NATIONAL WATER SUPPLY & DRAINAGE BOARD (NWSDB)
MINISTRY OF WATER SUPPLY AND DRAINAGE
THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

PREPARATORY SURVEY
ON
ANURADHAPURA NORTH
INTEGRATED WATER SUPPLY PROJECT
IN
THE DEMOCRATIC SOCIALIST REPUBLIC
OF
SRI LANKA

FINAL REPORT
(VOLUME II : MAIN)

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JAPAN INTERNATIONAL COOPERATION AGENCY

NJS CONSULTANTS CO., LTD.
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Preparatory Study - Summary Sheet for Planning

1. Field: Water Supply	**Anuradhapura North Integrated Water Supply Project**	Report Page
2. Outline of Plan	The Project is to integrate 56 existing small-scale water supply schemes dispersed in 6 DSDs in the northeastern part of Anuradhapura District into two regional systems, namely one for 2 DSDs and the other for 4 DSDs, cover the new area currently not served by water supply and to deliver water to the isolated areas not covered by pipe borne water supply systems due to low cost-effectiveness.	
3. Preconditions for Planning		
3.1 Supreme Plan, Beneficiaries, etc.	Out of a total population of 237,520 persons (2024) in 6 DSDs, served population is 170,490 persons, or 122,465 persons for pipe borne water supply and 48,025 persons for water delivery service by bowsers	P4-21
3.2 Meteorology	Climatology: dry zone Temperature: stable at 29～30ºC for April to September and around 26ºC during the coldest months of December to January Rainfall: 1,285 mm/year on average (two-thirds falls during October to March and more than 70% out of them are concentrated in October to December	P2-3~5
3.2 Topography and Geology	The project area covers three river basins. Ground elevations vary in the range of 91 m to 121 m for Mahakanadarawa area and 50 m to146 m in Wahalkada area with gentle slopes. There are more than 2,500 irrigation reservoirs dispersed. There is a base rock 2 m to 3 m below the ground in general with exposed rocks in some places.	P2-1~3 P5-40
3.3 Population and Water Demand Projection	Mahakanadarawa System 2024 / 2034 Design population: 97,333 persons / 111,900 persons Served population: 70,097 persons / 111,900 persons Design flow (Daily max.): 8,585 m^3/day / 17,297 m^3/day Wahalkada System 2024 / 2034 Design population: 140,187 persons / 161,468 persons Served population: 100,393 persons / 161,468 persons Design flow (Daily max.): 13,318 m^3/day / 26,870 m^3/day	P4-21 P4-21
3.4 Project Evaluation	EIRR (excluding CKD-related benefit) [*1]: 6.91% for Mahakanadarawa System 6.59% for Wahalkada System Both proposed water treatment plant (WTP) sites are located out of the sanctuary and environmentally-sensitive area. The change of land use from forest and archeological impact license have been already approved. IEE/EIA are not required due to water intake from an irrigation canal for both cases, but the environmental protection license must be obtained three months before the commissioning of water supply facilities.	P10-18 P10-20 P9-26~28
4. Study and Planning		

4.1 Study Conducted	1) Topographic survey	Line survey: 179 km, Area survey: 21.269 ha Minor area survey: 10 places, Bathymetric survey: 1 place Bathymetric survey intake area: 1 place	
	2) Geological survey	Conducted at 2 WTP sites and 12 elevated tank sites Total length of boring: 206.25m Standard penetration test: 187 samples including laboratory tests	
	3) Water quality examination	Irrigation reservoirs and canals: 6 times for 7 samples at 3 locations CBO water sources and private (groundwater): One time at 16 locations	P4-28~35 P2-34~38
	4) Socio-economic survey	NWSDB service area: 135 samples, CBO service area: 299 samples, industrial customers: 101 samples and non-service area: 450 samples, or 989samples in total	
	5) Fauna and flora survey	Conducted at 2 irrigation reservoirs, 2 WTP sites and 18 elevated tank sites and one sites on tranmission pipeline route, or 23 sites in total	
5. Design			
5.1 Design Criteria Used	Japan Waterworks Association: “Design Criteria for Water supply Facilities (2000)” Susumu Kawamura：”Integrated Design of Water Treatment Facilities”, John Wiley & Sons, Inc., 1991 NWSDB：Design Manual (March 1989))		
5.2 Design Conditions		Mahakanadarawa / Wahalkada 1) Intake: 9,400 m^3/day(2024) / 14,400 m^3/day(2024) 2) Daily max. water demand: 8,600 m^3/day(2024) / 13,300 m^3/day(2024)	P5-26,5-30
5.3 Major Facilities	1) WTP	Mahakanadarawa System Sedimentation basin: W4.0 m × L10.4 m × H4.0 m × 4 units Rapid sand filter: W3.0 m × L5.5 m × 4 units Others include chlorination chamber, clear water reservoir, backwash drain recycling tank, thickener, sludge drying bed, administrative building, etc. Wahalkada System Sedimentation basin: W4.0 m × L14.4 m × H4.0 m × 4 units Rapid sand filter: W4.0 m × L6.0 m × 4 units Others include chlorination chamber, clear water reservoir, backwash drain recycling tank, thickener, sludge drying bed, administrative building, etc.	P5-27 P5-31
	2) Transmission System	Mahakanadarawa System Main: 250~450 mm × 42.3 km Sub-main: 100~250 mm × 50.8 km Wahalkada System Main: 300~450 mm × 117.3 km	P5-54 P5-54

		Sub-main: 100~250 mm × 24.3 km	
	3) Distribution System	Mahakanadarawa System Main: 100~400 mm × 141.4 km、 Sub-system: 50~200 mm × 365.6 km Wahalkada System Main:100~400 mm × 326.7 km Sub-system: 50~200 mm × 546.0 km	P5-54 P5-54
	4) Elevated Tank	Mahakanadarawa System 250 m^3, 750 m^3, 1,250 m^3, 2,000 m^3: one unit for each Wahalkada System 250 m^3 × 3 units, 500 m^3 × 3 units, 750 m^3 × 2 units, 1,250 m^3 × 1 unit, 1,500 m^3 × 1 unit, 2,000 m^3 × 1 unit	P5-55~59 P5-55~59
	5) Ground Reservoir	Mahakanadarawa System 1,000 m^3, 1,500 m^3: one unit for each Wahalkada System 500 m^3 × 3 units, 1,000 m^3 × 2 units, 1,500 m^3 × 1 unit	P5-55~59 P5-55~59
5.4 Annex	Pump house, operational complex. chlorination bldg, workshop, staff quarters, etc. will be constructed		P5-55~59
5.5 Study on stability	Not done		

6. Considerations (Issues in Planning)

・For distribution pipeline routes, topographic survey was not conducted due to huge length. The size and length of distribution pipes given in the report is the estimation by selecting the model areas in the project area, conducting the distribution network analysis and applying the length by size to the entire project area.

・The geological survey was not conducted for five additionally proposed elevated tank sites, due to the delay of permission by the agencies concerned. The preliminary design was done based on the geological characteristics obtained in other sites.

・The topographic and geological survey was not conducted for a water intake station near the Wahalkada WTP site in consideration of farmers' fear on the reduction of irrigation water due to its close location to an irrigation canal. The preliminary design was done based on the geological characteristics obtained in other sites.

・It is supposed that piping materials required for service pipes will be provided by NWSDB and the installation work will be done by customers under the direction and supervision of NWSDB.

*1 EIRR is based on the method described in this report, but may be different depending on the benefit evaluation method.

EXECUTIVE SUMMARY

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1 WATER SUPPLY SECTOR IN SRI LANKA

1.1 National Development Plan (Mahinda Chintana - Vision for the Future)

"Mahinda Chintana - Vision for the Future", or the Five-year Plan of Sri Lanka, which was declared in August 2010, covering a period of 2011 to 2016 is articulated identifying specific targets aiming at achieving the Millennium Development Goals (MDGs) ahead of time. Among Mahinda Chintana Goals (MCGs) for 2016 include the following with other targets as shown in **Table 1** toward ***"Increasing access to clean water in urban areas from 65 to 90 percent"***.

Table 1 Access to Safe Water Coverage

Year	2005	2009	2015	2020*
Safe water coverage (%)	80	85	94	100
Pipe borne water availability (%)	29	37	44	60
Water connections ('000) (NWSDB schemes)	907	1,267	1,600	3,000

Source: "Mahinda Chintana – Vision for the Future", Department of National Planning, Ministry of Financing and Planning, 2010

1.2 Sector Organizations

The water supply sector is divided into two sub sectors as shown in **Table 2**.

Table 2 Water Supply Sub Sector

	Urban water supply sub sector	Rural water supply sub sector
Object area	Towns, cities, urban centres, industries and suburban areas	Rural areas
Key Actors	Ministry of Water Supply and Drainage NWSDB Provincial Councils Municipal Councils Urban Councils Pradeshiya Sabhas	Provincial Councils Local Authorities Community Based Organizations (CBOs) Non-Government Organizations (NGOs)
Water service mode	Pipe borne water supply	Dug wells Tube wells Rain water harvesting Small-scale pipe water supply

Source: "National Policy on Drinking Water", June 2009

For the urban area, NWSDB is responsible for the provision of water supply through the implementation of large scale water supply, in consultation with relevant local authorities under the superintendence and direction of the Ministry of Water Supply and Drainage. In principle, NWSDB directly manages and operates the water supply facilities implemented by itself from operation and maintenance to billing and collection. For this purpose, the country is divided into

five regions (Western, Central, Eastern, Northern and Southern) and eleven areas to which Additional General Managers and Deputy General Managers are deployed for management.

A rural area for this purpose is defined as any Grama Niladaree (GN) Division within a Pradeshiya Sabha (PS) area. The Provincial Councils are responsible for the implementation of small-scale rural water supply through local authorities (municipal councils, urban councils, pradeshiya sabhas). The roles of the Government, Provincial Council and the Local Government Authorities should be to regulate and facilitate in the implementation of the sector activities while the Community Based Organization (CBOs), Private Sector and NGOs should be the providers of services. Local Authorities also may provide services when required. In the National Policy for Rural Water Supply and Sanitation Sector (July 2001) says that users should (1) be encouraged to own and manage the facilities and assets, (2) be encouraged to share the capital investment incurred in creating the facilities, and (3) bear the full responsibility of sustainable operation and maintenance of the facilities.

1.3 Activities and Policies of International Development Partners and National Agencies of the Sector

After the conflict termination in April 2009, a variety of countries offer a helping hand to the assistance for Sri Lanka. According to “Performance Report 2011” by the Ministry of Water Supply and Drainage, there are thirty foreign-funded water supply and sewerage projects in which twelve countries and four international agencies are involved as shown in **Table 3**.

Table 3 Bi- and Multi-lateral Assistance to Sectors in Sri Lanka

	Water Supply			Sewerage
	Urban	Rural	Others	
Bilateral and Multi-lateral Assistance	Japan (JICA) Denmark (DANIDA) Hungary Spain Netherland Germany (KfW) Korea Austria Australia France Belgium	ADB	ADB UNICEF WB IFRC (Red Cross)	Japan Australia Sweden (SIDA)
	11 countries	1 agency	4 agencies	3 countries

Major donors during the year 2011 are ADB, JICA (Japan), KfW (Germany), SIDA (Sweden) , UNICEF, IFRC (International Federation of Red Cross and Red Crescent Societies), Austria, France, Spain, Hungary, Korea and Netherland.

2 NATURAL AND SOCIAL CONDITION

2.1 General

Anuradhapura is located about 280 km north-northeast of Colombo, and about 140 km north-northwest of Kandy and is an inland district in the North Central Province. The district is classified as a dry zone climatologically with less rainfall and has about 2,500 small tanks for irrigational use. The district capital of Anuradhapura and its surrounding area was the first capital of the Ancient Sunghalese Dynasty that flourished from the 3rd century BC to the 9th century AD and is registered as the world's cultural heritage.

The study area consisting of six Divisional Secretariat Divisions (DSDs), namely Padaviya, Kebithigollewa, Horowpothana, Kahatagasdigilia, Medawachchiya and Rambewa is located in the northeast part of Anuradhapura District as shown in **Figure 1** and is bounded by Trincomalee District to the east and by Vavuniya District to the north. It has a total area of 286,268 ha, a total population of 175,890 persons (2001 Census) and is a typical rural area.

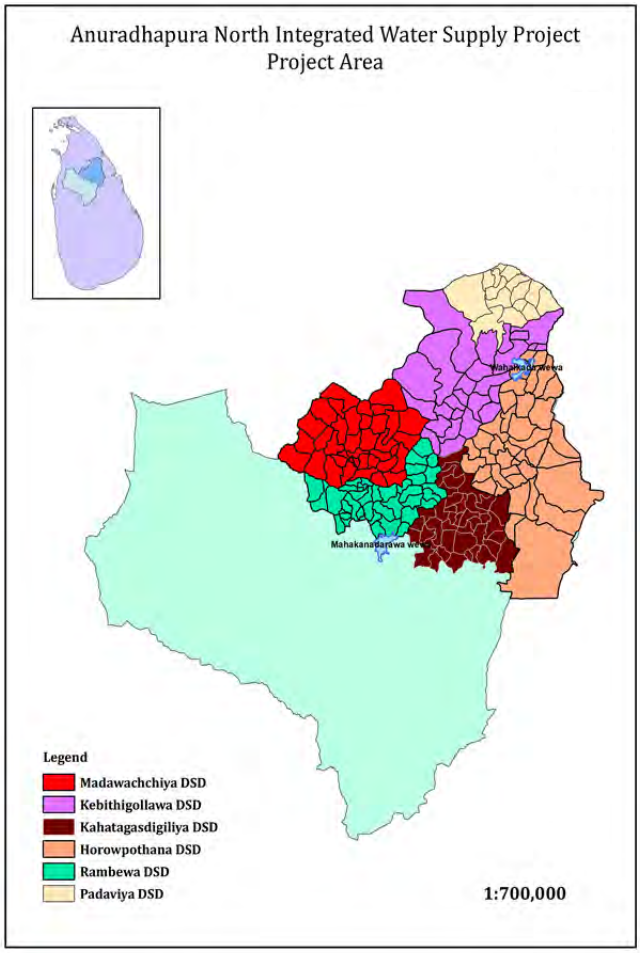

Figure 1
Location of Study Area

2.2 Natural Conditions

The climatological pattern is classified into two seasons for cultivation purposes as follows:

- Maha season from October to March called as the wet season
- Yala season from April to September called as the dry season

(1) Temperature

During the dry season from April to September, the monthly average temperature is very stable in the range of 29ºC to 30ºC. However at the start of the wet season from October, the temperature decreases with the coldest months being December and January at about 26 ºC, following which the temperature increases.

(2) Rainfall

The annual average rainfall in the period from 1961 to 1990 in Anuradhapura District was 1,285 mm, but more than two-thirds of the annual rainfall occurs in the Maha season. In addition, as more than 70% of the rainfall during this period is concentrated in the period from October to December, there is a large monthly fluctuation in rainfall.

2.3 Social Conditions

2.3.1 Population

Population, population density and population growth rate of Sri Lanka, Anuradhapura District and the study area is summarised in **Table 4**.

Table 4 Population, Population density and Growth Rate of Sri Lanka, Anuradhapura

	Area (km^2)	Population ('1,000)			Population Density (persons/km^2)		Annual Average Growth Rate (%)	
		1981	2001	2012	2001	2012	2001/1981	2012/2001
Sri Lanka	**66,510**	**14,846.8**	**18,797.3**	**20,277.6**	**300**	**323**	**1.16**	**0.71**
Urban		3,192.7	-	-			-	-
Rural		11,654.3	-	-			-	-
Anuradhapura	**7,179**	**587.9**	**745.7**	**855.6**	**112**	**128**	**1.25**	**1.33**
(% to Sri Lanka)		(4.0%)	(4.0%)	(4.2%)				
Urban		41.4	53.2	-			1.26	-
Rural		546.5	692.5	-			1.19	-
Study Area	**2,843**		**175,890**	**205,171**	**62**	**72**		**1.41**
Padaviya	240		21,146	22,924	88	96		0.74
Kebithigollewa	615		19,457	22,227	32	36		1.22
Horowpothana	845		29,642	36,714	35	43		1.96
Kahatagasdigiliya	352		33,572	40,137	95	114		1.64
Medawachchiya	482		40,469	46,743	84	97		1.32
Rambewa	309		31,604	36,426	102	118		1.30

- The total national population in the Census 2011 is 20,277,597 persons with an annual average growth rate of 0.71% in the period from 2001 to 2012, which is lower than 1.16% in the period from 1981 to 2001.
- Similarly, the population in Anuradhapura District in the Census 2011 is 855,562 persons with an annual average growth rate of 1.33% in the period from 2001 to 2012, which is the highest out of 18 districts covered in the Census 2011 and a small increase from the growth rate of 1.25% in the period from 1981 to 2001.

2.3.2 Land Use

The land use includes large areas of paddy fields, scrublands, forested areas, mixed cultivations, chena cultivations, home gardens and residences. The majority of the people in the area are farmers and largely depend on paddy cultivation. Apart from that the district economy is predominantly centred on chena and home gardens with vegetable cultivation. Additionally animal husbandry including cattle, goat and poultry is also common in some locations.

2.3.3 Income and Expenditure

(1) Income and Expenditure

The average monthly household income in the Household Income and Expenditure Survey 2009/2010 was Rs.36,451 as a whole, Rs.47,783 in urban areas and Rs.35,228 in rural areas at the national level, and Rs.37,586 in Anuradhapura District. While, the average monthly household expenditure was Rs.31,331 as a whole, Rs.44,928 in urban areas and Rs.29,423 in rural areas, and Rs.29,065 in Anuradhapura District.

(2) Percentage of Water Rate to Disposal Income in the Household Income and Expenditure

The monthly water and electricity bills[1] are Rs.99.75 and Rs.531.64 per household on national average, respectively, of which percentages to the total household income are 0.27% and 1.45%. The World Bank[2] estimates the limit for household affordability to pay for water supply services as 4% of household income. The present water charge in Sri Lanka at 0.27% of household income is around one-fifteenth of the ceiling (4%) set by an International organization.

Since the HI value for the country 8.9% for 2009/10, all the poor can be considered to belong to the1st decile or 10% from the lowest. On the assumption of a population of 4 persons/ household and an average water consumption of 11 m^3/month (= 4 persons × 91 Lpcd × 30.4 days/month), the water rate (Rs.168) is 2.8% to the 1st income decile median of Rs.6,080 in case of applying the

[1] Source: Department of Census and Statistics, "Household Income and Expenditure Survey -2009/10", August 2011

[2] "Information and Modeling Issues in Designing Water and Sanitation Subsidy Scheme", The World Bank, May 2000

special tariff (Domestic - Samurdhi Receipients), which is within 4% of the disposal income recommended by the World Bank. Even applying the normal tariff (Domestic – Non Samurdhi Tenement Garden) to the customer exceeding the 1st income decile median, the water rate is in the range of 2.8% to 2.6% to the disposal income which is in the level of no problem. This result suggests that there are households with an income of below Rs.4,200 (= Rs.168 / 0.04) that the water rate exceeds 4% of the disposal income. The percentage of the number of such households is estimated at about 3.5% (= 5% × Rs.4,200 / Rs.6,080) to the total district household number and about 0.8% (= 3.5% × 0.236) to the study area household number using the population percentage of study area to the whole district

2.4 Necessity of the Project

2.4.1 Principal Drinking Water Source

(1) Principal Drinking Water Source

In Census 2011, 75.4% of the people in the study area relied on groundwater through from dug wells (72.6%) and tube wells (2.8%), and tap water (4.1%), 18.9% on tap water and the remaining 5.7% on others such as bowser, bottled water, river, etc. (Note: the population coverage by water supply in the study area is approximately 27% according to the existing CBO water supply schemes survey, some of them may not regard tap water as the main water source in spite of the connection to a water supply schemes.) There are a decrease in the use of groundwater and an increase in the use of tap water. For the type of wells, unprotected dug wells and deep tube wells has substantially decreased and the protected dug wells have become popular. However, since the water source of such small-scale water supply schemes are almost groundwater, there is no change in relying on groundwater.

(2) Water-fetching Distance to Water Source

Since the data on water-fetching distance in the study area is not available, that is described using the district-level data.

The distribution of drinking water sources in Sri Lanka is 76.3% within premises and 23.7% outside premises, while in Anuradhapura District, they are 58.0% and 42.0% respectively. It shows that the percentage of a drinking water source outside premises is rather high. The percentage of the number of households engaged in the water-fetching work is secondarily high following that in Jaffina District.

The distance allocation from a housing unit to a drinking water source is 16.0% for equal or less than 100 m, 3.3% for 101 – 200 m, 3.1% for 201 – 500 m and 1.3% for above 500 m (The national average for a rural area is 16.4%, 3.7%, 3.5% and 1.4%, respectively.), while in Anuradhapura District they are 18.3%, 7.8%, 9.5% and 6.4%, respectively, showing that the people in the district

are forced the water-fetching work for a longer distance than a national average. As for the water-fetching distance, Anuradhapura District is ranked at the second for within 100 m, third for 101 to 200 m and second for above 500 m. On a national basis, the district is placed in a severe condition as well as Jaffina District. In case of tap water, 43.4% of housing units have a tap indoors, 38.2% within premises and 18.4% outside premises. It means that one out of five housing units have no tap within premises.

(3) Per Capita Water Consumption at Existing CBOs

There are 50 existing water supply schemes maintained and operated by CBOs in the study area, of which the per capita water consumption is 66 Lpcd at 46 existing CBOs on average.

(4) Water Quailty at Existing CBOs

1) Distribution of fluoride concentration of groundwater in Sri Lanka

Fluoride is present particularly in rocks, soils and water in Sri Lanka. In 1987, a nationwide field survey was carried out and the distribution of fluoride concentration in groundwater was revealed. High concentration of fluoride occurs in several places and the study area is seriously affected.

2) Fluoride and hardness Concentratiion in the Study Area

Although there are 50 water supply schemes under CBOs in the study area out of which 45 CBOs have their water quality data of tap water. A fluoride concentration is above a desirable standard of 0.6 mg/L in 27 CBOs and above a permissible limit of 1.5 mg/L in 6 CBOs with the maximum value of 1.9 mg/L. The served population who are exposed to a risk of fluorosis by a fluoride concentration above a desirable limit counts 29,460 persons against 8,205 persons with no risk. The rate of populations with a risk versus with no risk is 78.2:21.8, that is to say, four out of five persons are exposed to a risk of fluorosis. Among them, a served population of 4,435 persons are exposed to a higher risk due to a fluoride concentration of above a permissible limit. In addition, out of 21 CBOs with a water quality data of hardness, 18 CBOs have above a desirable limit of 250 mg/L. The high concentration of hardness as well as fluoride is a big characteristics of this area.

(5) Water Supply Hours at CBOs

NWSDB NC has 24 water supply schemes and almost performs 24-hour water supply, which is ranked as the top class in NWSDB RSCs. While looking at the study area, out of 46 water supply schemes surveyed, water supply hours are reportedly significantly limited during a dry period at 20 water supply schemes. They are less than five hours at ten schemes, five to ten hours at six schemes and ten to fifteen hours at four schemes. In addition, two water supply schemes limit the maximum water supply hours at eight hours. The water supply hours in the worst cases are two hours in Ekamuthu and three hours in Dimuthu, Samagi and Suwasetha.

(6) Technical Problems at Existing CBOs

The existing CBO water supply systems have technical problems in designing and operation such as no master meter at water tanks and/or tube-well pumps, leakage, no operational valve, insufficient pressure due to under-sized pipes, improper chlorination, unstable power supply, invisible customer meter location, malfunction of tube-well pumps and water shortage in the dry season.

2.4.2 Dental Fluorosis

Dental fluorosis has been recognized as an endemic problem affecting different areas of Sri Lanka with naturally occurring fluorides in drinking water. In 2002-2003, the National Oral Health Survey was conducted by the Ministry of Health and Nutrition under cooperation of WHO. Using such data, the CFI (Community Fluorosis Index) in each district was calculated for only the results of 12 age as dental fluorosis significantly occurs until such age.

The CFI is calculated as shown in **Figure 2** with the following formula. The weightage is defined based on the classification of cases. If the CFI is above 0.6, generally it can be said that dental fluorosis is a public health problem in the area.

CFI = ∑weightage x number in each score group/number of cases examined

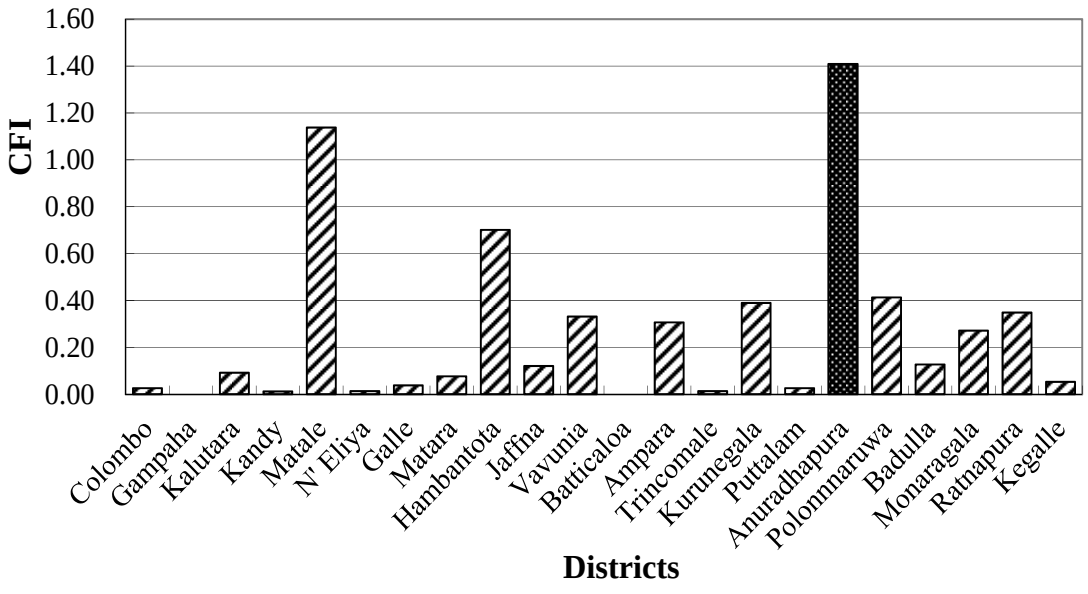

Figure 2 Comparison of CFI

2.4.3 Chronic Kidney Diseases (CKD)

Chronic kidney disease (CKD) is a progressive loss in renal function over a period of months or years. CKD is an emerging health problem and it has a high economical cost on the patient,

family, community and health system. In recent years, an increase in CKD cases has been observed in some parts of the country especially in the North Central Provinces.

Since 2003, the Provincial Department of Health Services has also conducted a DSD-wise CKD prevalence survey in the North Central Province. The prevalence in each DSD were compared as shown in **Figure 3**. The distribution of the CKD prevalence is not equal, with the highest rates in Medawachchiya, Kebitigollewa and Padaviya, which are all within the study area.

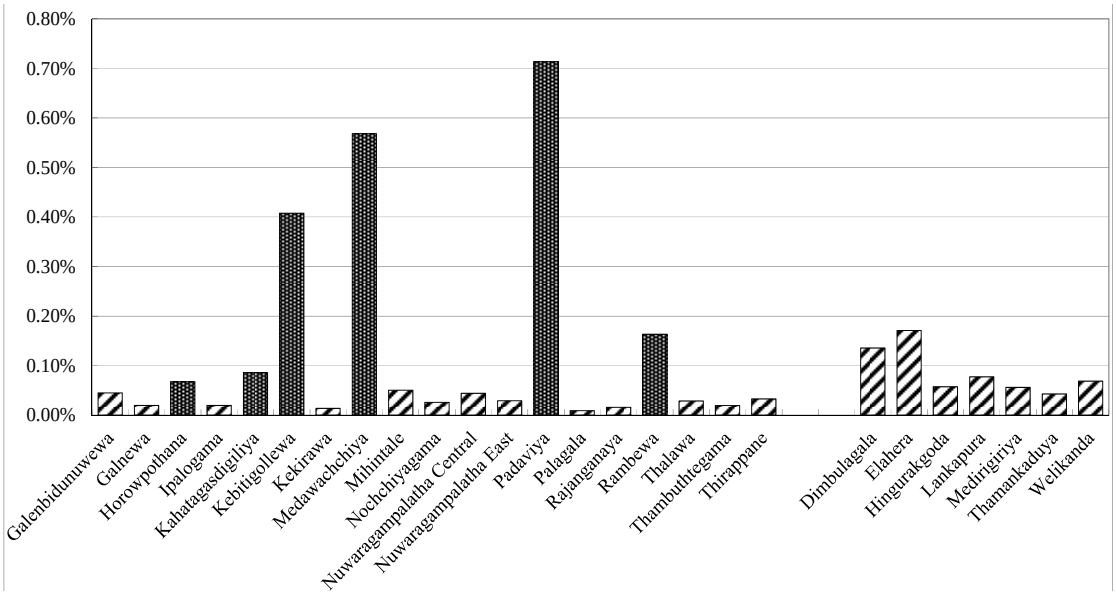

Figure 3 DSD-wise Distribution of CKD in North Central Province

Compared to dental fluorosis, the causes of CKD are still unclear. For example, in Padaviya and Medawachchiya there are high levels of fluoride in drinking water and high levels of CKD prevalence. On the other hand, in Kebitigollewa the level of fluoride in drinking water is low, but the CKD prevalence is high. More detailed investigation will be needed to identify the cause(s) of CKD. However, at least it is well known that high fluoride levels of drinking water causes worsening CKD for CKD patients. Provision of treated surface water supply which is able to supply lower levels of fluoride will help to protect people's daily life.

2.4.4 Necessity of the Project

As mentioned above, the necessity of the project can be summarized as follows:.

The people in the study area are facing the following problems regarding the principal water source and existing water supply schemes.

- According to the Census 2011, 75.4% of the people in the study area rely on groundwater as the principal water source and 18.9% of the people use tap water through the NWSDB's and CBO's water supply schemes. However the water source of such

water supply schemes is groundwater with a few exceptions

- The people in the study area are forced to be engaged in the water-fetching work for a distance longer than that in other districts.
- Four out of five persons are exposed to the risk of fluorosis in the study area.
- Many existing CBO's water supply schemes have experienced the water shortage during the dry season and cannot maintain the 24-hour water supply.
- Most existing CBO's water supply schemes have a variety of problems in structure, designing and operation.

Then water quality problem. Water quality of drinking water sources is an important issue which is directly related to the health of residents. Therefore, a groundwater quality survey of the current drinking water source was conducted. As a result, it was found in the survey that the most significant problem is the high concentration of fluoride. It was also confirmed that dental fluorosis due to high level fluorosis has occurred in Anuradhapura and the prevalence is higher than in other districts.

Removal of fluoride from the current groundwater sources is unrealistic from the viewpoint of technical and economic considerations. Therefore, it is urgently necessary to proceed with a project which utilizes surface water sources with low fluoride concentration. In addition, although Anuradhapura has been known as an area with a high prevalence of CKD, DSDs with a high prevalence of CKD were also found within the project area. However, no clear cause of CKD has been identified yet. For example, the project survey found that some DSDs showed a high prevalence of CKD with high fluoride concentration in drinking water sources, but in other DSDs there was no relationship between the CKD and fluoride concentrations. However, even if it is not possible to identify the causes of CKD, at least it is well known that high fluoride levels of drinking water causes worsening CKD for CKD patients[3]. Conversion to surface water sources which is able to supply lower levels of fluoride will significantly contribute to residents health.

As mentioned above, in order to solve the current water quantity and quality problem, it is essential to implement this project promptly.

3 EXISTING WATER SUPPLY FACILITIES IN THE STUDY AREA

3.1 Water Supply Schemes in Anuradhapura District

Water supply schemes in Anuradhapura District are classified into those operated and maintained by NWSDB and Community-Based Organizations (CBOs). Water supply schemes under CBOs are

[3] *Based on the talk of Dr. Akio Koizumi, Professor of Graduate School of Medicine, Kyoto University, Kyoto, Japan*

further categorized into those constructed under ADB 3rd and 4th projects and Community Water Supply and Sanitation Project (CWSSP) under the WB's assistance, but they are hereinafter named generically CBOs. Water supply schemes in Anuradhapura District are summarized as shown in **Table 5**.

Table 5 Water Supply Schemes in Anuradhapura District

No of families	171,060
Population	855,304
Water Supply Schemes	18
No of service connections - NWSDB	54,220
Total No. of Beneficiaries	325,320
Piped water coverage - NWSDB	37%
Rural Schemes Coverage - CBO	19%
Total Piped Water Supply Coverage in the District	56%

Source: NWSDB RSC(N/C)

3.2 Existing Water Supply Facilities under NWSDB (N/C)

There are 24 water supply schemes operated by NWSDB (N/C). Out of these 24 schemes, 18 are located in Anuradhapura District, whereas six are located in Polonnaruwa District

The large- and medium-scale schemes mostly use surface water and with full treatment used, typically pre-chlorination + aeration + sedimentation + rapid sand filtration + post-chlorination. The small-scale schemes are using ground water (bore holes and tube wells) with chlorination for treatment. The development of water supply started in Anuradhapura Town in 1972 and expanded to the fringe areas to the east and north in the 2000's. Other medium-scale schemes were developed in the 1980's and small-scale schemes in the 1980-90's. Usually mechanical and electrical equipment in water treatment plants and pump stations has deteriorated 20 to 30 years after construction. Therefore, some facilities which were constructed in the 1980's need rehabilitation or augmentation due to the increase in water demand. The water supply system in NWSDB (N/C) RSC, supplies water 24 hours, 7 days a week, except when there is a power failure, repair of leakage etc, which occasionally occurred.

3.3 Existing Water Supply Facilities under NWSDB in the Study Area

There are 56 water supply schemes in total in the project areas including 50 numbers of CBOs facilities (served population: approximately 38,700 persons, coverage: 19.1%) and 6 number of NWSDB facilities (served population: approximately 16,000 persons, coverage: 7.8%), out of which Rambewa is not an independent system but a part of Anuradhapura North Water Supply Scheme (WSS) and Mihintale WSS with both water sources in Nuwarawewa.

The served population by these six NWSDB systems is approximately 16,000 with a population

coverage of 7.8%. Their water sources NWSDB facilities in the area started their operation in the period between 1964 and 1989. System capacities are ranging from 137 to 1,062 m^3/day, and all of their water sources rely on ground water except for Rambewa similarly to those for CBO water supply schemes. The total capacity of storage tank is 685 m^3, and all storage tanks are of the elevated tank except Padaviya. High fluoride concentrations are found in Horowpothana, Kahatagasdigiliya and Medawachchiya.

3.4 Existing Water Supply Facilities under CBO in the Study Area

The existing CBO water supply scheme survey reveals as follows:

- Out of 50 CBOs, 7 CBOs has not yet started into operation or been operated
- CBOs supply schemes covers 19 % of the total population of the Project area Therefore, it is crucial to maintain CBO's system under sound management.
- 44 CBOs out of 50 are functioned and most of CBOs have started their operation from the year 2006 or around.
- Due to the power failure or water shortage, all the CBOs systems have operated under limited water supply hours. Water shortage occurs in the dry season from August to October
- A high concentration of fluoride are found in many CBOs and also high hardness in some CBOs.
- CBO facilities are relatively new and only two elevated tanks are required for repairing.
- Distribution pipe network is all PVC type 600 with diameters ranging from OD 32 mm to 225 mm. The pipe sizes are too small in some CBOs, hence water pressure at the distribution pipe end is not enough.
- Bulk meter is not installed or not functioned in many CBOs, which makes difficult to control the NRW.
- Chlorination is, in principle not properly made. It is presumed that most of CBOs have used hypochlorite only occasionally or not used at all.
- Through the survey, many sketch of distribution networks are collected, however they are not accurate, and cannot be used for analysis. No updated information has been found.
- The CBO is operated and managed by the community members.

4 PROJECTION OF POPULATION AND WATER DEMAND IN THE STUDY AREA

4.1 Basic Policy for Planning

The study area covers six DSDs (Divisional Secretary Divisions), namely, Padaviya, Kebithigollewa, Horowpothana, Kahatagasdigiliya, Medawachchiya and Rambewa which are located in the

north-eastern part of Anuradhapura District with a population of 204,738 persons (estimated for the year of 2012) and an area of 2,740.48 km^2 forming the typical rural area. The people in this area mainly rely their drinking water source on groundwater through dug/tube wells, however due to a high content of fluoride in groundwater, the patience of dental and skeletal diseases occur. In addition, they say that a high prevalence of chronic kidney diseases (CKDs) is also attributed to the high fluoride concentration in Sri Lanka. In the study area, there are six water supply systems operated and maintained by NWSDB and 50 water supply schemes under CBOs. They are all small-scale water supply schemes with water sources in dug/tube wells except for one CBO system and mostly have a problem of high fluoride concentration in groundwater. Water shortage is also found in the many existing CBO systems especially during the dry season.

To solve these problems, the new water supply system is proposed to integrate the existing NWSDB and CBO water supply schemes under the following basic policy for planning:

- The water source will be converted from groundwater to surface water to meet the Sri Lanka drinking water standards. The surface water will be taken from the irrigation canals originated from Mahakanadarawa Tank and Wahalkada Tank for irrigational purpose.
- Taking into account the overall topography of the study area and the location of proposed water sources, the study area will be divided into two water supply systems, namely, Mahakanadarawa System covering Medawachchiya and Rambewa DSDs and Wahalkada System covering Padaviya, Kebithigollewa, Horowpothana and Kahatagasdigiliya DSDs.
- The proposed water supply sytems will supply water to the existing service area under NEWSDB and CBOs and the new service area currently not served,
- The study area is composed of 194 GNDs under six DSDs, out of which 60.8% of GNDs have a population density of less than 100 persons per km2 and 87.6% of GNDs for less than 200 persons /km2. Since the population is sparsed thinly in an extensive area as mentioned-above, it is clearly not cost-effective to develop ordinary water supply systems (hereinafter referred to as " pipe borne water supply"). For this reason, some area will be covered by non pipe borne water supply systems in which safe water treated at water treatment plants will be delivered by water bowser to the water tanks strategically arranged to minimise the water-fetching works of the people (hereinafter referred to as "bowser water supply").
- The new water transmission pipes will be connected to the elevated tanks of existing systems and the existing water distribution facilities will be used as they will be as much as possible.
- Some out of the existing CBO systems will be excluded from the integration to the new water supply systems, if they have currently no problem in quality, quantity, operation, etc.

4.2 Estimation of Design Water Supply

(1) Design Service Area

The design service area shall be six DSDs, namely, Padaviya, Kebithigollewa, Horowpothana,

Kahatagasdigiliya, Medawachchiya and Rambewa which are located in the north-eastern part of Anuradhapura District.

(2) Design Period

NWSDB Design Manual (March 1989) describes that "*As a general principle it is recommended that future urban schemes be designed for a 20-year planning horizon in two 10-year stages*". For reference, the Japanese design criteria recommend to set the target year at15 to 20 years ahead. Therefore, it is reasonable to set the target year in 2034 with an interim target year of 2024 for staged construction.

(3) Design Parameters

Based on the design parameters, water demand is estimated as shown in **Tables 6 to Table 8**.

Table 6 Parameters for Water Demand Estimation

Parameters	Basis
Design Population	Projected changing the annual population growth rate corresponding to the local conditions of each GND based on the actual one of Census 1980-2001
Demarcation of GNDs by water supply mode	Based on the location of facilities of existing CBO WSS and proposed WSS, urban centre and main roads
Existing CBOs to be excluded from integration	Based on the conditions such as no problem in water quality and quantity or distance from the proposed WSS transmission routes in addition to no major operational trouble at present
Non domestic consumption	Based on the actual performance at the existing small-scale WSS under NWSDB operation
Per capita domestic consumption	Based on the actual performance (CBO average: 66Lpcd, NWSDB WSS in the study area: 85-107 Lpcd) considering an annual increment of 0.5 Lpcd from 80 Lpcd in the base year of 2012..
NRW	Based on the actual performance of NWSDB N/C
Design Served population	Based on the assumption of population coverage (%)
Design Load Factor	Based on the actual performance of NWSDB N/C
Production Capacity	Considered 5% allowance for miscellaneous use at WTP

Table 7 Water Demand in the Target Year of 2034

Design Water Demand		Application to Facility Design	Unit	Mahakanadarawa System			Waghalkada System		
Water Supply Mode				Pipe Borne Water Supply	Bowser Water Supply	Total	Pipe Borne Water Supply	Bowser Water Supply	Total
Design Population			(prs.)	92,597	19,303	111,900	144,745	16,723	161,468
Per Capita Domestic Water Consumption	= 80 + 0.5 x (2034 - 2012) = 91		(Lpcd)	91	10		91	10	
Premium for Non-domestic Water (35%)	= 1.35			1.35	1		1.35	1	
NRW Ratio (20%)	= 100 / (100 - 20) = 1.25			1.25	1		1.25	1	
Design Daily Average Water Supply (Dave)			(m^3/day)	14,219	193	14,412	22,227	167	22,394
Design Load Factor to Dmax	= 1.2								
Design Daily Maximum Water Supply (Dmax)	= Dave x 1.20	Transmission facility	(m^3/day)			17,294			26,873
Design Peak Factor	= 2.0								
Design Hourly Maximum Water Supply (Hmax)	= Dmax x 2.0	Dstribution facility	(m^3/day)			34,588			53,746
Design Water Intake	= Dmax x 1.05	Intake pump station	(m^3/day)			18,245			28,217
		Raw water transmission facility				18,200			28,200
						▲ 600			▲ 600
		WTP							
Water Right			(m^3/day)			**18,800**			**28,800**

Table 8 Yearly Water Demand for Mahakanadarawa and Wahalkada Systems

Mahakanadarawa System (Encl. Independent CBO)

		2012 *3	2014 *3	2016 *3	2018	2020	2022	2024	2026	2028	2030	2032	2034
Total Population (persons)		**83,858**	**86,208**	**88,626**	**91,120**	**93,684**	**96,321**	**99,043**	**101,838**	**104,719**	**107,686**	**110,736**	**113,884**
46 - Maha Kumbukgollewa *1	Population	1,430	1,473	1,518	1,564	1,611	1,660	1,710	1,761	1,815	1,870	1,926	1,984
	Served Population	286	589	789	860	886	996	1,026	1,233	1,361	1,496	1,733	1,984
	Water Demand	39	81	109	120	126	143	149	181	202	225	263	305
Target Total Population (persons)		**82,428**	**84,735**	**87,108**	**89,556**	**92,073**	**94,661**	**97,333**	**100,077**	**102,904**	**105,816**	**108,810**	**111,900**
for Pipe Borne WS	Pipe Borne WSS	62,778	64,665	66,608	68,613	70,680	72,808	75,010	82,347	84,796	87,319	89,915	92,597
	(Existing)	46,591	48,010	49,473	50,982	52,541	54,141	55,802	57,512	59,277	61,098	62,974	64,912
	(New)	16,187	16,655	17,135	17,631	18,139	18,667	19,208	24,835	25,519	26,221	26,941	27,685
for Non Pipe Borne WS	Non Pipe Borne WSS	19,650	20,070	20,500	20,943	21,393	21,853	22,323	17,730	18,108	18,497	18,895	19,303
Coverage (%)		**31.4**	**59.4**	**63.0**	**65.2**	**67.5**	**69.7**	**72.0**	**74.8**	**82.1**	**88.4**	**94.7**	**100.0**
for Pipe Borne WS	Pipe Borne WSS	41.2	46.8	51.6	54.6	57.7	60.7	63.7	69.4	78.2	85.9	93.6	100.0
	(Existing)	56.0	60.0	64.0	68.0	72.0	76.0	80.0	84.0	88.0	92.0	96.0	100.0
	(New)	0.0	10.0	17.0	17.0	17.0	17.0	17.0	40.0	60.0	75.0	90.0	100.0
for Non Pipe Borne WS	Non Pipe Borne WSS	100	100	100	100	100	100	100	100	100	100	100	100
Served Population (persons) *2		**25,892**	**50,347**	**54,890**	**58,431**	**62,142**	**66,025**	**70,097**	**74,846**	**84,458**	**93,515**	**103,019**	**111,900**
for Pipe Borne WS	Pipe Borne WSS	25,892	30,277	34,390	37,488	40,749	44,172	47,774	57,116	66,350	75,018	84,124	92,597
	(Existing)	25,892	28,611	31,476	34,491	37,665	40,998	44,509	48,196	52,073	56,144	60,419	64,912
	(New)	-	1,666	2,914	2,997	3,084	3,174	3,265	8,920	14,277	18,874	23,705	27,685
for Non Pipe Borne WS	Non Pipe Borne WSS	-	20,070	20,500	20,943	21,393	21,853	22,323	17,730	18,108	18,497	18,895	19,303
Water Demand (Dave: m3/day)		**3,495**	**4,341**	**4,961**	**5,456**	**5,994**	**6,557**	**7,154**	**8,562**	**10,029**	**11,448**	**12,963**	**14,414**
Pipe Borne WS	Pipe Borne WSS	3,495	4,141	4,756	5,247	5,779	6,337	6,982	8,384	9,847	11,263	12,774	14,221
	(Existing)	3,495	3,913	4,354	4,828	5,341	5,882	6,459	7,075	7,728	8,429	9,175	9,970
	(New)	-	228	402	419	438	455	523	1,309	2,119	2,834	3,599	4,251
Non Pipe Borne WS	Non Pipe Borne WSS	-	200	205	209	215	220	172	178	182	185	189	193
Water Demand for Transmission (Dmax = Dave x 1.20 : m3/day)		**4,194**	**5,209**	**5,953**	**6,547**	**7,193**	**7,868**	**8,585**	**10,274**	**12,035**	**13,738**	**15,556**	**17,297**
Water Demand for Treatment (= Dmax x 1.05 : m3/day)		**4,400**	**5,500**	**6,300**	**6,900**	**7,600**	**8,300**	**9,000**	**10,800**	**12,600**	**14,400**	**16,300**	**18,200**

Wahalkada System (Encl. Independent CBOs)

		2012 *3	2014 *3	2016 *3	2018	2020	2022	2024	2026	2028	2030	2032	2034
Total Population (persons)		**120,880**	**124,293**	**127,794**	**131,417**	**135,150**	**138,985**	**142,940**	**147,008**	**151,200**	**155,525**	**159,978**	**164,562**
32 - Kurulugama *1		1,354	1,379	1,403	1,429	1,455	1,481	1,508	1,535	1,563	1,591	1,620	1,649
119 - Ihala Angunachchiya *1		1,041	1,073	1,105	1,139	1,173	1,208	1,245	1,283	1,321	1,361	1,402	1,445
Sub-Total		2,395	2,452	2,508	2,568	2,628	2,689	2,753	2,818	2,884	2,952	3,022	3,094
Served Population													
32 - Kurulugama *1		271	552	730	786	800	889	905	1,075	1,172	1,273	1,458	1,649
119 - Ihala Angunachchiya *1		208	429	575	626	645	725	747	898	991	1,089	1,262	1,445
Sub-Total		479	981	1,305	1,412	1,445	1,614	1,652	1,973	2,163	2,362	2,720	3,094
Water Demand													
32 - Kurulugama *1		37	75	101	110	113	128	131	158	174	191	221	253
119 - Ihala Angunachchiya *1		28	59	80	88	91	104	108	132	147	164	192	222
Sub-Total		65	134	181	198	204	232	239	290	321	355	413	475
Target Total Population (persons)		**118,485**	**121,841**	**125,286**	**128,849**	**132,522**	**136,296**	**140,187**	**144,190**	**148,316**	**152,573**	**156,956**	**161,468**
for Pipe Borne WS	Pipe Borne WSS	95,911	98,775	101,715	104,766	107,907	111,145	114,485	128,836	132,633	136,549	140,587	144,745
	(Existing)	49,985	51,530	53,117	54,762	56,462	58,216	60,026	67,997	70,064	72,193	74,394	76,664
	(New)	45,926	47,245	48,598	50,004	51,445	52,929	54,459	60,839	62,569	64,356	66,193	68,081
for Non Pipe Borne WS	Non Pipe Borne WSS	22,574	23,066	23,571	24,083	24,615	25,151	25,702	15,354	15,683	16,024	16,369	16,723
Coverage (%)		**22.7**	**51.2**	**62.7**	**64.8**	**66.9**	**69.1**	**71.6**	**74.2**	**80.7**	**87.1**	**93.6**	**100.0**
for Pipe Borne WS	Pipe Borne WSS	28.1	39.9	54.0	56.7	59.4	62.1	65.2	71.2	78.4	85.6	92.8	100.0
	(Existing)	54.0	18.0	62.0	66.0	71.0	75.0	79.0	59.0	80.0	84.0	87.0	91.0
	(New)	0.0	20.0	45.0	46.0	47.0	48.0	50.0	60.0	70.0	80.0	90.0	100.0
for Non Pipe Borne WS	Non Pipe Borne WSS	100	100	100	100	100	100	100	100	100	100	100	100
Served Population (persons) *2		**26,925**	**62,431**	**78,510**	**83,471**	**88,692**	**94,133**	**100,393**	**107,042**	**119,656**	**132,911**	**146,846**	**161,468**
for Pipe Borne WS	Pipe Borne WSS	26,925	39,365	54,939	59,388	64,077	68,982	74,691	91,688	103,973	116,887	130,477	144,745
	(Existing)	26,925	29,916	33,072	36,392	39,895	43,576	47,449	51,521	55,803	60,302	65,033	70,000
	(New)	-	9,449	21,867	22,996	24,182	25,406	27,242	40,167	48,170	56,585	65,444	74,745
for Non Pipe Borne WS	Non Pipe Borne WSS	-	23,066	23,571	24,083	24,615	25,151	25,702	15,354	15,683	16,024	16,369	16,723
Water Demand (Dave: m3/day)		**3,636**	**6,611**	**7,843**	**8,556**	**9,336**	**10,147**	**11,098**	**13,616**	**15,599**	**17,719**	**19,979**	**22,392**
Pipe Borne WS	Pipe Borne WSS	3,636	5,384	7,608	8,315	9,087	9,893	10,841	13,463	15,441	17,556	19,815	22,225
	(Existing)	3,636	4,203	4,577	5,097	5,658	6,248	6,888	7,566	8,286	9,058	9,874	10,748
	(New)	-	2,240	3,031	3,218	3,429	3,645	3,953	5,897	7,155	8,498	9,941	11,477
Non Pipe Borne WS	Non Pipe Borne WSS	-	1,227	235	241	249	254	257	153	158	163	164	167
Water Demand for Transmission (Dmax = Dave x 1.20 : m3/day)		**4,363**	**7,933**	**9,412**	**10,267**	**11,203**	**12,176**	**13,318**	**16,339**	**18,719**	**21,263**	**23,975**	**26,870**
Water Demand for Treatment (= Dmax x 1.05 : m3/day)		**4,600**	**8,300**	**9,900**	**10,800**	**11,800**	**12,800**	**14,000**	**17,200**	**19,700**	**22,300**	**25,200**	**28,200**

(4) Design Flow of Water Treatment Plants for Stage Construction

Both water treatment plants for Mahakanadarawa and Wahalkada Systems shall be constructed by stage construction. The reasons for stage construction is described in **Section 5.2.1**. The design flow for Phase 1 (2024) and Long-term Plan (2034) is shown in **Table 9**.

Table 9 Design Flow of Water Treatment Plants for Stage Construction

	Phase 1 (2024)	Long-term Plan (2034)
Mahakanadarawa WTP		
Daily Maximum Water Supply	8,950 m3/day	17,900 m3/day
Production Capacity	9,400 m3/day	18,800 m3/day
Wahalkada WTP		
Daily Maximum Water Supply	13,700m3/day	27,400 m3/day
Production Capacity	14,400 m3/day	28,800 m3/day

4.3 Water Availability

4.3.1 Water source

As mentioned in Chapter 2, there is a high risk of fluoride concentration in the groundwater of the Study Area, therefore the source for drinking water needs to be shifted to the surface water. In the Study Area of Anuradhapura District, there are available only seasonal rivers, that flows during the rainy season, therefore, the surface water source for drinking water is expected only from water reservoirs, Mahakanadarawa wewa and Wahalkada wewa.

4.3.2 Water Quality

Seasonal changes of water quality due to rainy and dry seasons also occurs. Recharge water of targeted water sources in the dry season is reduced, and the existing water in targeted water sources are concentrated by evaporation so the contents are increased. This trend is remarkable in Mahakandawara wewa though Wahalkada shows less of a trend of this.

In Sri Lanka, high concentrations of fluoride are found in groundwater in many areas and the project area is also known as a higher concentration area of fluoride. Therefore, continuous water quality monitoring of the said parameter is essential. As fluoride is a substance derived from minerals, both groundwater and surface water contain flouride if it has come into contact with the mineral. As for fluoride in targeted water sources, the same as EC, Cl and Hardness, the concentrations are lower in the rainy season and becomes higher in the dry season. The trends are shown as follows.

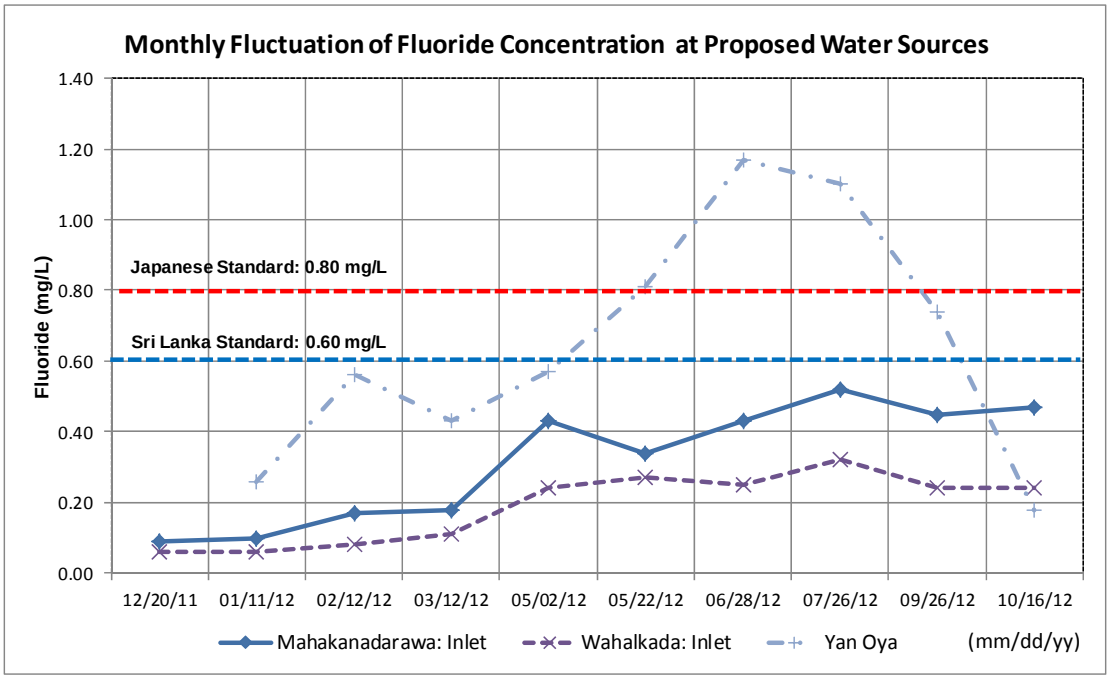

Figure 4 Water Quality (Fluoride)

4.3.3 Present Operation of Irrigation Reservoir

The water uses of the above tanks are irrigation and fisheries. Irrigation water is mainly used for paddy fields and partly used for other upland crops under an annual irrigation program. The general condition of the irrigation scheme is shown in **Table 10**.

Table 10 General Condition of Irrigation Scheme

Item	Outline
Irrigation period in Maha	Nov. – March
Irrigation period in Yala	May – September
Major Crops	Rice (Paddy field)
Irrigation Area	Mahakanadarawa Scheme： Max. Irrigable area: 6,000Ac（2,420ha) Irrigable area by FSL: 3,600Ac（1,460ha） (around 50% is available in Yala season) Wahalkada Scheme： Max. Irrigable area: 2,257Ac（910ha) Irrigable area by FSL: 2,000Ac（810ha）

Table 4.6 shows the annual irrigation water use in 2009-2011. In the case of the Mahakanadarawa scheme, water use varied from 19.41 to 42.42 MCM, with the amount partly being dependent on the quantity of water stored early in the season. On the other hand, in the case of the Wahalkada scheme, the variation in irrigation water use is not as big as in the Mahakanadarawa scheme, ranging from about 12 to 16 MCM, with the storage volume early in

the season varying.

Table 11 Irrigation Water Used in 2009-2011

	Mahakanadarawa tank		Wahalkada Tank	
	Storage in Jan. 1 (MCM)	Irrigation Water Supply (MCM)	Storage in Jan. 1 (MCM)	Irrigation Water Supply (MCM)
Gross Calc. for Average Rainfall		22.2		10.9
2009	44.78	No data	17.45	12.13
2010	22.50	19.41	21.50	16.13
2011	44.78	42.42	26.73	15.95

4.3.4 Water Availability from Irrigation Reservoir

(1) Gross Estimation of Water Balance

The gross water balance is estimated by assuming runoff coefficients as shown in **Table 12**. The runoff coefficient from the whole catchment area is estimated at 20% in Wahalkada Wewa, and 8% in Mahakanadarawa Wewa. Seepage is neglected because this is a relatively small amount, compared to the total storage volume.

Table 12 Gross Estimation of Water Balance

	Mahakanadarawa	Wahalkada
Average Rainfall (mm/yr)	1,240	1,440
Catchment Area(km^2)	334	83
Runoff Coefficient (%)	8	20
Water Area of Reservoir (km^2)	9	2.1
Annual inflow to the Reservoir (MCM)	33.13	23.90
Volume by rainfall (MCM)	11.16	2.96
Evaporation from water surface (MCM)	11.93	2.60
Seepage (MCM)	—	—
Average Annual Storage (MCM)	32.36	23.77
Average Annual Storage (Acft)	26,244	19,278

(2) Water intake for drinking water in 2016, 2024 and 2034

Water intake for drinking water is estimated as shown in **Table 13**.

Table 13 Water Intake for Drinking Water

Drinking Water Supply	Mahakanadarawa Tank		Wahalkada Tank	
	(m^3/day)	(MCM/year)	(m^3/day)	(MCM/year)
Water intake in 2016	6,700	2.45	10,500	3.83
Water intake in 2024	9,400	3.25	14,400	5.26
Water intake in 2034	18,800	6.53	28,800	10.00

(3) Irrigation water

Tendency of storage variation in both reservoirs, annual irrigation water use is estimated as follows.

- Mahakanadarawa scheme: 20-30 MCM (40 MCM is corresponding to water use for FSL)
- Wahalkada scheme: 12-16 MCM

4.3.5 Mahakanadarawa Wewa

(1) Situation

For Mahakandarawa wewa, the average annual storage is estimated at around 32.36 MCM, and the irrigation use varies between 20-30 MCM/year. On the other hand, the water supply for drinking will be annually 3.25 MCM in 2024 and 6.53 MCM in 2034. Assuming that the priority is given to water supply for drinking, the water shortage will occur even in 2016 for an irrigation use of 30 MCM/year. If the NCP Canal Project will not be completed, water allocation between irrigation and water supply for drinking will be a big issue, since an amount of water shortage will increase.

If the NCP Canal Project will be completed in 2016 as scheduled, it will catch the commencement of operation for water supply in 2018 (**Figure 5**). Basically, the NCP Canal Project includes drinking water of around 70 MCM/year for 15 major towns in North Central and North Provinces. Most of the target towns served by the Mahakanadarawa water supply system under the "Anuradhapura North Integrated Water Supply Project" are corresponding to the towns covered by the NCP Canal Project. In 2034, the total amount of 80.53 MCM composed of 6.53 MCM for water supply and 74 MCM required to irrigate the maximum irrigation area of 2,420 ha of the Mahakanadarawa Irrigation Scheme will be necessary for both purposes. However, the average storage of Mahakanadarawa Wewa is approximately 32.36 MCM, and the balance of 48.17 MCM should be covered by the NCP Canal Project with a design capacity of 700 MCM which will make the further supplement of water possible. Therefore, an enough amount of water will be maintained for both water supply and irrigation (**Figure 6**).

(2) Implementation Schedule of the NCP Canal Project

GOSL has taken an initiative to implement the Moragahakanda/Kalu Ganga Project which was identified as essential infrastructure for the implementation of the NCP Canal Project. The Moragahakanda/Kalu Ganga Project is under construction since 2007, and programmed to be completed by 2014. However, the project has been delayed because of financial and environmental problems. Finally, the Chinese Government agreed to provide loan assistance in 2012, then the Project started the second stage. According to the newspapers, the Project is expectedly completed by 2016.

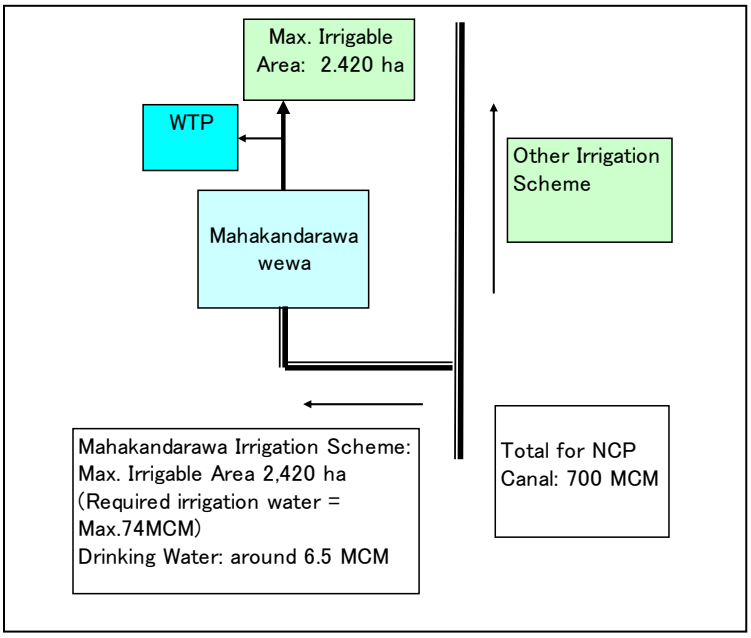

Figure 5 Image of Assumed Additional Water from NCP Project

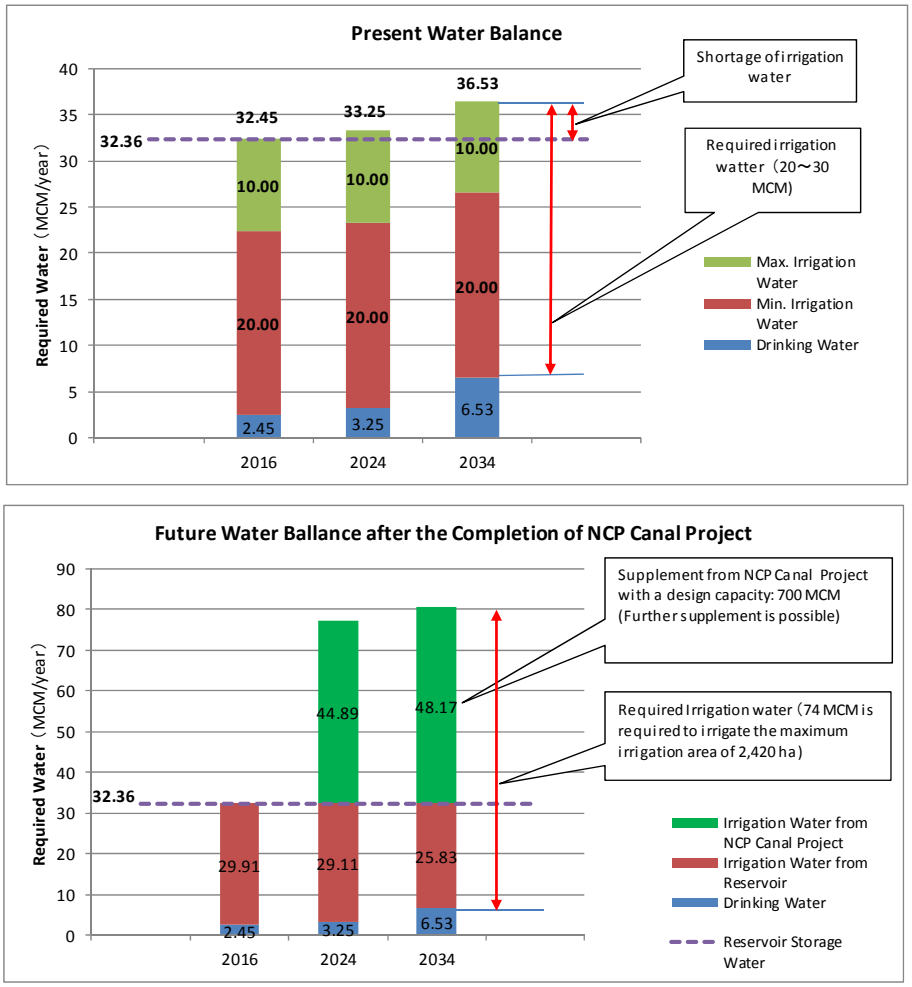

Figure 6 Water Availability in the Mahakanadarawa Wewa

4.3.6 Wahalkada Wewa

(1) Situation

For Wahalkada Wewa, the average annual storage is estimated at around 23.77 MCM, and the irrigation use varies between 12-16 MCM. On the other hand, the water supply for drinking will be annually 5.26 MCM in 2024 and 10.00 MCM in 2034. According to this result, this reservoir water will not be enough to cover the water use for water supply and irrigation without an appropriate allocation in 2034.

The Yan Oya Reservoir Project will have an irrigable area of 4,780 ha by a new reservoir capacity of 254 MCM. Its left side irrigation canal will pass in the Wahalkada Irrigation Scheme, and irrigate an area of around 400 ha under the Wahalkada Irrigation Scheme. An additional water supply from Yan Oya Reservoir Project is assumed 7 MCM at the maximum as shown in **Figure 7** In other word, the Wahalkada Wewa will have an excess water with the same amount as it, namely 5.94 MCM to 11.51 MCM as shown in **Figure 8**. Therefore, the storage water will be enough for water supply and irrigation even in 2034.

It should be noted that the Yan Oya Reservoir has a problem in water quality. The fluoride concentrations of the Yan Oya River has recorded 0.81 mg/L to 1.2 mg/L in May to July 2012 exceeding the Japanese drinking water standard of 0.8 mg/L, while those of the Wahalkada Wewa has kept 0.25 mg/L to 0.38 mg/L during the same period. Therefore, the water to be used for drinking water supply should be that of the Wahalkada Wewa.

(2) Implementation Schedule of the Yan Oya Reservoir Project

Financial award was signed with a project cost of Rs.19 billion between the Chinese and Sri Lankan Governments in November 4, 2011. The EIA report has been submitted to the CEA and review of it is still in progress. After the approval of the EIA, the construction work is expected to start and around 4 years will be required for the completion of the project.

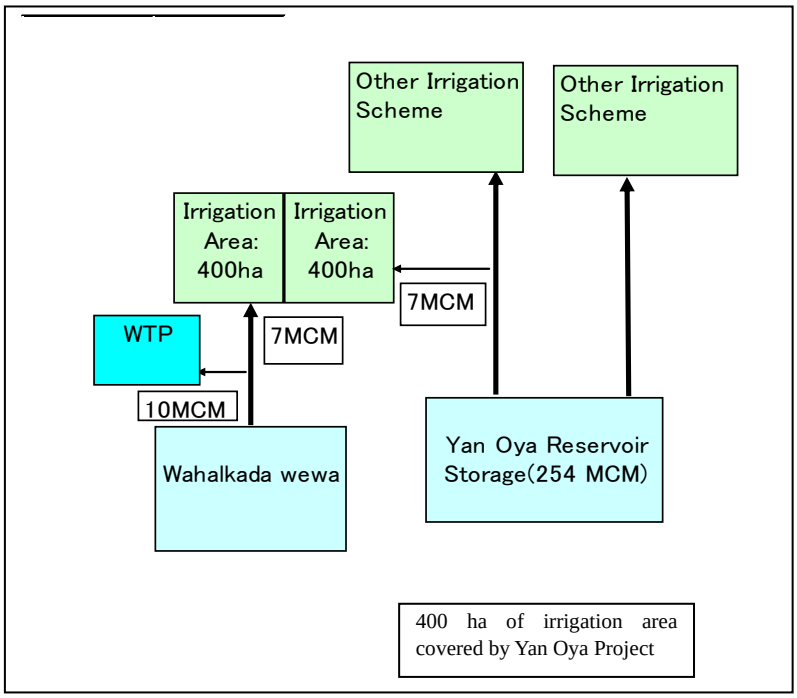

Figure 7 Image of Assumed Additional Water from Yan Oya Project

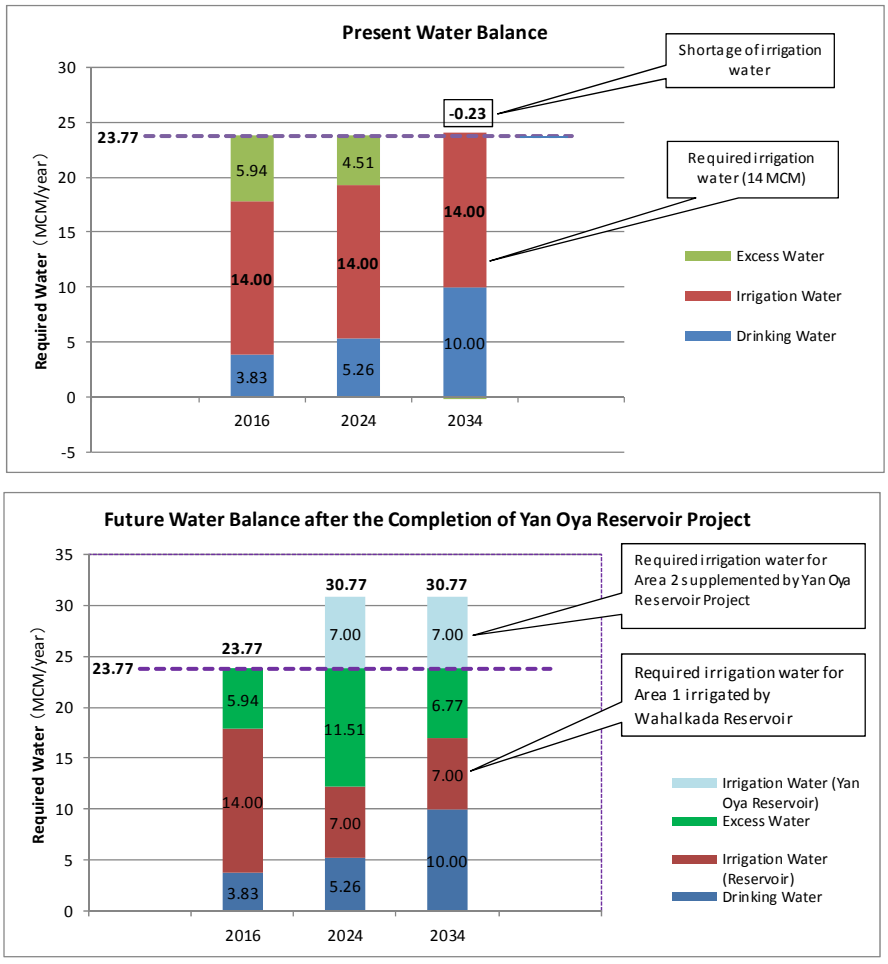

Figure 8 Water Availability in the Wahalkada Wewa

5 PLAN OF PROPOSED WATER SUPPLY SYSTEM

5.1 Water Intake Works

The Irrigation Department, as the management entity for the Mahakanadarawa and Wahalkada Reservoirs, considered intake methods for the Project, and decided that only the canal intake method is suitable

Drinking water will be supplied based on the agreement between the Irrigation Department and NWSDB. A Memorandum of Understanding (MOU) for extracting water from Mahakanadarawa Wewa and Wahalkada Wewa for the Anuradhapura North Water Supply Scheme is in Article 3 shown in **Table 14**.

Table 14 Memorandum for Extracting Water

Year	2016	2034	Remarks
Mahakanadarawa	6,700 m3/day	18,800 m3/day	Amount in 2016 will be after completion of WTP Amount in long term plan will be after completion of Upper Elahara Canal Project
Wahalkada	10,500 m3/day	28,800 m3/day	

In case of periods of exceptional water scarcity, Article 9 mentions that the Irrigation Department, Irrigation Management Division, NWSDB, Divisional Secretary, Member of Project Management Committee (established under the Irrigation Ordinance and chaired by the District Secretary) will hold a meeting and decide on water allocation rights.

5.2 Water Treatment Plant

5.2.1 Stage Construction of water treatment Plants

Since the water transmission and distribution facilities is constructed with a full design capacity for the year of 2034 due to the difficulty in split construction, the water treatment plant, etc. to which stage construction is applicable, shall be constructed with a half capacity for the year of 2024 to reduce an initial investment as much as possible.

- NWSDB Design Manual (March 1989) *recommend the ten-year stage construction.*
- The NWSDB Guidelines suggest the difficulty to increase the population coverage by water supply in the rural area.
  - 92.8% of the people in the study area have any types of their own water sources. Whether the people will connect to a water supply system or not is left to their discretion.
  - Even though connected to a water supply system, the people may use either of groundwater or tap water selectively by use.

  - Even though the pipe borne water supply is applied to GNDs, it will take time to attain the full coverage of a distribution network in the situation of a population density of less than 100 persons per km^2 that a housing unit is located every 100 m to 400 m.
- If the equipment is installed in full construction but not in stage construction, a variety of waste will occur. The equipment once installed will be unavoidably idle.
- Assuming that the total construction cost will be reduced by 10% in case of full construction of a water treatment plant, the comparative study of FIRR shows that FIRR of stage construction will be better than that of full construction.
- The NCP Canal and Yan Oya Reservoir projects that supplement the water supply condition of Mahakanadarawa and Wahalkada Tanks have not yet started and their completion time has not been assured.

5.2.2 Selection of Water Treatment Process

There are two major treatment processes to select: slow sand filters and rapid sand filters.
Slow sand filters are simple, cost effective, reliable, and easy to operate. However slow sand filters generally treat source water turbidity of less than 10 degrees successfully. Rapid sand filters can treat high turbidity water if the water is properly coagulated and settled out. The turbidity of Mahakanadarawa and Wahalkada water is higher than 10 degrees and ranges 1 to 20 degrees. There is a possibility that roughing filters can serve as a pretreatment to reduce the turbidity loading to the slow sand filters. To determine the applicability of the slow sand filters with help of roughing filters, pilot plant tests were conducted. However, the turbidity was insufficiently removed, less than 5 degrees even though adjusting the filtration velocity, and for the color, no difference was observed and treated water was yellowish green color.

In conclusion, the implementation of rapid sand filter system is recommended for the Anuradhapura North Water Supply Project. Rapid sand filter systems are widely used in Sri Lanka so that Water Board will have no difficulties in operation and maintenance. Also it is recommended to install ACF (Active Carbon Filter) as soon as possible to remove the odor, if a bad odor occurred in the treated water for a long period, after operation of Phase - 1 facility started. Wooden and coconut granular carbon produced in Sri Lanka is available there. Some water treatment plants in Sri Lanka use powder and granular activated carbon.

5.2.3 Mahakanadarawa WTP

(1) Flow diagram

The flow diagram of Mahakanadarawa WTP are shown in **Figure 9**.

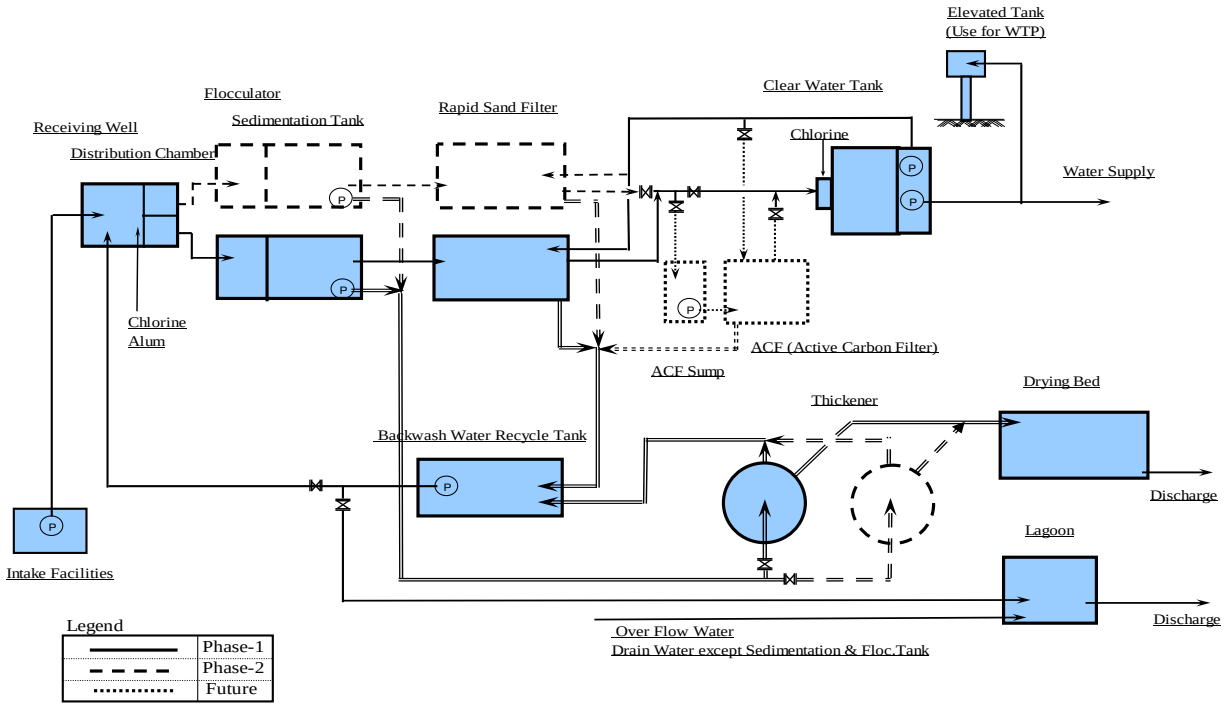

Figure 9 Flow Diagram of Mahakanadarawa WTP

(2) Outline of Mahakanadarawa WTP

Mahakanadarawa WTP takes water from an irrigation canal from Mahakanadarawa Tank at approximately 120m downstream of Mahakanadarawa Tank. The WTP is located on the left of the irrigation channel. The capacity of the WTP including 5% treatment process loss is shown in **Table 15**.

