	NENO																				
Total		562.396		257.070		540.493		969.259		749.026		513.386		418.275		2,120.903		1,378.215		995.139	

Note:* = MUZUZU is included in MZIMBA

Table 6.4.42 District-Crop Area Ratio in WRU (4-E~6-D) (4/7)

Unit/km^2

WRA		4				5								6							
WRU		E		F		C		D		E		F		A		B		C		D	
		C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio
Region/District																					
North	**CHITIPA**																				
	KARONGA																				
	NKHATABAY																				
	RUMPHI																				
	MZIMBA*																			1,097.508	0.146
	LIKOMA																				
Central	**KASUNGU**					405.690	0.089	699.506	0.153	228.246	0.050	555.441	0.121	265.971	0.058	240.147	0.052	1,232.965	0.269	955.929	0.209
	NKHOTAKOTA					61.479	0.032													272.443	0.143
	NTCHISI					260.308	0.182	592.151	0.415												
	DOWA	13.721	0.005	333.367	0.125			1,058.226	0.396	449.280	0.168										
	SALIMA																				
	LILONGWE	704.501	0.162	206.234	0.047					889.289	0.204										
	MCHINJI									1,282.399	0.616	798.944	0.384								
	DEDZA																				
	NTCHEU																				
South	**MANGOCHI**																				
	MACHINGA																				
	ZOMBA																				
	CHIRADZULO																				
	BLANTYRE																				
	MWANZA																				
	THYOLO																				
	MULANJE																				
	PHALOMBE																				
	CHIKWAWA																				
	NSANJE																				
	BALAKA																				
	NENO																				
Total		718.222		539.601		727.478		2,349.882		2,849.213		1,354.385		265.971		240.147		1,232.965		2,325.880	

Note:* = MUZUZU is included in MZIMBA

Table 6.4.43 District-Crop Area Ratio in WRU (7-A~9-A) (5/7)

Unit/km^2

	WRA	7																8		9	
	WRU	A		B		C		D		E		F		G		H		A		A	
		C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio
Region/District																					
North	CHITIPA																	419.665	0.202	590.639	0.284
	KARONGA																	81.345	0.065	199.446	0.159
	NKHATABAY							0.838	0.001												
	RUMPHI					106.759	0.094			215.136	0.190	207.891	0.184	391.321	0.346	144.990	0.128				
	MZIMBA*	2,331.553	0.310	1,021.713	0.136	503.598	0.067	1,601.052	0.213	737.211	0.098	30.437	0.004	48.584	0.006						
	LIKOMA																				
Central	KASUNGU																				
	NKHOTAKOTA																				
	NTCHISI																				
	DOWA																				
	SALIMA																				
	LILONGWE																				
	MCHINJI																				
	DEDZA																				
	NTCHEU																				
South	MANGOCHI																				
	MACHINGA																				
	ZOMBA																				
	CHIRADZULO																				
	BLANTYRE																				
	MWANZA																				
	THYOLO																				
	MULANJE																				
	PHALOMBE																				
	CHIKWAWA																				
	NSANJE																				
	BALAKA																				
	NENO																				
Total		2,331.553		1,021.713		610.356		1,601.890		952.347		238.328		439.904		144.990		501.010		790.085	

Note:* = MUZUZU is included in MZIMBA

Table 6.4.44 District-Crop Area Ratio in WRU (9-B~15-A) (6/7)

Unit/km^2

	WRA	9		10		11		12		13		14								15	
	WRU	B		A		A		-		-		A		B		C		D		A	
		C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio
Region/District																					
North	CHITIPA	1066.595	0.514																		
	KARONGA	365.429	0.292																		
	NKHATABAY																				
	RUMPHI																				
	MZIMBA*																				
	LIKOMA							9.876	0.780	2.791	0.220										
Central	KASUNGU																				
	NKHOTAKOTA																			131.438	0.069
	NTCHISI																			91.127	0.064
	DOWA																			644.602	0.241
	SALIMA																			1066.662	0.602
	LILONGWE																				
	MCHINJI																				
	DEDZA																				
	NTCHEU																				
South	MANGOCHI			846.216	0.214	812.423	0.205														
	MACHINGA					840.773	0.445														
	ZOMBA																				
	CHIRADZULO											113.956	0.160	226.370	0.317						
	BLANTYRE											43.374	0.030								
	MWANZA																				
	THYOLO											305.647	0.191	600.149	0.376			197.111	0.123		
	MULANJE													617.365	0.431	639.675	0.446				
	PHALOMBE													97.146	0.091	26.104	0.025				
	CHIKWAWA																				
	NSANJE																	42.249	0.041		
	BALAKA																				
	NENO																				
Total		1432.025		846.216		1653.196		9.876		2.791		462.978		1541.030		665.779		239.360		1933.828	

Note:* = MUZUZU is included in MZIMBA

Table 6.4.45 District-Crop Area Ratio in WRU (15-B~17-C) (7/7)

Unit/km^2

	WRA	15				16						17					
	WRU	B		C		E		F		G		A		B		C	
		C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio	C. area	ratio
Region/District																	
North	CHITIPA																
	KARONGA											73.797	0.059	89.598	0.072	441.949	0.353
	NKHATABAY					294.587	0.193	912.507	0.597	320.693	0.210						
	RUMPHI									30.123	0.027					34.998	0.031
	MZIMBA*					117.033	0.016	30.926	0.004	0.985	0.000						
	LIKOMA																
Central	KASUNGU																
	NKHOTAKOTA	1,105.955	0.582	80.390	0.042	247.303	0.130										
	NTCHISI	483.682	0.339														
	DOWA																
	SALIMA																
	LILONGWE																
	MCHINJI																
	DEDZA																
	NTCHEU																
South	MANGOCHI																
	MACHINGA																
	ZOMBA																
	CHIRADZULO																
	BLANTYRE																
	MWANZA																
	THYOLO																
	MULANJE																
	PHALOMBE																
	CHIKWAWA																
	NSANJE																
	BALAKA																
	NENO																
Total		1,589.637		80.390		658.924		943.434		351.801		73.797		89.598		476.947	

Note:* = MUZUZU is included in MZIMBA

(vi) Crop water requirement (CWR) & Irrigation requirement (IR)

CWR and IR for each crop type were determined using the procedures adopted in WRIS (Water Resources Investment Strategy) as shown in **Table 6.4.50 to Table 6.4.51**.

(vii) Irrigation Efficiency

In calculating irrigation demand, it is important to distinguish between the water requirements of crops themselves and the other pressures on water caused by irrigation systems (conveyance loss, Field application loss and so on). Crop irrigation demand represents the amount of water actually needed by the crop to grow effectively. Gross irrigation demand equates to crop irrigation demand plus an additional amount of water that is lost to infiltration, surface run-off or evaporation, having not been taken up by the crop itself. The volumetric difference between crop and gross irrigation demand will depend on the "efficiency" of an irrigation method. Conveyance efficiency, field application efficiency and overall efficiency for different types of irrigation method are presented in **Table 6.4.46**. As shown in the table, the former is universal and the latter is specified in Malawi. Therefore, overall irrigation efficiencies are taken as 48% for surface irrigation, 68% for sprinkler irrigation, 81% for drip irrigation and 85~90% for center-pivot irrigation.

Table 6.4.46 Irrigation Efficiency

Irrigation efficiency	Convey -ance	Field application	Overall	Data source (1)	Convey -ance	Field application	Overall	Data source (2)
Surface (border, furrow, basin)	75%	60%	45%	WRIS, Final for Component I (FAO, 1989)	80%	60%	**48%**	From DOI
Sprinkler	75%	75%	56%		90%	75%	**68%**	
Drip	75%	90%	68%		90%	90%	**81%**	
Centre Pivot							85~90%	

(viii) Irrigation return flow

Water sometimes recovers from the irrigation site and reused. It is often collected in field drainage channels if available. This water may be reused on-site or alternatively allowed to flow as run-off to surface waters or infiltrate to groundwater where it is then available to downstream users. Irrigation fields in Malawi are usually close to a river; therefore, water recovered from irrigation sites is assumed to flow to surface water bodies and none to groundwater and water that percolate into the ground is assumed to enter surface waters as part of the base-flow component.

The rate of irrigation return flow data are very difficult to find. The following table shows the example of the rate of irrigation return flow. In case of the middle column, California's Central Valley, USA, has well-arranged facilities including drainage system and therefore, the rate of return flow is rather high. From the field observation, the Project Team understood that the rate of return flow is rather low because of ordinary irrigation facilities and less drainage facilities. Therefore, 10% is finally taken for paddy and none for other crops which will prevent overestimation of available water supply. However, the return flow rate may be revised in case DOI again offers to use an appropriate rate in consideration of actual conditions of Malawi.

Table 6.4.47 Example of Rate of Irrigation Return Flow

Type of Crop	WRIS	Paper, "Surface irrigation return flows vary"	This M/P
Paddy	30%	25% (32%, overall)	**10%**
Other Crops	20%		**0%***
Data Source	Irrigation project in Maipo Valley, Chile	California's Central Valley, USA	* Through the discussion with DOI

Source: Shown in the table

(ix) Irrigation potential area by WRA

DOI has set up irrigation potential area by WRA as shown in the following table. When it comes to the calculation of future irrigation water demand, estimated irrigation area in each WRA is kept not to exceed the respective figure in the table.

Table 6.4.48 Irrigation Potential Area by WRA

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

Source: DOI/WRIS

2) Calculation on Irrigation Water Demand

The IR (expressed in mm per unit area) for each crop is applied to the estimated irrigated area for each crop type in each WRU to calculate the crop irrigation demand. Irrigation demand is determined for the dry and wet season by applying the total IR calculated for the periods May–October and November–April respectively. The annual average irrigation demand is determined by applying the total IR calculated over the year. The sum of the IRs for each crop type in each WRU provides the total crop irrigation demand for the WRA.

Based on the parameters mentioned above, irrigation water demand is calculated as follows:

(i) Conversion of district crop area data to WRU level data:

Using crop area's ratio, as shown in **Table 6.4.39** to **Table 6.4.45,** converted crop areas in WRAs/WRUs are shown in **Table 6.4.52** to **Table 6.4.53**.

(ii) Base year irrigated area across WRAs:

As explained in the previous section, the base year irrigated areas across WRAs and WRUs are calculated as shown in **Table 6.4.56** to Table 6.4.59.

(iii) Net Irrigation Requirement (mm/month):

Net irrigation requirement is shown in **Table 6.4.50** to Table 6.4.51. Illustrative figures of net irrigation requirement, effective rainfall, etc., for each crop in WRA-1 are shown in **Figure 6.4.7**.

(iv) Base year water demand:

Base year water demand is calculated and summarized in **Table 5.4.60** and **Table 5.4.61**.

3) Future Irrigation Water Demand

Base year and target year are 2011 and 2035 respectively. The estimation for the years 2015, 2020, 2025, 2030 and 2035 has been carried out as follows:

(i) Existing/Ongoing Major Irrigation Projects:

Together with GBI pilot projects, DOI has several existing/ongoing projects as shown in **Table 6.4.62**. The latter data has no geographic information.

(ii) Major Irrigation Project to be implemented:

At present, DOI has several projects to be implemented utmost by 2020 as shown in Table 6.4.63, however, there is no plan after 2020.

(iii) Annual increase in Irrigation Planning:

DOI is applying 5,000 ha for annual increase in irrigation planning. Annual increase rate of 6% would be considered rather high estimate. The projection of water demand is shown in Figure 6.4.8.

(iv) Geographic information:

Geographic information is necessary to locate the area in WRU; however, DOI's projects have very limited information and they will provide relevant data at the beginning of July, 2013.

(v) Future Irrigation Water Demand:

Based on the proportion of base year irrigation area, similar proportion is adopted to decide irrigation area of the target year as shown in **Table 6.4.64**. Thus the irrigation water demand for 2015, 2020, 2025, 2030 and 2035 are worked out as shown in **Table 6.4.65** to Table 6.4.70.

4) Underground Water Demand for Irrigation

According to the abstraction data by the Ministry of Agriculture, Irrigation and Water Development, only 93 groundwater points are registered and the total amount of which is 4,351 m^3/day. The records show that the water is used not only for irrigation but also other purposes. In addition, the registered records do not cover all the groundwater points. In 1980s, Experimental farm of 70 ha using groundwater had been succeeded in Golowingo, Salima District. Since then, only a few groundwater irrigation projects had been carried out with the borehole depth of 50 ~ 70 m. Therefore, groundwater is not common as the source of irrigation. As for estates, only four estates are using groundwater among around 70 estates.

(2) Water Demand for Livestock

In the Central and Northern Regions, livestock production is mainly associated with smallholders, particularly chickens, goats, cattle and pigs are the main types of livestock. Large herds of cattle are found in the Lower Shire valley associated with meat production industries in Blantyre. The following steps were taken to provide a 2011 base year livestock population for each WRA:

1) Base year livestock population, population of target year and livestock ratio:

The livestock population of 2010/11 lacks two ADDs' data and is supplemented using the growth rate of the same type of livestock from the data of 2011/12. Revised livestock population in 2010/11, population of target year and livestock ratio are shown in **Table 6.4.75**.

2) Consumption Figures for Livestock:

There is no standard for livestock water consumption in Malawi, therefore, Mid-range water consumption figures typical of Southern Africa were applied to determine livestock water demand as shown in **Table 6.4.49**. For the purposes of this assessment, it was assumed that there was no difference in consumption between the wet and dry season.

Table 6.4.49 Consumption Figures for Livestock

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

Source: WRIS (Water Resources Investment Strategy)

3) Base year water demand for livestock:

As shown in Table 6.4.76 to **Source:** Project Team

Table 6.4.78, base year water demand for livestock is estimated.

4) Target year water demand for livestock:

Target year water demand for livestock is estimated as shown in **Table 6.4.79** and Table 6.4.80**,**

Table 6.4.50 Crop Water and Irrigation Requirement Input Data (1/2)

Climate Station:Chileka

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Mean Ref. Crop Evapotransp. ETo (mm/day)	4.4	4.3	4.2	4.2	3.9	3.6	3.7	5.1	6.0	6.7	6.0	4.8	1,706.7
Effective rainfall (mm/month) *	135.3	128.8	115.0	42.5	9.7	2.1	2.4	1.2	3.5	27.8	79.2	127.3	674.8
Etc (mm/month)													
Maize/wheat	146.2	141.1	121.1	7.6	19.7	54.3	133.1	195.2	172.6	4.3	27.4	71.1	1,093.7
Rice	158.4	141.6	110.6		29.1	118.0	136.3	195.0	219.0	89.1	42.6	163.6	1,403.3
Tobacco	156.0	127.0	114.3	6.5						56.3	134.7	170.7	765.5
Coffee	123.8	108.5	118.0	116.6	117.8	108.2	116.9	156.3	179.4	203.8	175.0	148.0	1,672.3
Cotton	121.5	139.6	150.2	117.4	35.4						32.0	64.4	660.5
Sugarcane	170.3	149.1	160.4	153.7	147.1	108.0	32.5		39.6	113.3	190.8	186.7	1,451.5
Tea	130.7	114.7	126.1	124.0	124.4	112.5	121.3	162.1	186.5	212.7	183.8	151.8	1,750.6
Net Irrigation Requirement (mm/month)													
Maize/wheat	14.8	14.2	7.8	0	17	52	130.8	194	169	4.3	0	0	603.9
Rice	23.2	14.6	11.7		117.4	257.7	133.9	193.9	215.5	83.4	98.1	126.4	1275.8
Tobacco	20.9	6.1	5.6	6.5						38.2	55.6	43.4	176.3
Cotton	5.6	13.1	35.4	74.8	28.3						0	0	157.2
Coffee	0	0	10	74	108	106	114.6	154.9	175.9	176	96	20.7	1036.1
Sugarcane	35.2	20.5	45.5	111.1	137.3	105.9	31.7		36.3	85.4	111.7	59.6	780.2
Tea	0.9	0	12.9	81.3	114.5	110.4	118.9	160.8	182.8	184.8	104.8	19.5	1091.6

Climate Station:Lilongwe

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Mean Ref. Crop Evapotransp. ETo (mm/day)	3.9	3.9	3.9	4.0	4.0	4.0	4.2	5.2	6.5	7.5	6.3	4.4	1,729.2
Effective rainfall (mm/month) *	143.7	132.6	103.0	38.3	9.8	1.0	2.0	0.0	1.0	9.8	58.2	133.4	632.8
Etc (mm/month)													
Maize/wheat	134.5	130.5	116.7	7.7	20.4	62.5	162.0	218.6	206.9	5.7	28.4	65.4	1,159.3
Rice	143.9	130.2	105.1		30.3	129.4	157.7	215.1	253.1	107.6	43.6	149.4	1,465.4
Tobacco	143.5	117.6	109.7	6.5						63.0	143.9	160.3	744.5
Coffee	98.5	87.0	101.0	106.1	115.7	113.8	125.8	154.1	185.1	218.4	178.0	123.8	1,607.3
Cotton	111.5	129.3	143.3	117.7	38.1						33.2	58.9	632.0
Sugarcane	159.1	139.9	155.1	154.2	156.8	128.4	41.8		43.0	128.8	209.1	178.0	1,494.2
Tea	117.0	103.3	120.0	125.9	137.4	135.1	149.3	182.9	219.7	259.4	211.4	147.2	1,908.6
Net Irrigation Requirement (mm/month)													
Maize/wheat	4.5	2.3	13.8	0	17.5	61.4	160	218.5	205.9	5.7	2.3	0	691.9
Rice	4.4	2	16.2		118.4	272.3	155.9	215	252	106.5	103.8	107.3	1353.8
Tobacco	2.9	0	8.5	6.5						54.8	85.5	27	185.2
Cotton	0	1.3	40.4	79.3	31.1						4.2	0	156.3
Coffee	0	0	8.6	67.6	105.8	112.7	123.9	153.9	184	208.5	119.6	8.8	1093.4
Sugarcane	15.4	9	52.2	115.8	146.9	127.3	41.1		41.9	118.9	150.8	44.8	864.1
Tea	0	0	18	87.5	127.5	134	147.4	182.7	218.6	249.5	153.1	17.7	1336

Climate Station:Mulanje

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Mean Ref. Crop Evapotransp. ETo (mm/day)	4.1	4.0	3.4	3.3	2.7	2.2	2.5	3.1	4.0	5.1	4.6	4.2	1,294.5
Effective rainfall (mm/month) *	156.8	156.6	159.0	124.7	62.9	54.2	32.2	33.9	17.5	59.8	131.4	153.8	1,142.8
Etc (mm/month)													
Maize/wheat	131.4	126.2	97.0	5.5	13.3	33.6	84.6	116.7	108.2	2.9	21.7	61.2	802.3
Rice	143.8	127.5	90.0		19.4	75.0	89.0	117.4	140.8	62.5	33.9	141.5	1,040.8
Tobacco	140.0	113.5	91.9	5.0						42.7	103.6	143.9	640.6
Coffee	101.3	88.4	85.8	76.3	65.7	53.8	60.8	76.3	94.3	120.4	108.1	103.0	1,034.2
Cotton	108.9	124.3	121.1	87.7	23.4						25.3	55.5	546.2
Sugarcane	150.5	131.4	128.2	115.1	97.5	64.6	19.9		27.0	83.6	143.2	154.8	1,115.8
Tea	120.4	105.1	103.4	93.8	82.2	67.9	76.6	96.3	118.7	151.4	136.1	126.9	1,278.8
Net Irrigation Requirement (mm/month)													
Maize/wheat	0	0	0	0	0	0	52.4	82.7	90.5	2.9	0	0	228.5
Rice	0	0	0		90.7	110.9	56.9	83.6	123.2	48.2	91.3	90	694.8
Tobacco	0	0	0	5						6.4	0	0	11.4
Cotton	0	0	0	0	0						0	0	0
Coffee	0	0	0	0	6.2	1.9	28.4	42.4	76.6	60.5	0	0	216
Sugarcane	0.7	0	0	1.1	34.6	10.5	7.5		16.8	23.8	11.9	3.8	110.7
Tea	0	0	0	0	19.2	13.8	44.4	62.4	101.1	91.5	9.4	0	341.8

* Effective rainfall value shown may differ from that used to calculate net irrigation requirement due to the duration of crop growth period within the month

Source: WRIS (Water Resources Investment Strategy)

Table 6.4.51 Crop Water and Irrigation Requirement Input Data (2/2)