Table 15 Capacity of Proposed WTP

Year	In 2024	In 2034	Remarks
Water rights (m3/d)	6,700 to 18,800	18,800	
Water demand (day ave.) (m3/d)	7,154	14,414	According to water demand projection
Water demand (day Max.) (m3/d)	8,600	17,300	day ave. x 1.2
Production capacity of WTP(m3/d)	8,900	17,900	Output of WTP; Capacity of WTP x 0.95
Capacity of WTP (m3/d)	9,400	18,800	Input to WTP

Table 16 Detail of Facilities

Facility	Phase-1	Phase-2	Remarks
Receiving Well	W4.0m x L4.6m x H6.0m x 1unit	-	*
Distribution Chamber	W2.0m x L2.0m x H5.0m x 2units	-	*
Flocculator tank	5 stages x 62.8m3 x 4 units	5 stages x 62.8m3 x 4 units	
Sedimentation tank	W4.0m x L10.4m x H4.0m x 4units	W4.0m x L10.4m x H4.0m x 4unit	Plate settler
Rapid sand filter tank	W3.0m x L5.5m x 4units	W3.0m x L5.5m x 4units	
ACF sump	W8.0m x L12.0m x H3.0m x 1unit		future
ACF tank	W2.5m x L5.0m x 4units		future

Facility	Phase-1	Phase-2	Remarks
Chlorine Mixing Chamber	W2.0m x L5.0m x H4.0m x 2units	-	*
Reservoir	W8.0m x L17.0 x H4.0m x 2units	-	*
Backwash water recycle tank	W4.0m x L14.0 x H3.0m x 2units	-	*
Thickener	Dia 10.0m x H4.0m x 1unit	Dia 10.0m x H4.0m x 1unit	
Drying bed	W12.5m x L20.0m x H1.0m x 4units	W12.5m x L20.0m x H1.0m x 2units	
Lagoon	W10.0m x 27.0m x 1.0m x 1unit	-	*
Administration Bldg.	W12.0m x L25m x 2 stories	-	*
Chemical house	W11.5m x L12.0m	-	*
Chlorine House including neutralization facilities	W12.0m x L14.0m	-	*
Pump House	W8.0m x L26.5m	-	*
Blower House	W7.3m x L13.5m		*
Generator House	W4.5m x L8.0m	-	*
Ware House	W10.0m x L17.0m	-	*

*The capacity of the facilities constructed in phase 1 includes the whole capacity required for the project up to Phase 2.

5.2.4 Wahalkada WTP

(1) Flow diagram

The flow diagram of Wahalkada WTP is the same as in **Figure 9**.

(2) Outline of Wahalkada WTP

Wahalkada WTP takes water from an irrigation canal from Wahalkada Tank at approximately 420m downstream from Wahalkada Tank. The capacity of the WTP is determined in consideration of water rights, daily maximum water demand and 5% treatment process loss in **Table 17**.

Table 17 Capacity of Proposed WTP

Year	In 2024	In 2034	Remarks
Water rights (m3/d)	10,500-28,800	28,800	
Water demand (day ave.) (m3/d)	11,098	22,392	According to water demand projection
Water demand (day Max.) (m3/d)	13,300	26,900	day ave. x 1.2
Production capacity of WTP(m3/d)	13,700	27,400	Output of WTP; Capacity of WTP x 0.95
Capacity of WTP (m3/d)	14,400	28,800	Input to WTP

The treatment process is the same as at Mahakanadarawa WTP, except that an elevated tank is provided to supply water to the neighboring villages. Treated water is pumped to the elevated tank, which is located in the WTP site and also to the served areas through transmission pipelines.

The facilities in Wahalkada WTP are summarized in **Table 18**.

Table 18 Detail of Facilities

Facility	Phase-1	Phase-2	Remarks
Receiving Well	W5.6 x L5.0m x H6.0m x 1unit	-	*
Distribution Chamber	W2.5 x L2.0m x H5.0m x 2units	-	*
Flocculator tank	7stages x89.3m^3 x 4 units	7stages x89.3m^3 x 4 units	
Sedimentation tank	W4.0m x L14.4m x H4.0m x 4units	W4.0m x L14.4m x H4.0m x 4unit	Plate settler
Rapid sand filter tank	W4.0m x L6.0m x 4units	W4.0m x L6.0m x 4units	
ACF sump	W10.0m x L14.0m x H3.0m x 1unit		future
ACF tank	W3.5m x L5.0m x 4units		future
Chlorine Mixing Chamber	W2.0m x L6.75m x H4.0m x 2units	-	*
Reservoir	W10.0m x L21.0m x H4.0m x 2units	-	*
Backwash water recycle tank	W5.0m x L15.0m x H4.0m x 2units	-	*
Thickener	Dia 12.5m x H4.0m x 1unit	Dia 12.5m x H4.0m x 1unit	
Drying bed	W15.0m x L25.0m x H1.0m x 4units	W15.0m x L25.0m x H1.0m x 2units	
Lagoon	W12.0m x 25.0m x 1.5m x 1unit	-	*
Administration Bldg.	W12.0m x L25m x 2 stories	-	*
Chemical house	W11.5m x L12.0m	-	*
Chlorine House including neutralization facilities	W12.0m x L14.0m	-	*
Pump House	W8.0m x L35.0m	-	*
Blower House	W7.3m x L13.5m		*
Generator House	W5.0m x L9.5m	-	*
Ware House	W10.0m x L17.0m	-	*

*The capacity of the facilities constructed in phase 1 includes the whole capacity required for the project up to Phase 2.

5.3 Transmission and Distribution System

5.3.1 Transmission System

There are six NWSDB's systems and 50 existing community water supply systems in the project area. The NWSDB systems, covering 25 GNDs, are located in the core area(s). Generally, each CBO covers a part of a GND. Some CBOs, however, cover multiple GNDs or two to three GNDs. New water supply systems for GNDs other than the existing CBOs will be constructed under this project. However some of the GNDs will not have piped supply systems, but will be supplied from an indirect system to which water will be transferred by water tankers (Bowsers). All the existing CBOs receive treated water at their elevated tanks except for three CBOs.

The number of GNDs presently supplied by NWSDB, existing CBO or new system established under the present project is summarized in **Table 19**. **Figure 10** shows such GNDs supplied by the existing piped system, new system and indirect supply.

Table 19 Summery of GNDs in Project Area

DSD	NWSDB	GNDs by CBOs	New GNDs		Indirect (Isolated) GNDs	
			Year 2024	Year 2034	Year 2024	Year 2034
Padaviya [1)]	3	4	5	8	4	1
Kebithigollewa	5	2	17	17	1	1
Medawachchiya	8	13	8	9	6	5
Rambewa	4	12	6	10	16	12
Horowpothana	2	6	21	21	8	8
Kahatagasdigiliya	3	18	7	11	12	8
Total	25	55	64	76	47	35

Note [1)]: GND 2 of Padaviya DSD is supplied from both NWSDB and existing CBO (29)

Two water sources are selected for the present integrated water supply system in the northern and southern parts of the project area, namely Wahalkada Wewa and Mahakanadarawa Wewa respectively, from where raw water is conveyed, after treatment, to the entire project area through two transmission systems.

The transmission system from the Mahakanadarawa Wewa is named as the Mahakanadarawa System, which will cover DSDs of Medawachchiya and Rambewa. The Wahalkada system from Wahalkada Wewa transmits treated water to the DSDs of Padaviya, Kebithigollewa, Horowpothana and Kahatagasdigiliya.

From the demand projection for the year of 2034, the transmission capacity for the Mahakanadarawa and Wahalkada systems is determined as 17,300 m^3/day and 26,900 m^3/day respectively.

Each transmission system is composed of a transmission main system and a sub-main system. The main system is formed to cover the entire supply zone from the respective water treatment plant and the sub-system supplements the main system to convey bulk water to the elevated tanks, which are placed at strategic locations to distribute water to the new system of GNDs and transmit bulk water to the existing CBOs.

The transmission main system is composed of transmission mains and service centers where a pumping station and an elevated tank are provided. In addition, booster pump stations are provided at strategic locations. The transmission main route of each system is, in general, selected to run along the main roads mentioned above, from the water treatment plant and between service centers. Elevated tanks are provided at key locations to distribute treated water directly to the new distribution systems of GNDs. On the other hand, the existing systems will receive bulk water from the transmission system at the elevated tanks.

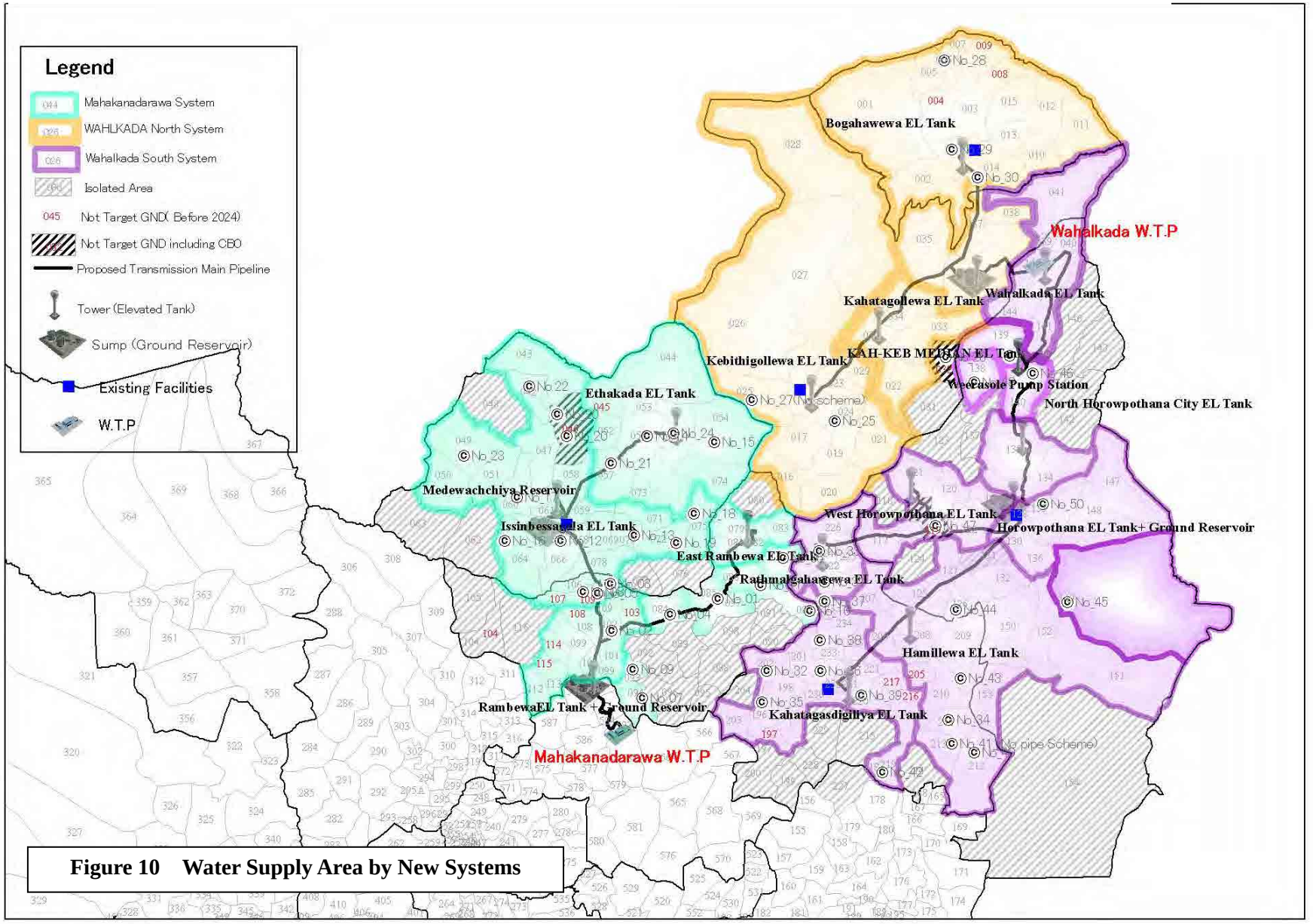

Figure 10 Water Supply Area by New Systems

5.3.2 Distribution System

Distribution system is composed of distribution main and distribution sub-system. Distribution main conveys water from the elevated tank directly to the GND's distribution sub-system which distributes water to each customer directly. On the other hand, the main feeds water to the existing elevated tank of CBO, from where distribution sub-system distributes water to each customer. In both cases, a water meter will be installed at the inlet of either distribution sub-system of new system of GND or existing elevated tank of CBO.

1) Distribution Main

The preliminary design of distribution main is carried out using Google map to obtain distance and ground elevation for analysis of sizing of distribution main for the purpose of cost estimate. The sizing of distribution main was determined peak hour demand of year 2034 requirement for new system of GND and day maximum demand of year 2034 for the existing CBO.

2) Distribution Sub-system

The study on distribution sub-system is carried out mainly for cost estimate purpose using the unit length of each size of distribution pipe per service connection obtained from network analysis of model networks at three typical existing CBO systems with a different size. Using unit length to service connection, the pipeline length for each size was estimated for Phase I (year 2024) based on the following considerations:

- Pipeline lengths of 100mm or larger were estimated for year 2034 requirement
- Pipeline lengths of 50mm and 75mm were estimated for year 2024 requirement corresponding to the construction period.

5.3.3 Major Facilities of Transmission and Distribution System

The summary of major facilities of transmission and distribution system is presented below and in **Tables 5.7**.

I. Mahakanadarawa System

1) Transmission Mains	250 – 450 mm x 42.3 km
2) Transmission Sub-mains	100 – 250 mm x 50.8 km
3) Distribution Mains	200 – 400 mm x 141.4 km
4)-1 Distribution Sub-System (NWSDB scheme)	50 – 200 mm x 201.6 km
4)-2 Distribution Sub-System (Existing CBO scheme)	50 – 200 mm x 315.1 km

II. Mahakanadarawa System

1) Transmission Mains	300 – 450 mm x 117.3 km
2) Transmission Sub-mains	100 – 250 mm x 24.3 km
3) Distribution Mains	100 – 400 mm x 326.7 km
4)-1 Distribution Sub-System (NWSDB scheme)	50 – 200 mm x 378.4 km
4)-2 Distribution Sub-System (Existing CBO scheme)	50 – 200 mm x 254.6 km

Table 20 Summery Table of the Facilities to Be Constructed

System	Site	Elevated Tank	Ground Reservoir	Pump House	Operational Complex *1	Chlorinator Building	Generator	Workshops	Quarters for Staff	Quarters for Operator	Surge Tank (100m3)
Mahakanadarawa	Rambewa	1,250m3	1,500m3	✓	✓	✓	✓		✓	✓	
	Medawachchiya		1,000m3	✓	✓*2 *3	✓	✓	✓	✓	✓	
	Issinbassagala	2,000m3				✓				✓	
	Ethakada	750m3				✓				✓	
	East Rambewa	250m3				✓				✓	
	Mahakanadarawa ~Rambewa										✓✓
Wahalkada South	Wahalkada	500m3				✓				✓	
	Kahatagollewa	250m3	1,000m3	✓		✓	✓			✓	
	Bogahawewa	2,000m3			✓	✓			✓	✓	
	KAH-KEB Median	250m3				✓				✓	
	Kebithigollewa	750m3	500m3	✓	✓*3	✓	✓	✓	✓	✓	
Wahalkada North	Weerasole		1,500m3	✓		✓	✓			✓	
	North Horowpothana	250m3				✓				✓	✓
	Horowpothana	500m3	1,000m3	✓	✓*3	✓	✓	✓	✓	✓	
	West Horowpothana	750m3				✓				✓	
	Rathmalgahawewa	500m3				✓				✓	
	Hamillewa	1,250m3				✓				✓	
	Kahatagasdigilliya	1,500m3	500m3	✓	✓	✓	✓		✓	✓	
Total		**15**	**7**	**7**	**6**	**17**	**7**	**3**	**6**	**17**	**3**

*1 Lab., OICs Office, Customer Counter, Room for Crews

*2 Satelite Office is to be included

*2 OIC Office should be replaced to Area Engineers Office

5.4 Water Supply System for Isolated Areas

The Project is to integrate the existing small-scale water supply systems into two large-scale ones.

The following priority of factors is considered to select service areas of two pipe borne water supply systems.

1st GNDs with an existing water supply system
2nd GNDs where the facilities of a proposed water supply system are included
3rd GNDs covering a urban centre including its surrounding GNDs
4th GNDs along with main roads designated

As the result of analysis, the remaining areas are categorized as isolated areas. The population is 53,500 for isolated areas, 225,000 for non-isolated areas and 278,500 in total for the target year of 2034, respectively.

The water supply system in the isolated areas consists of water tanks (capacity 5 m3) and water bowsers (capacity 5 m3) and 10 Lpcd of water will be provided to each population.
Figure 5. 3 shows the concept of water supply system in the isolated area. Totally, 107 water tanks and 20 water bowsers are required for the water supply for the isolated areas.

6 MANAGEMENT, OPERATION AND MAINTENANCE OF THE PROPOSED WATER SUPPLY SYSTEM

6.1 Project Implementation Arrangements

The project implementation system will consist of the following: (i) The ***project executing agency*** will the MWSD. Its role will be oversight monitoring of NWSDB's responsibilities in implementing the project. This will be performed through its Planning and Monitoring Division and its Procurement Division. (ii) The ***project implementing agency*** will be NWSDB. Its role will be technical monitoring and financial monitoring of the project, which it has had plenty of previous experiences. This will be performed by the Office of Water Supply Projects. (iii) A ***project management and coordination unit*** (PMCU), to be headed by a Project Director, will be created under the Office of Water Supply Projects, but will be physically based in the North Central RSC. It will manage the day-to-day activities of the Project and will be involved in the entire cycle of the project as reflected in the whole range of services to be provided by the project consultants' team. (iv) The ***project coordination committee*** (PCC) will be composed of the representatives of the key stakeholders of the Project. The DGM of the N/C RSC will chair the PCC, with the PD of the PMCU as co-chair. The key stakeholders identified are the Central Environment Authority, the Irrigation Department, the Department of Wildlife Conservation, the Department of Health Services, the Department of Archaeology, the Department of Forestry, the Land Commissioner's General Department, the Local Authorities and representatives of Community-Based Organisations in the six project areas.

6.2 Operation and Maintenance Organisation

(1) Enhancement of Existing Service Centres and New Set-up

There are four water supply schemes presently operating in the Project Area. However, Rambewa will need to be organised into a new water supply scheme to manage the newly constructed facilities that will be operational by 2018. Meantime, the other three existing WSS shall be expanded to enable it to take on the added O&M responsibilities given the new facilities.

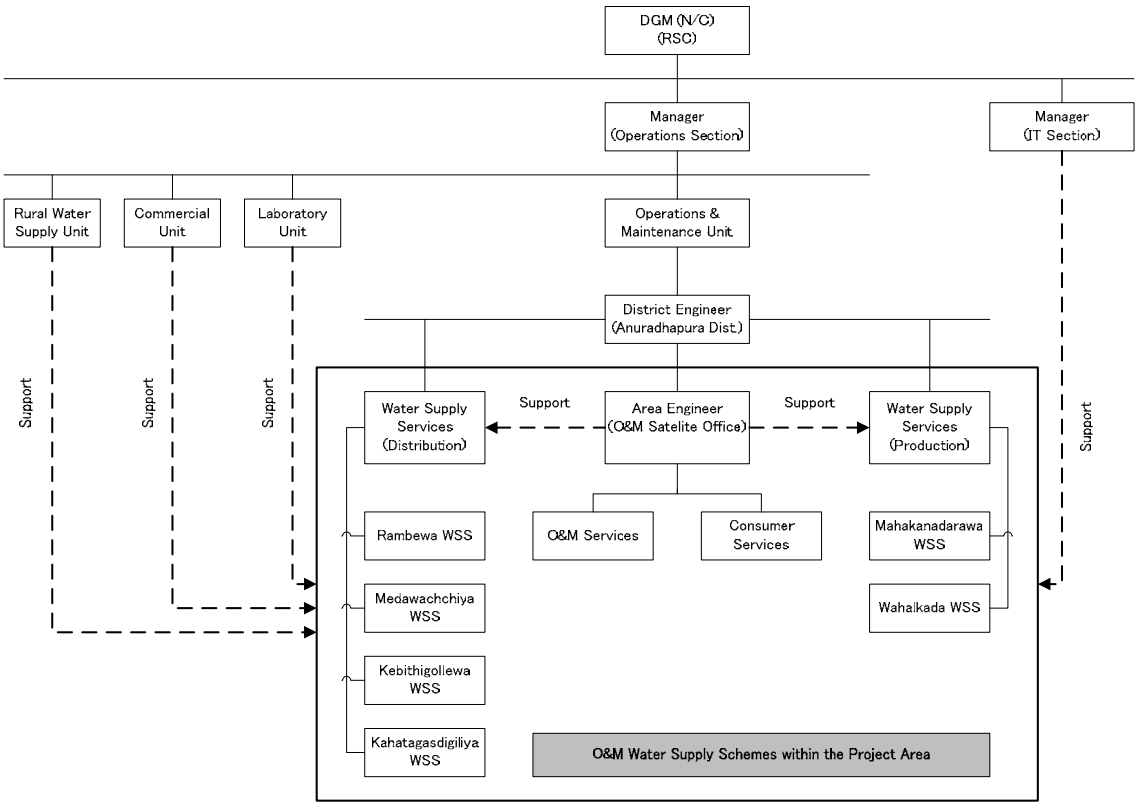

Figure 11 O&M Organization and Supporting System after Commissioning

(2) Establishment of Mahakanadarawa and Wahalkada Water Supply Schemes

Two new water supply schemes are be organised to operate and maintain the Mahakanadarawa and Wahalkada water treatment plants before the end of the construction period, to have ample lead time to train for the pre-operation and star-up operational phases of the WTPs.

(3) Establishment of O&M Area (Satellite) Office for WSS in the Project Area

It is proposed that the O&M satellite office be organised in Medawachchiya, to be staffed by five personnel (headed by an officer-in-charge). The area office will function to: (i) *deliver quick response to O&M and technical issues* that need immediate resolution and which were inadequately dealt with by the schemes; (ii) *provide closer consumer service support services* considering the increased number of new customers to be generated by the completion of the Project, (iii) *spearhead the public information, education and communication (IEC) programme* on the importance of water to health; (iv) *assist the WSS in delivering potable water* to the remote villages not covered by the piped system, but which is required due to water quality health concerns.

(4) Enhancing Other Sections / Units in Support of O&M

There are other sections and units in the NC RSC that need to be enhanced to support the proper operation and maintenance of the new facilities. These are the (i) regional laboratory, for the upgrade of laboratory facilities and training on water quality monitoring; (ii) the rural water supply unit, for capacity building of CBOs and spearheading the public awareness campaign under the IEC programme; (iii) the commercial unit, for improving customer services guided by

the NWSDB Customer Charter; and (iv) the IT section, for the enhancement of customer services through the expanded use of the call centre service, and the improvement of billing efficiency with the use of a point-of-sales system.

(5) Supporting O&M through Equipment and Engineering Software

It is equally important that the water supply schemes, the O&M area office, and the regional workshop are equipped with basic O&M equipment and vehicles. The equipment proposed are four units each of asphalt cutters, tapping machines, compactors, and vibrating hammers; six units of portable generators; one unit of small lift hoist / crane; one unit of pump bed test / machine; and 20 units of assorted vehicles (cabs, water bowser, mini-backhoe and motorcycles. The latest versions of engineering software (01 with 5-user licence) required are: Small World Water Network Information System, ArcGIS, WaterCAD, Surge Analysis Software, Structural Design Software, and Project Management Software

6.3 Mode of Water Supply Services

(1) Community Based Organisations

CBOs operating in the Project area were formed as rural community organisations capable of providing and sustaining the management of the water supply and sanitation facilities to their beneficiary community under either ADB, World Bank or bilateral projects. The functions of the CBOS are enshrined in the National Policy for Rural Water Supply.

(2) CBO-Managed Water Supply Schemes in the Project Area

Based on the criteria for the inclusion of CBOs into the project's service area, three CBOs, namely (i) Tristar and (ii) Dirimathaya and (iii) Al Naja will be excluded for various reasons.

In terms of suitability of the CBOs for inclusion / connection to the bulk water system, 36 CBOs or 72 percent are technically suitable, thus can be recommended for immediate inclusion; 06 CBOs or 12 percent are recommended, but improvements are required; 05 CBOs or 10 percent are also recommended, pending resolution of larger issues; and 03 or six percent are excluded, as explained above. Actions to address the issues by the NWSDB NC are proposed in this Study.

As for the willingness of the CBOs to connect to the bulk water system, a resounding majority of 42 CBOs or 84 percent are willing to connect to the new distribution system. One CBO

(two percent) said it was not willing to connect; one (two percent) was undecided; one (two percent) did not respond. One the other hand, one (two percent) does not have CBO/scheme, while one (two percent) is a rainwater harvesting scheme. Three CBOs (six percent) have been excluded from the study.

(3) Approaches in Providing Water Supply Services to the CBOs

In view of the preceding, it is proposed to categorise CBOs for inter-connection with the bulk supply, as shown below:

Table 21 Categorisation of CBOs Based on Willingness to Connect, Conditions Set and Technical Suitability

	CATEGORY 1	CATEGORY 2	CATEGORY 3	CATEGORY 4	CATEGORY 5
CBO	• Willing to connect • No conditions • Suitable for bulk supply	• Willing to connect • No conditions • Requires improvements	• Willing to connect • With conditions • Suitable for bulk supply	• Willing to connect • Requires major rehabilitation • Undecided	• Not willing to connect • Excluded
TOTAL	**11**	**6**	**24**	**5**	**4**
%	***22***	***12***	***48***	***10***	***8***

After the new water supply system will enter into operation, NWSDB will be responsible for management, operation and maintenance of new systems. If NWSDB will take over the existing CBO system based on the resolution at the general meeting of the community, the NWSDB's water tariff is imposed to the respective customers, while if the existing CBO will keep an independence from NWSDB, the NWSDB's bulk water supply rate will be imposed to the total water consumption of the CBO. For the new service area, since NWSDB has no intention to allow the new CBO establishment. NWSDB's water tariff will be applied to all the new customers. Takeover of the existing CBO facilities will be done in principle for nothing, since the materials required for the construction of facilities were originally provided by the Government for nothing.

In case of a bulk supply from NWSDB to existing CBOs, the bulk supply charge will be newly imposed, while the consumerable expenditures such as electricity or diesel oil and chlorine will be cut from the present expenditures. The profit/loss estimated reveals that 17 CBOs (about 41%) out of 41CBOs will show a loss. Although the total payment of one community will be higher than the current one, the water supply by NWSDB still has advantages of (i) safe water supply to meet the Sri Lankan drinking water standards even for fluoride, (ii) stable water supply even in the dry season, (iii) proper chlorination of water, (iv) professional operation and maintenance for distribution facilities such as replacement of defective water meters, repair of leaks.

7 Environmental and Social Consideration

7.1 Natural Conditions

(1) Natural Conditions in the Study Area

The project area is a suburban and rural area, which is located in the northern part of Anuradhapura District. The climate is classified into the dry zone. The main industry is the agriculture for rice as a main crop. The land covered by forest and shrub is the largest in area. Compared with the heavy rain area, the species of fauna and flora are less and the biodiversity is poor due to less rare species. Some of project sites are lacated in the forest but they are the secondary forest and special attention is not required for the environmental protection.

(2) Protected Area

[Sanctuary]

The protection of a sanctuary is provided in “Fauna and Flora Protection Ordinance” and is controlled by the Department of Wildlife Conservation. The level of protection of a sanctuary is not so severe among the protection areas and a mion development action ican be done with a permission of the authority although being required the implementation of EIA/IEE.

Around Mahakanadarawa Wewa, one of the proposed water sources in the project is designated as a sanctuary. The boundaries of an sanctyary is defined as within 400 yards (366 m) from the Full Supply Level of the reservoir or a center line of the bund wherever there is a bund as an artificial structure. While, the Central Environmental Authority (CEA) designated the buffer zone within 100 m from the boundary as a most susceptible area to an environmental impact. Since in the initial plan of the project, water was planned to be taken from the reservoir directly, the project was classified into Category B due to the fear of an impact on the protection area. However, thereafter, the plan of direct water intake was cancelled and instead changed so as to take water from an irrigation canal of the reservoir and the site for a water treatment plant was fixed outside a sanctuary. Therefore, an environmental impact was significantly reduced.

[Environmental Sensitive Area]

The prescribed projects which are requested to implement EIA/IEE are defined and listed in the Gazette no 772/22 of 24th June, 1993 and 859/14 of 23rd February 1995. Only large-scale development projects that are likely to have significant impacts on the environment are listed as prescribed projects. There are two categories, although they are not applicable to the project.

On the other hand, from the view point of the susceptibility of an environmental impact, the following points were expected to be problematic.

- Within 100 meters from the boundaries of or within any area declared as a Sanctuary under the Fauna and Flora Protection Ordinance
- Within 100 meters from the high flood level contour of or within a public lake as defined in the Crown Lands Ordinance.

In the project, the water source is the reservoir but both an intake works and water treatment plant are more than 100 m downstream of the reservoir for both cases and the prescribed project is not applicable to.

[Forest]

There is no forest reserve land in the proposed sites. But if the land is designated as the forest, the permission for land use alteration is required from the Department of Forestry. NWSDB has received the permission for those of the construction sites that is included in the forest from the Department of Forestry

[Archeological Impact]

All the projects are required the assessment of an archeological impact. NWSDB has the permission of project implementation at the stage of pre-feasibility study. For the sites changed thereafter, NWSDB has submiited an additional application and got the permission for almost sites except for three locations which have been still waiting for the permission.

[Necessity of IEE/EIA]

In the initial plan, the direct water intake from the reservoir was supposed, but due to the instruction from the Irrigation Department, a water intake from the irrigation canal downstream of the reservoir was decided and any development action will not be done within the sanctuary or environmentally sensitive area. Therefore, although the environmental consideration will be required subsequently, it is not necessary to conduct the IEE/EIA. The environmental recommendation has been already received from the CEA, it is required to meet the conditions described therein. On the other hand, NWSDB has an obligation to get the environmental protection license three months before the commencement of facility operation.

7.2 Social Consideration

(1) Minority and Indigenous People

There are indigenous people called **‘Veddas’** in Sri Lanka, but there are none living in the study area. The ethnic composition in the study area is 91% Sinhalese, 1% Tamil and 8% Muslim. In Anuradhapura, the ratio of Sinhalese is higher than the national average at more than 90%.

(2) Socio-economic Conditions

The largest land use of the study area is covered by forest, followed by scrub. Cultivated land is mainly paddy fields. 70% of the people are engaged in the agriculture. The area has two rainy seasons, namely the months of October to December which is the main cultivation season and the period of March to April with scattered rains. Double cropping is possible if the rainfall is enough. The irrigation agriculture has been done from the ancient times in the study area with many tanks. Although the people have been trying to make use of limited water resource as much as possible, but the annual harvest heavily relies on the available water amount. Therefore. the desiring level of the people for water is very high. According the annual report of the Central Bank for the year of 2012, the poverty household in Anuradhapura District is 4.6% which is higher than the national average of 7.0%.

7.3 Human Resettlement and Land Acquisition

(1) Human Resettlement

Although the proposed sites for water treatment plants are the government land but there are the illegal occupants. For the Wahalkada site, the measures to shift the so as to avoid the human resettlement is taken. However, for the Mahakanadarawa site, since the available land limited for the facility layout, the human resettlement of one occupant is finally required. Therefore, the preliminary human resettlement programme was prepared. In Sri Lanka, there is the National Involuntary Resettlement Policy（NIRP）which has no significant gap with the JICA's guidelines including the compensation in accordance with the reacquisition price. The guideline has already established for the contents to be included in the RAP which meets the JICA requirements. NWSDB has already started the explanation to the residents on the project and resettlement. The household is the family of two, Sinhalese or the majority people in Sri Lanka.

(2) Land Acquisition

Most of the project sites (30 acres) are the government land and NWSDB can use them through the payment of a lease fee, while 2. 2 acres of them is the private land which requires the acquisition. For all sites, the procedures to transfer the right for land use have been already commenced and waited for the progress of public process among the agencies concerned which will take usually six months.

7.4 Mitigation Measures

The adverse impacts and its mitigation measures are listed in **Table 22**. The column of Impact shows the evaluation of potential impact after taking mitigation measures.

Table 22 List of Adverse Impacts and Its Mitigation Measures

Pre construction stage

Impact	Object	Mitigation measures	Impact	In charge or implemented by	Supervising
Noise and vibration	Pump, generator and other noise generation facility	● Low noise/vibration pump and generator are specified in tender document. ● Building is designed with the consideration to decrease noise and vibration to meet the requirement. ● Location of these facilities is examined.	Minor	NWSDB HO	PMCU (CEA)
Waste	Construction waste and Domestic waste	● Waste management plan is prepared under discussion with CEA and DS. ● Temporally dumping area is secured.	Minor	NWSDB RSC	PMCU DS CEA
Ecological impact	Clearing land	● Clearing land and cutting tree are planned under the discussion with Forest Dept and/or CEA.	Minor	NWSDB RSC	PMCU Forest Dept CEA
	Rare species	● Making a plan of transplant and recovery of habitat	Minor	NWSDB RSC	PMCU Wildlife dept CEA
Resettlement	Resettlement	● Progress of resettlement and its fairness are monitored.	Minor	NWSDB RSC	PMCU DS
Social impact	Stakeholder meeting	● Discussion and making agreement about construction schedule, procedure, and impact	Minor	NWSDB RSC	PMCU PCC
	Public relation activities for local residents	● Explanation for local residents and to develop understanding about construction work schedule, expected impacts, mitigation measures etc.	Minor	NWSDB RSC	PMCU DS

NWSDB RSC : National Water Supply and Drainage Board
PMCU: Project Management Coordination Unit
PCC: Project Coordination Committee
DS: Divisional Secretariat
Additional GM for water supply

Construction stage

Impact		Mitigation measures	Impact	In charge or implemented by	Supervising
Air pollution	Exhaust gas	● To ensure the use of vehicles and machineries officially registered, and properly maintained.	Minor	Contractor	PMCU
	Dust	● To cover the earth or dusty materials ● To sprinkle water to prevent the dust raising.	Minor	Contractor	PMCU
	Leakage of chlorine gas	● Guidance of proper installation ● Safety training to laborer	Minor	Contractor	PMCU
Noise	Vehicles and machinery	● To ensure the use of vehicles and machineries officially registered, and properly maintained. ● Unnecessary idling is not allowed. ● Route of transportation is examined to prevent noise or other effect on vicinity.	Minor	Contractor	PMCU
	Construction work	● To avoid doing the work generating noise and vibration at nighttime.	Minor	Contractor	PMCU

Impact		Mitigation measures	Impact	In charge or implemented by	Supervising
		● Sound insulation wall will be used if necessary.			
Water quality	Water source	● Making water resource protection plan with the commitment of relevant authority	Minor	PMCU	PD
	Discharge water	● Clean water such as rain water is separately collected to prevent from mixing with muddy materials ● Turbid water generated by earthwork is introduced to the sedimentation basin and turbid material will be settled. ● If necessary further treatment (use of coagulant) is done.	Minor	Contractor	PMCU
	Domestic effluent	● Effluent is treated by the soak pit.	Minor	Contractor	PMCU
	Oil and grease	● Oil and grease are kept separately in the container. ● Oil absorbent is prepared.	Minor	Contractor	PMCU
Waste	Construction waste	● The waste reduction plan and dumping procedure will be proposed at the tender document and implemented. ● The temporally dumping yard for construction waste is secured. ● Waste is segregated in order to recycling purpose. ● Recyclable material is transferred to the recycling manufacturer. ● Waste which is not recyclable is disposed to follow the fixed rule of relevant DS.	Minor	Contractor	PMCU
	Domestic waste generated by laborer	● Domestic waste is placed at the temporally damping yard, and transferred to the officially operated disposal field	Minor	Contractor	PMCU
Ecological environment	Violation to ecosystem	● Training and awareness program for laborer is planned and done. ● Scheduled patrol of the site	Minor	Contractor	PMCU
	Trees and plant	● Clearing land is minimized and the large tree is remained as far as possible, or transplanted.	Minor	Contractor	PMCU
	Rare species	● If the special species will be found out at the site, report to NWSDB and receive the guidance of CEA or wildlife dept.	Minor	Contractor	PMCU CEA Wildlife dept
Archaeological impact	Excavating antiquity	● If the antiquity will be excavated at the site, report to NWSDB and receive the guidance of Archaeological dept.	Minor	Contractor	PMCU Archaeological dept.
Social impact	Social conflict caused by laborer	● Training and awareness program for laborer are planned and done. ● Security guard is appointed.	Minor	Contractor	PMCU
	Inconvenience of livelihood	● Pipe laying work on the road is planned carefully to prevent inconvenience as much as possible. ● Refraining from working during peak hours to prevent road traffic blocks ● Public notice prior to construction	Minor	Contractor	PMCU
Working	Occupational	● Training and awareness program	Minor	Contractor	PMCU

Impact		Mitigation measures	Impact	In charge or implemented by	Supervising
condition	safety	for laborer is planned and done. ● Safety tools are provided to laborer by Contractor.			

Operation stage

Impact		Mitigation measures	Impact	In charge or implemented by	Supervising
Air pollution	Leakage of chlorine gas	● Gas monitor is working always at proper condition ● Safety training to laborer	Minor	NWSDB RSC	NWSDB HO
Noise	Noise generation facility (pump etc)	● To ensure the proper operation and maintenance	Minor	NWSDB RSC	NWSDB HO
Water quality	Discharge water	● Under drain water from sludge drying bed should be managed to meet the standards.	Minor	NWSDB RSC	NWSDB HO
	Domestic effluent	● Effluent is treated by the soak pit.	Minor	NWSDB RSC	NWSDB HO
	Oil and grease	● Oil and grease are kept separately in the container	Minor	NWSDB RSC	NWSDB HO
Waste	Domestic waste	● Domestic waste is placed at the temporally collection place, and transferred to the officially operated disposal field	Minor	NWSDB RSC	NWSDB HO
	Sludge	● Sludge is dried up at the drying bed to reduce its quantity ● Dried sludge is dumped by the contract with the approval of land owner.	Minor	NWSDB RSC	NWSDB HO
Working condition	Safety and health	● Safety and emergency tool is always ready. ● Safety training is provided on schedule. ● Newly hired employee shall have safety training.	Minor	NWSDB RSC	NWSDB HO

8 FINANCIAL AND ECONOMIC ANALYSIS

8.1 Financial Analysis

(1) Preconditions and Methods

- The calculation is based on the net or constant price because tariffs are controlled by the government and not easy to raise although inflation is occurring.
- The investment amount and the construction schedule are used as described in Chapter 7, “Project Cost,” and Chapter 8, “Project Implementation.” The investment costs include taxes, but they exclude interest payments during the construction period, because IRR treats only cash flow.
- Part of the invested assets such as buildings and plants has longer lives (depreciation periods) such as 50 or 60 years and the planning period is shorter so that the remaining residual values of these long life assets are input as minus investment at the end of the

calculation period. However, shorter life assets such as machines and vehicles are not reinvested after their lifetimes such as seven or 10 years end within the planning period because they are usually used continuously and not reinvested.

- The income from operation is based on the tariffs, but specifically, the billed amount and water used in 2011 shown by the NWSDB statistics are used to calculate income per water volume (North Central Region domestic 25.0 Rs./ m3) and this unit is multiplied by the estimated demand water volume. However, the NWSDB tariffs were raised from October 1, 2012 and new income per water volume is not clear because there is no statistic data after the tariff increase. Assuming the income per water volume becomes 1.5 times. The North Central Region domestic 25.0 Rs./ m3 increases to 37.5 Rs./ m3 (=25 x 1.5). Therefore, this FIRR calculation uses 37.5 Rs./ m3 as income per water volume.
- The operations costs are based on the estimates described in 7.6 “Operation and Maintenance Cost,” Chapter 7, “Project Cost.”

(2) FIRR Results

1) Mahakanadarawa

- The Mahakanadarawa water source area FIRR calculation result is -2.71% (Case 1: Phase 2 investment in 2024 is made). In Case 2, Phase 2 investment is not made and the water demand after 2025 is the same as that in 2024. In both cases, FIRRs are minus and so this project cannot be covered by the profits. The difference between the two cases is 0.12% and small. In order to make it positive, the tariffs should be raised 2.5 times of the present level. In addition, since this is calculated in net (constant price), it is assumed that tariffs are almost always revised based on the inflation in gross (market price).
- Since the tariffs need to be 2.5 times of the present level in order to make FIRR positive, sensitivity analyses are neither effective nor useful. Therefore, sensitivity analysis is omitted. However, NWSDB will bear only 20% of the investment costs in this project because this project area includes no municipalities. Instead of sensitivity analysis, FIRR of a case that investment cost decreases to 20% of the total investment is calculated. If the income per water volume increases 1.5 times (37.5 Rs./m3) because of the tariff raise, the FIRR becomes positive (0.42%). NWSDB may be able to pay interest and repay JICA if making efforts. However, this does not mean that the total project is covered by the profits. Of course, this 1.5 times increase of tariffs is also based on the additional inflation coverage.

2) Wahalkada

- The result of Wahalkada FIRR calculation is -2.88% in Case 1 and -2.80% in Case 2. The result is a little worse than those of Mahakanadarawa Cases because Wahalkada is a lower-density area and the investment is less efficient than Mahakanadarawa.

- Similarly to the Mahakanadarawa case, a case in which NWSDB's burden is 20% of the investment is calculated and the FIRR becomes 1.5%, higher than the Mahakanadarawa case because of the more demand compared with the reduced investment.

8.2 Economic Analysis

(1) Preconditions and Methods

The preconditions and methods of EIRR calculation are similar to those of FIRR above, but with some differences as follows.

- The investment costs exclude taxes and interest payments during the construction period. In addition, domestic currency part of the investment is converted to border price using a conversion factor. The conversion factor, 0.9, used in Sri Lanka will also be used in this analysis.
- Benefits are estimated instead of the operation income in FIRR, but it is necessary to explain the benefits in detail so that they are described separately below.

(2) Benefits

- Main benefits are derived from willingness-to-pay (WTP) amounts. The other benefits are reduction of medical and related costs caused by water borne diseases such as diarrhea, dysentery and viral hepatitis.
- The WTP amounts are set based on the new users (No Supply) group as lower amount of either actual payment per m3 or 4% income per m3 because No Supply group and CBO users can use safer water of NWSDB by the project. In addition, these benefits are calculated only for No Supply group and CBO user group. Although some existing NWSDB water users use well water, the benefits of NWSDB users are excluded in this benefit calculation because the benefits should be conservative..
- Water borne diseases such as fluorosis, diarrhea, dysentery and viral hepatitis can be reduced as this project enables the residents to use clean and better quality water. Although some diseases such as diarrhea, dysentery and viral hepatitis are not only caused by water but also by bad foods and unsanitary conditions, the social economic survey separated the users into three groups, namely NWSDB, CBO and No Supply, so that the water borne disease rates in these groups can be compared.

(3) EIRR Results

1) Mahakanadarawa

- In Case 1 (with Phase 2 investment), the EIRR EIRR of Mahakandarawa Case 1 (Unit: Mill. Rs.) is 6.91% and is better as compared with those of other water supply projects. In addition, if CKD benefits are included, the EIRR becomes 11.8%, a satisfactory

figure.

- In Case 2 (without the additional investment), the EIRR is 5.54%, less than that of Case 1. If CKD benefits are included, the EIRR becomes 10.4%.
- In order to estimate sensitivity, the investment, operational costs and benefits are changed to plus 10% or minus 10%. The investment cost change affects the EIRR the most, but the difference is only -0.73% or +0.86%. The second most effective change is the operations cost and the difference is -0.06% or +0.07%. The benefit change difference is very small at –0.01% or +0.01%.

Table 23 Mahakanadarawa Sensitivity Analysis Results

Alternatives	Investment Plus 10%	Op. Cost Plus 10%	Benefits Minus 10%	Standard (Case 1)	Investment Minus 10%	Op. Cost Minus 10%	Benefits Plus 10%
EIRR	6.18%	6.85%	6.90%	6.91%	7.77%	6.98%	6.92%

2) Wahalkada

- The Wahalkada water resource area mainly consists of the DSDs other than Rambewa and Medawachchiya. WTPs of these four DSDs are used. The result of EIRR is 6.59% (Case 1). If CKD benefits are included, the EIRR becomes 11.5%. Case 2 EIRR is 4.46% and lower than that of Case 1 (6.59%).
- In order to estimate sensitivity, the investment, operational costs and benefits are changed to plus 10% or minus 10%. The results are shown in Table 10.15. The investment cost change affects the EIRR most, but the difference is only -0.70% or +0.81%. The second most effective change is the operations cost and the difference is -0.10% or +0.09%. The benefit change difference is very small at –0.01% or +0.01%.

9 OPERATION AND EFFECT INDICATORS

9.1 Operation Indicators

The operation indicators are to show to what extent the water supply scheme is operated efficiently, to achieve the target.

In addition to usual operational indicators for water supply such as served population (persons), water distribution (m3/day), facility utilisation rate (%) and NRW ratio (%), the compliance rate of drinking standard for fluoride concentration (%) is proposed.

The purpose of this project to supply safe water to customers especially focusing on the Sri Lankan Drinking Standard for a fluoride concentration of 0.6 mg/L. The compliance rate of the

said standard should be 100%. The analysis shall be conducted semi-monthly.

Table 24 Operation Indicators for Water supply

Cate-gorty	Indicators	Calculation Equation of Indicators	Target		
			Present	2020	2024
Mahakanadarawa System					
Basic	Served population (persons)	Served population by pipe borne water supply = (No. of connections) × (Average per HU population)	25,900	40,700	47,800
		Served population by bowsers = (total population)	0	21,400	22,300
		Total served population = Served population + Served population by bowsers	25,900	62,100	70,100
Basic	Water distribution (m^3/day)	Daily maximum water distribution = (the biggest one in the daily water distribution records throughout a year)	0	7,193	8,585
		Daily average water distribution = (annual water distribution amount) / (annual days)	0	5,994	7,154
Basic	Facility utilization rate (%)	Facility utilization rate (Max.) = (Daily maximum water production) / (treatment capacity) × 100	0	83	103
		Facility utilization rate (Ave.) = (Daily average water production) / (treatment capacity) × 100	0	70	90
Basic	Compliance rate of drinking standard for fluoride (%)	No. of samples with a fluoride concentration of below 0.6 mg/L / Total no. of samples *100	-	100	100
Basic	NRW ratio (%)	NRW ratio＝(NRW volume) / (water distribution) × 100	-	20%	20%
Wahalkada System					
Basic	Served population (persons)	Served population by pipe borne water supply = (No. of connections) × (Average per HU population)	26,900	64,100	74,700
		Served population by bowsers = (total population)	0	24,600	25,700
		Total served population = Served population + Served population by bowsers	26,900	88,700	100,400
Basic	Water distribution (m^3/day)	Daily maximum water distribution = (the biggest one in the daily water distribution records throughout a year)	0	11,203	13,318
		Daily average water distribution = (annual water distribution amount) / (annual days)	0	9,336	11,098
Basic	Facility utilization rate (%)	Facility utilization rate (Max.) = (Daily maximum water production) / (treatment capacity) × 100	0	78	93
		Facility utilization rate (Ave.) = (Daily average water production) / (treatment capacity) × 100	0	65	77
Basic	Compliance rate of drinking standard for fluoride (%)	No. of samples with a fluoride concentration of below 0.6 mg/L / Total no. of samples *100	-	100	100
Basic	NRW ratio (%)	NRW ratio＝(NRW volume) / (water distribution) × 100	-	20%	20%

9.2 Effect Indicators

The effect indicators shows that the people's living will be comfortable and the risk reduction that may be suffered from skeletal and dental fluorosis as well as chronic kidney diseases.

In addition to usual effect indicators for water supply such as population coverage (%) and per capita daily consumption (Lpcd), the fluorosis risk avoidance rate (%) is proposed.

When the water source of existing CBO has a fluoride concentration above the Sri Lankan Drinking standard (0.6 mg/L), such served population is defined as the population with a risk for fluorosis. Assuming that the percentage of the population with a risk to the total population within the existing CBO service area is applicable to the entire study area, it can be reduced with the connection to a proposed integrated water supply system as shown in **Table 25**

Table 25 Fluorosis Risk Rate (Mahakanadarawa Service Area)

Population with a risk for fluorosis (2012)	16,930 persons	
Population with no risk for fluorosis (2012)	3,135 persons	
Percentage of population with a risk (2012)	16,930 / 20,065 × 100 = 84.4%	
Water supply mode in 2020	Total population	Served population
Pipe borne water supply	70,680 persons	40,749 persons (57.7%)
Bowser water supply	21,393 persons	21,393 persons (100%)
Total	92,073 persons	62,142 persons (67.5%)
Prevalence risk in 2020	(92,073 – 62,142) / 92,073 × 100 = 32.5%	

Table 26 Effect Indicators for Water supply

Cate-gorty	Indicators	Calculation Equation of Indicators	Target		
			Present	2020	2024
Mahakanadarawa System					
Basic	Population coverage by water supply	(Pipe borne water supply) Population coverage = (Served population) / (Administrative population) × 100 (Water delivery service by bowsers) Population coverage = (Served population) / (Administrative population) × 100 (Population coverage for an access to safe water) Population coverage = (Served population) / (Administrative population) × 100	41% 0 % 31%	58% 100% 68%	64% 100% 72%
Basic	Fluoride risk rate	(Fluoride risk rate) = 100 - (Population coverage for an access to safe water)	-	32%	28%
Assist	Per capita consumption	Per capita daily maximum consumption = (Daily maximum domestic consumption) / (Served population) Per capita daily average consumption = (Daily average domestic consumption) / (Served population)	96 Lpcd 80 Lpcd	101 Lpcd 84 Lpcd	103 Lpcd 86 Lpcd

Wahalkada System					
Basic	Population coverage by water supply	(Pipe borne water supply) Population coverage = (Served population) / (Administrative population) × 100 (Water delivery service by bowsers) Population coverage = (Served population) / (Administrative population) × 100 (Population coverage for an access to safe water) Population coverage = (Served population) / (Administrative population) × 100	28% 0 % 23%	59% 100% 67%	65% 100% 72%
Basic	Fluoride risk rate	(Fluoride risk rate) = 100 - (Population coverage for an access to safe water)	-	33%	28%
Assist	Per capita consumption	Per capita daily maximum consumption = (Daily maximum domestic consumption) / (Served population) Per capita daily average consumption = (Daily average domestic consumption) / (Served population)	96 Lpcd 80 Lpcd	101 Lpcd 84 Lpcd	103 Lpcd 86 Lpcd

10 Project Risk

10.1 Project Risk

The proposed Project is constructed based on the important preconditions described below. If any of them will be lack, it may cause a serious problem in the management, operation and maintenance of proposed water supply systems.

(1) Water Availability

This project assures the sustainability of drinking water supply from Mahakanadarawa Wewa and Wahalkada Wewa as water sources under the assumption that the NCP Canal Project and Yan Oya Reservoir Project will be implemented. Therefore, the progress of the irrigation projects concerned should be carefully monitored and prompt action be taken to drive the project. as required.

(2) Water Quality of Proposed Water Sources

During the JICA study period covering from May to October 2012, in spite that the study area has experienced the severer drought than usual with no precipitation, the fluoride concentrations of both Mahakanadarawa Wewa and Wahalkada Wewa as the proposed water sources for drinking water supply were 0.52 mg/L and 0.38 mg/, respectively, at the maximum below the Sri Lankan Drinking Water Standard of 0.6 mg/L, although they have shown an increase of fluoride concentrations for April to July. For this reason, fluoride concentrations of both Mahakanadarawa Wewa and Wahalkada Wewa should be monitored subsequently thereafter.

In the North Central Province, water is used repeatedly for irrigation in the cascade irrigation system. Attention be paid for the use of agricultural chemicals in their basins and measures to ban their use should be taken to ensure the safety of water sources for drinking water, if required.

(3) Increase of Coverage and Water Demand in the Proposed Water Supply System

Due to the high level prevalence of dental fluorosis and chronic kidney diseases (CKDs) in the project area, the people have great expectations for the project to shift the water source from groundwater to surface water with a less fluoride concentration. However, as NWSDB has so far experienced the difficulty to increase the coverage by pipe borne water supply in the rural area, it is a risk to over-estimate such situations. It depends on an awareness campaign to what extent the number of connections can be increased. If actual water consumption will be less than the estimation, the income will be decreased resulting in a heavy financial burden on NWSDB.

10.2 Considerations in Planning

(1) Geological Survey Not Conducted for Some Facility Sites

The geological survey for some facility sites such as elevated tanks, intake works, etc. couldn’t be conducted and the preliminary design of such facilities was done based on the general geological characteristics obtained from other sites surveyed in the project area.

(2) Quantity Survey for Distribution Systems

The size and length of water distribution pipes given in this report are estimated by selecting the model area in the project are, conducting a distribution network analysis, checking the pipe length by size, and applying the per connection pipe length by size to the entire project area, and will not correspond to the actual requirement.

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REFERENCES

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Reference 1 Water Quality Data

- 1.1 Water Quality Survey Results
- 1.2 Sri Lanka Drinking Water Standards
- 1.3 The Hydrogeochemical Atlas of Sri Lanka, C.B. DISSANAYAKE & S.V.R. WEERASOORIYA,

Reference 2 Longitudinal Section of Transmission Pipelines Drawings

Reference 3 Laws and Regulations about Social and Environmental Consideration

- 3.1(a) National Environmental Act 1980
- 3.1(b) National Environmental Act amendment 2000
- 3.2 Land Acquisition Act
- 3.3 Fauna Flora Protection Act 22(2009)
- 3.4 Antiquities Ordinance
- 3.5 Irrigation Ordinance
- 3.6 Forest Ordinance
- 3.7 National Involuntary Resettlement Policy (NIRP) 2001
- 3.8 Protection & Quality Reg. 1534-18_2008 (EPL)
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- 3.10 EPL prescribed List
- 3.11 Protection & Quality Reg. 1534-18_2008 (Discharge Water Quality)
- 3.12 EIA amendment (Prescribed activities) 1104.22_1999
- 3.13 PAAs_859.14_1995
- 3.14 Prescribed projects
- 4.15 Procedure of approval projects_No.772.22_1993
- 3.16 Antiquities permission
- 3.17 Mahakandarawa Sanctuary Gazette Notification
- 3.18 Reg. 1295-11_2003, Gas emission
- 3.19 Reg. 850-4_1994, Ambient air
- 3.20 Reg. 595-16_1990, Discharge std & EPL
- 3.21 Reg. 1137-35_2000, Mobile emission
- 3.22 Reg. 1159-22_2000, Prescribed project EPL
- 3.23 Land acquisition act
- 3.24 Amendments to the Prescribed Activities 1373.6_2004
- 3.25 Reg. 924-12, Noise Control
- 3.26 Archeological Impact Assessment
- 3.27 Drinking water standard
- 3.28 Mahaweli irrigation forest act
- 3.29 Basic Information Questionnaire, Water board to CEA

ABBREVIATIONS

AC pipe	Asbestos Cement Pipe
ADB	Asian Development Bank
AIA	Archaeological Impact Assessment
ANIWSP	Anuradhapura North Integrated Water Supply Project
BIQ	Basic Information Questionnaire
CBO	Community-Based Organization
CEA	Central Environmental Authority, the Ministry of Environment and Natural Resources (ME&NR)
CEB	Ceylon Electric Board
CFI	Community Fluorosis Index
CKD	Chronic Kidney Diseases
CMC	Colombo Municipal Council
CRM	Certified Reference Material
CWSSP	Community Water Supply and Sanitation Program
DI pipe	Ductile Iron Pipe
DSD	Divisional Secretary Division
EA	Engineering Assistant
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EOI	Expression of Interest
ET	Elevated Tank
FB	Freeboard
FC	Foreign Currency
FIRR	Financial Internal Rate of Return
FR	Forest Reserve
FSD	Full Supply Depth
FSL	Full Storage Level
GND	Grama Niladhari Division
GOJ	Government of Japan
GOSL	Government of Sri Lanka
GPRS	General Packed Radio Service
HH	Household
HWL	High Water Level
ID	Irrigation Department
IDP	Internally Displaced Persons
IEE	Initial Environmental Examination
IFRC	International Federation of Red Cross and Red Crescent Societies
JICA	Japan International Cooperation Agency
KfW	German Government-owned Development Bank, (Kreditanstalt für Wiederaufbau)
NC	North Central
LA	Local Authority
LAA	Land Acquisition Act
LB	Left Bank
LC	Local Currency
LCD	Liquid Crystal Display
Lpcd	Litre per capita per day
LWL	Low Water Level
MCB	Miniature Circuit Breaker

MCC	Motor Control Centre
MCCB	Molded Case Circuit Breaker
MCGs	Mahinda Chintana Goals
MCM	Million Cubic Meter (1,000,000 m^3)
MDGs	Millennium Development Goals
MWSD	Ministry of Water Supply and Drainage
NABL	National Accreditation Board for Testing and Calibration Laboratories
N/C	North Central
NCP	North Central Province
ND	Nominal Diameter
NEA	National Environmental Act
NEP	National Environmental Policy
NHWA	National Heritage Wilderness Area
NIRP	National Involuntary Resettlement Policy
NRW	Non Revenue Water
NWSDB	National Water Supply and Drainage Board
OIC	Officer-in-Charge
PAA	Project Approving Agency
PCC	Project Coordination Committee
PCV pipe	Un-plasticized Polyvinyl Chloride Pipe
PD	Project Director
PEA	Project Executing Agency
PE pipe	Polyethylene Pipe
PLC	Programmable Logic Controler
PMU	Project Management Unit
PR	Proposed Reserve
PS	Pump Station
RAP	Resettlement Action Plan
RSC(N/C)	Regional Support Centre (North Central)
RSF	Rapid Sand Filter
RWS	Rural Water Supply
SCADA	Supervisory Control and Data Acquisition
SIDA	Swedish International Development Agency
SLAB	Sri Lanka Accreditation Board
SP	Steel Pipe
SSF	Slow Sand Filter
TEC	Technical Evaluation Committee
UDA	Urban Development Authority
UNICEF	United Nations International Children's Emergency Fund
UPS	Uninterruptible Power Systems
VPN	Virtual Private Network
VSD	Variable Speed Driver
WB	World Bank
WFP	Work and Financial Plan
WHO	World Health Organization
WLPSA	Wildlife Protected Area
WSP	Water Supply Project
WSS	Water Supply Scheme
WTP	Water Treatment Plant

Ac	= 4,047 m^2
Acft	= 1,234 m^3

CHAPTER 1

WATER SUPPLY SECTOR IN SRI LANKA

CHAPTER 1 WATER SUPPLY SECTOR IN SRI LANKA

1.1 Country Background

(1) Domestic Affairs

Sri Lanka is a democratic country, which adopts the presidential system. Since independence in 1948, the political power has generally alternated between the two main political parties, namely SLFP (Sri Lanka Freedom Party) and UNP (United National Party) through elections. At present, the UPFA (United People's Freedom Alliance) with a core of SLFP has taken over the reins of government under the President Mahinda Rajapaksa, who was elected in November 2005.

In May 2009, President Mahinda Rajapaksa terminated the conflict in the country. Due to his popularity nationally, he was reelected in the presidential election, which was conducted in January 2010. The governing party, UPFA had a majority of 144 seats out of the 255 members in the parliament in the general election, which was conducted in April 2010, as well as more than seventy percent of the majorities in the local government election in 2011.

(2) Economic conditions

Sri Lanka's economy historically depended on traditional plantation crops such as tea, rubber and coconut, but the manufacturing industry, as well as wholesale and retail commerce, etc. have developed and recently garment products became the biggest export item.

The real GDP growth rate was 8.0% in 2010 with a per capita GDP of US$2,400 (Rs.271,346) [1], the highest in the past 30 years. The contribution of the service industry to the GDP in 2010 was very high, as internal demand was stimulated by termination of the conflict. Wholesale and retail commerce also had a strong showing and in addition, hotel and restaurant businesses showed significant growth due to an increase in the number of tourists. The demand for restoration of the northern and eastern areas of the country and construction materials for various infrastructure projects has also increased.

1.2 Present Situation and Issues in the Sector

1.2.1 National Development Plan and Sector Development Plan

(1) National Development Plan (Mahinda Chintana - Vision for the Future)

"Mahinda Chintana - Vision for the Future", or the Five-year Plan of Sri Lanka, which was declared in August 2010, covering a period of 2011 to 2016 is articulated identifying specific

[1] *Source: "Economic and Social Statistics of Sri Lanka 2012", Central Bank of Sri Lanka*

targets aiming at achieving the Millennium Development Goals (MDGs) ahead of time. Among Mahinda Chintana Goals (MCGs) for 2016 include the following with other targets as shown in **Table 1.1**, toward ***"Increasing access to clean water in urban areas from 65 to 90 percent"***.

Table 1.1 Safe Water and Sewerage Coverage

Year	2005	2009	2015	2020*
Safe water coverage (%)	80	85	94	100
Pipe borne water availability (%)	29	37	44	60
Water connections ('000) (NWSDB schemes)	907	1,267	1,600	3,000
Pipe borne sewerage coverage (%)	2.0	2.5	3.0	7.0

Source: "Mahinda Chintana – Vision for the Future", Department of National Planning, Ministry of Financing and Planning, 2010

Mahinda Chintana also gives a strategic approach to "City Water Supply 2020" as shown in **Table 1.2**.

For the emerging metro centres and large townships as shown in **Table 1.3**, water supply and sewerage related infrastructure assets will be created to cater for the long-term and growing demands:

Table 1.2 City Water Supply 2020

Affordability	
Per capita consumption	
Average tariff	
Production cost	
Quality	
Quality compliance	
Treatment facilities	
Breakdown frequency	
Reliability	
Hours of supply	24 hrs
City coverage	100%
Efficiency	
Non revenue water	20%
Staff per 1,000 connections	5
Customer complaints	No
Response to requests	100%

Source: "Mahinda Chintana – Vision for The Future", Department of National Planning, Ministry of Financing and Planning, 2010

Table 1.3 Strategic Approach

Emerging metro centres	Kandy, Hambantota, Trincomalee, Dambulla, Jaffna, Galle, Gampaha, Kurunegala, Nuwara Eliya
Large Township	Vanuviya, Badulla, Matara, Anuradhapura, Ratnapura

Source: "Mahinda Chintana – Vision for The Future", Department of National Planning, Ministry of Financing and Planning, 2010

(2) National Policy on Drinking Water (Updated on June 2009)

In the National Policy on Drinking Water, "**1.5 Principles of the Policy**" includes the following nine principles.

i) Access to safe drinking water is a basic human right with commensurate responsibilities on the recipients.
ii) Planning and development will be people centered, participatory and demand responsive.
iii) The government acts as the custodian for the protection and proper management of drinking water resources.
iv) Abstraction of water and the protection of the resource shall be carried out in recognition of downstream impacts.
v) Where issues arise relating to competing demands, drinking water needs will have priority over the others, with reasonable consideration for other important needs.
vi) Development of drinking water supplies and distribution of water to people shall be done efficiently and equitably.
vii) Piped water supplies will be provided to populations/communities where other supply arrangements are inadequate.
viii) The operational activities will be decentralized to the lowest appropriate level, giving due consideration to the capacity and efficiency.
ix) Water safety will be practiced at all levels and ensured by all parties.

Among others, v) is most important as it gives the first priority to drinking water over others.

The following ideas in "**5.0 Cost Recovery**" attract attention:

- The following cost components of processing and delivery will be recovered through a service charge.
  - capital cost and interest incurred
  - operation and maintenance cost
  - replacement and rehabilitation cost
- In consideration of the lifeline requirement a subsidy shall be provided to the poor and marginalized communities.
- The cost recovery system shall be applicable and be implemented uniformly within respective administrative boundaries.

The above suggests full cost recovery, consideration for the poor and allowance for different water tariffs compared to the current situation where there is a uniform tariff throughout the whole of the country.

(3) NWSDB Corporate Plan 2012-2016 (Draft)

In response to "Mahinda Chintana", NWSDB has prepared a draft "Corporate Plan 2012 – 2016" to clarify their principles and values, functions, goals and objectives and strategies.

NWSDB is not covering the whole of the drinking water sector in the country and part of this provision will be done by some Local Authorities and other organizations as described in "**1.2.4 Sector Organization**". As shown in **Table 1.4**, NWSDB plans to supply about 40% of the population in 2016 with a pipe borne water supply, compared to about 52% of the total population served. However the above figures are not consistent with the pipe borne water availability of 44% in 2015 in "Mahinda Chintana"

Table 1.4 Planned Water Supply & Sewerage Coverage 2012 - 2016

Year	2011	2012	2013	2014	2015	2016
Population	20,861,045	21,0 69,655	21,280,352	21,493,156	21,708,087	21,925,168
Pipe borne water supply coverage	9,074,555	9,523,484	10,001,765	10,488,660	10,984,292	11,488,788
NWSDB pipe borne water supply connected coverage (%)	33.00%	34.50%	36.00%	37.40%	38.90%	40.40%
Overall pipe borne water supply connected coverage (%)	43.50%	45.20%	47.00%	48.80%	50.60%	52.40%
Pipe borne sewerage coverage**	479,804	505,672	532,009	558,822	586,118	613,905
Pipe borne sewerage coverage (%)	2.30%	2.40%	2.50%	2.60%	2.70%	2.80%

Source: NWSDB, "Corporate Plan 2012 – 2016 (Draft)"

1.2.2 Water Supply Undertakings (Service Ratios and Level)

The present situation of water supply service under NWSDB is summarised as shown in **Table 1.5** and **Table 1.6**, respectively.

Findings are as follows:

- The population coverage under NWSDB control was 36.9% as of December 2009.
- The total number of connections was 1,353,573, out of which 349,372 (25.8%) were in the

Central area, 164,259 (12.1%) in the Western-central area, 163,335 (12.1%) in the Western-south area and 141,601 (10.5%) in the Western-north area. Colombo and Kandy, as well as the areas surrounding both cities account for 60.5% of the total number of connections.

- The NRW ratio ranged from 13.8% in the North-eastern area to 37.8% in Sabaragamuwa, whereas in the Colombo Municipal Council (CMC) area it was 53.05%, which is significantly higher than the national average of 32.1%.
- The number of staff per 1,000 connections was lowest in the Western-central area (Colombo) at 2 followed by 4.2 in the Western-south area (Kalutara), 5 in the Western-north area (Gampaha) and 6 in the Central (Kandy, Matale and Nuwala Eliya) and North-central (Anuradhapura and Polonnaruwa) area. Uva has the highest number of staff per 1,000 connections at 27.4. As shown in **Table 1.6**, for the whole of NWSDB, the number of staff per 1,000 connections decreased steadily from 8.2 in 2007 to 7.5 in 2008 and 7.2 in 2009.
- Water availability or the time of water supply is worst at 3.7 hours per day in the Northern area followed by 9.6 hours in Uva, 10.9 hours in the Eastern area, 12.0 hours in the Western-south area and 12.9 hours in the North-western area. In the case of the Northern area, the damage caused by the conflict, which ended in 2009 is significant.
- The average tariff exceeds the production cost in only three out of 11 regions. The average tariff of the Western-central area (Colombo) is 2.56 times the production cost followed by 1.26 times in the Western-south area (Kalutara and 1.15 times in the Central area (Kandy, Matale and Nuwala Eliya). On the contrary, in the Northern and North-western areas the average tariff is 0.45 times and 0.48 times the production cost, respectively.
- As shown in **Table 1.6**, the percentage of the number of estimated bills to total bills decreased from 12% in 2007 to 7% in both 2008 and 2009, but this figure is still high.
- Per capita consumption ranges from 94.0 Lpcd in Uva to 138.5 Lpcd in Sabaragamuwa.
- The collection period of accounts receivables has improved from 60 days for domestic and commercial institutions and 65 days for government institutions in 2008 to 55 days and 44 days, respectively, in 2009, with the improvement for government institutions being significant (refer to **Table 1.6**).

Table 1.5 NWSDB Key Facts and Figures

Service Indicators	Regional Support Centre (Regional Average)										
	Western - North	Western - Central	Western - South	Central	North - Western	North - Central	Sabaraga-muwa	Southern	Uva	Northern	Eastern
	2008	2008	2008	2009	2008	2008	2008	2008	2008	2008	2008
Number of Connections (As of December 2010)	141,401	164,259	163,335	349,372	40,947	62,579	69,264	203,820	56,771	6,456	95,169
1 Service Standard Indicators											
Water Coverage (%) Pipe System maintained by NWSDB	25.1%	33.5%	48.4%	29.4%	5.9%	16.9%	9.3%	35.1%	16.2%	3.8%	23.9%
Per Capita Consumption (l/c/d)	117.1	125.7	122.3	101.3	99.7	103.2	138.5	103.6	94	116.7	79.7
Water Availability (hours)	21.4	23.2	12	22	12.9	24	18.6	22.4	9.6	3.7	10.9
Water Quality - Bacteriological Quality Compliance	94.7%	n/a	95.1%	97.7%	97.7%	99.7%	92.8%	96.5%	94.1%	96.2%	96.2%
Water Quality - Bacteriological Testing Compliance	100.0%	n/a	100.0%	83.3%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Water Quality - All Samples Compliance	95.8%	n/a	99.5%	95.7%	40.9%	94.4%	98.3%	84.8%	71.2%	96.3%	88.8%
Sewerage Coverage (%)	2.5%	0.0%	2.3%	0.1%	-	-	-	0.3%	-	-	-
2 Operational Indicators											
Non-Revenue Water (%)	24.1%	33.5%	33.0%	32.5%	13.8%	19.8%	37.8%	30.5%	30.0%	16.4%	32.9%
Non-Revenue Water - m3/conn/day	0.23	0.49	0.32	0.20	0.10	0.16	0.28	0.27	0.23	0.12	0.27
Defective Meters per '000 connections	51	15	23	16	8	48	44.9	17.3	124.6	22	29
Total Staff/ 1000 connection	5	2	4.2	6	9	6	7.4	6.5	27.4	20	11
Operational Staff/ 1000 connection	3	2	4.1	5	8	6	6	3.5	25.4	15	10
Estimated Bills/ 1000 connections	126	53	80	33	18	112	18.9	44.9	186.4	168	89
3 Performance in Customer Service											
Response to requests for new service connections (%)	95.8%	94.8%	90.0%	100.0%	100.0%	100.0%	94.6%	90.2%	90.8%	76.9%	62.2%
Customer Complaints Volume (Complaints/ 1000 connection)	109.1	13.5	219.3	135	56.6	11.1	34.9	127.7	230	17.7	7.1
Customer Complaints Resolution	86.2%	91.6%	33.0%	94.5%	86.9%	91.1%	94.3%	86.3%	67.5%	83.3%	81.4%
4 Key Performance Indicators (KPIs)											
Collection Ratio (%)	102.0%	98.7%	99.0%	110.0%	99.1%	102.9%	99.7%	99.3%	97.4%	78.4%	97.1%
Accounts Receivable Period (months)	4.2	2.6	4.8	1.4	1.6	3.1	3.8	3.0	3.3	7.2	4.2
Collectable Accounts Receivable Period (months)	1.4	1.7	1.5	0.4	0.1	1.8	1.7	1.2	1.3	2.9	2.6
Operating Ratio	1.01	0.54	1.02	1.00	1.69	0.98	1.42	1.26	1.34	1.98	1.57
Production Cost (LKR/ m3 Produced)	17.08	11.42	15.36	19.60	31.70	25.71	24.60	21.52	24.42	56.46	25.35
Average Tariff (LKR/ m3 Sold)	16.68	29.25	19.30	22.50	15.31	21.20	20.71	16.32	18.68	25.64	15.59
Stock Efficiency (LKR/ connection)	2,189	1,323	1,790	2,602	2,672	3,754	1,888	2,227	n/a	n/a	2,528

Source: NWSDB Website

Table 1.6 NWSDB Progress Towards Stated Goals

Goal	Key Objective:	Target end 2007	Achievement end 2007	Target end 2008	Achievement end 2008	Target end 2009	Achievement end 2009
1. Increase WS and sanitation coverage	1.1 Pipe-borne water supply coverage	32.0%	32.0%	33.9%	34.0%	37.5%	36.9%
	1.2 Piped sewerage coverage	2.50%	2.40%	2.60%	2.40%	2.70%	2.50%
	1.3 Access to safe drinking water supply coverage	76.4%	77.0%*	77.6%	78.0%*	79.5%	80.0%*
	1.4 Total sanitation covei		83.2%*		85.7%*		85.7%*
2. Improve operational efficiency	2.1 NRW (island-wide)	33.0%	33.1%	33.0%	32.1%	32.0%	31.1%
	2.2 Total staff for 1,000 connections	8.3	8.2	7.8	7.6	7.5	7.2
	2.3 Expenditure on power to total recurrent cost	23.0%	22.7%	23.0%	24.3%	23.0%	22.6%
	2.4 Maintenance exp enses to total recurrent cost	7.5%	5.1%	7.5%	4.1%	7.0%	4.7%
	2.5 Establishment expenses to total recurrent cost	10.5%	9.5%	10.5%	10.9%	10.0%	10.7%
3. Achieve customer satisfaction	3.1 Public awareness programmes to be carried out (schools/other)	20 Nos.	12 Nos.	30 Nos.	32 Nos.	30 Nos.	37 Nos.
	3.2 Complaints unresolved to total received	10.0%	7.3%	9.0%	7.3%		
4. Increase commercial viability	4.1 % of estimated bills to total number of bills	10%	12%	10%	7%	8%	7%
	4.2 Collection efficiency lOO%	100%	100%	100%	99%	100%	94%
	4.3 Accounts receivable from -						
	(a) Domestic and commercial institutions	60 days	60 days	60 days	60 days	60 days	55 days
	(b) Government institutions	65 days	65 days	60 days	65 days	60 days	44 days
5. Ensure greater accountability	Initiatives were taken to develop a whole range of management and business tools on human resource development, management information system and business plan.[#]						
	* Delegation of financial authority						
	* Training on budgetary control & financial regulations						
	* Audits on commercial operations						
	* Audits on stores and supplies						
	* Audits on cash/ cheque payments						
	* Audits on construction contracts						
	* Valuation of assets						
	* Improved management information and coordination						
6. Promote Institutional Development	6.1 In-house training programmes	150	113	150	105	160	110
	6.2 In-country external training (no. of persons)	240	258	240	272	250	170
	6.3 Overseas training (no. of persons)	75	68	75	129	80	115
7. Provide facilities and service supp ort to rural and marginalis ed communities	7.1 Rural water supply by the NWSDB (managed by CBOs)	4.5%	4.5%	4.5%	4.0%	5.0%	4.5%

* Estimated as 83.1% for water supply and 96.7% for sanitation from a sample survey carried out during 2006-2007 by the Department of Census and Statistics excluding Jaffna, Kilinochchi, Mullaitivu, Mannar and Vavuniya districts.

[#] The Merchant Bank of Sri Lanka has been selected to prepare the Business Plan; The draft plan prepared was presented to the senior M anagement of NWSDB for comments. Under ADB Technical Assistance 7078, separate business plan are being prepared for RSCs for decentralized service delivery in the water sector.

Source: NWSDB, "Annual Reports 2007-2009"

1.2.3 Water Resource and Management

The water resources in Sri Lanka have been facing the following problems since 1990's.

- Water scarcity due to spatial and seasonal variations especially in the dry zone
- Water demand increase caused by rapid industrial growth, urbanization and irrigational water requirement in the agricultural sector
- Water pollution because of haphazard disposal of industrial and domestic waste
- Soil erosion and salinity intrusion attributed to indiscriminate sand mining in the river courses

Problems such as depletion and deterioration of water resources, competition over water within and among sectors and associated conflict over allocation of water have emerged making it very difficult to manage water resources within the existing institutional and legal framework

These problems demand the integrated management of water resources. Asian Development Bank (ADB) funded Water Resources Management Project aiming at establishing institutions for integrated water resources management (IWRM) and adopting strategic planning and management approach for the management of river basins (Water Resources Policy, 2000). The existing water resources management institutions lacks arrangements for all the stakeholders to participate in decision making for managing water resources in a river basin context.

There are 20 principle agencies set up by the Government of Sri Lanka to plan and implement different activities related to management of water resources including the Irrigation Department (ID), the National Water Supply and Drainage Board (NWSDB), the Ceylon Electricity Board (CEB), the Mahaweli Authority of Sri Lanka, etc. and 10 main enactments providing legal authority and power to the water sector agencies for managing water resources.

The new policy to set up a legal and institutional framework for establishing integrated water resource management (IWRM) proposed the establishment of new institutions specifically the National Water Resources Authority (NWRA), the Water Resources Council (WRC) and the Water Resources Tribunal (WRT) to deal with changes required for sustainable water resources management as shown in **Table 1.7** and **Figure 1.1**.

Table 1.7 Proposed Organization for National Water Resources Management

Organisation	Function
National Water Resources Authority (NWRA)	The apex body in the water sector, responsible for coordination, planning, regulation, and monitoring of water resources in the country.- formulation of policy proposals; - river basin planning and catchment management; - issuing of bulk water entitlements; and - monitoring and enforcement.
Water Resources Council (WRC)	A permanent high level coordinating and advisory body
Water Resources Tribunal (WRT)	An independent appeal tribunal for parties affected by water entitlements administered by the NWRA
River Basin Committees	To be created by NWRA in selected river basins for the allocation of entitlements.

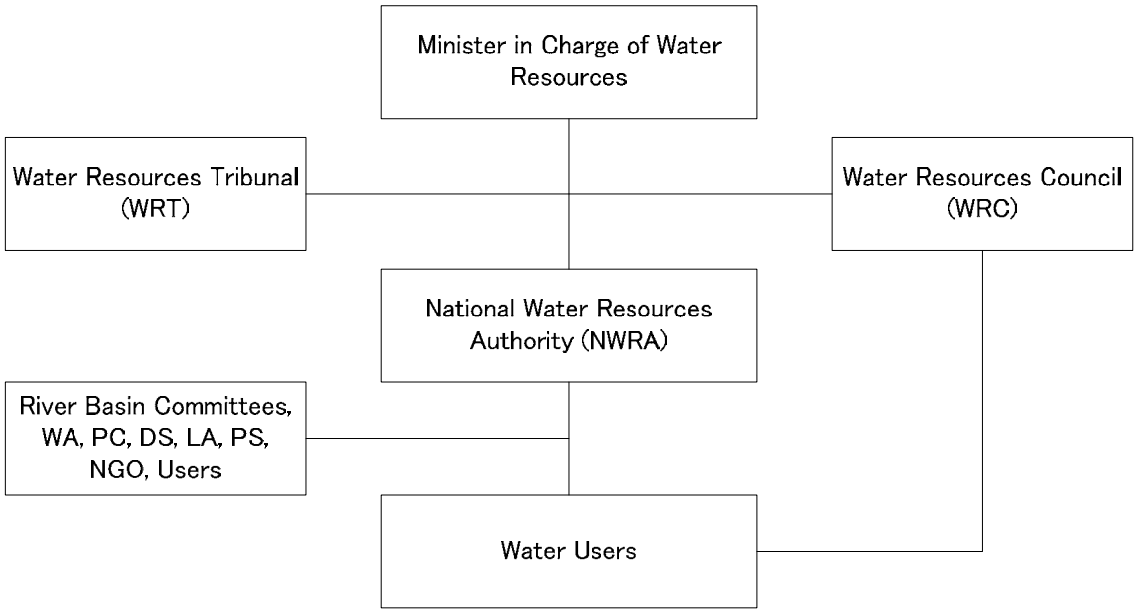


Figure 1.1 Proposed Framework of National Water Resource Management

The Government successfully established a national water sector apex body since 1996 in the form of the national Water Resources Council (WRC), supported by a full-time Water Resources Secretariat (WRS). This was an interim arrangement, pending the establishment of the National Water Resources Authority. The new "National Water Resources Policy and Institutional Arrangements" was passed by the Cabinet of Ministers in 2000. A National Water Resources Act was drafted which would establish the NWRA and set up formalised River Basin Committees for the allocation of water rights, among other functions. To date this has not been passed into law.