Climate Station:Mzuzu

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Mean Ref. Crop Evapotransp. ETo (mm/day)	3.5	3.6	3.2	3.2	2.8	2.5	2.6	3.2	4.2	5.1	4.5	4.0	1,271.7
Effective rainfall (mm/month) *	137.2	127.9	143.7	140.4	53.3	28.1	28.7	11.6	10.2	33.4	81.0	134.9	930.4
Etc (mm/month)													
Maize/wheat	115.9	113.8	91.9	5.5	14.1	38.0	90.5	122.1	117.1	3.1	21.1	58.0	791.1
Rice	126.8	114.8	84.9		20.7	83.4	93.6	122.2	150.2	65.2	33.2	134.2	1,029.2
Tobacco	124.0	102.6	87.2	4.9						42.7	102.1	137.5	601.0
Coffee	89.1	79.4	81.6	76.7	71.2	62.7	66.2	81.2	102.9	127.1	111.7	100.9	1,050.7
Cotton	96.3	112.4	114.8	86.7	24.3						24.7	52.6	511.8
Sugarcane	133.8	119.1	121.9	113.9	102.8	73.7	22.0		28.0	84.2	142.1	148.7	1,090.2
Tea	106.0	94.4	98.2	93.5	88.0	77.9	82.3	100.9	127.6	157.4	138.5	123.4	1,288.1
Net Irrigation Requirement (mm/month)													
Maize/wheat	0	0	0	0	0	13	61.9	110.3	106.9	3.1	0	0	295.2
Rice	0.2	0	0		96.7	198.5	65	110.5	139.8	57.4	91.3	93.8	853.2
Tobacco	0	0	0	4.9						22.1	21	5.8	53.8
Cotton	0	0	0	0	0						0	0	0
Coffee	0	0	0	0	19.5	34.7	37.6	69.6	92.7	93.6	30.6	0	378.3
Sugarcane	1.9	1.5	0	0	49.4	45.4	12		21.6	50.9	60.9	13.9	257.5
Tea	0	0	0	0	34.7	49.8	53.8	89.2	117.3	124.2	57.3	1.9	528.2

Climate Station:Nkhata Bay

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Mean Ref. Crop Evapotransp. ETo (mm/day)	3.7	4.1	3.9	3.9	3.5	3.3	3.4	4.0	4.8	5.4	5.1	4.2	1,473.9
Effective rainfall (mm/month) *	143.8	136.3	160.8	153.3	105.3	35.0	30.8	5.2	3.2	13.7	95.7	149.4	1,032.5
Etc (mm/month)													
Maize/wheat	114.7	123.7	105.2	6.3	17.7	48.5	113.2	146.4	125.1	3.0	23.5	59.8	887.1
Rice	127.1	125.5	98.4		26.3	109.0	120.1	147.4	164.1	65.7	36.6	141.8	1,162.0
Tobacco	124.0	102.6	87.2	4.9						42.7	102.1	137.5	601.0
Coffee	89.1	79.4	81.6	76.7	71.2	62.7	66.2	81.2	102.9	127.1	111.7	100.9	1,050.7
Cotton	96.3	112.4	114.8	86.7	24.3						24.7	52.6	511.8
Sugarcane	133.8	119.1	121.9	113.9	102.8	73.7	22.0		28.0	84.2	142.1	148.7	1,090.2
Tea	106	94.4	98.2	93.5	88	77.9	82.3	100.9	127.6	157.4	138.5	123.4	1288.1
Net Irrigation Requirement (mm/month)													
Maize/wheat	0	1	0	0	0	20.5	82.4	141	121.8	3	0	0	369.7
Rice	0	1.6	0		90.9	221.3	89.5	142.1	160.9	64.6	91.4	92.1	954.4
Tobacco	0	0	0	5.7						33.1	15.5	2.5	56.8
Cotton	0	0.7	0	0	0						0	0	0.7
Coffee	0	0	0	0	1.1	41.6	50.1	89.9	105.5	110	20.4	0	418.6
Sugarcane	0.2	3.1	0	0	18.8	56.4	15.7		29.3	74.1	56.5	6.2	260.3
Tea	0	0	0	0	8.9	62.1	71.9	115.7	134.8	143.6	48.8	0	585.8

* Effective rainfall value shown may differ from that used to calculate net irrigation requirement due to the duration of crop growth period within the month

Source: WRIS (Water Resources Investment Strategy)

Table 6.4.52 Converted Crop Area in WRAs/WRUs (ha) , Maize, rice, tobacco, cotton (1/2)

WRA	WRU	Maize			Rice			Tobacco			Cotton		
		Sum.	Est.	Win.	Sum.	Est.	Win.	Sum.	Est.	Win.	Sum.	Est.	Win.
1	A	19,036	46	1,037	2,407	0	76	222	67	0	413	0	0
	B	33,540	79	2,180	2,469	0	78	636	126	0	677	0	0
	C	20,984	54	1,162	115	0	1	106	9	0	208	0	0
	E	19,606	61	1,371	122	0	6	44	10	0	663	0	0
	F	13,724	45	3,072	415	0	50	21	15	0	2,116	0	0
	G	8,228	0	7,540	1,011	0	139	0	0	0	1,696	0	0
	H	16,771	0	8,568	1,668	0	177	2	6	0	14,123	0	0
	K	19,594	14	5,376	972	0	98	2	9	0	8,506	0	0
	L	3,246	1	1,328	261	0	27	1	1	0	2,325	0	0
	M	14,304	15	815	13	0	0	0	3	0	665	0	0
	N	4,136	10	247	15	0	0	7	1	0	125	0	0
	O	34,129	17	1,834	209	0	0	218	9	0	1,841	0	0
	P	18,178	32	387	115	0	0	53	1	0	2,569	2	0
	R	41,574	37	1,843	381	0	0	324	16	0	3,087	2	0
	S	30,226	79	474	330	0	1	102	14	0	4,496	4	0
	T	11,294	49	385	281	0	0	101	24	0	797	1	0
Subtotal		308,569	539	37,619	10,784	0	651	1,840	311	0	44,308	10	0
2	A	25,611	177	3,338	3,242	0	0	359	7	0	4	0	0
	B	76,215	225	5,030	4,283	0	69	1,666	248	0	1,205	0	0
	C	17,989	46	1,198	1,383	0	42	458	87	0	424	0	0
	D	7,452	0	468	1,510	0	54	85	29	0	128	0	0
Subtotal		127,267	448	10,034	10,418	0	165	2,568	372	0	1,760	0	0
3	A	13,815	74	612	454	0	0	165	42	0	377	0	0
	B	6,315	34	280	207	0	0	76	19	0	172	0	0
	C	13,732	67	661	420	0	3	162	38	0	372	0	0
	D	31,335	34	2,098	431	0	25	340	23	0	827	0	0
	E	25,883	88	2,492	575	0	107	284	23	0	631	0	0
	F	16,082	117	2,089	640	0	121	383	45	0	747	1	0
Subtotal		107,162	414	8,231	2,728	0	256	1,410	190	0	3,126	1	0
4	A	13,325	97	1,740	526	0	102	298	35	0	581	1	0
	B	73,695	491	10,320	2,249	0	473	3,480	1,760	0	1,960	2	0
	C	50,733	633	8,130	176	0	4	7,354	5,146	0	175	0	0
	D	38,411	174	6,342	99	0	0	5,877	3,902	0	0	0	0
	E	27,606	156	4,544	70	0	0	4,201	2,813	0	2	0	0
	F	18,012	842	2,634	21	0	0	2,196	2,041	0	40	0	0
Subtotal		221,782	2,393	33,711	3,142	0	580	23,407	15,697	0	2,758	3	0
5	C	16,970	2,325	2,017	2,138	0	14	1,496	2,657	0	83	0	0
	D	63,958	6,851	8,197	3,394	0	0	5,718	8,643	0	258	0	0
	E	106,243	14,707	21,489	1,592	0	0	9,599	9,124	0	54	0	0
	F	45,566	10,173	9,327	2,940	0	0	3,287	4,797	0	0	0	0
Subtotal		232,737	34,056	41,029	10,064	0	14	20,100	25,221	0	396	0	0
6	A	5,922	1,148	372	1,290	0	0	901	1,493	0	0	0	0
	B	5,347	1,036	336	1,164	0	0	813	1,348	0	0	0	0
	C	27,451	5,320	1,724	5,979	0	0	4,176	6,923	0	0	0	0
	D	42,252	4,608	2,970	5,400	0	62	3,929	5,978	0	117	0	0
Subtotal		80,972	12,112	5,401	13,833	0	62	9,820	15,743	0	117	0	0
7	A	38,009	895	2,367	14	0	0	1,324	1,053	0	4	0	0
	B	16,656	392	1,037	6	0	0	580	462	0	2	0	0
	C	9,537	224	719	13	0	0	956	380	0	1	0	0
	D	26,109	615	1,626	11	0	0	910	723	0	3	0	0
	E	14,693	345	1,166	24	0	0	1,769	641	0	1	0	0
	F	3,081	72	435	19	0	0	1,322	312	0	0	0	0
	G	5,658	132	810	37	0	0	2,483	582	0	0	0	0
	H	1,803	42	282	13	0	0	910	208	0	0	0	0
Subtotal		115,547	2,718	8,442	138	0	0	10,254	4,361	0	11	0	0
8	A	6,748	0	740	761	0	80	60	4	0	113	0	0
Subtotal		6,748	0	740	761	0	80	60	4	0	113	0	0

Source: Project Team

Table 6.4.53 Converted Crop Area in WRAs/WRUs (ha), Maize, rice, tobacco, cotton (2/2)

WRA	WRU	Maize			Rice			Tobacco			Cotton		
		Sum.	Est.	Win.	Sum.	Est.	Win.	Sum.	Est.	Win.	Sum.	Est.	Win.
9	A	11,055	0	1,386	1,743	0	197	88	6	0	278	0	0
	B	20,060	0	2,524	3,189	0	360	159	11	0	510	0	0
Subtotal		31,115	0	3,910	4,931	0	557	247	17	0	788	0	0
10	A	20,787	111	920	683	0	0	249	63	0	567	0	0
Subtotal		20,787	111	920	683	0	0	249	63	0	567	0	0
11	A	42,178	107	2,279	5,158	0	161	493	148	0	927	0	0
Subtotal		42,178	107	2,279	5,158	0	161	493	148	0	927	0	0
12	A	120	0	23	2	0	0	1	2	0	0	0	0
Subtotal		120	0	23	2	0	0	1	2	0	0	0	0
13	A	34	0	6	1	0	0	0	0	0	0	0	0
Subtotal		34	0	6	1	0	0	0	0	0	0	0	0
14	A	14,889	50	606	10	0	0	89	15	0	30	0	0
	B	55,043	116	2,555	2,287	0	0	311	29	0	53	0	0
	C	26,555	7	1,216	2,013	0	0	107	0	0	23	0	0
	D	6,209	26	690	57	0	8	12	8	0	102	0	0
Subtotal		102,695	198	5,066	4,367	0	8	519	53	0	209	0	0
15	A	46,497	1,953	5,820	1,494	0	106	3,389	2,727	0	2,982	6	0
	B	25,949	1,292	4,584	3,078	0	252	474	1,124	0	573	0	0
	C	908	18	153	224	0	18	20	34	0	34	0	0
Subtotal		73,354	3,263	10,557	4,796	0	376	3,883	3,885	0	3,589	6	0
16	E	7,483	101	901	1,150	0	120	147	178	0	105	0	0
	F	9,124	12	995	1,427	0	198	77	78	0	0	0	0
	G	3,420	9	398	504	0	70	210	66	0	0	0	0
Subtotal		20,027	122	2,294	3,082	0	388	434	322	0	105	0	0
17	A	1,353	0	300	584	0	73	3	0	0	103	0	0
	B	1,642	0	364	709	0	88	3	0	0	125	0	0
	C	8,536	10	1,863	3,499	0	436	236	51	0	616	0	0
Subtotal		11,532	10	2,526	4,791	0	597	242	52	0	844	0	0
Total		1,502,626	56,492	172,788	79,678	0	3,894	75,528	66,443	0	59,617	20	0

Source: Project Team

Table 6.4.54 Converted Crop Area in WRAs/WRUs (ha), Wheat, Coffee, Sugarcane, Tea (1/2)

WRA	WRU	Wheat			Coffee			Sugarcane			Tea		
		Sum.	Est.	Win.	Sum.	Est.	Win.	Sum.	Est.	Win.	Sum.	Est.	Win.
1	A	0	0	0	0	88	0	0	0	0	0	0	0
	B	0	0	0	0	14	0	0	0	0	0	0	0
	C	0	0	0	0	12	0	0	0	0	0	0	0
	E	0	0	0	0	45	0	0	0	0	158	832	0
	F	0	0	0	0	101	0	0	0	0	356	1,868	0
	G	0	0	0	0	0	0	0	0	0	0	0	0
	H	0	0	0	0	0	0	0	0	0	0	0	0
	K	3	0	0	0	0	0	0	0	0	0	0	0
	L	0	0	0	0	0	0	0	0	0	0	0	0
	M	367	0	0	0	0	0	0	0	0	0	0	0
	N	44	0	0	0	0	0	0	0	0	0	0	0
	O	455	0	41	0	0	0	0	0	0	0	0	0
	P	65	0	5	0	0	0	0	0	0	0	0	0
	R	0	0	55	0	12	0	0	0	0	0	0	0
	S	0	0	0	0	45	0	0	0	0	0	0	0
	T	0	0	0	0	81	0	0	0	0	0	0	0
Subtotal		935	0	102	0	397	0	0	0	0	514	2,700	0
2	A	5	0	0	0	0	0	0	0	0	1	6	0
	B	2	0	0	0	75	0	0	0	0	146	765	0
	C	0	0	0	0	11	0	0	0	0	0	0	0
	D	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal		6	0	0	0	86	0	0	0	0	147	771	0
3	A	1	0	0	0	142	0	0	0	0	0	0	0
	B	0	0	0	0	65	0	0	0	0	0	0	0
	C	1	0	3	0	124	0	0	0	0	0	0	0
	D	1	0	54	0	25	0	0	0	0	0	0	0
	E	2	0	29	0	0	0	0	0	0	0	0	0
	F	2	0	0	0	0	0	0	0	0	0	0	0
Subtotal		5	0	85	0	355	0	0	0	0	0	0	0
4	A	1	0	0	0	0	0	0	0	0	0	0	0
	B	7	0	0	0	0	0	0	0	0	0	0	0
	C	0	0	0	0	0	0	0	0	0	0	0	0
	D	0	0	0	0	0	0	0	0	0	0	0	0
	E	0	0	0	0	0	0	0	0	0	0	0	0
	F	1	0	0	0	0	0	0	0	0	0	0	0
Subtotal		10	0	0	0	0	0	0	0	0	0	0	0
5	C	3	0	0	1	0	0	0	0	0	0	0	0
	D	10	0	0	2	0	0	0	0	0	0	0	0
	E	1	0	0	0	0	0	0	0	0	0	0	0
	F	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal		14	0	0	2	0	0	0	0	0	0	0	0
6	A	0	0	0	0	0	0	0	0	0	0	0	0
	B	0	0	0	0	0	0	0	0	0	0	0	0
	C	0	0	0	0	0	0	0	0	0	0	0	0
	D	1	0	0	63	0	0	0	0	0	0	0	0
Subtotal		1	0	0	63	0	0	0	0	0	0	0	0
7	A	2	0	0	134	0	0	0	0	0	0	0	0
	B	1	0	0	59	0	0	0	0	0	0	0	0
	C	2	0	0	106	0	0	0	0	0	0	0	0
	D	2	0	0	92	0	0	0	0	0	0	0	0
	E	4	0	0	197	0	0	0	0	0	0	0	0
	F	3	0	0	151	0	0	0	0	0	0	0	0
	G	6	0	0	284	0	0	0	0	0	0	0	0
	H	2	0	0	104	0	0	0	0	0	0	0	0
Subtotal		23	0	0	1,128	0	0	0	0	0	0	0	0
8	A	3	0	0	810	0	0	0	0	0	0	0	0
Subtotal		3	0	0	810	0	0	0	0	0	0	0	0

Source: Project Team

Table 6.4.55 Converted Crop Area in WRAs/WRUs (ha), Wheat, Coffee, Sugarcane, Tea (2/2)

WRA	WRU	Wheat			Coffee			Sugarcane			Tea		
		Sum.	Est.	Win.	Sum.	Est.	Win.	Sum.	Est.	Win.	Sum.	Est.	Win.
9	A	5	0	0	1,140	0	0	0	0	0	0	0	0
	B	9	0	0	2,058	0	0	0	0	0	0	0	0
Subtotal		14	0	0	3,198	0	0	0	0	0	0	0	0
10	A	1	0	0	0	214	0	0	0	0	0	0	0
Subtotal		1	0	0	0	214	0	0	0	0	0	0	0
11	A	1	0	0	0	205	0	0	0	0	0	0	0
Subtotal		1	0	0	0	205	0	0	0	0	0	0	0
12	A	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal		0	0	0	0	0	0	0	0	0	0	0	0
13	A	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal		0	0	0	0	0	0	0	0	0	0	0	0
14	A	0	0	0	0	106	0	0	0	0	319	1,673	0
	B	1	0	0	0	208	0	0	0	0	1,140	5,985	0
	C	0	0	0	0	0	0	0	0	0	533	2,799	0
	D	0	0	0	0	58	0	0	0	0	205	1,079	0
Subtotal		1	0	0	0	372	0	0	0	0	2,197	11,535	0
15	A	3	0	0	0	0	0	0	0	0	0	0	0
	B	6	0	0	1	0	0	0	0	0	0	0	0
	C	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal		9	0	0	2	0	0	0	0	0	0	0	0
16	E	3	0	0	50	0	0	0	0	0	24	124	0
	F	10	0	0	135	0	0	0	0	0	73	383	0
	G	4	0	0	69	0	0	0	0	0	26	135	0
Subtotal		18	0	0	254	0	0	0	0	0	122	642	0
17	A	0	0	0	0	0	0	0	0	0	0	0	0
	B	0	0	0	0	0	0	0	0	0	0	0	0
	C	1	0	0	25	0	0	0	0	0	0	0	0
Subtotal		1	0	0	25	0	0	0	0	0	0	0	0
Total		1,041	0	187	5,482	1,630	0	0	0	0	2,980	15,647	0

Source: Project Team

Table 6.4.56 Base Year Irrigated Area across WRAs (ha)