Later the WRS has changed its role and been termed by some the Interim National Water Resources Authority for a while, but the WRC and WRS were brought under the purview of the Ministry of Irrigation and Water Resources Management in 2001 and then were moved to the new Ministry of Mahaweli and River Basin Development by Presidential Decree in April 2004.

At present, the Irrigation Department under the Ministry of Irrigation and Water Resources Management is responsible for preparation of master plan for development of the different river basins for the optimum utilization of land and water resources under the objective for development of land and water resources for irrigated agriculture, hydropower, flood control, domestic usage, industrial usage and aquaculture development.

1.2.4 Sector Organizations

The water supply sector is divided into two sub sectors as shown in **Table 1.8**.

Table 1.8 Water Supply Sub Sector

	Urban water supply sub sector	Rural water supply sub sector
Object area	Towns, cities, urban centres, industries and suburban areas	Rural areas
Key Actors	Ministry of Water Supply and Drainage NWSDB Provincial Councils Municipal Councils Urban Councils Pradeshiya Sabhas	Provincial Councils Local Authorities Community Based Organizations (CBOs) Non-Government Organizations (NGOs)
Water service mode	Pipe borne water supply	Dug wells Tube wells Rain water harvesting Small-scale pipe water supply

Source: "National Policy on Drinking Water", June 2009
Note: From Wikipedia

For the urban area, NWSDB is responsible for the provision of water supply through the implementation of large scale water supply, in consultation with relevant local authorities under the superintendence and direction of the Ministry of Water Supply and Drainage. In principle, NWSDB directly manages and operates the water supply facilities implemented by itself from operation and maintenance to billing and collection. For this purpose, the country is divided into five regions (Western, Central, Eastern, Northern and Southern) and eleven areas to which Additional General Managers and Deputy General Manages are deployed for management.

A rural area for this purpose is defined as any Grama Niladaree (GN) Division within a Pradeshiya Sabha (PS) area. The Provincial Councils are responsible for the implementation of small-scale rural water supply through local authorities (municipal councils、urban councils, pradeshiya sabhas). The roles of the Government, Provincial Council and the Local Government Authorities should be to regulate and facilitate in the implementation of the sector activities while the Community Based Organization (CBOs), Private Sector and NGOs should be the providers of services. Local Authorities also may provide services when required. In the National Policy for Rural Water Supply and Sanitation Sector (July 2001) says that users should (1) be encouraged to own and manage the facilities and assets, (2) be encouraged to share the capital investment incurred in creating the facilities, and (3) bear the full responsibility of sustainable operation and maintenance of the facilities.

As shown in **Table 1.4**, the target of population coverage by pipe borne water supply is 52.4% as a whole out of which 40.4% is undertaken by NWSDB for attainment and the remaining 12.0% is the target for rural water supply.

Local government is the third and lowest level of government in Sri Lanka - after the central government and provincial councils. The local government bodies are collectively known as local authorities. They are responsible for providing a variety of local public services including roads, sanitation, drains, housing, libraries, public parks and recreational facilities. Local authorities are divided into three different groups: municipal councils, urban councils and rural councils (pradeshiya sabha). As of January 2011 there were 335 local authorities (18 municipal councils, 42 urban councils and 270 rural councils). All local authorities are elected using the open list proportional representation system.

The role of agencies, which are involved in the water supply sector is shown in **Table 1.9**.

Table 1.9 Role of Agencies Involved in Water Supply Sector

Functions	Ministry	NWSDB	Provincial Council	Local Authorities	Users (CBOs)
Formulate the national policy	×				
Facilitate with the Government to secure internal and external funding for sector development	×				
Monitor the sub-sector development activities	×				
Coordinate, monitor and promote sub-sector development activities	×				
Undertake design, construction and operation of pipe borne water supply schemes		×			
Provide technical assistance		×			
Transfer the O&M function of RWS schemes to LAs and CBOs		×			
Enact the RWS and sanitation policy			×		
Coordinate the planning and implementation of RWS schemes implemented and managed by LAs			×		
Monitor the RWS sub-sector development activities			×		
Make decisions on resource allocation among LAs			×		
Prepare policies, guidelines and strategies for all sector development activities			×		
Undertake planning, design and implementation of RWS schemes				×	
Undertake the O&M of water schemes				×	
Facilitate the CBOs in implementing and managing the water supply systems and provide the necessary technical assistance to CBOs				×	
Coordinate and participate with the service provider in sector development activities					×
Actively participate and contribute during the planning, design and construction stages of a project					×
Implement and manage community water supply schemes by forming CBOs					×

LAs: Local Authorities, CBOs: Community Based Organizations

RWS: Rural water supply

Source: Prepared by the Study Team based on "the National Policy of Drinking Water"

1.2.5 Financial Situations of the Sector

The financial aspects of the whole of NWSDB are reviewed.

According to the financial statements of NWSDB from 2003 to 2011, the profit/ loss table is shown in **Table 1.10**. The operating account balances show an operating profit in 2003, 2005, 2006, 2009 and 2011.

The tariff was increased in 2004 and in the following two years there was an operating profit

mainly due to the increase in income from sales. However the tariff increase had a short term effect, because in the second year (2006) after the increase, profits decreased and after that there were operating losses in 2007 and 2008, with the loss in 2008 being much higher than the previous year. Therefore, the tariff was increased in 2008, which resulted in an operating profit in 2009, followed by a large operating loss in 2010.

In 2011, an operating profit was achieved and it is understood that NWSDB made efforts to cut costs. This year is unusual from the aspect of the current account balance, because non-operating account losses were much more than operating profits and so the current account balance which was negative from 2003 to 2010, became positive in 2011 for the first time during the past nine years.

However, it is not possible to comments on whether current account profits will continue in the future, as the tariff is controlled by the government at a low level and increases in the tariff are generally delayed and do not keep up with inflation. In addition, the finance cost in 2011 was less than in 2009 and 2010, by approximately 0.5 billion Rs in each year. If the finance cost in 2011 was at the level of the cost in 2009 or 2010, the non-operating loss would be 1.78 billion Rs., which is more than the operating profit (1.76 billion Rs.) and as such the current account balance would be negative (This is discussed again later in balance sheet analysis).

Among the direct operating costs (expenses), personnel costs are the biggest in most years, accounting for 44.8% in 2011. The second biggest operating cost in 2011 was administration overheads with a share of 32.8%. The above two costs account for more than 75% of direct operating costs. However, the average annual increase in repair and maintenance costs was higher than for all other direct operating costs (18.0%) from 2003 to 2011. The second highest was that of rents, rates, taxes, etc. (17.3%). Operating costs for pumping and depreciation showed lower average annual increase rates (9.1% and 9.2%, respectively), excluding that of other operating costs that fluctuate.

NWSDB's balance sheet from 2003 to 2011 is shown in **Table 1.11**. The first table shows "assets." The "capital work in progress" in the non-current assets is more than "property, plant & equipment" in every year and increases every year. This means that construction and rehabilitation work is always more than fixed assets.

The second table shows "equity and liabilities." In "capital and reserves," "government grant" and "capital grants" are very high in the past nine years accounting for 85% of "total equity and liabilities" in 2011. In addition, "capital grants" (mostly foreign grants) were less than the "government grant" from 2003 to 2005, but since then they have been more than the "government grant" in every year except for 2007. It is also noticeable that the "accumulated

loss" increased each year and this is covered by grants and liabilities. It is strange that the "accumulated loss" increased in 2011 although the current account balance was positive in this year. However, it has been ascertained that the "accumulated loss" increased because of prior year adjustments, such as salary arrears and Ministry advance write-off. In the "non-current liabilities," the "loan payable" is less than grants, but it increased every year. Furthermore, the "loan interest payable" has been increasing in recent years, in particular from 2008. This corresponds to the discussion about the finance costs in the profit/ loss above. This means more loan interest payments were delayed recently and the current account balance seems red substantially in 2011.

Consequently, the financial situations of NWSDB do not seem sound. NWSDB has a lot of loans and so has to pay the loan interest and repay the loans. However, it can make neither operating profits nor current balance profits easily. In order to improve the situation, it is necessary to increase revenues and cut expenses. However, the income relates closely to the tariff which is controlled by the government, so it is not easy to increase revenues. It seems that if NWSDB lacks money, the government may give grants. Therefore, NWSDB cannot be considered a financially independent sustainable entity.

Table 1.10 Profit/ Loss of NWSDB

(Unit: Rs.)

Item / Year	2003	2004	2005	2006	2007	2008	2009	2010	2011
Sales of water	4,135,900,339	4,263,830,351	5,446,263,579	5,869,448,092	6,481,915,574	6,743,217,327	9,669,975,867	10,744,059,534	11,616,045,254
Other operating income	727,867,450	645,046,477	814,457,513	1,074,822,450	1,129,364,580	1,391,118,020	1,397,317,115	1,566,297,797	2,081,716,017
Operating Income	4,863,767,789	4,908,876,828	6,260,721,092	6,944,270,542	7,611,280,154	8,134,335,347	11,067,292,982	12,310,357,331	13,697,761,271
Direct operating expenses	2,834,131,407	3,454,131,782	3,604,024,192	4,080,524,657	4,902,547,316	6,088,841,694	6,321,949,712	7,061,727,544	7,470,490,082
Personnel cost	1,068,274,105	1,408,733,213	1,599,810,859	1,829,346,805	2,335,091,573	2,633,355,899	2,830,486,142	3,346,857,362	3,345,000,435
Pumping cost	1,207,036,638	1,248,338,029	1,217,702,035	1,360,669,505	1,587,873,327	2,104,778,364	2,025,805,684	2,103,576,701	2,417,486,303
Chemical cost	193,376,960	286,914,658	301,387,232	319,570,787	349,492,607	436,027,228	421,702,108	412,935,647	426,959,662
Repairs & maintenance	155,126,555	238,273,589	221,268,901	256,858,175	287,034,821	454,778,478	485,572,435	560,276,883	581,807,386
Establishment expenses	91,162,859	106,428,937	122,737,408	137,637,825	152,013,097	213,069,370	229,811,749	248,970,965	272,493,532
Rent, rates, taxes, etc.	119,154,290	165,443,357	141,117,757	176,441,560	191,041,890	246,832,355	328,571,593	389,084,987	426,742,765
Administration overheads	784,536,152	962,238,646	999,273,784	1,348,603,525	1,762,775,528	1,895,309,365	2,062,268,144	2,564,857,342	2,447,412,103
Depreciation	966,206,589	752,748,842	1,043,413,735	1,100,006,942	1,381,373,713	1,397,510,699	1,409,852,073	3,258,762,679	1,769,054,208
Other operating expenses		123,242,899	177,410,662	159,864,181	139,810,303	468,138,615	1,089,308,312	3,953,088,317	249,979,834
Operating Expenditure	4,584,874,148	5,292,362,169	5,824,122,373	6,688,999,305	8,186,506,860	9,849,800,373	10,883,378,241	16,838,435,882	11,936,936,227
Operating Profit/ Loss	278,893,641	-383,485,341	436,598,719	255,271,237	-575,226,706	-1,715,465,026	183,914,741	-4,528,078,551	1,760,825,044
Non-operating income	136,474,325	96,556,001	32,633,847	114,477,942	203,386,141	59,918,167	48,782,302	97,644,018	131,257,102
Finance cost	613,048,615	647,054,533	663,370,716	511,983,308	851,942,058	1,192,769,345	1,568,941,934	1,419,459,214	943,355,146
Tsunami cost/Revaluation deficit	0	0	0	7,981,932	0	0	0	0	474,261,491
Non-operating Profit/ Loss	-476,574,290	-550,498,532	-630,736,869	-405,487,298	-648,555,917	-1,132,851,178	-1,520,159,632	-1,321,815,196	-1,286,359,535
Current-account payment balance	-197,680,649	-933,983,873	-194,138,150	-150,216,061	-1,223,782,623	-2,848,316,204	-1,336,244,891	-5,849,893,747	474,465,509

Source: NWSDB

Table 1.11(1) Assets in Balance Sheet of NWSDB

(Unit: Million Rs.)

Item / Year	2003	2004	2005	2006	2007	2008	2009	2010	2011
Non-current Assets	54,864	66,462	77,358	89,991	100,813	115,632	135,978	149,210	178,292
Property, Plant & Equipment	24,649	25,419	36,767	42,182	52,406	55,197	63,086	73,666	84,271
Capital Work in Progress	29,460	40,402	40,448	47,681	48,291	60,344	72,815	75,479	93,974
Intangible Assets	96	96	0	0	0	0	0	0	0
Investments	660	545	144	129	115	91	77	65	47
Current Assets	9,503	9,533	11,852	13,620	13,094	15,190	13,460	14,984	14,479
Non-operating Assets	0	0	192	191	191	191	159	187	130
Inventories	2,113	1,891	2,151	2,283	2,602	3,081	3,306	3,283	3,553
Trade & Other Receivables	3,209	3,872	4,994	5,079	6,021	5,250	4,301	4,164	4,631
Deposits & Advances	3,104	2,771	3,171	4,209	2,945	5,422	4,766	5,578	4,463
Investments	762	969	673	1,650	850	423	304	612	987
Cash & Cash Equivalents	315	29	672	207	484	823	625	1,161	715
Total Assets	64,368	75,995	89,210	103,611	113,907	130,822	149,438	164,194	192,772

Source: NWSDB

Table 1.11(2) Equity and Liabilities in Balance Sheet of NWSDB

(Unit: Million Rs.)

Item / Year	2003	2004	2005	2006	2007	2008	2009	2010	2011
Capital and Reserves	50,469	60,544	71,964	84,174	92,797	105,226	118,734	128,381	150,712
Assets taken over from Government	185	185	185	185	185	185	185	185	185
Equity Capital/ Government Grant	27,730	31,545	36,693	42,361	48,851	54,560	58,446	62,618	69,440
Capital Grants	22,878	29,976	36,339	43,096	46,507	56,142	67,190	78,620	94,203
Capital Recovery Fund	742	881	1,060	1,261	1,487	1,819	2,151	2,532	3,041
Staff Welfare Fund	10	10	12	12	12	15	13	13	14
Revaluation Reserve	310	310	310	310	310	310	310	0	0
Accumulated Profit/ Loss	-1,388	-2,363	-2,635	-3,051	-4,555	-7,804	-9,560	-15,588	-16,172
Non-current Liabilities	12,113	13,310	14,948	17,301	18,257	20,281	23,324	26,475	31,474
Loan Payable	10,816	11,913	13,466	15,697	16,526	18,113	20,137	23,071	27,839
Other Deferred Liabilities	1,297	1,397	1,482	1,604	1,731	2,167	3,188	3,405	3,635
Current Liabilities	1,787	2,141	2,298	2,136	2,852	5,315	7,379	9,338	10,586
Creditors	1,147	1,170	1,203	1,081	1,210	1,347	2,173	2,345	3,489
Loan Capital Payable	0	0	573	295	699	1,411	2,256	2,362	2,688
Loan Interest Payable	289	230	91	142	284	1,457	1,896	3,157	2,465
Non-operating Liabilities	0	0	115	115	115	115	115	161	133
Other Payables	351	740	317	502	544	985	939	1,312	1,811
Total Equity and Liabilities	64,368	75,995	89,210	103,611	113,907	130,822	149,438	164,194	192,772

Source: NWSDB

1.2.6 Activities and Policies of International Donors and National Agencies of the Sector

After the conflict termination in April 2009, a variety of countries offer a helping hand to the assistance for Sri Lanka. According to "Performance Report 2011" published by the Ministry of Water Supply and Drainage, there are thirty foreign-funded projects in which twelve countries and four international agencies are involved in the water supply and sewerage sectors (refer to **Appendix 1.2** for details). They are categorized on the sector basis as shown in **Table 1.12**.

Table 1.12 Bi- and Multi-lateral Assistance to Sectors in Sri Lanka

	Water Supply			Sewerage
	Urban	Rural	Others	
Bilateral and Multi-lateral Assistance	Japan (JICA) Denmark (DANIDA) Hungary Spain Netherland Germany (KfW) Korea Austria Australia France Belgium	ADB	ADB UNICEF WB IFRC (Red Cross)	Japan Australia Sweden (SIDA)
	11 countries	1 agency	4 agencies	3 countries

Major donors during the year 2011 are ADB, JICA (Japan), KfW (Germany), SIDA (Sweden) , UNICEF, IFRC (International Federation of Red Cross and Red Crescent Societies), Austria, France, Spain, Hungary, Korea and Netherland. As shown in **Table 1.10**, JICA provides assistance to both water supply and sewerage sectors, although focusing on urban water supply. On the contrary, ADB has concentrated into rural water supply and provided 6th assistance following 3rd and 4th assistance. JICA assistance includes not only the hard components represented by the construction of facilities but also the soft components like capacity building. KfW supports the energy saving project at Ambatale

ADB and IFRC were concerned with Tsunami-related assistance, while UNICEF is addressing to water, sanitation and hygiene programme and WB to the increase of number of sewerage connections and access to safe sanitation focusing on the poor.

CHAPTER 2

NATURAL AND SOCIAL CONDITIONS

CHAPTER 2 NATURAL AND SOCIAL CONDITION

2.1 General

Anuradhapura is located about 280 km north-northeast of Colombo, and about 140 km north-northwest of Kandy and is an inland district in the North Central Province. The district is classified as a dry zone climatologically with less rainfall and has about 2,500 small tanks for irrigational use. The district capital of Anuradhapura and its surrounding area was the first capital of the Ancient Sunghalese Dynasty that flourished from the 3rd century BC to the 9th century AD and is registered as the world's cultural heritage.

The study area consisting of six Divisional Secretariat Divisions (DSDs), namely Padaviya, Kebithigollewa, Horowpothana, Kahatagasdigilia, Medawachchiya and Rambewa is located in the northeast part of Anuradhapura District as shown in **Figure 2.1** and is bounded by Trincomalee District to the east and by Vavuniya District to the north. It has a total area of 286,268 ha, a total population of 175,890 persons (2001 Census) and is a typical rural area.

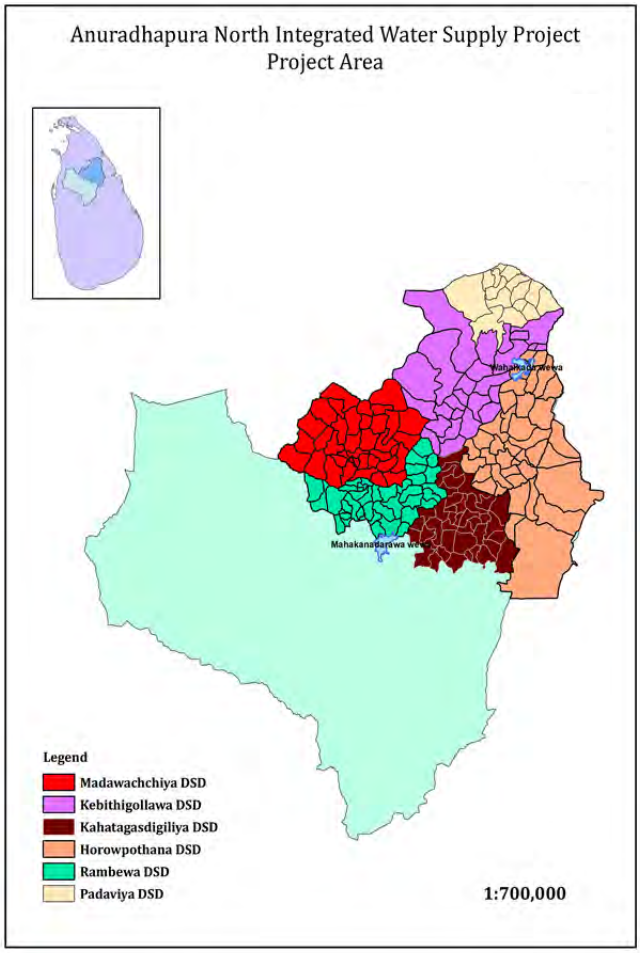


Figure 2.1
Location of Study Area

2.2 Natural Conditions

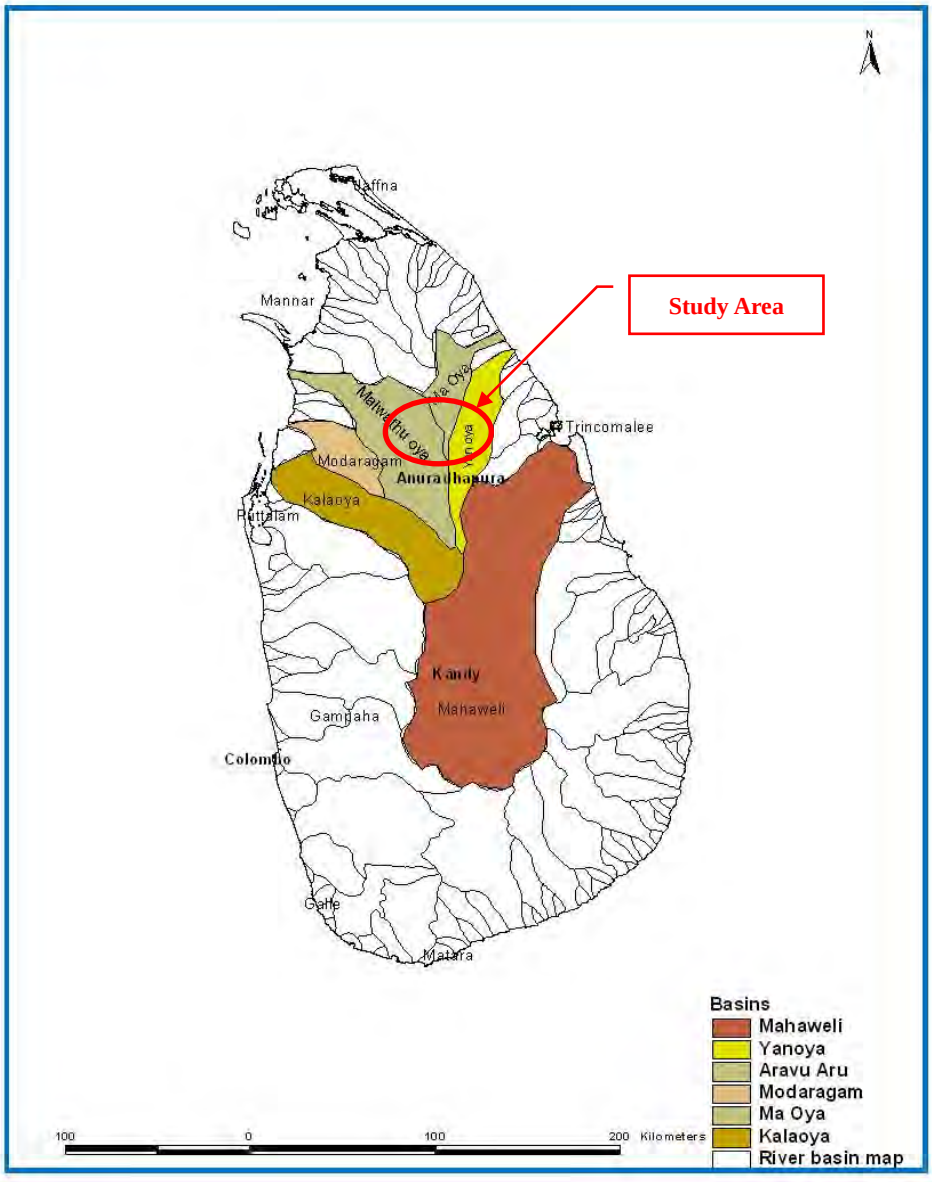
2.2.1 Topography

The study area extends over three river basins, namely, (1) Malwathu Oya, (2) Ma Oya and (3) Yan Oya. The watershed between the Ma Oya and Yan Oya runs one to two km west of national

road B211, while that between the Malwathu Oya and the Ma Oya and Yan Oya runs almost in the centre between national road A9 and B538 as shown in **Figure 2.2**.

The western terrain of the Malwathu Oya watershed generally slopes downwards in a northwesterly direction, while the eastern terrain slopes downwards in a southeasterly direction with undulations.

There are many major tanks in the study area that hold water throughout the year; however the minor tanks run dry during the dry period until they are replenished during the northeast monsoon.



Source: HYDROSULT Inc, "Anuradhapura Pilot Area – groundwater Monitoring Program", September 2010

Figure 2.2 River Basin

2.2.2 Geology

The geology of the major part of the study area is highly crystalline, formed by metamorphosis of well bedded sediments in an old geosyncline. Within the study area there are five rock types which are generally in the Central and Eastern parts of the district of the Highland series. Mica mines in Kebithigollewa and limestone deposits in Palagala to Horowpathana are the major mineral resources in the study area.

In the North Central region, the so-called "hard rock" or crystalline basement complex of rocks are well known for their very limited quantities of shallow groundwater. It is now recognized that this shallow groundwater benefits from the presence of several small tank cascades systems that are distributed across this landscape. This has enabled the recent development of agrowell farming, especially in the Anuradhapura district where it is reported that around 15,000 agrowells are in operation; and almost all of these are situated in the lower aspects of the shallow inland valleys which receive some degree of seepage from the small village tanks that are located upstream.[1] (Refer to **Section 4.3.1** (2) for more details).

Fluoride, derived from fluorite (the principal fluoride mineral in igneous rocks) and the minerals apatite and mica, is generally present in only low concentration in groundwater. Volcanic or fumarolic gases may contain fluoride, and in some areas these may be the source of fluoride in groundwater.[2]

2.2.3 Climate

(1) Temperature

The climatological pattern is classified into two seasons for cultivation purposes in Sri Lanka as follows:

- Maha season from October to March called as the wet season
- Yala season from April to September called as the dry season

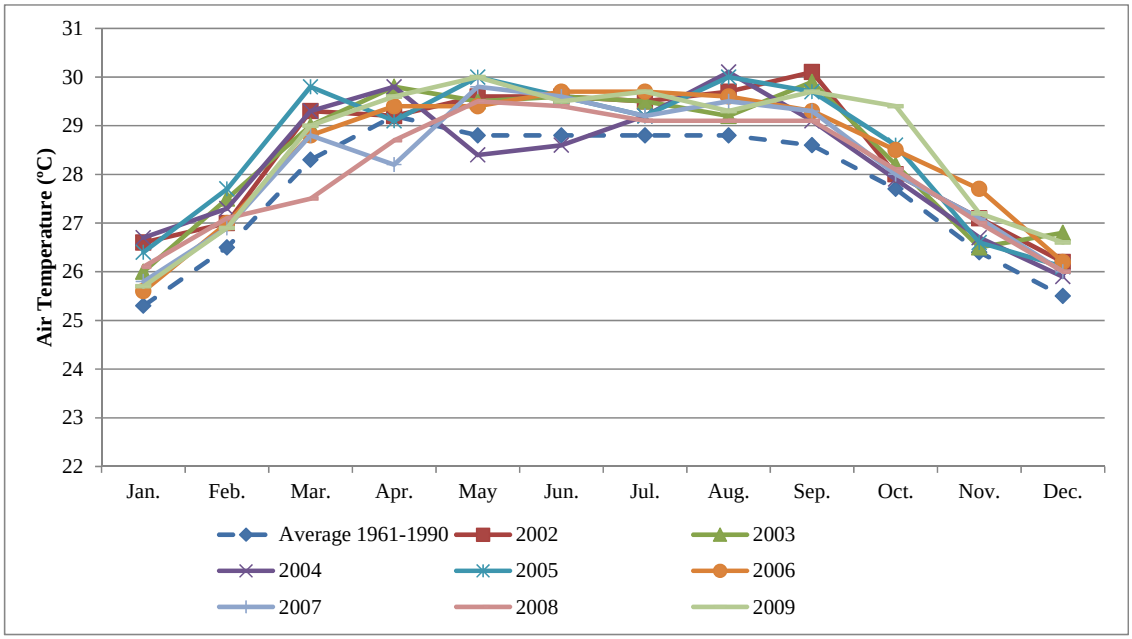
During the dry season from April to September, the monthly average temperature is very stable in the range of 29ºC to 30ºC. However at the start of the wet season from October, the temperature decreases with the coldest months being December and January at about 26 ºC, following which the temperature increases (refer to **Figure 2.3**).

Compared with the average temperature for 30 years from 1961 to 1990, it is noticeable that the

[1] *C. R. Panabokle, "Nature of occurence and sustainable use of groundwater resources for agriculture in the North central, north westen and North easternregions of Sri Lanka", Tropical Agriculture Research and Extention, July 2003*

[2] *Fletcher G. Driscoll, "Groundwater and Wells – Second Edition", Johnson Filtration Systems Inc., 1989*

temperature during the period of 2004 to 2009 was generally higher.

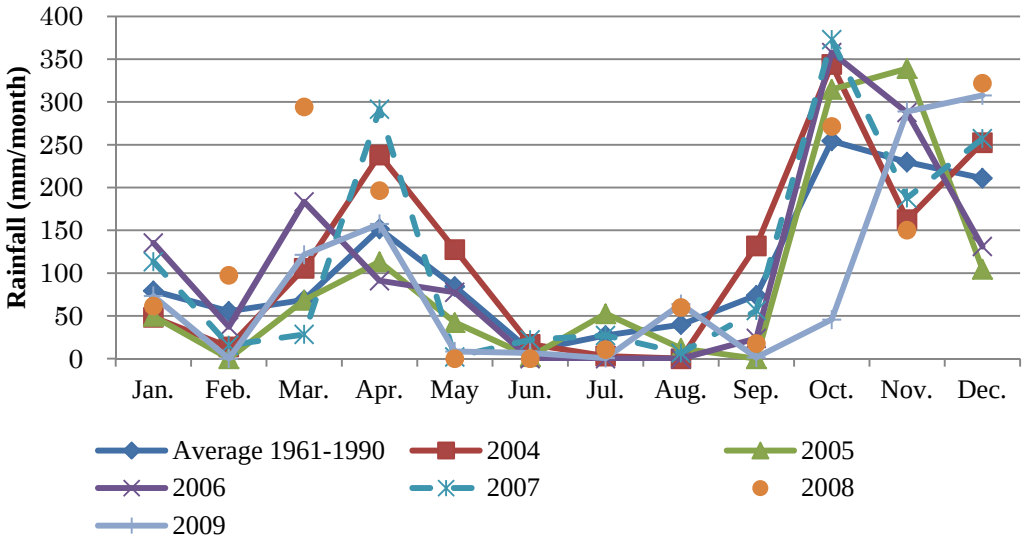


Source: "Statistical Abstract 2010", Department of Census and Statistics

Figure 2.3 Monthly Average Temperature in Anuradhapura District (2004~2009)

(2) Rainfall

The annual average rainfall in the period from 1961 to 1990 in Anuradhapura District was 1,285 mm, but more than two-thirds of the annual rainfall occurs in the Maha season. In addition, as more than 70% of the rainfall during this period is concentrated in the period from October to December, there is a large monthly fluctuation in rainfall, as shown in **Figure 2.4**.

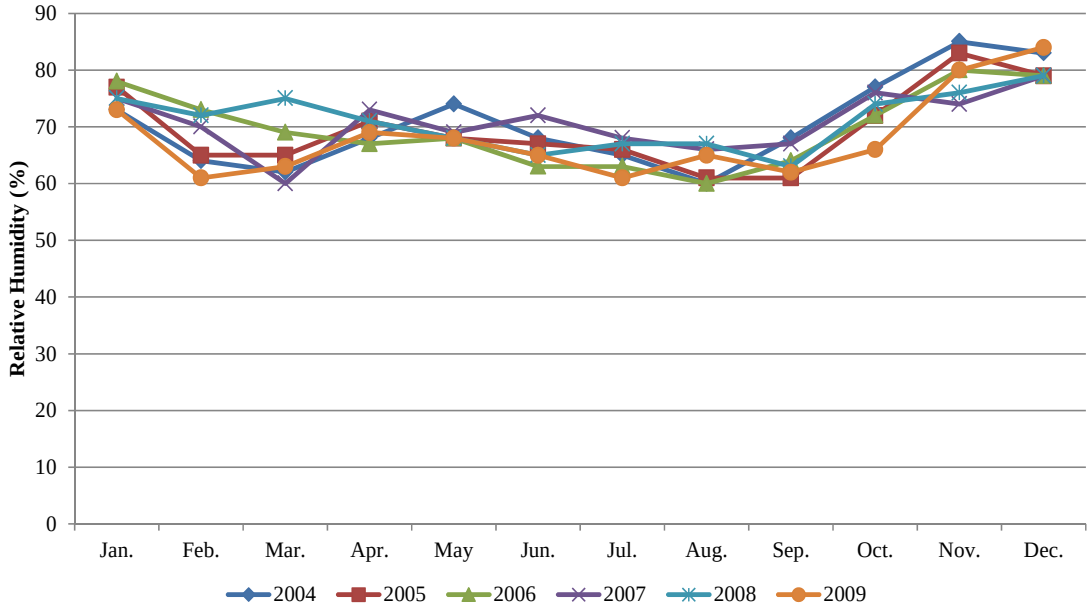


Source: "Statistical Abstract 2010", Department of Census and Statistics

Figure 2.4 Monthly Rainfall in Anuradhapura District (2004~2009)

(3) Relative Humidity

Relative humidity is stable during the period from February to September, then begins to increase with a peak of between 79% and 84% in December, following which it decreases.



Source: "Statistical Abstract 2010", Department of Census and Statistics

Figure 2.5 Monthly Average Relative Humidity in Anuradhapura District (2004~2009)

2.3 Social Conditions

2.3.1 Population

Population, population density and population growth rate of Sri Lanka, Anuradhapura District and study area is summarised in **Table 2.1**.

- The total population of Sri Lanka in the Census 2011 was 20,277,600 persons and the annual average population growth rate was significantly declined from previous 1.16% (1981-2001) to 0.71% (2001-2012).
- Vavuniya and Mullative Districts, which are located north of Anuradhapura District had the highest growth rate of 2.2%, while Jaffna District had the lowest at minus 2.0%, probably due to people being internally displaced people by the conflict.
- The total population of Anuradhapura District in the above census was 745,693 persons, composed of an urban population of 53,151 (7.1%), a rural population of 691,573 (92.7%) and an estate population of 969 (0.1%).

Table 2.1 Population, Population density and Growth Rate of Sri Lanka, Anuradhapura

	Area (km^2)	Population ('1,000)			Population Density (persons/km^2)		Annual Average Growth Rate (%)	
		1981	2001	2012	2001	2012	2001/1981	2012/2001
Sri Lanka	**66,510**	**14,846.8**	**18,797.3**	**20,277.6**	**300**	**323**	**1.16**	**0.71**
Urban		3,192.7	-	-			-	-
Rural		11,654.3	-	-			-	-
Anuradhapura	**7,179**	**587.9**	**745.7**	**855.6**	**112**	**128**	**1.25**	**1.33**
(% to Sri Lanka)		(4.0%)	(4.0%)	(4.2%)				
Urban		41.4	53.2	-			1.26	-
Rural		546.5	692.5	-			1.19	-
Study Area	**2,843**		**175,890**	**205,171**	**62**	**72**		**1.41**
Padaviya	240		21,146	22,924	88	96		0.74
Kebithigollewa	615		19,457	22,227	32	36		1.22
Horowpothana	845		29,642	36,714	35	43		1.96
Kahatagasdigiliya	352		33,572	40,137	95	114		1.64
Medawachchiya	482		40,469	46,743	84	97		1.32
Rambewa	309		31,604	36,426	102	118		1.30

- In Anuradhapura District, Anuradhapura and its surrounding area is categorised as an urban area with a population of 53,151 persons and all of the remaining is categorized as a rural area. Therefore, the entire study area is considered as a rural area.
- The average population density of Anuradhapura District was 104.0 persons/km^2 in the 2001 Census, with the density in the study area being lower than in other DSDs, especially in Kebithigollewa in Horowapothana. At 31.7 persons/km^2 and 35.8 persons/km^2 respectively. For reference, the average population density of the study area was 62.3 persons/km^2 in the 2001 Census.
- The total national population in the 2012 Census is 20,277,597 persons with an annual average growth rate of 0.71％ in the period from 2001 to 2012, which is lower than 1.16% in the period from 1981 to 2001.
- Similarly, the population in the Anuradhapura district in the 2012 Census is 855,562 persons with an annual average growth rate of 1.33％ in the period from 2001 to 2012, which is the highest out of the 18 districts covered in the Census 2001 and a small increase from the growth rate of 1.25% in the period from 1981 to 2001.

2.3.2 Land Use

Anuradhapura is the largest of all districts in Sri Lanka, covering an area of 738,953 ha which is 11% of the whole country's land surface. The land use includes large areas of paddy fields, scrublands, forested areas, mixed cultivations, Chena cultivations, home gardens and residences. The majority of the people in the area are farmers and largely depend on paddy cultivation. Apart from that the district economy is predominantly centred on chena and home gardens with vegetable cultivation. Additionally animal husbandry including cattle, goat and poultry is also

common in some locations.

The land area for agricultural use in the study area is summarised in **Table 2.2**.

Table 2.2 Land Area for Agricultural Use in the Study Area

	Land Area (ha)	Paddy (ha)	Highland Crop (ha)
Padaviya	**23,119**	**4,841**	**389**
Kebithigollewa	**56,062**	**5,304**	**593**
Horoupotana	**85,487**	**10,924**	**178**
Kahatagas digil iya	**33,141**	**8,605**	**575**
Medawachehiya	**50,730**	**6,791**	**666**
Rambewa	**25.509**	**7,399**	**671**
Total	**274,048**	**43,864**	**3,072**

Note: Highland crop means cashew, arecant, mango, orange, lime, jack, plantain and papaw.

2.3.3 Income and Expenditure

(1) Income

The national average monthly household income in the Household Income and Expenditure Survey 2009/2010 was Rs.36,451, Rs.47,783 in urban areas and Rs.35,228 in rural areas (73.7% of that in urban areas).

The average monthly household income in the North Central Province to which Anuradhapura District belongs was Rs.35,577, which is slightly below the national average (97.6%); however in Anuradhapura District itself the average income was Rs.37,586, which is a little bit higher than the national average (103.1%). For the average income, Anuradhapura District was ranked in 5th position behind Colombo (Rs.51,070), Gampala (Rs.48,870), Ratnapura (Rs.41,312) and Vanuviya (Rs.39,640). Details of the above are shown in **Table 2.3**, with other information on income shown in **Table 2.4** and **Table 2.5**.

Table 2.3 Average and Median of Household Income (Average Monthly) (2009/10)

	Mean Rs.	Median Rs.
Sri Lanka	36,451	23,746
Urban	47,783	31,000
Rural	35,228	23,126
Estate	24,162	17,366
Province		
Westem	47,118	30,600
Central	31,895	21,410
Southem	32,514	23,253
Northem	23,712	16,710
Eastem	23,922	18,030
NorthWestem	35,586	20,961
NorthCentral	35,577	24,993
Uva	28,717	19,761
Sabaragamuwa	36,173	21,676

	Mean Rs.	Median Rs.
District		
Colombo	51,070	34,186
Gampaha	48,870	29,821
Kalutara	35,780	27,511
Kandy	33,063	22,450
Matale	30,013	18,606
Nuwaraeliya	31,029	21,431
Galle	31,376	21,886
Matara	30,980	23,048
Hambantota	36,879	26,406
Jaffna	18,917	14,815
Vavunlya	39,640	29,370
Batticaloa	22,844	16,129
Ampara	24,721	19,082
Trincomalee	24,291	19,154
Kurunegala	36,922	20,778
Puttalama	32,918	21,593
Anuradhapura	37,586	25,682
Polonnaruwa	31,526	22,634
Badulla	32,313	20,982
Moneragala	22,161	17,226
Ratnapura	41,312	22,154
KeEalle	29,342	21,122

Source: Department of Census and Statistics, "Household Income and Expenditure Survey -2009/10", August 2011

Table 2.4 Share of Income to Total HH Income by HH Income Deciles (2009/10)

Decil group	Sri Lanka		Urban		Rural		Estate	
	Income group (Rs.)	Share of income (%)	Income group (Rs.)	Share of income (%)	Income group (Rs.)	Share of income (%)	Income group (Rs.)	Share of income (%)
	All deciles	**100.0**		**100.0**		**100.0**		**100.0**
1	Less than 8,627	1.6	Less than 12,000	1.7	Less than 8,333	1.6	Less than 7,380	2.1
2	8,627-12,500	2.9	12,000-16,854	2.9	8,334-12,143	2.9	7,381-10,658	3.8
3	12,501-16,019	3.9	16,855-21,526	4.0	12,144-15,690	4.0	10,659-12,700	4.8
4	16,020-19,655	4.9	21,527-26,107	5.0	15,691-19,167	4.9	12,701-14,815	5.7
5	19,656-23,746	6.0	26,108-3,1000	6.0	19,168-23,126	6.0	14,816-17,366	6.7
6	23,747-28,502	7.1	31,001-3,7533	7.2	31,270-27,795	7.2	17,367-20,320	7.8
7	28,503-35,167	8.7	37,534-46,510	0.8	27,796-34,179	8.7	20,321-23,700	9.1
8	35,168-44,762	10.8	46,51 1-60,389	11.1	34,180-43,169	10.9	23,701-28,010	10.6
9	44,763-64,443	14.6	60,390-87,667	15.1	43,170-61,693	14.5	28,011-37,629	13.4
10	More than 64,443	39.5	More than 87,667	38.2	More than 61,693	39.3	More than 37,629	36.0

Source: Department of Census and Statistics, "Household Income and Expenditure Survey -2009/10", August 2011

Table 2.5 Share of Income to Total HH Income and Percentage of HH by National HH Income Decile and Sector (2009/10)

Decile Group	Income group	Percentage of households				Share of income			
		Total	Urban	Rural	Estate	Total	Urban	Rural	Estate
	(Rs.)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
	All deciles	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1	Less than 8,627	10.0	5.0	10.7	13.4	1.6	0.6	1.7	3.2
2	8,627-12,500	10.0	6.6	10.3	15.3	2.9	1.5	3.1	6.8
3	12,501-16,019	10.0	6.7	10.2	15.8	3.9	2.0	4.1	9.2
4	16,020-19,655	10.0	8.1	10.1	14.0	4.9	3.0	5.1	10.2
5	19,656-23,746	10.0	8.2	10.2	11.9	6.0	3.7	6.3	10.7
6	23,747-28,502	10.0	10.5	9.9	10.6	7.1	5.7	7.3	11.4
7	28,503-35,167	10.0	11.5	9.9	7.0	8.7	7.7	1.9	9.3
8	35,168-44,762	10.0	11.9	9.9	5.5	10.8	9.9	11.1	1.9
9	44,763-64,443	10.0	13.9	9.7	3.9	14.6	15.7	14.6	8.3
10	More than 64,443	10.0	17.7	9.1	2.7	39.5	50.3	37.7	22.0

Source: Department of Census and Statistics, "Household Income and Expenditure Survey -2009/10", August 2011

In **Table 2.3**, the income average of Anuradhapura District is Rs.37,586 (Rs.36,451 on the national level), but the median is Rs.25,682 (Rs.23,746) or 68.3% (65.1%) to an average showing the significant bias to the lower direction. In the decile, the income data is arranged from the lowest to the highest and divided equally into ten groups in population size, the average is almost equal to the median in each decile except for the 10th income decile to which the bias are concentrated as shown in **Table 2.6**. Adversely, the median is 6.2% higher than the average in the 1st income decile.

Table 2.6 Relationship between Average and Median in the Decile

Decil Group	Range (Rs.)	Mean (Rs.)	Median (Rs.)	Percentage (%) (Mean=100)
	All groups	36,451	23,746	65.1
1	Less than 8,627	5,723	6,080	106.2
2	8,627－12,500	10,691	10,750	100.6
3	12,501－1,6019	14,285	14,283	100.0
4	16,020－19,655	17,833	17,821	99.9
5	19,656－23,746	21,712	21,685	99.9
6	23,747－28,502	26,047	26,000	99.8
7	28,503－35,167	31,656	31,506	99.5
8	35,168－44,762	39,448	39,157	99.3
9	44,763－64,443	53,192	52,531	98.8
10	More than 64,443	143,969	90,737	63.0

(2) Expenditure

The national average monthly household expenditure in the Household Income and Expenditure Survey 2009/2010 was Rs.31,331, Rs.44,928 in urban areas and Rs.29,423 in rural areas, which is 65.5% or about two-thirds of that of the urban area (refer to **Table 2.7**).

The average expenditure in the North Central Province to which Anuradhapura District belongs was Rs.29,065, which is slightly below the national average (94.0%), while that in Anuradhapura District itself was Rs.29,065, which is also lower than the national average (92.8%). For the average expenditure, Anuradhapura District was ranked in 9th position behind Colombo (Rs.47,291), Gampala (Rs.41,062), Kalutara (Rs.35,549) and so on, as shown in **Table 2.6**.

(3) Percentage of Water Rate to Disposal Income in the Household Income and Expenditure

The monthly water and electricity bills[3] are Rs.99.75 and Rs.531.64 per household on national average, respectively, of which percentages to the total household income are 0.27% and 1.45%. The World Bank[4] estimates the limit for household affordability to pay for water supply services as 4% of household income. The Pan American Health Organization[5] also recommends that the total water supply and sewerage charge should be less than 5% of the household income, consisting of 3.5% for water supply and 1.5% for sewerage. The present water charge in Sri Lanka at 0.27% of household income is around one-twelfth of the ceiling (3.5%) set by an International organization.

[3] *Source: Department of Census and Statistics, "Household Income and Expenditure Survey -2009/10", August 2011*

[4] *"Information and Modeling Issues in Designing Water and Sanitation Subsidy Scheme", The World Bank, May 2000*

[5] *"Methodology of Economic Evaluation in Development Study – 9. Water Supply -", JICA, march 2002 (Japanese)*

Table 2.7 Average Monthly HH Expenditure (2009/10)

Sector/Province/District	Total expenditure (Rs)	Expenditure on food & drink (Rs)	Food ratio (%)	Expenditure on non-food items (Rs)	Non-food ratio (%)
Sri Lanka	31,331	13,267	42	18,064	57.7
Sector					
Urban	44,928	16,003	36	28,925	64.4
Rural	29,423	12,859	44	16,564	56.3
Estate	23,988	12,201	51	11,792	49.2
Province					
Western	42,399	15,028	35	27,373	64.6
Central	28,308	12,669	45	15,639	55.2
Southern	28,809	12,628	44	16,181	56.2
Northern	25,656	15,102	59	10,553	41.1
Eastern	25,265	14,512	57	10,753	42.6
North Western	25,927	12,183	47	13,744	53.0
North Central	29,480	12,073	41	17,407	59.0
Uva	23,547	11,030	47	12,518	53.2
Sabaragamuwa	25,583	11,877	46	13,706	53.6
District					
Colombo	47,291	16,121	34	31,171	65.9
Gampaha	41,062	14,473	35	26,589	64.8
Kalutara	35,549	14,021	39	21,534	60.6
Kandy	29,767	12,773	43	16,994	57.1
Matale	26,528	11,739	44	14,789	55.7
Nuwaraeliya	26,841	13,105	49	13,736	51.2
Galle	27,370	12,514	46	14,855	54.3
Matara	29,408	12,561	43	16,846	57.3
Hambantota	30,744	12,941	42	17,803	57.9
Jaffna	22,725	14,787	65	7,938	34.9
Vavuniya	35,391	16,149	46	19,242	54.4
Batticaloa	23,508	13,799	59	9,709	41.3
Ampara	26,699	14,956	56	11,743	44.0
Trincomalee	25,623	14,906	58	10,717	41.8
Kurunegala	25,201	11,618	46	13,582	53.9
Puttalama	27,376	13,310	49	14,066	51.4
Anuradhapura	29,065	11,795	41	17,271	59.4
Polonnaruwa	30,315	12,635	42	17,680	58.3
Badulla	24,873	10,865	44	14,008	56.3
Moneragala	21,131	11,331	54	9,800	46.4
Ratnapura	25,477	11,732	46	13,745	54.0
Kegalle	25,723	12,069	47	13,654	53.1

Source: Department of Census and Statistics, "Household Income and Expenditure Survey -2009/10", August 2011

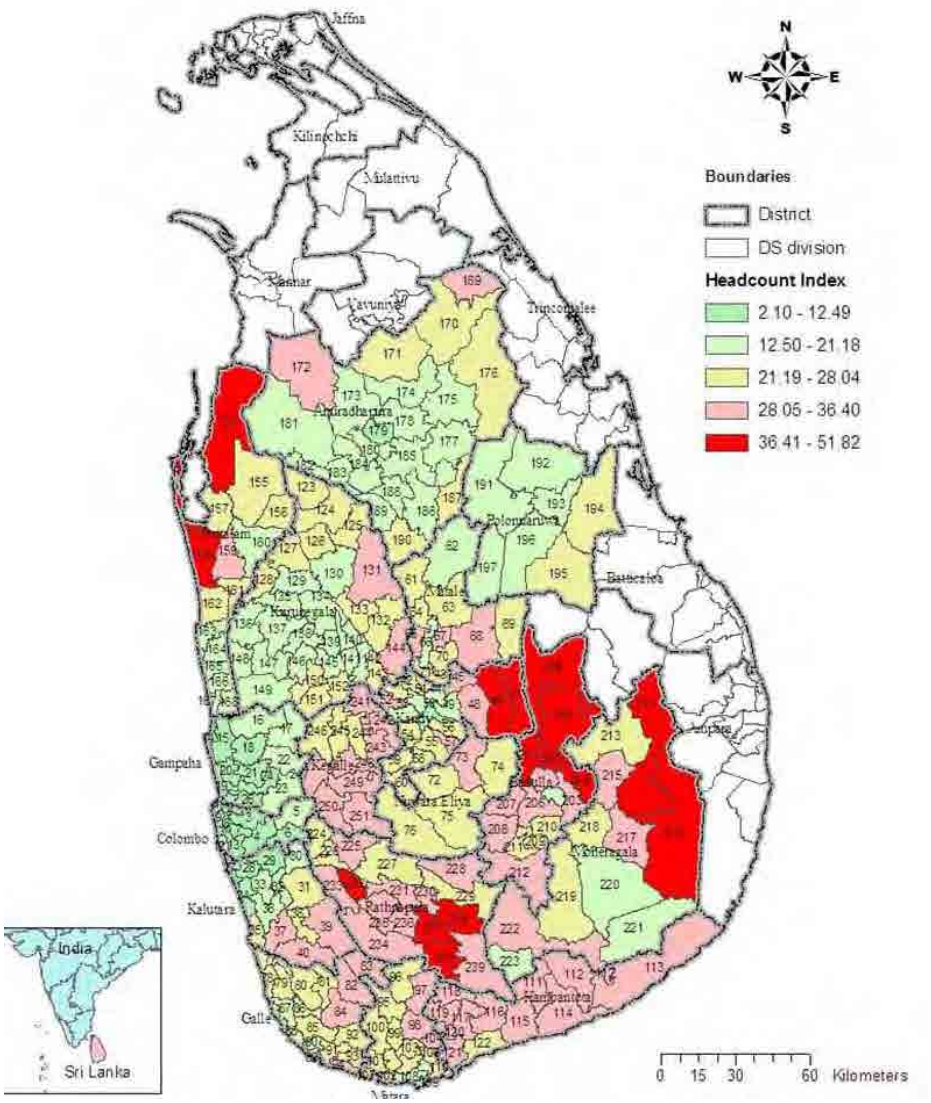
According to "Household Income and Expenditure Survey – 2009/10" (hereinafter referred to as "HIES 2009/10"), the HI (Poverty Head Count Index, the percentage of population below Poverty Line) in Anuradhapura District is 5.7%, ranked at the 4th following Vavuniya (2.3%), Colombo (3.6%) and Gampaha (3.9%) and categorised into a relatively rich province group. However, the five DSDs out of six DSDs in the study area have the higher HI values than the district average with 28.2% of the poor population against 23.6% of the total population in 2001 as shown in **Table 2.8** and **Figure 2.6**.

Table 2.8 Households Index (HI) and Household Population below Poverty Line

Study Area/ District	Headcount Index (HI)	Household Population Below Poverty (HPBPL) (persons)	Remarks
Study Area			
Padaviya	34.33	6,893	
Kebithigollewa	27.74	5,127	
Horowpothana	24.95	7,250	
Kahatagas digiliya	19.63	6,464	
Medawachchiya	21.34	8,113	
Rambewa	20.57	6,339	
		40,186	全県貧困層の 28.2%
Anuradhapura District	20.00	142,308	

Poverty Line is one of the widely used indicators to measure poverty in Sri Lanka. The purpose of estimating poverty line is to capture the basic needs necessary to meet minimum living standards

Headcount Index (HI) is defined as the percentage of **Household Population Below Poverty (HPBPL)**.



Source: "Household and Expenditure Survey – 2002" & "Census of Population and Housing – 2002" Department of Census and Statistics, 2005/07/01)

Figure 2.6 Households Index (HI) by DSD (2002)

The poverty line is to capture the basic needs necessary to meet minimum living standard defining the consumption bundle which include food and non-food items, and raises as the individual component price increases. The poverty line was Rs.2,142 at national level and Rs.2,099 in Anuradhapura District in the year of 2012, which increased to Rs.3,579 and Rs.3,508, respective in November 2012, but those corresponding to 2009/10 were not available.

Table 2.9 Basic Data

Year of Data	Item	Whole		Urban		Rural	
		Income (Rs.)	Percentage (%)	Income (Rs.)	Percentage (%)	Income (Rs.)	Percentage (%)
2009/10	1st Decile Average	5,723					
2009/10	1st Decile Median	6,080	5.0				
2009/10	Poverty Line (Anuradhapura Dist.)	N/A	8.9 (5.7)	N/A	5.3	N/A	9.4
2012-Nov.	Poverty Line (Anuradhapura Dist.)	3,579 (3,508)					
2009/10	1st Decile Upper Limit	8,627	10.0	12,000	10	8,333	10

Note: As the HI value of Anuradhapura District in 2009/10 was 8.9%, it should be placed between the median (5%) and the upper limit (10%) of the income 1st decile, but the poverty line for November 2012 is Rs, 3,508 which is below a 1st decile median of Rs.6,080 with a discrepancy, although the poverty line for 2009/10 is not available.

As shown in **Table 2.9**, the data for urban, rural, Anuradhapura District is not available, therefore the data for the whole or the country is used for the following study:

Since the HI value for the country 8.9% for 2009/10, all the poor can be considered to belong to the1st decile or 10% from the lowest. On the assumption of a population of 4 persons/ household and an average water consumption of 11 m^3/month (= 4 persons × 91 Lpcd × 30.4 days/month), the water rate (Rs.168) is 2.8% to the 1st income decile median of Rs.6,080 in case of applying the special tariff (Domestic - Samurdhi Receipients), which is within 4% of the disposal income recommended by the World Bank. Even applying the normal tariff (Domestic – Non Samurdhi Tenement Garden) to the customer exceeding the 1st income decile median, the water rate is in the range of 2.8% to 2.6% to the disposal income which is in the level of no problem. This result suggests that there are households with an income of below Rs.4,200 (= Rs.168 / 0.04) that the water rate exceeds 4% of the disposal income. The percentage of the number of such households is estimated at about 3.5% (= 5% × Rs.4,200 / Rs.6,080) to the total district household number and about 0.8% (= 3.5% × 0.236) to the study area household number using the population percentage of study area to the whole district

In this connection, under the old water tariff before September 30, 2012, the water rate of households with an income below the poverty line was Rs. 80.1 which was raised to Rs. 168 under the new tariff, or 110% up three times higher than that (37%) of households in the 1st income decile

to which the normal tariff is applied

Table 2.10 Water Tariff

(1) Customers below Poverty Line (Special Rate)

New Water Tariff (Effective since October 1, 2012			Water Amount (m^3)	Water Rate (Rs.)
Consumption (m^3)	Service Charge (Rs.)	Volumetric charge (Rs./m^3)		
00-05	50	5	5	25
06-10	50	10	5	50
11-15	50	15	1	15
Monthly service Charge applied to a consumption of 11 m^3/month				50
Billing before Taxation				140
VAT (20%)				28
Total				168
Percentage to the Median of First Decil Group of Rs.6,080 = (168 / 6,080) x 100				2.8%

(2) Customers of First Decil Group (Ordinary Rate)

New Water Tariff (Effective since October 1, 2012			Water Amount (m^3)	Water Rate (Rs.)
Consumption (m^3)	Consumption (m^3)	Consumption (m^3)		
00-05	50	8	5	40
06-10	65	11	5	55
11-15	70	20	1	20
Monthly service Charge applied to a consumption of 11 m^3/month				70
Billing before Taxation				185
VAT (20%)				37
Total				222
Percentage to the Upper Limit of First Decil Group of Rs.8,627 = (222 / 8,627) x 100				2.6%

(4) Poor Households

The percentage of poor households nationally based on the official poverty line has reduced from 24.3% in 1995/96 to 19.2% in 2002, 12.6% in 2006-07 and 7.0% in 2009/10, while the percentages in the same years in Anuradhapura District were 21.9%, 17.2%, 12.7% and 4.6%, respectively, following a similar pattern to the situation nationally, as shown in **Table 2.11**.

Table 2.11 Percentage of Poor Households Based on the Official Poverty Line

	1990/91	1995/96	2002	2006-07	2009/10
Percentage of poor households (%)					
Sri Lanka	21.8	24.3	19.2	12.6	7.0
Anuradhapura	20.1	21.9	17.2	12.7	4.6
Official poverty line (Rs.)					
Sri Lanka	475	833	1,423	2142	
Anuradhapura	456	816	1,380	2,099	

Source: "Announcement of the Official Poverty Line", Department of census and Statistics, 2004 June

Note: The official poverty line are Rs.3,545 at the national level and Rs.3,474 in Anuradhapura District for September 2012.

2.3.4 Sanitation Conditions

(1) Toilet Facilities

According to the Census 2001 and 2011, in Anuradhapura District, the availability of a toilet was changed as shown in **Table 2.12**. The percentage of "exclusively for the household" was increased to 83% from 73.2% but is still lower than the average of Sri Lanka (86.5%), the percentage of "not using a toilet" was decreased to 2.2% from 12.7% but is still higher than the average of Sri Lanka (1.7%). From these censuses, the toilet facilities condition in Anuradhapura district was improved but is still behind the average of Sri Lanka.

Table 2.12 Condition of Toilet Facilities in Anuradhapura District

Census	Exclusively by the household	Sharing with the another household	No toilet but sharing with another household	Common/ Public	Not using toilet
2001	73.20%	7.70%	4.60%	0.50%	12.70%
2011	83.00%	9.30%	3.30%	0.10%	2.20%
variation	9.80%	1.60%	-1.30%	-0.40%	-10.50%

For the study area, "exclusively for the household" was 79.65% or 3.4% lower than that for the district, whereas "not using a toilet" was 4.3%, or 2.1% higher than that for the district. There were no significant differences in other categories, when comparing the study area with the district. This result shows the study area is still behind condition from the average of the district but the differences have been narrowed. Especially housing units "not using a toilet" ranged from 2.3% to 5.7% in census 2011 is much lower than that of in census 2001 (from 23.5% to 33.3%).

In summary as far as sanitation is concerned, the situation in the study area was worse than that in the district, based upon the above census. The situation in the district and study area is summarized in **Figure 2.7**.

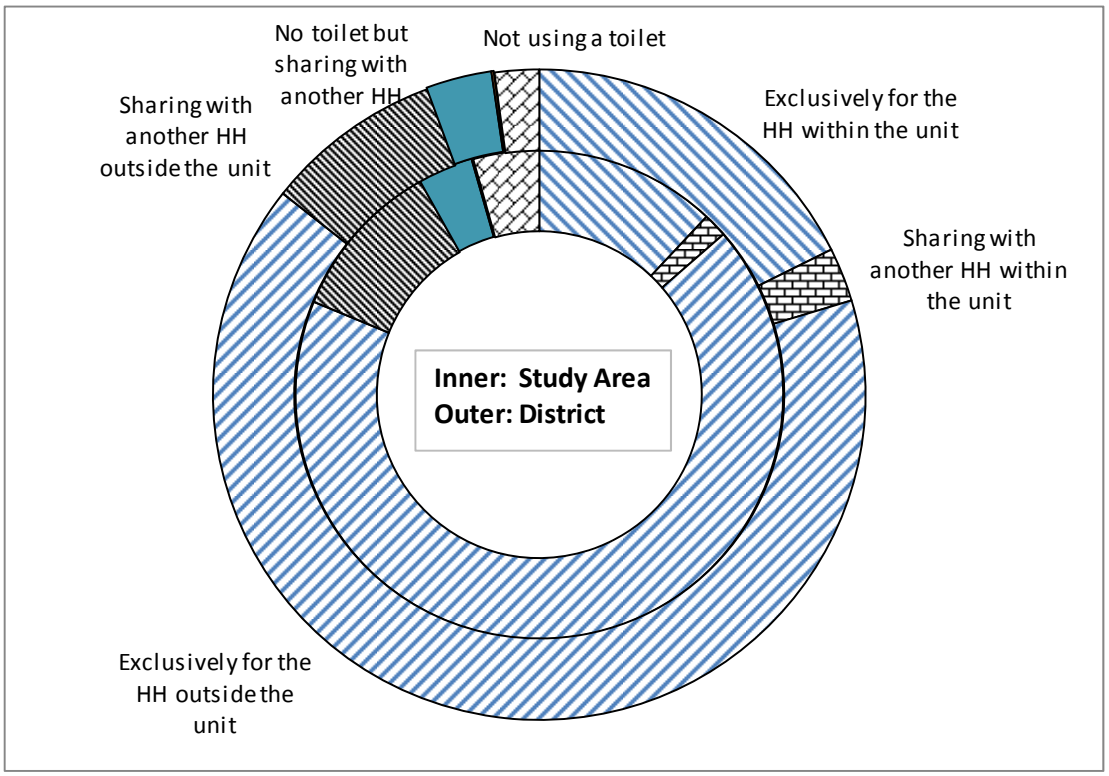


Figure 2.7 Availability of the Toilet in Anuradhapura District and the Study Area

(2) Type of Toilets

As for the type of toilets, Census 2011 data is not available. The following description is based on Census 2001 data.

From the viewpoint of the toilet type in the district, the percentages were 47.9% for “water seal” or almost a half in the district, 13.5% for “pour flush”, 21.6% for “pit”, 2.4% for “others”, 12.7% for “not using a toilet” and 2.1% for “not reported”. This shows a delay in the provision of improved sanitation.

For the study area, the percentage of “pit” was 12.8% or 8.8% below that in the district, while that of “not using a toilet” was 24.4% or 11.7% above that in the district.

For the DSDs in the study area, the percentage of “water seal” in Horowpothana was 38.5% or 9.4% below that in the district, and that of “pit” in Padaviya was 36.6% or 15.0% above that in the district. There are no significant differences in other types of toilet, when comparing the situation in the DSDs and the district. The situation in the district and study area is summarized in **Figure 2.8**.

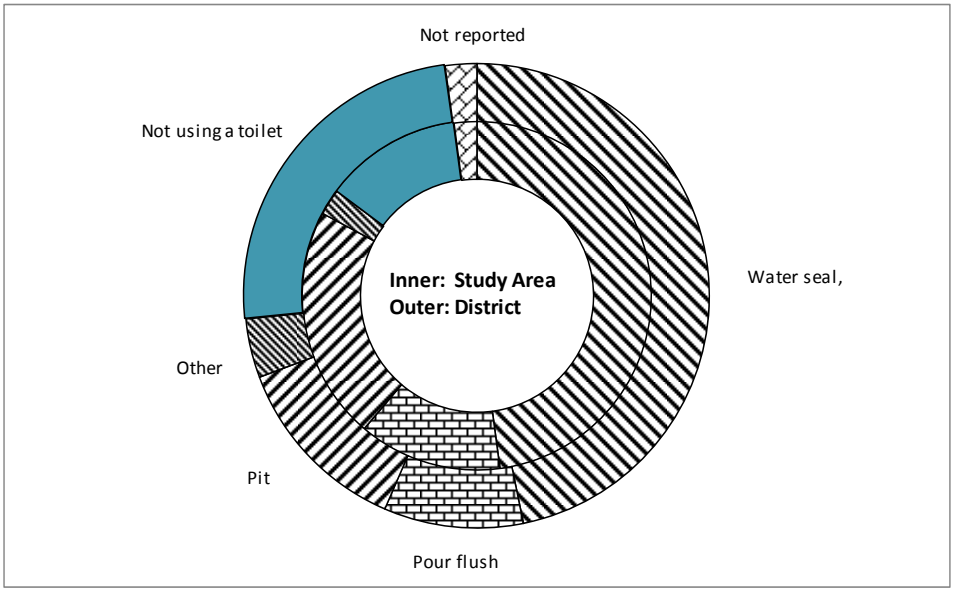


Figure 2.8 Type of Toilet in Anuradhapura District and the Study Area

Although Padaviya had a high percentage of toilets "exclusively for the household", it also had a high percentage of "pit", which shows a delay in the provision of improved sanitation in the area. Considering the whole of the study area, about one quarter of households did not have a toilet "exclusively for the household" and were either sharing with another household or not using a toilet. In addition, the spread of improved sanitation is delayed.

The JICA study team visited some schools in the study area. Most of schools, have pour flush toilets and the number of students per toilet is more than 50 students. Besides, maintenance condition is so different in each school. The school in Medawachchiya has a kind of cleaning system by their parents. In this school, 4 parents should clean the school facilities includes toilets. In another school, there are some pour flush type toilets but there is not enough water, so they cannot use toilets in the school. The students and teachers go to some houses or a mosque near from the school to use toilets.

Figure 2.9 Used Toilets for Girls

Figure 2.10 Not Used Toilets

(3) Sanitation improvement projects

Some sanitation improvement projects have been put in operation in 25 CBOs by ADB. In most of CBOs, some toilets were installed and in some CBOs, some motivation campaigns about sanitation were held. The detail of these projects is described in **Chapter 9.**

2.3.5 Source for Drinking Water

(1) Dug/Tube Well

In the study area, housing units depend on the following for drinking water source: (i) protected shallow wells within premises (24.8%), (ii) protected shallow wells without premises (40.0%), (iii) not protected shallow wells (15.5%), (iv) tube wells (12.5%), (v) tap water (4.1%), (vi) other (tank, river, etc.) (1.8%) and (vii) not reported (1.4%) in the Census 2001[6]. Accordingly, 92.8% of housing units had some form of well and used ground water for drinking. It should be noted that pipe water coverage was 9.8% in the whole of Anuradhapura District in 2001, which is higher than that for the study area.

(2) Rainwater Harvesting[7]

Domestic rainwater harvesting has been revived in Sri Lanka since 1995 with the Community Water Supply and Sanitation Project (CWSSP). At present, there are over 31,000 domestic rainwater harvesting systems in the country and more than 10% of such facilities have been constructed in Anuradhapura District in the dry zone, (where there is a high level of fluoride concentration in groundwater), as shown in **Figure 2.11**.

Rainwater is one of the purest sources of water available, as it does not come into contact with many of the pollutants such as exhaust gas from vehicles, smoke, dust, etc. which are emitted in urban areas, especially in rural areas such as the study area. It is free and can be used for both drinking water and non-drinking water purposes.

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[6] Department of Census and Statistics – Sri Lanka, "Census of Population and Housing 2001 – Anuradhapura District – Fnal Results (CD-ROM)"

[7] Tanuja Ariyananda, "Domestic Rainwater Harvesting as a Water Supply Option in Sri Lanka", Hydro Nepal Issue No.6, January 2010

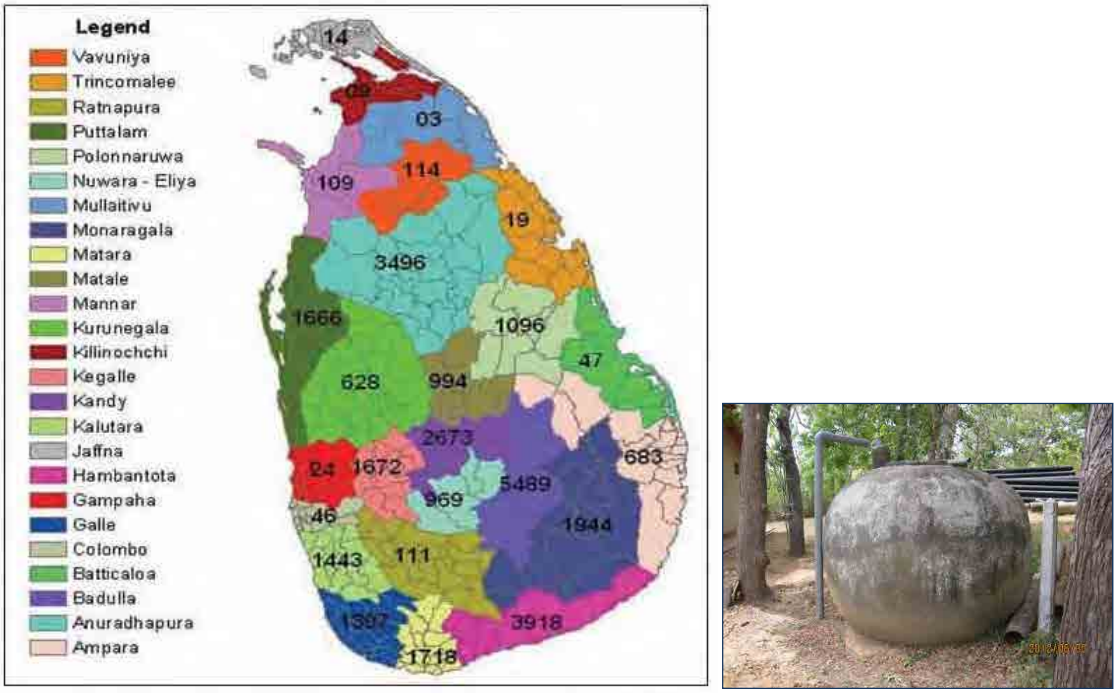


Figure 2.11 Distribution of the Number of Rainwater Harvesting Systems

In 2005, the Government of Sri Lanka, realizing the importance of rainwater harvesting to overcome the water scarcity in the country, passed a national policy of rainwater harvesting. Today, more than 23 institutions and organizations are promoting water harvesting nationwide.

Free-standing Ferro cement tanks with a volume of 5 m^3 (refer to **Figure 2.11**) are often seen in the study area, which are designed on the following assumptions:

Family size:	5 persons
Per capita consumption:	20 L/day
Maximum dry period:	50 days
Required volume:	5 × 20 × 50 = 5,000 Liters or 5 m^3

2.3.6 Solid Waste Disposal

(1) Solid waste management in the study area

All 6 DS in the study area have garbage collection systems in certain areas and final disposal sites, the detail shows in the **Table 2.13**. Only in Rambewa DS, the disposal method in the final disposal site is land fill, other 5 DSs have only open dump site.

Table 2.13 Solid Waste Management Condition in the Study Area

DSD (Pradesiyah Sabah)	Rambewa	Madawachchi	Paraviya	Kebithigollewa	Horoupothana	Kahatagasdigillia
Population	36,426	46,743	22,924	22,227	36,714	40,137
Collection cover ratio (by population)	12.2%	22.0%	14.0%	66.0%	61.0%	30.0%
Quantity of collected waste (ton/week)	15	24	18	14	12	15
No. of Collection vehicle	2	1	2[*1]	1	1	3
No. of Collection crew	4	11	3	3	8	8
Disposal Method	Land fill	Open dump	Rainy season: Soil cover Dry season: Open dump & burning			
Cost for solid waste management (Rs/year)	1,200,000	4,048,100	240,000	540,000	2,801,600	3,600,000
Collection experience	3 years	9 years	2.5 years	7 years	9 years	NA
Other projects/ programs	1 for compost	2for compost	1 for compost	1 for compost	1 for compost, 1 for separation	1 for compost

** Source of the number of population: Census of population and housing, 2011*
Source of other figures: Interview with the chairman of each DS

Figure 2.12
Landfill Dump Site in Rambewa

Figure 2.13
Open Dump Site in Medawachchiya

(2) Solid waste management projects

From March 2007 to March 2011, there is a JICA technical cooperation project, “Capacity Upgrading Project for the National Solid Waste Management Support Center” in Sri Lanka. The aim of this project is to upgrade the capacity of solid waste management in each local government and had some training programs for the officers and some constructions of compost facilities. According to this project, in the all DS, there are compost projects funded by JICA. Except for JICA-funded compost project, there are two projects supported by the national

government. One is a kind of compost project related with organic agricultural project, the other one is a garbage separation project based on the school.

2.4 Economic Conditions

According to the employment population by industry in Sri Lanka (**Table 2.14**), the population engaged in agriculture decreased from 46.8% in 1990 to 32.6% in 2001 (or a 14.2 percentage points decrease), while the population engaged in industry increased from 13.3% to 17.0% (or a 3.7 percentage points increase). In the same period employment in trade and hotels increased from 9.6% to 13.0% (or a 3.4 percentage points increase) and in services from 15.7% to 18.5% (or a 2.8 percentage points increase). The transition from an agriculture-dependent economy has been steadily progressing.

Table 2.14 Employment Persons by Major Industrial Groups

(Unit: %)

Year	Agriculture	Manufacturing	Construction	Trade & Hotels	Transport storage & comm.	Insurance, real estate & business service	Service	Other	Not defined
1990	46.8	13.3	3.9	9.6	4.1	1.3	15.7	2.2	3.2
1991	42.5	15	4.7	107	4.1	1.9	14.8	1.5	4.8
1992	42.1	13.1	4.8	11.3	4.4	1.5	16.9	2	4
1993	41.5	13.2	4.4	11.1	4.1	1.6	17.5	2.2	4.5
1994	39.5	14.3	4.1	12.2	4.7	1.8	18.1	1.4	4
1995	36.7	14.7	5.3	12.2	4.7	1.5	17.3	2.1	5.4
1996	34.4	14.6	5.4	12	4.9	2	18.2	2.1	3.5
1997	36.2	16.4	5.6	12.4	4.8	1.7	17.3	2.2	3.5
1998	39.3	14.9	5	11.6	4.9	1.9	17.1	2	3.2
1999	36.3	14.8	5.3	12.1	5.1	1.6	18.4	1.8	4.5
2000	36	16.6	5.5	12.7	4.9	2.1	17.5	1.6	3.2
2001	32.6	17	5.2	13	6.2	2.3	18.5	1.8	3.4

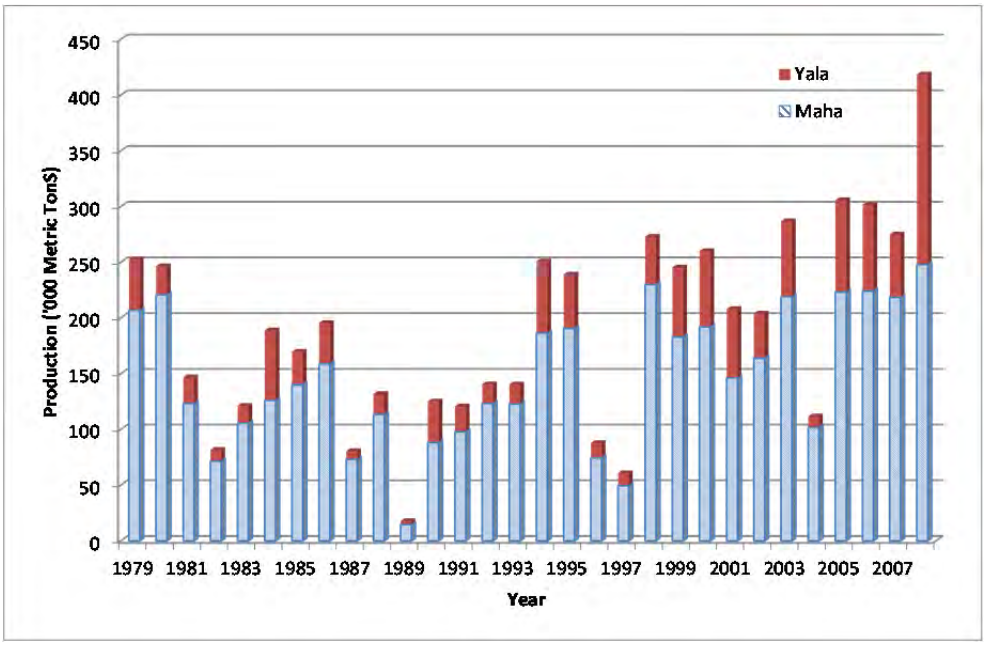
Source: "Statistical Abstract 2010", Department of Census and Statistics

2.4.1 Agriculture

The main industry of Anuradhapura District is agriculture but it does not produce significant quantities of the three major export products of the country, namely rubber, tea and coconut, accounting for only 3.6 % of the national total, with the major agricultural product being rice.

For the rice harvest from the paddy field, Anuradhapura District is ranked 4th in the country with a national share of 8.8% to 10.8% and it can be said that Anuradhapura District is one of the major rice-producing districts in Sri Lanka. However, as shown in **Figure 2.14**, the yearly

fluctuation of the rice harvest is heavily dependent on to what extent the irrigational water requirement is met during the drought period. Histrorical data shows that a long-term drought occurred during the period from 1987 to 1993.



Source: "Statistical Abstract 2010", Department of Census and Statistics

Figure 2.14 Yearly Fluctuation of Rice Harvest in Anuradhapura District

Apart from rice, the province's other products include sesame, millet, chilies, peanuts, fruit, vegetables and dairy produce.

2.4.2 Industry

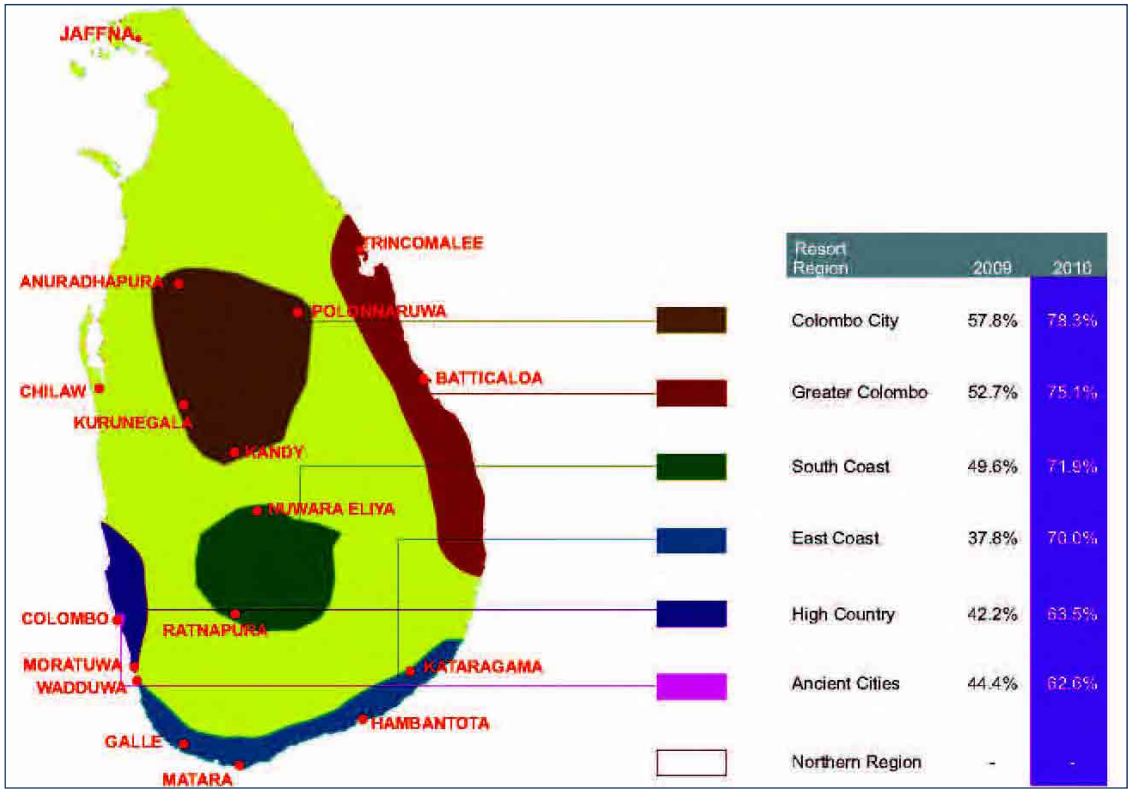
The industrial output product of Anuradhapura District in 2008 was Rs.12,036 billion, which is equivalent to 0.7% of the national industrial product of Rs.1,618,344 million. In the meaning of industrialization, Anuradhapura District is obviously lagging behind other parts of the country.

2.4.3 Tourism

Tourism areas in Sri Lanka are classified into seven resort regions as shown in **Figure 2.15** Anuradhapura District belongs to the group of “Ancient Cities” together with Kandy, Polonnaruwa and Kurunegala, focusing on the ancient Buddhism relics.

For the accommodation capacity (rooms) in Graded Establishment, Ancient Cities have kept a share of about 20% during the period from 2001 to 2010, but for the occupancy rates, there has been a drastic change. From 2001 to 2004, occupancy increased from 39.1% to 60.4%, but in

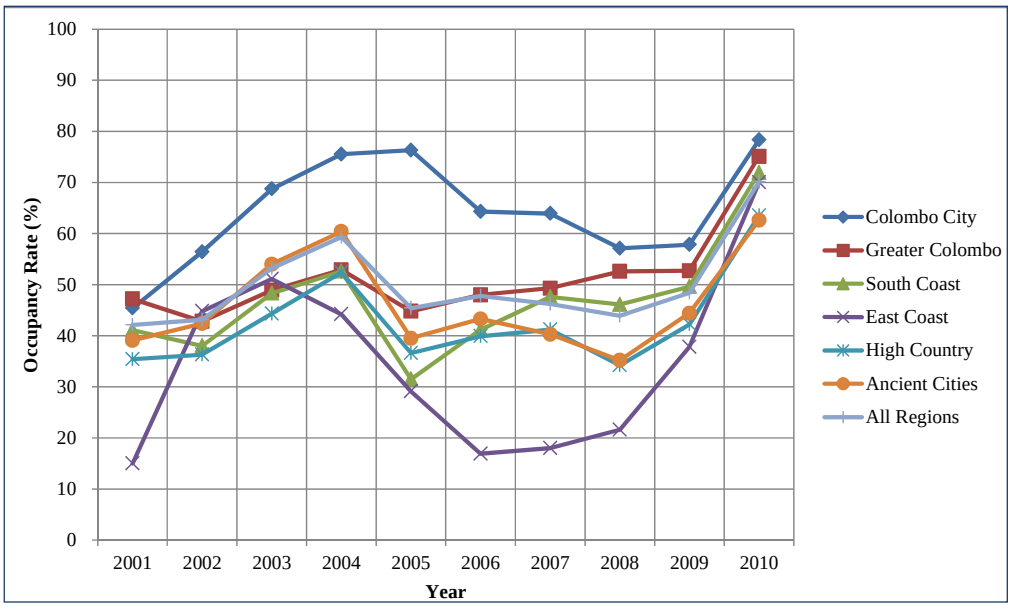
2005, there was a drastic drop to 39.5% and since that it has hovered at a low level of about 40%. In 2010 there was a significant improvement to 62.6%, or 18.2 percentage points up from the previous year of 44.4%, due to the end of conflict. **Figure 2.16** shows the trends in all regions combined and in each region, except for the Northern Region.



Source: Sri Lanka Tourism Development Authority, "Annual Statistical Report of Sri Lanka Tourism - 2010"

Figure 2.15 Resort Regions in Sri Lanka

Development of the tourism industry is expected to be significant in the future.



Source: Sri Lanka Tourism Development Authority, "Annual Statistical Report of Sri Lanka Tourism - 2010"

Figure 2.16 Occupancy Rate by Region (2020-2010)

According to the 2010 data, Kandy which had 55.6% of the total number of foreigners (375,939 guests) and 57.4% of the total number of locals (235,845 guests) in the Ancient Cities, was by far the most popular location. Anuradhapura had only 6.2% of the total number of foreigners (41,747 guests) and 12.7% of the total number of locals (52,326 guests). The number of foreigners (676,356 guests) in the Ancient Cities was 1.65 times the number of locals (411,055 guests), showing that foreigners had a higher interest in the area than locals; however in the case of Anuradhapura, the number of foreigners was 80% of the number of locals.

2.5 Necessity of the project

2.5.1 General

In the Anuradhapura North area, or the study area for the Preparatory Study on Anuradhapura North Integrated Water Supply Project, a number of small scale water supply systems under the operation and maintenance of the Community-Based Organizations (CBOs) and NWSDB are dispersed; however only about 60% of the total population receive piped water supply. In addition, the quantity of water amount is not enough to provide a 24-hour water supply.

Due to the lack of piped water supply coverage, most of the people living in the study area basically depend on groundwater sources such as tube wells and dug wells. According to the reports obtained from the NWSDB regional laboratory and water quality survey conducted by the project, groundwater contains high fluoride and other chemical substances, thereby is sometimes unsuitable for drinking purposes. However, since there are no other water sources,

local residents have no choice but to use such contaminated groundwater for drinking purpose. Especially, due to high concentration of fluoride, the prevalence of patients with fluorisis in the study area is very high.

Due to the above conditions, this project is proposed to solve the above problems, and thus has been started as a high priority project. Further information about the need for the project is as follows.

2.5.2 Drinking Water Source

(1) Principal Drinking Water Source

According to Census 2001 (**Table 2.15**), the drinking water sources are composed of groundwater (92.7%) from dug wells (80.2%) and tube wells (12.5%), and tap water (4.1%). The rural water supply was not reported at this point.

Table 2.15 Principal Source of Drinking Water in the Study Area (2001 & 2011)

Drinking Water Source (2001)

		Well				Pipe Born Water				Other			
	No. of HHs	Protected Well within Premises	Protected Well outside Premises	Unprotected Well	Tube Well	Tap within Unit	Tap within Premises but outside Unit	Tap outside Premises	Rural Water Supply Project	Bowser	Bottled Water	River / Tank / Stream / Spring and Other	Not Reported
	(HHs.)	(HHs)	(HHs)	(HHs)	(HHs)	(HHs)	(HHs)	(HHs)	(HHs)	(HHs)	(HHs)	(HHs)	
Anuradhapura District	189,699	41,482	71,316	25,931	26,630		12,279	5,858				3,538	2,665
			138,729		26,630		18,137		-		3,538		2,665
Wahalkada Area													
Padaviya	5,452	1,039	1,176	2,037	520		253	161				216	50
Kebithigollewa	4,903	932	1,845	1,086	560		139	87				151	103
Horowpothana	7,578	1,913	3,332	887	1,079		49	68				158	92
Kahatagasdigiliya	8,619	2,141	4,201	677	814		480	158				61	87
Sub-total	26,552	6,025	10,554	4,687	2,973		921	474				586	332
			21,266		2,973		1,395		-		586		332
Mahakanadarawa Area													
Medawachchiya	10,338	2,974	3,627	1,387	1,654		193	216				68	219
Rambewa	8,230	2,179	3,867	905	1,007		11	16				173	72
Sub-total	18,568	5,153	7,494	2,292	2,661		204	232				241	291
			14,939		2,661		436		-		241		291
Total	45,120	11,178	18,048	6,979	5,634		1,125	706				827	623
			36,205		5,634		1,831		-		827		623

Source: "Census 2001", Department of Census and Statistics

Drinking Water Source (2011)

		Well				Pipe Born Water				Other			
	No. of HHs	Protected Well within Premises	Protected Well outside Premises	Unprotected Well	Tube Well	Tap within Unit	Tap within Premises but outside Unit	Tap outside Premises	Rural Water Supply Project	Bowser	Bottled Water	River / Tank / Stream / Spring and Other	
	(HHs.)	(HHs)	(HHs)	(HHs)	(HHs)	(HHs)	(HHs)	(HHs)	(HHs)	(HHs)	(HHs)	(HHs)	
Anuradhapura District	**228,304**	**51,306**	**63,130**	**8,681**	**5,758**	**32,167**	**16,093**	**7,585**	**35,803**	**261**	**2,394**	**5,126**	
			123,117		5,758		55,845		35,803		7,781		
Wahalkada Area													
Padaviya	6,203	1,833	1,897	616	109	244	311	91	844	10	26	222	
Kebithigollewa	5,991	1,927	2,055	168	135	174	163	29	315		4	1,021	
Horowpothana	9,352	3,988	4,449	212	144	32	30	6	295		39	157	
Kahatagasdigiliya	10,386	3,355	4,404	179	114	463	340	73	1,236	1	126	95	
Sub-total	**31,932**	**11,103**	**12,805**	**1,175**	**502**	**913**	**844**	**199**	**2,690**	**11**	**195**	**1,495**	
			25,083		502		1,956		2,690		1,701		
Mahakanadarawa Area													
Medawachchiya	12,560	3,420	4,350	407	780	652	583	215	1,210	14	336	593	
Rambewa	9,757	2,739	3,162	214	229	459	357	446	1,691		58	402	
Sub-total	**22,317**	**6,159**	**7,512**	**621**	**1,009**	**1,111**	**940**	**661**	**2,901**	**14**	**394**	**995**	
			14,292		1,009		2,712		2,901		1,403		
Total	**54,249**	**17,262**	**20,317**	**1,796**	**1,511**	**2,024**	**1,784**	**860**	**5,591**	**25**	**589**	**2,490**	
			39,375		1,511		4,668		5,591		3,104		

Source: "Census 2011", Department of Census and Statistics

In Census 2011 (**Table 2.15)**, 75.4% of the people in the study area relied on groundwater through dug wells (72.6%) and tube wells (2.8%), and tap water (18.9%), and the remaining 5.7% on others such as bowser, bottled water, river, etc. (Note: the population coverage by water supply in the study area is approximately 27% according to the existing CBO water supply schemes survey, some of them may not regard tap water as the main water source in spite of the connection to a water supply schemes.) There are a decrease in the use of groundwater and an increase in the use of tap water. For the type of wells, unprotected dug wells and deep tube wells has substantially decreased and the protected dug wells have become popular. However, the water source of such small-scale water supply schemes are almost groundwater, there is no change in relying on groundwater.

1) Dug Wells and Deep Tubewells

Dug wells are shallow open wells which are less than 10 m deep, and are wells from which water is pulled using a bucket or other available container which can hold water (refer to **Figure 2.17** for a typical dug well). As groundwater from dug wells is a low cost water source for most rural and semi rural water supply, dug wells are distributed thoughout the country and provide the basic drinking water supply to a major proportion of rural residents. On the other hand, dug wells have disadvantages in comparison to tubewells. They are more difficult to protect from contamination and their yields are also very low, because they do not penetrate into the reliable, productive water table aquifer.

Figure 2.17 Dug Well

Deep tubewells are genarally more than 20 m deep wells from which water is pumped out using a submersible pump. Groundwater is allowed to enter the casing by either an open end pipe, perforated pipe or a well screen, depending on the size of the aquifer soil particles. Deep tubewells can protect from contamination, and their yields are relatively stable even in the dry season, because they penetrate into the productive water table aquifer.

Figure 2.18 shows a typical deep tubewell.

Figure 2.18 Deep Tubewell

2) Water Abstraction Facilities in CBOs

There are several rural water supply organizations using groundwater that is NWSDB, CBO and CWSSP. As CBOs account for the majority of these organizations, water abstraction facilities in CBO were investigated.

Considering these characteristics mentioned above, CBO has been using a combination of dug wells and deep tubewells. The ratio of the two methods are 57% and 43%, respectively, as shown in **Figure 2.19.** The datails of CBO information are in **Appendix 2.1**.

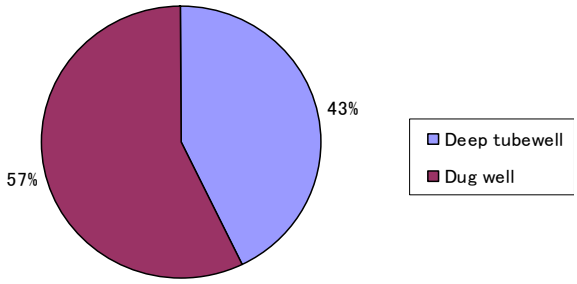


Figure 2.19 Water Abstraction Facilities in CBO

3) Spring water

There are some spring water (which is a “type” of groundwater) sites. Specifically spring water occurs in natural situations where water flows to the ground surface from underground. In the project area, this water sources occurs only in limited areas such as in Kebitigollewa DSD, as shown in **Figure 2.20**. In this location the spring water is of good quality and as such the local people prefer to use it for drinking purposes.

Figure 2.20 Spring Water in Kebitigollewa DSD

(2) Water-fetching Distance to Water Source

Since the data on water-fetching distance in the study area is not available, that is described using the district-level data.

Table 2.16 Water-fetching Distance in Anuradhapura District

Sector and District	Distance						
				Outside Premises			
	Total (%)	Within premises (%)	Outside Premises (%)	≤ 100 m (%)	101 – 200 m (%)	201 – 500 m (%)	> 500 m (%)
Sri Lanka	**100**	**76.3**	**23.7**	**16.0**	**3.3**	**3.1**	**1.3**
Urban	100	88.9	11.1	8.9	0.7	0.9	0.6
Rural	100	75.0	25.0	16.4	3.7	3.5	1.4
Estate	100	62.0	38.0	31.1	3.7	3.1	0.1
Anuradhapura	**100**	**58.0**	**42.0**	**18.3**	**7.8**	**9.5**	**6.4**

Source: Department of Census and Statistics, "Household Income and Expenditure Survey -2009/10", August 2011

The distribution of drinking water sources in Sri Lanka is 76.3% within premises and 23.7% outside premises, while in Anuradhapura District, they are 58.0% and 42.0% respectively. It shows that the percentage of a drinking water source outside premises is rather high. The percentage of the number of households engaged in the water-fetching work is secondarily high following that in Jaffina District.

The distance allocation from a housing unit to a drinking water source is 16.0% for equal or less than 100 m, 3.3% for 101 – 200 m, 3.1% for 201 – 500 m and 1.3% for above 500 m (The national average for a rural area is 16.4%, 3.7%, 3.5% and 1.4%, respectively.), while in Anuradhapura District they are 18.3%, 7.8%, 9.5% and 6.4%, respectively, showing that the people in the district are forced the water-fetching work for a longer distance than a national average. As for the water-fetching distance, Anuradhapura District is ranked at the second for within 100 m, third for 101 to 200 m and second for above 500 m. On a national basis, the district is placed in a severe

condition as well as Jaffina District.

In case of tap water, 43.4% of housing units have a tap indoors, 38.2% within premises and 18.4% outside premises. It means that one out of five housing units have no tap within premises.

(3) Per Capita Water Consumption at Existing CBOs

There are 50 existing water supply schemes maintained and operated by CBOs in the study area, of which the per capita water consumption is 66 Lpcd at 46 existing CBOs on average.

(4) Water Quailty at Existing CBOs

Although there are 50 water supply schemes under CBOs in the study area out of which 45 CBOs have their water quality data of tap water as shown in **Table 2.17**. A fluoride concentration is above a desirable standard of 0.6 mg/L in 27 CBOs and above a permissible limit of 1.5 mg/L in 6 CBOs with the maximum value of 1.9 mg/L. The served population who are exposed to a risk of fluorosis by a fluoride concentration above a desirable limit counts 29,460 persons against 8,205 persons with no risk. The rate of populations with a risk versus with no risk is 78.2:21.8, that is to say, four out of five persons are exposed to a risk of fluorosis. Among them, a served population of 4,435 persons are exposed to a higher risk due to a fluoride concentration of above a permissible limit.

Table 2.17 Water Quality of CBO's Supply System

S/N	Name of CBO	Water Quality							
		Hardness	Iron	Fluoride	Odor	Color	Turbi	pH	Condictivity
01	Swashakthi CBO	-		0.85	None	Clear	0.05	7.86	860
02	Ikra CBO	-	-	0.83	None	Clear	0.06	7.72	950
03	Arunalu CBO	-	-	0.59	Fishy	Clear	0.1	7.93	940
04	Samagi CBO	-		1.01	None	Clear	0	7.76	930
05	Ekamuthu CBO	-		0.32	None	Clear	0.08	7.74	700
	Ekamuthu CBO - Katukaliyawa			1.19	-	Clear	0.03	7.77	880
06	Rangiri CBO	-		0.88	None	Clear	0.03	7.79	1080
07	Nildiyadahara CBO	360/280	-	0.72	-	Clear	0.15	7.77	740
08	Eksath CBO	340	-	0.4,0.78	None	Clear			
09	Mahasen CBO	80	-	0.39	-	clear	0.08	7.6	730
10	Dimuthu CBO	312	-	0.57	-	Clear	0.12	7.91	610
11	Pragathi CBO	344	-	1.38	-	Clear	0.05	7.7	1450
12	Jayashakthi CBO	-		1.9	None	Clear	0.06	7.76	1570
13	Samagi CBO	332/270/330		1.08	None	Clear	0.07	7.8	1000
14	Samagi CBO	-	-	0.5	-	<5	0.02	-	590
15	Ekamuthu CBO	-		0.81	-	<5	0.03	-	650
16	Ran Arulnalu CBO	490/720/640	0.03/-/-	1.55/1.1/0.36					
17	Isuru CBO	High	-	0.98	None	Clear	0.05	7.84	1060
18	Randiya Dhahara CBO	-	-	1.15	None	Clear	0.09	7.76	840
19	Nelum CBO	-		1.11	None	Clear	0.05	7.86	970
20	Diriyamatha CBO	250/261/284		0.83	-	Clear	0.1	7.75	700
	Diriyamatha CBO -			0.69	-	Clear	0.12	7.79	870
21	Gemunu CBO	-		0.75	-	<5	0.21	-	950
22	Sisila Diyadahara CBO	-		0.76	None	Clear	0.06	7.86	880
23	Diriya Shakthi	373/342		0.86	None	Clear	0.1	7.64	1220
24	Ridi Nadee	-		0.21	None	Clear	0.06	7.75	610
25	Shakthi CBO	324	3.3	0.1		N/A			
26	Al-Naja	-	-	-					
27	CBO not formed &	-	-	-					
28	Parakum CBO	108	0.14	1.04	-	Clear	0	7.76	740
29	Suwasehana CBO	1.13	-	1.13		Clear	0.07	7.76	740
30	Suwasetha CBO	-	-	0.96		Clear	0.04	7.63	740
31	Vajira CBO	262/204		1.5/1.54					
32	Pragathi CBO	-		0.58	None	Clear	0.08	7.54	1430
33	Janasetha CBO	-	-	1.37		Clear	0.01	7.85	670
34	Sobasisila CBO	-		0.67		Clear	0.02	7.64	810
35	Randiya	-	-	0.31		Clear	0.14	7.76	760
36	Nilmini	-		-					
37	Senath CBO	-		1.9	None	Clear	0.02	7.75	1240
38	Eksath CBO	296		1.62	None	Clear	0.02	7.78	860
39	Praja Shakthi	-		0.42	None	Clear	0.01	7.85	520
40	Apsara	-		1.35		Clear	0.14	7.69	1380
41	Pinibindu CBO								
42	Sham Sham	-		-					
43	Ekamuthu CBO	264		0.14		Clear	0.05	7.6	640
44	Pradeepa	448		0.82		Clear	0.01	7.8	1150
45	Upul CBO	290		0.92		Clear	0	7.83	1000
46	Jalasavi	-		1.58		Clear	0.02	7.74	1330
47	Tristar CBO	300	-	0.001		2.5>	4.1	8.3	
48	Alhidra CBO	300		0.04	N/A	2.5	1.3	6.9	
49	Adhikwa CBO	280	-	0.7	N/A				
50	Hansajala CBO	442		1.8	N/A	<5	1	7.6	

In addition, out of 21 CBOs with a water quality data of hardness, 18 CBOs have above a desirable limit of 250 mg/L. The high concentration of hardness as well as fluoride is a big characteristics of this area.

(5) Water Supply Hours at CBOs

NWSDB NC has 24 water supply schemes and almost performs 24-hour water supply, which is ranked as the top class in NWSDB RSCs.

While looking at the study area, out of 46 water supply schemes surveyed, water supply hours are reportedly significantly limited during a dry period at 20 water supply schemes. They are less than five hours at ten schemes, five to ten hours at six schemes and ten to fifteen hours at four schemes. In addition, two water supply schemes limit the maximum water supply hours at eight hours. The water supply hours in the worst cases are two hours in Ekamuthu and three hours in Dimuthu, Samagi and Suwasetha.

Therefore, the people in the study area is forced the poor water supply conditions in comparison with other service area in NWSDB NC enjoying the 24-hour water supply.

(6) Technical Problems at Existing CBOs

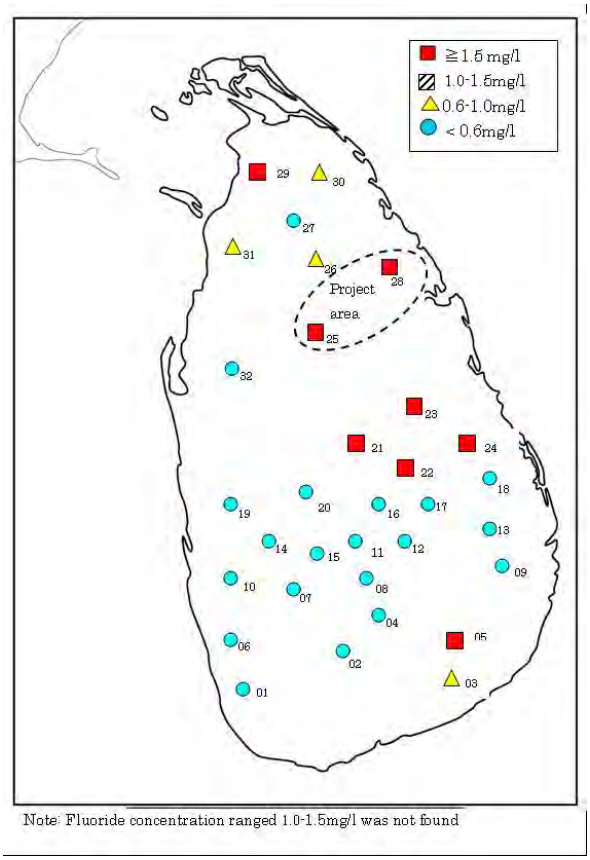
The existing CBO water supply systems have the following technical problems in structure, designing and operation.

- No master valves at water tanks and/or tube-well pumps are installed.
- Leakage from tanks and/or pipeline
- No operational valves (air valve, gate valve and wash-out valves, etc.) are installed.
- Insufficient pressure due to under-sized pipes
- No proper chlorination dosage.
- Unstable electricity supply (power cut/voltage variation)
- Invisible customer meters
- Malfunction of tube-well pump
- Little water in dry season

2.5.2 Dental Fluorosis

(1) Distribution of fluoride concentration of groundwater in Sri Lanka

Fluoride is present particularly in rocks, soils and water in Sri Lanka. Fluoride occurs naturally in water due to weathering of rocks that contain fluoride rich minerals such as hornblende; $NaCa_2(Mg,Fe,Al)_5(Si,Al)_8O_{22}(OH,F)_2$, biotite; $K(Mg,Fe)_3(AlSi_3O_{10})(OH,F)_2$, apatite; $Ca_5(PO4)_3(F,Cl,OH)$ and fluorite; $CaTiSi(O,F)_5$. In 1987, a nationwide field survey was carried out and fluoride in groundwater was revealed. From the survey results, the two major types of groundwater, Ca-Cl type and Ca-HCO_3 type, were selected and the fluoride concentrations of each were compiled. **Figure 2.21** shows the distribution of fluoride concentration in groundwater in Sri Lanka from the above survey. As shown in the figure, high concentration of fluoride occurs in several places and the study area is seriously affected. Detailed data are included in **Appendix 2.2**.



Source: "The Hydrogeochemical Atlas of Sri Lanka - 1985", Department of Geology, University of Peradenia

Figure 2.21 Distribution for Fluoride Concentration of Groundwater in Sri Lanka

(2) Distribution of Fluoride Concentration in the Study Area

NWSDB has been functioning as a testing laboratory not only for NWSDB facilities but also for other water supply organizations.

For the horizontal distribution (refer to **Figure 2.22**), it can be said that in 5 out of 6 DSD fluoride exceeded 0.6 mg/l and levels in excess of 1.5 mg/l of fluoride were found in Madawchchiya, Kahadagasdigilliya and Horowpathana. In Kebitigollawa fluoride was less than 0.6mg/l.

For vertical distribution, though it was not cleary distributed, there is a tendency that groundwater in deep aquifers has a higher fluoride concentration than that in shallow aquifers as shown in **Figure 2.23**. This is because groundwater generally occurs in association with geological materials containing soluble minerals and therefore higher concentrations of those minerals such as fluoride are normally expected in deep groundwater compared to shallow groundwater.

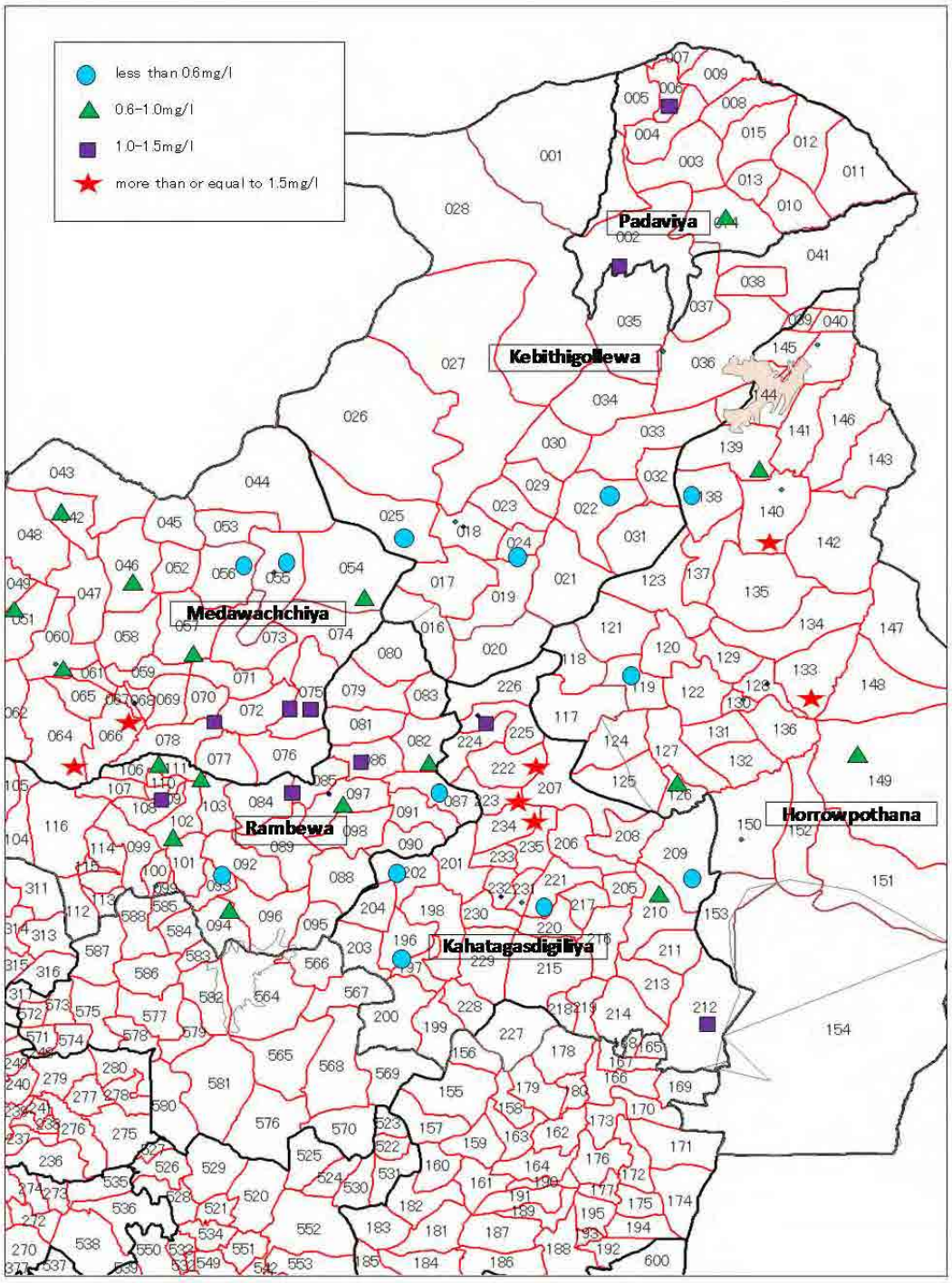


Figure 2.22 Fluoride Results for CBO Supply Water (Horizontal Distribution)

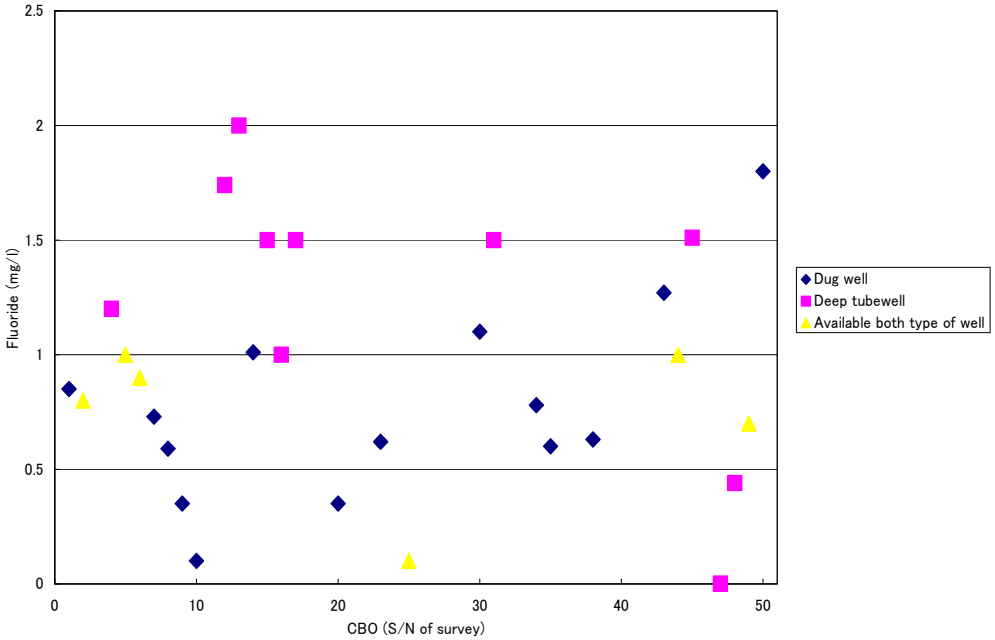


Figure 2.23 Fluoride Results for CBO Supply Water (Vertical Distribution)

(3) Results and Trend of Examination under JICA Study

Based on the existing data of groundwater as mentioned in the previous section, the JICA Study Team selected 16 groundwater sampling stations in order to examine water quality in detail. The selected sampling stations and their fluoride concentrations are shown in **Figure 2.24**. The field sampling was carried out in July 2012.

1) Methodology

The water samples for groundwarer quality analysis were collected from 16 sampling stations which were 14 CBO groundwater (dug wells and deep tubewells), 1 private dug well and 1 public spring well. The samples were systematically collected during the survey. The methods of sampling, analysis and quality assessment mentioned above were well planned and performed as follows.

(1-1) Sampling and field analysis

- For CBO groundwater, samples were collected from drains under each water tank which are used for chlorination. However, these drains were sometimes broken or not available and so it was not possible to take samples. In that case, samples were collected from the nearby tap.
- One private dug well was selected in Kebitigollawa, as there was no working CBO station in this location and people are drinking water from their own dug wells.
- One public spring well was also selected for the same reason as for the private dug well.
- The samples were collected in decontaminated containers, and were preserved during transport to the laboratory. All parameters are analysed in the laboratory except pH

which was measured at the sites mentioned above.

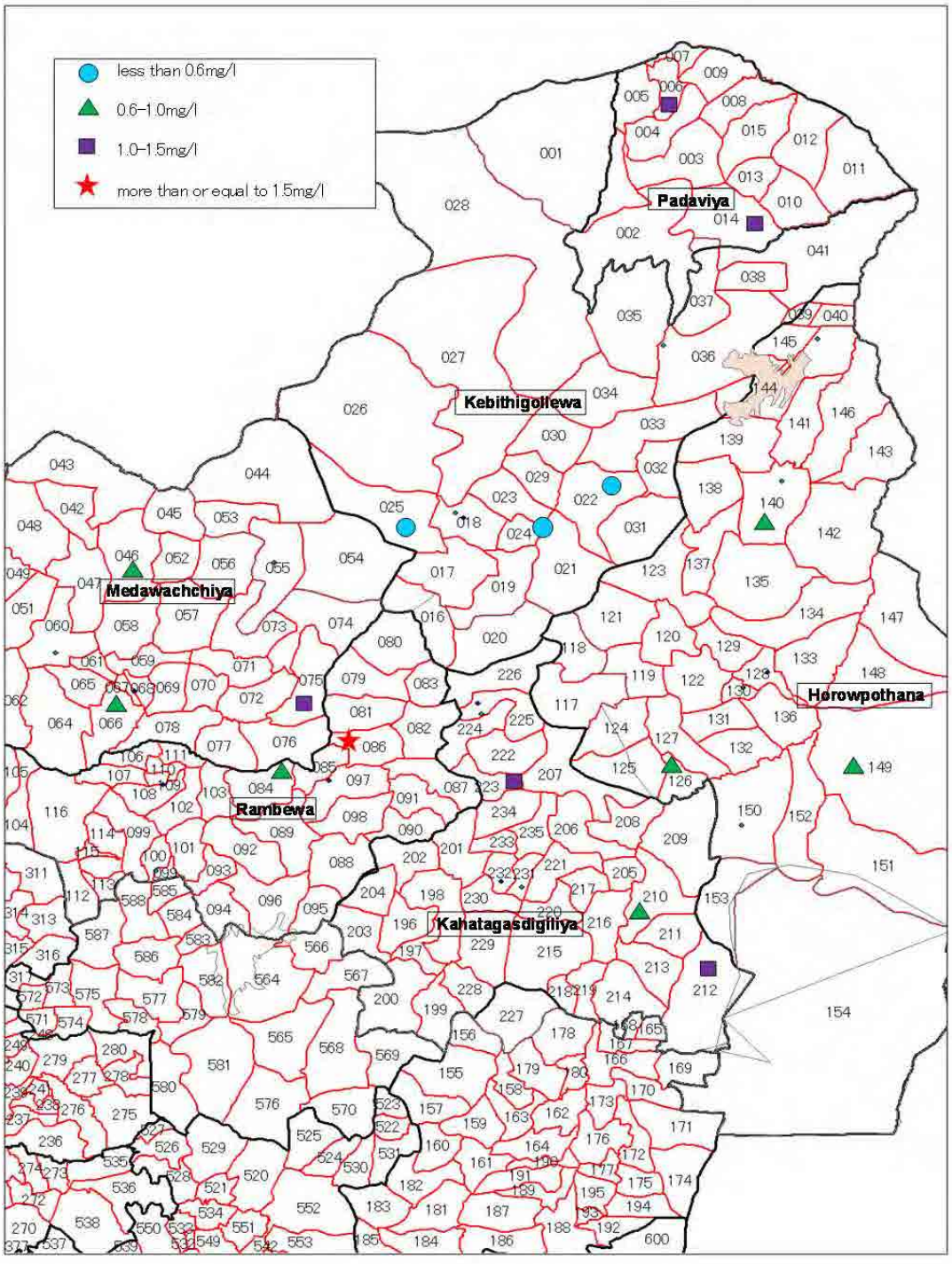


Figure 2.24 Selected Groundwater Sampling Stations and Fluoride Concentrations

Photos of sampling locations are shown in **Figure 2.25**.

Figure 2.25 CBO Water Tank (left) and Sampling Drain (Right)

(1-2) Laboratory analysis

The laboratory analyses was carried out at the SGS Lanka (Pvt) Ltd, the subcontractor's laboratory (hereafter SGS) which is accredited by Sri Lanka Accreditation Board (SLAB) and National Accreditation Board for Testing and Calibration Laboratories, India (NABL) under ISO 17025. The methods for the chemical and microbiological analysis of water are based on Sri Lankan drinking water standard 614:1983 and other standard methods such as APHA (American Public Health Association) or EPA (U.S. Environmental Protection Agency). **Table 2.18** outlines the test method followed.

Table 2.18 Analytical Parameters and Methods

Analytical item	Methods used
Colour	APHA 2120 B: 2005
Turbidity	APHA 2130 B: 2005
Odor	APHA 21st Ed. 2005, SLS 614: 1983 Part1
Taste	APHA 21st Ed. 2005, SLS 614: 1983 Part1
pH	APHA 4500 H+ B: 2005
Electrical Conductivity	APHA 2520 B: 2005
Chloride	APHA 4500-Cl B: 2005
Free residual chlorine	APHA 4500-Cl G: 2005
Free ammonia	SLS 614: 1983 Part 1, Appendix B
Nitrite	APHA 4500-NO2 B: 2005
Nitrate	APHA 4500-NO3 B: 2005
Albminoid ammonia	SLS 614: 1983 Part 1, Appendix B
Fluoride	APHA 4500-F- C: 2005
Iron	APHA 3500-Fe B: 2005
Sulphate	APHA 4500-SO_4^{2-} E: 2005
Alkalinity	APHA 2320 B: 2005
Total residue	APHA 2540 B: 2005
Hardness	APHA 2340 C: 2005
Phosphate	APHA 4500-P- C: 2005
As	APHA 3120B: 2005
Cd	APHA 3120B: 2006

2) Results

(2-1) General characteristics of targeted water sources

The results of the laboratory analysis for the selected groundwater are shown in **Table 2.19**. From these data, some general characteristics are found as mentioned below.

Since groundwater occurs in association with geological materials containing soluble minerals, higher concentrations of dissolved materials/parameters such as fluoride, hardness and electrical conductivity are observed in the survey results relative to the surface water results. All sampling stations show almost the same chemical characteristics except ones in Kebithigollewa DS division. They show lower fluoride, hardness and electrical conductivity. It can be said that groundwater samples in Kebithigollewa contain less carbonate minerals and it may relate to fluoride content as mentioned later.

Another problem is observed through the results even though it is not groundwater quality itself. All samples of “sampling point B”, which were sampled at a tap close to the water tank, show no free residual chloride. It means this water distributed to users is not chlorinated properly.

The chlorination of drinking water supplies has greatly reduced the prevalence of waterborne diseases as it is effective against almost all bacteria and viruses. Therefore, it is essential for water treatment. This needs to be remedied immediately.

(2-2) Fluoride

Fluoride is one current problem for drinking water in the project area. A total of 6.3% of fluoride samples exceeded the permissible limit, and 81% exceeded the desirable Sri Lankan drinking water standard. This occurrence is originated from minerals as mentioned before. It is notable that only one sample exceeded the permissible standard but the permissible standard is going to be revised (apparently by 2013) from 1.5 to 0.6mg/l. It means that 81% of surveyed CBO groundwater will exceed the revised standard of fluoride. Fluoride is distributed widely throughout the project area except Kebitigollewa.

(2-3)Hardness

High hardness concentration may cause scale deposition in the treatment works, distribution system and pipework and tanks within buildings. It also results in excessive soap consumption and subsequent “scum” formation. When such water is heated, deposits of calcium carbonate scale are also formed. A total of 13% of hardness samples exceeded the permissible limit, and 75% exceeded the desirable Sri Lankan drinking water standard.

Table 2.19 The results of the laboratory analysis for the selected groundwater

DSD	S/N of GND	Sampling station	Sampling point	Type of water source	Date	Odor	Colour	Turbidity	Taste	pH	Electrical C	Chloride	Free residual C	Free ammonia	Alkalinity	Albminoid ammonia	Nitrite	Nitrate	Fluoride	Phosphate	Total residue	Hardness	Ion	Arsenic	Cadmium	Sulphate
							Hazen Unit	NTU		-	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/l	mg/L	mg/L	mg/L	mg/L	mg/L
Rambewa	84	CBO	B	Deep tubewell	12/07/10	Unobject.	<2.5	1.1	objectiona	7.2	952	121	<0.01	<0.01	340	0.02	<0.01	0.64	0.92	0.4	584	329	<0.1	<0.02	<0.005	42
	86	CBO	B	Dugwell	12/07/10	Unobject.	<2.5	1.1	objectiona	7.4	1430	204	<0.01	<0.01	468	0.03	<0.01	1.2	1.5	0.39	971	630	<0.1	<0.02	<0.005	42
Madawachchiya	46	CBO	B	Dugwell	12/07/10	Unobject.	<2.5	1	objectiona	7.2	689	34	<0.01	<0.01	357	0.02	<0.01	<0.05	0.73	<0.15	444	265	<0.1	<0.02	<0.005	17
	66	CBO	A	Deep tubewell	12/07/10	Unobject.	<2.5	1	Object.	7.4	1571	237	<0.01	<0.01	468	0.03	<0.01	0.37	0.98	0.54	943	489	<0.1	<0.02	<0.005	49
	75	CBO	B	Dugwell	12/07/10	Unobject.	<2.5	1	Unobject.	7.1	837	58	<0.01	<0.01	386	<0.01	<0.01	2.7	1.2	0.3	614	471	<0.1	<0.02	<0.005	6.6
Kebithigollewa	22	Private well	C	Dugwell	12/07/11	Unobject.	<2.5	0.9	Unobject.	6.7	473	49	<0.01	<0.01	160	0.01	<0.01	2.1	0.22	0.47	385	203	<0.1	<0.02	<0.005	13
	24	CBO	A	Dugwell	12/07/11	Unobject.	<2.5	0.8	Unobject.	6.9	619	51	<0.01	<0.01	287	0.01	<0.01	<0.05	0.29	0.37	415	248	<0.1	<0.02	<0.005	6
	25	Public well	C	Spring	12/07/11	Unobject.	<2.5	0.9	Unobject.	5.4	140	42	<0.01	<0.01	107	<0.01	<0.01	0.87	0.06	0.19	113	79	<0.1	<0.02	<0.005	2.4
Padaviya	6	CBO	B	Deep tubewell	12/06/29	Unobject.	<2.5	0.3	Unobject.	7.3	681	47	<0.01	<0.01	328	0.02	<0.01	0.14	1.1	0.69	453	269	<0.1	<0.02	<0.005	19
	14	CBO	B	Dugwell	12/06/29	Unobject.	<2.5	0.3	Unobject.	7.2	750	43	<0.01	<0.01	340	0.02	<0.01	1.1	1.2	0.86	542	290	<0.1	<0.02	<0.005	25
Kahatagasdigiliy	210	CBO	B	Dugwell	12/07/12	Unobject.	<2.5	1.1	Unobject.	7.4	922	135	<0.01	<0.01	299	<0.01	<0.01		0.62	0.81	598	286	<0.1	<0.02	<0.005	9.3
	212	CBO	B	Dugwell	12/07/12	Unobject.	<2.5	0.9	Object.	7.5	1347	169	<0.01	<0.01	492	<0.01	<0.01	1.9	1.4	0.54	898	621	<0.1	<0.02	<0.005	42
	223	CBO	B	Dugwell	12/07/10	Unobject.	<2.5	0.8	Unobject.	7.1	1140	135	<0.01	<0.01	414	0.05	<0.01	0.48	1.1	0.76	713	88	<0.1	<0.02	<0.005	25
Horowpothana	126	CBO	B	Deep tubewell	12/07/11	Unobject.	<2.5	0.8	Unobject.	7.2	1149	138	<0.01	<0.01	439	<0.01	<0.01	0.09	0.92	0.61	753	555	<0.1	<0.02	<0.005	18
	140	CBO	B	Deep tubewell	12/07/11	Unobject.	<2.5	1	Unobject.	7.3	1444	194	<0.01	<0.01	468	0.01	<0.01	0.15	0.74	<0.15	1028	574	<0.1	<0.02	<0.005	39
	149	CBO	B	Deep tubewell	12/07/11	Unobject.	<2.5	1.2	Unobject.	7.4	928	109	<0.01	<0.01	312	<0.01	<0.01	0.36	0.95	<0.15	646	314	<0.1	<0.02	<0.005	39
Sri Lanka Standards (Desireble)						-	5	2		7.0-8.5	750	200			200				0.6	-	500	250	0.3	-	-	200
Sri Lanka Standards (Permissible)						Unobject.	30	8	Unobject.	6.5-9.0	3500	1200	0.2	0.06	400	0.15	0.01	10	1.5	2	2000	600	1	0.05	0.005	400

Sampling point A: Sampled before tubewell water enters the water tank
Sampling point B: Sampled at a tap close to the water tank
Sampling point C: Sampled directly from the well

(2-4) Relationship between fluoride and other parameters

It seems that there is some relationship between fluoride and other parameters as shown below. As mentioned before, the groundwater samples in Kebithigollewa show different characteristics including lower fluoride. There is one possibility that higher groundwater movement may occur in

Kebithigollewa. It is also suggested by the presence of spring water well in Kebithigollewa and the fact that the fluoride concentration of the spring well is quite low (0.06 mg/l).

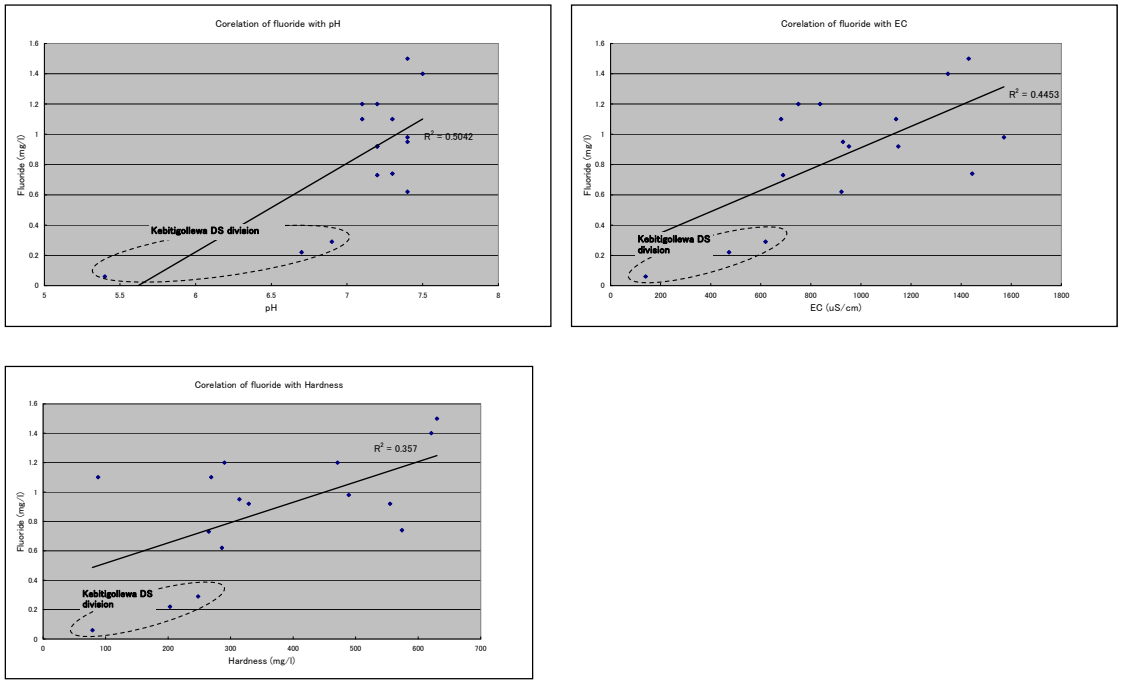


Figure 2.26 Relationship between fluoride and other parameters

3) Conclusion

The results of groundwater survey show non-conformity to the drinking standard of several parameters, namely taste, pH, electrical conductivity, free residual chlorine, alkalinity, fluoride, total residue and hardness. Especially high levels of fluoride and lack of free residual chlorine are most serious, and require immediate action.

As for relationship between fluoride and other parameters, the survey results show that high concentrations of fluoride mainly occurs at higher pH, electrical conductivity and hardness which indicate higher mineral contents. A spring well sample in Kebithigollewa which has higher groundwater movement shows quite low fluoride level and other samples in Kebithigollewa showed similar trends.

(4) Dental Fluorosis

Dental fluorosis has been recognized as an endemic problem affecting different areas of Sri Lanka with naturally occurring fluorides in drinking water. In 2002-2003, the National Oral Health Survey was conducted by the Ministry of Health and Nutrition under cooperation of WHO (see **Appendix 2.3**). The following results have been extracted from the above survey and the CFI (Community Fluorosis Index) in each district was calculated by the JICA Study Team. Though 12, 15 and 35-44 age of people were surveyed in the said survey, only the results of 12 age were extracted and used as dental fluorosis significantly occurs until such age.

The CFI was first published in 1934 and finalized in 1942. This index became the most universally accepted classification system for dental fluorosis.

(1) Classification of Criteria of Cases

The survey was done by interviews and clinical oral examination, and the classifications of criteria for dental fluorosis are as follows.

Table 2.20 Classification of Criteria of Cases

Score	Criteria	Weightage
0-Norrnal	The enamel surface is smooth, glossy	0.0
1-Questionable	The enamel shows slight abernttions from the translucency of normal enamel. May range from white flakes to occasional spots.	0.5
2-Very mild	Small opaque white areas scattered over tooth but involving less than 25% of labial surface.	1.0
3-Mild	White opacity covers less than 50% of the tooth surface.	2.0
4-Moderate	The enamel surface show marked wear and brown stain is frequently disfiguring.	3.0
5-Severe	Enamel surface badly affected, Pitted, worn areas and brown stains are widespread.	4.0

Source: the National Oral Health Survey 2002-2003

To calculate the Community Fluorosis Index, weight age is given. The CFIs are calculated according to the formula,

$$CFI = \Sigma \text{weightage x number in each score group/number of cases examined}$$

If the CFI is above 0.6, generally it can be said that dental fluorosis is a public health problem in the area.

(2) Prevalence of Dental Fluorosis

The prevalence of dental fluorosis was evaluated by CFI. The said survey results and calculated

CFI are shown in **Table 2.21**.

Table 2.21 Survey Results and Calculated CFI

No	Districts	Questionable (%)	Very mild (%)	Mild (%)	Moderate (%)	Severe (%)	CFI
1	Colombo	0	0	1.3	0	0	0.03
2	Gampaha	0	0	0	0	0	0.00
3	Kalutara	0	0	0.8	2.5	0	0.09
4	Kandy	0.8	0.8	0	0	0	0.01
5	Matale	7.5	7.5	17.5	22.5	0	1.14
6	N' Eliya	0	1.3	0	0	0	0.01
7	Galle	2.5	2.5	0	0	0	0.04
8	Matara	0	5	1.3	0	0	0.08
9	Hambantota	11	8.5	4.9	7.3	6.1	0.70
10	Jaffna	1.3	2.5	2.5	1.3	0	0.12
11	Vavunia	2.9	10.5	2.6	5.3	0	0.33
12	Batticaloa	0	0	0	0	0	0.00
13	Ampara	1.3	10	2.5	5	0	0.31
14	Trincomale	2.5	0	0	0	0	0.01
15	Kurunegala	7.5	8.8	6.3	3.8	0.6	0.39
16	Puttalam	0	0	1.3	0	0	0.03
17	Anuradhapura	3.8	18.8	31.3	12.5	5	1.41
18	Polonnnaruwa	2.5	22.5	5	2.5	0	0.41
19	Badulla	2.5	3.8	3.8	0	0	0.13
20	Monaragala	8.8	6.3	2.5	3.8	0	0.27
21	Ratnapura	4.2	1.7	5.8	4.2	1.7	0.35
22	Kegalle	0	1.3	0	1.3	0	0.05

Source: the National Oral Health Survey 2002-2003 except CFI

Note: No. of Districts is different from current situation as the survey was done in 2002-2003

(3) Comparison and District-wise Distribution of Dental Fluorosis

Based on the calculated CFI, the comparison of Anuradhapura with other districts and CFI distribution is shown in **Figure 2.27** and **Figure 2.28**.

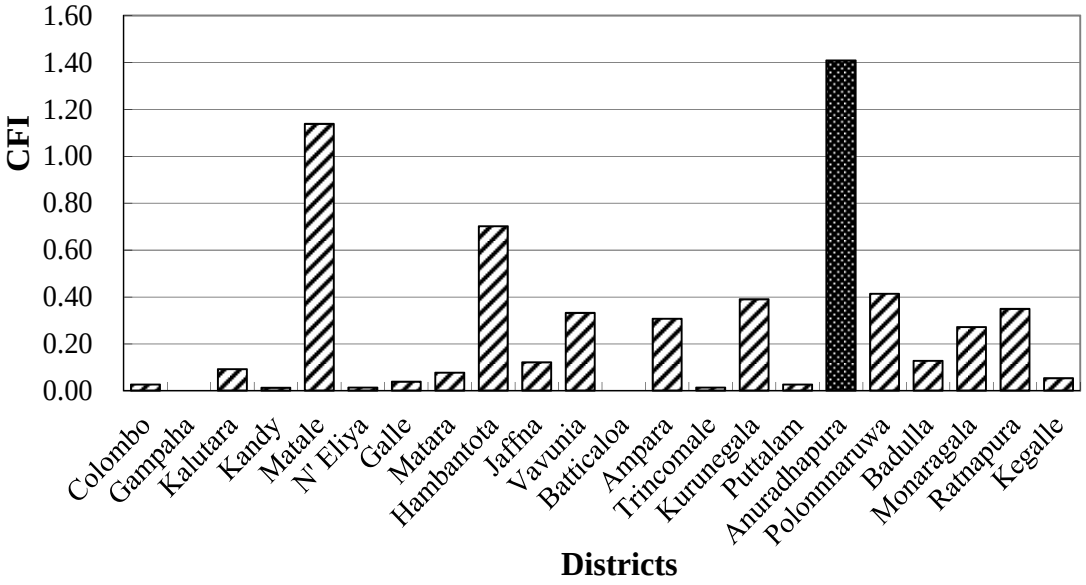


Figure 2.27 Comparison of CFI

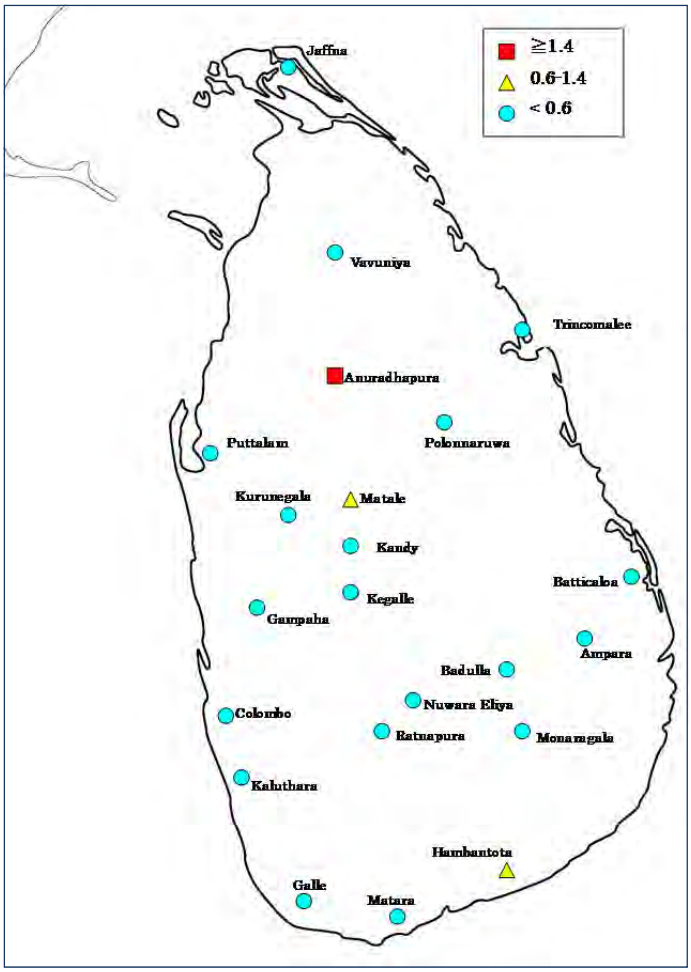


Figure 2.28 District-wise of CFI

(4) Conclusion

There was a distinct regional variation in the prevalence as well as severity of dental fluorosis in the districts of Anuradhapura and Matale followed by Hambantota. Anuradhapura district had the highest CFI at 1.41. As stated previously if the CFI is greater than 0.6, then this is a public health problem and as such immediate countermeasures are required in Anuradhapura district. Obviously one of causes of a high CFI is the high fluoride level in drinking water and therefore a safe drinking water supply is urgently required.

2.5.3 Chronic Kidney Diseases (CKD)

Chronic kidney disease (CKD) is a progressive loss in renal function over a period of months or years. CKD is an emerging health problem and it has a high economical cost on the patient, family, community and health system. In recent years, an increase in CKD cases has been observed in some parts of the country especially in the North Central provinces.

(1) Classification of Criteria of Cases

Generally the severity of chronic kidney disease is classified into five stages, with stage 1 being the mildest and usually causing few symptoms and stage 5 being a severe illness with poor life expectancy, if untreated. However, severity of CKD was not classified and individual patients were simply counted in the following two surveys. In the surveys CKD was identified by a blood test and testing of a urine sample.

(2) Prevalence of CKD

1) Prevalence of CKD in some selected area in Sri Lanka

In 2010, a survey was carried out by Peradeniya University and this showed that Medwachiya, which is a part of the study area, had the highest prevalence of CKD among the adult (more than 18 years) population at 3.7% and 5% of the overall population, in comparison to other regions surveyed. **Table 2.22** shows the prevalence of CKD. It can be said that the study area covers locations where there are public health problems.

Table 2.22 Prevalence of CKD in Some Selected Area in Sri Lanka

Province	**North Central**	North Central	Uva	Central	Southern	Eastern
Region	**Medawachchiya**	Huruluwewa	Girandurukotte	Yatinuwara	Hambanthota	Ampara
Year surveyed	**2003**	2001-2005	2006	2004	2008	2008
Sample size	**4,107**	233	1,345	253	4,023	3,232
CKD prevalence >18 years (%)	**3.7**	3.2	3.9	3.2	2.53	2.2
Overall Population (%)	**5**	0.2	4	3.2	3.49	3.15

Source: Chronic kidney diseases of uncertain etiology (CKDue) in Sri Lanka, 2010

2) DSD-wise prevalence of CKD in North Central Province

Since 2003, the Provincial Department of Health Services has also conducted a DSD-wise CKD prevalence survey in the North Central Province. As the survey periods were different in each district, the data were averaged by the JICA Study Team, in order to facilitate comparison with each other, as shown in **Table 2.23**.

Table 2.23 DSD-wise CKD Prevalence Survey in North Central Province

In Anuradhapura District					
No	MOH(≒DSD) area	Total patients in 2003-2011	Patient in av./year	Population in 2010	Patient in av./year/poplation
1	Galenbidunuwewa	207	23	51664	0.04%
2	Galnewa	64	7	36937	0.02%
3	*Horowpothana*	*274*	*30*	45329	0.07%
4	Ipalogama	73	8	41967	0.02%
5	*Kahatagasdigiliya*	*330*	*37*	42859	0.09%
6	*Kebitigollewa*	*878*	*98*	23938	0.41%
7	Kekirawa	107	12	87592	0.01%
8	*Medawachchiya*	*2723*	*303*	53240	0.57%
9	Mihintale	156	17	34546	0.05%
10	Nochchiyagama	123	14	53270	0.03%
11	Nuwaragampalatha Central	346	38	87936	0.04%
12	Nuwaragampalatha East	262	29	101256	0.03%
13	*Padaviya*	*2275*	*253*	35432	0.71%
14	Palagala	29	3	37414	0.01%
15	Rajanganaya	53	6	37773	0.02%
16	*Rambewa*	*659*	*73*	44917	0.16%
17	Thalawa	160	18	63153	0.03%
18	Thambuthtegama	73	8	42752	0.02%
19	Thirappane	102	11	35024	0.03%
In Polonnaruwa District					
No	MOH(≒DSD) area	Total patiants in 2006-2011	Av. /year	Population in 2010	Patiant in av./year/poplation
1	Dimbulagala	440	73	54231	0.14%
2	Elahera	475	79	46371	0.17%
3	Hingurakgoda	209	35	61171	0.06%
4	Lankapura	181	30	39150	0.08%
5	Medirigiriya	228	38	68375	0.06%
6	Thamankaduya	225	38	88164	0.04%
7	Welikanda	176	29	42999	0.07%

(3) DSD-wise Distribution of CKD prevalence

From the survey on DSD-wise prevalence of CKD in the North Central area, the prevalence in each DSD were compared as shown in **Figure 2.29**. As shown in the figure, the distribution on the prevalence of CKD is not equal, with the highest rates in Medawachchiya, Kebitigollewa and Padaviya, which are all within the study area.

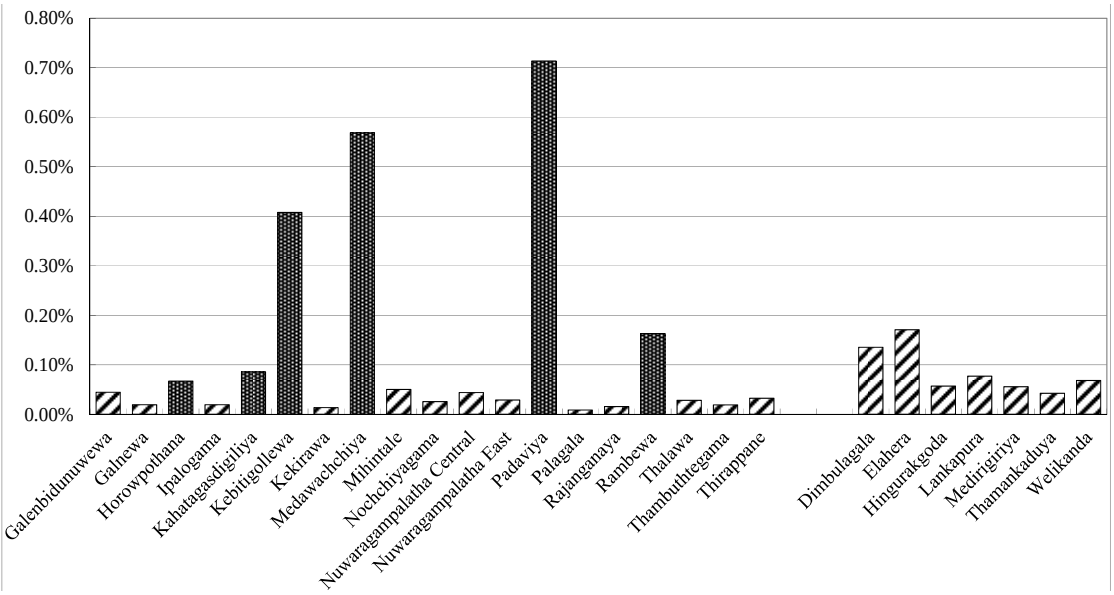


Figure 2.29 DSD-wise Distribution of CKD in North Central

(4) Conclusion

Compared to dental fluorosis, the causes of CKD are still unclear. For example, in Padaviya and Medawachchiya there are high levels of fluoride in drinking water and high levels of prevalence of CKD. On the other hand, in Kebitigollewa the level of fluoride in drinking water is low, but the prevalence of CKD is high. More detailed investigation will be needed to identify the cause(s) of CKD. However, at least it is considered that high fluoride levels of drinking water causes worsening CKD for CKD patients. Provision of treated surface water supply which is able to supply lower levels of fluoride will help to protect people's daily life.

2.5.4 Necessity of the Project

As mentioned above, the necessity of the project can be summarized as follows:.

The people in the study area are facing the following problems regarding the principal water source and existing water supply schemes.

- According to the Census 2011, 75.4% of the people in the study area rely on groundwater as the principal water source and 18.9% of the people use tap water through the NWSDB's and CBO's water supply schemes. However the water source of such water supply schemes is groundwater with a few exceptions

- The people in the study area are forced to be engaged in the water-fetching work for a distance longer than that in other districts.
- Four out of five persons are exposed to the risk of fluorosis in the study area.
- Many existing CBO's water supply schemes have experienced the water shortage during the dry season and cannot maintain the 24-hour water supply.
- Most existing CBO's water supply schemes have a variety of problems in structure, designing and operation.

Then water quality problem. Water quality of drinking water sources is an important issue which is directly related to the health of residents. Therefore, a groundwater quality survey of the current drinking water source was conducted. As a result, it was found in the survey that the most significant problem is the high concentration of fluoride. It was also confirmed that dental fluorosis due to high level fluorosis has occurred in Anuradhapura and the prevalence is higher than in other districts.

Removal of fluoride from the current groundwater sources is unrealistic from the viewpoint of technical and economic considerations. Therefore, it is urgently necessary to proceed with a project which utilizes surface water sources with low fluoride concentration. In addition, although Anuradhapura has been known as an area with a high prevalence of CKD, DSDs with a high prevalence of CKD were also found within the project area. However, no clear cause of CKD has been identified yet. For example, the project survey found that some DSDs showed a high prevalence of CKD with high fluoride concentration in drinking water sources, but in other DSDs there was no relationship between the CKD and fluoride concentrations. However, even if it is not possible to identify the causes of CKD, at least it is well known that high fluoride levels of drinking water causes worsening CKD for CKD patients[8]. Conversion to surface water sources which is able to supply lower levels of fluoride will significantly contribute to residents health.

As mentioned above, in order to solve the current water quantity and quality problem, it is essential to implement this project promptly.

[8] *Based on the talk of Dr. Akio Koizumi, Professor of Graduate School of Medicine, Kyoto University, Kyoto, Japan*

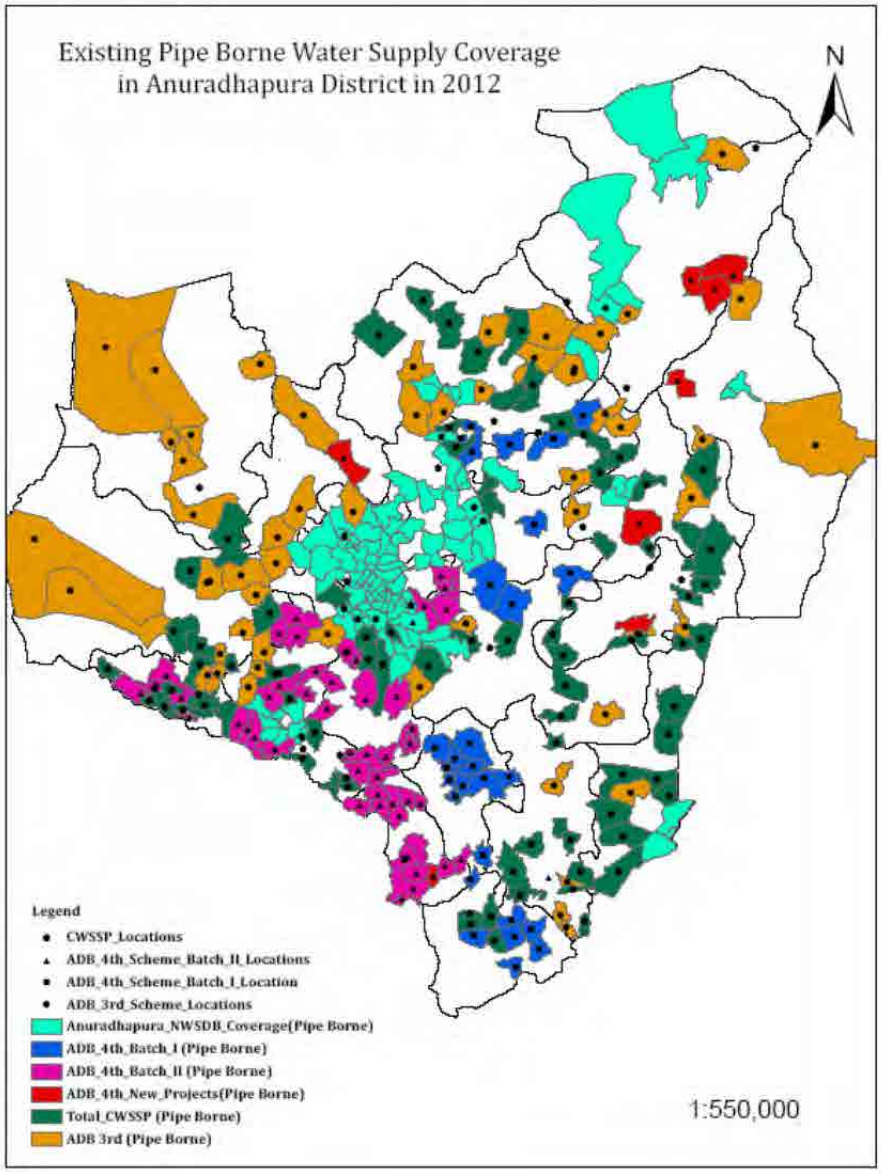
CHAPTER 3

EXISTING WATER SUPPLY FACILITIES IN THE STUDY AREA

CHAPTER 3 EXISTING WATER SUPPLY FACILITIES IN THE STUDY AREA

3.1 Water Supply Schemes in Anuradhapura District

Water supply schemes in Anuradhapura District are classified into those operated and maintained by NWSDB and Community-Based Organizations (CBOs) as shown in **Figure 3.1**. Water supply schemes under CBOs are further categorized into those constructed under ADB 3rd and 4th projects and Community Water Supply and Sanitation Project (CWSSP) under the WB's assistance, but they are hereinafter named generically CBOs.



Note: As shown in **Table 3.1**, NWSDB has 18 water supply systems in Anuradhapura District, but some of them are not shown herein.

Figure 3.1 Water Supply Schemes under NWSDB and CBOs in Anuradhapura District

Water supply schemes in Anuradhapura District are summarized as shown in **Table 3.1**.

Table 3.1 Water Supply Schemes in Anuradhapura District

No of families	171,060
Population	855,304
Water Supply Schemes - NWSDB	18
No of service connections - NWSDB	54,220
Total No. of Beneficiaries - NWSDB	325,320
Piped water coverage - NWSDB	37%
Rural Schemes Coverage - CBO	19%
Total Piped Water Supply Coverage in the District	56%

Source: NWSDB RSC(N/C)

Note: A water supply scheme means the working unit in NWSDB, which is not necessarily established based on the service area of each water treatment plant. The large-scale water treatment plant or project is handled as one of working units, therefore there may be separate water supply schemes for a water treatment plant and water transmission and distribution system under one water supply system. The number of water supply schemes in **Table 3.1** shows the number of independent water supply systems.

The CBO organizes the people and participates the distribution pipe installation work in the form of labour contribution using the materials provided by the government in the rural areas and is responsible for operation and maintenance of water supply facilities under a self-support accounting system placing the person–in-charge after its completion. However, most of CBOs are facing the difficulties in inadequate quantity of water supplied, deteriorating quality of water, increasing cost, inadequate revenue, lack of technical expertise and social and managerial problems.

NWSDB, in response to the requests from the CBOs and other agencies concerned, has taken the following steps to mitigate above situation.

- Establishment of rural water supply and sanitation units in all districts to provide necessary back up support for CBOs.
- Amending NWSDB act to facilitate activities of CBOs
- Enactment of bylaws
- Establishment of Credit Development Fund
- Enhance facilities for water quality testing
- Strengthening of coordination of sector partners by provincial level coordination meetings

For the study area, there are 56 water supply schemes in total in the project areas including 50 numbers of CBOs facilities and 6 number of NWSDB facilities out of which Rambewa is not an independent system but a part of Anuradhapura North and Mihintale WSSs with both water sources in Nuwarawewa. Piped water is in fact being supplied to approximately 55,000 people

(CBO 39,000 pers, NWSDB 16,600 pers) through CBO and NWSDB facilities, which is approximately 27% of the population in the six DSDs (refer to **Section 3.3** for more details).

The situations of NWSDB in Anuradhapura District and NWSDB and CBOs in the Study Area are described in **Sections 3.2 to 3.4**, respectively.

3.2 Existing Water Supply Facilities under NWSDB in Anuradhapura District

There are 24 water supply schemes operated by NWSDB (NC). Out of these 24 schemes, 18 are located in Anuradhapura District, whereas six are located in Polonnaruwa District Existing water supply facilities (schemes) in NWSDB (NC), Anuradhapura District and Polonnaruwa District are outlined in the following table by water source, treatment process, production capacity (m^3/d) and year constructed. Detailed information is shown in **Appendix 3.1**.

Five schemes in Anuradhapura District are located in the study area, namely Kebithigollewa, Kahatagasdigiliya, Horowpothana, Medawachchiya and Padaviya.

Table 3.2 Existing Water Supply Facilities in NWSDB (NC)

No.	Scheme	Water Source	Treatment Process	Served Population	Production (m^3/d)	Year Constructed
Anuradhapura District						
1	Anuradhapura New Town	Surface water	Full (RSF+Cl)	43,476	10,761	1972/84/05
2	Anuradhapura East	Surface water	Full (RSF+Cl)	20,000	2,787	2005
3	Anuradhapura North	Surface water	Full (RSF+Cl)	21,968	4,000	2008
4	Mihintale	Surface water	Full (RSF+Cl)	10,000	1,700	1985
5	Sacred City	Surface water	Full (RSF+Cl)	17,000	4,500	1984
6	*Medawachchiya*	Groundwater	Bleaching	5,000	-	1985
7	*Kebithigollawa*	Groundwater	Full (RSF+Cl)	3,200	600	1975
8	*Padaviya*	Groundwater	Chlorination	2,400	350	1991
9	*Kahatagasdigiliya*	Groundwater	Chlorination	3,800	350	1982
10	*Horowpothana*	Groundwater	Chlorination	650	150	1977
11	Thambuttegama	Surface water	Full (RSF+Cl)	11,500	1,500	1988
12	Eppawala	Surface water	Full (RSF+Cl)	600	120	1984
13	Maradankadawala	Surface water	Chlorination	5,000	4,000	2007
14	Kekirawa	Groundwater	Full (RSF+Cl)	20,500	3,300	1985
15	Habarana	Groundwater	Chlorination	3,000	400	1986
16	Galnewa-Bulnewa	Surface water	Full (RSF+Cl)	11,000	1,200	2002
17	Thalawa	Surface water	Full (RSF+Cl)	16,943	2,200	2007
18	Nachchaduwa	Surface water	Full (RSF+Cl)	7,000	980	2007
Polonnaruwa District						
19	Polonnaruwa	Surface water	Full (RSF+Cl)	35,000	5,232	1986
20	Hingurakgoda	Surface water	Full (RSF+Cl)	11,500	2,200	1986
21	Minneriya	Surface water	Full (RSF+Cl)	7,600	2,300	2003
22	Dimbulagala	Groundwater	Chlorination	-	200	1985
23	Bakamuna	Surface water	Full (RSF+Cl)	-	1,000	2003
24	Gallalla	Surface water	Full (RSF+Cl)	-	13,500	2011
25	Dehiattakandiya	Surface water	Full (RSF+Cl)	4,785	800	1993

Note: Although there are a total of 33 water supply schemes under the RSC(N/C) – 21 in the Anuradhapura district, and 12 in the Polonnaruwa district. **Table 3.2** shows only those that data is available.

The large- and medium-scale schemes mostly use surface water and with full treatment used, typically pre-chlorination + aeration + sedimentation + rapid sand filtration + post-chlorination. The small-scale schemes are using ground water (bore holes and tube wells) with chlorination for treatment. The development of water supply started in Anuradhapura Town in 1972 and expanded to the fringe areas to the east and north in the 2000's. Other medium-scale schemes were developed in the 1980's and small-scale schemes in the 1980-90's.

Usually mechanical and electrical equipment in water treatment plants and pump stations has deteriorated 20 to 30 years after construction. Therefore, some facilities which were constructed in the 1980's need rehabilitation or augmentation due to the increase in water demand.

The water supply system in NWSDB RSC(N/C), supplies water 24 hours, 7 days a week, except when there is a power failure, repair of leakage etc, which occasionally occurred.

As for the quality of water, high fluoride concentrations and hardness were recorded in the water, which is supplied from some water supply systems which have ground water sources, such as Medawachchiya, Padaviya, Kahatagasdigiliya, Horowpothana, Eppawala and Kerira High fluoride concentrations and hardness were recorded in the dry season between June and September.

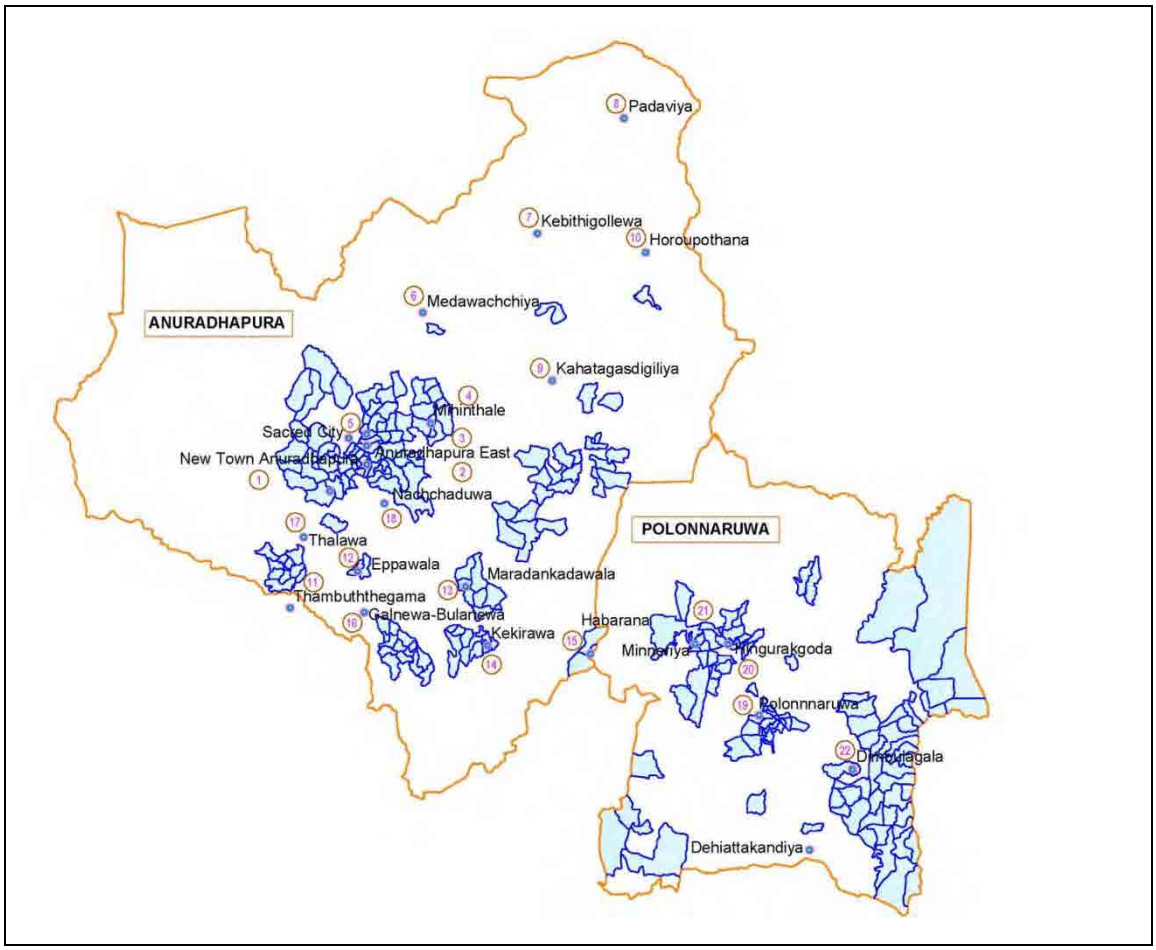


Figure 3.2 Existing Water Supply Facilities in NWSDB (NC)

3.2.1 Organizational

(1)Operation and Maintenance Organisation

The sound operation and maintenance (O&M) of the facilities after completion entails an organisation that is ready, capable, and skilled in performing the required works. Proper and rapid response is also essential in maintaining and repairing mechanical and electrical equipment at the water treatment plants and pumping stations, as well as the water transmission and distribution pipelines. Lastly, water quality management has to ensure compliance with the national standards.