WRA	WRU	Maize			Rice			Tobacco		Cotton		Wheat		Coffee		Sugarcane		Tea	
		Sum.	Est.	Win.	Sum.	Est.	Win	Sum.	Est.	Sum.	Est.	Sum	Win	Sum	Est.	S-hold	Est.	S-hold	Est.
1	C.A	308,569	789	37,619	10,784	250	651	1,840	311	44,308	9	934	101	0	398	0	23,723	514	2,700
	%	0.8	3.0	5.0	0.7	90.0	100.0	1.0	1.0	3.0	80.0	10.0	40.0	25.0	50.0	-	90.0	20.0	35.0
	I.A	2,469	24	1,881	75	225	651	18	3	1,329	7	93	40	-	199	-	21,351	103	945
2	C.A	127,267	723	10,034	10,418	0	165	2,568	372	1,760	0	7	0	0	188	0	0	147	771
	%	1.6	3.0	5.0	1.0	-	100.0	1.0	1.0	3.0	-	10.0	40.0	25.0	50.0	-	-	30.0	35.0
	I.A	2,036	22	502	104	0	165	26	4	53	0	1	0	0	94	0	0	44	270
3	C.A	107,162	931	8,231	2,728	0	256	1,410	190	3,126	1	5	85	0	355	0	0	0	0
	%	1.3	3.0	5.0	0.7	-	100.0	1.0	1.0	1.0	80.0	10.0	40.0	25.0	50.0	-	-	-	-
	I.A	1,393	28	412	19	0	256	14	2	31	1	1	34	0	178	0	0	0	0
4	C.A	221,782	2,532	33,711	3,142	0	580	23,407	15,697	2,758	3	9	0	0	0	0	0	0	0
	%	0.7	3.0	6.0	0.5	-	100.0	1.0	1.0	1.0	80.0	10.0	40.0	25.0	-	-	-	-	-
	I.A	1,552	76	2,023	16	0	580	234	157	28	2	1	0	0	0	0	0	0	0
5	C.A	232,737	34,056	41,029	10,064	0	14	20,100	25,221	396	0	14	0	3	0	0	261	0	0
	%	1.0	3.0	5.0	0.5	-	100.0	1.0	1.0	1.0	-	10.0	40.0	25.0	-	-	90.0	-	-
	I.A	2,327	1,022	2,051	50	0	14	201	252	4	0	1	0	1	0	0	235	0	0
6	C.A	80,972	12,112	5,401	13,833	0	62	9,820	15,743	117	0	1	0	63	0	0	8,065	0	0
	%	1.6	3.0	5.0	1.0	-	100.0	2.0	2.0	3.0	-	10.0	40.0	25.0	-	-	90.0	-	-
	I.A	1,296	363	270	138	0	62	196	315	4	0	0	0	16	0	0	7,259	0	0
7	C.A	115,547	2,718	8,442	138	0	0	10,254	4,361	11	0	23	0	1,128	112	0	0	0	0
	%	1.6	3.0	5.0	1.0	-	-	1.0	1.0	3.0	-	10.0	40.0	25.0	50.0	-	-	-	-
	I.A	1,849	82	422	1	0	0	103	44	0	0	2	0	282	56	0	0	0	0
8	C.A	6,748	0	740	761	0	80	60	4	113	0	3	0	810	0	0	0	0	0
	%	1.7	3.0	5.0	1.0	-	100.0	1.0	1.0	2.0	-	10.0	40.0	25.0	-	-	-	-	-
	I.A	115	0	37	8	0	80	1	0	2	0	0	0	203	0	0	0	0	0
9	C.A	31,115	0	3,910	4,931	0	557	247	17	788	0	14	0	3,198	0	0	0	0	0
	%	1.6	-	5.0	1.0	-	100.0	1.0	1.0	2.0	-	10.0	40.0	25.0	-	-	-	-	-
	I.A	498	0	196	49	0	557	2	0	16	0	1	0	800	0	0	0	0	0
10	C.A	20,787	111	920	683	0	0	249	63	567	0	1	0	0	214	0	0	0	0
	%	1.7	3.0	5.0	1.0	-	-	1.0	1.0	2.0	-	10.0	40.0	25.0	50.0	-	-	-	-
	I.A	353	3	46	7	0	0	2	1	11	0	0	0	0	107	0	0	0	0
11	C.A	42,178	107	2,279	5,158	0	161	493	148	927	0	1	0	0	205	0	0	0	0
	%	1.6	3.0	5.0	1.0	-	100.0	1.0	1.0	5.0	-	10.0	40.0	25.0	50.0	-	-	-	-
	I.A	675	3	114	52	0	161	5	1	46	0	0	0	0	103	0	0	0	0
12+13	C.A	154	0	29	3	0	0	1	2	0	0	0	0	0	0	0	0	0	0
	%	1.5	3.0	5.0	100.0	-	-	1.0	1.0	-	-	10.0	40.0	25.0	0.0	-	-	-	-
	I.A	2	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	C.A	102,695	342	5,066	4,367	0	8	519	53	209	0	1	0	0	651	0	83	2,197	24,065
	%	3.0	20.0	40.0	1.0	-	100.0	5.0	5.0	5.0	-	10.0	40.0	25.0	50.0	-	90.0	30.0	35.0
	I.A	3,081	68	2,026	44	0	8	26	3	10	0	0	0	0	326	0	75	659	8,423
15	C.A	73,354	3,263	10,557	4,796	0	376	3,883	3,885	3,589	6	9	0	1	0	0	5,597	0	0
	%	0.6	3.0	5.0	1.0	-	100.0	0.5	0.5	0.5	80.0	10.0	40.0	25.0	0.0	-	90.0	0.0	0.0
	I.A	440	98	528	48	0	376	19	19	18	5	1	0	0	0	0	5,037	0	0
16	C.A	20,027	122	2,294	3,082	0	388	434	322	105	0	17	0	254	0	0	623	122	662
	%	10.0	35.0	40.0	2.0	-	100.0	10.0	10.0	10.0	0.0	10.0	40.0	25.0	0.0	-	90.0	30.0	100.0
	I.A	2,003	43	918	62	0	388	43	32	11	0	2	0	64	0	0	561	37	662
17	C.A	11,532	10	2,526	4,791	0	597	242	52	844	0	1	0	25	0	0	0	0	0
	%	1.6	3.0	5.0	1.0	-	100.0	1.0	1.0	2.0	-	10.0	40.0	25.0	0.0	-	-	-	-
	I.A	185	0	126	48	0	597	2	1	17	0	0	0	6	0	0	0	0	0

Source: Project Team

Note: C.A = Crop area, I.A = Irrigated area, Sum. = Summer, Est. = Estate, Win. = Winter, S-hold = Small holder,

Assumption-Fixed: Rice/winter = 100%、Cotton/estate = 80%、Wheat/summer = 10%、winter = 40%、Coffee/estate = 50%、Sugarcane/estate = 90%、Tea/holder = 20~30%、 Tea/estate = 35%, 100% (obtained from the site)

Source: The Project Team

Table 6.4.57 Base Year Irrigated Area across WRUs (ha) (1/3)

WRA	WRU	Maize			Rice			Tobacco		Cotton		Wheat		Coffee		Sugarcane		Tea	
		Sum.	Est.	Win.	Sum.	Est.	Win	Sum.	Est.	Sum.	Est.	Sum	Win	Sum	Est.	S-ho	Est.	S-ho	Est.
1	A	19,036	46	1,037	2,407	0	76	222	67	413	0	0	0	0	88	0	0	0	0
	#	140	1	107	4	0	76	2	1	76	0	0	0	-	44	-	0	0	0
	B	33,540	79	2,180	2,469	0	78	636	126	677	0	0	0	0	14	0	0	0	0
	#	181	2	138	6	0	78	6	1	97	0	0	0	-	7	-	0	0	0
	C	20,984	54	1,162	115	0	1	106	9	208	0	0	0	0	12	0	0	0	0
	#	125	2	95	4	0	1	1	0	67	0	0	0	-	6	-	0	0	0
	E	19,606	61	1,371	122	0	6	44	10	663	0	0	0	0	45	0	0	158	832
	#	131	2	100	4	0	6	0	0	70	0	0	0	-	23	-	0	32	291
	F	13,724	45	3,072	415	0	50	21	15	2,116	0	0	0	0	101	0	0	356	1,868
	#	131	1	100	4	0	50	0	0	71	0	0	0	-	51	-	0	71	654
	G	8,228	0	7,540	1,011	0	139	0	0	1,696	0	0	0	0	0	0	818	0	0
	#	141	0	108	4	0	139	0	0	76	0	0	0	-	0	-	736	0	0
	H	16,771	250	8,568	1,668	250	177	2	6	14,123	0	0	0	0	0	0	22,905	0	0
	#	303	8	231	9	225	177	0	0	163	0	0	0	-	0	-	20,615	0	0
	K	19,594	14	5,376	972	0	98	2	9	8,506	0	3	0	0	0	0	0	0	0
	#	240	0	183	7	0	98	0	0	129	0	0	0	-	0	-	0	0	0
	L	3,246	1	1,328	261	0	27	1	1	2,325	0	0	0	0	0	0	0	0	0
	#	52	0	39	2	0	27	0	0	28	0	0	0	-	0	-	0	0	0
	M	14,304	15	815	13	0	0	0	3	665	0	367	0	0	0	0	0	0	0
	#	118	0	90	4	0	0	0	0	63	0	37	0	-	0	-	0	0	0
	N	4,136	10	247	15	0	0	7	1	125	0	44	0	0	0	0	0	0	0
	#	29	0	22	1	0	0	0	0	16	0	4	0	-	0	-	0	0	0
	O	34,129	17	1,834	209	0	0	218	9	1,841	0	455	41	0	0	0	0	0	0
	#	236	1	180	7	0	0	2	0	127	0	46	16	-	0	-	0	0	0
	P	18,178	32	387	115	0	0	53	1	2,569	2	65	5	0	0	0	0	0	0
	#	117	1	89	4	0	0	1	0	63	2	7	2	-	0	-	0	0	0
	R	41,574	37	1,843	381	0	0	324	16	3,087	2	0	55	0	12	0	0	0	0
	#	248	1	189	8	0	0	3	0	133	2	0	22	-	6	-	0	0	0
	S	30,226	79	474	330	0	1	102	14	4,496	4	0	0	0	45	0	0	0	0
	#	195	2	149	6	0	1	1	0	105	3	0	0	-	23	-	0	0	0
	T	11,294	49	385	281	0	0	101	24	797	1	0	0	0	81	0	0	0	0
	#	82	12	62	3	0	0	19	1	44	0	0	0	-	161	-	0	0	0
	⇒	2,469	34	1,881	75	225	653	36	4	1,329	6	93	40	-	320	-	21,351	103	945
	Σ	308,569	789	37,619	10,784	250	651	1,840	311	44,308	9	934	101	0	398	0	23,723	514	2,700
2	A	25,611	177	3,338	3,242	0	0	359	7	4	0	5	0	0	0	0	0	1	6
	#	432	5	106	22	-	0	5	0	0	-	1	-	-	0	-	-	0	2
	B	76,215	500	5,030	4,283	0	69	1,666	248	1,205	0	2	0	0	177	0	0	146	765
	#	1,144	15	282	59	-	69	14	2	36	-	0	-	-	89	-	-	44	268
	C	17,989	46	1,198	1,383	0	42	458	87	424	0	0	0	0	11	0	0	0	0
	#	286	1	70	15	-	42	4	1	13	-	0	-	-	6	-	-	0	0
	D	7,452	0	468	1,510	0	54	85	29	128	0	0	0	0	0	0	0	0	0
	#	175	0	43	9	-	54	2	0	4	-	0	-	-	0	-	-	0	0
	⇒	2,036	22	502	104	-	165	26	4	53	-	1	-	-	94	-	-	44	270
	∑	127,267	723	10,034	10,418	0	165	2,568	371	1,761	0	7	0	0	188	0	0	147	771
3	A	13,815	74	612	454	0	0	165	42	377	0	1	0	0	142	0	0	0	0
	#	218	2	64	3	-	0	2	0	5	0	0	0	-	28	-	-	-	-
	B	6,315	551	280	207	0	0	76	19	172	0	0	0	0	65	0	0	0	0
	#	100	17	29	1	-	0	1	0	2	0	0	0	-	13	-	-	-	-
	C	13,732	67	661	420	0	3	162	38	372	0	1	3	0	124	0	0	0	0
	#	210	2	62	3	-	3	2	0	5	0	0	1	-	27	-	-	-	-
	D	31,335	34	2,098	431	0	25	340	23	827	0	1	54	0	25	0	0	0	0
	#	376	1	111	5	-	25	4	1	8	0	0	22	-	48	-	-	-	-
	E	25,883	88	2,492	575	0	107	284	23	631	0	2	29	0	0	0	0	0	0
	#	291	3	86	4	-	107	3	0	7	0	0	12	-	37	-	-	-	-
	F	16,082	117	2,089	640	0	121	383	45	747	1	2	0	0	0	0	0	0	0
	#	199	4	59	3	-	121	2	0	4	1	0	0	-	25	-	-	-	-
	⇒	1,393	28	412	19	-	256	14	2	31	1	1	34	-	178	-	-	-	-
	∑	107,162	931	8,231	2,728	0	256	1,410	190	3,126	1	5	85	0	355	0	0	0	0

Source: Project Team

Table 6.4.58 Base Year Irrigated Area across WRUs (ha) (2/3)

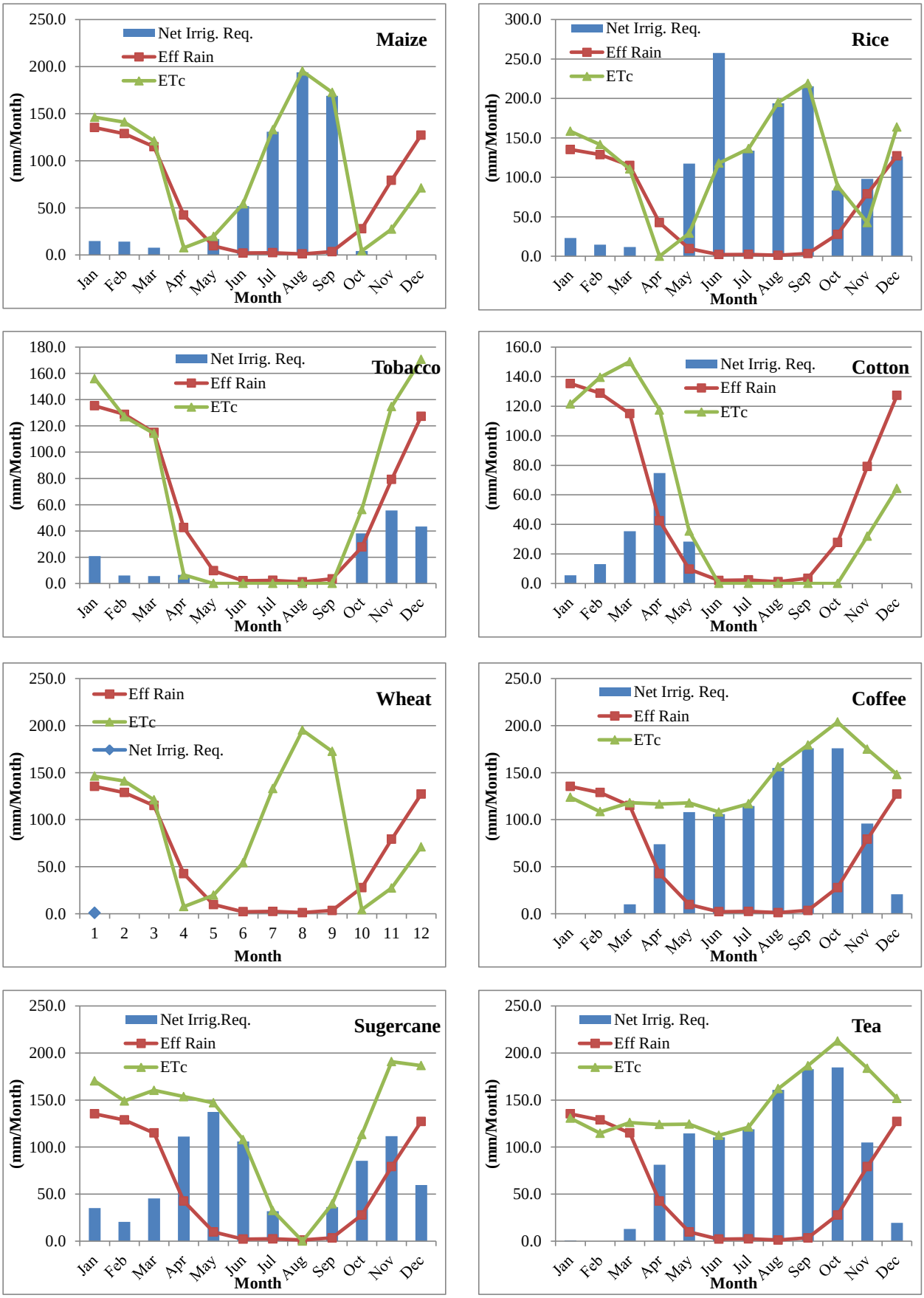
WRA	WRU	Maize			Rice			Tobacco		Cotton		Wheat		Coffee		Sugarcane		Tea	
		Sum.	Est.	Win.	Sum.	Est.	Win	Sum.	Est.	Sum.	Est.	Sum	Win	Sum	Est.	S-ho	Est.	S-ho	Est.
4	A	13,325	97	1,740	526	0	102	298	35	581	1	1	0	0	0	0	0	0	0
	#	105	5	137	1	-	102	16	11	6	1	0	-	-	-	-	-	-	-
	B	73,695	491	10,320	2,249	0	473	3,480	1,760	1,960	2	7	0	0	0	0	0	0	0
	#	534	26	695	5	-	473	80	54	20	2	1	-	-	-	-	-	-	-
	C	50,733	633	8,130	176	0	4	7,354	5,146	175	0	0	0	0	0	0	0	0	0
	#	347	17	452	4	-	4	52	35	2	0	0	-	-	-	-	-	-	-
	D	38,411	174	6,342	99	0	0	5,877	3,902	0	0	0	0	0	0	0	0	0	0
	#	250	12	326	3	-	0	38	25	0	0	0	-	-	-	-	-	-	-
	E	27,606	295	4,544	70	0	0	4,201	2,813	2	0	0	0	0	0	0	0	0	0
	#	181	9	235	2	-	0	27	18	0	0	0	-	-	-	-	-	-	-
	F	18,012	842	2,634	21	0	0	2,196	2,041	40	0	1	0	0	0	0	0	0	0
	#	136	7	177	1	-	0	20	14	0	0	0	-	-	-	-	-	-	-
	⇒	1,552	76	2,023	16	-	579	234	157	28	2	1	-	-	-	-	-	-	-
	∑	221,782	2,532	33,710	3,141	0	579	23,406	15,697	2,758	3	9	0	0	0	0	0	0	0
5	C	16,970	2,325	2,017	2,138	0	14	1,496	2,657	83	0	3	0	1	0	0	261	0	0
	#	233	102	205	5	-	14	20	25	1	-	0	-	0	-	-	235	-	-
	D	63,958	6,851	8,197	3,394	0	0	5,718	8,643	258	0	10	0	2	0	0	0	0	0
	#	751	330	662	16	-	0	65	81	3	-	1	-	1	-	-	0	-	-
	E	106,243	14,707	21,489	1,592	0	0	9,599	9,124	54	0	1	0	0	0	0	0	0	0
	#	911	400	803	20	-	0	79	99	1	-	0	-	0	-	-	0	-	-
	F	45,566	10,173	9,327	2,940	0	0	3,287	4,797	0	0	0	0	0	0	0	0	0	0
	#	433	190	382	9	-	0	37	47	0	-	0	-	0	-	-	0	-	-
	⇒	2,327	1,022	2,051	50	-	14	201	252	4	-	1	-	1	-	-	235	-	-
	∑	232,737	34,056	41,030	10,064	0	14	20,100	25,221	395	0	14	0	3	0	0	261	0	0
6	A	5,922	1,148	372	1,290	0	0	901	1,493	0	0	0	0	0	0	0	0	0	0
	#	85	24	18	9	-	0	13	21	0	-	0	-	0	-	-	0	-	-
	B	5,347	1,036	336	1,164	0	0	813	1,348	0	0	0	0	0	0	0	0	0	0
	#	77	21	16	8	-	0	12	19	0	-	0	-	0	-	-	0	-	-
	C	27,451	5,320	1,724	5,979	0	0	4,176	6,923	0	0	0	0	0	0	0	0	0	0
	#	393	110	82	42	-	0	60	96	0	-	0	-	0	-	-	0	-	-
	D	42,252	4,608	2,970	5,400	0	62	3,929	5,978	117	0	1	0	63	0	0	8,065	0	0
	#	741	208	155	79	-	62	112	180	4	-	0	0	16	0	0	7,259	-	-
	⇒	1,296	363	270	138	-	62	196	315	4	-	0	-	16	-	-	7,259	-	-
	∑	80,972	12,112	5,402	13,833	0	62	9,819	15,742	117	0	1	0	63	0	0	8,065	0	0
7	A	38,009	895	2,367	14	0	0	1,324	1,053	4	0	2	0	134	56	0	0	0	0
	#	587	26	134	0	-	-	33	14	0	-	0	-	34	28	-	-	-	-
	B	16,656	392	1,037	6	0	0	580	462	2	0	1	0	59	0	0	0	0	0
	#	257	11	59	0	-	-	14	6	0	-	0	-	15	0	-	-	-	-
	C	9,537	224	719	13	0	0	956	380	1	0	2	0	106	0	0	0	0	0
	#	154	7	35	0	-	-	9	4	0	-	0	-	27	0	-	-	-	-
	D	26,109	615	1,626	11	0	0	910	723	3	0	2	0	92	56	0	0	0	0
	#	403	18	92	0	-	-	22	10	0	-	0	-	23	28	-	-	-	-
	E	14,693	345	1,166	24	0	0	1,769	641	1	0	4	0	197	0	0	0	0	0
	#	240	11	55	0	-	-	13	6	0	-	0	-	49	0	-	-	-	-
	F	3,081	72	435	19	0	0	1,322	312	0	0	3	0	151	0	0	0	0	0
	#	60	3	14	0	-	-	3	1	0	-	0	-	38	0	-	-	-	-
	G	5,658	132	810	37	0	0	2,483	582	0	0	6	0	284	0	0	0	0	0
	#	111	5	25	0	-	-	6	3	0	-	1	-	71	0	-	-	-	-
	H	1,803	42	282	13	0	0	910	208	0	0	2	0	104	0	0	0	0	0
	#	37	2	8	0	-	-	2	1	0	-	0	-	26	0	-	-	-	-
	⇒	1,849	82	422	1	-	-	103	44	0	-	2	-	282	56	-	-	-	-
	∑	115,546	2,717	8,442	137	0	0	10,254	4,361	11	0	22	0	1,127	112	0	0	0	0
8	A	6,748	0	740	761	0	80	60	4	113	0	3	0	810	0	0	0	0	0
	#	115	-	37	8	-	80	1	0	2	-	0	0	203	-	-	-	-	-
	∑	6,748	0	740	761	0	80	60	4	113	0	3	0	810	0	0	0	0	0

Source: Project Team

Table 6.4.59 Base Year Irrigated Area across WRUs (ha) (3/3)

WRA	WRU	Maize			Rice			Tobacco		Cotton		Wheat		Coffee		Sugarcane		Tea	
		Sum.	Est.	Win.	Sum.	Est.	Win	Sum.	Est.	Sum.	Est.	Sum	Win	Sum	Est.	S-ho	Est.	S-ho	Est.
9	A	11,055	0	1,386	1,743	0	197	88	6	278	0	5	0	1,140	0	0	0	0	0
	#	177	-	70	18	-	197	1	0	6	-	1	-	284	-	-	-	-	-
	B	20,060	0	2,524	3,189	0	360	159	11	510	0	9	0	2,058	0	0	0	0	0
	#	321	-	126	32	-	360	2	0	10	-	1	-	515	-	-	-	-	-
	⇒	498	-	196	49	-	557	2	0	16	-	1	-	800	-	-	-	-	-
	∑	31,115	0	3,910	4,931	0	557	247	17	788	0	14	0	3,198	0	0	0	0	0
10	A	20,787	111	920	683	0	0	249	63	567	0	1	0	0	214	0	0	0	0
	#	353	3	46	7	-	-	2	1	11	-	0	-	-	107	-	-	-	-
	∑	20,787	111	920	683	0	0	249	63	567	0	1	0	0	214	0	0	0	0
11	A	42,178	107	2,279	5,158	0	161	493	148	927	0	1	0	0	205	0	0	0	0
	#	675	3	114	52	-	161	5	1	46	-	0	-	-	103	-	-	-	-
	S	42,178	107	2,279	5,158	0	161	493	148	927	0	1	0	0	205	0	0	0	0
12	A	120	0	23	2	0	0	1	2	0	0	0	0	0	0	0	0	0	0
13	A	34	0	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12+13	#	2	-	1	3	-	-	0	0	-	-	-	-	-	-	-	-	-	-
	S	154	0	29	3	0	0	1	2	0	0	0	0	0	0	0	0	0	0
14	A	14,889	50	606	10	0	0	89	15	30	0	0	0	0	106	0	0	319	1,673
	#	490	11	322	7	-	0	4	0	2	-	0	-	-	53	-	0	105	586
	B	55,043	259	2,555	2,287	0	0	311	29	53	0	1	0	0	208	0	50	1,140	12,267
	#	1,632	36	1,073	23	-	0	14	1	6	-	0	-	-	104	-	45	349	4,293
	C	26,555	7	1,216	2,013	0	0	107	0	23	0	0	0	0	100	0	0	533	9,046
	#	705	16	464	10	-	0	6	1	2	-	0	-	-	50	-	0	151	3,166
	D	6,209	26	690	57	0	8	12	8	102	0	0	0	0	237	0	33	205	1,079
	#	253	6	167	4	-	8	2	0	1	-	0	-	-	119	-	30	54	378
	⇒	3,081	68	2,026	44	-	8	26	3	10	-	0	-	-	326	-	75	659	8,423
	∑	102,696	342	5,067	4,367	0	8	519	52	208	0	1	0	0	651	0	83	2,197	24,065
15	A	46,497	1,953	5,820	1,494	0	106	3,389	2,727	2,982	6	3	0	0	0	0	558	0	0
	#	236	53	283	26	-	106	10	10	10	5	0	-	0	-	-	502	-	-
	B	25,949	1,292	4,584	3,078	0	252	474	1,124	573	0	6	0	1	0	0	4,697	0	0
	#	194	43	233	21	-	252	9	9	8	0	1	-	0	-	-	4,227	-	-
	C	908	18	153	224	0	18	20	34	34	0	0	0	0	0	0	341	0	0
	#	10	2	12	1	-	18	0	0	0	0	0	-	0	-	-	307	-	-
	⇒	440	98	528	48	-	376	19	19	18	5	1	-	0	-	-	5,036	-	-
	∑	73,354	3,263	10,557	4,796	0	376	3,883	3,885	3,589	6	9	0	1	0	0	5,596	0	0
16	E	7,483	101	901	1,150	0	120	147	178	105	0	3	0	50	0	0	0	24	0
	#	675	14	309	21	-	120	15	11	11	-	0	-	21	-	-	0	12	0
	F	9,124	12	995	1,427	0	198	77	78	0	0	10	0	135	0	0	623	73	662
	#	967	21	443	30	-	198	21	16	0	-	1	-	31	-	-	561	18	662
	G	3,420	9	398	504	0	70	210	66	0	0	4	0	69	0	0	0	26	0
	#	361	8	165	11	-	70	8	6	0	-	0	-	11	-	-	0	7	0
	⇒	2,003	43	918	62	-	388	43	32	11	-	2	-	64	-	-	561	37	662
	∑	20,027	122	2,294	3,081	0	388	434	322	105	0	17	0	254	0	0	623	123	662
17	A	1,353	0	300	584	0	73	3	0	103	0	0	0	0	0	0	0	0	0
	#	21	0	15	6	-	73	0	0	2	-	0	-	0	-	-	-	-	-
	B	1,642	0	364	709	0	88	3	0	125	0	0	0	0	0	0	0	0	0
	#	26	0	18	7	-	88	0	0	2	-	0	-	0	-	-	-	-	-
	C	8,536	10	1,863	3,499	0	436	236	51	616	0	1	0	25	0	0	0	0	0
	#	137	0	94	36	-	436	2	1	13	-	0	-	6	-	-	-	-	-
	⇒	185	0	126	48	-	597	2	1	17	-	0	-	6	-	-	-	-	-
	∑	11,532	10	2,526	4,791	0	597	242	52	844	0	1	0	25	0	0	0	0	0
Total		①	②	172,788	79,678	250	③	75,528	④	59,617	19	⑤	187	⑥	⑦	0	38,351	⑧	28,198

Note: ①= 1,502,626, ②= 57,815, ③= 3,894, ④= 66,443, ⑤= 1,041, ⑥= 5,482, ⑦= 2,123, ⑧=2,980, A~T=Crop area in WRU, #=Irrigated area in WRU, ⇒=Subtotal of Irrigated area in WRU, ∑=Subtotal of Crop area in WRU; Source: Project Team



Source: Project Team

Figure 6.4.7 Net Irrigation Requirement, Effective Rainfall and ETc for each Crop in WRA 1

Table 6.4.60 Base Year Water Demand (1/2)

WRA	WRU	Irrigated Area(ha)	Monthly gross water requirement ($x10^3m^3$)												Total
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	A	452	56	64	89	186	368	623	612	887	884	305	100	33	4,208
	B	516	74	83	105	163	313	586	616	903	869	180	34	24	3,950
	C	302	49	57	73	114	90	124	282	416	368	33	21	14	1,641
	E	658	56	60	143	546	708	737	934	1,301	1,370	1,015	572	117	7,559
	F	1,133	61	60	228	1,090	1,584	1,715	1,855	2,559	2,795	2,332	1,273	249	15,801
	G	1,205	501	324	658	1,529	2,166	2,207	1,084	997	1,464	1,335	1,427	768	14,459
	H	21,730	12,739	7,494	16,399	39,741	49,963	40,055	13,037	2,586	15,545	31,073	40,180	21,800	290,614
	K	658	93	109	136	201	381	725	772	1,136	1,085	187	15	19	4,858
	L	148	20	23	29	43	96	188	183	269	260	50	3	4	1,171
	M	311	57	64	73	99	69	98	245	364	317	8	7	9	1,410
	N	73	13	15	17	25	17	25	62	92	80	2	2	2	352
	O	615	106	121	142	198	145	213	536	796	693	19	17	21	3,008
	P	284	48	56	69	101	71	100	251	372	324	9	8	10	1,418
	R	612	98	113	143	220	168	243	592	876	768	44	31	26	3,321
	S	485	77	90	118	204	170	219	468	687	619	99	59	26	2,837
	T	383	44	43	84	320	415	436	586	819	851	613	350	94	4,654
	Σ	29,564	14,091	8,775	18,508	44,781	56,725	48,292	22,117	15,060	28,292	37,305	44,099	23,217	361,261
2	A	574	0	0	0	1	42	52	621	978	1,086	59	42	41	2,922
	B	2,021	0	0	0	2	346	365	1,992	3,085	3,675	773	288	239	10,764
	C	437	0	0	0	0	108	131	461	720	828	86	108	106	2,548
	D	288	0	0	0	0	119	145	313	486	573	77	120	118	1,951
	Σ	3,320	0	0	0	3	615	693	3,387	5,268	6,162	995	558	505	18,185
3	A	323	91	87	57	51	174	386	851	1,253	1,118	135	65	22	4,289
	B	163	46	44	28	23	85	193	431	635	566	63	30	10	2,155
	C	315	89	85	55	49	175	388	829	1,221	1,092	135	68	29	4,215
	D	601	175	163	107	88	367	820	1,588	2,337	2,106	277	162	104	8,292
	E	549	176	152	103	68	497	1,101	1,463	2,147	2,010	366	305	311	8,699
	F	418	142	117	82	48	455	1,004	1,119	1,639	1,570	333	306	339	7,154
	Σ	2,368	720	647	433	326	1,753	3,892	6,281	9,233	8,461	1,309	936	815	34,805
4	A	384	34	16	116	15	349	901	1,160	1,589	1,603	288	283	245	6,600
	B	1,890	170	81	564	53	1,652	4,320	5,739	7,859	7,898	1,364	1,336	1,145	32,180
	C	912	82	39	254	15	317	1,086	2,743	3,746	3,538	213	211	66	12,310
	D	654	59	28	181	9	221	768	1,971	2,692	2,539	148	146	41	8,803
	E	472	43	20	131	6	159	554	1,423	1,943	1,833	106	105	30	6,353
	F	355	32	15	99	5	120	416	1,069	1,460	1,377	80	79	22	4,776
	Σ	4,668	421	201	1,345	102	2,818	8,045	14,105	19,288	18,788	2,200	2,160	1,549	71,022
5	C	840	108	58	351	408	752	1,239	2,004	2,544	2,562	570	669	223	11,487
	D	1,910	174	84	535	25	679	2,324	5,867	8,013	7,568	412	381	119	26,181
	E	2,311	211	102	646	25	819	2,815	7,109	9,709	9,169	497	460	144	31,706
	F	1,098	100	49	307	11	389	1,338	3,379	4,615	4,358	236	219	68	15,070
	Σ	6,159	593	293	1,839	469	2,640	7,716	18,359	24,880	23,657	1,716	1,728	554	84,444
6	A	169	15	6	45	5	68	213	450	615	589	73	85	39	2,204
	B	152	13	6	41	4	62	192	406	555	532	66	77	35	1,990
	C	782	68	30	210	21	317	986	2,087	2,851	2,730	340	395	181	10,215
	D	8,815	2,061	1,185	6,955	14,560	19,172	18,181	9,322	5,707	10,780	15,727	19,791	6,090	129,530
	Σ	9,918	2,157	1,227	7,251	14,589	19,618	19,572	12,265	9,729	14,631	16,206	20,348	6,345	143,939
7	A	856	0	0	0	5	26	249	1,013	1,807	1,784	190	60	6	5,141
	B	363	0	0	0	2	6	100	434	774	758	60	19	3	2,157
	C	235	0	0	0	1	11	73	273	489	488	70	22	2	1,429
	D	597	0	0	0	3	21	177	703	1,255	1,243	148	47	4	3,601
	E	374	0	0	0	2	20	119	433	774	776	125	40	3	2,292
	F	119	0	0	0	0	15	48	129	231	244	81	26	1	775
	G	221	0	0	0	1	29	90	238	428	453	152	49	1	1,441
	H	76	0	0	0	0	11	32	81	145	154	55	18	0	496
	Σ	2,840	0	0	0	15	140	888	3,303	5,904	5,900	880	282	20	17,331
8	A	445	0	0	0	0	259	550	473	845	985	510	296	171	4,089
	Σ	445	0	0	0	0	259	550	473	845	985	510	296	171	4,089
9	A	752	1	0	0	0	548	1,160	832	1,474	1,724	827	590	419	7,574
	B	1,367	2	0	0	0	999	2,114	1,512	2,678	3,133	1,503	1,074	766	13,780
	Σ	2,119	3	0	0	0	1,546	3,273	2,343	4,152	4,857	2,330	1,664	1,185	21,354

Note: Σ = Sub-Total, Source: Project Team

Table 6.4.61 Base Year Water Demand (2/2)

WRA	WRU	Irrigated Area(ha)	Monthly gross water requirement (x103m3)												Total
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
10	A	531	130	125	98	183	407	709	1,372	2,001	1,841	443	232	67	7,608
	Σ	531	130	125	98	183	407	709	1,372	2,001	1,841	443	232	67	7,608
11	A	1,160	355	312	237	231	1,058	2,226	2,996	4,391	4,119	821	647	610	18,004
	Σ	1,160	355	312	237	231	1,058	2,226	2,996	4,391	4,119	821	647	610	18,004
12+13	A	7	0	0	0	0	0	0	0	0	0	0	0	0	0
	Σ	7	0	0	0	0	0	0	0	0	0	0	0	0	0
14	A	1,580	0	0	0	0	227	167	1,418	2,152	2,747	1,112	115	13	7,951
	B	7,577	0	0	0	2	1,432	1,036	6,213	9,250	12,524	6,780	714	46	37,998
	C	4,570	0	0	0	1	980	711	3,541	5,204	7,364	4,693	486	19	22,998
	D	1,021	0	0	0	1	181	128	849	1,276	1,705	809	90	23	5,062
	Σ	14,749	1	0	0	4	2,820	2,043	12,021	17,881	24,340	13,395	1,405	101	74,010
15	A	1,241	1	39	0	2	388	1,268	1,344	2,071	2,110	775	675	300	8,974
	B	4,996	12	212	0	2	1,686	4,967	2,294	2,192	3,932	5,016	4,038	910	25,261
	C	351	1	15	0	0	121	353	147	126	256	362	292	65	1,738
	Σ	6,589	15	266	0	5	2,195	6,588	3,785	4,389	6,299	6,153	5,005	1,275	35,974
16	E	1,210	0	26	0	3	269	1,110	2,019	3,422	3,090	356	298	271	10,864
	F	2,967	2	63	0	4	677	2,780	3,770	6,106	6,067	2,553	1,417	490	23,929
	G	647	0	14	0	2	155	620	1,089	1,845	1,670	198	170	156	5,920
	Σ	4,823	2	102	0	9	1,101	4,511	6,878	11,373	10,826	3,107	1,886	918	40,714
	A	117	0	3	0	0	149	377	208	338	354	108	150	151	1,838
	B	141	0	4	0	0	179	455	251	408	428	130	180	182	2,218
	C	725	0	21	0	0	893	2,279	1,284	2,089	2,183	665	902	905	11,222
	Σ	982	0	28	0	0	1,221	3,112	1,743	2,835	2,965	904	1,232	1,238	15,278
Total		90,242	18,487	11,977	29,711	60,718	94,917	112,110	①	137,228	②	88,271	82,476	38,570	948,016

Note: ①= 111,429, ②= 162,123, ∑= Subtotal; Source: Project Team

Table 6.4.62 Existing/Ongoing Major Irrigation Projects (DOI)

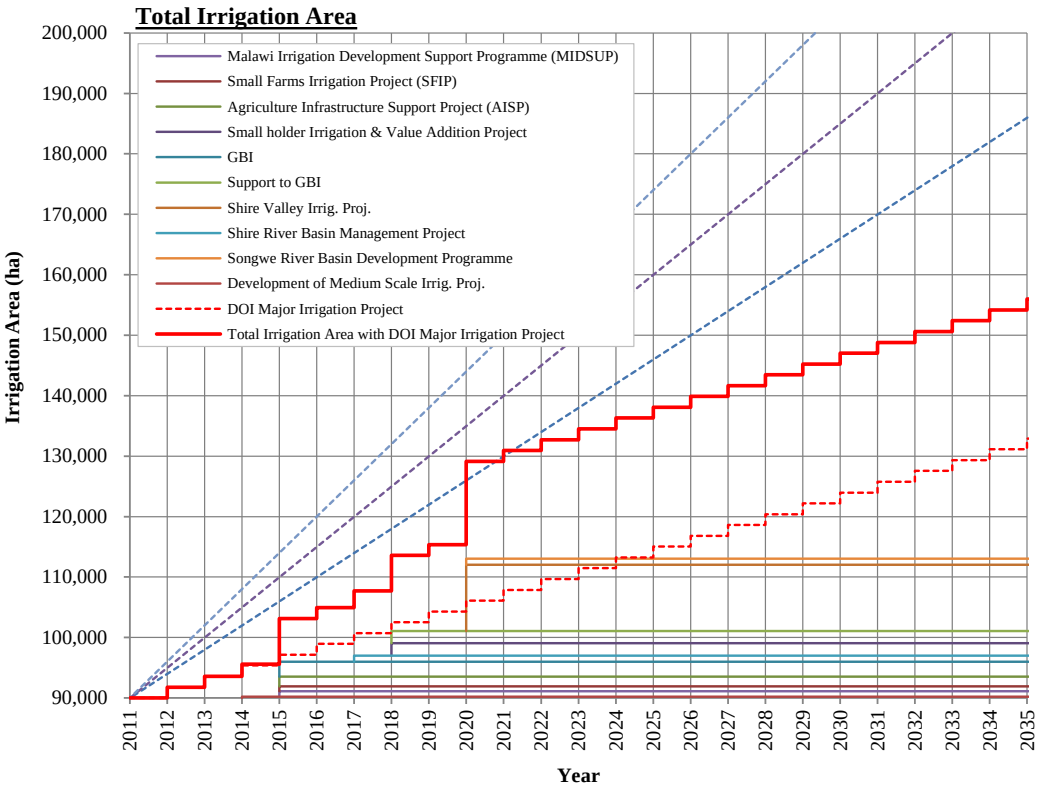
ISD	Existing / New	Name of Project	Irrig. Area (ha)	Major crop	Water Source	Budget	Completion /Target Year
Karonga	Existing	Lufilya I.S.	425		Lufilya R.		
		Wovwe I.S.	368		Wovwe R.		
		Hara I.S.	275		Hara R.		
	Ongoing	Nothla/Ilora-Ngosi Irrig. Site (GBI-pilot)	1,200		L. Malawi		
		Mphenga Corled	480		Wovwe R.		
		Timoti Irrig. S.	75		Tinofi R.		
		Ukanga Irrig. Site	30		Nyungwe R.		
Mzuzu	Ongoing	Limphasa (Gravity)	403	rice	Limphasa R.		
	Under const.	Lweya (pumping)	800				
Machinga	Existing	Domosi (Machinga)	500		Domosi R.		
		Nkopola (Mangochi)	800		L. Malawi		
		Likangala	397				
		Khanda	42				
		Njala	40				
		Segula	32				
		Chiliko	20				

Note: Additional data will be provided form DOI, Source: DOI

Table 6.4.63 Major Project to be Implemented

Project Name	Irrig. Area (ha)	F/S	Implementation	Crops	Remarks
Malawi Irrigation Development Support Programme (MIDSUP)	900		2015	Various	Already started.
Small Farms Irrigation Project (SFIP)	800	1 year	2015	Rice & others	Already started.
Agriculture Infrastructure Support Project (AISP)	1,600		2015	Horticulture & maize	Already started.
Small holder Irrigation &Value Added Project	2,050		~2018		The project already started.
GBI	2,500		2015	Rice & sugarcane	Already started.
Support to GBI	2,000	F/S	2018		
Shire Valley Irrig. Proj.	11,000	F/S	2020	Sugarcane, Rice, Cotton、	D/D: 2 years.
Shire River Basin Management Project	1,000		2017		Already started
Songwe River Basin Development Programme	1,000	F/S	2020		
Development of Medium Scale Irrig. Proj.	200		2014		Already started

Note: Additional data will be provided form DOI, Source: DOI



Source: Project Team

Figure 6.4.8 Relations between Demand Forecast and Ongoing/Future Projects

Table 6.4.64 Proportion of Irrigation Area for Water Demand Forecast

WRA	Base year	Irrig. area	2015	Irrig. area %	2020	Irrig. area %	2025	Irrig. area	2030	Irrig. area	2035	Irrig. area %	Irrig. .Potential (ha)
	2011(ha)	%	(ha)		(ha)		(ha)	%	(ha)	%	(ha)		DOI
1	29,414	32.65	35,915	32.65	47,250	35.00	56,000	35.00	64,750	35.00	73,500	35.00	103,450
2	3,320	3.68	4,048	3.68	5,400	4.00	6,400	4.00	7,400	4.00	8,400	4.00	61,500
3	2,368	2.63	2,893	2.63	4,050	3.00	4,800	3.00	5,550	3.00	6,300	3.00	43,300
4	4,669	5.18	4,895	4.45	4,887	3.62	4,880	3.05	4,884	2.64	4,893	2.33	4,890
5	6,159	6.84	8,327	7.57	9,963	7.38	12,720	7.95	16,466	8.90	18,207	8.67	21,200
6	9,918	11.01	12,111	11.01	13,500	10.00	16,000	10.00	18,500	10.00	21,000	10.00	28,800
7	2,841	3.15	3,465	3.15	4,050	3.00	4,800	3.00	5,550	3.00	6,300	3.00	31,200
8	445	0.49	539	0.49	675	0.50	800	0.50	925	0.50	1,050	0.50	1,700
9	2,119	2.35	2,585	2.35	2,700	2.00	3,200	2.00	3,700	2.00	4,200	2.00	18,300
10	531	0.59	649	0.59	675	0.50	800	0.50	925	0.50	1,050	0.50	3,600
11	1,160	1.29	1,430	1.30	2,700	2.00	3,200	2.00	3,700	2.00	4,200	2.00	12,630
12/13	7	0.01	7	0.00	7	0.00	7	0.00	7	0.00	7	0.00	-
14	14,749	16.37	18,011	16.37	20,243	14.99	23,993	15.00	27,743	15.00	28,093	13.38	28,100
15	6,590	7.31	8,041	7.31	6,750	5.00	8,000	5.00	9,250	5.00	13,900	6.62	94,500
16	4,823	5.35	5,885	5.35	6,750	5.00	8,000	5.00	9,250	5.00	10,500	5.00	16,800
17	982	1.09	1,199	1.09	5,400	4.00	6,400	4.00	6,400	4.00	8,400	4.00	15,000
Total	90,094	100	110,000	100.00	135,000	100.00	160,000	100.00	185,000	100.00	210,000	100.00	484,970

Note: In WRA 4 & 14, proportion is adjusted not to exceed the potential area. Irrigation area is to be increased 5,000 ha annually.