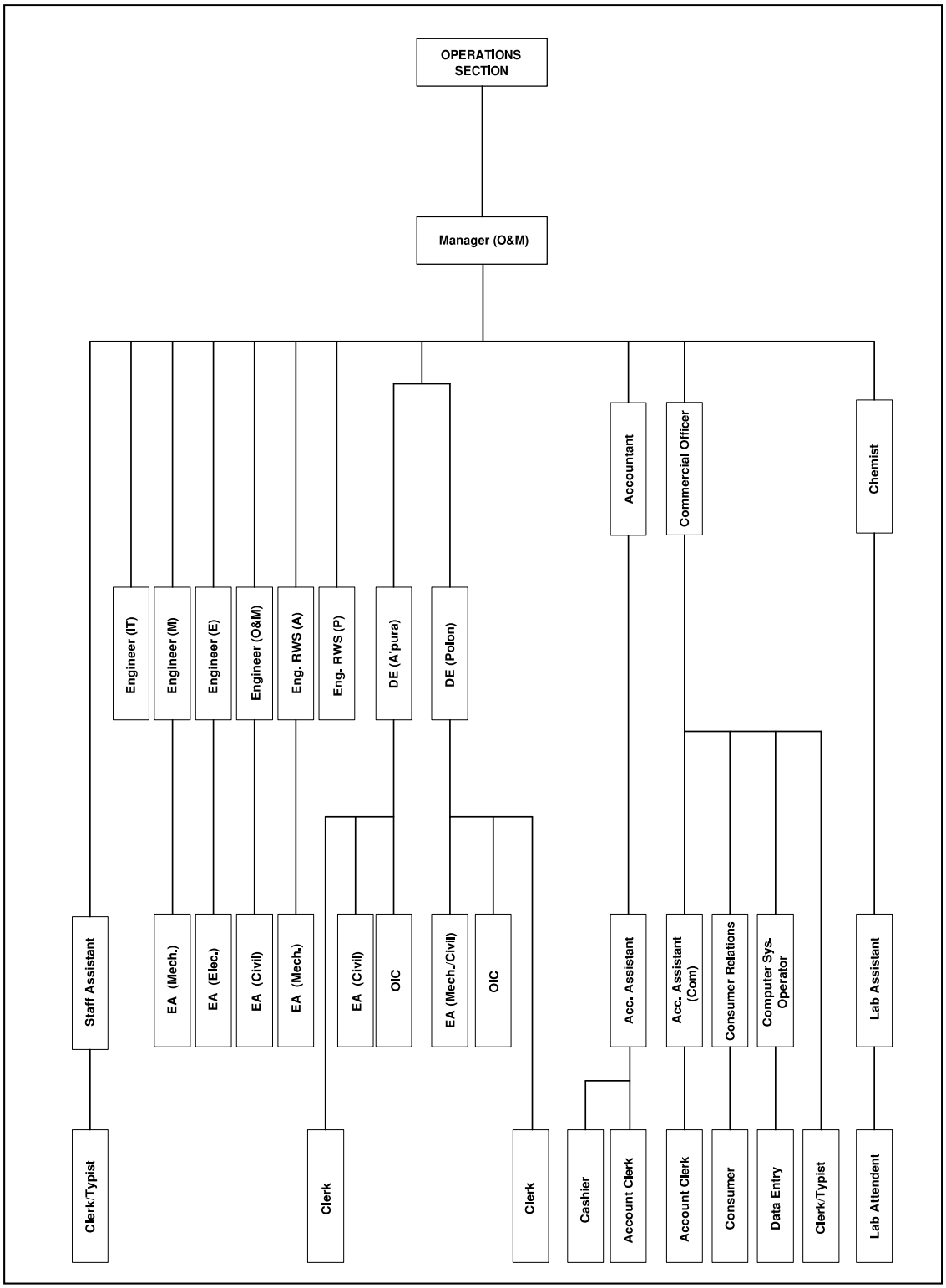
1) The Operations Section

Certain criteria need to be satisfied for an organization to have a good O&M system. Among these criteria are: (i) Having a rational O&M organisational structure in place, together with written job descriptions for each position that clearly define the O&M roles and responsibilities; (ii) Having competent and trained O&M personnel to execute the operation and maintenance activities; (iii) The availability of tools, equipment, vehicles, instrumentation, and chemicals to perform the required O&M work; (iv) The presence of stores to provide spare

parts and supplies for prompt repair and maintenance work; (v) The availability of outside contractors to provide quality O&M services; and (vi) An operation and maintenance program that is customized to the needs of the organization.

a) Structure of the Operations Section

The organisational structure of the Operations Section, which is headed by the O&M Manager, is shown in **Figure 3.3**. This section performs all operation and maintenance activities of the regional support centre. While the organisational structure is more inclined to show and highlight positions and grade levels (ranks) of the section personnel, in actuality, the section is divided into functional units. These are (i) The Operation and Maintenance (O&M) Unit, (ii) The Rural Water Supply (RWS) Unit, (iii) The Commercial Unit, (iv) The Regional Laboratory, and (v) The O&M Workshop. Among these five units, it is the O&M Unit that is also organised spatially, or along geographic (service) areas. The total number of personnel IN the Operations Section is as follows: Posts in the Approved Cadre, 391, of which 315 posts have been filled up, and 76 posts remain vacant. In addition, there are 31 outsourced / casual personnel.



Source: Human Resource Office, NWSDB SC(N/C)

Figure 3.3 Current Organisational Structure of the Operations Section, NWSDB N/C

- The O&M Unit

The O&M Unit is headed by the O&M Manager, who is also the concurrent head of the Section. The Unit is charged with producing and distributing adequate and potable water to the satisfaction of its consumers. It performs its functions through the water supply schemes, the smallest operating unit under the NWSDB, which, in addition to water supply operations, also performs managerial, commercial (consumer services), and administrative support functions. The O&M unit is divided into two districts – the Anuradhapura and Pollonuwara districts, headed by district engineers, under each of which there are several operational water supply schemes.

- The O&M Workshop

The O&M Workshop is a centralised unit that undertakes both corrective and preventive maintenance services for all the WSS. According to the officers-in-charge OICs of the WSS in the six study areas, a team of engineers visit the WSS on a monthly basis to provide preventive maintenance services, such as checking and cleaning of pumps and other equipment; while routine preventive maintenance work, such as oil and lubrication, is handled by the WSS. When a pump breakdown cannot be repaired at the WSS level, the workshop team at the RSC is called to perform corrective action or repair. However, if the regional workshop cannot accomplish the required repair, the RSC then requests for the assistance of the Head Office, or outsources the repair work.

- The Regional Laboratory

The Regional Laboratory provides services for water and wastewater quality monitoring and control. It ensures that water supplied by the schemes is in compliance with the national standards for drinking water in Sri Lanka. It performs monthly water quality testing on physical, biological and chemical parameters of samples collected by the WSS. In addition, the laboratory provides its services to other schemes outside the RSC(N/C) and to registered rural water supply CBOs, for which it provides two free tests per year.

- The Commercial Unit

The Commercial Unit supports the NWSDB customer charter by providing prompt and satisfactory customer service, particularly for new connections and reconnections. It also attends and finds solutions to service complaints, requests and other observations of the consumers, and implements the disconnection policy of NWSDB. The Unit also consolidates all billing and collection and consumer services data submitted by the WSS.

- The RWS Unit

The RWS Unit initiates, as well as supports, rural water supply organizing activities in the Anuradhapura and Pollonurawa districts. It provides technical assistance to the CBOs to enable them to capably manage, operate and maintain water supply (and sanitation) facilities for their membership. It also coordinates with the other sectors – government, non-government, private and public – where there is a problem of water quantity, or where water quality is not suitable.

In addition to the organisational structure and delineation of unit functions, there are written job descriptions for all categories / designations in the Approved Cadre of NWSDB, including those of the O&M personnel. The job descriptions delineate the vertical reporting lines upward (superior[s]) and downward (subordinates[s]); the posting and grade level; the division and location; the purpose of job; and work environment and conditions. They define the key responsibilities, broken down into critical key responsibilities, supportive key responsibilities and supportive responsibilities. They also identify accountability, norms, authority and relationships. It seems, however, that in the RSC, the O&M personnel are not fully aware of the existence of their own particular job descriptions.

(2) Organisation of Water Supply Schemes in the Study Area

There are a total of 33 water supply schemes under the RSC – 21 in the Anuradhapura district, and 12 in the Pollonurawa district. **Appendix 3.2(a)** shows the distribution of O&M personnel of water supply schemes under the Anuradhapura district; while that of the Pollonuwara district is found in **Appendix 3.2(b).**

Each scheme is headed by an OIC who holds the cadre category/designation of engineering assistant (EA). Five smaller schemes share officers-in-charge / engineering assistants, as follows: (i) Thuruwila, which shares EA with Natchchiyaduwa WSS; (ii) Padaviya, which shares EA with Kebithigollewa WSS; (iii) Horowpothana, which shares EA with Kahatagasdigiliya WSS; (iv) Mahakadalawa and (v) Habarana, which both share EA with Kerikawa. The number and distribution of O&M personnel in the six study areas are shown in **Table 3.3**.

Table 3.3 Distribution of O&M Personnel in the WSS of the Six Study Areas

OFFICE SCHEME	POST (CATEGORY)	Outsourced / Contractual	Approved Posts		Total
			Vacant	Filled	
ANURADHAPURA NORTH WSS (This WSS covers Rambewa)					**13**
	Engineering Assistant			1	
	Pump Operator Mechanic			4	
	Pipefitter			2	
	Driver			1	
	Labourer	2		3	
MEDAWACHCHIYA WSS					**8**
	Engineering Assistant			1	
	Pump Operator	1		2	
	Pipefitter			1	
	Meter Reader	1			
	Labourer	1		1	
KEBITHIGOLLEWA WSS (EA/OIC covers Padaviya)					**6**
	Engineering Assistant			1	
	Pump Operator Mechanic			3	
	Labourer			2	
PADAVIYA WSS					**7**
	Pump Operator Mechanic			3	
	Pipefitter			1	
	Caretaker			1	
	Labourer			2	
KAHATAGASDIGILIYA WSS (EA/OIC covers Horowpothana)					**7**
	Engineering Assistant			1	
	Pump Operator			1	
	Pipefitter			1	
	Labourer	3		1	
HOROWPOTHANA WSS					**2**
	Caretaker	2			
TOTAL		**10**	**0**	**33**	**43**

Source of Raw Data: HR Office and O&M Section (As of July 2012)

A closer look at the water supply schemes shows different types of schemes – purely distribution or purely production-type schemes; water treatment plant-type schemes; a mix of production, treatment and distribution. The operations of the mixed schemes encompass a wide range of water utility activities such as production and treatment, distribution, billing and collection and other consumer services, human resources and support services. The number of O&M personnel, therefore, is dependent on the type of WSS. The number and distribution of O&M personnel in the three water treatment plant schemes in Anuradhapura City are shown in **Table 3.4**.

Table 3.4 Distribution of O&M Personnel in the WTP/WSS in Anuradhapura City

WTP / WSS (Anuradhapura City)	POST (CATEGORY)	Outsourced / Contractual	Approved Posts		Total
			Vacant	Filled	
THURUWILA WTP					**9**
	Engineering Assistant			2	
	Electrician			1	
	Plant Operator Technician			3	
	Labour		3		
SACRED CITY WSS					**30**
	Engineering Assistant			1	
	Pump Operator Mechanic			3	
	Storekeeper			1	
	Meter Reader	3	2		
	Pipefitter			3	
	Driver			1	
	Labour	9	2	5	
ANURADHAPURA NEW TOWN WSS					**24**
	Engineering Assistant			1	
	Lab Supervisor			1	
	Store Keeper			1	
	Meter Reader	2		3	
	Pipefitter			4	
	Driver			1	
	Labour	2		9	
NUWARAWEWA WTP (Under the Anuradhapura New Town)					**13**
	Engineering Assistant			1	
	Pump Operator Mechanic			7	
	Pipefitter			1	
	Labour	1		3	
TOTAL		**17**	**7**	**52**	**76**

Source of Raw Data: HR Office and O&M Section (As of July 2012)

Note: For **Table 3.2** and **Table 3.3**) **"**Approved Posts" means posts in the approved cadre of NWSDB, whether these have been filled or not been filled, in which case the post is vacant; while **"**Outsourced or Contractual" means posts that are not in the Approved Cadre of NWSDB RSC(N/C), but for which people have been hired (outsourced) on contract basis to perform particular tasks.

(3) Profile of the O&M Personnel in the Study Areas

A survey was undertaken on the O&M personnel in the water supply schemes in the study areas to ascertain their profile in terms of age, employment status, number of years of employment with NWSDB, educational level and trainings received. Of the 34 personnel surveyed, 64.71% had permanent employment status, 8.82% were casual, while the rest did not indicate their status. This is consistent with the fact that labourers, caretakers and meter readers are outsourced in the scheme levels.

Table 3.5 Profile of O&M Personnel according to Age and Years with NWSDB

Water Supply Scheme	# of Employees [1/]	Average Age	Average Years with NWSDB N/C
Medawachchiya WSS	6	47	20
Kebithegollewa and Horowpothana WSS	5	44	21
Padaviya WSS	8	52	28
Kahatagasdigiliya WSS	4	47	23
Anuradhapura North (Rambewa) WSS	11	52	25
Total	**34**	-	-

[1/] Number of employees who returned survey questionnaire from the six study areas.

As to the educational attainment of the O&M personnel, **Table 3.6** reveals a low level of education where approximately 65% did not reach high school and 3% did not possess any formal education. This may be explained by that the skills requirements in the WSS are usually in the labour and equivalent grades. However, the inadequacy of educational attainment was not augmented by vocational or other short courses, as attendance at these was not reported by any of the personnel surveyed.

Table 3.6 Profile of O&M Personnel according to Educational Level

Water Supply Scheme	Primary	Secondary	Grade 7/8	High School	High School (NCT)	University Level	No Education
Medawachchiya WSS	0	5	0	0	1	0	0
Kebithegollewa and Horowpothana WSS	0	0	1	4	0	0	0
Padaviya WSS	1	0	3	2	1	0	1
Kahatagasdigiliya WSS	1	1	0	2	0	0	0
Anuradhapura North (Rambewa) WSS	9	1	0	0	0	1	0
Total	11	7	4	8	2	1	1
Percentage	32.35%	20.59%	11.76%	23.53%	5.88%	2.94%	2.94%

Ideally, regular and on-the-job training should be made available for personnel who have low levels of education and whose jobs are skills-based. However, such is not the case for the O&M personnel in the WSS surveyed. As shown in **Table 3.7**, the personnel received only a total or 30 days training, which translates to a very low 1.4 days of training days per employee over the last five years. (Note that this low number may be influenced by “no data” submitted by the survey participants/O&M personnel of Anuradhapura North (Rambewa) on the training portion of the questionnaire).

Table 3.7 Training Profile of O&M Personnel for the Six Study Areas

Water Supply Scheme	Total Training Days	Average per Employee
Medawachchiya WSS	9	2
Kebithegollewa and Horowpothana WSS	4	1
Padaviya WSS	5	1
Kahatagasdigiliya WSS	12	3
Anuradhapura North (Rambewa)	0	0
Total	**30**	

The bulk of training was provided by the NWSDB; although there were two other organisations that also provided training. The day-long training "courses" were on the following: repair and maintenance of small pumps, chlorinators and pipes; use of chlorine in water treatment, construction technology, new connections estimation and new accounts, rain water harvesting, 5S training, and administrative procedures. **Appendix 3.2(c)** provides the summary of profile of the O&M personnel surveyed.

(4) O&M Practices of the WSS

A good operations and maintenance program on the WSS level consists of two basic components – standard operating procedures and O&M records. The WSS surveyed could not present written standard operating procedures that describe how each operational task is to be performed. However, the OICs/EAs concerned stated that by experience and by training, and with their guidance and supervision, the personnel of the WSS visited possess sufficient technical knowledge in operating and maintaining WSS equipment.

As for O&M records and/or reports, **Table 3.8** provides the list of O&M records and frequency of reporting to the RSC, which in turn submits the same to the NWSDB Head Office.

Table 3.8 Frequency of O&M Reports / Records

	NAME OF REPORT / RECORD	CONTENT	FREQUENCY	
			Daily	Monthly
1.	Water Production Report	Volume of water produced per source	✓	
2.	Water Quality Report	Results of tests on 12 parameters for physical and chemical qualities, and 3 parameters for bacteriological quality		✓
3.	Data Relating to Operational Aspect Report	Reports on 17 aspects – water production, major breakdowns, number of staff, chemical consumption, replacement of old or defective meters, total number of connections, disconnections, illegal connections, number and types of leaks in distribution and main lines and repairs or replacements made		✓
4.	Monthly Detail Report	Similar content as *Data Relating to Operational Aspect* in terms of production, metered connections and leak repair		✓
5.	Energy Conservation Report	Energy consumption and production per pumping station		✓
6.	Rainfall Report	Daily report on whether or not there is rainfall, its measurement in millimetres, time of occurrence and other observations	✓	
7.	Operating Expense Report	Reports on total income from water sales less capital recovery costs, and total operating expenses from salary cost, utility cost chemical cost, repair and maintenance cost, establishment cost or office running cost security rent, finance charges and others, showing defective metre cost, new connection materials and extension cost		✓
8.	Billing and Collection Information Report	Reports on the particular billing period for a region/ area for all consumer categories and payment details		✓
9.	Defective Meter Report	Reports on number defective meters, including serial numbers, and meter reading		✓
10.	Details on New Water Connection	Name and address of new consumer, type and date of connection, meter number and reading		✓
11.	Consumer Complaint / Bill Adjustment	Contains nature and number of consumer complaints, and action taken		✓
12.	Attendance Sheet	Attendance of personnel assigned to the WSS	✓	✓
13.	Employee Leaves	Leaves of personnel assigned to the WSS		✓
14.	Overtime Sheet	Overtime report of WSS workers	✓	✓

While not all WSS has stores or a storekeeper position, the OIC is tasked to manage the inventory of fixed equipment and consumables. Reports and records to monitor and control the inventory of different supply types and spares parts, are: (i) Inventory Report on Program Usage, (ii) Stores Register Record; (iii) Material Issue Note; and (iv) Material Transfer Note.

In the maintenance of the transmission and distribution systems, water towers and associated hardware are inspected regularly, while pipelines and fittings are visually inspected for leaks. In addition to this, the consumers are active in reporting observed leaks to the WSS office for its

immediate repair. Non-functioning and malfunctioning water meters are also reported to the WSS office either by the meter readers or the consumers themselves after which these are either repaired, or if beyond repair, are replaced.

As mentioned earlier, preventive and corrective maintenance are performed on pumps, motors, motor control panels, valves, instrumentation, control equipment, chemical mixing tanks and associated hardware, flocculators and sedimentation tanks, filters, chlorinators and building structures by both the WSS personnel and the O&M workshop team / unit at the RSC. Corrective maintenance work that cannot be done by the RSC is brought to the attention of the Head Office, or is referred to outside service contractors.

3.2.2 Technical

(1) Operation

The water supply system is operated by a team of operators, caretakers, meter readers, drivers, labours etc. headed by OIC (Officer-in-Charge). The team operates and monitors the pumps and treatment plants in the system. The OIC has the responsibility to operate, monitor and maintain the water supply system. At present most of water supply facilities are operating smoothly.

The OIC has to report monthly on the operation to the Operation Manager (O&M) in RSC(N/C). The monthly report covers all the aspects relating to the system operation and contains the following information.

a. treated water produced (m3/month)
b. major downtime (hrs)
c. power/chemical consumption
d. nos. of staff
e. billing
f. leak
g. defective water meters etc.

Table 3.9 Operation of Water Supply Facilities in NWSDB (NC)

Scheme	Total Prod.	Total Consump.	NRW (%)	Leak Reported	Leak Repairs	Total Conn.	Illegal Conn.	Defect. meter	Defect. (%)	Defective meter Replace-ment	Disconn.	Zero Bills	Zero Bills (%)	Est. Bills	Est. Bills %	Total No. of Staff
I. Anuradhapura District																
Anuradhapura New Town	400,148	269,986	32.5	98	98	11,236	0	82	0.7	74	413	506	4.5	178	1.6	38
Anuradhapura East	130,792	117,371	10.3	49	49	5,587	0	26	0.5	26	65	199	3.6	48	0.9	12
Anuradhapura North	141,075	119,921	15.0	15	15	6,083	0	30	0.5	32	40	219	3.6	127	2.1	11
Mihintale	68,571	50,501	26.4	28	28	2,640	0	12	0.5	12	78	138	5.2	49	1.9	14
Sacred City	146,021	125,727	13.9	36	36	4,758	0	42	0.9	29	69	231	4.9	116	2.4	16
Medawachchiya	26,718	20,275	24.1	8	8	1,267	0	40	3.2	38	55	71	5.6	83	6.6	7
Kebithigollawa	15,880	12,035	24.2	14	14	853	0	4	0.5	4	49	67	7.9	11	1.3	4
Padaviya	12,292	8,697	29.2	12	12	595	0	2	0.3	2	21	23	3.9	9	1.5	8
Kahatagasdigiliya	21,701	14,905	31.3	34	34	1,093	0	3	0.3	3	37		0.0	15	1.4	4
Horowpothana	3,660	3,377	7.7	8	8	172	0	1	0.6	1	18		0.0	7	4.1	
Thambuttegama	58,832	48,551	17.5	36	36	3,178	0	19	0.6	19	95	119	3.7	38	1.2	12
Eppawala	3,617	3,532	2.4	3	3	150	0	1	0.7	1	10	13	8.7	5	3.3	4
Maradankadawala	141,115	103,607	26.6			1,279	0	0	0.0	0	11	28	2.2	5	0.4	21
Kekirawa				12	12	6,025	0	11	0.2	6	141	399	6.6	37	0.6	
Habarana	14,379	11,707	18.6	6	6	775	0	0	0.0	0	11	56	7.2	2	0.3	4
Galnewa-Bulnewa	45,994	34,116	25.8	12	12	2,934	0	8	0.3	8	41	64	2.2	12	0.4	6
Thalawa	86,215	71,302	17.3	80	80	4,290	0	7	0.2	7	19	177	4.1	9	0.2	4
Nachchaduwa	29,016	24,022	17.2	6	6	1,936	0	0	0.0	0	10	60	3.1	0	0.0	5
II. Polonnaruwa District																
Polonnaruwa	204,887	136,629	33.3	61	61	7,830	0	57	0.7	52	193	317	4.0	124	1.6	32
Hingurakgoda	85,422	54,924	35.7	43	43	2,917	0	22	0.8	22	92	137	4.7	31	1.1	6
Minneriya	62,581	55,161	11.9	12	12	2,026	0	5	0.2	5	42	76	3.8	9	0.4	13
Dimbulagala	4,100	4,100	0.0	0	0	2	0	0	0.0	0	0	0	0.0	0	0.0	1
Bakamuna	15,718	10,955	30.3	0	0	757	0	0	0.0	0	12	31	4.1	22	2.9	3
Gallalla*	11,571	1,990	82.8	0	0	243	0	0	0.0	0	0	0	0.0	0	0.0	1
Total (2 districts)	1,730,305	1,303,391	24.3	573	573	68,626	0	372	0.5	341	1,522	2,931	4.3	937	1.4	226

Note: Gallala is newly commissioned and is not operated constantly. Therefore, it is not calculated in “Total-NRW”. *Source: NWSDB (NC), March 2012*

The above table is prepared by RSC(N/C) to monitor the NRW in each water supply system. The NRW is accurately monitored and calculated by using meter readings of bulk meters and water meters from all connections. The range of NRW is between around 10 to 35%, with the exception of two locations. In the large-scale and old systems NRW is higher at more than 30%, in comparison with that in the small-scale and new systems, where it is less than 20%. The table also shows all NRW related information, such as number of leaks, illegal connections, defective meters, zero-bills and estimated bills. By close monitoring of the information, NWSDB endeavors to minimize NRW.

Along with NRW, NWSDB (NC) is conscious on cost and expenses, and all necessary information.

(2) Maintenance

Maintenance services mainly consist of leak repair works and mechanical/electrical repair works. The leak repair works are mostly implemented by OIC's team based on leaks reported, as breakdown maintenance. As for mechanical/electrical equipment, the Regional Workshop is implementing breakdown and preventive maintenance.

1) Breakdown Maintenance

The following table shows major repair works and implementing organizations. Due to lack of maintenance machines and manpower, some repair works are transferred to the Central Workshop at NWSDB Head Office and some works are ordered to be undertaken by private companies.

It is cost effective to utilize the Central Workshop or private companies, instead of having all machines and manpower to meet peak repair works or complicated works which rarely occur.

Table 3.10 Major Repair Works and Organization

Repair work	NWSDB Head Office Central Workshop	NWSDB RSC(N/C) Regional Workshop	Private (Colombo)
Burnt motor	✓		
Pump overhaul		✓	
Generator overhaul			✓
Automation - PLC	✓(programming)	✓(setting)	✓(special)
Automation - instrument			✓
Panel		✓	✓(special)
Others		✓	

All maintenance services done by the Regional Workshop of NWSDB RSC(N/C) are recorded on a Workshop Job Card, which includes Scheme/ Job Description/ Cost (material, machine, labor, transport, others and overheads) for cost control.

2) Preventive Maintenance

Preventive maintenance is conducted to keep equipment working and/or extend the life of the equipment. The Regional Workshop of NWSDB RSC(N/C) in principle implements preventive maintenance for all water supply systems once a month, and usually it takes 15 working days. By the end of every month, the workshop plans the schedule of the preventive maintenance, and implements accordingly, considering the urgent requirements for breakdown maintenance.

Monthly Inspection Check List	centrifugal pump, borehole pump, air blower, compressor, generator (including motor and starter)

Table 3.11 Schedule of the Preventive Maintenance

Equip	No	Maintenance Task	Freq
Pump	1.1	Clean Exterior surfaces & Control cubical by Vacuum Cleaner	2M
	1.2	Grease bearing / Change bearing Lube oil	1M
	1.3	Check gland packing / mechanical seal replace if necessary	2M
	1.4	Check shaft alignment motor shaft	2M
	1.5	Check shaft sleeve for gland & mechanical seal replace if necessary	2M
	1.6	Check coupling bushes, replace if necessary, Check for shafting alignment	2M
	1.7	Check flow rate	1M
Motor	2.1	Check slip ring and clean / adjust carbon brushes	2M
	2.2	Check for vibration & operating temperature	1M
	2.3	Clean dust by vacuum cleaner / brushes	1M
	2.4	Check for noisy bearing / grease bearing	1M
	2.5	Check wire terminals for loose connections	1M
	2.6	Check balance full load current	1M
	2.7	Check insulation resistance	6M
Starter	3.1	Clean dust by vacuum cleaner	1M
	3.2	Check wire terminals for loose connections / & overheating	1M
	3.3	Check proper operation of relays, connectors, indicating lamps, meters etc.	1M
Common	4.1	Building Lights	1M
	4.2	Street Lamps	1M
	4.3	Lighting protection system Earth	1M
	4.4	Pump replacement	A
	4.5	Hour run meter value	1M

Beside the monthly preventive maintenance, operators at the plants or the stations implement daily inspection. The inspection consists of checking appearance, unusual noise, vibration, temperature, tightness of bolts, gauged pressure etc.

Daily Inspection Check List	centrifugal pump, borehole pump, air blower, compressor, generator, motor, clarifier, mixer

Table 3.12 A List of Daily Inspection for the Monthly Preventive Maintenance

No.	Maintenance Task	Frequency
1−1	Cleaning exterior surfaces.	Daily
1−2	Check free rotation of pump.	Daily
1−3	Check foundation bolts for tightness.	Daily
1−4	Check for unusual noise, vibration and rise in temperature.	Daily
1−5	Check gland packing leakage, adjust if necessary.	Daily
1−6	Check the functioning of vacuum & pressure gauges.	Daily
1−7	Check shaft coupling for tightness.	Daily

3.2.3 Financial

North Central Regional Office of NWSDB covers this project site. Therefore, the financial situation of this regional office is analyzed at first.

The accountant of the office provided JICA Study Team with “Income and Expenditure Statements” from 2006 to 2011. They can be shown in **Table 3.13**.

Table 3.13 Revenues and Expenditures of North Central Office

(Unit: Rs.)

Item \ Year	2006	2007	2008	2009	2010	2011
Sales of water	211,529,041	228,146,633	248,423,362	404,774,818	438,335,713	481,521,169
Other operating income	24,386,682	48,339,366	83,346,790	72,501,027	77,598,820	67,715,576
Operating Income	276,485,999	235,915,723	331,770,152	477,275,845	515,934,533	549,236,745
Direct operating expense	184,099,380	226,161,790	283,311,215	317,241,696	369,840,475	401,377,546
Personnel cost	97,070,685	125,864,817	140,762,285	155,568,143	186,361,433	187,710,103
Utility cost	41,276,082	47,198,858	77,254,487	66,683,530	78,007,992	89,072,286
Chemical cost	16,478,972	19,083,357	25,471,952	29,157,320	26,791,869	27,156,443
Repairs & maintenance	10,767,587	12,471,710	7,489,222	24,934,072	29,290,055	31,068,927
Establishment expenses	6,941,355	8,693,522	11,138,275	14,387,781	15,586,225	17,658,668
Rent, rates, taxes, etc.	11,564,699	12,849,526	21,194,994	26,510,850	33,802,901	48,711,119
Other operating expenses	11,791,880	26,482,579	31,312,587	34,738,424	40,848,121	32,408,216
Operating Expenditure	195,891,260	252,644,369	314,623,802	351,980,120	410,688,596	433,785,762
Operating Surplus/ Deficit	40,024,463	23,841,630	17,146,350	125,295,725	105,245,937	115,450,983

Source: North Central Office, NWSDB

The table shows surplus every year in the past six years. From 2009, the surpluses are more than 100 million Rs. reflecting the tariff raise in 2009. Therefore, North Central Office can sustain itself financially from the viewpoint of cash flow. However, the operating expenditures do not include depreciation. In addition, the account does not include non-operating account such as finance costs. The Head Office manages those matters so that it is necessary to analyze the whole financial aspects of NWSDB as follows.

(2) Water Tariff

The latest water tariff was issued on 18 September, 2012 and in force from 1 October 2012 in accordance with the National Water Supply and Drainage Law No.02 of 1974 (Refer to

Appendix 3.3).

3.2.4 Water Supply Development Plan of NWSDB in Anuradhapura District

Currently 12 water supply projects are nominated for future development in Anuradhapura District as shown in **Table 3.14** and **Appendix 3.4**.

Table 3.14 Water Supply Development Project in Anuradhapura District

Sr. No	Project Name	Cost (million Rs)	Population	Capacity (m3 / d)	Present Status
I. Anuradhapura District					
1	Anuradhapura South integrated WSP - Phase II	12,275.0	73,412	21,000	Eol evaluation completed RFP completed
			29,897	5,500	
			36,211	7,000	
2	Anuradhapura North Integrated WSP	10,462.0	186,025	22,500	JICA team has mobilized to do feasibility study
			85,500	11,250	
3	Mahawilachchiya	976.0	21,980	4,500	Awaiting for funding
4	Padaviya	2,055.0	42,000	9,000	Included in the Anuradhapura North project
5	Galenbindunuwewa	1,707.8	77,125	13,500	Awaiting for funding
6	Thambuttegama	1,805.0	155,000	-	Arranged to get Chinese fund
7	Parasangaswewa (Included Paragoda)	31.0	3,956	-	Awaiting for funding
8	Viharapalugama	365.0	22,000	1,184	
9	Palugaswewa Integrated	2,237.4	37,652	6,750	Awaiting for funding
10	Eppawal	4,537.0	84,000	15,000	Awaiting for NPD & source Approval
11	Galnewa-Bulnewa	-	-	-	under study
12	Rajanganaya	-	-	-	Studies will be completed within two months
II. Polonnaruwa District					
13	Lankapura WSS	1,853.0	55,428	9,000	Awaiting for funding
14	Welikanda	2,776.0	58,247	9,000	Awaiting for funding
15	Dimbulagala	-	-	-	PAC Will be completed within 03 months
16	Hingurakgoda	609.0	36,233	-	PAC report has been sent to P&D - H/O for the comment
17	Minneriya	832.0	52,464	9,000	
18	Elahera-Bakamoona	-	-	-	Study to be started
19	Medirigiriya Stage 2	825.0	-	-	to be sent to P&D-O/H section for comments

Source: NWSDB (NC)

Two projects are under process for implementation. The Ministry of Water Supply & Drainage nominated five “Priority Water Supply Projects” in June 2011, and both Anuradhapura South Integrated WSP - Phase II and Anuradhapura North Integrated WSP were selected. These five

projects were planned to be implemented by potential investors or project developers on a design build basis supported with funding arrangement.

Anuradhapura South Integrated WSP - Phase II is under EOI (Expression of Interest) evaluation, while, the EOI for the Anuradhapura North Integrated WSP was canceled, because JICA dispatched their study team for a preparatory study to identify the potential for funding. All other development projects have a small project cost.

3.3 Existing Water Supply Facilities under NWSDB in the Study Area

There are 56 water supply schemes in total in the project areas including 50 numbers of CBOs facilities and 6 number of NWSDB facilities out of which Rambewa is not an independent system but a part of Anuradhapura North Water Supply Scheme (WSS) and Mihintale WSS with both water sources in Nuwarawewa.

Table 3.15 below shows the number of existing water supply schemes and the served population in each DSD, in which it is apparent that the service coverage in Rambewa and Medawachchiya DSD is higher than in other areas (34.1% and 30.9% respectively), with coverage in Horowpothana (13.8%) and Kebithigollewa (16.6%) being lower than in other areas. There are only six NWSDB supply facilities located in six different DSDs, and approximately 30% of the population are served by NWSDB and the remainder by CBOs.

Table 3.15 Existing Supply Schemes and Served Population

DSD	No. of Water Supply Schemes			Served Population				Population (2012)
	NWSDB	CBOs	Total	NWSDB	CBOs	Total	Coverage (%)	
Wahalkada								
Padaviya	1	3	4	2,191	4,675	6,866	28.5	24,130
Kebithigollewa	1	3	4	2,585	1,165	3,750	16.6	22,555
Horowpothana	1	7	8	705	4,005	4,710	13.8	34,044
Kahatagasdigiliya	1	13	14	3,656	8,760	12,416	32.1	38,688
Sub-total	4	26	30	9,137	18,605	27,742	23.2	119,417
Mahakanadarawa								
Medawachchiya	1	13	14	4,630	9,905	14,535	30.9	47,100
Rambewa	1	11	12	2,139	10,160	12,299	34.1	36,024
Sub-total	2	24	26	6,769	20,065	26,834	32.3	83,124
Total	6	50	56	15,906 (7.8%)	38,670 (19.1%)	54,576 (26.9%)	26.9	202,541 (100%)

(5) NWSDB Facilities in the areas

In the project areas, there are six NWSDB water supply facilities, however source of Rambewa system is out of the Project area although some of GNDs are included in the Project area.

Therefore, Rambewa is excluded in this section. **Table 3.16** shows general information on the five NWSDB's facilities.

Table 3.16 NWSDB Facilities (General Information)

Facility Name	Starting Year	Served Pop	System Capacity (m^3/d)	Water souce		Storage		Distribution Pipes	
				Type	nos.	Type	Capacity	Type	Lnegth (m)
Padavia	1990	2,191	578	Deep	3	Ground	40m3	PVC	13,205
Kebithigollewa	1973	2,585	677	Deep	3	Elevated	225m3	PVC	35,832
Horowpothana	1979	705	137	Deep	1	Elevated	50m3	PVC	3,150
Kahatagasdigiliya	1982	3,656	893	Deep	1	Elevated	100m3	PVC	26,200
Medawachchiya	1965	4,630	1,062	Deep/Shallow	5 / 2	Elevated	135m3 x2	PVC/AC/DI	56,491

The population served with water by NWSDB is 14,000 and average service coverage is 47.5%. NWSDB facilities in the area started their operation in the period between 1964 and 1989. The oldest facility is Medawachchiya system. System capacities are ranging from 137 to 1,062 m^3/day, and all of their water sources rely on ground water. The total capacity of storage tank is 685 m^3 , and all storage tanks are of the elevated tank except Padaviya.

Distribution pipes are PCV pipes except in Medawachchiya, where ACP (Asbestos Cement Pipe) are partly used for 50 – 225 mm in diameters. There is no Non Revenue Water data available in these systems.

In the survey, only three water quality items of pH, Turbidity and Fluoride were collected as shown in **Table 3.17**.

Table 3.17 Water Quality of NWSDB Facilities in the Area

Facility Name	pH	Turbidity	Fluorine
Padaviya	7.65	0.49	0.32
Kebithigollewa	7.01	1.29	0.11
Horowpathana	7.64	6.13	1.42
Kahatagasdigiliya	7.62	0.50	1.90
Medawachchiya	7.53	0.50	0.77

3.4 Existing Water Supply Facilities under CBO in the Study Area

3.4.1 General

(1) General

In the Anuradhapura Integrated Water Supply Project Area, a number of small scale water supply systems have been located under the operation and maintenance of Community Based Organizations (CBOs) which funded by ADB-3rd or ADB-4th. In addition, Community Water Supply and Sanitation Program (CWSSP) have been funded by World Bank (WB). However, as

a CBO supply system, these all water facilities have been operated at the moment.

A survey of the existing water supply system was carried out to analyze present water supply conditions and problems encountered in the water supply facilities, and this provides essential information for the planning of a new water supply system.

Since information and data available to understand and analyze the present water supply conditions were limited, implementation of a detailed survey was indispensable. The survey of the existing water supply system was implemented comprehensively through interview to CBO staffs by a local consultants firm.

NWSDB on the other hand, have operated six existing water supply facilities in Rambewa, Medawachchiya, Kebithigollewa, Padaviya, Kahatagasdigilliya and Hollowpothana. The preparatory survey team conducted data collection and survey directly for the NWSDB's facilities through interview to OIC staffs.

The survey aims to search the followings.

- General Information: name of CBO, location, contact details, year of establishment, year/period of operation, service area, population.
- Water supply system details including, type of water source, treatment system, water storage and detail of distribution system. Supply conditions such as: supply service (continuous/ intermittent), supply pressure, and estimated water loss.
- Details of operation and maintenance including managerial and operational personnel, consumption of power / fuel, chemicals, repairs / replacements etc.
- Financial conditions including revenue (water tariff, connection fee and other revenue) and expenditure including annual cost of personnel, power, chlorine, cost of maintenance and depreciation.
- Willingness to connect to new surface water system including proposed tariff.
- Relevant data and information of service area, system layout and drawing of major facilities.

The field survey was commenced on 25th May 2012 and completed by the end of July 2012, and the results of surveys were given as described in **Sections 3.4.2 to 3.4.4**.

In the survey area at the present, the majority of people are provided water by the community operated water supply facilities (CBOs), and only a limited people are served by piped water supplied by NWSDB.

The list of existing CBO water facilities is shown below in **Table 3.18**,

.

Table 3.18 List of CBO Water Facilities

S/N	Name of CBO	Location				Population of GND			Population served
		PS	DS	GND	Village	No of Village Covered	No of Village Excluded	Population in Service GND	
01	Swashakthi CBO	Rambewa	Rambewa	Kendewa (97) & Galkandagama (85)	Kendewa	3	-	3000	755
02	Ikra CBO	Rambewa	Rambewa	Ikkirigollawa (102)	Ikkirigollawa	3	-	-	3015
03	Arunalu CBO	Rambewa	Rambewa	Sangilikandarawa (111)	Sangilikandarawa	5	-		915
04	Samagi CBO	Rambewa	Rambewa	Thalgahawewa (84)	Thalgahawewa	2	0		660
05	Ekamuthu CBO	Rambewa	Rambewa	Wahamalgollawa (109)	Wamalgollawe	1	-		1220
06	Rangiri CBO	Rambewa	Rambewa	Wewalkatiya (82)	Wewalkatiya	2	-		590
07	Nildiyadahara CBO	Rambewa	Rambewa	Maha Kandarawa yaya -01 (94)	Maha Kandarawa Yaya	1	-	1080	715
08	Eksath CBO	Rambewa	Rambewa	Katukeliya - 106	Katukeliya	3	-	1080	575
09	Mahasen CBO	Rambewa	Rambewa	Mahakandarayaya - 02 (93)	Weliwewa	3	-	-	755
10	Dimuthu CBO	Rambewa	Rambewa	Ihala Kolangaswewa (87)	Ihala Kolangaswewa	3	-	1050	325
11	Pragithi CBO	Rambewa	Rambewa	Bala Honda Wewa(86) &Ihala Kolangaswewa (87)	Bala Hondawewa	4	-	885	635
12	Jayashakthi CBO	Madawachchiya	Madawachchiya	Katuwela (66)	Katuwela	3	1		1090
13	Samagi CBO	Madawchchiya	Madawchchiya	Halambagaswewa (70)	Halambagaswewa, Palukandawewa	2	-		935
14	Samagi CBO	Madawachchiya	Madawachchiya	Ataweeragollewa (56)	Pahala Thammannagama, Kubukkollawa, Attaweeragollawa	3	-	1580	540
15	Ekamuthu CBO	Madawachchiya	Madawachchiya	Hirulugama (54)	Hirulugama	1	-		855
16	Ran Arulnalu CBO	Madawachchiya	Madawachchiya	Wiralmurippu (64)	Wiralmurippu, Kulikkada	2	-	1375	945
17	Isuru CBO	Madawachchiya	Madawachchiya	Kadawathgama (60)	Kadawathgama	3	-	2640	895
18	Randiya Dhahara CBO	Madawachchiya	Madawachchiya	Unagaswewa (75)	Unagaswewa	3	-		520
19	Nelum CBO	Madawachchiya	Madawachchiya	Kirigalwewa (72)	Kirigalwewa	4	-		680
20	Diriyamatha CBO	Madawachchiya	Madawachchiya	Maha Kumbugollawa (46)	Maha Kumbugollawa, Kuda Halmillawa	3	-		890
21	Gemunu CBO	Madawachchiya	Madawachchiya	Maha Divulwewa (57)	Maha Divulwewa	1	2		345
22	Sisila Diyadahara CBO	Madawachchiya	Madawachchiya	Kidawarankulama (42)	Kidawarankulama	2	-		935
23	Diriyamatha CBO	Madawachchiya	Madawachchiya	Periyakulama (49), Yakkawewa (50)	Periyakulama	3	1		675
24	Ridi Nadi	Madawachchiya	Madawachchiya	Athakade (55)	Athakade	2	1		600
25	Shakthi CBO	Kebithigollawa	Kebithigollawa	Ayyatigewewa (24)	Ayyatigewewa	1	-	2015	1165
26	Al-Naja	Kebitigollawa	Kebitigollawa	Muslim Attaweerawewa (32)	Attaweerawewa (Paranagama, Aluthgama, Kurulugama)	2	-	2050	Connection not given yet
27	CBO not formed & Scheme Not implemented	Kebitigollawa	Kebitigollawa	Gonumariyaya (25)	Gonumariyaya	-	-	-	-
28	Parakum CBO	Padaviya	Padaviya	Parakramapura(06), Buddhangala(05), Elikumbulagala (07)	Parakiramapura Town	11	5	-	2820
29	Suwasehana CBO	Padaviya	Padaviya	18 Kanuwa (02)	18 Kanuwa, Deewara Gammanan, Isipathana gama	3	-	1750	945
30	Suwasetha CBO	Padaviya	Padaviya	Bogahawewa (14)	Bogahawewa	6	-	1750	910
31	Vajira CBO	Kahadagasdigilliya	Kahadagasdigilliya	Maha Kumbukwewa (222)	Maha Kumbukwewa	2	-		665
32	Pragathi CBO	Kahadagasdigilliya	Kahadagasdigilliya	Moragahawela (202)	Moragahawela	3	1		640

Table 3.18 List of CBO Water Facilities (cont'd)

S/N	Name of CBO	Location				Population of GND			Population served
		PS	DS	GND	Village	No of Village Covered	No of Village Excluded	Population in Service GND	
33	Janasetha CBO	Kahadagasdihilliya	Kahadagasdihilliya	Ratmalgahawewa(225), Paalishpothana(224), Kirigallawa (226)	Palispothana	5	5	1500	920
34	Sobasisila CBO	Kahadagasdigiliya	Kahadagasdigiliya	Pandarella(210), Panwella (211)	Kokabe, Panderellawewa, Panwella, Thimbiriwewa	4	3		875
35	Randiya	Kahatagasthigiliya	Kahatagasthigiliya	Ranpathwila (196)	Ranpathwila (196) Rotapukuna	2	-		1130
36	Nilmini	Kahatagasthigiliya	Kahatagasthigiliya	Kokmaduwa(201)	Kokmaduwa	1	3		795
37	Senath CBO	Kahadagasdigilliya	Kahadagasdigilliya	Gonamaruwewa (223)	Gonamaruwewa, Nelugolla Kade	2	1		385
38	Eksath CBO	Kahadagsdiliyya	Kahadagsdiliyya	Turukkuragama (234) & Maha Kiri Ibbawa (233)	Aluthwattha, Galwala, Hijra Mawatha, Maha Kiri Ibbawa	4	3		470
39	Praja Shakthi CBO	Kahadagasdigilliya	Kahadagasdigilliya	Mahawewa (221)	Wirandagollawa, Mahawewa	5	1		810
40	Apsara	Kahadagasdigiliya	Kahadagasdigiliya	Meekumbukwewa (212)	Meeminnawala, Aluthwewa, Kumbukwewa	3	-		1480
41	Pinibindu CBO	Kahadagasdigiliya	Kahadagasdigiliya	Ambagahawewa - 213	Rainwater supply implmented in 60 Households. No Piped Water Supply				
42	Sham Sham	Kahadagasdigilliya	Kahadagasdigilliya	Weligollawa (218), Kuncha Halmillawa (219)	Weligollawa, Kunchahalmillawa, Ihalamillawa	3	-		210
43	Ekamuthu CBO	Kahadagasdigilliya	Kahadagasdigilliya	Kumbukgollawa (209)	Kumbukgollawa	1	2		380
44	Pradeepa	Horowpathana	Horowpathana	Wadigewewa (126)	Wadigewewa	5	1		805
45	Upul CBO	Horowpathana	Horowpathana	Parangiwadiya (149)	Parangiwadiya	2	-		905
46	Jalasavi	Horowpathana	Horowpathana	Kapugollewa (140)	Kapugollewa	2	1		785
47	Tristar CBO	Horowpathana	Horowpathana	Agunuchchiya (119)	Parangiwadiya	2	1		215
48	Alhidra CBO	Horowpathana	Horowpathana	Anolondawewa (138)	Alondawewa	2	1		730
49	Adhikwa CBO	Horowpathana	Horowpathana	Weerasole (139)	Weerasole	1	1		-
50	Hansajala CBO	Horowpathana	Horowpathana	Maradankadawala (133)	Maradankadawala	3	2		565

In accordance with the survey, seven CBO have not been operated nor started operation as described herein below.

- No.27 Gonumariyaya CBO (Kebithigollewa DSD): Project has not been implemented; thus no water supply facility exists.
- No.26 Al Naja CBO (Kebithigollewa DSD): Construction work has not been completed; thus supply of water has not been commenced.
- No.36 Nilmini CBO (Kahatagasdigiliya DSD): In 2010 the water pump was broken due to lightning; since then no water has been provided.
- No.47 Tristar CBO (Horowpothana DSD), No.48 Alhidra CBO (Horowpothana DSD) and No. 49 Adhikawa CBO (Horowpothana DSD): Construction has been completed, but the CBO organizations have not been formally organized and water is used without proper management.
- N0.41 Pinibindu CBO (Kahatagasdigiliya DSD): No CBO has been organized, as there is no

proper water source and people rely on rainwater.

Figure 3.4 is a location map of CBO's facilities, which shows that the facilities are sparsely located over the project area.

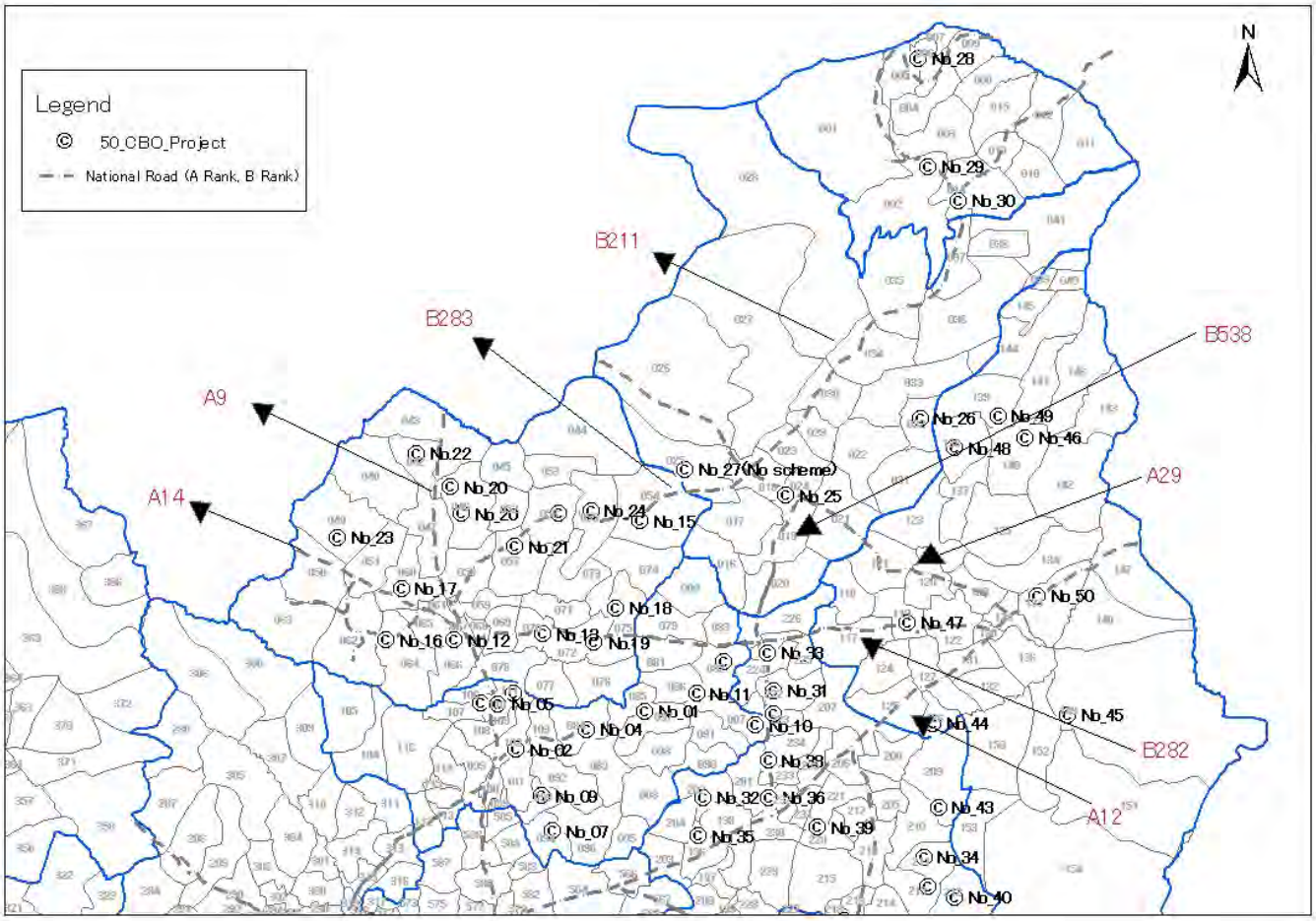


Figure 3.4 Distribution Map of CBO Facilities

The earliest operation of CBO's facilities was commenced in the year 2003 and most of CBOs started their operation from the 2006 to 2009. All of CBO's facilities are relatively new, and they are, more or less, still in good conditions and it is expected to be used in the future, with the exception of in the seven CBOs, as described earlier. **Figure 3.5** shows years of commencement of operation of CBOs.

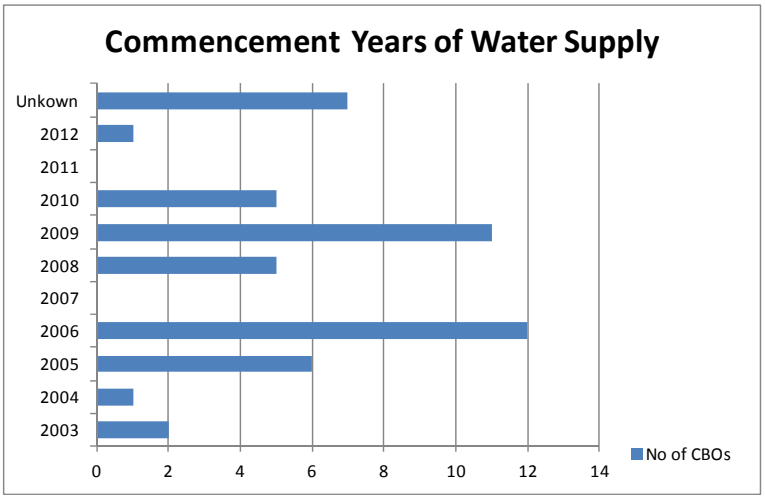


Figure 3.5 Commencement Year of CBO Facilities

(2) Water sources

In the most of CBOs, ground water is used either by installation of shallow wells, deep wells or a combination of both. CBO No. 41 Pinibindu in Kahatagasdigiliya DSD relies on rain water because of the limitation of the water source, and only 60 people are served in this CBO service area. The detailed analysis of water quality is described in another section, however, it is briefly described based on the field survey results related to hardness and fluoride concentrations which are of the most concern to people in these areas. Caution shall be paid that information has been collected from CBO's managerial persons by the field team, and accuracy could be confirmed.

Many CBOs stated that the systems have insufficient water quantity especially in dry season, insufficient supply pressure, poor and unsuitable water quality, etc.

The following are the problems that CBO's managerial persons have stated during the field survey:

- 10 CBOs stated; "We have a problem in shortage of water during dry season."
- 3 CBOs stated; "Not sufficient pressure in the line so that water could not reach the end of the system or higher places.
- 2 CBOs stated; "We have difficulties to further increase the number of connections to houses because of insufficient water."
- 3 CBOs stated; "We cannot operate the system continuously due to low voltage of electricity."

Table 3.19 presents kinds of water source of CBOs and water quality of hardness and Fluoride in **Table 3.20**.

Table 3.19 Water Source in CBO Facilities

Water source	No. of CBOs
Deep wells	16
Shallow wells	24
Both types of wells	7
Rainwater	1
Surface water	Non

Table 3.20 Hardness and Fluoride

	Hardness	Fluoride
No. of CBOs	20	24
Ave.	323 mg/L	0.88 mg/L
Max.	720 mg/L	1.80 mg/L
Min.	80 mg/L	Less than 0.1 mg/L

(3) Water Quality

According to the field survey, there is no CBO which has treatment facilities, such as filters or aerations. Further, limited chlorination facilities were installed in the water supply facilities, Eight CBOs have experience of dosing hypochlorite in the elevated tanks either occasionally or consistently. Most of CBOs have not dosed chlorine due to either lack of skill relating to O&M or financial reason.

Water quality information collected by the field team is listed in **Table 2.17**.

(4) Components of Facilities

In most CBO's water supply systems, raw water is taken either from deep wells or shallow wells, then pumped up to elevated tanks, before being distributed by gravity to houses through PVC pipes. As shown in **Table 3.21** and **Table 3.22** the total storage capacity in all CBOs is 2,805 m^3 and on average 58 m^3 of storage capacity is provide in each CBO's water supply system.

In accordance with the field survey, low water levels of elevated tanks are between 10 and 15 m from the ground level and water depth is about 2.1 m. Information of distribution pipes was collected from 48 CBOs. Distribution pipes are PVC type 600 (PN6) with nominal diameters of 25 mm to 150(OD160) mm. Many CBOs use small size of distribution pipe of less than 50(OD63) mm in diameter.

Table 3.21 Capacity of Elevated Tanks

No. of CBOs	48
Total Capacity	2,805 m^3
Ave.	58.5 m^3
Max.	22.5 m^3
Min.	20 m^3

Table 3.22 Distribution Pipes

No. of CBOs	48
Total Length	392,299 m
Ave.	8,173 m
Per Connection	51 m

3.4.2 Operation and Maintenance

(1)Present Condition on O&M (Operation and Maintenance)

A committee has been formed in most of CBO water supply schemes and the committee manages water supply system. Members of the committee are locally elected personnel by the community,

who are like school teachers, public sector employees or local businesspersons. Operation and maintenance of the system is carried out on a day-to-day basis by two to three persons selected persons, one clerical and one or two technical personnel usually. **Table 3.24** shows the consumption of electricity and chlorine, repairs/replacement and maintenance.

For the maintenance of facilities, it was observed that;

- Repair and/or replacement of distribution pipelines have been carried out by 33 CBOs in the past.
- Water meters have been replaced by 16 CBOs. The total meters replaced were 276 meters.
- Elevated tanks have been cleaned several times by 20 CBOs .

Although the levels of O&M practice vary by the CBO, the majority of CBOs are seemed to carry out operation and maintenance in a good manner, for routine operation and maintenance.

However, the following operation and maintenance problems were reported by the field survey team:

- 6 CBOs (No.02 Ikra CBO, No.06 Rangiri CBO, No.33 Janasetha CBO, No.46 Jalasavi CBO, No.48 Alhidra CBO and No.40 Apsara Meekumbukwewa CBO): Gate valves or pipes are leaking.
- 5 CBOs (No.06 Rangiri, No.10 Dimuthu CBO, No.35 Randiya CBO, No.37 Senath CBO and No.40 Apsara CBO): CBO management is poor and capacity building is necessary.
- No.36 Nilmini CBO: leakage from elevated tank.
- No.50 Hansajala CBO: Connection pipe to elevated tank to be replaced.
- All CWSSP schemes (No.07Nildiyadahar, No.08Eksath, No.09Mahasen, No.10Dimuthu, No.11Pragithi, No.18Randiya Dhahara, No.19Nelum, No.20Diriyamatha, No.21Gemunu, No.22Sisila Diyadahara, No.23Diriyamatha No.24Ridi Nadi, No.36Nilmini, No.37Senath, No.38Eksath, No.39Praja Shakthi, No.40Apsara, No.42 Sham Sham, No.43Ekamuthu): no bulk meters are installed.

Table 2.17 Water Quality of CBO's Supply System

S/N	DSD	Water Source	Water Quality							
			Hardness (mg/L)	Iron (mg/L)	Fluoride (mg/L)	Odor	Color (Haxen Unit)	Turbidity (NTU)	pH	Conductivity (µS/cm)
1	Swashakthi CBO	S	-		**0.85**	None	Clear	0.05	7.86	**860**
2	Ikra CBO	D-1, S-1	-	-	**0.83**	None	Clear	0.06	7.72	**950**
3	Arunalu CBO	S	-	-	**0.59**	fishy	Clear	0.1	7.93	**940**
4	Samagi CBO	D	-		**1.01**	None	Clear	0	7.76	**930**
5	Ekamuthu CBO	S	-		0.32	None	Clear	0.08	7.74	700
	Ekamuthu CBO-Kakukaliyawa				**1.19**	-	Clear	0.03	7.77	**880**
6	Rangiri CBO	D	-		**0.88**	None	Clear	0.03	7.79	**1,080**
7	Nildiyadahara CBO	S	**360/280**	-	**0.72**	-	Clear	0.15	7.77	740
8	Eksath CBO	S	**340**	-	**0.4/0.78**					
9	Mahasen CBO	S	80	-	0.39	-	Clear	0.08	7.6	730
10	Dimuthu CBO		**312**	-	0.57	-	Clear	0.12	7.91	610
11	Pragithi CBO		**344**	-	**1.38**	-	Clear	0.05	7.7	**1,450**
12	Jayashakthi CBO	D	-		**1.9**	None	Clear	0.06	7.76	**1,570**
13	Samagi CBO	D	**332/270/330**		**1.08**	-	Clear	0.07	7.8	**1,000**
14	Samagi CBO	S	-	-	0.5	-	<5	0.02	-	590
15	Ekamuthu CBO	D	-		**0.81**	-	<5	0.03	-	650
16	Ran Arulnalu CBO	D	**490/720/640**	0.03/-/-	**1.55/1.1/0.36**					
17	Isuru CBO	D	High	-	**0.98**	None	Clear	0.05	7.84	**1,060**
18	Randiya Dhahara CBO		-	-	**1.15**	None	Clear	0.09	7.76	**840**
19	Nelum CBO	S	-		**1.11**	None	Clear	0.05	7.86	**970**
20	Diriyamatha CBO		**250/261/284**		**0.83**	-	Clear	0.1	7.75	**700**
	Diriyamatha CBO				**0.69**	-	Clear	0.12	7.79	**870**
21	Gemunu CBO		-		**0.75**	-	<5	0.21	-	**950**
22	Sisila Diyadahara CBO		-		**0.76**	None	Clear	0.06	7.83	**880**
23	Diriyamatha CBO		**373/342**		**0.86**	None	Clear	0.1	7.64	**1,220**
24	Ridi Nadi				0.21	None	Clear	0.06	7.75	610
25	Shakthi CBO	D	**324**	**3.3**	0.1					
26	Al-Naja	D	-	-						
27	CBO not formed		-	-						
28	Parakum CBO	D	108	0.14	**1.04**	-	Clear	0	7.76	740
29	Suwasehana CBO	D	1.13	-	**1.13**	-	Clear	0.07	7.76	740
30	Suwasetha CBO	S	-	-	**0.96**	-	Clear	0.04	7.63	740
31	Vajira CBO	D	**262/204**		**1.5/1.54**					
32	Pragathi CBO	D	-		0.58	None	Clear	0.08	7.54	**1,430**
33	Janasetha CBO	S	-	-	**1.37**	-	Clear	0.01	7.85	670
34	Sobasisila CBO	S	-		**0.67**	-	Clear	0.02	7.64	810
35	Randiya	S-2	-	-	0.31	-	Clear	0.14	7.76	760
36	Nilmini	D	-							
37	Senath CBO		-		**1.9**	None	Clear	0.02	7.75	**1,240**
38	Eksath CBO	S	**296**		**1.62**	None	Clear	0.02	7.78	**860**
39	Praja Shakthi CBO		-		0.42	None	Clear	0.01	7.85	520
40	Apsara	S	-		**1.35**	-	Clear	0.14	7.69	1,380
41	Pinibindu CBO	R								
42	Sham Sham		-							
43	Ekamuthu CBO	Well-2	**264**		0.14	-	Clear	0.05	7.6	640
44	Pradeepa	D	**448**		**0.82**	-	Clear	0.01	7.8	**1,150**
45	Upul CBO	D	**290**		**0.92**	-	Clear	0	7.83	**1,000**
46	Jalasavi	D	-		**1.58**	-	Clear	0.02	7.74	**1,330**
47	Tristar CBO	D	**300**	-	0.001					
48	Alhidra CBO	D	**300**		0.04					
49	Adhikwa CBO	D	**280**	-	**0.7**					
50	Hansajala CBO	S	**442**		**1.8**					
	Sri Lanka Standard (Desirable)		**250**	**0.3**	**0.6**		**5**	**2**	**7.0-8.5**	**750**
	Sri Lanka Standard (Permissible)		**600**	**1**	**1.5**	**Unobjection**	**30**	**8**	**6.5-9.0**	**3,500**

S: Shallow Well, D: Deep Well, R: Rain Water Tank The figure after hyphon (-) shows the number of wells.

300 Above the desirable limit **300** Above the permissible limit

In addition, out of 21 CBOs with a water quality data of hardness, 18 CBOs have above a desirable limit of 250 mg/L. The high concentration of hardness as well as fluoride is a big characteristics of this area.

Information on Non-Revenue Water (NRW) has not been obtained from the CBO's managerial people. Thus, an examination on NRW was made including as follows.

NRW in CBO's water supply schemes is estimated adopting the following methods.

1) Comparing distribution water measured by bulk meter and consumption record.
2) Comparing distribution water estimated by pump capacity with operation hours and consumption record where bulk meter is not available or malfunctioned.
3) Flow Monitoring of night flow, by using elevated tank measuring water level drop during night time, where above two methods are not possible or they are considered to be checked.

The summary of NRW Results for 27 schemes is given in **Table 3.24**. The details of calculation of NRW for the schemes are given in Annex.

Table 3.24 Results of Leakage Tests of Non-Revenue Water / Leakage

S/ No	GND	GND No	DS Division	NRW %		
				Field Test	Bulk Meter	Pump Detail
1	Kendewa	97	Rambewa		20.75	
3	Sangilikandarawa	111	Rambewa		23.68	
8	Thalgahawewa	84	Rambewa		18.44	16.9
9	Mahakandarayaya 02	93	Rambewa	22.95		
	Average for Rambewa DSD			**22.95**	**20.96**	**16.9**
12	Katuwela	66	Madawachchiya	30.14		
13	Halambagaswewa	70	Madawachchiya	18.28	22	10.2
14	Attaweeragollawa	56	Madawachchiya			18.42
15	Hirulugama	54	Madawachchiya			11.67
16	Wiralmurippu	64	Madawachchiya		10.7	
17	Kadawathgama	60	Madawachchiya		8.39	16.74
19	Kirigalwewa	72	Madawachchiya	14.31		
22	Kidawarankulama	42	Madawachchiya			46.32
23	Periyakulama	49	Madawachchiya	41.38		
24	Athakade	55	Madawachchiya	16.03		
	Average for Madawachchiya DSD			**24.03**	**13.70**	**20.67**
25	Ayyatigewewa	24	Kebitigollawa	17.97		
	Average for Kebitigollawa DSD			**17.97**		
29	18 Kanuwa	2	Padaviya	16.98		12.91
	Average for Padaviya DSD			**16,98**		**12.91**
31	Maha Kumbukwewa	222	Kahadagasdigilliya		29.53	24.89

S/ No	GND	GND No	DS Division	NRW %		
				Field Test	Bulk Meter	Pump Detail
32	Moragahawewa	202	Kahatagasdigiliya		4.51	6.97
33	Palispotana	224	Kahatagasdigiliya		29.4	26.92
34	Pandaralla	210	Kahadagasdigilliya			21.74
38	Turrukkuragama	234	Kahadagasdigilliya	2.75		
39	Mahawewa	221	Kahadagasdigilliya	6.84		
40	Meekumbukwewa	212	Kahadagasdigilliya	33.96		
43	Kumbukgollawa	209	Kahadagasdigilliya	19.17		
	Average for Kahadagasdigilliya DSD			**15.68**	**16.95**	**18.54**
44	Wadigawewa	126	Horowpothana		4.63	
45	Parangiyawadi	149	Horowpothana		3.58	
50	Maradankadawala	133	Horowpothana	23.74		
	Average for Horowpothana DSD			**23.74**	**4.10**	

As a result of NRW tests in typical 27 CBOs, NRW were assessed at ranging from 4.10 to 24.03%..

In relation to NRW, the following problems were identified:

- NRW of seven (7) NWSDB systems could not be obtained due to lack of data and large scale and complex system.
- Shortage of resources such as manpower, materials and vehicles for leak detection and repair,
- Lack of knowledge and skills for active leakage survey technology, and
- No specific programme for leakage control supported by NWSDB.
- Pipe data on water distribution network only covers up to the diameter of 63 mm or bigger. Smaller diameters are not covered in most cases, and
- Pipeline information in many CBOs has not been updated. Continuous update and verification of the pipeline information is necessary for the efficient operation and maintenance.

3.4.3 Financial Conditions

Information is collected from all CBOs with the exception of the CBOs which have not been in operation.

(1) Tariff and Revenue

Main sources of revenue are payment of water supply based on the tariffs and connection fee (as most CBOs have such charge) when a new family joins to the CBO. In some CBOs,

suspension charge is also adopted if anyone delays paying a water bill.

Tariff information is obtained from 44 CBOs (except CBOs are not functioned), among which typical tariff structures are shown in **Table 3.25**

Most of CBOs have adopted a similar tariff structure. Water tariff is composed of basic charge and consumption rate by block progressive tariff rate. In addition, a connection charge is levied on the consumer, and similarly replacement of meter is also charged to the consumer.

Tariff is varied depending on the CBOs scheme. ADB3rd and ADB4th schemes generally have a minimum tariff varying from Rs. 10/- to 20/- per m^3 in Volumetric Rate.

However, in CWSSP schemes the tariff is higher than the above rates varying from Rs. 10/- to 30/- per unit.

Table 3.25 Sample of CBO Tariff Structures

Serial No: 01	**CBO: Swashakthi**	**PS: Rambewa**		**GND : Kendewa (97) & Galkandagama (85)**			
	Structure:	unit rate with a block progressive water rate					
	consumption:	< (10)	(11) ~ (30)	> (30)			
	volumetric rate:	20	30	40			
Serial No: 12	**CBO: Jayashakthi**	**PS: Madawachchiya**		**GND : Katuwela (66)**			
	Structure:	unit rate with a block progressive water rate					
	consumption:	< (10)	(11) ~ (15)	(16) ~ (20)	(21) ~ (25)	(26) ~ (30)	> (30)
	volumetric rate:	15	17	20	23	25	30
Serial No: 25	**CBO: Shakthi**	**PS: Kebithigollawa**		**GND : Ayyatigewewa (24)**			
	Structure:	unit rate with a block progressive water rate					
	consumption:	< (10)	(11) ~ (15)	(16) ~ (20)	(21) ~ (25)	> (26)	
	volumetric rate:	10	15	17	22	27	
Serial No: 28	**CBO: Parakum**	**PS: Padaviya**		**GND : Parakramapura(06), Buddhangala(05), Elikumbulagala (07)**			
	Structure:	unit rate with a block progressive water rate					
	consumption:	< (10)	(11) ~ (15)	(16) ~ (20)	(21) ~ (25)	> (26)	
	volumetric rate:	10	12.5	15	18	20	
Serial No: 31	**CBO: Vajira**	**PS: Kahadagasdigilliya**			**GND : Maha Kumbukwewa**		
	Structure:	unit rate with a block progressive water rate					
	consumption:	< (10)	(11) ~ (15)	(16) ~ (20)	(21) ~ (25)	> (26)	
	volumetric rate:	20	22.5	25	27.5	30	
Serial No: 50	**CBO: Hansajala**	**PS: Horowpathana**		**GND : Maradankadawala**			
	Structure:	unit rate with a block progressive water rate					
	consumption:	< (15)	(16) ~ (20)	(21) ~ (25)	> (26)		
	volumetric rate:	15	20	25	30		
	Base charge (Rs/mon):	50					
	Minimum monthly charge (Rs/mon):	10					

(2) Expenditure

CBOs expenditures are basically composed of (1) personnel costs (payment to operating staff), (2)electricity, (3) maintenance costs, (4)purchase of chemical and (5)other miscellaneous costs. The shares of personnel costs range from 0% to 68.1% and 45% on average. The shares of consumable costs in the expenditures are from 23.3% to 72.5% and the average is 40.7%. The

shares of maintenance costs in the expenditures are from 0% to 63.2% and the average is 14%. The Personnel costs and electricity bills are the major expenses. And the maintenance costs are widely varied from zero to Rs. 240,000 per year depending on conditions of facilities and/or manner of maintenance philosophy. (Zero expenditure is doubtful though, it may be due to lack of book keeping)

Figure 3.6 shows the composition of expenditures by category in the year 2011. Among the total expenditure, O&M personnel and power consumption are 82% of the expenditures.

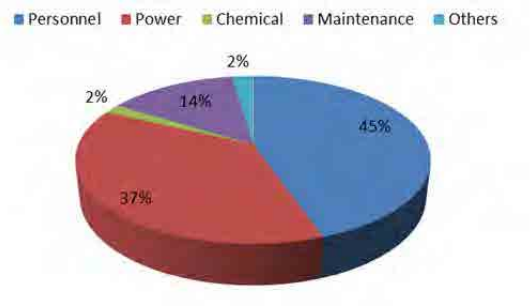


Figure 3.6 Expenditure of CBO

(3) Financial Status

Based on the CBO survey results, the financial situation of CBOs can be summarized in **Table 3.26**. Although some CBOs did not answer the questions about their financial conditions, the other answering CBOs financial accounts are good. All the CBOs, which answered, show more revenues than expenditures. The profit rates to revenues (mostly sales) are from 5% to 73.8% and it is 44.6% on average.

For reference, profit (Rs.) per unit sold water (m^3) is shown in the right column of the table. It ranges from 0.9 to 43 and the average is 11.7. The difference is too large.

Table 3.26 Profit/ Loss of CBOs

(Unit: Rs.)

DSD	GND	CBO	Revenue	Expenditure	Profit/loss	Profit / Revenue	Personnel / Expenditure	Consumables / Expenditure	Maintenance / Expenditure
Padaviya	Padaviya	Suwasehana	1,025,364	425,928	599,436	58.5%	19.7%	23.9%	56.3%
	Parakramapura	Parakum	2,045,400	618,380	1,427,020	69.8%	56.3%	31.2%	12.5%
	Bogahawewa	Suwasetha	730,052	478,348	251,704	34.5%	37.6%	34.4%	28.0%
Kebithigollewa	Ayyatigewewa	Shakthi	562,758	534,519	28,239	5.0%	40.4%	27.8%	31.8%
Medawachchiya	Kidawarankulama	Sisila Diyadahara	535,060	373,612	161,448	30.2%	41.8%	55.6%	2.7%
	Maha Kumbugollewa	Diriyamatha	562,228	421,037	141,191	25.1%	42.8%	33.5%	23.8%
	Periyakulama &Yakawewa	Diriyashakthi	490,000	362,432	127,568	26.0%	36.4%	57.2%	6.3%
	Hirulugama	Ekamuthu	394,796	358,672	36,124	9.2%	55.2%	33.6%	11.2%
	Athakade	Ridinadi	446,472	224,569	221,903	49.7%	53.4%	32.3%	14.3%
	Ataweeragollewa	Samagi	434,792	289,904	144,888	33.3%	33.1%	63.4%	3.4%
	Maha Divulwewa	Gemunu	192,684	81,420	111,264	57.7%	36.8%	63.2%	0.0%
	Kadawathgama	Isuru	714,806	476,204	238,602	33.4%	54.2%	29.3%	16.5%
	Viralmurippuwa	Ran Arulnalu	402,264	176,323	225,941	56.2%	57.8%	39.8%	2.3%
	Katuwela	Jayashakthi	927,904	632,164	295,740	31.9%	45.6%	46.5%	7.9%
	Helabagaswewa	Samagi	1,270,584	332,448	938,136	73.8%	57.4%	32.1%	10.5%
	Kirigalwewa	Nelum	286,620	159,624	126,996	44.3%	45.1%	54.9%	0.0%
	Unagasewewa	Randiya Dhahara	527,540	291,700	235,840	44.7%	26.7%	62.1%	11.1%
Rambewa	Wewelketia & Thamarahamillewa	Rangiri	341,832	192,492	149,340	43.7%	49.9%	50.1%	0.0%
	Talgahawewa	Samagi	432,168	260,950	171,218	39.6%	62.1%	27.4%	10.5%
	Balahodawewa	Pragithi	290,772	123,515	167,257	57.5%	53.4%	37.8%	8.7%
	Ihala Kolongasw.	Dimuthu	147,732	81,263	66,469	45.0%	59.1%	37.6%	3.3%

DSD	GND	CBO	Revenue	Expenditure	Profit/loss	Profit / Revenue	Personnel / Expenditure	Consumables / Expenditure	Maintenance / Expenditure
Rambewa	Mahakanadarawa 2	Mahasen	319,376	266,966	52,410	16.4%	44.9%	50.2%	4.9%
	Mahakanadarawa 1	Nildiyadahara	391,396	242,219	149,177	38.1%	47.1%	38.5%	14.4%
	Kedewa & Galkandegama	Swashakthi	441,276	199,605	241,671	54.8%	60.1%	32.5%	7.3%
	Ikirigollewa	Ikra	1,883,160	1,084,874	798,286	42.4%	49.8%	48.7%	1.5%
	Katukeliyawa	Eksath	305,352	226,842	78,510	25.7%	42.3%	24.1%	33.6%
	Wahamalgollewa 3	Ekamuthu	616,920	347,832	269,088	43.6%	48.3%	50.4%	1.3%
	Sangilikanadarawa	Arunalu	974,584	466,315	508,269	52.2%	38.6%	46.7%	14.7%
Horowpothana	Wadigawewa	Pradeepa	382,908	226,651	156,257	40.8%	52.9%	23.3%	23.7%
	Maradankadawela	Hansajala	392,044	224,817	167,227	42.7%	0.0%	36.8%	63.2%
	Kapugollewa	Jalasavi	331,324	224,859	106,465	32.1%	41.8%	36.9%	12.3%
	Parangiyawadiya	Upul	613,428	224,501	388,927	63.4%	58.8%	31.0%	10.2%
Kahatagasdigiliya	Moragahawela	Pragathi	339,660	176,620	163,040	48.0%	67.9%	26.4%	5.7%
	Kubukgollewa	Ekamuthu	200,900	159,532	41,368	20.6%	30.1%	64.0%	5.9%
	Pandarellewa & Panwella	Sobasisila	510,720	242,664	268,056	52.5%	49.5%	50.5%	0.0%
	Mee-Kumbukwewa	Apsara	290,592	192,548	98,044	33.7%	49.9%	49.1%	1.0%
	Mahawewa	Praja Shakthi	624,740	368,669	256,071	41.0%	40.7%	27.0%	32.4%
	Maha Kubukwewa	Vajira	431,496	290,632	140,864	32.6%	68.1%	24.3%	7.6%
	Gonumeru Wewa	Senath	275,312	185,640	89,672	32.6%	12.9%	72.5%	14.5%
	Palippothana ~ Kirigallewa	Janasetha	615,476	249,024	366,452	59.5%	48.2%	47.0%	4.8%
	M. Kiribbewa & Kurukuragama	Eksath	214,800	196,116	18,684	8.7%	49.0%	51.0%	0.0%
Average			558,958	309,571	249,387	44.6%	46.5%	40.7%	15.7%

Source: CBO Survey

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3.4.4 Summary of Survey Results

(1) Existing Conditions in CBO Water Supply Schemes

The conditions of exiting water supply schemes are summarized for the **Table 3.27** as follows.