Table 6.4.65 Irrigation Water Demand for 2015 (1/2)

WRA	WRU	Irrigated Area(ha)	Monthly gross water requirement ($x10^3m^3$)												Total
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	A	549	68	78	109	226	447	756	744	1,078	1,074	371	122	40	5,113
	B	627	90	101	128	198	381	712	748	1,097	1,055	218	41	30	4,799
	C	366	60	70	88	139	109	150	342	505	447	41	26	17	1,993
	E	800	68	73	174	663	861	896	1,135	1,581	1,664	1,234	694	142	9,183
	F	1,376	74	73	277	1,324	1,924	2,083	2,254	3,108	3,395	2,833	1,546	303	19,195
	G	1,463	609	394	799	1,857	2,631	2,681	1,316	1,211	1,778	1,622	1,733	933	17,565
	H	26,398	15,475	9,103	19,922	48,279	60,696	48,660	15,838	3,142	18,885	37,748	48,811	26,483	353,043
	K	799	113	132	165	244	462	880	938	1,380	1,318	227	18	24	5,902
	L	180	24	28	36	53	117	228	222	327	316	61	4	5	1,422
	M	378	69	78	88	120	84	118	298	442	385	10	9	12	1,713
	N	89	16	18	21	30	21	30	75	111	97	3	2	3	427
	O	747	129	147	172	241	176	259	652	967	842	24	21	26	3,655
	P	345	58	68	84	122	86	121	305	452	394	11	10	12	1,722
	R	743	119	138	174	267	204	295	719	1,064	933	53	38	31	4,035
	S	590	93	109	144	247	207	266	569	835	752	120	71	32	3,446
	T	465	53	52	102	389	504	530	712	995	1,034	745	425	114	5,654
	Σ	35,915	17,118	10,660	22,483	54,401	68,911	58,666	26,868	18,295	34,369	45,319	53,572	28,205	438,867
2	A	700	-	-	-	1	52	63	758	1,192	1,324	72	52	50	3,563
	B	2,465	-	-	-	2	421	445	2,429	3,762	4,482	942	351	292	13,126
	C	533	-	-	-	1	131	160	562	877	1,010	105	131	129	3,106
	D	351	-	-	-	-	145	177	382	592	699	94	146	144	2,379
	Σ	4,048	-	-	-	4	749	845	4,130	6,424	7,514	1,213	680	615	22,175
3	A	395	111	106	69	62	212	472	1,040	1,531	1,366	164	79	27	5,241
	B	199	57	54	35	28	104	236	527	776	691	77	36	12	2,633
	C	384	109	103	68	60	213	474	1,013	1,492	1,334	165	83	36	5,151
	D	734	213	199	131	107	448	1,002	1,940	2,855	2,573	339	198	127	10,132
	E	670	215	185	126	83	607	1,345	1,787	2,624	2,456	447	372	380	10,629
	F	511	174	143	100	58	557	1,226	1,367	2,003	1,918	407	374	414	8,741
	Σ	2,894	879	791	529	398	2,141	4,756	7,674	11,281	10,338	1,599	1,143	996	42,526
4	A	402	36	17	122	15	366	945	1,216	1,666	1,681	302	296	257	6,920
	B	1,981	178	85	591	56	1,732	4,530	6,018	8,240	8,281	1,430	1,401	1,201	33,740
	C	956	86	41	266	15	332	1,138	2,876	3,927	3,709	224	221	69	12,906
	D	686	62	30	190	9	232	805	2,067	2,822	2,662	155	153	43	9,229
	E	495	45	21	137	6	167	581	1,491	2,037	1,921	112	111	31	6,661
	F	373	34	16	103	6	126	437	1,121	1,531	1,444	84	83	23	5,007
	Σ	4,894	441	210	1,410	107	2,954	8,435	14,788	20,223	19,698	2,306	2,265	1,624	74,464
5	C	1,136	146	78	474	551	1,017	1,675	2,709	3,439	3,463	770	905	301	15,530
	D	2,582	235	114	723	33	918	3,142	7,933	10,834	10,232	557	515	160	35,396
	E	3,125	285	138	874	34	1,108	3,806	9,611	13,126	12,397	672	622	194	42,866
	F	1,485	135	66	415	15	526	1,809	4,568	6,239	5,893	319	295	92	20,375
	Σ	8,327	802	396	2,486	634	3,569	10,432	24,822	33,638	31,984	2,319	2,337	748	114,168

Source: Project Team

Table 6.4.66 Irrigation Water Demand for 2015 (2/2)

WRA	WRU	Irrigated	Monthly gross water requirement ($x10^3m^3$)												Total
		Area(ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
6	A	206	18	8	55	6	83	260	550	751	719	89	104	48	2,691
	B	186	16	7	50	5	75	235	496	678	649	81	94	43	2,430
	C	955	83	36	256	26	387	1,205	2,548	3,482	3,334	415	482	221	12,474
	D	10,764	2,517	1,447	8,493	17,778	23,410	22,200	11,383	6,969	13,163	19,203	24,166	7,436	158,164
	Σ	12,111	2,634	1,498	8,854	17,814	23,955	23,899	14,976	11,880	17,865	19,788	24,846	7,747	175,758
7	A	1,044	-	-	-	6	32	303	1,235	2,205	2,177	232	74	8	6,271
	B	443	-	-	-	3	8	122	530	945	925	73	23	3	2,631
	C	286	-	-	-	2	13	89	333	596	595	85	27	2	1,743
	D	728	-	-	-	4	26	216	857	1,530	1,516	180	57	5	4,393
	E	456	-	-	-	2	25	145	528	944	947	152	49	3	2,796
	F	145	-	-	-	1	19	59	157	282	297	99	32	1	946
	G	270	-	-	-	1	35	110	291	523	552	185	60	1	1,758
	H	92	-	-	-	-	13	38	98	177	188	67	22		605
	Σ	3,465	-	-	-	18	171	1,083	4,029	7,201	7,197	1,073	344	25	21,141
8	A	539	-	-	-	-	313	666	573	1,023	1,193	617	359	207	4,952
	Σ	539	-	-	-	-	313	666	573	1,023	1,193	617	359	207	4,952
9	A	918	1	-	-	-	668	1,415	1,015	1,798	2,103	1,009	719	512	9,240
	B	1,667	2	-	-	-	1,218	2,579	1,844	3,267	3,822	1,833	1,311	934	16,811
	Σ	2,585	3	-	-	-	1,886	3,993	2,859	5,065	5,925	2,843	2,030	1,446	26,050
10	A	649	159	152	120	224	497	867	1,677	2,445	2,250	541	283	82	9,296
	Σ	649	159	152	120	224	497	867	1,677	2,445	2,250	541	283	82	9,296
11	A	1,430	438	385	292	285	1,305	2,744	3,694	5,413	5,078	1,012	797	752	22,195
	Σ	1,430	438	385	292	285	1,305	2,744	3,694	5,413	5,078	1,012	797	752	22,195
12+13	A	7	-	-	-	-	-	-	-	-	-	-	-	-	-
	Σ	7	-	-	-	-	-	-	-	-	-	-	-	-	-
14	A	1,930	-	-	-	1	278	204	1,732	2,628	3,355	1,358	140	16	9,710
	B	9,253	1	-	-	3	1,749	1,265	7,588	11,296	15,295	8,280	872	56	46,404
	C	5,581	-	-	-	1	1,196	868	4,325	6,355	8,993	5,731	594	23	28,086
	D	1,247	-	-	-	1	221	157	1,037	1,558	2,082	988	110	29	6,181
	Σ	18,011	1	-	-	5	3,443	2,494	14,681	21,836	29,724	16,358	1,715	123	90,381
15	A	1,515	2	48	-	3	474	1,548	1,640	2,527	2,575	945	823	366	10,950
	B	6,097	15	258	-	2	2,057	6,061	2,799	2,675	4,798	6,120	4,927	1,111	30,824
	C	428	1	18	-	-	148	430	180	154	313	442	356	79	2,121
	Σ	8,040	18	325	-	6	2,679	8,038	4,618	5,356	7,686	7,508	6,107	1,555	43,895
16	E	1,476	-	31	-	4	329	1,355	2,463	4,176	3,770	434	364	331	13,256
	F	3,620	2	77	-	5	826	3,393	4,600	7,450	7,402	3,115	1,729	598	29,197
	G	789	-	17	-	2	189	757	1,329	2,252	2,038	241	208	191	7,223
	Σ	5,885	2	125	-	11	1,344	5,504	8,392	13,877	13,210	3,790	2,301	1,120	49,677
17	A	142	-	4	-	-	182	461	254	412	432	132	183	184	2,243
	B	172	-	5	-	-	219	556	307	498	522	159	220	222	2,708
	C	885	-	25	-	-	1,091	2,782	1,568	2,550	2,665	812	1,101	1,105	13,699
	Σ	1,199	-	34	-	-	1,491	3,798	2,128	3,461	3,620	1,103	1,503	1,511	18,651
Total		109,999	22,495	14,577	36,175	73,908	115,410	136,222	135,909	167,417	197,652	107,391	100,283	46,758	1,154,197

Source: Project Team

Table 6.4.67 Irrigation Water Demand for 2020 (1/2)

WRA	WRU	Irrigated Area(ha)	Monthly gross water requirement ($x10^3m^3$)												Total
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	A	726	90	103	144	299	591	1,000	984	1,425	1,420	491	161	53	6,760
	B	829	118	134	169	262	503	941	989	1,451	1,395	289	55	39	6,346
	C	485	79	92	117	184	145	199	452	668	591	54	34	22	2,636
	E	1,058	89	96	230	877	1,138	1,184	1,501	2,090	2,200	1,631	918	188	12,143
	F	1,820	98	96	367	1,751	2,545	2,755	2,980	4,110	4,489	3,747	2,044	400	25,382
	G	1,935	805	521	1,056	2,456	3,479	3,545	1,741	1,601	2,352	2,145	2,292	1,234	23,226
	H	34,906	20,463	12,038	26,344	63,840	80,260	64,344	20,943	4,155	24,971	49,915	64,544	35,019	466,837
	K	1,057	149	174	219	323	611	1,164	1,241	1,825	1,742	300	24	31	7,804
	L	238	32	38	47	70	155	302	294	432	418	81	5	7	1,881
	M	500	91	103	117	158	111	157	394	585	509	13	12	15	2,266
	N	118	21	24	28	40	28	40	99	147	128	3	3	4	565
	O	988	171	194	228	319	232	343	862	1,278	1,114	31	28	34	4,833
	P	457	77	89	111	162	114	160	403	598	521	14	13	16	2,277
	R	982	157	182	230	354	270	390	950	1,407	1,234	70	50	41	5,335
	S	780	124	145	190	327	274	351	752	1,104	994	159	94	43	4,557
	T	615	70	69	135	514	666	700	942	1,316	1,367	985	562	150	7,477
	Σ	47,491	22,635	14,096	29,730	71,936	91,123	77,575	35,528	24,191	45,447	59,927	70,839	37,296	580,324
2	A	933	-	-	-	1	69	84	1,011	1,590	1,766	96	69	67	4,753
	B	3,288	-	-	-	3	562	594	3,240	5,019	5,978	1,257	469	389	17,510
	C	711	-	-	-	1	175	213	749	1,170	1,347	140	175	173	4,144
	D	468	-	-	-	-	194	237	509	790	932	125	195	192	3,174
	Σ	5,400	-	-	-	5	1,000	1,127	5,509	8,569	10,024	1,618	908	821	29,581
3	A	553	156	149	97	87	297	660	1,456	2,144	1,913	230	110	38	7,336
	B	279	79	76	49	40	145	331	738	1,087	968	108	51	17	3,686
	C	538	153	145	95	84	299	664	1,418	2,088	1,868	230	117	50	7,210
	D	1,027	299	279	183	150	628	1,402	2,715	3,997	3,602	474	278	178	14,183
	E	938	302	259	177	116	850	1,883	2,502	3,673	3,438	626	521	532	14,880
	F	716	243	200	140	81	779	1,717	1,914	2,804	2,685	570	524	580	12,237
	Σ	4,051	1,231	1,107	741	557	2,998	6,658	10,743	15,792	14,473	2,239	1,601	1,395	59,533
4	A	402	36	17	122	15	365	944	1,214	1,663	1,678	302	296	257	6,908
	B	1,978	178	84	590	56	1,729	4,522	6,008	8,226	8,267	1,428	1,398	1,199	33,685
	C	955	86	41	266	15	332	1,137	2,871	3,921	3,703	223	221	69	12,885
	D	685	62	30	190	9	231	803	2,063	2,818	2,658	154	153	43	9,214
	E	494	45	21	137	6	167	580	1,489	2,034	1,918	111	110	31	6,650
	F	372	34	16	103	6	126	436	1,119	1,528	1,442	84	83	23	4,999
	Σ	4,886	440	210	1,408	107	2,950	8,421	14,764	20,190	19,666	2,302	2,261	1,622	74,342
5	C	1,359	175	93	567	660	1,217	2,004	3,242	4,115	4,144	922	1,083	360	18,582
	D	3,089	281	136	865	40	1,098	3,760	9,491	12,962	12,242	667	616	192	42,351
	E	3,738	341	165	1,045	40	1,326	4,554	11,499	15,705	14,832	804	744	233	51,288
	F	1,777	162	78	496	18	630	2,165	5,466	7,465	7,050	382	354	111	24,378
	Σ	9,963	959	474	2,974	759	4,270	12,482	29,698	40,247	38,268	2,775	2,796	896	136,598
6	A	230	20	9	62	6	93	290	613	837	802	100	116	53	2,999
	B	207	18	8	56	6	84	262	553	756	724	90	105	48	2,708
	C	1,065	93	41	286	29	431	1,343	2,840	3,881	3,716	462	538	246	13,904
	D	11,998	2,806	1,613	9,467	19,817	26,095	24,746	12,688	7,768	14,673	21,406	26,937	8,288	176,304
	Σ	13,500	2,936	1,670	9,870	19,857	26,703	26,640	16,694	13,242	19,914	22,058	27,696	8,636	195,916

Source: Project Team

Table 6.4.68 Irrigation Water Demand for 2020 (2/2)

WRA	WRU	Irrigated Area(ha)	Monthly gross water requirement ($x10^3m^3$)												Total
			Jan	Jan	Jan	Jan	Jan	Jan	Jan	Jan	Jan	Jan	Jan	Jan	
7	A	1,220	-	-	-	7	37	355	1,444	2,577	2,544	271	86	9	7,329
	B	517	-	-	-	3	9	143	619	1,104	1,081	85	27	4	3,075
	C	334	-	-	-	2	16	104	390	697	695	100	32	2	2,037
	D	851	-	-	-	5	30	253	1,002	1,789	1,772	211	67	6	5,134
	E	533	-	-	-	3	29	170	617	1,104	1,107	178	57	4	3,268
	F	170	-	-	-	1	22	69	183	329	348	115	37	1	1,105
	G	316	-	-	-	1	41	128	340	611	645	216	70	2	2,055
	H	108	-	-	-	-	15	45	115	207	220	79	26	1	707
	Σ	4,050	-	-	-	21	200	1,265	4,709	8,417	8,412	1,254	402	29	24,710
8	A	675	1	-	-	-	392	834	718	1,281	1,494	773	449	260	6,202
	Σ	675	1	-	-	-	392	834	718	1,281	1,494	773	449	260	6,202
9	A	959	1	-	-	-	698	1,478	1,060	1,878	2,197	1,054	751	534	9,651
	B	1,741	2	-	-	-	1,272	2,694	1,926	3,412	3,992	1,915	1,369	976	17,559
	Σ	2,700	3	-	-	-	1,970	4,171	2,986	5,290	6,189	2,969	2,120	1,510	27,209
10	A	675	166	159	125	233	517	902	1,744	2,544	2,340	563	294	85	9,672
	Σ	675	166	159	125	233	517	902	1,744	2,544	2,340	563	294	85	9,672
11	A	2,700	827	727	551	538	2,464	5,181	6,974	10,221	9,588	1,912	1,506	1,419	41,907
	Σ	2,700	827	727	551	538	2,464	5,181	6,974	10,221	9,588	1,912	1,506	1,419	41,907
12+13	A	7	-	-	-	-	-	-	-	-	-	-	-	-	-
	Σ	7	-	-	-	-	-	-	-	-	-	-	-	-	-
14	A	2,169	-	-	-	1	312	229	1,946	2,953	3,770	1,526	157	18	10,914
	B	10,400	1	-	-	3	1,965	1,422	8,528	12,696	17,190	9,307	980	63	52,154
	C	6,273	-	-	-	1	1,345	976	4,861	7,142	10,107	6,442	667	26	31,566
	D	1,401	-	-	-	1	248	176	1,165	1,751	2,340	1,110	124	32	6,947
	Σ	20,243	1	-	-	6	3,870	2,804	16,500	24,542	33,408	18,385	1,928	139	101,582
15	A	1,272	2	40	-	3	398	1,299	1,377	2,121	2,161	794	691	307	9,192
	B	5,118	13	217	-	2	1,727	5,087	2,349	2,245	4,028	5,138	4,136	933	25,875
	C	360	1	15	-	-	124	361	151	129	263	371	299	66	1,780
	Σ	6,749	15	273	-	5	2,249	6,748	3,877	4,496	6,452	6,302	5,126	1,306	36,848
16	E	1,693	-	36	-	4	377	1,554	2,825	4,789	4,324	498	417	380	15,204
	F	4,152	2	88	-	6	947	3,891	5,276	8,545	8,490	3,573	1,984	686	33,489
	G	905	-	19	-	2	217	868	1,525	2,583	2,337	277	238	219	8,285
	Σ	6,750	2	143	-	13	1,541	6,313	9,626	15,917	15,151	4,348	2,639	1,284	56,978
17	A	641	-	19	-	-	818	2,074	1,143	1,857	1,947	594	823	828	10,102
	B	775	-	23	-	-	986	2,503	1,381	2,244	2,352	717	992	999	12,197
	C	3,984	-	114	-	2	4,912	12,530	7,060	11,487	12,004	3,657	4,957	4,977	61,699
	Σ	5,400	-	155	-	2	6,715	17,107	9,584	15,587	16,303	4,969	6,771	6,804	83,998
Total		135,240	29,216	19,014	45,399	94,039	148,961	178,229	169,655	210,527	247,129	132,393	127,336	63,502	1,465,400

Source: Project Team

Table 6.4.69 Irrigation Water Demand for 2025 (1/2)