- CBOs supply schemes are presently the major water supply system where about 70 % of served population or 19 % of total population of the Project area is supplied by CBO's system. Therefore, it is crucial to maintain CBO's system with sound manner.
- 44 CBOs out of 50 are functioned and most of CBOs have started their operation from the year 2006 or around.
- All elevated tanks other than S/No. 36 Kokmaduwa in Kahadagasdigilliya (leakages are observed) are sound to receive treated water by ANIWSP.
- Most of CBOs express their willing to connect to the treated water system constructed by the present project of Anuradhapura North Integrated Water Supply Project (ANIWSP), and they desire to keep operation and maintenance by themselves. (except one CBO – 10 Mimuth CBO was not willing to connect)
- Distribution pipe network is all PVC type 600 with the diameter ranging from OD 32 mm to 225 mm. The length of the distribution system varies depending on the size of CBSs schemes, ranging from 4.5 Km to 24 km.
- Bulk meter is not installed or not functioned in many CBOs, which makes difficult to monitor tendency of distribution water and monitor and control of NRW

Table 3.27 Summary of the Present Condition of the CBO

S/ No.	CBO	GND	Present Conditions
01	Swashakthi	Kendewa (97), Galkandagama (85)	The 60m^3 water tower is structurally sound and the distribution system is satisfactorily. NRW is 20.75%using bulk meter readings. The present system capacity is 160m^3/day.
02	Ikra	Ikkirigollawa (102)	The 225m^3 water tower is structurally sound. The system capacity is 516 m^3/ day. Water source is shallow well and deep well. There are some valve leaks.
03	Arunalu	Sangilikandarawa (111)	The 80 m^3 water tower is in good condition. The water source is a shallow well and deep well. The current system capacity is 196m^3/day. O&M and financial management are satisfactory. Suitable for bulk supply.
04	Samagi	Thalgahawewa (84)	The 40m^3 water tower is in good condition. Water source is a deep well. The system capacity is 111m^3/day and NRW 18.44%.O&M and financial management are fairly satisfactory.
05	Ekamuthu	Wahamalgollawa (109)	The 80m^3 water tower is in good condition. The water source is deep well and shallow well. The system capacity is 227m^3/day. NRW not available, but there are visible leaks. No record of repairs/ replacement in distribution system. O&M is fair and financial management is satisfactory. Cumulative balance is Rs. 3.5 Million. Suitable for bulk supply with increase in staff to 3 nos. and training of O&M group and CBO key staff. .

S/ No.	CBO	GND	Present Conditions
06	Rangiri	Wewalkatiya (82)	The 60m^3 water tower is in good condition. The water source is deep well (satisfactory) and shallow well (not fully completed). The system capacity is 179m^3/day. The tapping pressure is low (4m). There are considerable gate valve leaks.
07	Nildiyadahara	Maha Kandarawa yaya -01 (94)	The 40m^3 water tower and the distribution system are in good condition. The water source is a shallow well and the system capacity is 108m^3/day. Financial management is satisfactory. Connection to bulk supply system is recommended.
08	Eksath	Katukeliya - 106	The 40m^3 water tower is structurally sound. The water source is a shallow well and the system capacity is 89m^3/day. NRW not available. The distribution system is in fairly good condition. O&M and financial management are satisfactory.
09	Mahasen	Mahakandarayaya - 02 (93)	The 40m^3 water tower is structurally sound. The water source is a shallow well and the system capacity is 110m^3/day. No evidence of repair/ replacement and well/ tank cleaning during maintenance (2011).Field test indicate NRW of 22.95% and the distribution system appear satisfactory. Annual revenue and expenditure is maintained.
10	Dimuthu	Ihala Kolangaswewa (87)	The 20m^3 water tower in good condition. The water source is a shallow well and the system capacity is 72m^3/day. NRW value unreliable. No evidence of repair/ replacement and well/ tank cleaning during maintenance (2011). Annual revenue and expenditure is maintained.
11	Pragithi	Bala Honda Wewa (86) Ihala Kolangaswewa (87)	The 40m^3 water tower in good condition. There is no indication of leakage in the distribution system. The water source is a shallow well and the system capacity is 109m^3/day. NRW is not estimated. There has been repair and replacement of pipes, but no evidence of maintaining pump, well & tank during 2011. Annual revenue and expenditure is maintained.
12	Jayashakthi	Katuwela (66)	The 60m^3 water tower in good condition. The water source is a deep well and the system capacity is 216m^3/day, but the fluoride level is high (1.9 mg/L). Field measurements indicate NRW of 30.14%. O&M and financial management are satisfactory and the scheme is running with good profit.
13	Samagi	Halambagaswewa (70)	The 50m^3 water tower in good condition. The water source is a deep well and the system capacity is 180m^3/day. Field test indicate NRW is 18.28%. O&M and financial management are satisfactory and the scheme is running with good profit.
14	Samagi	Ataweeragollewa (56)	The 60m^3 water tower in good condition. The water source is a shallow well and the system capacity is 144m^3/day. Pump details indicate NRW as 18.42%. Annual revenue and expenditure is maintained.
15	Ekamuthu	Hirulugama (54)	The 50m^3 water tower in good condition. The water source is a deep well and the system capacity is 144m^3/day. The tapping pressure is low (4m). Pump details indicate NRW is 11.67%. No evidence of repair/ replacement and well/ tank cleaning during maintenance (2011). Annual revenue and expenditure is maintained.
16	Ran Arulnalu	Wiralmurippu (64)	The 30m^3 water tower is in satisfactorily condition. The water source is a deep well and the current system capacity is 173m^3/day which need to expand to 250m^3/day. NRW is 10.7% (bulk meter reading). Hardness and fluoride exceed permissible limits. Annual revenue and expenditure is maintained.
17	Isuru	Kadawathgama (60)	The 60m^3 water tower and distribution system are in good condition and the CBO functioning well. The water source is a deep well and the system capacity is 180m^3/day to be expanded to 225m^3/ day. NRW from pump details is 16.12%. Rs. 79,000 spent on maintenance and the O&M

S/ No.	CBO	GND	Present Conditions
			and financial management are satisfactory.
18	Randiya Dhahara	Unagaswewa (75)	The 40m^3 water tower is in good condition. The water source is a shallow well and the system capacity is 90m^3/day. No data to calculate NRW. The distribution system is maintained fairly well and the financial management is satisfactory.
19	Nelum	Kirigalwewa (72)	The 40/60m^3 water tower is in satisfactorily condition. The water source is a shallow well and the current system capacity is 105m^3/day, to be expanded to163m^3/day. Field test indicate 14.31% NRW. No evidence of maintenance expenditure, but financial management is satisfactory. The distribution system is satisfactory.
20	Diriyamatha	Maha-Kumbugollawa (46)	The two 40m^3 water towers are in satisfactorily condition. The water source is 2 shallow wells and the system capacity is 169m^3/day. NRW not recorded. The Annual revenue and expenditure is maintained.
21	Gemunu	Maha Divulwewa (57)	The 40m^3 water tower is in satisfactorily condition. The water source is a shallow well and the system capacity is 98m^3/day. NRW not recorded. Tapping pressure is low (3m). Maintenance level is low (no expenses recorded). Annual revenue and expenditure is maintained.
22	Sisila Diyadahara	Kidawarankulama (42)	The 40m^3 water tower is in satisfactorily condition. The water source is a shallow well and the system capacity is 139m^3/day. Tapping pressure is very low (2m) in section of the distribution system. Pump details give 46.32% NRW (can be due to illegal tapping for agriculture / industry). Repair, replacement of pipes and cleaning of well / tank. Annual revenue and expenditure is maintained.
23	Diriyamatha	Periyakulama(49), Yakkawewa (50)	The 40m^3 water tower is in satisfactorily condition. The water source is a shallow well, providing water of moderately high hardness and the system capacity is 95m^3/day. Field test indicate NRW of 41.38% (can be due to illegal tapping for agriculture/ industry). Repair, replacement of pipes and frequent cleaning of well / tank. The financial management is satisfactory.
24	Ridi Nadi	Athakade (55)	The 40m^3 water tower is in satisfactorily condition. The water source is a shallow well and the system capacity is 87m^3/day. Field test indicate NRW of 16.03%. Distribution system is satisfactory but no evidence of Maintenance (2011). Annual revenue and expenditure is maintained.
25	Shakthi	Ayyatigewewa (24)	The 60m^3 water tower is in satisfactorily condition. The water sources are Deep well & shallow well and the system capacity is 252m^3/day. Field test indicate NRW of 17.97%. Maintenance included repair &, replacement of pipes. The financial management is satisfactory.
26	Al-Naja	Muslim Attaweerawewa (32	This ADB 4 funded scheme is newly constructed (2012) & not yet commissioned. The 30m^3 & 40 m^3 water towers are both new and structurally sound. This scheme established in 2009 is not commissioned yet.
27	No CBO	Gonumariyaya (25)	The Scheme is not implemented. Hence there is no water supply scheme to be incorporated to ANIWSP.
28	Parakum	Parakramapura(06), Buddhangala(05), Elikumbulagala (07)	This is the largest among the community water supply schemes. The 225m^3 RC water tower is structurally sound. Water source is 02 deep well and the system capacity is 405m^3/day. The O&M of the Distribution system & financial management are satisfactory. The annual balance is Rs.1.4 million & the scheme is sustainable.
29	Suwasehana	18 Kanuwa (02)	The 35m^3 capacity water tower is in good condition. The water source is a deep well and the system capacity is 124 m^3/day & field tests indicate

S/ No.	CBO	GND	Present Conditions
			16.98% NRW. Hardness & fluoride levels are moderately high. The distribution system is well maintained & financial management is good. The annual balance is nearly Rs. 600,000/-.
30	Suwasetha	Bogahawewa (14)	The 40m^3 water tower is in good condition. The water source is a shallow well. The system capacity is 173m^3/day. There is no NRW measurement. The scheme maintenances is satisfactory and financial management is good, with a annual balance over Rs. 250,000/-
31	Vajira	Maha Kumbukwewa (222)	The 60m^3 water tower is structurally sound, water source is a deep well and the system capacity is 108m^3/day. The water has high fluoride (1.5/1.54 mg/L) and the water loss is 29.5% (bulk meter). The annual revenue & expenditure is maintained. The scheme is running in good condition. This scheme can be connected to bulk supply.
32	Pragathi	Moragahawela (202)	The 40m^3 water tower is in good condition. The water source is a deep well & the system capacity is 90m^3/day. In the maintenance of the scheme in 2011 no pipe repair/ replacement was necessary, but repair/service of pump & cleaning of well & tank was done. NRW is recorded as 4.51% (bulk meter) & 6.97 % (pump details). The O&M and the financial management are satisfactory.
33	Janasetha	Ratmalgahawewa(225), Paalishpothana(224), Kirigallawa (226)	The 60m^3 water tower is structurally sound and the shallow well is the water source. The system capacity is 144m^3/day. The fluoride level is 1.37mg/L & only 8 hrs. supply during dry period. NRW based in bulk meter reading is 29.4% & by pump details is 26.92 %. The annual revenue and expenditure is maintained. CBO is willing to get bulk connection.
34	Sobasisila	Pandarella(210), Panwella (211)	The 60m^3 water tower in in sound condition. The water source is a shallow well & the system capacity is 126m^3/day. The NRW is 21.74% based on pump details – only 4hrs/day supply during dry period. Scheme maintenance satisfactory. Annual revenue & expenditure is well maintained.
35	Randiya	Ranpathwila (196)	The 80m^3 RC Water tower is structurally sound. The water source is a shallow well & the system capacity is 180m^3/day. No value of NRW. Very little expenditure on system maintenance. The annual revenue & expenditure is well maintained and the annual balance is nearly 2/3rd of the revenue.
36	Nilmini	Kokmaduwa(201)	This is a CWSSP scheme. The 40m^3 water tower appear to be structurally sound. The scheme started operation in 2006, but the borehole pump was damaged in the same year. The scheme did not operate from late 2006. The system capacity was 55m^3/ day. The water quality was not acceptable due to high hardness. The presently community travel 2-3 km to collect water.
37	Senath	Gonamaruwewa (223)	This is a CWSSP Scheme with a 60m^3 water tower in good condition. The water source is a shallow well & the system capacity is 83m^3/day. The fluoride level is high at 1.9mg/L No power at the intake and a land master tractor engine is used to drive the pump. There is no record of repair/replacing pipes & repair /service/ pump and cleaning well / tank during 2011. Also only one employed technical staff was used.
38	Eksath	Turukkuragama (234) & Maha Kiri Ibbawa (233)	This is a CWSSP scheme. The 40 m^3 water tower is in good condition. The water source is a shallow well & the system capacity is 89m^3/ day. The well water hardness is 296 mg/L & fluoride is 1.62 mg/L. Field test indicate low NRW of 2.75%. There is very low pressure in part of the distribution system. The annual revenue & expenditure is not correctly maintained. Only one pump is working, CBO willing to connect to bulk

S/ No.	CBO	GND	Present Conditions
			supply.
39	Praja Shakthi	Mahawewa (221)	The 40m^3 water tower is in good condition. The water source is two shallow wells and the system capacity is 110m^3/day. But the water supply is limited to 12hrs/day normally and 2.5hrs/day during dry period. Field test indicate NRW of 6.84%. During maintenance in 2011. The annual revenue & expenditure is maintained.
40	Apsara	Meekumbukwewa (212)	The 30m^3 capacity water tower is in good condition. The water source is one shallow well & the system capacity is 82m^3/day. The water supply has to be restricted to12 hrs/day during dry period. The fluoride level is 1.35 mg/L. Field test indicate NRW of 33.96%. The annual revenue and expenditure is maintained. The tapping pressure is satisfactory (10m).
41	Pinibindu	Ambagahawewa - 213	This is a rainwater harvesting scheme 60 households have individual collection systems. CBO is willing to be connected bulk supply.
42	Sham Sham	Weligollawa (218), Kuncha Halmillawa (219)	This is a CWSSP scheme, with 40m^3 water tower which appears to be in good condition. The water source is a bore hole (deep well) which failed after one year operation in 2008. The pump was also damaged & is not replaced. CBO wishes to connect to bulk supply. However, if the scheme is to be incorporated the system must be "charged" and the status of the water tank & distribution system checked.
43	Ekamuthu	Kumbukgollawa (209)	The 35m^3 water tower is in good condition. The water source is a shallow well & the system capacity is 93m^3/day. The water supply is only 2 hrs/day during dry period. Both hardness & fluorides are moderately high. Field tests indicate NRW of 19.17%. There is no power & diesel driven pump is used. The annual revenue and expenditure in recorded, but the annual balance is small.
44	Pradeepa	Wadigewewa (126)	The 50m^3 water tower & distribution system are in good condition. The water sources consist of the deep well and 04 shallow wells. The system capacity is 145m^3/day. Hardness level is 448 mg/L fluoride 0.82 mg/L. The annual revenue & expenditure are well maintained.
45	Upul	Parangiwadiya (149)	The 60m^3 water tower is structurally sound. The water source is a deep well & the system capacity is 145m^3/day. Though water quality results are: Hardness 290 mg/L & Fluoride 0.92 mg/L the consumers complain in of high fluoride. The distribution is a good condition & maintained well. The financial management is also very good with an annual revenue of Rs. 613,428/ - and an annual balance of Rs.389,000/-.
46	Jalasavi	Kapugollewa (140)	The 50m^3 water tower is in good condition. The water source is deep well. The system capacity is 112m^3/day. The water quality is a problem with high fluoride of 1.58 mg/L. The distribution system has many leaking valves and the leaking valves at domestic connections. Field test indicate NRW of 34%. The annual revenue & expenditure is maintained.
47	Tristar	Agunuchchiya (119)	The 60m^3 water tower is structurally sound. The water source consists of 2 deep wells. Hardness is 290 mg/L & fluoride is 0.92mg/L. The full system capacity is not fixed as the scheme is only partially operating. The scheme is not handed over to the CBO and O&M is not started and the tariff is not charged, though water is being used. CBO is willing to connect to bulk supply.

S/ No.	CBO	GND	Present Conditions
48	Alhidra	Anolondawewa (138)	This CBO is adjacent to Weerasole and also completed in March 2012. The 80m^3 water tower is new in good condition. The water source consists of 2 deep well (tube wells) & the system capacity is 335m^3/day. Though the system is not officially opened for consumes water is supplied as connection are given. This is increased from 35 units in March 2012 to 884 units in May 2012.
49	Adhikwa	Weerasole (139)	The 40m^3 water tower is new and structurally sound. The water source consist of 1 tube well & 01 shallow well. The water quality is tolerable (Hardness 280 mg/L & fluoride 0.70 mg/L). The scheme is under NWSDB but water is supplied to part of the consumers. The completed scheme is not handed over to CBO.
50	Hansajala	Maradankadawala (133)	The 50m^3 water tower is satisfactory but the pipe network has not been properly constructed to cover the whole service area. The water source is 01 shallow well & the system capacity is 150m^3/day. The water quality is poor, hardness is 442 mg/L & fluoride level is 0.8mg/L. Field test indicates NRW of 23.74%. The annual revenue and expenditure is not fully recorded. Full time staff is not recruited.

(2) Problems in CBO Managed Water Supply Schemes

As a result of the survey, the existing facilities of CBOs are mostly in good conditions except a few CBOs. It is, however identified the problems in technical and non-technical aspects as shown in **Table 3.28**.

- None of CBOs has 24-hour continuous supply. The reason are (1) shortage of raw water source of groundwater especially in dry season and (2) unstable power supply in some CBOs.
- High concentration of fluoride and also high hardness of well water are observed in many wells of CBOs.
- In several CBOs distribution pipe networks, where pipelines are less than OD65mm diameter, the pipe sizes are too small; hence water pressure at the distribution pipe end is not enough.
- Bulk meters are not installed or not functioned in many CBOs, which makes difficult to monitor distribution of water and to control NRW.
- Cash flow of the most of CBOs is positive, while their water tariff is relatively higher than that of NWSDB.
- Chlorination is, in principle not properly made. It is presumed that most of CBOs have used hypochlorite only occasionally or not used at all.
- Through the survey, many sketch of distribution networks are collected, however they are not accurate, and cannot be used for analysis. No updated information has been found.

Table 3.28 Summary of Problems in the CBOs

S/ No.	CBO	GND	Problems													
			Technical									Non Technical				
			A	B	C	D	E	F	G	H	I	a	b	c	d	e
1	Swashakthi	Kendewa (97), Galkandagama (85)									X					
2	Ikra	Ikkirigollawa (102)	X	X	X			X		X						
3	Arunalu	Sangilikandarawa (111)									X					
4	Samagi	Thalgahawewa (84)										X		X	X	X
5	Ekamuthu	Wahamalgollawa (109)														
6	Rangiri	Wewalkatiya (82)		X			X						X			
7	Nildiyadahara	Maha Kandarawa yaya -01 (94)	X		X				X		X		X			
8	Eksath	Katukeliya (106)	X		X		X				X		X			
9	Mahasen	Mahakandarayaya - 02 (93)	X		X		X				X		X			
10	Dimuthu	Ihala Kolangaswewa (87)	X		X		X				X		X			
11	Pragithi	Bala Honda Wewa (86), Ihala Kolangaswewa (87)	X		X		X						X			
12	Jayashakthi	Katuwela (66)	X								X					
13	Samagi	Halambagaswewa (70)														
14	Samagi	Ataweeragollewa (56)	X				X						X			
15	Ekamuthu	Hirulugama (54)	X			X							X			
16	Ran Arulnalu	Wiralmurippu (64)	X											X		
17	Isuru	Kadawathgama (60)														
18	Randiya Dhahara	Unagaswewa (75)	X		X		X	X					X			
19	Nelum	Kirigalwewa (72)	X				X				X		X			
20	Diriyamatha	Maha-Kumbugollawa (46)	X		X		X						X			
21	Gemunu	Maha Divulwewa (57)	X			X	X						X			
22	Sisila Diyadahara	Kidawarankulama (42)	X		X	X	X						X			
23	Diriyamatha	Periyakulama (49), Yakkawewa (50)	X		X		X	X			X		X			
24	Ridi Nadi	Athakade (55)	X				X				X					
25	Shakthi	Ayyatigewewa (24)	X								X					
26	Al-Naja	Muslim Attaweerawewa (32)	X				X						X			
27	No CBO	Gonumariyaya (25)														
28	Parakum	Parakramapura (06), Uddhangala (05), Elikumbulagala (07)	X													
29	Suwasehana	18 Kanuwa (02)	X				X						X			
30	Suwasetha	Bogahawewa (14)	X								X		X			
31	Vajira	Maha Kumbukwewa														
32	Pragathi	Moragahawela (202)														
33	Janasetha	Ratmalgahawewa (225), Paalishpothana (224), Kirigallawa (226)						X			X	X				
34	Sobasisila	Pandarella(210), Panwella (211)	X								X					
35	Randiya	Ranpathwila (196)	X								X					
36	Nilmini	Kokmaduwa (201)	X				X						X			
37	Senath	Gonamaruwewa (223)	X		X		X	X			X		X		X	
38	Eksath	Turukkuragama (234), Maha Kiri Ibbawa (233)	X			X	X				X		X			
39	Praja Shakthi	Mahawewa (221)	X				X				X		X			
40	Apsara	Meekumbukwewa (212)	X	X			X				X		X			
41	Pinibindu	Ambagahawewa (213)														
42	Sham Sham	Weligollawa (218), Kuncha Halmillawa	X		X		X						X			
43	Ekamuthu	Kumbukgollawa (209)	X			X	X	X			X		X			
44	Pradeepa	Wadigewewa (126)												X		
45	Upul	Parangiwadiya (149)		X	X									X		
46	Jalasavi	Kapugollewa (140)		X										X	X	
47	Tristar	Agunuchchiya (119)														
48	Alhidra	Anolondawewa (138)														
49	Adhikwa	Weerasole (139)														
50	Hansajala	Maradankadawala (133)		X	X									X		

Technical

A: No master valves at water tanks and/or tube-well pumps are installed.

B: Leakage from tanks and/or pipeline

C: No operational valves (air valve, gate valve and wash-out valves, etc.) are installed.

D: Insufficient pressure due to under-sized pipes
E: No proper chlorination dosage.
F: Unstable electricity supply (power cut/voltage variation)
G: Invisible customer meters
H: Malfunction of tube-well pump
I: Little water in dry season

Non Technical
a: O&M records not succeeded due to change of committee member
b: No administration office
c: No proper O&M record keeping due to insufficient training
d: No enough number of O&M staff
e: Poor management of billing system (meter reader does not read exactly)

(3) Conclusion and Recommendations

- Most of CBOs' facilities are new and in good conditions. They are capable to receive bulk water supply from ANIWSP.
- All CBOs in operation (with the exception of one CBO) are willing to connect to the bulk water supply system and desire to maintain operation and maintenance by themselves.
- In order that the ANIWSP connects and supplies bulk water to the CBOs, the following technical and non-technical recommendations are taken into account:
  - Proper installation of valves such as air valve, wash out valve and sectional valve shall be made in CBOs' distribution lines.
  - On connecting to the ANIWSP, it is necessary to install bulk meter at the inlet pipe of each CBO's tank, which will be a scope of ANIWSP. In addition installation of another master meters at the outlet of CBOs tanks are recommended with the assistance by NWSDB.
  - Repair and rehabilitation of network is recommended where low pressure is observed resulting from unsuitable pipe sizes in a part of distribution system.
  - NRW is properly monitored and controlled with an assistance of NWSDB. Where NRW ratios are higher than 20%, counter measures will be taken.
  - With the assistance of NWSDB, necessary capacity building is conducted for CBOs managerial staff, which includes billing system, record keeping, technics of O&M, etc.

Div. Sec. Area - : Rambewa, GN Division - : Wewalkatiya - 82

From left Eelvated tank, shallow well pumps and CBO office

Div. Sec. Area - : Madawachchiya, GN Division - : Katuwela (66)

Bore Hall Intake

Pump House

Panel Board

Div. Sec. Area - : Kebitigollawa, GN Division - : Ataweerawewa (22)

Tank 2-30 m3 Tank, Muslim

Intake

Pump House

Figure 3.7 Existing Facilities in Each DSD

Div. Sec. Area - : Padaviya, GN Division - : Bogahawewa (14)

Water Tower

Shallow Well Intake

Pump House

Div. Sec. Area - : Kahatagasdigiliya, GN Division - : Pandarallawa (210)

Shallow Well Intake

Flow Meter

Panel

Div. Sec. Area - :Horowpothana, GN Division - : Ihala Angunochchiya CBO

Water Tower

Control Room -01

Intake Borehole No-01

Figure 3.7 Existing Facilities in Each DSD (Cont'd)

CHAPTER 4

PROJECTION OF POPULATION AND WATER DEMAND IN THE STUDY AREA

CHAPTER 4 PROJECTION OF POPULATION AND WATER DEMAND IN THE STUDY AREA

4.1 Basic Policy for Planning

The study area covers six DSDs (Divisional Secretary Divisions), namely, Padaviya, Kebithigollewa, Horowpothana, Kahatagasdigiliya, Medawachchiya and Rambewa which are located in the north-eastern part of Anuradhapura District with a population of 204,738 persons (estimated for the year of 2012) and an area of 2,740.48 km^2 forming the typical rural area. The people in this area mainly rely their drinking water source on groundwater through dug/tube wells, however due to a high content of fluoride in groundwater, the patience of dental and skeletal diseases occur. In addition, they say that a high prevalence of chronic kidney diseases (CKDs) is also attributed to the high fluoride concentration in Sri Lanka. In the study area, as described in **Chapter 3**, there are six water supply systems operated and maintained by NWSDB and 50 water supply schemes under CBOs. They are all small-scale water supply schemes with water sources in dug/tube wells except for one CBO system and mostly have a problem of high fluoride concentration in groundwater. Water shortage is also found in the many existing CBO systems especially during the dry season.

To solve these problems, the new water supply system is proposed to integrate the existing NWSDB and CBO water supply schemes under the following basic policy for planning:

- The water source will be converted from groundwater to surface water to meet the Sri Lanka drinking water standards. The surface water will be taken from the irrigation canals originated from Mahakanadarawa Tank and Wahalkada Tank for irrigational purpose.
- Taking into account the overall topography of the study area and the location of proposed water sources, the study area will be divided into two water supply systems, namely, Mahakanadarawa System covering Medawachchiya and Rambewa DSDs and Wahalkada System covering Padaviya, Kebithigollewa, Horowpothana and Kahatagasdigiliya DSDs. (See below for “one integrated water supply system” as an alternative)
- The proposed water supply sytems will supply water to the existing service area under NWSDB and CBOs and the new service area currently not served,
- The study area is composed of 194 GNDs under six DSDs, out of which 60.8% of GNDs have a population density of less than 100 persons per km2 and 87.6% of GNDs for less than 200 persons /km2. Since the population is sparsed thinly in an extensive area as mentioned-above, it is clearly not cost-effective to develop ordinary water supply systems (hereinafter referred to as “ pipe borne water supply”). For this reason, some area will be covered by non pipe borne water supply systems in which safe water treated at water treatment plants will be delivered by water bowser to the water tanks strategically arranged to minimise the water-fetching works of the people (hereinafter referred to as “bowser water supply”).
- The new water transmission pipes will be connected to the elevated tanks of existing

systems and the existing water distribution facilities will be used as they will be as much as possible.

- Some out of the existing CBO systems will be excluded from the integration to the new water supply systems, if they have currently no problem in quality, quantity, operation, etc.

<For one integrated water supply system as an alternative>

In the study area, another option to cover the whole study area by one water supply system is considered but excluded due to the reason described below.

The study area is divided into the eastern and western areas by the ridge with ground elevations of +146M at Kahatagasdigiliya, +122M at Rathmalgahawewa and +122M at Kebithigolle proposed for elevated tank sites running in the almost centre of the study area, and has slopes to the Mahakanadarawa WTP site southwestward (GE +91M) and the Wahalkada WTP site ((GE +56M)) northeastward. Since the Wahalkada WTP site is located at the lowest ground elevation in the study area, it has the most disadvantage to transmit all amount of water from the WTP to the whole area from the viewpoint of energy consumption. On the contrary, it is possible to transmit water from Mahakanadarawa WTP site with less energy consumption. However, the storage capacity of Wahalkada Wewa is not enough to cover the water demand for irrigation and drinking water supply in the year of 2016 even in case of two water supply system, namely Mahakanadarawa System and Wahalkada System and water intake from Mahakanadarawa Wewa with a full amount will clearly make water shortage more serious, that is to say, there is a problem in the stability as a water source. Hence there is a crucial disadvantage for water supply from either Mahakanadarawa Wewa or Wahalkada Wewa from the different reasons. Such problems can be mitigated by dividing the study area into two parts and constructing an independent water supply system, respectively.

The design water supply is estimated in accordance with the flowchart as shown in **Figure 4.1**.

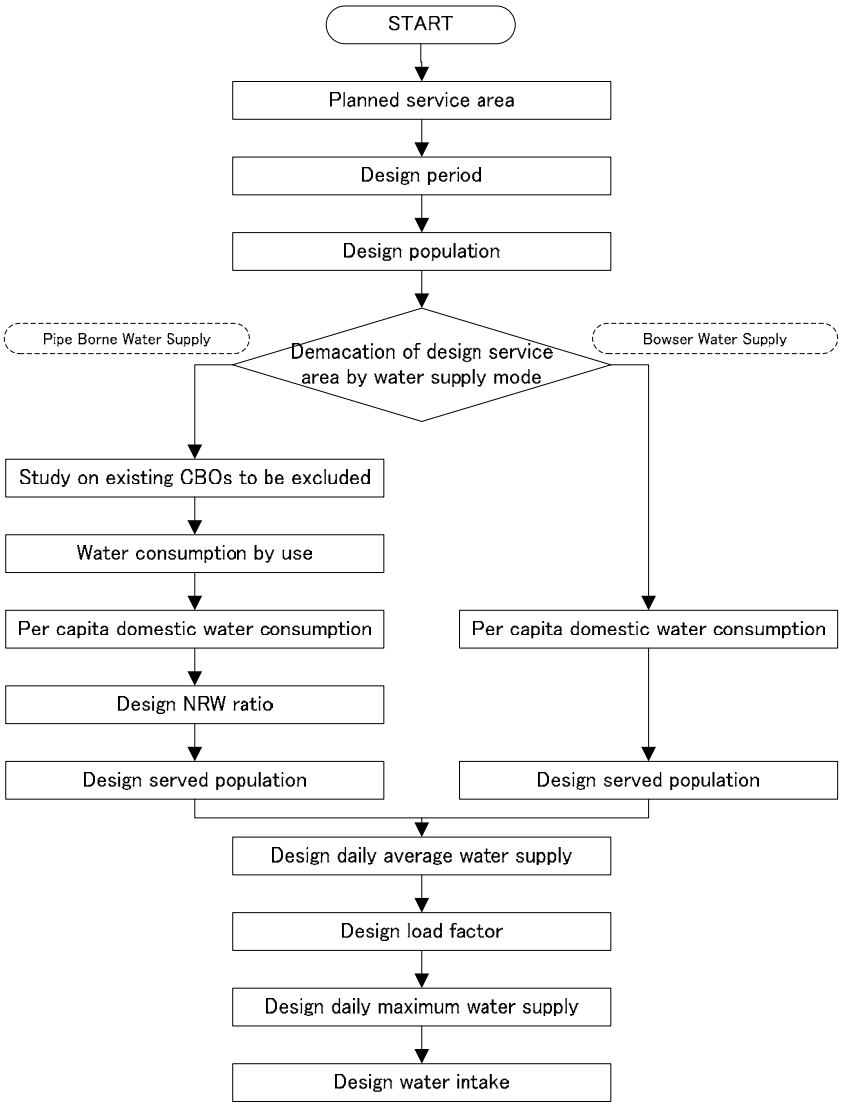


Figure 4.1 Flowchart of Design Water Supply Estimation

4.2 Estimation of Design Water Supply

4.2.1 Design Service Area

The design service area shall be six DSDs, namely, Padaviya, Kebithigollewa, Horowpothana, Kahatagasdigiliya, Medawachchiya and Rambewa which are located in the north-eastern part of Anuradhapura District, as previously stated.

4.2.2 Design Period

"Pre-Feasibility Report on Anuradhapura North Integrated Water Supply" prepared by NWSDB in

December 2012 set the target year in 2034. NWSDB Design Manual (March 1989) describes that "*As a general principle it is recommended that future urban schemes be designed for a 20-year planning horizon in two 10-year stages*". For reference, the Japanese design criteria recommend to set the target year at15 to 20 years ahead. Therefore, it is reasonable to set the target year in 2034 with an interim target year of 2024 for staged construction.

4.2.3 Design Population

The percentage of the population in the Anuradhapura District of the total national population was 2.6% in 1963, 3.1% in 1971 and 4.0% in 1981 showing a steady increase, but thereafter being similar to 1981 at 4.0% in 2001 and 4.2% in 2012, as shown in **Table 4.1**.

Table 4.1 Historical Census Population

	1953	1963	1971	1981	2001	2012
Population						
Sri Lanka	8,097.9	10,582.0	12,689.9	14,846.8	18,797.3	20,277.6
Urban	1,239.1	2,016.3	2,848.1	3,192.7	-	-
Rural	6,858.7	8,565.8	9,841.8	11,654.3	-	-
Anuradhapura	229.3	279.8	388.8	587.9	745.7	855.6
(% to Sri Lanka)	(2.8%)	(2.6%)	(3.1%)	(4.0%)	(4.0%)	(4.2%)
Urban	18.4	32.9	38.8	41.4	53.2	-
Rural	210.9	246.9	349.9	546.5	692.5	-
Annual Average Growth Rate						
Sri Lanka	2.8	2.7	2.3	1.6	1.16	0.71
Urban	2.8	5.0	4.4	1.1	-	-
Rural	2.8	2.2	1.8	1.7	-	-
Anuradhapura	7.4	2.0	4.2	4.2	1.25	1.33
Urban	5.9	6.0	2.1	0.7	1.26	-
Rural	7.5	1.6	4.5	4.6	1.19	-

Source: "Statistical Abstract 2010", Department of Census and Statistics
Source: "Population of Sri Lanka by District – Preliminary Report (Provisional) - 1", Department of Census and Statistics, April 20, 2012

For the urban area of Anuradhapura District, the annual average growth rates were 2.1% in the 1960s and 0.7% in the 1970s, both of which were lower than the national urban average of 4.4% and 1.1%, respectively. The average growth rate in the period from 1981 to 2001 was 1.26%, marginally higher than the national average of 1.16%.

On the contrary, the annual average growth rates in the rural areas were 4.5% in the 1960s and 4.6% in the 1970s, both of which were significantly higher than the national average of 1.8% and 1.7%, respectively. The average growth rate in the period from 1981 to 2001 was 1.19%, which is also a little bit higher than the national average of 1.16%.

The rural population in Anuradhapura District has increased from 246,900 in 1963 to 692,500 in 2001 or 2.8 times during this period. The annual growth rates of the national population were 2.7% in the period to 1963, and 2.3%, 1.6%, 1.16% and 0.71% in the subsequent periods to 1971, 1981, 2001 and 2012 respectively.

Therefore, even though the agricultural development policy will be assumed, it is considered that the high growth rate which occurred in the period from 1981 to 2001 in Anuradhapura District cannot be expected in the future. Then, the GNDs in the study area are classified into four types in consideration of local conditions as shown below. The annual average growth rate of 1.2% for 1981 to 2001 is applied to GNDs adjoining the GNDs with the national roads, 0.3%-increased 1.5% to the GNDs with the national roads and 0.3%-decreased 0.9% to remaing GNDs except for the GNDs currently forming the urban centre of each DSD and its surrounding area to which 1.8% is applied due to the high potential for future development, since they are located at the crossings of national roads.

GNDs with a main road	1.5%
GNDs adjoining to the above GNDs	1.2%
Remaining GNDs	0.9%
GND as the city centre and its surrounding GNDs	1.8%

The population projection is summarized in **Table 4.2** (The GND-level population in Census 2012 was not available at the time of population projection.).

Table 4.2 Population Projection in the Study Area

	Census	Estimated Population			Annual Average Growth Rate (%)		
	2001	2012	2024	2034	2012/2001	2024/2012	2034/2012
Padaviya	21,146	24,403	28,583	32,655	1.31	1.33	1.33
Kebithigollewa	19,457	23,007	27,661	32,276	1.54	1.55	1.55
Horoupothana	29,642	34,374	40,462	46,412	1.36	1.37	1.37
Kahatagasdigillia	33,572	39,096	46,234	53,219	1.39	1.41	1.41
Sub-total	**103,817**	**120,880**	**142,940**	**164,562**	**1.39**	**1.41**	**1.41**
Medawachchiya	40,469	47,533	56,688	65,677	1.47	1.48	1.48
Rambewa	31,604	36,325	42,355	48,207	1.27	1.29	1.29
Sub-total	**72,073**	**83,858**	**99,043**	**113,884**	**1.39**	**1.40**	**1.40**
Total	**175,890**	**204,738**	**241,983**	**278,446**	**1.39**	**1.40**	**1.41**

The gap of design population between NWSDB Pre-Feasibility Study Report and JICA study is described in **Appendix 4.1** for reference.

4.2.4 Demarcation of Design Service Area by Water Supply Mode

In the study area, the population is distributed extensively and the population density is low. The maximum population density is 15.4 persons/ha in Medawachchiya West (Medawachchiya GND 67) followed by 6.6 persons/ha in Medawachchiya East (Medawachchiya GND 68), 5.6 persons/ha in Elikimbulagala (Padaviya GND 7) and 5.6 persons/ha in Pandukabhayapura (Rambewa GND 115), respectively, with about 87.7% of GNDs having a population density of less than 2 persons/ha (**Figure 4.2**). In fact, in some sections even along the main roads, there is no housing unit or housing units are very sparsely distributed. Hence, the idea that a water distribution network will be developed along with the road network is obviously not cost-effective.

For this reason, it is necessary to categorize the GNDs into two groups, namely, (1) ones to provide a piped water supply system and (2) the others to deliver water by any other means, for example, the use of water bowsers, which are called “the isolated areas”.

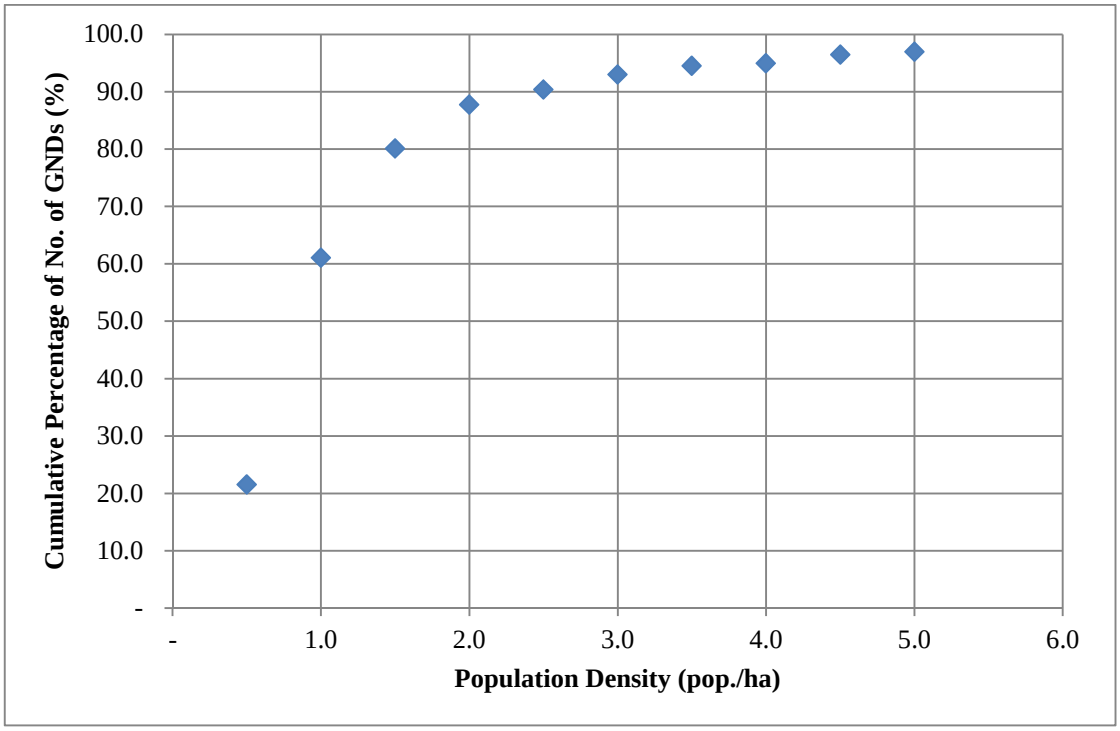


Figure 4.2 Distribution of GND Population Density in the Study Area (2001)

The following four factors are considered for the identification of isolated areas (GNDs):

1) **Figure 4.3** shows the distribution of existing water supply systems by category such as NWSDB, ADB-3rd, ADB-4th and CWSSP.
2) **Figure 4.4** shows the location of structures such as a water treatment plant, pumping stations and service reservoirs proposed for an integrated water supply system, as well as the routes in which water transmission mains will be installed. In the construction of a

new system, cooperation of the residents is indispensable and special attention should be paid for the provision of water distribution pipes to respond to their high expectations.

3) **Figure 4.5** shows the urban centre of respective DSDs and their surrounding GNDs, which have a high potential for development in the future
4) **Figure 4.6** shows the route of main roads compared to the location of GNDs. The main roads designated below have a potential for development following the urban centre in the study area as stated in 3) above.

   Class A national road: A9, A12, A14, A20
   Class B national road: B282, B283, B211, B538

These four factors are prioritized from the viewpoint of importance as follows:

Since one of the purposes of the Project is to integrate the existing small-scale water supply systems into two large-scale ones, the first priority should be given to GNDs with an existing water supply system. This is followed by GNDs and the surrounding ones, where the structures proposed for an integrated water supply system will be located as well as the routes that water transmission mains will be installed to respond to their cooperation to the construction works and high expectation for connection. From the viewpoint of development potentiality in the future, the urban center and GNDs along main roads have the third and fourth priority.

The priority of factors is summarized below.

1st GNDs with an existing water supply system
2nd GNDs where the facilities of a proposed water supply system are included
3rd GNDs covering a urban centre including its surrounding GNDs
4th GNDs along with main roads designated

From the overlapping of these factors, the following three options are developed:

Option 1 (refer to **Figure 4.7**): All

Existing system + Proposed system + Urban centre + Main roads

Option 2 (refer to **Figure 4.8**):

Existing system + Proposed system + Urban centre

Option 3 (refer to **Figure 4.8**):

Existing system + Proposed system

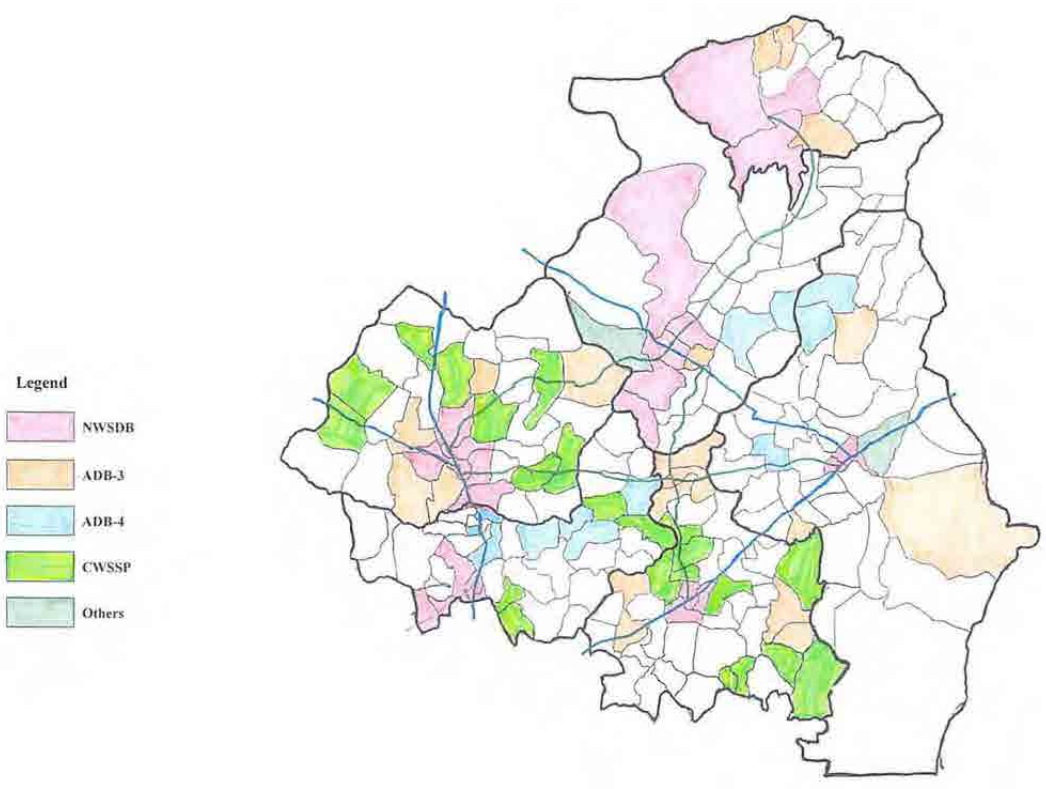


Figure 4.3 Existing Water Supply Scheme in the Study Area

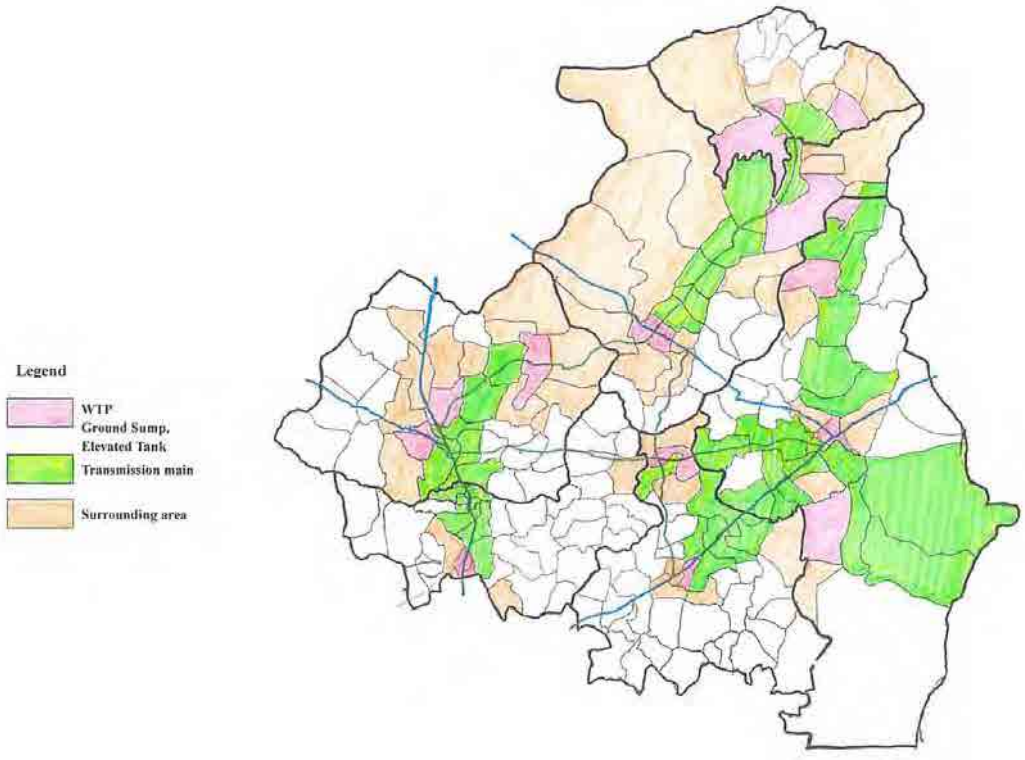


Figure 4.4 Proposed Water Supply Scheme in the Study Area

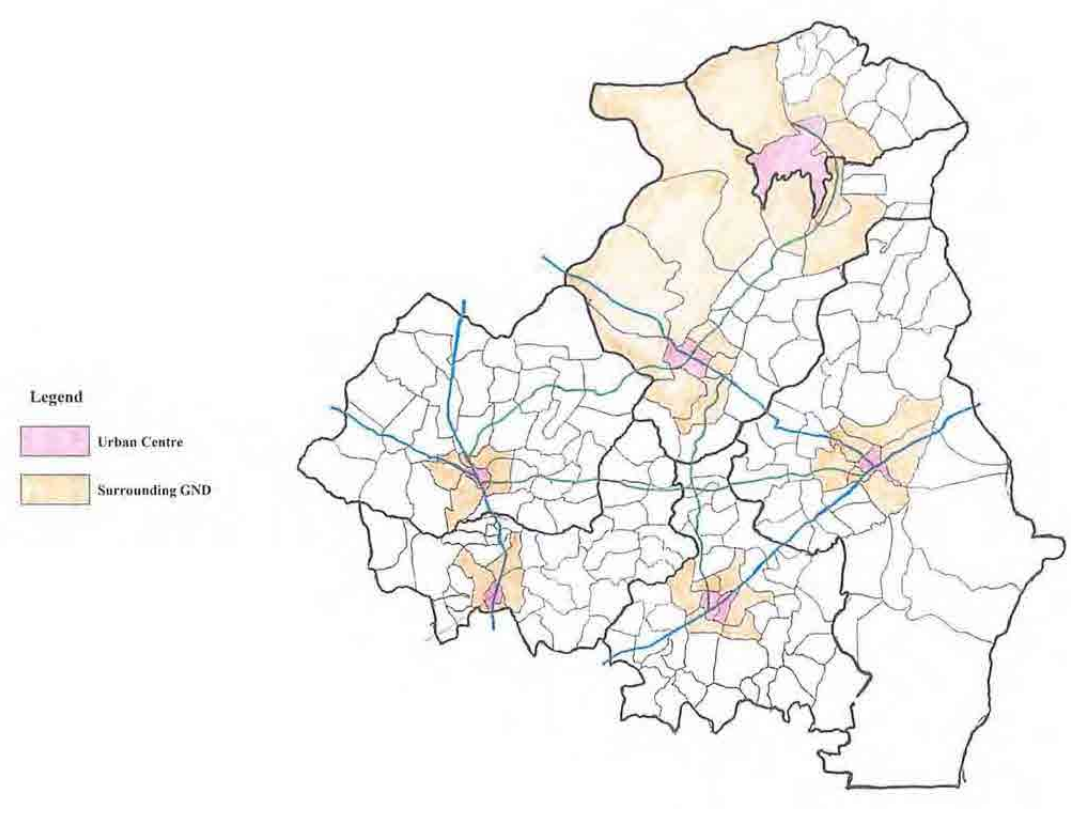


Figure 4.5 Urban Centre

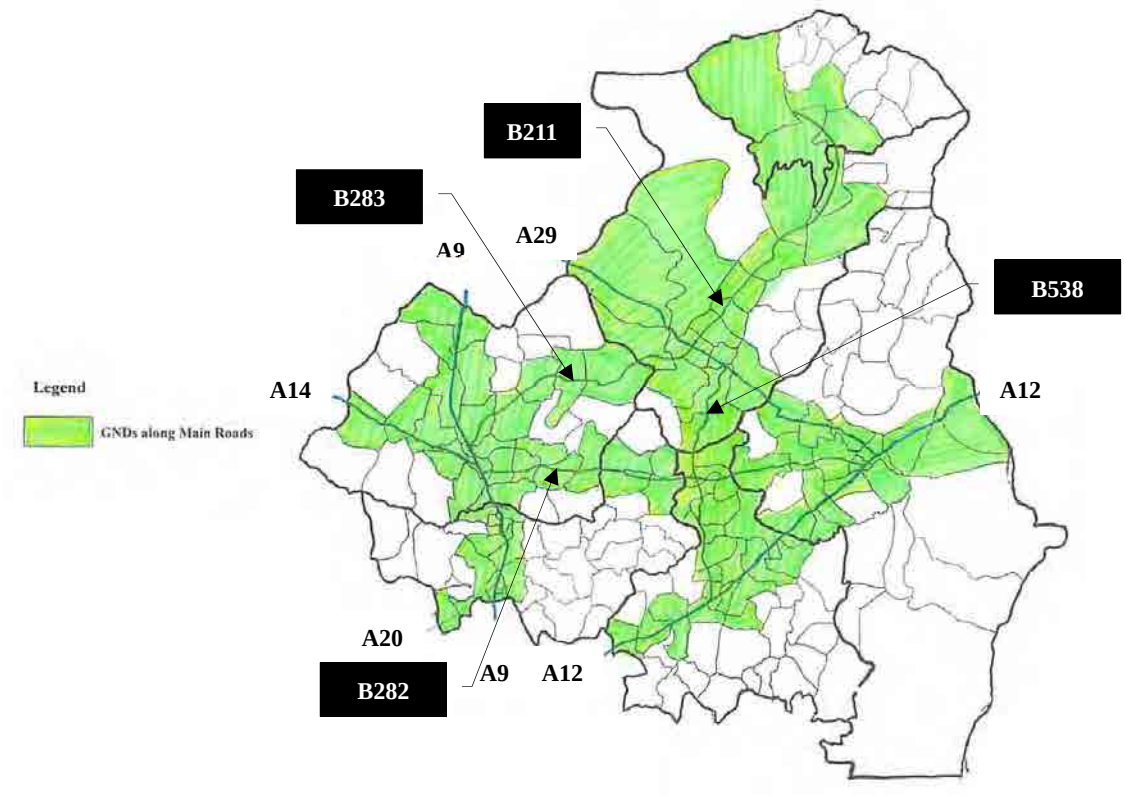


Figure 4.6 Main Road

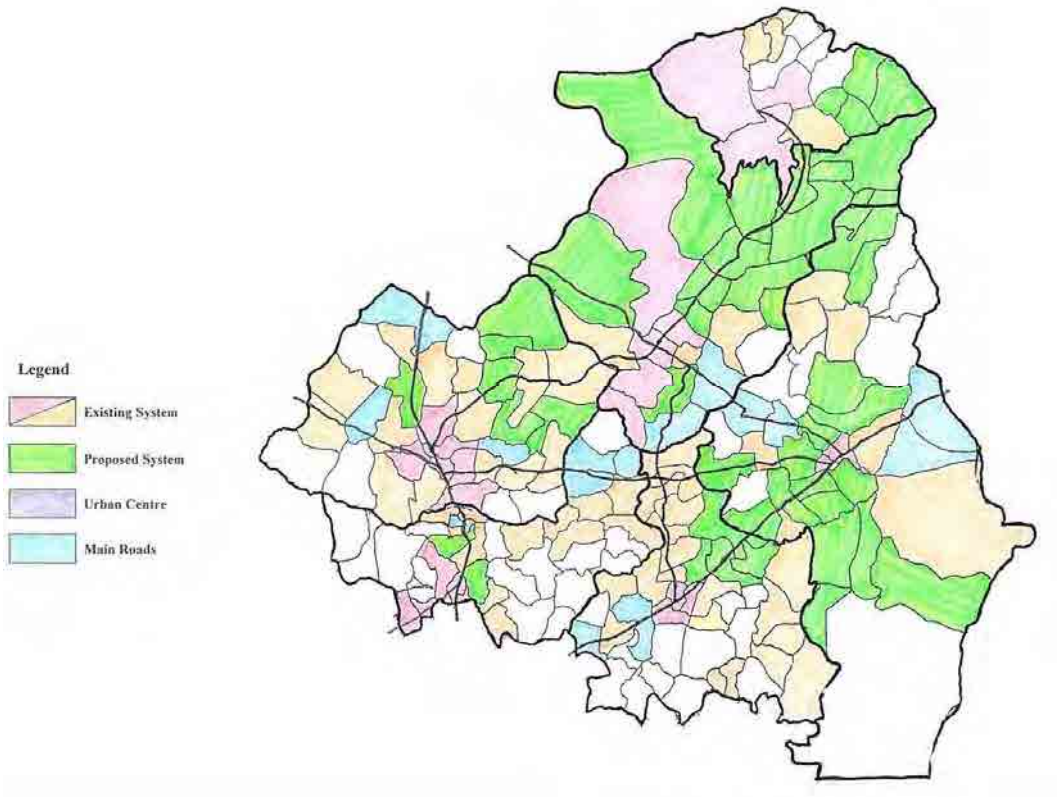


Figure 4.7 Option 1 (No. of Isolated Areas: 47 GNDs)

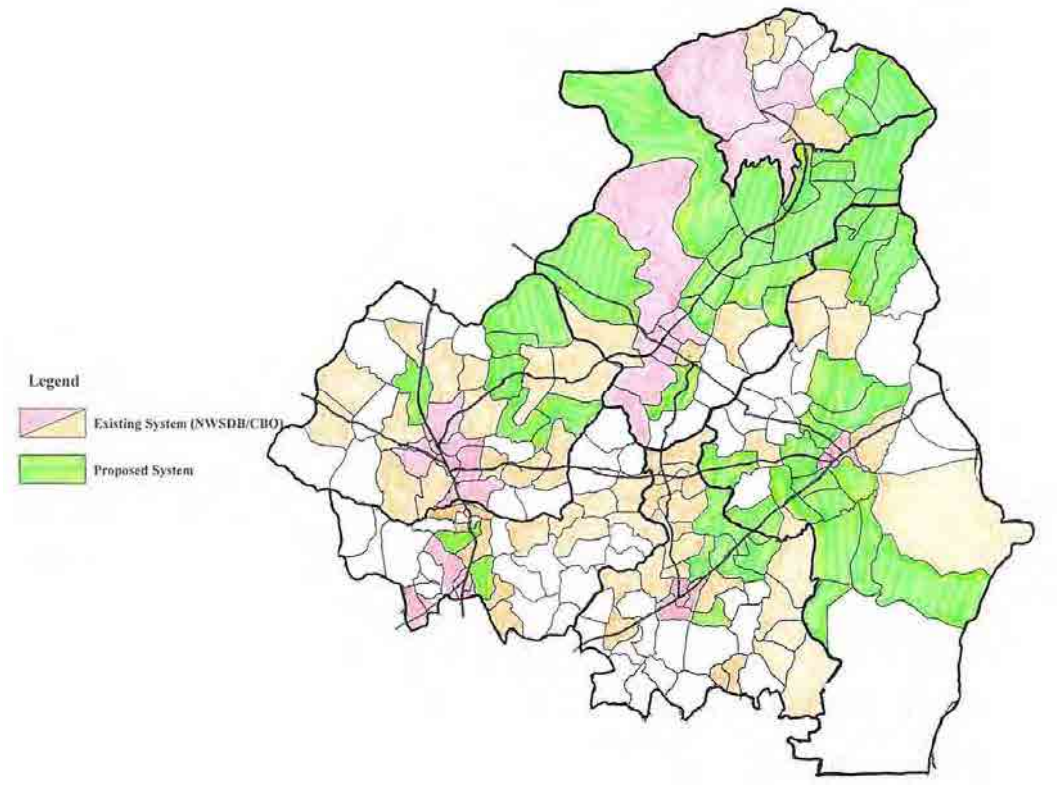


Figure 4.8 Option 2&3 (No. of Isolated Areas: 61 GNDs)

Option 2 shows the same result as that of Option 3, since all the GNDs involved in the urban centres are also involved in the category of existing and/or proposed water supply systems.

.

The GNDs which are excluded from the above options are then identified and termed as "**isolated areas**", for which a different water supply system to a piped water supply system shall be considered for these areas.

The results of water demand estimation by option are shown in **Table 4.3** in brief (refer to **Appendix 4.2(b)** for details).

Table 4.3 Comparison of Three Options

Option	Design pop. (pers.)	No. of GNDs as isolated areas	Design water demand on the daily maximum basis (m3/day)	
			Mahakanadarawa	Wahalkada
1	**278,446**	**47**	**17,900**	**27,400**
2&3	278,446	61	16,500	25,800

In **Table 4.3**, the results of Options 2 and 3 are exactly the same, which means that GNDs as the city centre has been already included in other three factors.

4.2.5 Existing CBOs to Be Excluded from Integration

1) No problem in Fluoride Concentration

According to **Table 4.4**, out of 50 existing CBO water supply schemes, water quality examination was done at 33 CBOs and 5 CBOs show fluoride concentrations of below the Sri Lankan drinking standard. The operational status of these CBOs is shown in **Table 4.4** involving several problems.

Table 4.4 CBOs with No problem in Fluoride Concentration

S/N	Name of CBO	Supply Service hours/day	Fluoride (mg/L)	Extent of Satisfaction		Major Problem, if any	Connected to ANIWSS?
				Quantity	Quality		
09	Mahasen CBO	24/6	0.39 / 0.3	Tolerable	Satisfy	Limited water Aug. - Oct.	Yes
10	Dimuthu CBO	24/3	0.1	Tolerable	Satisfy	Limited water Aug. - Oct.	Yes
20	Diriyamatha CBO	24	0.28 / 0.44 / 0.32	Satisfy	Satisfy		**No**
25	Shakthi CBO	24	0.1	Tolerable	Problem	High Iron 3.3 mg/L	Yes
47	Tristar CBO	24	0.001	Satisfy	Satisfy		**No**

Source: Prepared by the Study Team based on "Existing CBO Water Supply Scheme Survey"

- Problem in water quality 1 CBO (25)
- Limited water supply during Aug. to Oct. 2 CBOs (09,10)

Note: Figures in parentheses shows S/N of CBO in **Table 4.12.**

As a result, two CBOs (20 and 47) has no problem in quantity and quality.

2) CBO Located Far Away from Proposed Transmission Main Routes

Table 4.5 shows the existing CBO water supply schemes locating far away from proposed transmission main routes. These CBOs have also many problems in operation.

Table 4.5 CBOs Located Far Away from Proposed Transmission Main Routes

S/N	Name of CBO	Supply Service hours/day	Fluoride (mg/L)	Extent of Satisfaction		Major Problem, if any	Connected to ANIWSS?
				Quantity	Quality		
01	Swashakthi CBO	24/5	0.85	Shortage	Satisfy	4hrs. Supply in dry period	Yes
07	Nildiyadahara CBO	24/5	0.72 / 0.47 / 1.0	Tolerable	Problem	Limited water Aug. - Oct.	Yes
09	Mahasen CBO	24/6	0.39 / 0.3	Tolerable	Satisfy	Limited water Aug. - Oct.	Yes
11	Pragathi CBO	24	1.1	Satisfy	Satisfy		Yes
26	Al-Naja	-	-	-	-	Not yet commissioned	**No**
34	Sobasisila CBO	24/4	0.78	Tolerable	Satisfy	4hrs. Supply in dry period	Yes
41	Pinibindu CBO					Rainwater Supply	Yes
42	Sham Sham	24		Poor	Poor		Yes
43	Ekamuthu CBO	24/2	1.27	Shortage	Satisfy		Yes
45	Upul CBO	24	1.51	Satisfy	Problem	High Flouride	Yes
46	Jalasavi	24		Satisfy	Problem	High Flouride 1.58 mg/L	Yes

Source: Prepared by the Study Team based on "Existing CBO Water Supply Scheme Survey"

- High fluoride concentration above the standard 7 CBOs (01, 07, 11, 34, 43, 45, 46)
- Limited water supply during Aug. to Oct. 3 CBOs (07, 09, 43)
- Limited water supply in dry period 2 CBOs (01, 34)
- Not yet commissioned 1 CBO (26)
- Rainwater supply 1 CBO (41)
- Poor in quantity and quality 1 CBO (42)

Note: Figures in parentheses shows S/N of CBO in **Table 4.13**.

Although there is no information on the operational status of S/N 26 Al-Naja due to "not yet commissioned", but it is considered in good conditions due to the latest water supply scheme.

Therfore, the following three CBOs, namely 2 CBOs of "No problem in Fluoride Concentration" group and one CBO of "CBO Located Far Away from Proposed Transmission Main Routes" group, are considered to have no necessity to connect to the proposed integrated water supply system

- 20. Diriyamatha CBO (Maha Kumbugollawa [GND S/N 46])
- 47. Tristar CBO (Agunuchchiya [GND S/N 119])
- 26. Al-Naja (Muslim Attaweerawewa [GND S/N 32])

4.2.6 Breakdown of Water Consumption

The breakdown of water consumption in 19 water supply systems under NWSDB in the Anuradhapura District in March 2012 is shown in **Appendix 4.2(a)**. Based on the rate of the number of connections to the total number of connections, such areas are divided into three

groups, namely (1) large (more than or equal to 10%), (2) middle (5% to 10%) and (3) small (less than 5%) for comparison as shown in **Table 4.6**. All five DSDs in the study area except for Rambewa which are included in Anuradhapura North and Mihintale Systems, are classified into the small-scale group.

Table 4.6 Breakdown of Water Consumption in Anuradhapura District (March 2012)

(a) Number

Category	Large-scale (.>10%)		Middle-scale (5%~10%)		Small-scale (≤5%)		Overall	
	Conn. (nos.)	Cons. (m3/mo.)	Conn. (nos.)	Cons. (m3/mo.)	Conn. (nos.)	Cons. (m3/mo.)	Conn. (nos.)	Cons. (m3/mo.)
Domestic	20,343	324,026	19,658	267,402	9,514	121,363	49,515	712,791
Schools	32	13,585	57	5,006	31	3,993	120	22,584
Govt. institution	196	31,088	155	6,423	121	10,270	472	47,781
Army	24	51,831	9	13,463	10	1,977	43	67,271
Police	9	2,916	17	2,122	14	2,764	40	7,802
Hospitals	16	25,128	25	3,318	22	5,580	63	34,026
Commercial/Industrial	2,079	50,691	1,010	13,648	938	16,290	4,027	80,629
Religious	97	5,481	119	46,709	54	3,154	270	55,344
Others	110	2,532	135	8,388	56	701	301	11,621
Total	22,906	507,278	21,185	366,479	10,760	166,092	54,851	1,039,849

(b) Percentage

Category	Large-scale (.>10%)		Middle-scale (5%~10%)		Small-scale (≤5%)		Overall	
	Conn. (%)	Cons. (%)	Conn. (%)	Cons. (%)	Conn. (%)	Cons. (%)	Conn. (%)	Cons. (%)
Domestic	88.8	63.9	92.8	73.0	88.4	73.1	90.3	68.5
Schools	0.1	2.7	0.3	1.4	0.3	2.4	0.2	2.2
Govt. institution	0.9	6.1	0.7	1.8	1.1	6.2	0.9	4.6
Army	0.1	10.2	0.0	3.7	0.1	1.2	0.1	6.5
Police	0.0	0.6	0.1	0.6	0.1	1.7	0.1	0.8
Hospitals	0.1	5.0	0.1	0.9	0.2	3.4	0.1	3.3
Commercial/Industrial	9.0	10.0	4.8	3.7	8.7	9.8	7.3	7.7
Religious	0.4	1.1	0.5	12.7	0.5	1.9	0.5	5.3
Others	0.5	0.5	0.6	2.3	0.5	0.4	0.5	1.0
Total	99.9	100.1	99.9	100.1	99.9	100.1	100.0	99.9

Source: NWSDB

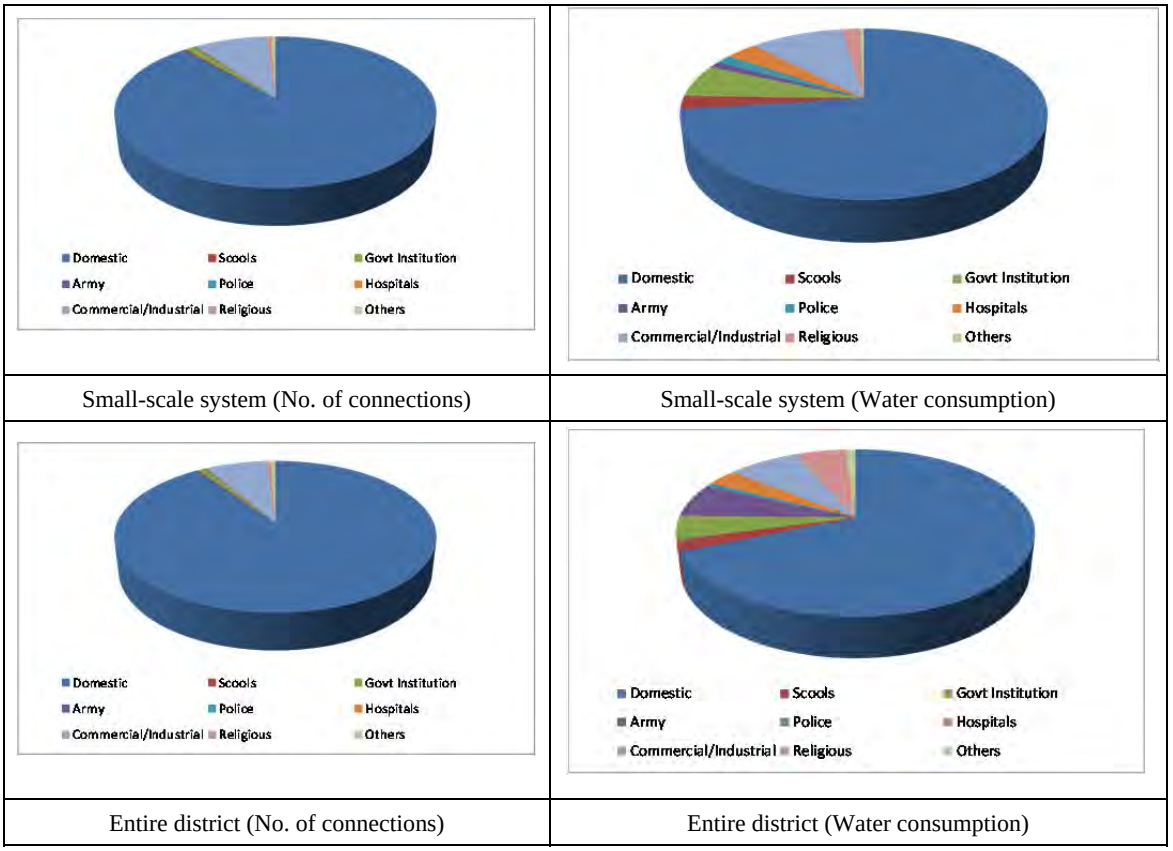
Note:

1) "Domestic" means the summation of "Domestic", "Board quarters", "Govt. Quarters" and "Domestic Samurdhi".
2) "Commercial/Industrial" the summation of "Commercial Institution", "Tourist/Guest", "Industrial/Construction" and "Other Commercial and Private".
3) "Others" means the summation of "Tenaman Garden", "Stand Post", "Garden Taps" and "NWSDB premises".
4) The percentage of "Domestic Samurdhi" is 0.1% in the number of connections and 0.1% in monthly consumption.
5) Stand post counts 65 units with a total consumption of 376 m3/month.

Classification of areas is as follows:

Large (3): Anuradhapura, Anuradhapura North, Anuradhapura East
Middle (6): Kekirawa, Ipalogama, Sacret City, Tambuttegama, Galnawa,Talawa
Small (10): Eppawala, Habarana, Horowpothana, Kahatagasdigilia, Kebithigollewa, Maradankadawala, Medawachchiya, Mihintale, Padaviya Village, Nachchaduwa

In a small-scale water supply systems, domestic connections account for about 90% of the total number of connections, but about 75% of water consumption followed by 15% for institutional use and 10% for commercial/industrial use, as shown in **Figure 4.9**. For the entire district, the percentage of army and religious uses is higher than that in the small-scale group, whereas domestic use is 5% lower than that in the small-scale group.



Small-scale system (No. of connections)	Small-scale system (Water consumption)
Entire district (No. of connections)	Entire district (Water consumption)

Source: Prepared by the Study Team based on ***Table 4.6***

Figure 4.9 Composition of Consumption in the Small-Scale Group and Entire District

Based upon the above, non-domestic water use equivalent to 35 % of domestic consumption is added to the per capita water consumption in order to calculate the water demand projection.

4.2.7 Per Capita Domestic Water Consumption

(1) Pipe Borne Water Supply

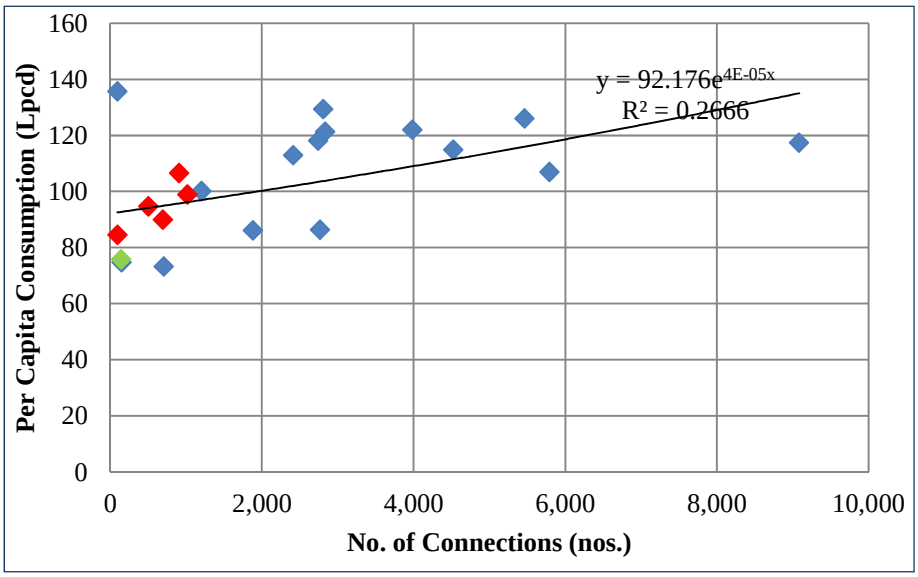
Per capita water consumption is calculated by dividing the water consumption by served population, which is obtained from the number of connections and per house unit population. The relationship between the number of connections and per capita water consumption is shown in **Table 4.7** and **Figure 4.10**.

There is a trend that the higher the number of connections the bigger is the per capita water consumption, although the correlation between the two is not so strong.

Table 4.7 Relationship between No. of Connections and Per Capita Consumption

Area No.	Location	Consumption (m^3/mo.)	Connection (nos.)	Consumption (Lpcd)	Family Size (pers./HU)
1	Anuradhapura	160,833	9,085	117	5.03
27	Anuradhapura North	79,363	5,794	107	4.27
30	Anu-East	83,830	5,464	126	4.06
18	Sacret City	66,526	4,524	115	4.27
28	Thalawa	55,658	3,983	122	3.82
13	Ipalogama	38,382	2,836	121	3.72
25	Galnawa	38,595	2,809	129	3.54
10	Kekirawa	30,782	2,766	86	4.30
21	Thambuththega	37,459	2,740	118	3.86
14	Mihinthale	35,215	2,413	113	4.31
29	Nachchaduwa	21,318	1,884	86	4.38
11	Maradankadawala	14,436	1,202	100	4.00
12	Medawachchiya	13,005	1,017	99	4.31
8	Kahatagasdigiliya	11,890	907	107	4.10
5	Habarana	8,464	705	73	5.47
9	Kebithigollewe	8,567	693	90	4.58
15	Padaviya Village	5,863	502	95	4.11
III	Mahakanadaeawa Yaya 02-93	1,170	151	75	3.46
II	Mahakanadarawa Yaya 01-94	1,182	142	76	3.66
4	Eppawala	1,617	96	136	4.14
7	Horowpothana	988	95	85	4.10

Source: Prepared by the Study Team using NWSDB data



Source: Prepared by the Study Team

Note: Red and green marks show NWSDB and DBO systems, respectively, in the study area.

Figure 4.10 Relationship between No. of Connections and Per Capita Consumption

The existing CBO water supply scheme survey reveals that the average per capita consumption is 66 Lpcd at 46 CBOs during three months from February to April 2012 with no fear of water shortage due to the rainy season. Its frequency distribution is shown in **Figure 4.11**. While they are in the range of 85 to 107 Lpcd at five water supply systems under NWSDB located within the study area as shown in **Table 4.7**. Although there is an obvious gap between both per capita consumptions, this is caused by the service area of the NWSDB system covering the urban center and its surrounding area of each DSD where the water consumption is generally higher than the rural area.

The low per capita consumption at the existing CBOs suggests the following three possibilities:

- Unreliability on the existing CBO water supply (quantity, quality, operation, etc.)
- Selective use of either well water and tap water by use
- Affordability –to-pay for CBOs' water tariff

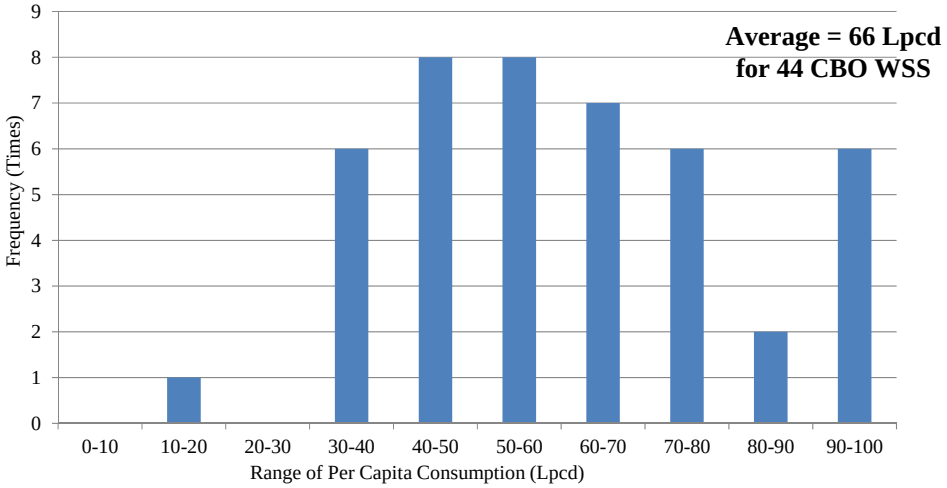


Figure 4.11 Frequency Distribution of Per Capita Consumption at Existing CBOs

Since the NWSDB water supply system covers the core area of the respective DSDs, which is the most developed area in the study area, the per capita water consumption is considered to be relatively higher than in other areas. Therefore, the per capita water consumption is set at 80 Lpcd for the year of 2012 with an annual increment of 0.5 Lpcd. Accordingly, the per capita water consumption is 86 Lpcd in 2024 and 91 Lpcd in 2034.

(2) Bowser Water Supply

However, for the isolated areas, as discussed later, the per capita water consumption is fixed at 10 Lpcd with no annual increment, since the NWSDB Guidelines for rural Water Supply says that *"The strategy to supply safe drinking water to these communities would be to develop a means of providing a supply of treated water exclusively for drinking and cooking purposes. A per capita supply of 5 – 6 Lpcd is considered adequate."*

4.2.8 Non-revenue Water (NRW)

The average NRW ratio of NWSDB in 2009 is 53.05% on national average in CMC, compared to 31.07% island wide in the same year, which shows the relatively low value in the developing countries as shown in **Table 4.8**. It is 19.8% especially in RSC (N/C) which is better following 13.8% in RSC(North-Western) and 16.4% in RSC(North).

Table 4.8 Non-Revenue Water Ratio

	2005	2006	2007	2008	2009
CMC	51.25	51.83	53.19	53.96	53.05
Island wide	33.83	34.37	33.09	32.13	31.07
RSC (North Central)				19.80	

Source: NWSDB, "Annual Report 2009"

In the project, the water distribution facilities in the existing water supply schemes will be used for the proposed integrated water supply system as much as possible; however since water transmission and other distribution pipelines will be newly installed, the present NRW level of 20% in Anuradhapura District is assumed to be maintained in the future.

4.2.9 Design Served Population

(1) Pipe Borne Water Supply

The change in the number of connections for 2001-2012 at five water supply systems under NWSDB in the study area is shown in **Figure 4.12**.

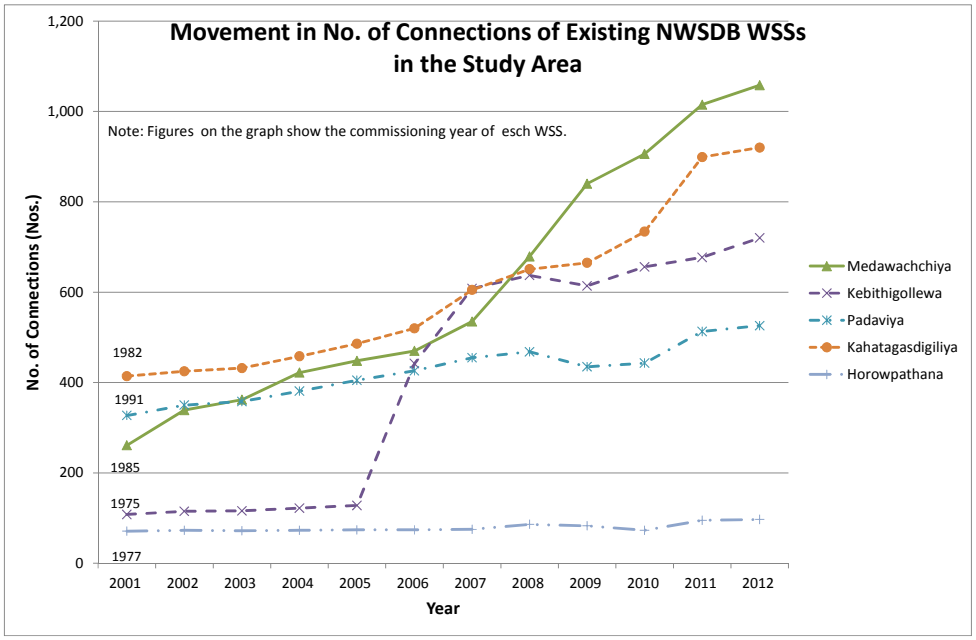


Figure 4.12 Change in the No. of Connections at Five Water Supply Systems under NWSDB

Taking into account the commissioning year of each system as shown in **Figure 4.12**, the increase of connection number in the past was very slow even in the study area. The annual increase from the commissioning year to 2001 is 32.7 connections in Padaviya, 10.8 connections in Kebithigollewa, 3.0 connections in Horowpothana, 21.8 connections in Katahagasdigiliya and 16.3 connections in Medawachchiya, although 314 connections was recorded at Kebithigollewa in 2006. Since the people with high expectation for pipe bore water supply would like to connect to a system as soon as possible, the connection works to a system will have a peak during a few years after the completion of a system and thereafter become slow in general.

In the GNDs with an existing system, the population coverage is assumed to grow linearly from the present coverage to 100% in 2034, while in those with no system, the population coverage is assumed to become larger in the later years

(2) Bowser Water Supply

Water supply in the isolated area will be done regularly using water bowsers and arranging the water tank at the convenient locations for water fetching of the people. Population coverage is set at 100% constant.

4.2.10 Design Load Factor to Daily Maximum Water Supply

The monthly fluctuation of five NWSDB water supply systems in the study area is shown in **Table 4.9**, in which the maximum monthly demand varies from 1.18 to 1.23 times the average monthly demand with an average of 1.15. The conversion factor from the average daily demand to the maximum daily demand, which is usually higher than that to the maximum monthly demand, is set at 1.20.

Table 4.9 Monthly Water Supply Fluctuation in NWSDB Systems in the Study Area

	Padaviya Village				Horowpothana				Kahatagosdigiliya				Kebithigollewe				Medawachchiya				Total			
	Conn.	Cons.	Per Conn.		Conn.	Cons.	Per Conn.		Conn.	Cons.	Per Conn.		Conn.	Cons.	Per Conn.		Conn.	Cons.	Per Conn.		Conn.	Cons.	Per Conn.	
	(nos.)	(m3/mo.)	(m3/mo.)	(%)	(nos.)	(m3/mo.)	(m3/mo.)	(%)	(nos.)	(m3/mo.)	(m3/mo.)	(%)	(nos.)	(m3/mo.)	(m3/mo.)	(%)	(nos.)	(m3/mo.)	(m3/mo.)	(%)	(nos.)	(m3/mo.)	(m3/mo.)	(%)
Jan.	577	9,230	16.0	0.86	158	2,885	18.3	0.91	948	13,399	14.1	0.93	822	9,764	11.9	0.80	1,186	17,212	14.5	0.89	3,691	52,490	14.2	0.88
Feb.	577	10,291	17.8	1.06	159	2,430	15.3	0.84	955	13,222	13.8	1.01	823	9,971	12.1	0.91	1,188	15,736	13.2	0.90	3,702	51,650	14.0	0.96
Mar.	577	9,413	16.3	0.88	161	2,487	15.4	0.77	975	13,216	13.6	0.90	825	9,855	11.9	0.80	1,188	19,301	16.2	1.00	3,726	54,272	14.6	0.90
Apr.	578	10,431	18.0	1.00	163	3,223	19.8	1.02	983	14,621	14.9	1.02	825	12,615	15.3	1.07	1,188	16,104	13.6	0.87	3,737	56,994	15.3	0.98
May	578	11,136	19.3	1.04	163	3,049	18.7	0.93	1,005	12,941	12.9	0.85	828	12,398	15.0	1.01	1,202	20,846	17.3	1.07	3,776	60,370	16.0	0.99
Jun.	578	12,786	22.1	1.23	165	3,350	20.3	1.05	1,017	15,413	15.2	1.04	830	14,050	16.9	1.18	1,204	19,610	16.3	1.04	3,794	65,209	17.2	1.10
Jul.	578	11,383	19.7	1.06	165	3,351	20.3	1.01	1,017	18,902	18.6	1.23	831	13,607	16.4	1.11	1,204	23,180	19.3	1.19	3,795	70,423	18.6	1.15
Aug.	582	11,462	19.7	1.06	168	3,689	22.0	1.10	1,032	15,481	15.0	0.99	835	13,231	15.8	1.07	1,209	21,864	18.1	1.11	3,826	65,727	17.2	1.06
Sep.	582	11,153	19.2	1.07	168	3,907	23.3	1.20	1,049	17,222	16.4	1.12	846	13,842	16.4	1.15	1,214	21,065	17.4	1.11	3,859	67,189	17.4	1.11
Oct.	584	11,300	19.3	1.04	168	3,657	21.8	1.09	1,060	17,304	16.3	1.08	848	12,579	14.8	1.00	1,233	19,689	16.0	0.99	3,893	64,529	16.6	1.03
Nov.	584	9,698	16.6	0.92	168	3,364	20.0	1.03	1,076	14,367	13.4	0.92	848	11,761	13.9	0.97	1,234	18,619	15.1	0.96	3,910	57,809	14.8	0.95
Dec.	590	8,982	15.2	0.82	170	3,412	20.1	1.00	1,084	14,053	13.0	0.86	851	11,185	13.1	0.89	1,256	17,283	13.8	0.85	3,951	54,915	13.9	0.86
Ave.	580	349		0.601	165	107		0.647	1,017	495		0.487	834	398		0.477	1,209	633		0.524	3,805	1,982		0.521

4.2.11 Design Daily Average and Maximum Water Supply and Design Production Capacity

The design fundamentals are summarized in **Table 4.10** and **Figure 4.13** shows the service area of water borne and bowser water supply. Yearly change of design daily average water supply, design daily maximum water supply and design water production is shown in **Table 4.11** for Mahakanadarawa System and Wahalkada System, respectively. Design water production capacity is set so as to have 5% allowance to design daily maximum water supply taking into account the miscellaneous use of water at a water treatment plant.

Table 4.10 Summary of Design Fundamentals

Design Water Demand		Application to Facility Design	Unit	Mahakanadarawa System			Waghalkada System		
Water Supply Mode				Pipe Borne Water Supply	Bowser Water Supply	Total	Pipe Borne Water Supply	Bowser Water Supply	Total
Design Population			(prs.)	92,597	19,303	111,900	144,745	16,723	161,468
Per Capita Domestic Water Consumption	= 80 + 0.5 x (2034 - 2012) = 91		(Lpcd)	91	10		91	10	
Premium for Non-domestic Water (35%)	= 1.35			1.35	1		1.35	1	
NRW Ratio (20%)	= 100 / (100 - 20) = 1.25			1.25	1		1.25	1	
Design Daily Average Water Supply (Dave)			(m^3/day)	14,219	193	14,412	22,227	167	22,394
Design Load Factor to Dmax	= 1.2								
Design Daily Maximum Water Supply (Dmax)	= Dave x 1.20	Transmission facility	(m^3/day)			17,294			26,873
Design Peak Factor	= 2.0								
Design Hourly Maximum Water Supply (Hmax)	= Dmax x 2.0	Dstribution facility	(m^3/day)			34,588			53,746
Design Water Intake	= Dmax x 1.05	Intake pump station Raw water transmission facility WTP	(m^3/day)			18,245 18,200 ▲ 600			28,217 28,200 ▲ 600
Water Right			(m^3/day)			**18,800**			**28,800**

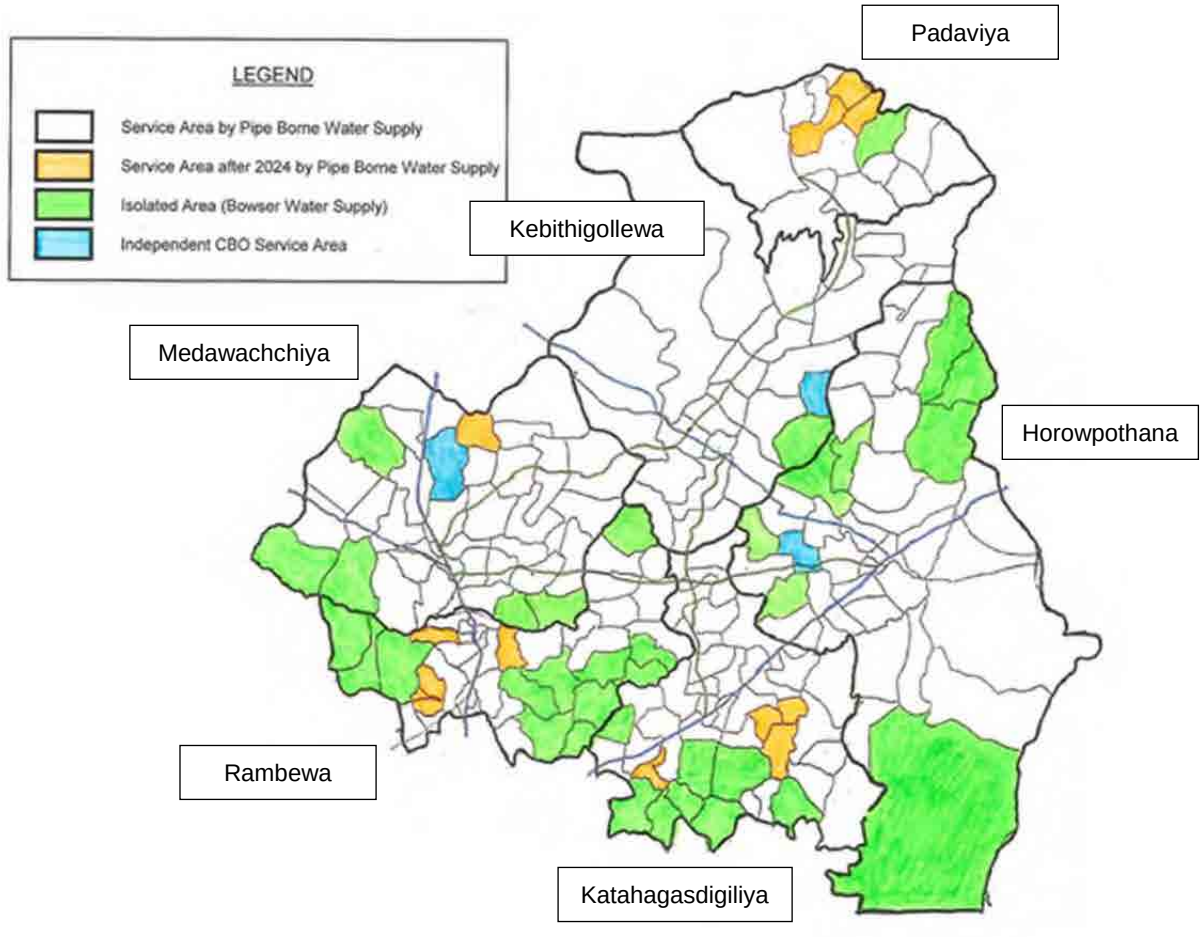


Figure 4.13 Service Area by Pipe Borne and Bowser Water Supply

Table 4.11 Annual Change in Design Daily Average and Maximum Water Supply

Mahakanadarawa System (Encl. Independent CBO)

		2012 *3	2014 *3	2016 *3	2018	2020	2022	2024	2026	2028	2030	2032	2034
Total Population (persons)		**83,858**	**86,208**	**88,626**	**91,120**	**93,684**	**96,321**	**99,043**	**101,838**	**104,719**	**107,686**	**110,736**	**113,884**
46 - Maha Kumbukgollewa *1	Population	1,430	1,473	1,518	1,564	1,611	1,660	1,710	1,761	1,815	1,870	1,926	1,984
	Served Population	286	589	789	860	886	996	1,026	1,233	1,361	1,496	1,733	1,984
	Water Demand	39	81	109	120	126	143	149	181	202	225	263	305
Target Total Population (persons)		**82,428**	**84,735**	**87,108**	**89,556**	**92,073**	**94,661**	**97,333**	**100,077**	**102,904**	**105,816**	**108,810**	**111,900**
for Pipe Borne WS	Pipe Borne WSS	62,778	64,665	66,608	68,613	70,680	72,808	75,010	82,347	84,796	87,319	89,915	92,597
	(Existing)	46,591	48,010	49,473	50,982	52,541	54,141	55,802	57,512	59,277	61,098	62,974	64,912
	(New)	16,187	16,655	17,135	17,631	18,139	18,667	19,208	24,835	25,519	26,221	26,941	27,685
for Non Pipe Borne WS	Non Pipe Borne WSS	19,650	20,070	20,500	20,943	21,393	21,853	22,323	17,730	18,108	18,497	18,895	19,303
Coverage (%)		**31.4**	**59.4**	**63.0**	**65.2**	**67.5**	**69.7**	**72.0**	**74.8**	**82.1**	**88.4**	**94.7**	**100.0**
for Pipe Borne WS	Pipe Borne WSS	41.2	46.8	51.6	54.6	57.7	60.7	63.7	69.4	78.2	85.9	93.6	100.0
	(Existing)	56.0	60.0	64.0	68.0	72.0	76.0	80.0	84.0	88.0	92.0	96.0	100.0
	(New)	0.0	10.0	17.0	17.0	17.0	17.0	17.0	40.0	60.0	75.0	90.0	100.0
for Non Pipe Borne WS	Non Pipe Borne WSS	100	100	100	100	100	100	100	100	100	100	100	100
Served Population (persons) *2		**25,892**	**50,347**	**54,890**	**58,431**	**62,142**	**66,025**	**70,097**	**74,846**	**84,458**	**93,515**	**103,019**	**111,900**
for Pipe Borne WS	Pipe Borne WSS	25,892	30,277	34,390	37,488	40,749	44,172	47,774	57,116	66,350	75,018	84,124	92,597
	(Existing)	25,892	28,611	31,476	34,491	37,665	40,998	44,509	48,196	52,073	56,144	60,419	64,912
	(New)	-	1,666	2,914	2,997	3,084	3,174	3,265	8,920	14,277	18,874	23,705	27,685
for Non Pipe Borne WS	Non Pipe Borne WSS	-	20,070	20,500	20,943	21,393	21,853	22,323	17,730	18,108	18,497	18,895	19,303
Water Demand (Dave: m3/day)		**3,495**	**4,341**	**4,961**	**5,456**	**5,994**	**6,557**	**7,154**	**8,562**	**10,029**	**11,448**	**12,963**	**14,414**
Pipe Borne WS	Pipe Borne WSS	3,495	4,141	4,756	5,247	5,779	6,337	6,982	8,384	9,847	11,263	12,774	14,221
	(Existing)	3,495	3,913	4,354	4,828	5,341	5,882	6,459	7,075	7,728	8,429	9,175	9,970
	(New)	-	228	402	419	438	455	523	1,309	2,119	2,834	3,599	4,251
Non Pipe Borne WS	Non Pipe Borne WSS	-	200	205	209	215	220	172	178	182	185	189	193
Water Demand for Transmission (Dmax = Dave x 1.20 : m3/day)		**4,194**	**5,209**	**5,953**	**6,547**	**7,193**	**7,868**	**8,585**	**10,274**	**12,035**	**13,738**	**15,556**	**17,297**
Water Demand for Treatment (= Dmax x 1.05 : m3/day)		**4,400**	**5,500**	**6,300**	**6,900**	**7,600**	**8,300**	**9,000**	**10,800**	**12,600**	**14,400**	**16,300**	**18,200**

Wahalkada System (Encl. Independent CBOs)

		2012 *3	2014 *3	2016 *3	2018	2020	2022	2024	2026	2028	2030	2032	2034
Total Population (persons)		**120,880**	**124,293**	**127,794**	**131,417**	**135,150**	**138,985**	**142,940**	**147,008**	**151,200**	**155,525**	**159,978**	**164,562**
32 - Kurulugama *1		1,354	1,379	1,403	1,429	1,455	1,481	1,508	1,535	1,563	1,591	1,620	1,649
119 - Ihala Angunachchiya *1		1,041	1,073	1,105	1,139	1,173	1,208	1,245	1,283	1,321	1,361	1,402	1,445
Sub-Total		2,395	2,452	2,508	2,568	2,628	2,689	2,753	2,818	2,884	2,952	3,022	3,094
Served Population													
32 - Kurulugama *1		271	552	730	786	800	889	905	1,075	1,172	1,273	1,458	1,649
119 - Ihala Angunachchiya *1		208	429	575	626	645	725	747	898	991	1,089	1,262	1,445
Sub-Total		479	981	1,305	1,412	1,445	1,614	1,652	1,973	2,163	2,362	2,720	3,094
Water Demand													
32 - Kurulugama *1		37	75	101	110	113	128	131	158	174	191	221	253
119 - Ihala Angunachchiya *1		28	59	80	88	91	104	108	132	147	164	192	222
Sub-Total		65	134	181	198	204	232	239	290	321	355	413	475
Target Total Population (persons)		**118,485**	**121,841**	**125,286**	**128,849**	**132,522**	**136,296**	**140,187**	**144,190**	**148,316**	**152,573**	**156,956**	**161,468**
for Pipe Borne WS	Pipe Borne WSS	95,911	98,775	101,715	104,766	107,907	111,145	114,485	128,836	132,633	136,549	140,587	144,745
	(Existing)	49,985	51,530	53,117	54,762	56,462	58,216	60,026	67,997	70,064	72,193	74,394	76,664
	(New)	45,926	47,245	48,598	50,004	51,445	52,929	54,459	60,839	62,569	64,356	66,193	68,081
for Non Pipe Borne WS	Non Pipe Borne WSS	22,574	23,066	23,571	24,083	24,615	25,151	25,702	15,354	15,683	16,024	16,369	16,723
Coverage (%)		**22.7**	**51.2**	**62.7**	**64.8**	**66.9**	**69.1**	**71.6**	**74.2**	**80.7**	**87.1**	**93.6**	**100.0**
for Pipe Borne WS	Pipe Borne WSS	28.1	39.9	54.0	56.7	59.4	62.1	65.2	71.2	78.4	85.6	92.8	100.0
	(Existing)	54.0	18.0	62.0	66.0	71.0	75.0	79.0	59.0	80.0	84.0	87.0	91.0
	(New)	0.0	20.0	45.0	46.0	47.0	48.0	50.0	60.0	70.0	80.0	90.0	100.0
for Non Pipe Borne WS	Non Pipe Borne WSS	100	100	100	100	100	100	100	100	100	100	100	100
Served Population (persons) *2		**26,925**	**62,431**	**78,510**	**83,471**	**88,692**	**94,133**	**100,393**	**107,042**	**119,656**	**132,911**	**146,846**	**161,468**
for Pipe Borne WS	Pipe Borne WSS	26,925	39,365	54,939	59,388	64,077	68,982	74,691	91,688	103,973	116,887	130,477	144,745
	(Existing)	26,925	29,916	33,072	36,392	39,895	43,576	47,449	51,521	55,803	60,302	65,033	70,000
	(New)	-	9,449	21,867	22,996	24,182	25,406	27,242	40,167	48,170	56,585	65,444	74,745
for Non Pipe Borne WS	Non Pipe Borne WSS	-	23,066	23,571	24,083	24,615	25,151	25,702	15,354	15,683	16,024	16,369	16,723
Water Demand (Dave: m3/day)		**3,636**	**6,611**	**7,843**	**8,556**	**9,336**	**10,147**	**11,098**	**13,616**	**15,599**	**17,719**	**19,979**	**22,392**
Pipe Borne WS	Pipe Borne WSS	3,636	5,384	7,608	8,315	9,087	9,893	10,841	13,463	15,441	17,556	19,815	22,225
	(Existing)	3,636	4,203	4,577	5,097	5,658	6,248	6,888	7,566	8,286	9,058	9,874	10,748
	(New)	-	2,240	3,031	3,218	3,429	3,645	3,953	5,897	7,155	8,498	9,941	11,477
Non Pipe Borne WS	Non Pipe Borne WSS	-	1,227	235	241	249	254	257	153	158	163	164	167
Water Demand for Transmission (Dmax = Dave x 1.20 : m3/day)		**4,363**	**7,933**	**9,412**	**10,267**	**11,203**	**12,176**	**13,318**	**16,339**	**18,719**	**21,263**	**23,975**	**26,870**
Water Demand for Treatment (= Dmax x 1.05 : m3/day)		**4,600**	**8,300**	**9,900**	**10,800**	**11,800**	**12,800**	**14,000**	**17,200**	**19,700**	**22,300**	**25,200**	**28,200**

*1 GND excluded from integration

*2 Served population increases as the number of connections increases.

*3 The served population for both pipe borne and non pipe borne water supply before 2018 when the new water supply systems will enter into operation shows the potential figure.

*4 Some GNDs will shift from bowser service area to pipe borne water supply service area in Stage-2 (2025-2034)

4.2.12 Design Flow of Water Treatment Plants for Stage Construction

Both water treatment plants for Mahakanadarawa and Wahalkada Systems shall be constructed by stage construction. The reasons for stage construction is described in **Section 5.2.1**.

The design flow for Phase 1 (2024) and Long-term Plan (2034) is shown in **Table 4.12**.

Table 4.12 Design Flow of Water Treatment Plants for Stage Construction

	Stage-1 (2024)	Stage-2 (2034)
Mahakanadarawa WTP		
Daily Maximum Water Supply	8,950 m3/day	17,900 m3/day
Production Capacity	9,400 m3/day	18,800 m3/day
Wahalkada WTP		
Daily Maximum Water Supply	13,700m3/day	27,400 m3/day
Production Capacity	14,400 m3/day	28,800 m3/day

4.3 Water Availability

As mentioned in **Section 2.5**, there is a high risk of fluoride concentration in the groundwater of the Study Area, therefore the source for drinking water needs to be shifted to the surface water. This section will discuss availability of the water source focused only on surface water.

In the Study Area of Anuradhapura District, there are available only seasonal rivers, that flows during the rainy season, therefore, the surface water source for drinking water is expected only from water reservoirs, Mahakanadarawa wewa and Wahalkada wewa.

4.3.1 Water source

(1) Climate

1) Climate Data

Rainfall and Temperature data is collected from Meteorological Department in Sri Lanka (refer to **Appendix 4.3(a) to (d)**)..

Table 4.13 Outline of the Stations

Station	Observation Items	Observation Year	ID
Anuradhapura *	Integrated	1870 ～ present	43421
Wahalkada	Rainfall	1997 ～ present	01AN527B

** Nearest rainfall station of Mahakanadarawa is at Anuradhapura*

2) Monthly Average Rainfall, Temperature and Evaporation

This area belongs to the Central Dry Zone with annual rainfall of 1000mm～1500mm.

The amount of rainfall varies depending upon the South-East Monsoon between May and September (Yala period) and the North-East Monsoon between November and March (Maha Period). **Figure 4.14** and **Figure 4.15** show the monthly average rainfall in Anuradhapura and

Wahalkada stations. The rainy season is from October to January, and light rain period is available in Anuradhapura during April to May, but in Wahalkada. Annual rainfall is around 1240mm in Anuradhapura, and around 1440mm in Wahalkada.

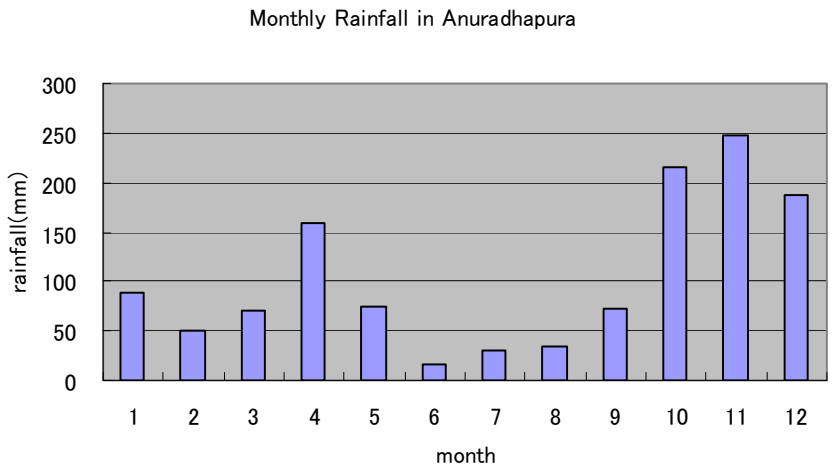


Figure 4.14 Monthly Average Rainfall in Anuradhapura Station

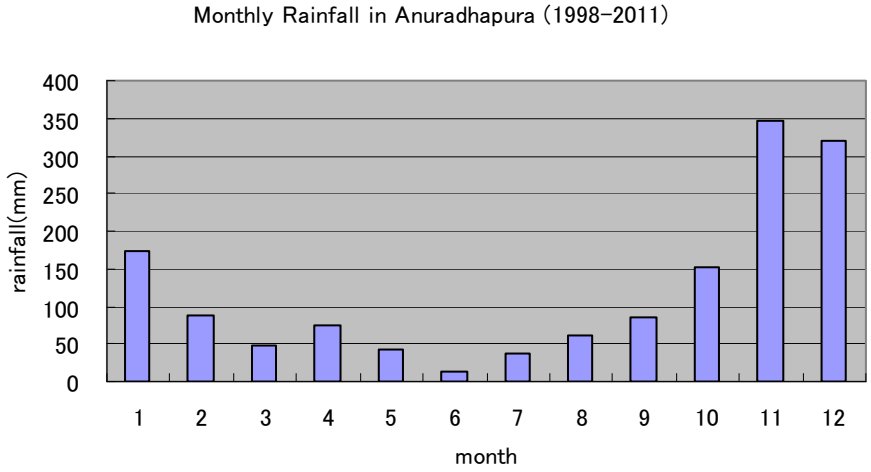


Figure 4.15 Monthly Average Rainfall in Wahalkada

Daily evaporation data at Mahailuppallama Station and Vavuniya Station is shown in **Table 4.14**.

Table 4.14 Monthly Average Evaporation (2000～2011)

(Unit:mm/day)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly
Maha Iluppallama	2.39	3.20	3.84	3.59	4.19	4.5	4.68	4.83	4.66	3.39	2.26	2.04	1326
Vavuniva	2.16	2.88	3.46	3.40	4.13	4.58	4.53	4.34	4.46	2.94	1.92	1.84	1237

Source: Meteorological Department

3) Long-term Annual Rainfall

Figure 4.16 shows the annual rainfall of Anuradhapura Station in 1980～2010, with 5 year moving averages. Average of annual rainfall is 1246mm. 5 year moving average rainfall varies not so much, therefore tendency of rainfall is considered relatively stable.

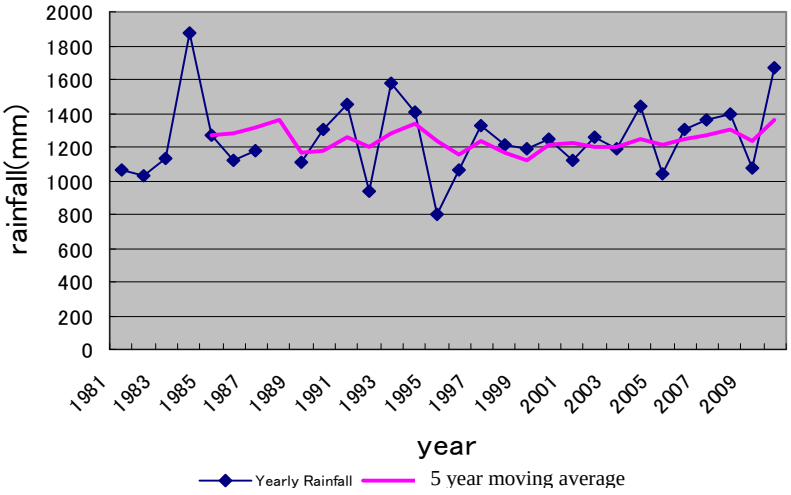


Figure 4.16 Annual Rainfall in Anuradhapura Station(1981-2010)

Figure 4.17 shows the annual rainfall at Wahalkada Station in the period from 1998 to 2011, with 5 year moving averages. The average annual rainfall is 1440mm. It is noticeable that rainfall from the end of 2010 to February 2011 was very high and the annual rainfall in 2011 was 2,300mm. The 5 year moving average rainfall does not vary much and therefore the trend of rainfall is considered to be relatively stable.

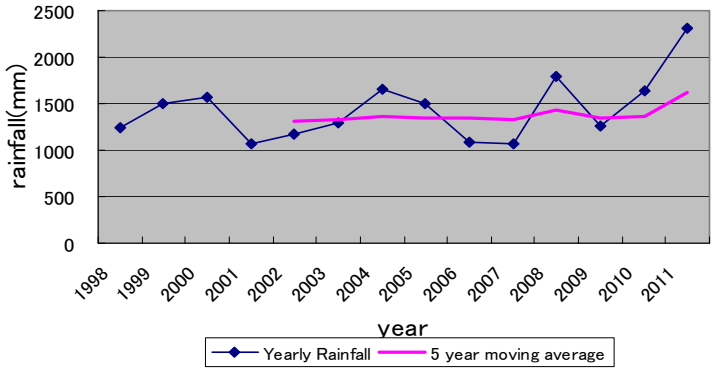
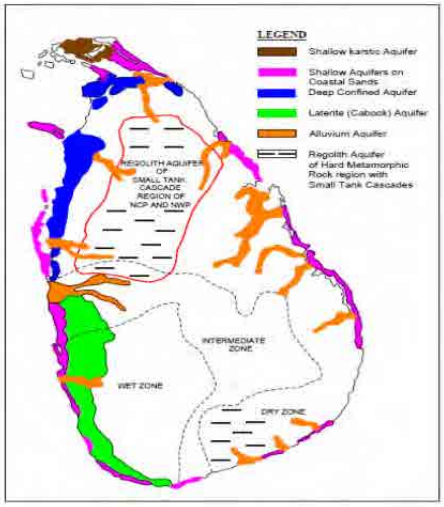


Figure 4.17 Annual Rainfall in Anuradhapura Station(1998-2011)

(2) Condition of the catchment area

According to "Groundwater Resources of Sri Lanka : Water Resources Board, 2005", the Project Area is classified as "Shallow Regolith Aquifer of the Hard Rock Region" (ref. **Figure 4.18** Groundwater Zone in Sri Lanka) .

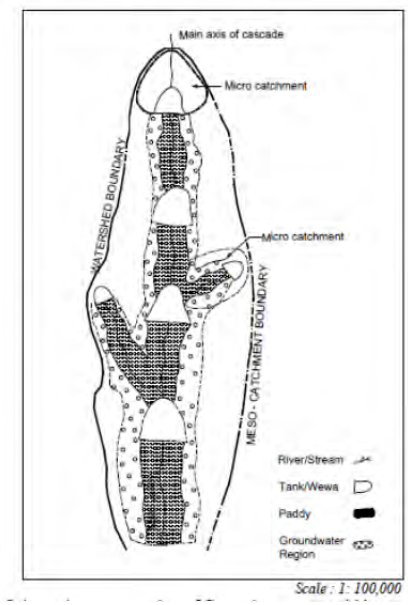


Source: Groundwater Resources of Sri Lanka ： Water Resources Board, 2005

Figure 4.18 Groundwater Classification

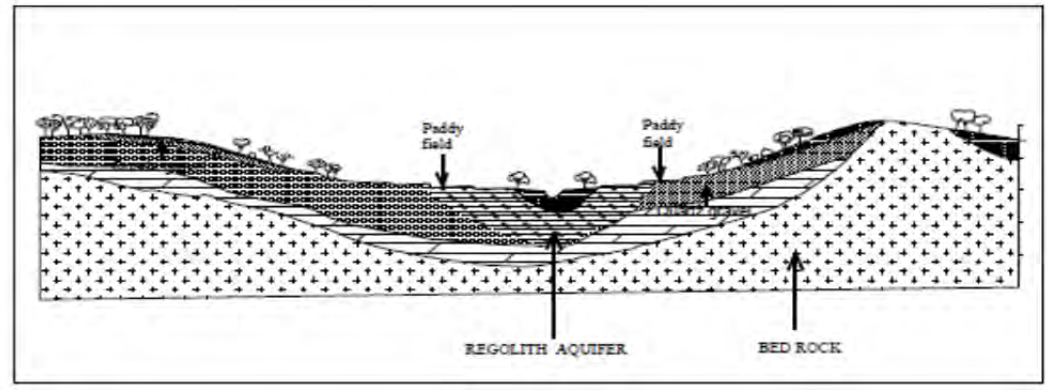
It has been recognized that groundwater in the hard rock region is found both in the weathered rock zone, or regolith, as well as in the deeper fracture zone of the basement rocks.

The shallow regolith aquifer is mainly confined to a narrow belt along the inland valley systems of this undulating mantled plain landscape, benefited from small tank cascade, as shown in **Figure 4.19** and **Figure 4.20**. The average thickness of the regolith in this region is not more than 10m and the traditional hand-dug wells have been abstracting water from this basement regolith aquifer for village domestic requirement. These small tank cascade systems are used for irrigation and have an influence on the water cycle in the catchment area.



Source: Groundwater Resources of Sri Lanka：Water Resources Board, 2005

Figure 4.19 Image of Small Tank Cascade in Sri Lanka



Source: Groundwater Resources of Sri Lanka：Water Resources Board, 2005:

Figure 4.20 Image of the Flow under Tank Cascade

The catchment areas of Mahakanadarawa and Wahalkada tanks are shown in **Figure 4.21** and **Figure 4.22**

Many small tanks exist in the catchment area, and flow from the catchment area to the reservoir occurs directly from both the surrounding area of the reservoir and groundwater flow from catchment area.

Table 4.15 shows the catchment area, direct flow area and water area of Mahakanadarawa and Wahalkada Wewa, which are estimated from the topographic map scaled at 1:50,000 and the Satellite image by Google.

Table 4.15 General Features of Reservoirs

Reservoir	Mahakanadarawa	Wahalkada
Catchment Area(km2)	334	83
Catchment Area with direct flow(km2)	83	47
Water Area(k m2)	9	2.1

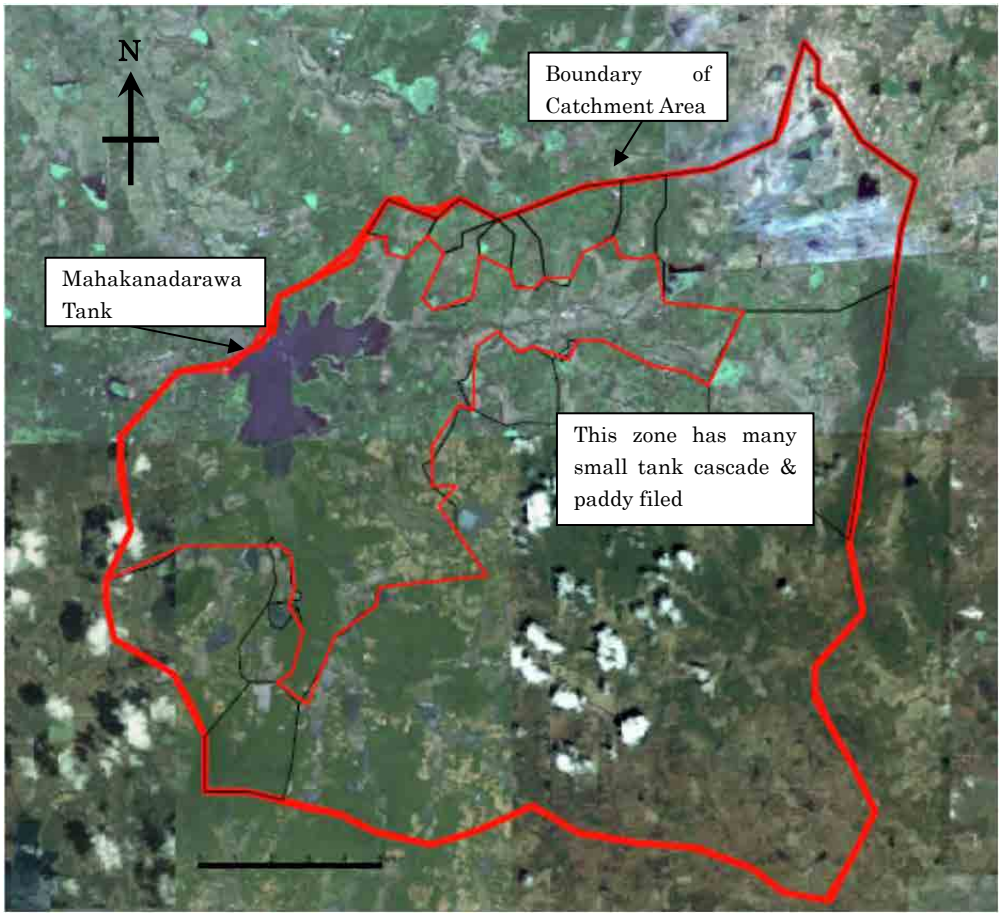


Figure 4.21 Mahakanadarawa Wewa Catchment Area

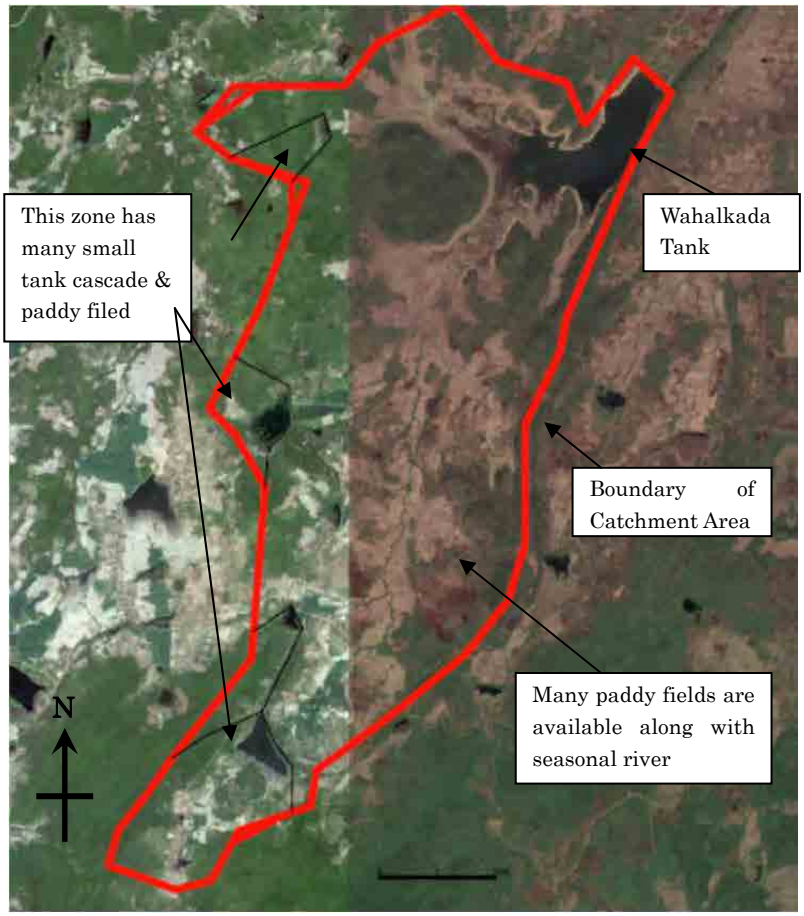


Figure 4.22 Wahalkada Wewa Catchment Area

4.3.2 Water Quality

(1) Purpose

To evaluate the water resources for a safe drinking water supply, it is very important to investigate essential water quality parameters in the water resources. The analysis of water quality can provide chemical and biological characteristics of the water as well as basic information of the safety of the water. Attention should be paid particularly on some substances that will have a health impact by drinking. In this subchapter, at first the general characteristics of Mahakandawara wewa, Wahalkada wewa and Yan Oya irrigation water are mentioned. The results of the general water quality analysis done in the study are evaluated by comparison with the Sri Lanka drinking water standard 614:1983.

A series of quality control measures, which are operational techniques and activities that are used to fulfill requirements of JICA Study Team for quality tests, were also conducted. The quality control program conducted consists of an internal quality control and an external quality control. Additionally, data comparison between the NWSDB lab in Anuradhapura and the SGS's

laboratory in Colombo, the subcontractor under the Study Team, was also performed as part of capacity development of the NWSDB lab.
As for groundwater survey, see **Section 2.5.2**

(2) Water quality analysis

1) Methodology

The water samples for water quality analysis were collected from targeteded water sources, Mahakandawara wewa, Wahalkada wewa and Yan Oya. The samples were systematically collected during the survey. The methods of sampling, analysis and quality assess mentioned above planned and performed as follows.

(a) Sampling and field analysis

For Mahakandawara and Wahalkada wewa, sampling locations at the sites are as follows.

- Irrigation canal
- Near the outlet connecting to an irrigation canal within wewa at a depth of 30cm from the water surface)
- Deepest point (minimum 50 m away from embankment)

In case irrigation water was not discharged, the sample of irrigation canal was instead collected near the outlet connecting to an irrigation canal within wewa.

For Yan Oya, the sampling was to be carried out at a location downstream of the junction of the three rivers.

In total seven samples were to be collected and analysed every month. Each sampling location was as follows.

Table 4.16 Sampling Sites with GPS Coordinates

Sampling site	GPS coordinates
a. Mahakandawara Irrigation canal	8.39253, 80.53843
b. Mahakandawara Irrigation canal connection	8.38967, 80.53348
c. Mahakandawara Deepest point	8.38062, 80.54088
d. Wahalkada Irrigation canal	8.73882, 80.85230
e. Wahalkada Irrigation canal connection	8.73838, 80.85268
f. Wahalkada Deepest point	8.73750, 80.85218
g. Yan Oya	8.75373, 80.87997

The samples were collected in decontaminated containers, and were preserved during transport to the laboratory. All parameters were analysed in the laboratory except pH which was measured at the sites mentioned above.

Figure 4.23 Location of Sampling Sites (Mahakandawara Wewa)

Figure 4.24 Location of Sampling Sites (Wahalkada Wewa)

Figure 4.25 Location of Sampling Sites (Yan Oya Reservoir Water)

(b) Laboratory analysis

The laboratory analyses was carried out at the SGS. The methods for the chemical and microbiological analysis of water are based on Sri Lankan drinking water standard 614:1983 (refer to **Reference 1.2**) and other standard methods such as APHA (American Public Health Association) or EPA (U.S. Environmental Protection Agency). **Table 4.17** outlines the test method followed. It is noted that JICA directly conducted preliminary water quality survey from December 2011 until April 2012 though analysis paremeters are somewhat different. These results are also shown as reference.

Table 4.17 Analytical Parameters and Methods

Analytical item	Methods used
Colour	APHA 2120 B: 2005
Turbidity	APHA 2130 B: 2005
Odor	SLS 614: 1983 Part 1
Taste	SLS 614: 1983 Part 1
pH	APHA 4500 H+ B: 2005
Electrical Conductivity	APHA 2520 B: 2005
Chloride	APHA 4500-Cl B: 2005
Free ammonia	SLS 614: 1983 Part 1
Nitrite	APHA 4500-NO2 B: 2005
Nitrate	APHA 4500-NO3 B: 2005
Albminoid ammonia	SLS 614: 1983 Part 1
Fluoride	APHA 4500-F- C: 2005
Iron	APHA 3500-Fe B: 2005
Sulphate	APHA 4500-SO_4^{2-} E: 2005
Alkalinity	APHA 2320 B: 2005
Total residue	APHA 2540 B: 2005
Hardness	APHA 2340 C: 2005
Phosphate	APHA 4500-P- C: 2005
As	APHA 3120 B: 2005
Cd	APHA 3120 B: 2006
CN	APHA 4500-CN-E, Colorimetric Method
Pb	APHA 3120 B: 2005
Hg	APHA 3120 B: 2005
Se	APHA 3120 B: 2005
T-Cr	APHA 3120 B: 2005
Total coliform	SLS – 614:1983, Part 2 (most probable number)
E-Coli	SLS – 614:1983, Part 2 (most probable number)
Chlorophyl-a	EPA 446

2) Results

(a) General characteristics of targeted water sources

The results of the laboratory chemical and microbiological analysis for the targeted water sources are shown in **Table 4.18**. From these data, some general characteristics are found as mentioned below.

Table 4.18 Results of Laboratory Chemical and Microbiological Analysis for Proposed Water Sources

Water source	Sampling station	Date	Odor	Colour	Turbidity	Taste	pH	EC	Chloride	Free residual C	Free ammonia	Alkalinity	Albminoid ammonia	Nitrite	Nitrate	Fluoride	Phosphate	Total residue	Hardness	Ion	Sulphate	Anionic detergent	Phenol conpound	COD	O&G	Ca	M_g	Cu	Mn	Zn	Al	Total plate count	E. coli	Total coliform	Chlorophyl a
				Hazen Unit	NTU		-	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/l	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	CFU/mL	MPN/100mL	MPN/100mL	mg/L
Mahakanadarawa Wewa	inlet	11/12/20	Object.	5	4	Object.	6.7	344	51	<0.04	<0.04	86	<0.04	<0.01	0.26	0.09	<0.05	166	96	0.1	2	<0.1	<0.002	14	<1	16	14	<0.02	<0.03	<0.01	<0.08	$3.2x10^2$	13	79	
	outlet	11/12/20	Object.	5	4	Object.	6.5	343	51	<0.04	<0.04	88	<0.04	<0.01	0.11	0.08	0.05	164	92	0.1	2	<0.1	<0.002	17	<1	16	13	<0.02	<0.03	<0.01	<0.08	$2.0x10^2$	5	8	
	Deepest	11/12/21	Object.	5	3.8	Object.	6.7	343	51	<0.04	<0.04	87	<0.04	<0.01	0.07	0.11	<0.05	176	96	0.1	2	<0.1	<0.002	20	<1	16	14	<0.02	<0.03	<0.01	<0.08	$1.7x10^2$	ND	23	
	inlet	12/01/11	Unobject.	7.5	3.7	Unobject.	7.8	348	52	<0.04	<0.04	93	0.05	<0.01	0.09	0.10	0.2	132	95	0.2	1.4	<0.1	<0.002	<5	<1	18	12	<0.02	<0.03	<0.01	<0.08	34	ND	8	
	outlet	12/01/21	Unobject.	10	3.5	Unobject.	7.9	355	53	<0.04	0.22	94	0.35	<0.01	0.07	0.12	0.16	172	96	0.1	1	<0.1	<0.002	<5	<1	18	13	<0.02	<0.03	<0.01	<0.08	64	ND	9	
	Deepest	12/01/21	Unobject.	7.5	2.9	Unobject.	7.7	370	52	<0.04	0.2	97	0.28	<0.01	0.07	0.14	0.23	170	96	0.3	1.4	<0.1	<0.002	<5	<1	17	13	<0.02	<0.03	<0.01	<0.08	40	ND	8	
	inlet	12/02/14	Unobject.	5	2.7	Unobject.	7.6	411	61	0.14	0.04	107	0.36	<0.01	<0.05	0.17	0.06	226	104	0.2	1.4	<0.1	<0.002	21	<1	18	9.0	<0.02	<0.03	<0.01	<0.08	$4.9x10^2$	13	130	
	outlet	12/02/14	Unobject.	5	3.7	Unobject.	7.7	415	54	<0.04	0.22	107	0.33	0.01	<0.05	0.33	0.09	235	105	0.2	3.4	<0.1	<0.002	16	<1	30	9.7	<0.02	<0.03	<0.01	<0.08	$2.0x10^2$	13	79	
	Deepest	12/02/14	Unobject.	5	6.8	Unobject.	7.7	417	60	0.1	0.15	96	0.22	<0.01	<0.05	0.30	0.06	234	109	0.3	1.5	<0.1	<0.002	20	<1	22	9.2	<0.02	<0.03	<0.01	<0.08	$9.5x10^2$	2	79	
	inlet	12/03/19	Unobject.	ND	3.9	Unobject.	7.6	471	76	<0.04	0.05	112	0.27	0.05	0.41	0.18	<0.05	279	94	0.48	4	<0.1	<0.002	42	<1	21	10.0	<0.02	<0.03	<0.01	<0.08	$3.0x10^2$	ND	2	
	outlet	12/03/19	Unobject.	ND	3	Unobject.	7.9	462	79	<0.04	0.07	120	0.28	0.01	0.38	0.17	<0.05	250	100	<0.1	4.2	<0.1	<0.002	14	<1	22	11.0	<0.02	<0.03	<0.01	<0.08	$5.8x10^2$	ND	240	
	Deepest	12/03/19	Unobject.	ND	3	Unobject.	7.8	470	79	<0.04	0.05	55	0.23	<0.01	0.23	0.17	<0.05	263	96	<0.1	5.4	<0.1	<0.002	10	<1	22	10	<0.02	<0.03	<0.01	<0.08	$2.3x10^2$	ND	5	
	inlet	12/05/02	Unobject.	5	5.1	Unobject.	8.2	464	74	<0.04	0.33	138	0.91	<0.01	0.12	0.43	0.1	277	148	0.2	2.1	<0.1	<0.002	14	<1	24	22.0	<0.02	0.11	0.04	0.1	$2.8x10^2$	ND	33	
	outlet	12/05/02	Unobject.	5	4.3	Unobject.	7.4	223	80	<0.04	0.3	139	0.82	<0.01	0.21	0.38	0.06	208	144	<0.1	1.5	<0.1	<0.002	20	<1	24	21.0	0.35	0.16	0.09	<0.08	$2.8x10^2$	8	49	
	Deepest	12/05/02	Unobject.	5	3.4	Unobject.	7.7	251	79	<0.04	0.38	134	0.84	<0.01	0.18	0.37	<0.05	264	144	0.1	1.8	<0.1	<0.002	22	<1	24	21	<0.02	0.12	0.02	<0.08	$1.6x10^2$	ND	13	
	IC Conn. S.	12/05/22	Unobject.	5	6.8	Unobject.	8.2	512	86		<0.04	130	0.49	<0.01	0.16	0.34	0.14	339	142	0.2	3.8												23	23	0.0022
	IC Conn. B.	12/05/22	Unobject.	5	7.5	Object.	8	512	85		0.16	125	0.66	<0.01	0.15	0.38	0.12	332	144	0.3	2												13	23	0.074
	Deepest	12/05/22	Unobject.	5	8.8	Object.	7.4	509	86		<0.04	134	0.57	<0.01	0.3	0.37	0.1	361	146	0.1	1.6												2	33	0.091
	IC Conn. S.	12/06/28	Unobject.	7.5	15	Object.	8.6	576	95		<0.04	100	0.14	<0.01	0.19	0.43	0.54	375	151	0.6	12												ND	25	0.2
	IC Conn. B.	12/06/28	Unobject.	10	15	Object.	8.5	580	77		0.02	110	0.12	0.02	0.45	0.36	0.8	289	119	0.4	10												2	25	0.2
	Deepest	12/06/28	Unobject.	10	16	Object.	8.4	585	92		<0.04	143	0.15	<0.01	0.21	0.45	0.92	359	158	0.5	9.9												2	25	0.18
	IC Conn. S.	12/07/26	Unobject.	10	12	Object.	8.5	620	105		<0.01	152	0.26	<0.01	0.54	0.52	0.21	400	161	0.6	1.6												8	1600	0.21
	IC Conn. B.	12/07/26	Unobject.	10	11	Object.	8.2	624	103		0.02	70	0.22	<0.01	0.13	0.51	<0.21	404	163	<0.1	1.9												2	80	0.28
	Deepest	12/07/26	Unobject.	10	13	Object.	8.4	625	104		0.02	94	0.33	<0.01	0.56	0.51	<0.21	399	159	0.8	2.4												7	70	0.23
	IC Conn. S.	12/09/26	Unobject.	10	18	Object.	8.4	736	142		0.53	162	2.7	<0.01	0.3	0.45	0.32	456	173	0.6	23												8	23	0.54
	IC Conn. B.	12/09/26	Unobject.	10	18	Object.	8.3	746	140		0.45	162	2.3	<0.01	0.57	0.46	0.3	457	179	0.6	21												14	35	0.59
	Deepest	12/09/26	Unobject.	10	20	Object.	8.7	738	144		0.35	164	2.5	<0.01	0.27	0.47	0.31	480	173	0.6	22												2	8	0.5
	IC Conn. S.	12/10/16	Unobject.	10	15	Object.	7.9	711	131		0.12	155	1.6	<0.01	0.27	0.47	0.21	420	196	0.4	8.9												80	1600	0.34
	IC Conn. B.	12/10/16	Unobject.	10	27	Object.	7.3	719	133		0.13	152	1.6	<0.01	0.24	0.46	0.25	436	186	1	12												45	1600	0.38
	Deepest	12/10/16	Unobject.	10	20	Object.	7.6	685	123		0.14	184	1.8	<0.01	0.21	0.44	0.22	369	182	0.5	11												35	250	0.55
Wahalkada Wewa	inlet	11/12/21	Object.	ND	4.9	Object.	7.8	204	11	<0.04	<0.04	85	<0.04	<0.01	0.1	0.06	<0.05	84	69	0.1	2	<0.1	<0.002	13	<1	16	7	<0.02	<0.03	<0.01	<0.08	46	ND	8	
	outlet	11/12/21	Object.	ND	3.6	Object.	6.9	198	12	<0.04	<0.04	85	<0.04	<0.01	0.09	0.06	<0.05	82	71	0.2	3	<0.1	0.0002	12	<1	16	8	<0.02	<0.03	<0.01	<0.08	79	ND	8	
	Deepest	11/12/21	Object.	2.5	2.7	Object.	7.2	202	12	<0.04	<0.04	85	<0.04	<0.01	0.09	0.08	<0.05	90	78	0.2	2	<0.1	0.0002	15	<1	16	9	<0.02	<0.03	<0.01	<0.08	58	ND	23	
	inlet	12/01/12	Unobject.	10	4.7	Unobject.	8.7	200	12	<0.04	0.28	90	0.42	<0.01	0.1	0.07	0.14	86	70	0.2	1.4	<0.1	<0.002	<5	<1	15	8	<0.02	<0.03	<0.01	<0.08	$1.0x10^2$	5	27	
	outlet	12/01/12	Unobject.	10	4.5	Object.	8.5	203	12	<0.04	0.35	93	0.63	<0.01	0.08	0.07	0.15	70	68	0.2	1.5	<0.1	<0.002	<5	<1	15	7	<0.02	<0.03	<0.01	<0.08	$1.1x10^2$	5	34	
	Deepest	12/01/12	Unobject.	10	4.3	Unobject.	8.5	201	12	<0.04	0.39	86	0.53	<0.01	0.1	0.08	0.2	110	70	0.2	1.4	<0.1	<0.002	<5	<1	16	7	<0.02	<0.03	<0.01	<0.08	93	ND	17	
	inlet	12/02/15	Unobject.	5	4.6	Unobject.	8.0	218	12	<0.04	0.93	79	0.37	<0.01	0.26	0.11	0.1	136	77	<0.1	1.4	<0.1	<0.002	13	<1	16	3.4	<0.02	<0.03	<0.01	<0.08	$1.0x10^2$	8	49	
	outlet	12/02/15	Unobject.	5	7.3	Unobject.	8.4	222	12	<0.04	0.07	92	0.24	<0.01	<0.05	0.11	0.2	138	76	0.4	2.8	<0.1	<0.002	18	<1	14	4.5	<0.02	<0.03	<0.01	<0.08	$1.7x10^2$	ND	8	
	Deepest	12/02/15	Unobject.	5	1	Unobject.	7.8	222	12	<0.04	0.24	97	0.23	<0.01	0.21	0.22	0.06	128	72	<0.1	1.7	<0.1	<0.002	5	<1	17	3.2	<0.02	<0.03	<0.01	<0.08	49	ND	17	
	inlet	12/03/20	Unobject.	ND	3.5	Unobject.	8.7	237	15	<0.04	0.09	105	0.48	<0.01	<0.05	0.11	<0.05	180	54	<0.1	4.8	<0.1	<0.002	<5	<1	19	0.8	<0.02	<0.03	<0.01	0.3	$5.9x10^2$	ND	130	
	outlet	12/03/20	Unobject.	ND	3.4	Unobject.	8.7	233	15	<0.04	0.08	101	0.18	0.02	0.53	0.11	<0.05	137	56	<0.1	4.2	<0.1	<0.002	<5	<1	17	0.9	<0.02	<0.03	<0.01	0.4	$6.0x10^2$	ND	240	
	Deepest	12/03/20	Unobject.	ND	5.1	Unobject.	8.6	232	14	<0.04	0.09	118	0.18	<0.01	0.4	0.12	<0.05	132	56	0.1	4.8	<0.1	<0.002	5	<1	18	1.7	<0.02	<0.03	<0.01	<0.08	$2.0x10^2$	ND	79	
	inlet	12/05/03	Unobject.	5	1.3	Unobject.	8.1	240	15	<0.04	<0.04	118	0.93	<0.01	0.24	0.24	0.06	96	96	0.2	1.9	<0.1	<0.002	18	<1	18	12.0	<0.02	0.15	0.03	<0.08	$1.4x10^2$	5	22	
	outlet	12/05/03	Unobject.	5	3.6	Unobject.	8.2	245	15	<0.04	0.06	138	0.99	<0.01	0.23	0.24	<0.05	149	92	0.1	2.3	<0.1	<0.002	17	<1	17	12.0	<0.02	0.08	0.07	1.1	$1.0x10^2$	ND	170	
	Deepest	12/05/03	Unobject.	5	1.9	Unobject.	7.9	243	13	<0.04	0.06	126	1.01	<0.01	0.18	0.23	0.11	183	96	0.5	1.6	<0.1	<0.002	19	<1	19	12	0.08	0.1	0.1	<0.08	$1.7x10^2$	ND	33	
	IC Conn. S.	12/05/22	Unobject.	5	13	Object.	8	250	17		0.18	106	0.63	<0.01	0.12	0.27	0.07	178	98	0.1	2.8												ND	23	0.059
	IC Conn. B.	12/05/22	Unobject.	5	10	Object.	8.2	250	16		0.05	105	0.53	<0.01	0.14	0.29	0.24	176	98	<0.1	<1.7												ND	33	0.0911
	Deepest	12/05/22	Unobject.	5	11	Object.	8.1	249	16		0.05	102	0.62	<0.01	0.14	0.26	0.17	168	107	<0.1	2												ND	8	0.098
	IC Conn. S.	12/06/29	Unobject.	10	15	Unobject.	8.2	260	17		0.03	116	0.14	<0.01	0.19	0.25	0.53	172	79	0.3	12.2												2	25	0.26
	Irrigation C.	12/06/29	Unobject.	10	15	Unobject.	8.2	266	16		0.03	111	0.17	<0.01	0.21	0.28	0.36	184	100	0.3	8.8												8	25	0.25
	Deepest	12/06/29	Unobject.	10	15	Object.	7.9	266	17		0.04	110	0.14	<0.01	0.19	0.27	0.54	183	83	0.3	3.3												ND	25	0.19
	IC Conn. S.	12/07/27	Unobject.	10	11	Object.	7.8	270	18		0.06	118	0.21	<0.01	0.13	0.32	<0.21	212	91	0.7	1.6												ND	8	0.51
	Irrigation C.	12/07/27	Unobject.	7.5	3	Object.	8.2	275	18		0.17	118	0.15	<0.01	0.42	0.38	0.3	124	101	0.4	1.5												350	1600	0.37
	Deepest	12/07/27	Unobject.	10	9	Object.	8.6	270	18		0.04	124	0.23	<0.01	0.12	0.32	<0.21	196	93	0.2	1.4												5	25	0.5
	IC Conn. S.	12/09/25	Unobject.	10	19	Object.	8.7	288	47		0.36	119	3.1	<0.01	0.17	0.24	<0.15	187	87	0.2	13												ND	5	0.34
	IC Conn. B.	12/09/25	Unobject.	10	20	Object.	8.7	284	71		0.42	123	2.9	<0.01	0.12	0.23	0.29	175	85	0.1	13												ND	2	0.29
	Deepest	12/09/25	Unobject.	10	19	Object.	8.6	292	22		0.41	116	2.3	<0.01	0.17	0.24	0.25	205	111	0.2	13												ND	8	0.36
	IC Conn. S.	12/10/17	Unobject.	10	16	Object.	8.3	278	20		0.24	116	1.7	<0.01	0.14	0.24	0.31	168	96	0.3	6.6												17	130	0.42
	IC Conn. B.	12/10/17	Unobject.	10	14	Object.	8.1	274	20		0.39	114	1.6	<0.01	0.17	0.23	0.18	162	102	0.2	6.8												5	33	0.39
	Deepest	12/10/17	Unobject.	10	15	Object.	8.2	276	18		0.43	112	1.8	<0.01	0.13	0.23	0.26	175	98	0.2	6.1												ND	8	0.45
Yan Oya	Stream	12/01/12	Unobject.	10	24.3	Object.	8.2	600	83	<0.04	0.18	173	0.27	0.01	0.6	0.26	0.07	331	188	1.5	11	<0.1	<0.002	<5	ND	35	25	ND	ND	<0.01	<0.08	$2.5x10^2$	240	540	
	Stream	12/02/14	Unobject.	7.5	9	Unobject.	7.8	721	110	<0.04	0.42	187	0.2	<0.01	0.24	0.56	0.16	440	201	0.2	21	<0.1	<0.002	17	ND	20	36	ND	ND	<0.01	<0.08	$1.8x10^2$	33	70	
	Stream	12/03/20	Unobject.	ND	2.4	Unobject.	7.9	1186	230	<0.04	0.06	73	0.17	0.01	0.57	0.43	<0.05	612	342	0.5	3.8	<0.1	<0.002	<5	ND	82	63	ND	ND	<0.01	0.6	$2.3x10^2$	130	130	
	Stream	12/05/02	Unobject.	5	6.4	Unobject.	7.7	492	181	<0.04	<0.04	212	0.33	<0.01	0.58	0.57	0.38	386	295	0.3	30	<0.1	<0.002	16	ND	39	48	ND	0.11	0.35	0.25	$5.3x10^2$	ND	130	
	Stream	12/05/23	Unobject.	5.6	5.6	Object.	7.9	2010	466		0.22	316	0.2	<0.01	0.1	0.81	0.26	1634	569	0.3	46												23	79	0.0058
	Stream	12/06/29	Unobject.	5	3.8	Unobject.	7.9	3320	840		<0.04	369	0.05	<0.01	0.15	1.2	0.54	1401	957	<0.1	101												8	25	0.01
	Stream	12/07/27	Unobject.	5	6	Object.	7.9	1769	108		0.03	264	0.2	<0.01	0.81	1.1	<0.21	1332	485	0.5	62												25	25	0.049
	Stream	12/09/25	Unobject.	5	2.7	Object.	7.7	4680	1360		1.72	369	4.4	<0.01	0.18	0.74	0.17	3742	1311	0.2	11												25	130	0.15
	Stream	12/10/17	Unobject.	20	7.8	Object.	7.4	452	72		0.19	75	0.71	<0.01	0.22	0.18	0.45	371	128	5.2	51												79	240	0.21
Sri Lanka Standards (Desirable)			-	5	2		7.0-8.5	750	200			200				0.6	-	500	250	0.3	200	0.2	0.0001			100	(30-150)	0.05	0.05	5			0	0	
Sri Lanka Standards (Permissible)			Unobject.	30	8	Unobject.	6.5-9.0	3500	1200	0.2	0.06	400	0.15	0.01	10	1.5	2	2000	600	1	400	1	0.0002	10	1.0	240	140	1.5	0.5	15	0.2	(100)	0	10	

Chlorophyl a: In case result is less than 0.08mg/l (LOD), raw data is shown as reference

ND: Not detected

IC Conn. S. : Irrigation Canal Connection Surface

IC Conn. B. : Irrigation Canal Connection Bottom

Irrigation C. : Irrigation Canal

Table 4.18 Results of Laboratory Chemical and Microbiological Analysis For Proposed Water Sources (Cont'd)

Water source	Sampling station	Date	Arsenic	Cadmium	Cyanide	Lead	Mercury	Selenium	Total chromuim
			mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Mahakanadarawa Wewa	inlet	11/12/20	<0.01	<0.005	<0.03	<0.03	<0.001	<0.01	<0.02
	outlet	11/12/20	<0.01	<0.005	<0.03	<0.03	<0.001	<0.01	<0.02
	Deepest	11/12/21	<0.01	<0.005	<0.03	<0.03	<0.001	<0.01	<0.02
	inlet	12/01/11	<0.02	<0.005	<0.03	<0.03	<0.001	<0.005	<0.02
	outlet	12/01/21	<0.02	<0.005	<0.03	<0.03	<0.001	<0.005	<0.02
	Deepest	12/01/21	<0.02	<0.005	<0.03	<0.03	<0.001	<0.005	<0.02
	inlet	12/02/14	<0.02	<0.005	<0.06	<0.03	<0.001	<0.005	<0.03
	outlet	12/02/14	<0.02	<0.005	<0.06	<0.03	<0.001	<0.005	<0.03
	Deepest	12/02/14	<0.02	<0.005	<0.06	<0.03	<0.001	<0.005	<0.03
	inlet	12/03/19	<0.01	<0.005	<0.06	<0.03	<0.0005	<0.005	<0.02
	outlet	12/03/19	<0.01	<0.005	<0.06	<0.03	<0.0005	<0.005	<0.02
	Deepest	12/03/19	<0.01	<0.005	<0.06	<0.03	<0.0005	<0.005	<0.02
	inlet	12/05/02	<0.02	<0.005	<0.06	<0.03	<0.001	<0.005	<0.02
	outlet	12/05/02	<0.02	<0.005	<0.06	<0.03	<0.001	<0.005	<0.02
	Deepest	12/05/02	<0.02	<0.005	<0.06	<0.03	<0.001	<0.005	<0.02
	IC Conn. S.	12/05/22	<0.01	<0.005	<0.06	<0.01	<0.0005	<0.01	<0.01
	IC Conn. B.	12/05/22	<0.01	<0.005	<0.06	<0.01	<0.0005	<0.01	<0.01
	Deepest	12/05/22	<0.01	<0.005	<0.06	<0.01	<0.0005	<0.01	<0.01
	IC Conn. S.	12/06/28	<0.02	<0.005	<0.06	<0.03	<0.001	<0.005	<0.02
	IC Conn. B.	12/06/28	<0.02	<0.005	<0.06	<0.03	<0.001	<0.005	<0.02
	Deepest	12/06/28	<0.02	<0.005	<0.06	<0.03	<0.001	<0.005	<0.02
	IC Conn. S.	12/07/26	<0.02	<0.005	<0.03	<0.04	<0.001	<0.01	<0.01
	IC Conn. B.	12/07/26	<0.02	<0.005	<0.03	<0.04	<0.001	<0.01	<0.01
	Deepest	12/07/26	<0.02	<0.005	<0.03	<0.04	<0.001	<0.01	<0.01
	IC Conn. S.	12/09/26	<0.02	<0.005	<0.03	<0.04	<0.001	<0.01	<0.01
	IC Conn. B.	12/09/26	<0.02	<0.005	<0.03	<0.04	<0.001	<0.01	<0.01
	Deepest	12/09/26	<0.02	<0.005	<0.03	<0.04	<0.001	<0.01	<0.01
	IC Conn. S.	12/10/16	<0.02	<0.005	<0.03	<0.04	<0.001	<0.01	<0.01
	IC Conn. B.	12/10/16	<0.02	<0.005	<0.03	<0.04	<0.001	<0.01	<0.01
	Deepest	12/10/16	<0.02	<0.005	<0.03	<0.04	<0.001	<0.01	<0.01
Wahalkada Wewa	inlet	11/12/21	<0.01	<0.005	<0.03	<0.03	<0.001	<0.01	<0.02
	outlet	11/12/21	<0.01	<0.005	<0.03	<0.03	<0.001	<0.01	<0.02
	Deepest	11/12/21	<0.01	<0.005	<0.03	<0.03	<0.001	<0.01	<0.02
	inlet	12/01/12	<0.02	<0.005	<0.03	<0.03	<0.001	<0.005	<0.02
	outlet	12/01/12	<0.02	<0.005	<0.03	<0.03	<0.001	<0.005	<0.02
	Deepest	12/01/12	<0.02	<0.005	<0.03	<0.03	<0.001	<0.005	<0.02
	inlet	12/02/15	<0.02	<0.005	<0.06	<0.03	<0.001	<0.005	<0.03
	outlet	12/02/15	<0.02	<0.005	<0.06	<0.03	<0.001	<0.005	<0.03
	Deepest	12/02/15	<0.02	<0.005	<0.06	<0.03	<0.001	<0.005	<0.03
	inlet	12/03/20	<0.01	<0.005	<0.06	<0.03	<0.0005	<0.005	<0.02
	outlet	12/03/20	<0.01	<0.005	<0.06	<0.03	<0.0005	<0.005	<0.02
	Deepest	12/03/20	<0.01	<0.005	<0.06	<0.03	<0.0005	<0.005	<0.02
	inlet	12/05/03	<0.02	<0.005	<0.06	<0.03	<0.001	<0.005	<0.02
	outlet	12/05/03	<0.02	<0.005	<0.06	<0.03	<0.001	<0.005	<0.02
	Deepest	12/05/03	<0.02	<0.005	<0.06	<0.03	<0.001	<0.005	<0.02
	IC Conn. S.	12/05/22	<0.01	<0.005	<0.06	<0.01	<0.0005	<0.01	<0.01
	IC Conn. B.	12/05/22	<0.01	<0.005	<0.06	<0.01	<0.0005	<0.01	0.01
	Deepest	12/05/22	<0.01	<0.005	<0.06	<0.01	<0.0005	<0.01	<0.01
	IC Conn. S.	12/06/29	<0.02	<0.005	<0.06	<0.03	<0.001	<0.005	<0.02
	Irrigation C.	12/06/29	<0.02	<0.005	<0.06	<0.03	<0.001	<0.005	<0.02
	Deepest	12/06/29	<0.02	<0.005	<0.06	<0.03	<0.001	<0.005	<0.02
	IC Conn. S.	12/07/26	<0.02	<0.005	<0.03	<0.04	<0.001	<0.01	<0.01
	Irrigation C.	12/07/26	<0.02	<0.005	<0.03	<0.04	<0.001	<0.01	<0.01
	Deepest	12/07/26	<0.02	<0.005	<0.03	<0.04	<0.001	<0.01	<0.01
	IC Conn. S.	12/09/25	<0.02	<0.005	<0.03	<0.04	<0.001	<0.01	<0.01
	IC Conn. B.	12/09/25	<0.02	<0.005	<0.03	<0.04	<0.001	<0.01	<0.01
	Deepest	12/09/25	<0.02	<0.005	<0.03	<0.04	<0.001	<0.01	<0.01
	IC Conn. S.	12/10/17	<0.02	<0.005	<0.03	<0.04	<0.001	<0.01	<0.01
	IC Conn. B.	12/10/17	<0.02	<0.005	<0.03	<0.04	<0.001	<0.01	<0.01
	Deepest	12/10/17	<0.02	<0.005	<0.03	<0.04	<0.001	<0.01	<0.01
Yan Oya	Stream	12/01/12	<0.02	<0.005	<0.03	<0.03	<0.001	<0.005	<0.02
	Stream	12/02/14	<0.02	<0.005	<0.06	<0.03	<0.001	<0.005	<0.03
	Stream	12/03/20	<0.01	<0.005	<0.06	<0.03	<0.0005	<0.005	<0.02
	Stream	12/05/02	<0.02	<0.005	<0.06	<0.03	<0.001	<0.005	<0.02
	Stream	12/05/23	<0.01	<0.005	<0.06	<0.01	<0.0005	<0.01	<0.01
	Stream	12/06/29	<0.02	<0.005	<0.06	<0.03	<0.001	<0.005	<0.02
	Stream	12/07/27	<0.02	<0.005	<0.03	<0.04	<0.001	<0.01	<0.01
	Stream	12/09/25	<0.02	<0.005	<0.03	<0.04	<0.001	<0.01	<0.01
	Stream	12/10/17	<0.02	<0.005	<0.03	<0.04	<0.001	<0.01	<0.01
Sri Lanka Standards (Desireble)			-	-	-	-	-	-	-
Sri Lanka Standards (Permissible)			0.05	0.005	0.05	0.05	<0.001	0.01	0.05

Table 4.18 Results of Laboratory Chemical and Microbiological Analysis for Proposed Water Sources (Cont'd))

Water source	Sampling station	Date	alpha - HCH	beta - HCH	gamma - HCH	delta - HCH	ALDRIN	DIELDRIN	HEPTACHLOR	HEPTACHLOR EPOXIDE	ENDRIN	ENDRIN ALDEHYDE	ENDOSULFAN I	ENDOSULFAN II	ENDOSULFAN SULPHATE	o,p' DDT	p,p' DDT	o,p' DDD	p,p' DDD
			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/l	mg/L
Mahakanadarawa Wewa	inlet	11/12/20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	outlet	11/12/20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Deepest point	11/12/21	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	inlet	12/01/11	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	outlet	12/01/21	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Deepest point	12/01/21	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	inlet	12/02/14	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	outlet	12/02/14	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Deepest point	12/02/14	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	inlet	12/03/19	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	outlet	12/03/19	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Deepest point	12/03/19	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	inlet	12/05/2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	outlet	12/05/2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Deepest point	12/05/2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Wahalkada Wewa	inlet	11/12/21	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	outlet	11/12/21	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Deepest point	11/12/21	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	inlet	12/01/12	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	outlet	12/01/12	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Deepest point	12/01/12	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	inlet	12/02/15	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	outlet	12/02/15	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Deepest point	12/02/15	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	inlet	12/03/20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	outlet	12/03/20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Deepest point	12/03/20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	inlet	12/05/3	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	outlet	12/05/3	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Deepest point	12/05/3	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Yan Oya	Stream	12/01/12	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Stream	12/02/14	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Stream	12/03/20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Stream	12/05/2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Water source	Sampling station	Date	CHLOROPYRIFOS	DIMETHOATE	DIAZINON	FENTHION	FENITROTHION	MALATHION	PARATHION	PARATHION METHYL	PIRIMPHOS METHYL	PROFENOPHOS	QUINALPHOS	CARBOFURAN	CHLOROTHALONIL	CAPTAN	METALAXYL	ALACHLOR	PROPANIL
			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/l	mg/l	mg/l	mg/l	mg/l
Mahakanadarawa Wewa	inlet	11/12/20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	outlet	11/12/20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Deepest point	11/12/21	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	inlet	12/01/11	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	outlet	12/01/21	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Deepest point	12/01/21	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	inlet	12/02/14	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	outlet	12/02/14	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Deepest point	12/02/14	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	inlet	12/03/19	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	outlet	12/03/19	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Deepest point	12/03/19	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	inlet	12/05/2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	outlet	12/05/2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Deepest point	12/05/2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Wahalkada Wewa	inlet	11/12/21	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	outlet	11/12/21	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Deepest point	11/12/21	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	inlet	12/01/12	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	outlet	12/01/12	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Deepest point	12/01/12	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	inlet	12/02/15	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	outlet	12/02/15	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Deepest point	12/02/15	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	inlet	12/03/20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	outlet	12/03/20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Deepest point	12/03/20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	inlet	12/05/3	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	outlet	12/05/3	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Deepest point	12/05/3	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Yan Oya	Stream	12/01/12	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Stream	12/02/14	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Stream	12/03/20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Stream	12/05/2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Firstly, it can be said that eutrophication of the lakes has progressed at both the target water sources. Eutrophication occurs by nutrition increases such as nitrogen and phosphorous, then phytoplankton in the water increases due to the nutrition increases. High concentration of albuminoid ammonia and free ammonia in the water quality results show this phenomenon. In addition, both the target water sources have a greenish color and the water quality results show the high color values and chlorophyll a. It can be said that this greenish color caused by phytoplankton is increasing in the water. High concentration of albuminoid ammonia and COD seems to reflect an increase in the content of organic matter in lake water by phytoplankton growth. Both the target water sources show high value, around 8 of pH, and it seems to be due to the carbonate consumption and hydroxyl ions release in water by the growth of phytoplankton. Such eutrophication seems not be caused by human sewage as the population sorrounding both water souces is not high. One possibility is overfertilization of paddy fields and other fields surrounding the water sources.

Seasonal changes of water quality due to rainy and dry seasons also occurs. Recharge water of targeted water sources in the dry season is reduced, and the existing water in targeted water sources are concentrated by evaporation so the contents are increased. This trend is remarkable in Mahakandawara wewa though Wahalkada shows less of a trend of this. The figures below show the said change of some water quality parameters of both water sources.