WRA	WRU	Irrigated Area(ha)	Monthly gross water requirement ($x10^3m^3$)												Total
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	A	860	106	122	170	354	700	1,185	1,166	1,689	1,683	581	191	63	8,012
	B	982	140	159	200	311	597	1,115	1,172	1,720	1,654	342	65	47	7,521
	C	574	94	109	138	218	171	236	536	791	701	63	40	26	3,124
	E	1,253	106	114	272	1,040	1,349	1,404	1,779	2,477	2,608	1,933	1,088	223	14,392
	F	2,156	116	114	435	2,075	3,016	3,265	3,532	4,871	5,321	4,440	2,423	474	30,082
	G	2,294	954	617	1,252	2,911	4,123	4,202	2,063	1,898	2,787	2,542	2,716	1,462	27,528
	H	41,370	24,253	14,267	31,222	75,662	95,123	76,260	24,821	4,924	29,596	59,159	76,496	41,504	553,288
	K	1,252	177	207	259	383	725	1,379	1,470	2,163	2,065	356	29	37	9,249
	L	281	38	45	56	83	184	357	348	512	496	96	6	8	2,229
	M	593	108	122	138	188	132	186	467	693	604	15	14	18	2,685
	N	140	24	28	33	47	33	47	118	175	152	4	4	5	669
	O	1,171	202	230	270	378	276	406	1,021	1,515	1,320	37	33	40	5,728
	P	541	91	106	131	192	135	190	478	709	617	17	15	19	2,699
	R	1,164	186	215	273	419	320	462	1,126	1,667	1,462	83	60	49	6,323
	S	924	147	171	225	388	325	417	892	1,309	1,179	188	111	50	5,400
	T	729	83	82	160	609	790	830	1,116	1,559	1,620	1,167	666	178	8,861
	Σ	56,286	26,827	16,707	35,236	85,257	107,997	91,941	42,107	28,671	53,863	71,024	83,958	44,203	687,791
2	A	1,106	-	-	-	1	82	99	1,198	1,885	2,093	114	82	80	5,633
	B	3,897	-	-	-	3	666	704	3,839	5,947	7,085	1,489	555	461	20,751
	C	842	-	-	-	1	208	253	888	1,387	1,597	166	208	205	4,911
	D	554	-	-	-	1	229	280	603	936	1,105	148	231	228	3,761
	Σ	6,399	-	-	-	6	1,185	1,336	6,529	10,155	11,879	1,917	1,076	973	35,056
3	A	655	184	176	115	103	352	783	1,725	2,541	2,267	273	131	45	8,695
	B	331	94	90	58	47	172	392	874	1,288	1,147	128	60	21	4,369
	C	638	181	172	112	99	354	787	1,681	2,475	2,214	273	138	59	8,546
	D	1,217	354	330	217	178	744	1,662	3,218	4,737	4,269	562	329	211	16,810
	E	1,112	358	307	210	137	1,008	2,232	2,966	4,353	4,074	742	618	631	17,635
	F	848	288	237	166	97	923	2,035	2,268	3,323	3,182	676	621	687	14,503
	Σ	4,801	1,459	1,312	878	660	3,553	7,891	12,732	18,717	17,153	2,653	1,897	1,653	70,558
4	A	401	36	17	121	15	365	942	1,213	1,661	1,676	301	295	256	6,898
	B	1,975	177	84	590	56	1,726	4,516	5,999	8,214	8,255	1,426	1,396	1,197	33,637
	C	953	86	41	265	15	331	1,135	2,867	3,915	3,698	223	221	69	12,867
	D	684	62	30	190	9	231	802	2,060	2,814	2,654	154	153	43	9,201
	E	494	45	21	137	6	167	579	1,487	2,031	1,916	111	110	31	6,641
	F	371	34	16	103	6	126	435	1,117	1,526	1,440	84	83	23	4,992
	Σ	4,879	440	210	1,406	107	2,945	8,409	14,743	20,161	19,638	2,299	2,258	1,619	74,236
5	C	1,735	224	119	724	842	1,554	2,559	4,139	5,253	5,290	1,177	1,382	460	23,724
	D	3,944	359	174	1,105	51	1,402	4,800	12,117	16,549	15,630	851	786	245	54,070
	E	4,773	435	211	1,334	51	1,692	5,814	14,681	20,051	18,937	1,027	950	297	65,481
	F	2,268	207	100	634	24	804	2,764	6,979	9,531	9,001	488	451	141	31,123
	Σ	12,720	1,224	605	3,798	969	5,452	15,936	37,916	51,384	48,858	3,543	3,569	1,143	174,398
6	A	272	24	10	73	7	110	343	726	992	950	118	137	63	3,555
	B	246	21	9	66	7	100	310	656	896	858	107	124	57	3,210
	C	1,262	110	48	338	34	511	1,591	3,366	4,600	4,404	548	637	292	16,479
	D	14,220	3,325	1,912	11,220	23,487	30,927	29,329	15,038	9,207	17,390	25,369	31,926	9,823	208,953
	Σ	16,000	3,480	1,980	11,697	23,535	31,648	31,573	19,785	15,695	23,602	26,142	32,825	10,235	232,196

Source: Project Team

Table 6.4.70 Irrigation Water Demand for 2025 (2/2)

WRA	WRU	Irrigated Area(ha)	Monthly gross water requirement ($x10^3m^3$)												Total
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
7	A	1,446	-	-	-	8	44	420	1,711	3,054	3,015	321	102	11	8,687
	B	613	-	-	-	4	11	169	734	1,309	1,282	101	32	5	3,644
	C	396	-	-	-	2	19	123	462	826	824	118	38	3	2,414
	D	1,008	-	-	-	6	36	299	1,187	2,120	2,100	250	79	8	6,085
	E	632	-	-	-	3	34	201	731	1,308	1,312	211	68	4	3,873
	F	201	-	-	-	1	26	82	217	390	412	137	44	1	1,310
	G	374	-	-	-	2	49	152	403	724	765	256	83	2	2,436
	H	128	-	-	-	-	18	53	136	245	261	93	30	1	837
	Σ	4,799	-	-	-	25	237	1,500	5,581	9,976	9,970	1,486	476	34	29,286
8	A	800	1	-	-	-	465	988	851	1,518	1,770	916	532	308	7,350
	Σ	800	1	-	-	-	465	988	851	1,518	1,770	916	532	308	7,350
9	A	1,136	1	-	-	-	827	1,751	1,256	2,226	2,603	1,249	891	633	11,438
	B	2,064	2	-	-	-	1,508	3,192	2,283	4,044	4,732	2,270	1,623	1,157	20,810
	Σ	3,200	4	-	-	-	2,335	4,944	3,539	6,270	7,335	3,519	2,513	1,790	32,248
10	A	800	196	188	148	276	613	1,068	2,067	3,014	2,773	667	349	101	11,459
	Σ	800	196	188	148	276	613	1,068	2,067	3,014	2,773	667	349	101	11,459
11	A	3,200	980	862	653	638	2,920	6,140	8,266	12,114	11,363	2,266	1,785	1,682	49,668
	Σ	3,200	980	862	653	638	2,920	6,140	8,266	12,114	11,363	2,266	1,785	1,682	49,668
12+13	A	7	-	-	-	-	-	-	-	-	-	-	-	-	-
	Σ	7	-	-	-	-	-	-	-	-	-	-	-	-	-
14	A	2,571	-	-	-	1	370	272	2,307	3,501	4,469	1,809	187	21	12,936
	B	12,326	1	-	-	4	2,330	1,686	10,108	15,047	20,375	11,031	1,161	75	61,816
	C	7,435	-	-	-	1	1,594	1,157	5,761	8,466	11,979	7,635	791	30	37,414
	D	1,661	-	-	-	1	294	209	1,381	2,075	2,773	1,316	147	38	8,234
	Σ	23,993	1	-	-	7	4,587	3,323	19,557	29,089	39,596	21,791	2,285	164	120,400
15	A	1,507	2	48	-	3	471	1,540	1,632	2,514	2,562	940	819	364	10,894
	B	6,066	15	257	-	2	2,047	6,030	2,785	2,661	4,774	6,089	4,902	1,105	30,667
	C	426	1	18	-	-	147	428	179	153	311	440	354	78	2,110
	Σ	7,999	18	323	-	6	2,665	7,997	4,595	5,328	7,647	7,469	6,076	1,547	43,671
16	E	2,007	-	43	-	5	447	1,842	3,349	5,676	5,125	590	494	450	18,020
	F	4,921	3	104	-	7	1,123	4,612	6,253	10,127	10,063	4,235	2,351	813	39,690
	G	1,072	-	23	-	3	257	1,029	1,807	3,061	2,770	328	283	259	9,819
	Σ	8,000	3	170	-	15	1,827	7,482	11,409	18,864	17,957	5,153	3,128	1,522	67,530
17	A	760	-	22	-	-	969	2,459	1,355	2,200	2,307	704	975	982	11,973
	B	918	-	27	-	-	1,169	2,966	1,637	2,659	2,788	850	1,176	1,184	14,455
	C	4,722	-	135	-	2	5,821	14,851	8,367	13,614	14,227	4,335	5,875	5,898	73,124
	Σ	6,400	-	184	-	2	7,959	20,276	11,359	18,474	19,322	5,889	8,025	8,064	99,553
Total		160,284	34,632	22,539	53,816	111,503	176,387	210,805	201,036	249,430	292,727	156,735	150,751	75,040	1,735,401

Source: Project Team

Table 6.4.71 Irrigation water demand for 2030 (1/2)

WRA	WRU	Irrigated Area(ha)	Monthly gross water requirement ($x10^3m^3$)												Total
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	A	994	123	142	197	410	810	1,371	1,348	1,953	1,946	672	220	72	9,264
	B	1,135	162	183	231	360	690	1,290	1,355	1,988	1,912	396	75	54	8,696
	C	664	109	126	160	252	198	272	620	915	810	73	47	30	3,612
	E	1,449	123	131	315	1,202	1,559	1,623	2,057	2,864	3,015	2,235	1,258	258	16,641
	F	2,493	135	131	502	2,400	3,487	3,775	4,084	5,632	6,152	5,134	2,802	548	34,783
	G	2,652	1,104	713	1,448	3,365	4,768	4,859	2,385	2,194	3,223	2,939	3,141	1,690	31,829
	H	47,834	28,042	16,496	36,101	87,484	109,986	88,176	28,699	5,694	34,220	68,402	88,449	47,989	639,739
	K	1,448	204	239	300	443	838	1,595	1,700	2,501	2,388	411	33	43	10,695
	L	325	44	52	65	96	212	413	403	592	573	111	7	9	2,577
	M	685	125	141	160	217	152	215	540	801	698	18	16	21	3,105
	N	161	28	32	38	54	38	54	136	202	176	5	4	5	774
	O	1,354	234	266	312	437	319	470	1,181	1,752	1,526	43	38	46	6,623
	P	626	105	122	151	222	156	220	553	820	714	19	17	22	3,121
	R	1,346	215	249	316	484	370	534	1,302	1,928	1,690	96	69	56	7,311
	S	1,068	169	198	260	448	375	482	1,031	1,513	1,363	217	129	58	6,244
	T	843	96	94	185	704	913	960	1,291	1,803	1,873	1,350	770	206	10,246
	Σ	65,081	31,019	19,317	40,741	98,579	124,872	106,307	48,686	33,151	62,279	82,122	97,076	51,109	795,259
2	A	1,279	-	-	-	1	95	115	1,385	2,179	2,420	132	94	92	6,514
	B	4,506	-	-	-	4	770	814	4,440	6,877	8,193	1,722	642	533	23,995
	C	974	-	-	-	1	240	292	1,027	1,604	1,846	192	240	237	5,679
	D	641	-	-	-	1	265	324	698	1,083	1,278	171	267	263	4,349
	Σ	7,400	-	-	-	7	1,370	1,545	7,549	11,743	13,737	2,217	1,244	1,125	40,537
3	A	757	-	-	-	119	407	905	1,995	2,938	2,621	316	151	52	10,054
	B	382	-	-	-	54	199	453	1,011	1,489	1,326	147	69	24	5,052
	C	737	209	199	130	114	409	910	1,944	2,862	2,560	316	160	68	9,881
	D	1,408	409	382	251	205	860	1,922	3,721	5,477	4,936	650	381	244	19,437
	E	1,286	413	355	243	159	1,165	2,581	3,429	5,033	4,711	858	714	730	20,391
	F	981	333	274	192	112	1,068	2,353	2,622	3,842	3,680	781	718	794	16,769
	Σ	5,551	1,687	1,517	1,015	764	4,108	9,123	14,722	21,641	19,833	3,068	2,193	1,911	81,583
4	A	401	36	17	122	15	365	943	1,214	1,662	1,677	302	296	257	6,904
	B	1,977	178	84	590	56	1,728	4,519	6,004	8,221	8,262	1,427	1,398	1,198	33,664
	C	954	86	41	266	15	332	1,136	2,869	3,919	3,701	223	221	69	12,877
	D	685	62	30	190	9	231	803	2,062	2,816	2,656	154	153	43	9,209
	E	494	45	21	137	6	167	580	1,488	2,032	1,917	111	110	31	6,646
	F	372	34	16	103	6	126	436	1,118	1,527	1,441	84	83	23	4,996
	Σ	4,883	440	210	1,407	107	2,948	8,416	14,755	20,177	19,654	2,301	2,260	1,621	74,296
5	C	2,246	290	154	938	1,090	2,011	3,312	5,358	6,800	6,848	1,523	1,789	596	30,710
	D	5,105	465	225	1,430	66	1,814	6,214	15,686	21,423	20,233	1,102	1,018	317	69,994
	E	6,178	563	273	1,727	67	2,191	7,526	19,005	25,956	24,514	1,329	1,229	384	84,765
	F	2,936	268	130	821	31	1,041	3,577	9,034	12,338	11,652	632	584	183	40,289
	Σ	16,466	1,585	783	4,916	1,254	7,057	20,629	49,083	66,517	63,247	4,587	4,621	1,480	225,758
6	A	315	27	12	84	8	127	397	840	1,147	1,098	137	159	73	4,110
	B	284	25	11	76	8	115	358	758	1,036	992	123	143	66	3,711
	C	1,459	127	56	391	39	591	1,840	3,892	5,318	5,092	633	737	338	19,054
	D	16,442	3,845	2,211	12,973	27,157	35,759	33,911	17,388	10,645	20,107	29,333	36,914	11,358	241,602
	Σ	18,500	4,024	2,289	13,525	27,212	36,593	36,506	22,877	18,147	27,289	30,227	37,953	11,835	268,477

Source: Project Team

Table 6.4.72 Irrigation Water Demand for 2030 (2/2)

WRA	WRU	Irrigated Area(ha)	Monthly gross water requirement ($x10^3m^3$)												Total
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
7	A	1,672	-	-	-	9	51	486	1,978	3,532	3,486	371	118	13	10,044
	B	709	-	-	-	4	12	196	848	1,513	1,482	116	36	6	4,214
	C	458	-	-	-	2	21	142	534	955	953	137	44	3	2,791
	D	1,166	-	-	-	6	42	346	1,373	2,451	2,429	289	92	9	7,036
	E	731	-	-	-	4	40	233	846	1,512	1,517	244	78	5	4,478
	F	233	-	-	-	1	30	94	251	451	476	158	51	1	1,515
	G	433	-	-	-	2	57	176	466	837	884	296	96	2	2,816
	H	148	-	-	-	1	21	62	157	283	301	108	35	1	968
	Σ	5,549	-	-	-	29	274	1,734	6,453	11,535	11,528	1,719	551	40	33,862
8	A	925	1	-	-	-	538	1,143	984	1,756	2,047	1,060	615	356	8,499
	Σ	925	1	-	-	-	538	1,143	984	1,756	2,047	1,060	615	356	8,499
9	A	1,314	2	-	-	-	956	2,025	1,452	2,573	3,010	1,445	1,030	732	13,225
	B	2,386	3	-	-	-	1,744	3,691	2,639	4,676	5,471	2,624	1,876	1,337	24,062
	Σ	3,700	4	-	-	-	2,700	5,716	4,092	7,249	8,481	4,069	2,906	2,069	37,287
10	A	925	227	217	171	319	709	1,235	2,390	3,485	3,206	771	403	117	13,250
	Σ	925	227	217	171	319	709	1,235	2,390	3,485	3,206	771	403	117	13,250
11	A	3,700	1,133	997	755	737	3,376	7,100	9,557	14,006	13,138	2,620	2,063	1,945	57,428
	Σ	3,700	1,133	997	755	737	3,376	7,100	9,557	14,006	13,138	2,620	2,063	1,945	57,428
12+13	A	7	-	-	-	-	-	-	-	-	-	-	-	-	-
	Σ	7	-	-	-	-	-	-	-	-	-	-	-	-	-
14	A	2,973	-	-	-	1	428	314	2,668	4,048	5,167	2,092	216	25	14,957
	B	14,253	1	-	-	4	2,694	1,949	11,688	17,399	23,559	12,755	1,343	86	71,478
	C	8,597	-	-	-	1	1,843	1,337	6,661	9,789	13,852	8,828	915	35	43,262
	D	1,920	1	-	-	1	340	241	1,597	2,400	3,207	1,522	169	44	9,521
	Σ	27,743	1	-	-	8	5,304	3,842	22,613	33,635	45,785	25,197	2,642	190	139,218
15	A	1,743	2	55	-	3	545	1,780	1,886	2,907	2,962	1,087	947	421	12,597
	B	7,013	17	297	-	3	2,367	6,972	3,220	3,077	5,519	7,041	5,668	1,278	35,459
	C	493	1	21	-	-	170	495	207	177	360	508	409	91	2,440
	Σ	9,249	21	374	-	6	3,081	9,247	5,313	6,161	8,841	8,637	7,025	1,789	50,495
16	E	2,320	-	49	-	6	517	2,130	3,872	6,563	5,925	682	571	521	20,836
	F	5,690	3	121	-	8	1,298	5,332	7,230	11,709	11,635	4,897	2,718	940	45,892
	G	1,240	-	27	-	3	297	1,190	2,089	3,539	3,203	379	327	300	11,354
	Σ	9,250	3	197	-	17	2,112	8,652	13,191	21,812	20,763	5,958	3,617	1,760	78,081
17	A	760	-	22	-	-	969	2,459	1,355	2,200	2,307	704	975	982	11,973
	B	918	-	27	-	-	1,169	2,966	1,637	2,659	2,788	850	1,176	1,184	14,455
	C	4,722	-	135	-	2	5,821	14,851	8,367	13,614	14,227	4,335	5,875	5,898	73,124
	Σ	6,400	-	184	-	2	7,959	20,276	11,359	18,474	19,322	5,889	8,025	8,064	99,553
Total		185,329	40,144	26,083	62,531	129,042	203,000	241,472	233,625	289,489	339,151	180,439	173,195	85,412	2,003,583

Source: Project Team

Table 6.4.73 Irrigation Water Demand for 2035 (1/2)

WRA	WRU	Irrigated Area(ha)	Monthly gross water requirement ($x10^3m^3$)												Total
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	A	1,129	140	161	223	465	919	1,556	1,531	2,217	2,209	763	250	82	10,516
	B	1,289	184	208	263	408	783	1,464	1,538	2,257	2,170	449	85	61	9,871
	C	754	123	143	182	286	225	309	703	1,038	920	83	53	34	4,100
	E	1,645	139	149	357	1,365	1,770	1,842	2,335	3,252	3,422	2,537	1,428	293	18,889
	F	2,830	153	149	570	2,724	3,958	4,285	4,636	6,393	6,983	5,828	3,180	622	39,483
	G	3,010	1,253	810	1,643	3,820	5,412	5,515	2,708	2,491	3,658	3,336	3,565	1,919	36,130
	H	54,299	31,832	18,725	40,979	99,307	124,849	100,091	32,578	6,463	38,845	77,646	100,401	54,475	726,190
	K	1,644	232	271	340	503	951	1,810	1,930	2,839	2,710	467	38	48	12,140
	L	369	50	59	73	109	241	469	457	672	651	126	8	10	2,925
	M	778	142	160	182	247	173	244	613	909	792	20	18	24	3,524
	N	183	32	37	44	62	43	61	155	229	200	5	5	6	879
	O	1,537	266	302	354	496	362	533	1,341	1,988	1,732	49	43	53	7,518
	P	711	120	139	172	252	177	249	627	930	810	22	20	25	3,543
	R	1,528	244	283	359	550	420	607	1,478	2,188	1,919	109	79	64	8,299
	S	1,213	192	225	296	509	426	547	1,170	1,718	1,547	247	146	66	7,088
	T	957	109	107	210	799	1,037	1,090	1,465	2,047	2,127	1,532	874	234	11,630
	Σ	73,875	35,210	21,928	46,247	111,900	141,746	120,673	55,265	37,631	70,696	93,219	110,195	58,016	902,726
2	A	1,452	-	-	-	1	107	130	1,572	2,474	2,747	150	107	105	7,394
	B	5,115	-	-	-	4	874	924	5,040	7,807	9,300	1,955	729	605	27,238
	C	1,105	-	-	-	1	273	332	1,166	1,821	2,096	218	273	269	6,446
	D	728	-	-	-	1	301	368	792	1,229	1,450	194	303	299	4,937
	Σ	8,400	-	-	-	8	1,555	1,754	8,570	13,330	15,593	2,517	1,412	1,277	46,015
3	A	860	242	231	151	135	462	1,027	2,264	3,335	2,976	358	172	59	11,412
	B	434	123	118	76	62	226	514	1,147	1,691	1,505	167	79	27	5,734
	C	837	237	225	147	130	465	1,033	2,206	3,249	2,906	358	182	78	11,216
	D	1,598	465	433	284	233	977	2,182	4,224	6,217	5,603	737	432	277	22,063
	E	1,460	469	403	275	180	1,322	2,929	3,892	5,713	5,348	974	811	828	23,146
	F	1,113	378	311	218	127	1,212	2,671	2,977	4,362	4,177	887	815	902	19,035
	Σ	6,302	1,915	1,721	1,152	867	4,663	10,356	16,711	24,566	22,514	3,483	2,490	2,170	92,607
4	A	402	36	17	122	15	366	945	1,216	1,665	1,680	302	296	257	6,917
	B	1,980	178	85	591	56	1,731	4,528	6,015	8,236	8,277	1,430	1,400	1,200	33,726
	C	956	86	41	266	15	332	1,138	2,875	3,926	3,708	223	221	69	12,901
	D	686	62	30	190	9	232	804	2,066	2,821	2,661	155	153	43	9,226
	E	495	45	21	137	6	167	581	1,491	2,036	1,921	112	110	31	6,658
	F	372	34	16	103	6	126	436	1,120	1,530	1,443	84	83	23	5,005
	Σ	4,892	441	210	1,410	107	2,953	8,432	14,782	20,215	19,690	2,305	2,264	1,624	74,433
5	C	2,484	320	171	1,037	1,206	2,224	3,662	5,924	7,519	7,572	1,685	1,979	659	33,957
	D	5,645	514	249	1,582	73	2,006	6,870	17,345	23,688	22,372	1,219	1,125	351	77,394
	E	6,832	623	302	1,910	74	2,422	8,322	21,015	28,701	27,105	1,470	1,359	425	93,727
	F	3,247	296	143	907	34	1,151	3,956	9,989	13,642	12,884	699	646	202	44,549
	Σ	18,207	1,753	865	5,436	1,386	7,804	22,811	54,272	73,550	69,934	5,072	5,109	1,637	249,628
6	A	357	31	14	96	10	145	451	953	1,302	1,247	155	180	83	4,666
	B	323	28	12	87	9	131	407	860	1,176	1,126	140	163	75	4,213
	C	1,656	144	63	444	44	671	2,089	4,418	6,037	5,780	719	836	383	21,629
	D	18,664	4,364	2,509	14,726	30,827	40,592	38,494	19,737	12,084	22,824	33,297	41,903	12,893	274,250
	Σ	21,000	4,568	2,598	15,353	30,889	41,538	41,440	25,968	20,599	30,977	34,312	43,082	13,434	304,758

Source: Project Team

Table 6.4.74 Irrigation water demand for 2035 (2/2)

WRA	WRU	Irrigated Area(ha)	Monthly gross water requirement ($x10^3m^3$)												Total
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
7	A	1,898	-	-	-	11	57	552	2,246	4,009	3,958	422	134	14	11,401
	B	805	-	-	-	5	14	222	963	1,718	1,682	132	41	6	4,783
	C	520	-	-	-	3	24	161	606	1,084	1,081	155	50	4	3,168
	D	1,324	-	-	-	7	47	393	1,558	2,783	2,757	327	104	10	7,987
	E	829	-	-	-	4	45	264	960	1,717	1,721	277	89	6	5,083
	F	264	-	-	-	1	34	107	285	512	541	179	58	1	1,719
	G	491	-	-	-	2	64	200	528	950	1,004	337	109	3	3,197
	H	168	-	-	-	1	24	70	179	322	342	122	40	1	1,099
	Σ	6,299	-	-	-	33	310	1,969	7,325	13,093	13,086	1,951	625	45	38,438
8	A	1,050	1	-	-	-	611	1,297	1,117	1,993	2,324	1,203	698	404	9,647
	Σ	1,050	1				611	1,297	1,117	1,993	2,324	1,203	698	404	9,647
9	A	1,314	2	-	-	-	956	2,025	1,452	2,573	3,010	1,445	1,030	732	13,225
	B	2,386	3	-	-	-	1,744	3,691	2,639	4,676	5,471	2,624	1,876	1,337	24,062
	Σ	3,700	4	-	-	-	2,700	5,716	4,092	7,249	8,481	4,069	2,906	2,069	37,287
10	A	1,050	257	247	194	362	804	1,402	2,713	3,956	3,640	875	458	132	15,041
	Σ	1,050	257	247	194	362	804	1,402	2,713	3,956	3,640	875	458	132	15,041
11	A	4,200	1,286	1,131	857	837	3,832	8,059	10,849	15,899	14,914	2,974	2,342	2,208	65,189
	Σ	4,200	1,286	1,131	857	837	3,832	8,059	10,849	15,899	14,914	2,974	2,342	2,208	65,189
12+13	A	7	-	-	-	-	-	-	-	-	-	-	-	-	-
	Σ	7	-	-	-	-	-	-	-	-	-	-	-	-	-
14	A	3,010	-	-	-	1	433	318	2,701	4,099	5,232	2,118	218	25	15,146
	B	14,433	1	-	-	4	2,728	1,974	11,835	17,619	23,857	12,915	1,360	87	72,379
	C	8,706	-	-	-	1	1,866	1,354	6,746	9,912	14,026	8,940	926	36	43,807
	D	1,944	1	-	-	1	344	244	1,617	2,430	3,247	1,541	172	45	9,641
	Σ	28,093	1	-	-	8	5,371	3,891	22,899	34,059	46,363	25,514	2,676	192	140,974
15	A	2,619	3	83	-	5	819	2,675	2,835	4,368	4,451	1,634	1,423	632	18,929
	B	10,539	26	447	-	4	3,556	10,476	4,838	4,623	8,294	10,580	8,518	1,920	53,284
	C	740	2	32	-	-	255	744	311	266	541	764	615	136	3,666
	Σ	13,898	31	562	-	10	4,631	13,895	7,983	9,258	13,286	12,978	10,556	2,689	75,879
16	E	2,634	-	56	-	7	586	2,417	4,395	7,450	6,726	774	649	591	23,651
	F	6,459	4	137	-	9	1,474	6,053	8,207	13,292	13,207	5,558	3,086	1,067	52,093
	G	1,408	-	30	-	4	338	1,350	2,372	4,018	3,636	431	371	340	12,888
	Σ	10,500	4	223	-	20	2,398	9,821	14,974	24,760	23,569	6,763	4,105	1,998	88,633
17	A	997	-	29	-	-	1,272	3,227	1,778	2,888	3,028	925	1,279	1,289	15,715
	B	1,205	-	35	-	-	1,534	3,893	2,149	3,490	3,659	1,115	1,543	1,554	18,973
	C	6,198	-	177	-	2	7,641	19,492	10,982	17,868	18,672	5,689	7,710	7,741	95,976
	Σ	8,400	-	241	-	3	10,446	26,612	14,909	24,247	25,360	7,729	10,533	10,584	130,663
Total		209,873	45,471	29,727	70,649	146,431	231,362	278,127	262,430	324,405	380,424	204,963	199,452	98,479	2,271,918

Source: Project Team

Table 6.4.75 Revised Livestock Population in 2010/11, Population of Target Year & Livestock Ratio

	Livestock Population (x10^3)					Population (human) (x10^3)						Household Livestock Ratio				
District	Cattle	goats	sheep	pigs	Chicken	2011	2015	2020	2025	2030	2035	Cattle	goats	sheep	pigs	Chicken
Chitipa	56	44	4	39	881	195	217	247	279	314	365	1.36	1.05	0.11	0.95	21.26
Karonga	93	35	3	78	1,112	298	337	394	459	532	618	1.47	0.55	0.05	1.23	17.55
	177	203	12	103	1,371											
Mzimba	176	203	11	101	1,306	796	896	1,042	1,213	1,404	1,631	4.62	5.31	0.30	2.66	34.22
Mzuzu C	1			2	65	169	224	306	405	522	607	0.02	0.01	0.00	0.04	1.85
Rumphi	16	36	4	20	276	187	209	238	269	309	359	0.39	0.87	0.11	0.48	6.66
Nkhata Bay	9	28	2	16	479	237	269	316	368	426	495	0.20	0.61	0.05	0.34	10.30
Likoma	-	271	-	-	13	10	10	11	11	11	12	0.02	134.97	0.00	0.06	6.31
Kasungu	68	242	16	151	1,305	708	826	1,002	1,211	1,460	1,696	0.46	1.64	0.11	1.02	8.85
Ntchisi	23	113	7	64	323	250	286	337	398	470	545	0.43	2.12	0.14	1.20	6.08
Dowa	44	340	14	175	955	642	764	939	1,136	1,365	1,585	0.31	2.44	0.10	1.25	6.85
Mchinji	76	215	12	221	1,304	512	590	703	837	995	1,156	0.70	1.97	0.11	2.03	11.97
	84	560	15	169	12,567											
Lilongwe C	23	175	-	53	6,753	817	1,037	1,366	1,750	2,200	2,555	0.13	0.94	0.00	0.28	36.36
Lilongwe R	61	385	15	116	5,814	1,325	1,456	1,643	1,864	2,118	2,460	0.21	1.31	0.05	0.40	19.75
Dedza	48	213	8	52	996	671	735	826	929	1,044	1,213	0.31	1.36	0.05	0.33	6.38
Ntcheu	62	190	3	227	1,927	514	573	654	744	847	984	0.51	1.55	0.02	1.86	15.75
Salima	21	145	6	24	550	372	419	486	563	650	755	0.25	1.72	0.07	0.28	6.51
Nkhotakota	8	64	16	23	1,117	335	379	444	521	609	707	0.12	0.91	0.23	0.33	16.01
Machinga	12	124	21	8	467	538	608	713	839	987	1,146	0.09	0.97	0.17	0.06	3.64
Mangochi	22	356	20	16	5,667	885	1,017	1,216	1,458	1,743	2,024	0.11	1.73	0.10	0.08	27.52
	18	206	20	144	1,127											
Zomba C	3	2	1	15	110	108	139	185	240	304	354	0.12	0.10	0.02	0.62	4.70
Zomba R	15	204	19	129	1,017	614	661	725	797	871	1,012	0.10	1.39	0.13	0.88	6.95
Balaka	15	178	15	47	1,243	349	396	467	550	646	750	0.18	2.14	0.18	0.57	14.95
Mwanza	4	38	-	66	577	98	104	112	120	127	147	0.16	1.69	0.01	2.88	25.35
Neno	25	68	3	27	726	124	151	190	234	284	330	0.87	2.36	0.10	0.93	25.09
	28	98	7	122	7,687											
Blantyre C	1	51		9	4,996	752	884	1,073	1,287	1,531	1,778	0.01	0.29	0.00	0.05	28.58
Blantyre R	27	47	7	112	2,691	365	399	447	501	557	647	0.31	0.54	0.08	1.29	30.98
Chiradzulu	13	167	1	151	1,477	302	318	341	364	388	451	0.18	2.27	0.02	2.06	20.07
Phalombe	18	93	2	62	584	338	374	427	492	565	656	0.22	1.13	0.02	0.75	7.08
Mulanje	20	218	1	135	145	544	572	612	657	703	817	0.15	1.64	0.01	1.02	1.09
Thyolo	18	205	-	120	2,684	603	644	705	777	853	991	0.12	1.40	0.00	0.81	18.25
Chikwawa	107	171	5	58	428	475	534	620	720	835	969	1.01	1.62	0.04	0.55	4.06
Nsanje	32	112	1	34	266	256	282	320	365	418	485	0.55	1.96	0.02	0.60	4.67

Source; Project Team

Table 6.4.76 Base Year Water Demand for Livestock (1/3)

WRA	WRU	District	Crop area(ha)	ratio	popu. (10^3)	Livestock No. (10^3)					water (lit/day) (10^3)						
						cattle	goats	sheep	pigs	chicken	cattle	goats	sheep	pigs	chicken		WRU 計
1	A	MANGOCHI	347.659	0.112	99	2	40	2	2	635	99	279	16	27	222	643	
		MACHINGA	397.122	0.210	113	2	26	4	2	98	97	182	31	24	34	368	
		BALAKA	0.000	0.000	-	-	-	-	-	-	-	-	-	-	-	-	1,012
	B	MACHINGA	260.251	0.138	74	2	17	3	1	64	63	119	20	16	23	241	
		ZOMBA	449.637	0.234	144	4	48	5	30	238	144	333	32	454	83	1,046	
		BLANTYRE	246.583	0.183	67	5	9	1	21	492	196	60	9	308	172	746	
		BALAKA	0.114	0.000	-	-	-	-	-	-	-	-	-	-	-	-	
		NENO	0.561	0.000	-	-	-	-	-	-	1	-	-	-	-	1	2,035
	C	ZOMBA	14.759	0.008	5	-	2	-	1	8	5	11	1	15	3	34	
		CHIRADZULU	82.306	0.115	35	2	19	-	17	170	61	135	1	262	60	518	
		BLANTYRE	543.602	0.404	147	11	19	3	45	1,087	433	133	20	681	380	1,647	
		BLANTYRE C	22.907	0.200	150	-	10	-	2	999	10	72	-	28	350	460	
		NENO	0.259	0.000	-	-	-	-	-	-	-	-	-	-	-		2,660
	E	BLANTYRE	440.067	0.327	119	9	15	2	37	880	351	108	16	551	308	1,333	
		BLANTYRE C	46.810	0.410	308	1	21	-	4	2,049	20	147	-	58	717	943	
		THYOLO	151.970	0.095	57	2	20	-	11	256	67	137	-	171	89	465	
		CHIKWAWA	54.133	0.018	9	2	3	-	1	8	78	22	1	16	3	120	2,861
	F	THYOLO	341.356	0.214	129	4	44	-	26	574	151	308	1	384	201	1,044	
		CHIKWAWA	189.207	0.064	31	7	11	-	4	28	274	77	2	55	10	418	
		NSANJE	164.248	0.158	40	5	18	-	5	42	199	123	1	81	15	420	1,882
	G	NSANJE	749.351	0.721	185	23	80	-	25	192	910	563	5	370	67	1,916	1,916
	H	CHIKWAWA	1,522.107	0.517	245	55	88	2	30	221	2,206	617	17	446	77	3,364	
		NSANJE	82.847	0.080	20	3	9	-	3	21	101	62	1	41	7	212	3,575
	K	MWANZA	345.478	0.637	62	2	24	-	42	367	94	171	1	627	129	1,022	
		CHIKWAWA	925.750	0.314	149	34	54	1	18	135	1,342	376	10	271	47	2,046	3,068
	L	BLANTYRE	6.302	0.005	2	-	-	-	1	13	5	2	-	8	5	20	
		MWANZA	14.914	0.027	3	-	1	-	2	16	4	7	-	27	6	44	
		CHIKWAWA	253.539	0.086	41	9	15	-	5	37	367	103	3	74	13	560	625
	M	MWANZA	182.288	0.336	33	1	13	-	22	194	50	90	1	331	68	539	
		NENO	441.071	0.393	49	10	27	1	11	285	394	187	8	159	100	848	1,388
	N	BLANTYRE	100.767	0.075	27	2	4	1	8	202	80	25	4	126	71	306	
		CHIKWAWA	1.403	0.000	-	-	-	-	-	-	2	1	-	-	-	3	
		NENO	53.709	0.048	6	1	3	-	1	35	48	23	1	19	12	103	412
	O	NTCHEU	606.279	0.220	113	14	42	1	50	424	547	293	5	750	148	1,743	
		BLANTYRE	0.006	0.000	-	-	-	-	-	-	-	-	-	-	-	-	
		BALAKA	97.118	0.049	17	1	9	1	2	61	30	61	5	35	21	152	
		NENO	548.847	0.489	61	12	33	1	13	355	490	233	10	198	124	1,055	2,950
	P	NTCHEU	77.510	0.028	14	2	5	-	6	54	70	37	1	96	19	223	
		BLANTYRE	0.088	0.000	-	-	-	-	-	-	-	-	-	-	-	-	
		BALAKA	464.260	0.230	80	3	41	4	11	286	140	287	25	163	100	714	
		NENO	78.511	0.070	9	2	5		2	51	70	33	1	28	18	151	1,088
	R	NTCHEU	812.416	0.295	151	18	56	1	67	568	733	392	6	1,004	199	2,335	
		MANGOCHI	45.569	0.015	13	-	5	-	-	85	13	37	2	4	30	86	
		BALAKA	455.382	0.230	80	3	41	4	11	286	140	287	25	163	100	714	3,135
	S	MANGOCHI	180.100	0.058	51	1	21	1	1	329	51	145	8	14	115	333	
		MACHINGA	3.642	0.002	1	-	-	-	-	1	1	2	-	-	-	3	
		ZOMBA	0.003	0.000	-	-	-	-	-	-	-	-	-	-	-	-	
		BALAKA	851.273	0.430	150	7	77	7	20	534	261	536	46	304	187	1,334	1,671
	T	MANGOCHI	320.446	0.103	91	2	37	2	2	584	91	257	15	25	204	592	
		BALAKA	113.323	0.057	20	1	10	1	3	71	35	71	6	41	25	178	769
2	A	ZOMBA	3.551	0.002	1	-	-	-	-	2	1	3	-	4	1	8	
		MULANJE	1.299	0.001	-	-	-	-	-	-	1	1	-	2		4	
		PHALOMBE	689.993	0.649	220	12	61	1	40	379	477	425	8	604	133	1,646	1,658
	B	ZOMBA	1,103.236	0.573	352	9	117	11	74	583	352	817	78	1,112	204	2,562	
		ZOMBA C	14.190	0.863	93	2	2	-	13	95	96	15	3	188	33	336	
		CHIRADZULU	291.398	0.408	123	5	68	1	62	603	216	476	4	926	211	1,833	
		BLANTYRE	1.037	0.001	-	-	-	-	-	1	1	1	-	-	-	2	
		BLANTYRE C	7.480	0.065	49	-	3	-	1	325	3	23	-	9	114	149	
		MULANJE	174.821	0.122	66	2	27	-	16	18	95	186	1	247	6	536	
		PHALOMBE	249.154	0.235	79	4	22	-	15	137	172	153	3	218	48	594	6,014

Source: Project Team

Table 6.4.77 Base Year Water Demand for Livestock (2/3)

WRA	WRU	District	Crop area(ha)	ratio	popu. (10^3)	Livestock No. (10^3) cattle	goats	sheep	pigs	chicken	water (lit/day) (10^3) cattle	goats	sheep	pigs	chicken		WRU 計
2	C	MACHINGA	104.415	0.055	30	1	7	1		26	25	48	8	6	9	97	
		ZOMBA	353.409	0.184	113	3	37	4	24	187	113	262	25	357	65	823	
		ZOMBA C	2.248	0.137	15	-	-	-	2	15	15	2	1	30	5	53	973
	D	MACHINGA	281.969	0.149	80	2	18	3	1	70	69	129	22	17	24	262	262
3	A	MANGOCHI	562.396	0.181	160	4	64	4	3	1,026	160	451	26	44	359	1,040	1,040
	B	MANGOCHI	257.070	0.083	73	2	30	2	1	470	73	207	12	20	165	477	477
	C	DEDZA	8.608	0.004	2	-	1	-	-	4	7	5	-	3	1	16	
		NTCHEU	42.205	0.015	8	1	3	-	3	30	38	20	-	52	10	121	
		MANGOCHI	489.679	0.157	139	3	56	3	3	890	139	391	22	38	311	902	1,040
	D	DEDZA	75.394	0.031	21	2	7		2	31	60	47	2	24	11	144	
		NTCHEU	795.773	0.289	148	18	55	1	66	556	718	384	6	984	195	2,288	
		MANGOCHI	98.092	0.032	28	1	11	1	1	181	28	80	5	8	63	184	2,616
	E	DEDZA	327.091	0.136	92	7	29	1	7	136	262	203	8	105	48	626	
		NTCHEU	421.936	0.153	79	10	29		35	295	381	204	3	522	103	1,213	1,839
	F	SALIMA	183.403	0.103	38	2	15	1	2	57	88	105	4	37	20	254	
		DEDZA	329.983	0.138	92	7	29	1	7	137	264	205	8	106	48	632	886
4	A	SALIMA	134.744	0.076	28	2	11		2	42	65	77	3	27	15	187	
		DEDZA	283.531	0.118	79	6	25	1	6	118	227	176	7	91	41	543	730
	B	SALIMA	329.604	0.186	69	4	27	1	4	102	158	189	8	66	36	457	
		LILONGWE	417.768	0.101	134	6	39	2	12	587	246	272	11	176	206	912	
		DEDZA	1,373.530	0.573	384	28	122	5	29	570	1,100	853	34	442	200	2,629	3,998
	C	DOWA	175.126	0.065	42	3	22	1	11	63	114	156	6	172	22	470	
		SALIMA	57.930	0.033	12	1	5		1	18	28	33	1	12	6	80	
		LILONGWE	1,068.180	0.259	343	16	100	4	30	1,506	632	698	28	453	527	2,337	
		LILONGWE C	76.979	0.330	270	8	58	-	17	2,228	308	404	-	260	780	1,752	4,641
	D	LILONGWE	950.822	0.231	306	14	89	4	27	1,343	564	623	25	404	470	2,085	
		LILONGWE C	44.316	0.190	155	4	33	-	10	1,283	178	233	-	150	449	1,009	3,094
	E	DOWA	13.721	0.005	3	-	2	-	1	5	9	12	-	13	2	37	
		LILONGWE	609.244	0.148	196	9	57	2	17	861	361	399	16	259	301	1,336	
		LILONGWE C	95.257	0.408	333	10	71	-	21	2,755	381	499	-	322	964	2,167	3,539
	F	DOWA	333.367	0.125	80	5	42	2	22	119	218	297	12	327	42	895	
		LILONGWE	189.328	0.046	61	3	18	1	5	267	112	124	5	80	94	415	
		LILONGWE C	16.906	0.072	59	2	13	-	4	486	67	88	-	57	170	382	1,693
5	C	KASUNGU	405.690	0.089	63	6	21	1	13	115	241	150	10	200	40	642	
		NKHOTAKOTA	61.479	0.032	11	-	2	1	1	36	10	14	4	11	13	52	
		NTCHISI	260.308	0.182	46	4	21	1	12	59	166	144	9	174	21	514	1,208
	D	KASUNGU	699.506	0.153	108	10	37	2	23	199	415	258	17	346	70	1,106	
		NTCHISI	592.151	0.415	104	9	47	3	26	134	379	327	21	396	47	1,170	
		DOWA	1,058.226	0.396	254	17	135	5	69	378	692	943	38	1,038	132	2,842	5,118
	E	KASUNGU	228.246	0.050	35	3	12	1	8	65	136	84	6	113	23	361	
		DOWA	449.280	0.168	108	7	57	2	29	161	294	400	16	441	56	1,207	
		LILONGWE	889.289	0.216	286	13	83	3	25	1,256	527	582	23	377	440	1,949	
		MCHINJI	1,282.399	0.616	315	47	132	7	136	803	1,869	927	52	2,045	281	5,174	8,690
	F	KASUNGU	555.441	0.121	86	8	29	2	18	158	330	205	14	274	55	879	
		MCHINJI	798.944	0.384	196	29	82	5	85	500	1,164	577	32	1,274	175	3,223	4,102
6	A	KASUNGU	265.971	0.058	41	4	14	1	9	76	158	98	7	131	26	421	421
	B	KASUNGU	240.147	0.052	37	4	13	1	8	68	143	89	6	119	24	380	380
	C	KASUNGU	1,232.965	0.269	190	18	65	4	41	351	732	455	31	609	123	1,950	1,950
	D	MZIMBA	1,097.508	0.148	118	26	30	2	15	193	1,045	210	12	225	68	1,559	
		KASUNGU	955.929	0.209	148	14	50	3	31	272	568	353	24	472	95	1,512	
		NKHOTAKOTA	272.443	0.143	48	1	9	2	3	160	46	64	16	49	56	232	3,303
7	A	MZIMBA	2,331.553	0.314	250	55	64	4	32	410	2,216	445	25	478	144	3,309	3,309
	B	MZIMBA	1,021.713	0.138	110	24	28	2	14	180	974	196	11	210	63	1,454	1,454
	C	RUMPHI	106.759	0.094	18	2	3		2	26	60	24	3	28	9	125	
		MZIMBA	503.598	0.068	54	12	14	1	7	89	480	96	5	103	31	716	841
	D	NKHATABAY	0.838	0.001	-	-	-	-	-	-	-	-	-	-	-	1	
		MZIMBA	1,527.656	0.206	164	36	42	2	21	269	1,454	292	17	313	94	2,171	
		MZUZU	73.396	0.730	123	-	-	-	1	47	19	2	1	16	17	54	2,225
	E	RUMPHI	215.136	0.190	36	3	7	1	4	52	121	48	6	57	18	251	
		MZIMBA	737.211	0.099	79	17	20	1	10	129	699	140	8	151	45	1,043	1,294
	F	RUMPHI	207.891	0.184	34	3	7	1	4	51	117	47	6	55	18	243	
		MZIMBA	30.437	0.004	3	1	1	-	-	5	29	6		6	2	43	285
	G	RUMPHI	391.321	0.346	65	6	13	2	7	95	221	88	11	104	33	457	
		MZIMBA	48.584	0.007	6	1	1	-	1	9	49	10	1	11	3	74	531

Source: Project Team

Table 6.4.78 Base Year Water Demand for Livestock (3/3)

WRA	WRU	District	Crop area(ha)	ratio	popu. (10^3)	Livestock No. (10^3) cattle	goats	sheep	pigs	chicken	water (lit/day) (10^3) cattle	goats	sheep	pigs	chicken		WRU 計
7	H	RUMPHI	144.990	0.128	24	2	5	1	3	35	82	32	4	39	12	169	169
8	A	CHITIPA	419.665	0.202	39	11	9	1	8	178	454	62	6	120	62	704	
		KARONGA	81.345	0.065	19	6	2	-	5	72	243	16	1	76	25	361	1,065
9	A	CHITIPA	590.639	0.284	55	16	12	1	11	250	639	87	9	168	88	991	
		KARONGA	199.446	0.159	47	15	6	-	12	177	595	39	3	186	62	885	1,876
	B	CHITIPA	1,066.595	0.514	100	29	22	2	20	452	1,155	157	16	304	158	1,790	
		KARONGA	365.429	0.292	87	27	10	1	23	325	1,091	72	6	340	114	1,622	3,412
10	A	MANGOCHI	846.216	0.214	189	5	76	4	3	1,211	189	533	30	52	424	1,228	1,228
11	A	MANGOCHI	812.423	0.261	231	6	93	5	4	1,479	230	650	37	64	518	1,499	1,499
	A	MACHINGA	840.773	0.445	240	10	159	9	7	2,523	393	1,110	63	109	883	2,558	2,558
12	A	LIKOMA	9.876	0.780	8	-	211	-	-	10	1	1,477	-	1	3	1,483	1,483
13	A	LIKOMA	2.791	0.220	2	-	60	-	-	3	-	417	-	-	1	419	419
14	A	CHIRADZULU	113.956	0.160	48	2	27	-	24	236	84	186	1	362	82	717	
		BLANTYRE	6.318	0.005	2	-	-	-	1	13	5	2	-	8	5	20	
		BLANTYRE C	37.057	0.324	244	-	17	-	3	1,619	16	116	-	46	567	745	
		THYOLO	305.647	0.191	115	3	39	-	23	514	135	275	1	344	180	935	2,418
	B	CHIRADZULU	226.370	0.317	96	4	53	-	48	468	168	370	3	720	164	1,424	
		THYOLO	600.149	0.376	227	7	77	-	45	1,009	266	541	1	675	353	1,836	
		MULANJE	617.365	0.431	234	8	94	1	58	62	336	657	4	874	22	1,893	
		PHALOMBE	97.146	0.091	31	2	9	-	6	53	67	60	1	85	19	232	5,385
	C	MULANJE	639.675	0.446	243	9	97	1	60	65	349	681	4	905	23	1,962	
		PHALOMBE	26.104	0.025	8	-	2	-	2	14	18	16	-	23	5	62	2,024
	D	THYOLO	197.111	0.123	74	2	25	-	15	331	87	178	-	222	116	603	
		NSANJE	42.249	0.041	10	1	5	-	1	11	51	32	-	21	4	108	711
15	A	NKHOTAKOTA	131.438	0.069	23	1	4	1	2	77	22	31	8	24	27	112	
		NTCHISI	91.127	0.064	16	1	7	-	4	21	58	50	3	61	7	180	
		DOWA	644.602	0.241	155	11	82	3	42	230	421	574	23	632	81	1,731	
		SALIMA	1,066.662	0.602	224	13	87	4	14	331	513	611	26	214	116	1,480	3,503
	B	NKHOTAKOTA	1,105.955	0.582	195	5	37	10	13	650	187	260	67	201	228	942	
		NTCHISI	483.682	0.339	85	8	38	2	22	110	309	267	17	323	38	955	1,898
	C	NKHOTAKOTA	80.390	0.042	14	-	3	1	1	47	14	19	5	15	17	68	68
16	E	NKHATABAY	294.587	0.193	46	2	5	-	3	92	72	38	3	45	32	191	
		MZIMBA	117.033	0.016	12	3	3	-	2	20	110	22	1	24	7	164	
		NKHOTAKOTA	247.303	0.130	44	1	8	2	3	145	42	58	15	45	51	211	565
	F	NKHATABAY	912.507	0.597	141	6	17	1	9	286	224	118	9	140	100	591	
		MZIMBA	3.773	0.001	1	-	-	-	-	1	7	1	-	2	-	11	
		MZUZU	27.153	0.270	46	-	-	-	-	18	7	1	-	6	6	20	622
	G	NKHATABAY	320.693	0.210	50	2	6	-	3	100	79	41	3	49	35	208	
		RUMPHI	30.123	0.027	5	-	1	-	1	7	17	7	1	8	3	35	
		MZIMBA	0.947	0.000	-	-	-	-	-	-	1	-	-	-	-	1	
		MZUZU	0.038	0.000	-	-	-	-	-	-	-	-	-	-	-	-	244
17	A	KARONGA	73.797	0.059	18	6	2	-	5	66	220	14	1	69	23	328	328
	B	KARONGA	89.598	0.072	21	7	3	-	6	80	267	18	1	83	28	398	398
	C	KARONGA	441.949	0.353	105	33	12	1	27	393	1,319	86	7	412	137	1,962	
		RUMPHI	34.998	0.031	6	-	1	-	1	9	20	8	1	9	3	41	2,003
		lit/day (x 10^3)															134,531
		m^3/year (x 10^3)															49,104

Source: Project Team

Table 6.4.79 Target Year Water Demand for Livestock (1/2)

WRA	WRU	Target Year (10^3lit/day)				
		2015	2020	2025	2030	2035
1	A	1,107	1,324	1,643	1,953	2,268
1	B	1,932	2,461	2,749	3,057	3,550
1	C	2,927	3,303	3,720	4,230	4,960
1	E	3,199	3,681	4,226	4,828	5,606
1	F	2,043	2,287	2,574	2,893	3,359
1	G	2,099	2,383	2,721	3,116	3,618
1	H	4,012	4,652	5,402	6,257	7,265
1	K	3,384	3,838	4,351	4,919	5,712
1	L	699	806	932	1,073	1,246
1	M	1,603	1,912	2,259	2,638	3,063
1	N	463	537	619	709	823
1	O	2,154	2,614	3,140	3,730	4,331
1	P	1,081	1,284	1,522	1,794	2,083
1	R	1,845	2,139	2,481	2,873	3,336
1	S	1,898	2,241	2,651	3,125	3,628
1	T	884	1,053	1,258	1,498	1,740
2	A	1,822	2,080	2,398	2,751	3,195
2	B	6,498	7,214	8,029	8,902	10,337
2	C	1,055	1,182	1,328	1,485	1,724
2	D	297	348	411	483	560
3	A	1,201	1,435	1,721	2,057	2,389
3	B	551	658	789	943	1,096
3	C	1,108	1,321	1,579	1,882	2,185
3	D	1,287	1,477	1,695	1,944	2,258
3	E	1,164	1,316	1,488	1,681	1,952
3	F	818	924	1,045	1,180	1,370
4	A	686	902	875	987	1,146
4	B	5,202	5,864	6,628	7,493	8,701
4	C	8,321	9,882	11,704	13,825	16,053
4	D	6,161	7,204	8,425	9,845	11,432
4	E	5,979	7,286	8,815	10,602	12,311
4	F	2,527	3,052	3,658	4,363	5,066
5	C	1,409	1,686	2,014	2,404	2,792
5	D	6,005	7,289	8,772	10,509	12,203
5	E	12,347	14,497	17,014	19,963	23,181
5	F	4,740	5,673	6,777	8,083	9,386
6	A	490	594	718	866	1,005
6	B	442	536	648	782	908
6	C	2,271	2,753	3,328	4,014	4,661
6	D	9,250	2,523	3,102	3,707	4,304
7	A	15,215	17,701	20,603	23,859	27,706
7	B	6,687	7,780	9,055	10,486	12,176
7	C	3,429	3,986	4,635	5,365	6,230
7	D	10,055	11,712	13,648	15,822	18,373
7	E	5,067	5,889	6,844	7,922	9,199

Source: Project Team

Table 6.4.80 Target Year Water Demand for Livestock (2/2)

WRA	WRU	Target Year (10^3lit/day)				
		2015	2020	2025	2030	2035
7	F	457	526	602	694	806
7	G	830	955	1,093	1,259	1,462
7	H	182	208	235	269	313
8	A	1,194	1,372	1,568	1,783	2,071
9	A	2,107	2,430	2,187	2,488	2,889
9	B	3,832	4,418	5,069	5,790	6,724
10	A	1,417	1,695	2,032	2,429	2,821
11	A	2,618	3,109	3,706	4,406	5,116
12+13		1,907	1,920	1,933	1,933	2,245
14	A	2,655	2,993	3,376	3,797	4,409
14	B	5,715	6,182	6,715	7,269	8,440
14	C	2,139	2,293	2,468	2,647	3,074
14	D	761	838	929	1,027	1,193
15	A	3,205	3,862	4,613	5,480	6,363
15	B	2,387	2,805	3,297	3,871	4,495
15	C	94	110	129	151	175
16	E	1,278	1,492	1,739	2,018	2,344
16	F	747	882	1,033	1,202	1,396
16	G	280	328	380	440	511
17	A	371	433	504	585	679
17	B	450	526	612	710	825
17	C	4,485	5,235	6,098	7,071	8,211
10^3lit/day		192,525	215,887	250,311	290,217	337,048
10^3m^3/year		70,272	78,799	91,364	105,929	123,022

Source: Project Team

6.4.3 Hydropower

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

Table 6.4.81 Summary of Maximum Water Demand for Hydropower in each WRA

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

Source: Project Team

(1) WRA-1

There are three existing hydropower plants and three hydropower projects for planning on the Shire River in WRA-1. One of the planning projects, Kapichira II, was supposed to start operation at the end of 2013 according to information from the Electricity Supply Corporation of Malawi Ltd. (ESCOM). Installed capacity of each plant and discharges are as shown in the table below.

Table 6.4.82 Water Demand for Hydropower (WRA-01)

WRA	River Name	Plant Name	Installed Capacity [MW]	Maximum Plant Discharge [m^3/s]	Firm Discharge [m^3/s]	Condition
1	Shire	Nkula (A+B)	124	69 + 195 = 264	211	Existing
		Tedzani (I+II+III+IV)	110.7	60+60+135.8+70 = 325.8	205 IV: N/A	Existing IV: Planning (Medium Term*)
		Kapichira (I+II)	128.8	134.6 + 127 + 82 = 343.6	I: 108 II: N/A III: 27	I: Existing II: Construction (2013) III: Planning (Medium Term*)
		Kholombidzo	170	285	183	Planning (Long term*)
		Mpatamanga	228	418	136~170	Planning(Medium Term*)

*Investment Term defined by MEIP (2011): Short Term: 0~5 years, Medium Term: 5~10 years, Long Term: More than 10 years
Source: Project Team based on interview by ESCOM, WB (1998) and Norconsult (2003) [9]

(2) WRA-5

There are four hydropower projects for planning on the Bua River in WRA-5. As described in **Chapter 3**, there is no information about the progress of these projects.

Table 6.4.83 Water Demand for Hydropower (WRA-05)

WRA	River Name	Plant Name	Installed Capacity [MW]	Maximum Plant Discharge [m^3/s]	Firm Discharge [m^3/s]	Condition
5	Bua	Mbongozi	44	50	16.3	Planning (Medium Term*)
		Malenga	62	50	16.6	Planning (Medium Term*)
		Chasombo	55	60	17	Planning (Medium Term*)
		Chizuma	50	60	18.5	Planning (Medium Term*)

*Investment Term defined by MEIP (2011): Short Term: 0 ~ 5 years, Medium Term: 5 ~ 10 years, Long Term: More than 10 years
Source: Project Team based on WB (1998), JICA expert report on electricity (2013)

(3) WRA-7

There are three hydropower projects on the South Rukuru River in WRA-7. As described in **Chapter 3**, the feasibility study on the Lower Fufu Project will begin sooner or later, and there is no information about the progress of the other projects.

Table 6.4.84 Water Demand for Hydropower (WRA-07)

WRA	River Name	Plant Name	Installed Capacity [MW]	Maximum Plant Discharge [m^3/s]	Firm Discharge [m^3/s]	Condition
7	South Rukuru	Rumphi	10	30	-	Planning (Long Term*)
		Henga Valley	28	40	-	Planning (Long Term*)
		Lower Fufu	100	40	-	Planning (Medium Term*)

*Investment Term defined by MEIP (2011): Short Term: 0 ~ 5 years, Medium Term: 5 ~ 10 years, Long Term: More than 10 years
Source: Project Team based on WB (1998)

(4) WRA-9

There are three hydropower projects for planning on the Songwe River in WRA-9. As described in **Chapter 3**, the detailed design study for the Lower Songwe (Manolo) project, which is one of the cascaded multipurpose dams, began in the beginning of 2013.

Table 6.4.85 Water Demand for Hydropower (WRA-09)

WRA	River Name	Plant Name	Installed Capacity [MW]	Maximum Plant Discharge [m^3/s]	Firm Discharge [m^3/s]	Condition
9	Songwe	Upper Songwe (Bupigu)	34	50	-	Planning (Medium Term*)
		Middle Songwe (Sofwe)	159	60	-	Planning (Medium Term*)
		Lower Songwe (Manolo)	148	70	-	Planning (Medium Term*)

*Investment Term defined by MEIP (2011): Short Term: 0 ~ 5 years, Medium Term: 5 ~ 10 years, Long Term: More than 10 years
Source: Project Team based on WB (1998) and SRBDP (2003)[10]

(5) WRA-14

There is one hydropower project (Zoa Falls Project) for planning on the Ruo River in WRA-14. Although the project is categorized as a Short Term (0~5 years) investment project in MEIP (2011) by MoNREE, there is no information about progress of the project.

Table 6.4.86 Water Demand for Hydropower (WRA-14)

WRA	River Name	Plant Name	Installed Capacity [MW]	Maximum Plant Discharge [m^3/s]	Firm Discharge [m^3/s]	Condition
14	Ruo	Zoa Falls	37	70	-	Planning (Short Term*)

*Investment Term defined by MEIP (2011): Short Term: 0 ~ 5 years, Medium Term: 5 ~ 10 years, Long Term: More than 10 years
Source: Project Team based on WB (1998)

(6) WRA-16

There is one hydropower project (Zoa Falls Project) for planning in WRA-14. Although the project is categorized as a Short Term (0~5 years) investment project in MEIP draft (2011) by MoNREE, there is no information about the progress of the project.

Table 6.4.87 Water Demand for Hydropower (WRA-16)

WRA	River Name	Plant Name	Installed Capacity [MW]	Maximum Plant Discharge [m^3/s]	Firm Discharge [m^3/s]	Condition
16	Dwambazi	Chimgonda	50	20	-	Planning (Long Term*)

*Investment Term defined by MEIP (2011): Short Term: 0 ~ 5 years, Medium Term: 5 ~ 10 years, Long Term: More than 10 years
Source: Project Team based on WB (1998)

(7) WRA-17

There is the Wovwe hydropower plant on the Wovwe River in WRA-17.

Table 6.4.88 Water Demand for Hydropower (WRA-17)

WRA	River Name	Plant Name	Installed Capacity [MW]	Maximum Plant Discharge [m^3/s]	Firm Discharge [m^3/s]	Condition
17	Wovwe	Wovwe	4.35	1.017	0.82	Existing

Source: Project Team based on the interview by ESCOM in September 2012