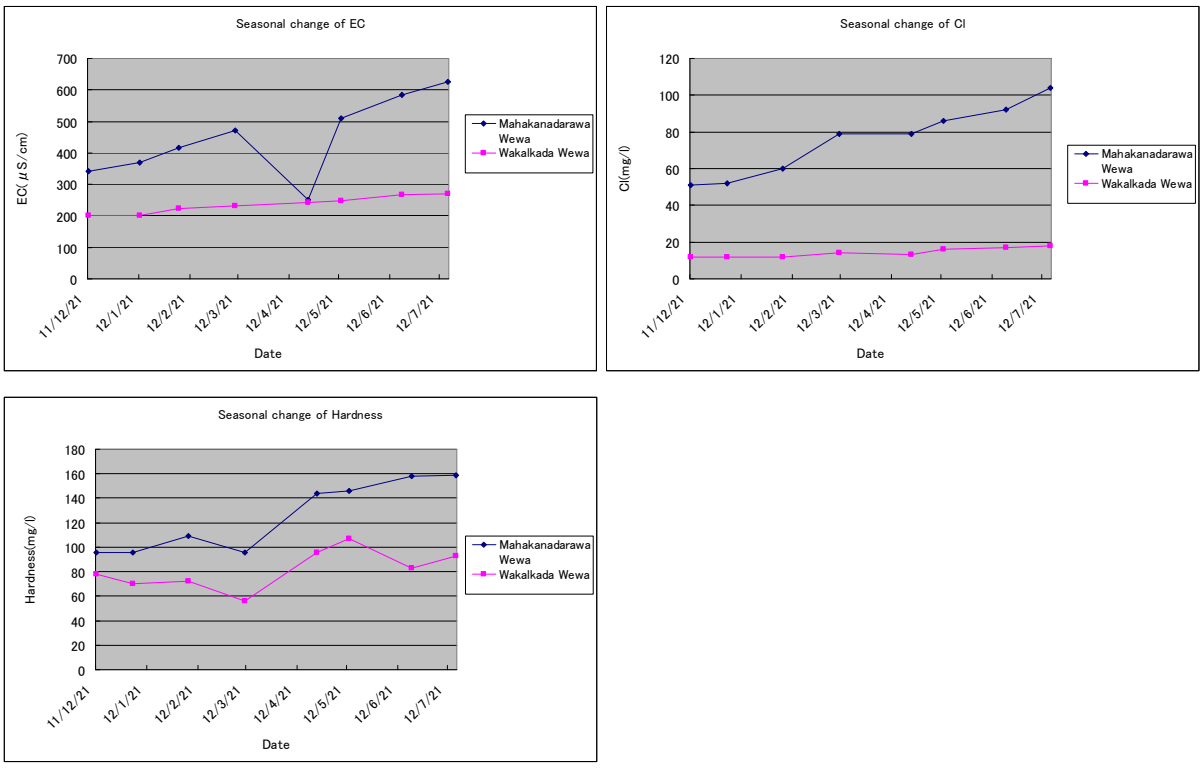


Figure 4.26 Seasonal Change of Water Quality

(b) Fluoride in targeted water sources

Fluorine is a common element that is widely distributed in the earth's crust and exists in the form of fluorides in a number of minerals, such as fluorspar, cryolite and fluorapatite. Traces of fluorides are present in many waters, with higher concentrations often associated with underground sources. In areas rich in fluoride-containing minerals, well water may contain up to about 10 mg/l, although much higher concentrations can be found. High fluoride concentrations can be found in many parts of the world, particularly in parts of India, China, Central Africa and South America, but high concentrations can be encountered locally in most parts of the world.

In Sri Lanka, high concentrations of fluoride are found in groundwater in many areas and the project area is also known as a higher concentration area of fluoride. Therefore, continuous water quality monitoring of the said parameter is essential. As fluoride is a substance derived from minerals, both groundwater and surface water contain flouride if it has come into contact with the mineral. As for fluoride in targeted water sources, the same as EC, Cl and Hardness, the concentrations are lower in the rainy season and becomes higher in the dry season. The trends are shown as follows.

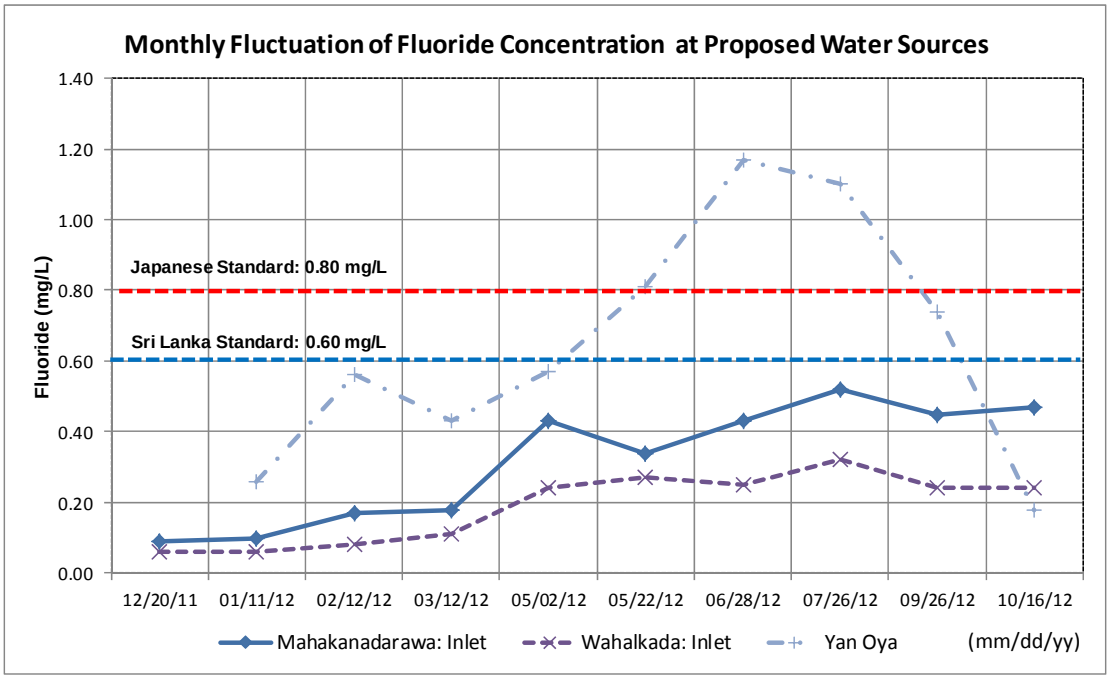


Figure 4.27 Seasonal Change of Fluoride

As shown in **Figure 4.27**, from May to June in the dry season, the fluoride concentrations have increased in any of three water source candidates, especially in Yan Oya of which fluoride has recorded at 1.2 mg/L in June and which cannot be used for drinking water supply without any treatment for fluoride removal. Those in Mahakanadarawa Wewa and

Wahalkada Wewa have also increased to 0.52 mg/L and 0.38 mg/L, respectively. Some of other parameters have exceeded the Sri Lankan drinking water standards but they were within the level to be treated in the course of water treatment.

(c) Evaluation of specific parameters including Sri Lankan standard comparison for targeted water sources

(c1) Odor and Taste

In the target water sources, taste and odor seem to be mainly produced by phytoplankton and aquatic plants. Though industrial and human wastes can also create odor and taste, they are quite low around the water source.

A total of 13% of odor samples and 46% of taste samples exceeded the permissible Sri Lankan drinking water standard. The planned treatment method for water purification plant will treat them.

(c2) Turbidity

Turbidity results from the scattering and absorption of incident light by particles, and the transparency is the limit of visibility in the water. Both can vary seasonally according to biological activity in the water and surface run-off carrying soil particles. As for the targeted water sources, turbidity is high. It seems to be caused by biological activity in the water. A total of 35% of turbidity samples exceeded the permissible Sri Lankan drinking water standard. As turbidity is easily treated at a purification plant, there will be no problem.

(c3) pH

pH is an important variable in water quality assessment as it influences many biological and chemical processes within a water body and all processes associated with water supply and treatment. When measuring the effects of an effluent discharge, it can be used to help determine the extent of the effluent plume in the water body. As these target water sources show, higher pH values are occurred by the photosynthesis and respiration cycles of algae in such eutrophic waters.

All samples are within the permissible Sri Lankan drinking water standard, although many samples show a high pH.

(c4) Free ammonia

Ammonia occurs naturally in water bodies arising from the breakdown of nitrogenous organic and inorganic matter in soil and water, excretion by biota, reduction of the nitrogen gas in water by micro-organisms and from gas exchange with the atmosphere. In water, free ammonia exists with the ammonium ion. In all, 48% of free ammonia samples exceeded the permissible Sri Lankan drinking water standard. It seems that as a

result of the death and decay of aquatic organisms, phytoplankton and bacteria in nutritionally rich waters. Free ammonia will be reduced through the water treatment process, thereby this excess will be resolved.

(c5) Albminoid ammonia

Albuminoid ammonia results from rapid decomposition that is induced artificially. It is a measure of the amount of organic matter present which may decay, and is simply what would be produced naturally in the course of time. As the results show, free and albuminoid ammonia are both high in the water resources. It means that they contain much decaying matter and would be decayed of aquatic organisms. A total of 77% of albuminoid ammonia samples exceeded the permissible Sri Lankan standard. The same as free ammonia, albuminoid ammonia will be reduced through the water treatment process, thereby this excess will be resolved.

(c6) Nitrate and nitrite

The nitrate is the common form of combined nitrogen found in natural waters. It may be biochemically reduced to nitrite by denitrification processes, usually under anaerobic conditions. The nitrite is rapidly oxidized to nitrate. Natural sources of nitrate in surface waters include igneous rocks and plant and animal debris. Nitrate is an essential nutrient for aquatic plants and seasonal fluctuations can be caused by plant growth and decay. Sometimes nitrate and nitrite are enhanced by municipal and industrial wastewater, including leachates from waste disposal sites and sanitary landfills. However, the targeted water sources are located in rural areas so use of inorganic nitrate fertilizers seems to be a possible source. In all, 10% of nitrite samples and none of nitrate samples exceeded the permissible Sri Lankan drinking water standard. The same as free ammonia, nitrate and nitrite will be reduced through the water treatment process, thereby this excess will be resolved.

(c7) Phenol compounds

Phenol compounds are an important group of pollutants which enter water bodies in the waste discharges of many different industries. They are also rarely formed naturally during the metabolism of aquatic organisms, biochemical decay and transformation of organic matter in the water and in bottom sediments.

They have detrimental effects on the quality and ecological condition of water bodies through direct effects on living organisms. The presence of phenol compounds causes deterioration in the organoleptic characteristics so they are strictly controlled in drinking water. Two phenol compound samples (7%) showed the same as the permissible Sri Lankan drinking water standard that is 0.0002mg/l. As there is less possibility of industrial pollution, the cause is unclear so far.

(c8) Chemical oxygen demand

Freshwater like the target water sources contain organic matter which can be measured by chemical oxygen demand (COD). The COD is a measure of the oxygen equivalent of the organic matter in a water sample that is susceptible to oxidation by a strong chemical oxidant. The COD is widely used as a measure of the susceptibility to oxidation of the organic and inorganic materials present in water bodies so. Though the test for COD is non-specific and it does not identify the oxidisable material such as the organic and inorganic material present, phytoplankton growth is a most probable reason due to the consideration of other test results. A total of 70% of COD samples exceeded the permissible Sri Lankan drinking water standard. However, this will be reduced through the water treatment process, thereby this excess will be resolved.

(c9) Aluminum

Aluminum occurs in the earth's crust in combination with silicon and oxygen to form feldspars, micas, and clay minerals. Therefore, this occurrence in the target water sources is quite natural as there are so many such minerals in Sri Lanka. A total of 10% of Aluminum samples exceeded the permissible Sri Lankan standard and it occurred only in Wahalkada Wewa. Generally aluminum potassium sulfate (alum), aluminum compound itself, is used in water-treatment processes to flocculate suspended particles, and it can be left as residue of aluminum in the finished water.

(c10) Total coliform and E. coli

The total coliform group includes both faecal and environmental species. Total coliforms include organisms that can survive and grow in water. Some of these bacteria are excreted in the faeces of humans and animals, but many coliforms are able to multiply in water and soil environments. E. coli is a kind of coliform and present in very high numbers in human and animal faeces and is rarely found in the absence of faecal pollution. Therefore, it is considered the most suitable index of faecal contamination. Occurrence of E. coli seems not to be human faeces but animal faeces as the populations around the both water sources are low. In all 77% of total coliform and 42% of E. Coli samples exceeded the permissible Sri Lankan drinking water standard. However, this will be eliminated through the water treatment process, thereby this excess will be resolved.

(d) General characteristics of Yan Oya reservoir water

Yan Oya Reservoir to be newly constructed will has a plan to supply water to the part of an irrigation area for Wahalkada Scheme and improve the water use condition of Wahalkada Wewa.

The results of the laboratory chemical and microbiological analysis for the Yan Oya reservoir water are shown in **Table 4.18**. From these data, some general characteristics are

found.

Firstly, it can be said that Yan Oya water shows a groundwater characteristics even though it is a surface water. Higher concentration of EC, chloride, hardness, fluoride, iron, sulphate, magnesium and aluminum compared with Mahakandawara and Wahalkada wewa were found. Some comparison figures are shown below.

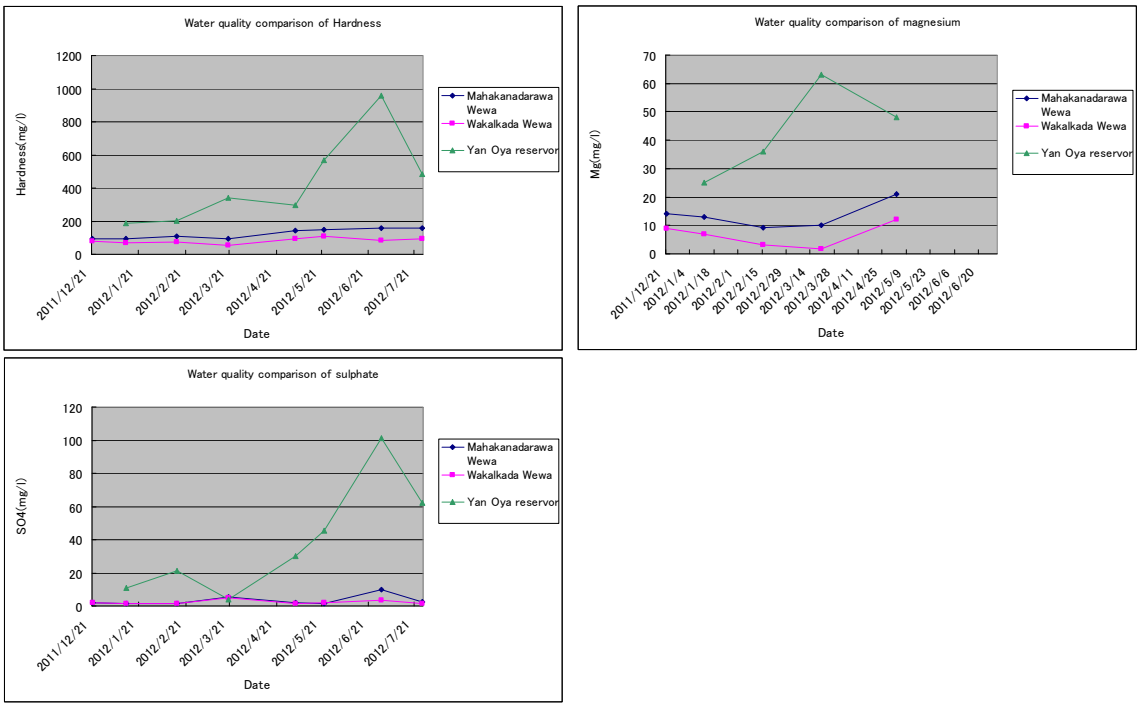


Figure 4.28 Water Quality Comparison

It seems that the water source of Yan Oya water contains a kind of groundwater located above the sampling site. On the other hand, the same as Mahakandawara and Wahalkada wewa, Yan Oya water contains high concentration of free and albuminoid ammonia. It seems to be caused by fertilizer application around Yan Oya as well. However, unlike the said two water sources, Yan Oya showed lower chlorophyl a concentration. It is because the water at Yan Oya water is flowing and not stagnant, meaning there is less chance of photosynthesis for phytoplankton growth to occour. Therefore, high COD, and free and albuminoid ammonia are caused not by the phytoplankton growth. One possible cause is influent animal waste around the Yan Oya stream. High values of Total coliform and E. coli indicate this.

(e) Fluoride in Yan Oya water

Unlike the other two water sources, Yan Oya shows a high fluoride content. As mentioned, one of Yan Oya water source seems to be groundwater, and that groundwater may have a high concentration of fluoride. Compared with other proposed water sources, fluoride

concentrations of Yan Oya water have exceeded 0.6 mg/L for a period of May to September as shown in **Figure 4.26**, which is the desirable level of Sri Lankan drinking water standard.

(f) Evaluation of specific parameters including Sri Lankan standard comparison for Yan Oya

(f1) Turbidity

In all, 29% of turbidity samples exceeded the permissible Sri Lankan drinking water standard. The reason is unknown but it seems not to be biological activity in the water. As turbidity is easily treated at a purification plant, this will not cause a problem. For general information of turbidity, see section c2

(f2) Taste

A total of 43% of taste samples exceeded the permissible Sri Lankan drinking water standard. The reason is unknown but slow sand filter method which is planned treatment method for water purification plant is able to treat them. For general information of taste, see section c1

(f2) Free and albminoid ammonia

In all, 57% of free ammonia and 86% of albminoid ammonia samples exceeded the permissible Sri Lankan drinking water standard. It seems that this is caused by fertilizer application in the same manner as Mahakandawara and Wahalkada wewa, and another possible cause is animal waste around the Yan Oya stream. Free and albminoid ammonia will be reduced through the water treatment process, thereby this excess will be resolved. For general information of free and albminoid ammonia, see section c8.

(f3) Iron

Iron occurs in the minerals hematite, magnetite, taconite, and pyrite. The iron originates by solution at sites of either reduction of ferric hydroxides or oxidation of ferrous sulphide and the process is strongly influenced by microbiological activity. The occurrence of iron in streams like Yan Oya and in lakes like Mahakandawara and Wahalkada wewa is natural, though groundwater generally contains higher iron than surface water. A total of 14% of iron samples exceeded the permissible Sri Lankan drinking water standard. However, this will be eliminated through the water treatment process, thereby this excess will be resolved.

(f4) Chemical oxygen demand

A total 50% of COD samples exceeded the permissible Sri Lankan drinking water standard. It seems that it is caused by decay of aquatic organisms and animal waste

around the Yan Oya stream. However, this will be reduced through the water treatment process, thereby this excess will be resolved. For general information of COD, see section c8.

(f5) Aluminum

A total of 50% of Aluminum samples exceeded the permissible Sri Lankan drinking water standard. As is the case with Mahakandawara and Wahalkada wewa, it seems that this occurrence is originated from groundwater as there are so many minerals containing aluminum in Sri Lanka. Generally aluminum potassium sulfate (alum), aluminum compound itself, is used in water-treatment processes to flocculate suspended particles, and it can be left as residue of aluminum in the finished water. For general information of aluminum, see section c9.

(f6) Total coliform and E. coli

All samples of total coliform and 86% of E. Coli samples exceeded the permissible Sri Lankan drinking water standard. This figure far exceeds the 40% of samples found at Mahakandawara and Wahalkada wewa. It seems that it is caused by animal waste around the Yan Oya stream. As this contamination will be eliminated through the water treatment process, its excess will be resolved. For general information of aluminum, see section c10.

(3) Quality control

A series of quality control measures, which are operational techniques and activities that are used to fulfill requirements of JICA Study Team for quality tests, were also conducted. The quality control program conducted consists of an internal quality control and an external quality control. The former refers to activities conducted within a laboratory to confirm performance and the latter refers to activities to compare with Japanese laboratory.

Additionally, data comparison NWSDB Anuradhapura lab to subcontractor lab was also conducted to evaluate the performance and find the problem.

1) Internal quality control

For the internal quality control, accuracy control of subcontractor’s lab using a certified reference material (CRM) was conducted. Certified reference materials (CRMs) are matrix-matched materials with assigned target values and assigned ranges for each variable, reliably determined from data obtained by repeated analysis. Target and range values may be generated from data produced by several laboratories using different analytical methods. Since CRM is prepared and checked under carefully controlled conditions, they are costly to produce and correspondingly expensive to purchase. Therefore, JST conducted this activity only one time in June.

(a) CRM used

- Model: Ontario-99,
- Manufactured by: Canada Environment
- Source water: Lake water with spike

(b) Procedures

CRM was prepared and provided the subcontractor lab with regular monitoring sample in June. The lab analyzed CRM with other regular samples and reported to JICA Study Team.

(c) Results

Analysis results of CRM by subcontractor are shown below.

Table 4.19 Analysis Results of CRM

Analytical parameters	Expected values (mg/l)	Analysis results by subcontractor (mg/l)	Recovery (%)
Alkalinity	93.1	97	104%
Chloride	20.8	21	101%
Fluoride	0.63	0.70	111%
Hardness	124	129	104%
Sulphate	26	37	142%

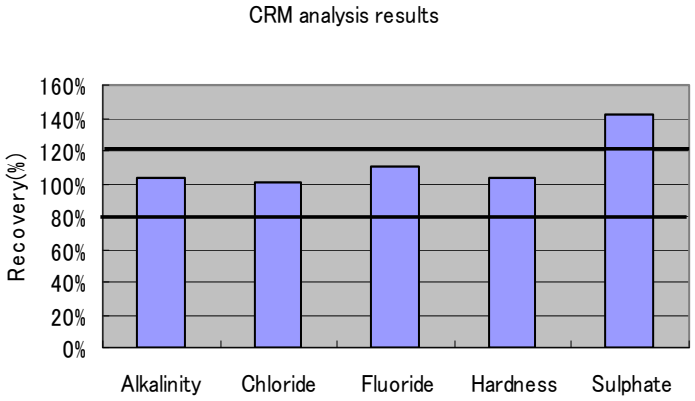


Figure 4.29 Recovery of CRM Results

As the results shown, subcontractor's lab performed good recovery which ranged within 120 to 80% for Alkalinity, Chloride, Fluoride and Hardness. However, Sulphate's recovery showed 142% and out of our expected criteria. The lab investigated the possible reason such as miscalculation or mistype but no mistake was found. Therefore, the cause is still unknown as it was only one time proficiency test and unable to test again due to the CRM volume limitation.

2) External quality control

External quality control (laboratory intercomparison)

External quality control is a way of confirming the accuracy of analytical results by

comparing the results of analyses made in one laboratory with the results obtained by others conducting the same analysis on the same material. This time a subcontractor lab and a Japanese lab results were simply compared so no statistical analysis was done.

(a) Sample used

- Sampling point: Mahakandawara wewa
- Sampling location: Irrigation canal connection
- Source water: Lake water without spike
- Laboratory used for comparison: Environmental Control Center, Japan

(b) Procedures

In the regular monitoring at irrigation canal connection of Mahakandawara wewa in May, the said sample was carefully subsampled into two sets. One was analyzed by subcontractor lab as usual and the other was sent to Japan to be analyzed by the Environmental Control Center. The results were compared and evaluated as follows.

(c) Results

Analysis results by subcontractor and Japanese labs are shown below.

Table 4.20 Analysis Result Comparison

Analytical parameters	Analysis results by Japanese lab (mg/l)	Analysis results by subcontractor lab (mg/l)	Recovery (%)
Fluoride	0.27	0.34	79%
Arsenic	<0.001	<0.02	100%**
Cadmium	<0.0003	<0.005	100%**
Lead	<0.001	<0.03	100%**
Mercury	<0.0005	<0.001	100%**
Selenium	<0.001	<0.005	100%**
Total Chromium	<0.001	<0.05	100%**
Iron	0.16	0.15*	107%

*----- Subcontractor lab performs LOD of Iron analysis as 0.1mg/l so raw data of 2 digits is shown as reference

**----As both lab showed below LOD, the recovery shall be 100%

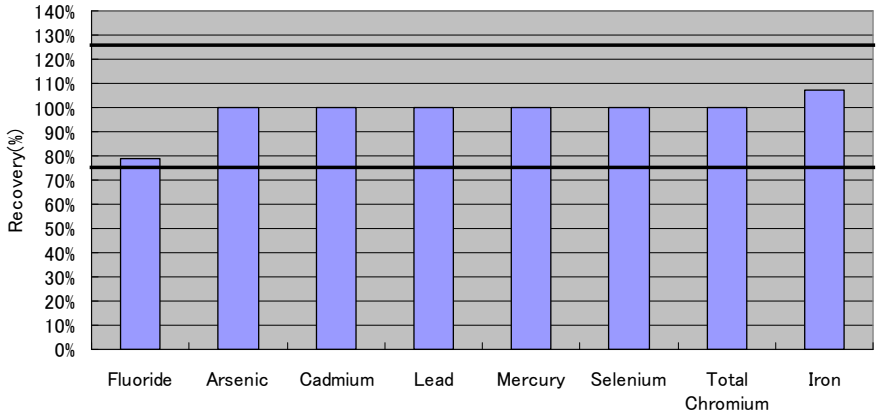


Figure 4.30 Recovery of Results

As the results shown, subcontractor's lab performed good recovery which ranged within 125 to 75% for all analytical parameters. Though fluoride result showed lower performance, it was acceptable as fluoride test is one of the variable analytical parameter.

3) Data comparison for NWSDB Anuradhapura lab

Data comparison of NWSDB Anuradhapura lab with subcontractor lab conducted for fluoride test as follows.

(a) Sample used

- Mahakandadrawa wewa
- Wahalkada wewa
- Yan Oya

(b) Procedures

In the regular monitoring of Mahakandawara and Wahalkada wewa in May, the samples were carefully subsampled into two sets for fluoride. One was analyzed by subcontractor lab and the other was done by NWSDB Anuradhapura lab. The results were compared and evaluated as follows.

Table 4.21 Analysis Result Comparison

	Mahakanadarawa Wewa			Wahalkada Wewa			Yan Oya
	Outlet surface	Outlet bottom	Lake center	Outlet surface	Outlet bottom	Lake center	River stream
SGS lab	0.34	0.38	0.37	0.27	0.29	0.26	0.81
NWSDB lab	---	0.1	0.12	0.12	0.14	0	0.62

Though the data volume is still limited, it is observed that NWSDB Anuradhapura lab generally performed lower concentration than the subcontractor lab, based on their respective results. Judging from the fact that the subcontracted lab performed well in the internal and external quality control, it seems that the NWSDB lab shows lower values of fluoride than true values. There are some possible causes but one thing to be done is sample pretreatment to remove interferences.

4) Conclusion

Generally, the subcontractor laboratory performed well and fulfilled the requirement of quality test except sulphate. For sulphate, other investigation is required later.

As for Data comparison for NWSDB Anuradhapura lab, investigation of the cause needs more time and maybe another program will be required such as dispatching of an expert(s).

4.3.3 Present Operation of Irrigation Reservoir

(1) Entity of the operation and management

Operation and management of the irrigation tanks is under the responsibility of the Irrigation Department, which is an "A class" Governmental Department. The Department was formed 110 years ago and is subject to the control and direction of the Ministry of Irrigation and Water Management, which is overall in charge of Irrigation. The Irrigation Department implements the policies and programs of the Ministry, as the principal organization for the regulation and control of irrigation waters.

The Regional Director of Irrigation, Anuradhapura has responsibility for the Mahakanadarawa and Wahalkada tanks. Four Irrigation Engineer Offices, which are located in Radviya, Anuradhapura, Rajanganay and Hurulu Wewa, and one Regional Engineer Office, which is located in Nachchaduwa for are responsible for management of irrigation schemes. Operation and management of Mahakanadarawa tank is controlled by the Irrigation Engineer's Office in Mahakanadarawa, and Wahalkada tank is controlled by the Office in Radviya.

(2) Condition of Irrigation and Water Use

The water uses of the above tanks are irrigation and fisheries. Irrigation water is mainly used for paddy fields and partly used for other upland crops under an annual irrigation program. The general condition of the irrigation scheme and basic factors of the irrigation program in this region are shown in **Table 4.22**.

Table 4.22 General Condition of the irrigation

Item	Outline
Irrigation period in Maha	Nov. – March
Irrigation period in Yala	May – August
Major Crops	Rice(Paddy field)
Irrigation Area	Mahakanadarawa Scheme： Max. Irrigable area: 6,000Ac（2,420ha) Irrigable area by FSL: 3,600Ac（1,460ha） (around 50% of 3,000 Ac is available in Yala season) Wahalkada Scheme： Max. Irrigable area: 2,257Ac（910ha) Irrigable area by FSL: 2,000Ac（810ha）

The irrigation water requirement is approximately calculated based on the above and the following conditions:

- Potential Evapotranspiration:
  - Mahakanadarawa Scheme: Data at Mahailluppallama Station
  - Wahalkada Scheme: Data at Vavniya Station
- Cropping factor: 0.90～1.15, depending on the growing stage
- Rainfall:
  - Mahakanadarawa Scheme: Data at Anuradhapura Station with efficiency of 80%
  - Wahalkada Scheme: Data at Wahalkada Station with efficiency of 80%
- Irrigation Period: Yala in May-August, Maha in Nov.-March
- Irrigation Area:
  - Mahakanadarawa Scheme: 1460 ha
  - Wahalkada Scheme: 810 ha
- Efficiency: 40% (case of no lining canal)

The annual irrigation water requirement for the Mahakanadarawa Scheme is approximately 22.2 MCM and that for Wahalkda is approximately 10.9 MCM as shown in **Table 4.23** and **Table 4.24**.

Table 4.23 Estimation of Irrigation Use in Mahakanadarawa Scheme

Month	1	2	3	4	5	6	7	8	9	10	11	12	Total
Cropping Calender (paddy field)	Maha				Yala						Maha		
(A) Days of month	31	28	31	30	31	30	31	31	30	31	30	31	
(B) kc	1.2	1.2	0.9		1.0	1.15	1.2	0.9			1.0	1.15	
(C) ETO (mm/day)	2.4	3.2	3.8	3.6	4.2	4.5	4.7	4.8	4.7	3.4	2.3	2	
(D) ETO (mm/month)	74.4	89.6	117.8	108	130.2	135	145.7	148.8	141	105.4	69	62	
(E) Etcrop (mm/month)	89.3	107.5	106	0	130.2	155.3	174.8	133.9	0	0	69	71.3	
(F) Crop water requirement (m^3/ha/month)	893	1,075	1,060	0	1,302	1,553	1,748	1,339	0	0	690	713	
(G) Rainfall (mm/month)	90	51	70	159	74	15	30	33	73	223	248	188	1254
(H) Effecive rainfall (m^3/ha/month)	717	408	558	1274	588	122	236	267	586	1784	1986	1502	
(I) Net water requirement (m^3/ha/month)	176	667	503	0	714	1,430	1,512	1,072	0	0	0	0	
(J) Irrigation area (ha) - FSL	1,460	1,460	1,460	1,460	1,460	1,460	1,460	1,460	1,460	1,460	1,460	1,460	
(K) Net water requirement (m^3/month)	257.2	974.1	733.7	0.0	1,042.2	2,088.5	2,207.8	1,565.0	0.0	0.0	0.0	0.0	8,868.4
(L) Efficiency	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	
(M) Gross water requirement (m^3/month)	642.9	2,435.3	1,834.3	0.0	2,605.4	5,221.1	5,519.5	3,912.5	0.0	0.0	0.0	0.0	22,171.0

Table 4.24 Estimation of Irrigation Use in Wahalkada Scheme

Month	1	2	3	4	5	6	7	8	9	10	11	12	Total
Cropping Calender (paddy field)	Maha				Yala						Maha		
(A) Days of month	31	28	31	30	31	30	31	31	30	31	30	31	
(B) kc	1.2	1.2	0.9		1.0	1.15	1.2	0.9			1.0	1.15	
(C) ETO (mm/day)	2.16	2.88	3.46	3.4	4.13	4.58	4.53	4.34	4.46	2.94	1.92	1.84	
(D) ETO (mm/month)	66.96	80.64	107.26	102	128.03	137.4	140.43	134.54	133.8	91.14	57.6	57.04	
(E) Etcrop (mm/month)	80.4	96.8	96.5	0	128	158	168.5	121.1	0	0	57.6	65.6	
(F) Crop water requirement (m^3/ha/month)	804	968	965	0	1,280	1,580	1,685	1,211	0	0	576	656	
(G) Rainfall (mm/month)	173	88	49	74	43	13	36	61	85	152	346	321	1441
(H) Effecive rainfall (m^3/ha/month)	1,380	707	389	590	341	107	289	490	683	1,217	2,765	2,569	
(I) Net water requirement (7000 m^3/ha/month)	0	261	576	0	939	1,473	1396	721	0	0	0	0	
(J) Irrigation area (ha) - FSL	809	809	809	809	809	809	809	809	809	809	809	809	
(K) Net water requirement (m^3/month)	0.0	210.8	466.2	0.0	0.8	1,191.9	1.1	583.2	0.0	0.0	0.0	0.0	4.3
(L) Efficiency	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	
(M) Gross water requirement ('1000 m^3/month)	0.0	527.1	1,165.6	0.0	1,899.4	2,979.6	2,823.3	1,457.9	0.0	0.0	0.0	0.0	10,853.0

(3) Operation Method for Irrigation Water Use

Mahakanadarawa scheme has 2 intake wells for irrigation and the Wahalkada Scheme has one. The irrigation water requirement varies throughout the year depending on factors such as storage volume, market price, availability of man power and machinery. Representatives of farmer's organization and the irrigation department discuss and determine the water volume and period for irrigation. Normally, there is a period of between 10 and 14 days for preparation period, then water is supplied 5 days, followed by a period of 5 days with no water, with the cycle continuously repeating. Water is controlled to keep a minimum water depth of 25 mm in the paddy field.

Table 4.25 shows the annual irrigation water use in 2009-2011. In the case of the Mahakanadarawa scheme, water use varied from 19.41 to 42.42 MCM, with the amount partly being dependent on the quantity of water stored early in the season. On the other hand, in the case of the Wahalkada scheme, the variation in irrigation water use is not as big as in the Mahakanadarawa scheme, ranging from about 12 to 16 MCM, with the storage volume early in the season varying.

Table 4.25 Irrigation Water Used in 2009-2011

	Mahakanadarawa tank		Wahalkada Tank	
	Storage in Jan. 1 (MCM)	Irrigation Water Supply (MCM)	Storage in Jan. 1 (MCM)	Irrigation Water Supply (MCM)
Gross Calc. for Average Rainfall		22.2		10.9
2009	44.78	No data	17.45	12.13
2010	22.50	19.41	21.50	16.13
2011	44.78	42.42	26.73	15.95

Figure 4.31 and **Figure 4.32** show the daily irrigation use in these irrigation schemes in the period 2090-2011. These figures show that irrigation water use is almost corresponding with the Yala and Maha periods, and some irrigation water is used in the Maha period, even in the rainy season.

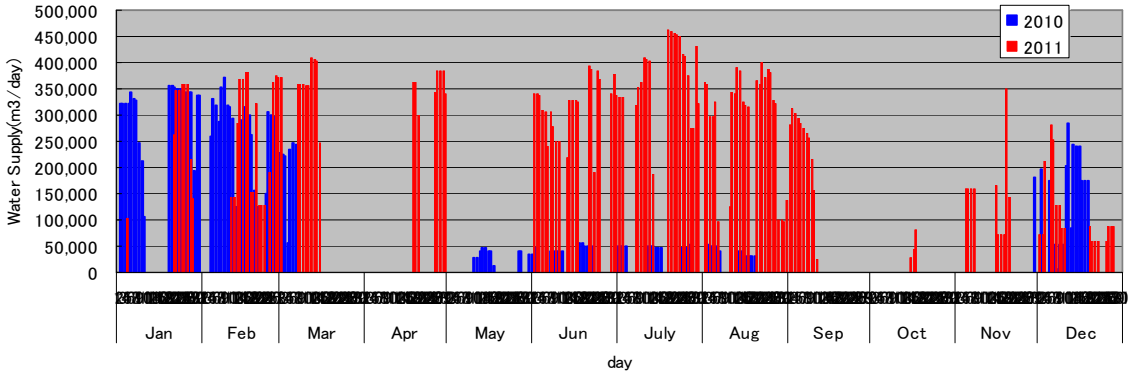


Figure 4.31 Irrigation Water Use in Mahakanadarawa Scheme（2009-2011）

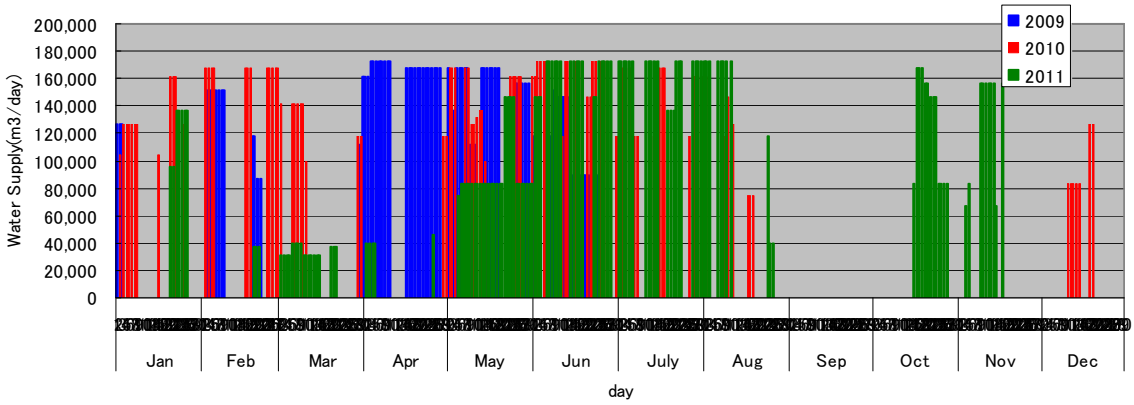


Figure 4.32 Irrigation Water Use in Wahalkada Scheme（2009-2011）

(2) Storage Variation of Mahakanadarawa and Wahalkada Wewa

Table 4.26 shows general details of the above reservoirs (refer to **Appendix 4.3(f)** for details).

Table 4.26 General Data of Mahakanadarawa and Wahalkada Tank

Item	Mahakanadarawa Wewa	Wahalkada Wewa
Full Supply Level (FSL)	311 ft	155 ft
Gross Storage for FSL	36,250 Ac.ft	43,000 Ac.ft
Dead Storage	2,000 Ac.ft	2,025 Ac.ft
High Flood Level	315 ft	156 ft
Top level	320 ft	162 ft
Top Width	18 ft	20 ft
Max. Height	19 ft	40 ft
Intake	2 places RB: Intake well、sluice gate LB: Intake well, sluice gate	1 places Intake well、sluice gate
Canal	2lines、only LB Canal in dry season	1 line

The water level and storage data of the reservoirs was collected from the Irrigation Regional Office in Anuradhapura (refer to **Appendix 4.3(g)** for details).

Mahakanadarawa Wewa

(a) This reservoir is a type of cycle regulation dam, and the storage amount varies year by year due to rainfall variation. Storage of Mahakanadarawa Wewa has been over the Full Storage Level (FSL) 4 times in the past 11 years.

(b) Many small tank cascades and paddy field exist in the catchment area, therefore this condition can affect inflow mechanism to the reservoir, i.e., initial rainfall is stored in small tanks and even in paddy fields. Direct flow to the reservoir can be limited to only the area surrounding the reservoir.

(c) Minimum storage was recorded in 2006, 500Acft (0.61MCM). The water level on the sill corresponding to this storage is 0.08 m.

(d) Irrigation water use in Yala season is determined based on the water level in the reservoir in the period March-May. When water level was FSL in January 2004, around 28,000Acft (34.4MCM) of water were used for irrigation in 3 months from April. This amount corresponds to 0.38MCM per day.

On the other hand, the storage volume was about 18,000Acft (22.14MCM) in January 2005, and only 15,000Acft (18.5MCM) were used for irrigation, corresponding to 167Acft (0.205MCM). Basically, the Mahakanadarawa scheme has the potential to irrigate an area of 6,000 Ac (2,420 ha). However, because of the limitation of water, 3,000 Ac is normally irrigated even under FSL storage conditions. The irrigation area in rhe Yala season is 1,500 Ac (730 ha), 50% of the area under FSL storage conditions.

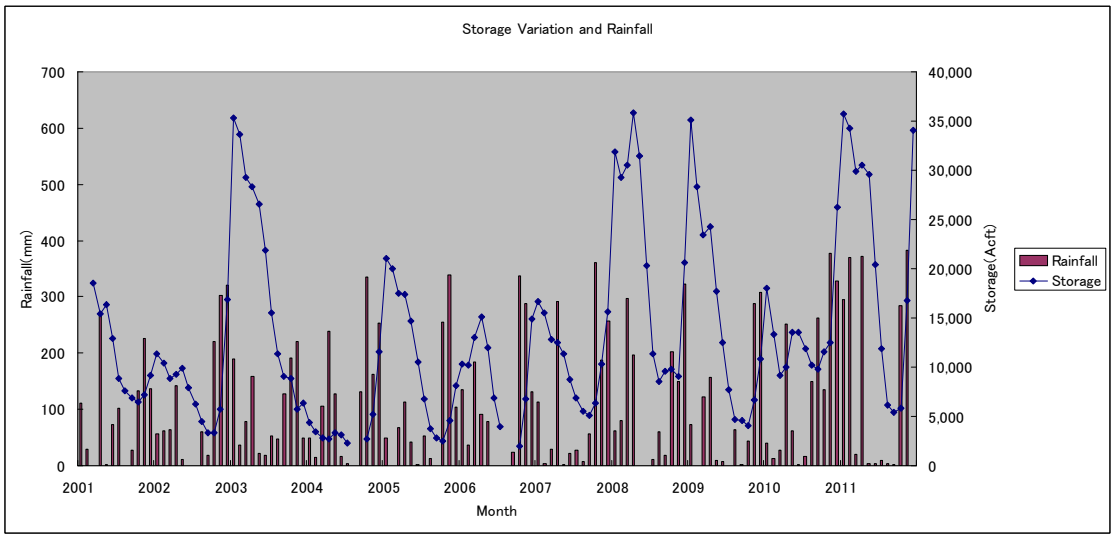


Figure 4.33 Monthly Rainfall and Storage in Mahakanadarawa Tank

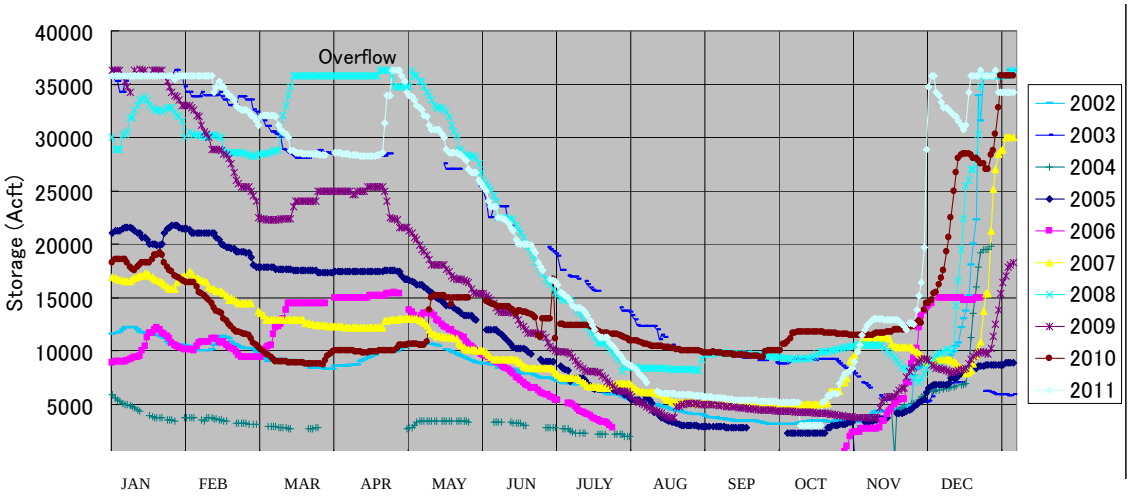


Figure 4.34 Monthly Variation of Storage in Mahakanadarawa Wewa

Wahalkada Wewa

(a) This reservoir is a type of cycle regulation dam, and the storage amount varies year by year due to rainfall variation. Storage of Wahalkada Wewa has been over the Full Supply Level (FSL) only once in the past 11 years.

(b) Many small tank cascades and paddy fields are present in the catchment area of this reservoir; therefore this condition can affect the flow into the reservoir, i.e., initial rainfall is stored in small tank and even paddy field. Direct flow can be limited to from only the area surrounding the reservoir.

(c) Storage of the reservoir has been recorded at about 35,000 Acft in 2005 and 2006 and the storage amount was less than 20,000 Acft until 2010. The amount of rainfall in these years has not been so low 1,256mm - 1,799mm.

(d) The record of storage in February of 2011 shows 59,000 Acft, which is bigger than the gross storage of 43,000 Acft. According to information from the Irrigation Engineer's office in Padaviya, the water inflow in 2011 was quite large, and the water was flowing

over the near point of the spillway. The Irrigation Department is considering expansion of spillway.

(e) Minimum storage was recorded in 2010, as 2,025Acft. The water level on the sill corresponding to this storage is 0.85m.

(f) Regardless of the storage amount, irrigation water use has a tendency to be the same amount in the period from April to July.

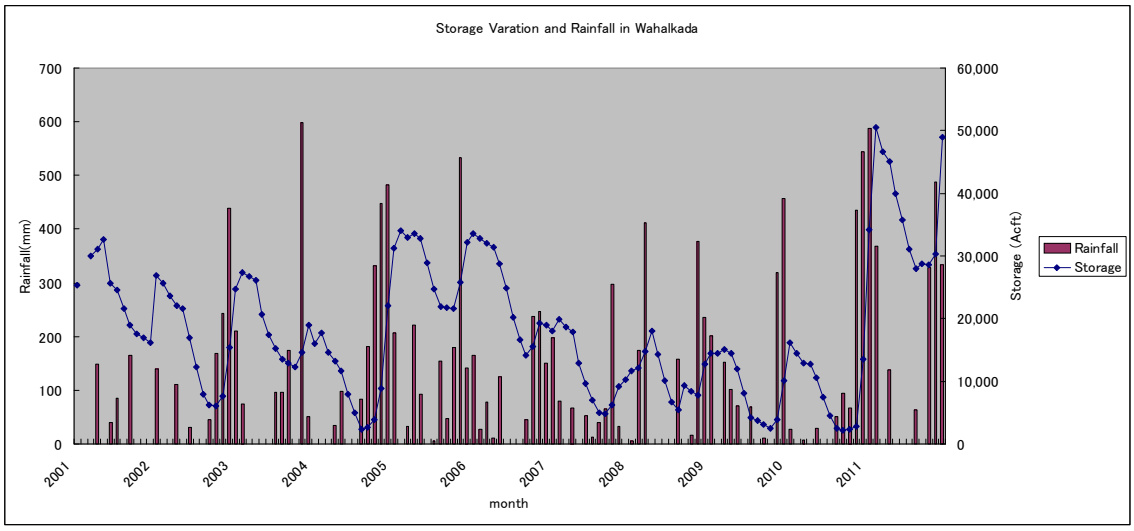


Figure 4.35 Monthly Rainfall and Storage in Wahalkada Tank

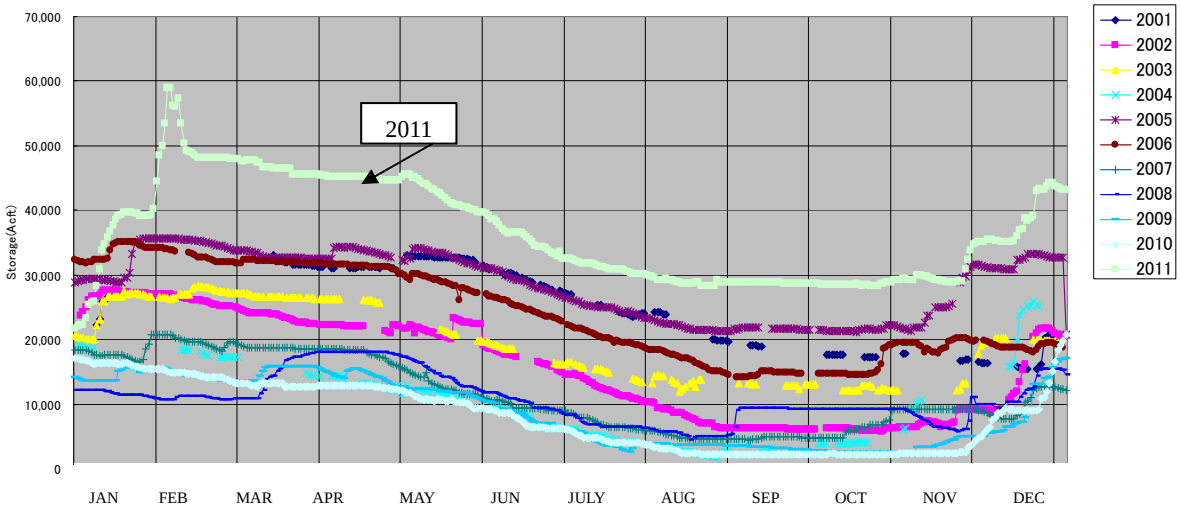


Figure 4.36 Monthly Variation of Storage in Wahalkada Tank

4.3.4 Water Availability from Irrigation Reservoir

The objective of this analysis is to evaluate the availability of water for drinking use from Mahakanadarawa and Wahalkada Wewa. The storage amount in the reservoirs vary depending upon rainfall and irrigation use, which itself is dependent on many factors such as agriculture

marketing aspect, use of machinery, input of man power, etc.

Because of the limited study period, no direct measurement of inflow to and outflow from the reservoirs or detailed model simulation was carried out. Basically, collected data and information from the Meteorological Department and Regional Irrigation Department were used for the evaluation.

(1) Water Balance of the reservoirs

An estimate of the gross annual water balance of reservoirs has been made. Factors in the water balance are inflow from the catchment area, rainfall, evaporation, seepage and irrigation use, as shown in **Figure 4.37**.

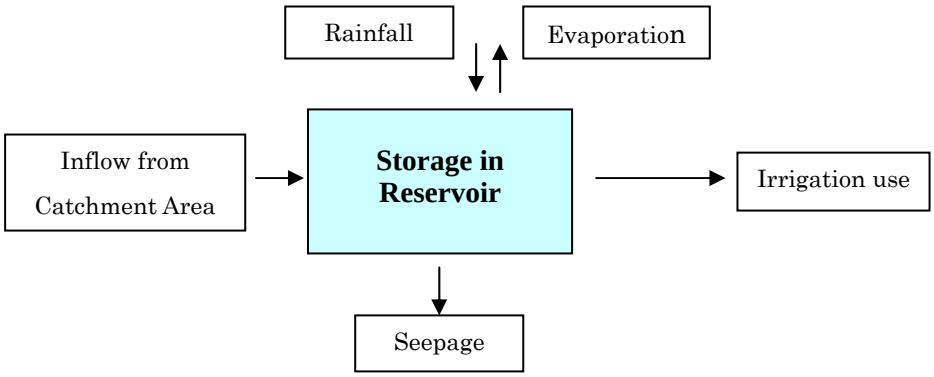


Figure 4.37 Image of Water Balance

1) Rainfall

Average annual rainfall in the Study Area is used as follows.

Anuradhapura Station : 1,246 mm
Wahalkada Station : 1,441 mm

2) Estimation of run-off from catchment area

Gross run-off coefficient from the catchment area to the reservoir is analyzed based on the increase in reservoir's storage and monthly rainfall from October to January at the start of the rainy season.

According to the intake data of the Irrigation Department, irrigation water is used even in the rainy season; therefore the calculated coefficient is considered on the safe side in order to maintain storage.

Table 4.27 and **Table 4.28** show that values of runoff varies between 3%～12% in Mahakanadarawa and between 5%～26% in Wahalkada. The catchment areas include many small tanks and paddy fields and as such the initial and small amounts of rainfall can be

stored in these places. Furthermore, outflow to the reservoir is only from the surrounding area and after filling of the paddy fields and small tanks, i.e. the variation in run off is due to the volume and continuity of rainfall.

Table 4.27 Runoff Coefficient Calculated in Mahakanadarawa Tank

Year-Year	Rainfall (mm)	Storage change (MCM)	Catchment Area (km^2)	Rainfall x Catchment Area (MCM)	Runoff Coefficient (%)
2001-2002	554	5.98	334	184.87	3.2
2002-2003	1,033	39.41	334	344.86	11.4
2003-2004	509	-5.52	334	170.11	-
2004-2005	801	22.58	334	267.40	8.4
2005-2006	834	9.56	334	278.66	3.4
2006-2007	870	18.07	334	290.45	6.2
2007-2008	868	31.52	334	289.88	10.9
2008-2009	747	31.16	334	249.56	12.5
2009-2010	682	17.17	334	228.34	7.5
2010-2011	1,134	29.80	334	381.16	7.9
					Average: 8%

Table 4.28 Runoff Coefficient Calculated in Wahalkada Tank

Year-Year	Rainfall (mm)	Storage change (MCM)	Catchment Area (km^2)	Rainfall x Catchment Area (MCM)	Runoff Coefficient (%)
2001-2002	643	4.96	83	53.40	9.3
2002-2003	1,061	23.96	83	88.10	27.2
2003-2004	648	5.23	83	53.82	9.7
2004-2005	1,468	39.11	83	121.83	32.1
2005-2006	1,020	13.53	83	84.64	16.0
2006-2007	833	3.98	83	69.13	5.8
2007-2008	568	8.90	83	47.12	18.9
2008-2009	705	11.10	83	58.47	19.0
2009-2010	804	13.32	83	66.77	19.9
2010-2011	1,823	59.05	83	153.13	38.6
					Average: 20%

3) Gross Estimation of Water Balance

The gross Water Balance is estimated by assuming runoff coefficients. Based on the mentioned calculation, the runoff coefficient from the whole catchment area is estimated at 20% in Wahalkada Wewa, and 8% in Mahakanadarawa Wewa.

Seepage is neglected because this is a relatively small amount, compared to the total storage volume.

Table 4.29 Gross Estimation of Water Balance

	Mahakanadarawa	Wahalkada
Average Rainfall (mm/yr)	1,240	1,440
Catchment Area(km^2)	334	83
Runoff Coefficient (%)	8	20
Water Area of Reservoir (km^2)	9	2.1
Annual inflow to the Reservoir (MCM)	33.13	23.90
Volume by rainfall (MCM)	11.16	2.96
Evaporation from water surface (MCM)	11.93	2.60
Seepage (MCM)	—	—
Average Annual Storage (MCM)	32.36	23.77
Average Annual Storage (Acft)	26,244	19,278

(2) Water availability for the Project

As a conclusion, water availability in Mahakanadarawa Wewa and Whahalkada Wewa is examined with following conditions.

- Average annual storage (MCM)
- Water supply for drinking water in 2016, 2024 and 2034
- Irrigation water
- NCP Canal Project and Yan Oya Reservoir Project

1) Average annual storage (MCM)

Average annual storage of two reservoirs is as follows.

- Mahakanadarawa Wewa: 32.36 MCM
- Wahalkada Wewa: 23.77 MCM

2) Water intake for drinking water in 2016, 2024 and 2034

Water intake for drinking water is estimated as shown in **Table 4.30** (See **Section 4.3.1**).

Table 4.30 Water Intake for Drinking Water

Drinking Water Supply	Mahakanadarawa Tank		Wahalkada Tank	
	(m^3/day)	(MCM/year)	(m^3/day)	(MCM/year)
Water intake in 2016	6,700	2.45	10,500	3.83
Water intake in 2024	9,400	3.25	14,400	5.26
Water intake in 2034	18,800	6.53	28,800	10.00

3) Irrigation water

Based on the Irrigation use shown in **Table 4.23** and **Table 2.34** tendency of storage variation

in both reservoirs, annual irrigation water use is estimated as follows.

- Mahakanadarawa scheme: 20-30 MCM (40 MCM is corresponding to water use for FSL)
- Wahalkada scheme: 12-16 MCM

4.3.5 Water Right

Reform of the water institution, National Water Resources Policy, Act and Regulation including the water right administration system has been proposed in cooperation with ADB, FAO, however, still under consideration.

According to "Water Institutional Reforms in Sri Lanka" by Madar Samad, International Water Management Institute, concerning laws of water right are as follows:

1) Irrigation Ordiance (No.32)

The Irrigation Ordinance (No. 32, 1946) was first enacted in 1856 by the British colonial administration to both legalize customary irrigation practices and to prescribe the conditions for water extraction, particularly for paddy cultivation. This ordinance has been amended from time to time to keep pace with the changing socio-economic conditions and requirements.

2) The State Lands Ordinance

The State Lands Ordinance (No. 8, Part IX) of 1947 defines public and private water and specifies the water uses for which no permit is required. It provides for the regulation and control of public water and streams through a system of permits and establishes the formal rights of the state to use, manage and control public water. Notably, this ordinance does not mandate a planning system nor does it address important issues such as inter-sectoral allocation including that during droughts and for environment.

3) Mahaweli Authority of Sri Lanka Act

The Mahaweli Authority of Sri Lanka Act (No. 23) of 1979 empowers the Mahaweli Authority of Sri Lanka (MASL) to use and develop the water resources of the Mahaweli River or any major river considered to be a special area in relation to which MASL exercises its authority. MASL is empowered to plan and implement all development activities under the Mahaweli Development Project that include irrigation, hydropower generation and land settlement.

Therefore, existing principal water rights are almost on the water allocation by the State (the Irrigation Department and the Mahaweli Authority of Sri Lanka) and customary irrigation practices particularly those attached to small tanks and anicuts.

In case of Mahakandarawa Wewa and Wahalkada Wewa, these reservoirs were constructed by the Irrigation Department in order to supply water for irrigation schemes, therefore the Irrigation Department, as an organization of the State, has water rights and controls allocation.

However, according to the Irrigation Ordinance, the Commissioner has responsible for the general supervision and control of Government Agent and "the Cultivation Committee or the Agrarian Service Committee", established under the Agricultural lands Law (No.42, 1973) or the Agrarian Service Act (No.58, 1979), respectively, has power to make rules for all or any of the irrigation works. Therefore, it is pointed out that farmer's consensus building is very important to proceed with the allocation of water from these reservoirs.

4.3.6 Mahakanadarawa Wewa

(1) Situation

For Mahakandarawa wewa, the average annual storage is estimated at around 32.36 MCM, and the irrigation use varies between 20-30 MCM/year. On the other hand, the water supply for drinking will be annually 3.25 MCM in 2024 and 6.53 MCM in 2034. Assuming that the priority is given to water supply for drinking, the water shortage will occur even in 2016 for an irrigation use of 30 MCM/year. If the NCP Canal Project will not be completed, water allocation between irrigation and water supply for drinking will be a big issue, since an amount of water shortage will increase.

If the NCP Canal Project will be completed in 2016 as scheduled, it will catch the commencement of operation for water supply in 2018. Basically, the NCP Canal Project includes drinking water of around 70 MCM/year for 15 major towns in North Central and North Provinces. Most of the target towns served by the Mahakanadarawa water supply system under the "Anuradhapura North Integrated Water Supply Project" are corresponding to the towns covered by the NCP Canal Project. In 2034, the total amount of 80.53 MCM composed of 6.53 MCM for water supply and 74 MCM required to irrigate the maximum irrigation area of 2,420 ha of the Mahakanadarawa Irrigation Scheme, presently cultivated by irrigation and rainfall, will be necessary for both purposes. However, the average storage of Mahakanadarawa Wewa is approximately 32.36 MCM, and the balance of 48.17 MCM should be covered by the NCP Canal Project with a design capacity of 700 MCM which will make the further supplement of water possible. Therefore, an enough amount of water will be maintained for both water supply and irrigation

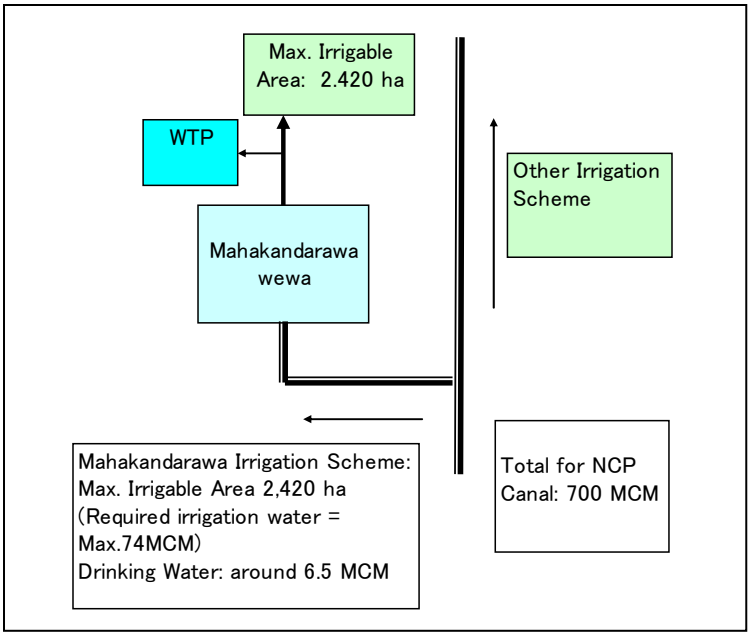
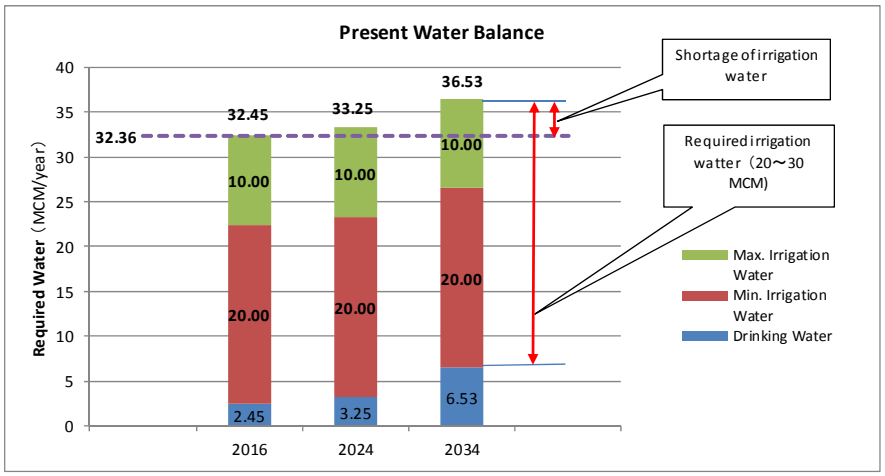


Figure 4.38 Image of Assumed Additional Water from NCP Project



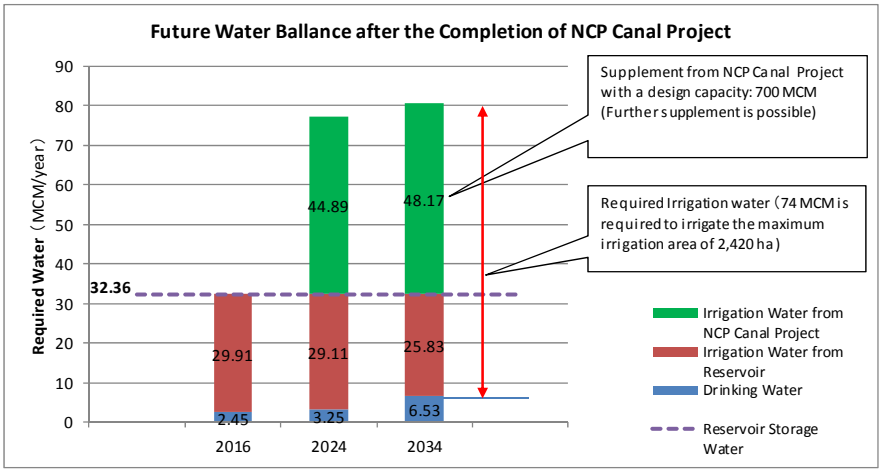


Figure 4.39 Water Availability in the Mahakanadarawa Wewa

(2) Implementation Schedule of the NCP Canal Project

GOSL has taken an initiative to implement the Moragahakanda/Kalu Ganga Project which was identified as essential infrastructure for the implementation of the NCP Canal Project. The Moragahakanda/Kalu Ganga Project is under construction since 2007, and programmed to be completed by 2014. However, the Moragahakanda/Kalu Ganga project has been delayed because of financial and environmental problems. Finally, the Chinese Government agreed to provide loan assistance in 2012, then the Moragahakanda/Kalu Ganga Project started the second stage. According to the newspapers, this Project is expectedly completed by 2016. GOSL has idea to start NCP Canal Project as soon as possible. However, the finance for NCP Project is under request, and mentioned schedule of the implementation of the NCP Project is not sure.

4.3.7 Wahalkada Wewa

(1) Situation

For Wahalkada Wewa, the average annual storage is estimated at around 23.77 MCM, and the irrigation use varies between 12-16 MCM. On the other hand, the water supply for drinking will be annually 5.26 MCM in 2024 and 10.00 MCM in 2034. According to this result, this reservoir water will not be enough to cover the water use for water supply and irrigation without an appropriate allocation in 2034.

The Yan Oya Reservoir Project will have an irrigable area of 4,780 ha by a new reservoir capacity of 254 MCM. Its left side irrigation canal will pass in the Wahalkada Irrigation Scheme, and irrigate an area of around 400 ha under the Wahalkada Irrigation Scheme based on the Proposal for Yan Oya Reservoir Project prepared by China's Contractor (CAMC Engineering Co., Ltd.). An additional water supply from Yan Oya Reservoir Project is assumed 7 MCM at the maximum as shown in **Figure 4.40**. This figure shows the water balance of the existing irrigation scheme of 800 ha based on the mentioned Proposal.

In other word, the Wahalkada Wewa will have an excess water with the same amount as it, namely 5.94 MCM to 11.51 MCM as shown in **Figure 4.41**. Therefore, the storage water will be enough for water supply and irrigation even in 2034.

It should be noted that the Yan Oya Reservoir has a problem in water quality. The fluoride concentrations of the Yan Oya River has recorded 0.81 mg/L to 1.2 mg/L in May to July 2012 exceeding the Japanese drinking water standard of 0.8 mg/L, while those of the Wahalkada Wewa has kept 0.25 mg/L to 0.38 mg/L during the same period. Therefore, the water to be used for drinking water supply should be that of the Wahalkada Wewa.

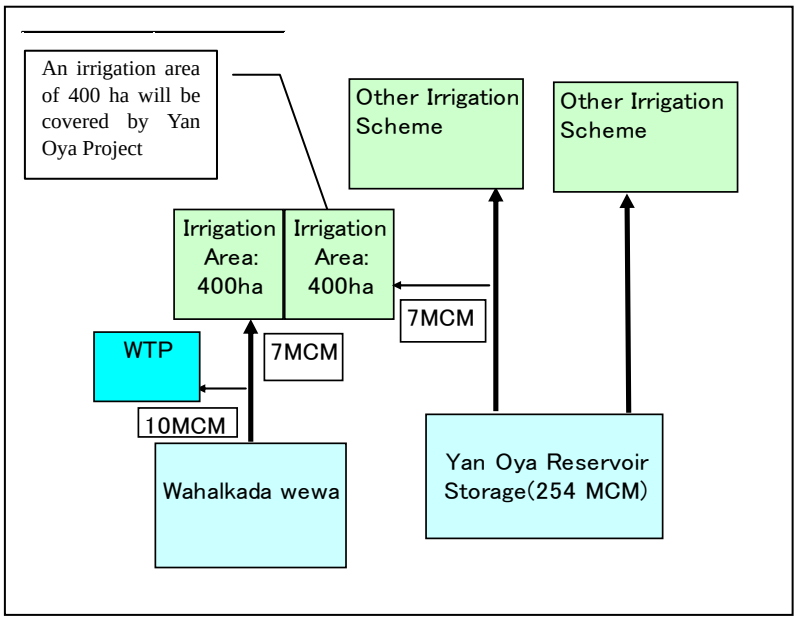
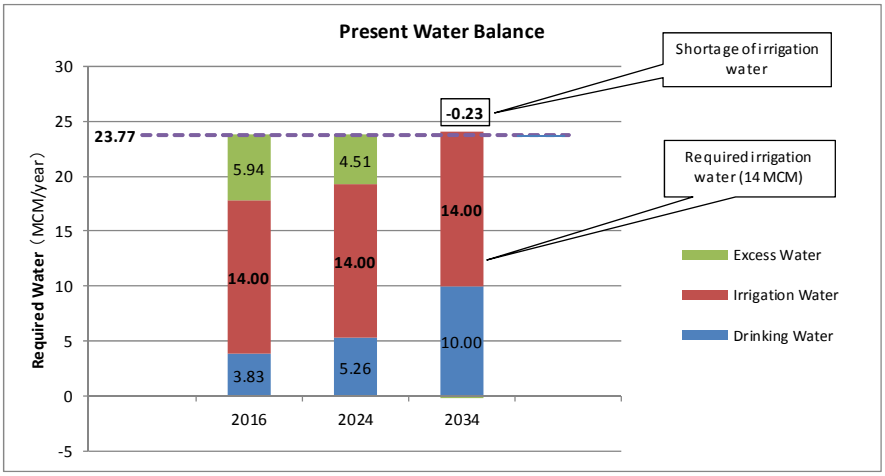


Figure 4.40 Image of Assumed Additional Water from Yan Oya Project



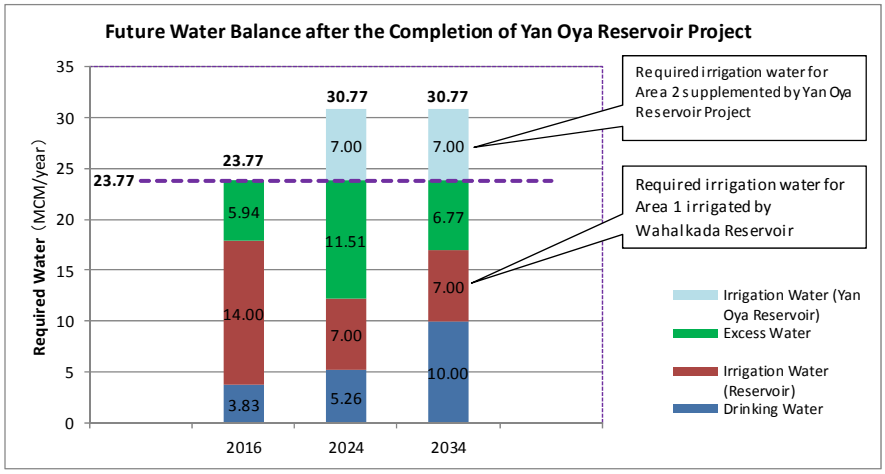


Figure 4.41 Water Availability in the Wahalkada Wewa

(2) Implementation Schedule of the Yan Oya Reservoir Project

Financial award was signed with a project cost of Rs.19 billion between the Chinese and Sri Lankan Governments in November 4, 2011. The EIA report has been submitted to the CEA and review of it is still in progress. According to the Irrigation Department, evaluation of the EIA was expected to announce in 2012. After the approval of the EIA, the construction work is expected to start and around 4 years will be required for the completion of the project.

4.3.8 North Central Province (NCP) Canal Development Project

(1) Outline

In the 1960', GOSL promoted the Mahaweli Development Program (MDP) to attain self-sufficiency in food by providing spare land for cultivation to landless people and existing water scarce irrigation schemes in the Northern Dry Zone areas of NCP, NP and EP with the objectives of guaranteed irrigation water, increase in job opportunities and to minimize the shortage of electric power.

North Central Province (NCP) Canal Development Project is the last project to be implemented under the original MDP. The general components of the NCP Canal Project are as follows.

Reservoirs:

Morogahakanda Dam (521 MCM)

Kaluganga (144 MCM)

Sub Projects:

a) Randenigala- kalu Ganga Transfer Canal Complex
b) Kainga Nuwara - Angamedilla-Minneriya tank Pumping Complex
c) NWP Diversion Canal
d) Pali Aru, Parangi Aru twin Tank Complex
e) NCP Canal from end of Upper Elahera Canal to Chemmadu Kulam Tank
f) Integrated development of NCP target area
g) Other relevant projects

Sub Project-5 Description:

Irrigation Canal from Upper Elahera to Chemmadu Kulam: Capacity 35-20 m^3/s. length 92m)

Sub Project-6 Integrated Development of NCP Target Area

Supply to 1000 minor tank cascades with command area of 3,000 ha, 10,000 ha of new land, 12,000 ha hnder major tanks, and 70 MCM of about 15 main Towns

(2) Relationship with Mahakanadarawa Wewa

About 1,060 MCM annually could be delivered to Upper Elahera canal from Moragahakanda and Kaluganga reservoir, out of which about 700 MCM could be utilized for the NCP Canal Development Project.

As shown in **Figure 4.42**, the Mahakanadarawa Irrigation scheme is also included in the target area. This Project includes irrigation water supply to existing irrigation area, and supplementary transmission water to the Mahakanadarawa Wewa.

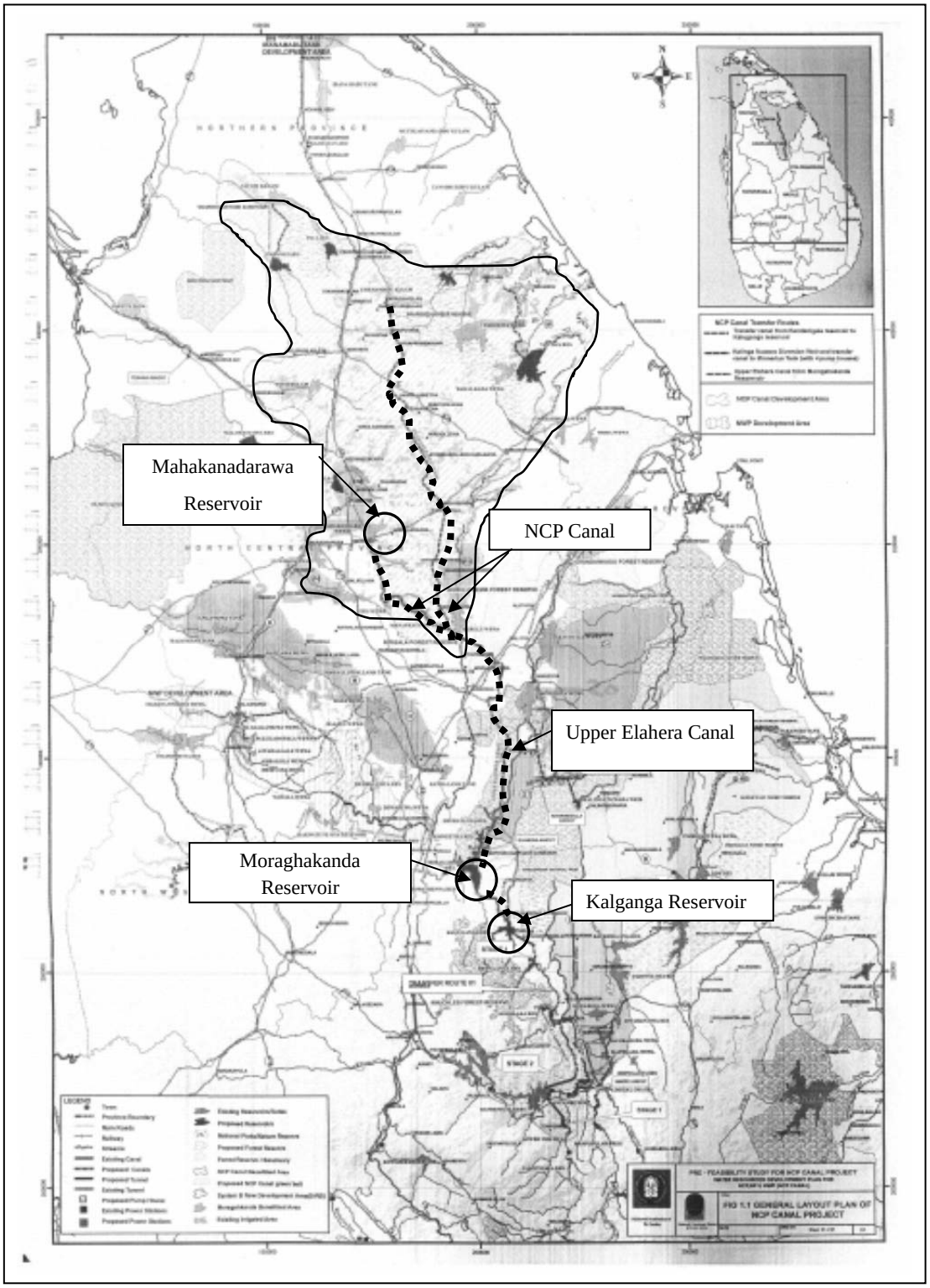


Figure 4.42 NCP Canal Development Project Location Map

(3) Project implementation Schedule

GOSL has taken an initiative to implement the Moragahakanda/ Kalu Ganga Project which was identified as essential infrastructure for the implementation of the NCP Canal Project. The Moragahakanda/ Kalu Ganga Project is under construction from 2007, and programmed to be completed by year 2014. However, the project has been delayed because of financial and environmental problems. Finally, the Chinese Government agreed to provide loan assistance in 2012, then the Project started the second stage. According to the newspapers, the Project is expected to finish in 2016. The finance for NCP Project is under request.

NCP Canal Project is planned to proceed in the following stages.

Stage 0 Update of Pre-Feasibility Study and detailed design of the components in 2012-2014
Stage 1 Randenigala-Kalu Ganga Transfer Complex- Stage1 in 2014-2017
(Irrigation scheme of Mahakanadarawa is covered in this Stage)
Stage 2 Randenigala-Kalu Ganga Transfer Complex- Stage2 in2016-2019
Stage 3 Randenigala-Kalu Ganga Transfer Complex- Stage3 in 2018-2022

(4) Water Availability for Water Supply

According to the “Pre-Feasibility Study for NCP Canal Project, Water Resources Development Plan for NCP & NWP (NCP Canal), 2002 by Mahaweli Authority of Sri Lanka”, Component for Target area 1&2 including Mahakanadarawa Area has “Multi Sector Development Strategy” objectives, which include not only irrigation but also uses for drinking and industry water as a high priority.

As a need of the NCP Canal Project, it is reported that acute kidney disease is spreading in the NCP due to non-availability of good quality drinking water, thus creating severe economic and social problems among the farming community. The government is spending large sums of money to provide health facilities to the affected persons who are suffering from kidney disease. The only way to provide much needed drinking water and irrigation water to this area is to revive the NCP Canal Project proposed in the original Mahaweli Master Plan.

Furthermore, drinking water supply of 70 MCM annually to about 15 main towns in NCP and NP is planned in the Pre-Feasibility Study Report. According to the Water Board in Anuradhapura, discussion on this theme between the Ministry of Irrigation and Water Resources Management has started, but detailed plan has not been completed.

(5) Water Quality of Planned Reservoirs

The NCP Canal Project, which plans to provide water to Mahakanadarawa, has two main water resources. One is the planned Moragahakanda reservoir and the other is Kalu Ganga reservoir. The water flow from both reservoirs to Mahakanadarawa is shown in **Figure 4.43.**

chemical analysis of water are based on Sri Lankan drinking water standard 614:1983 and other standard methods such as APHA or EPA. Table 2.8 in chapter 2.5.2 outlines the test method followed. According to the *Moragahakanda Biodiversity Study Report*, the dry seasons of this area are from January to February, and from June to September. Therefore, sampling was done in September to investigate the highest level of water quality contents. Both sampling locations were selected downstream of planned reservoirs of NCP canal project as shown in **Figure 4.44** and the water quality results are shown in **Table 4.31**.

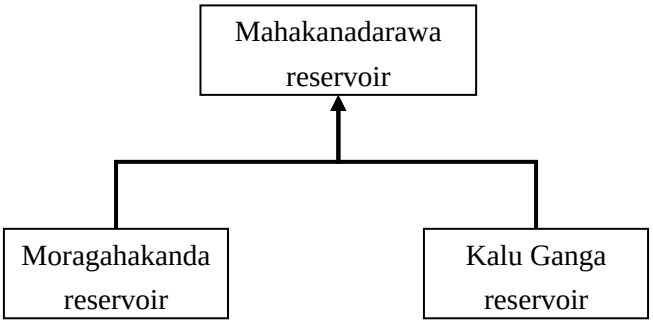


Figure 4.43 Water Flow from Both Reservoirs to Mahakanadarawa

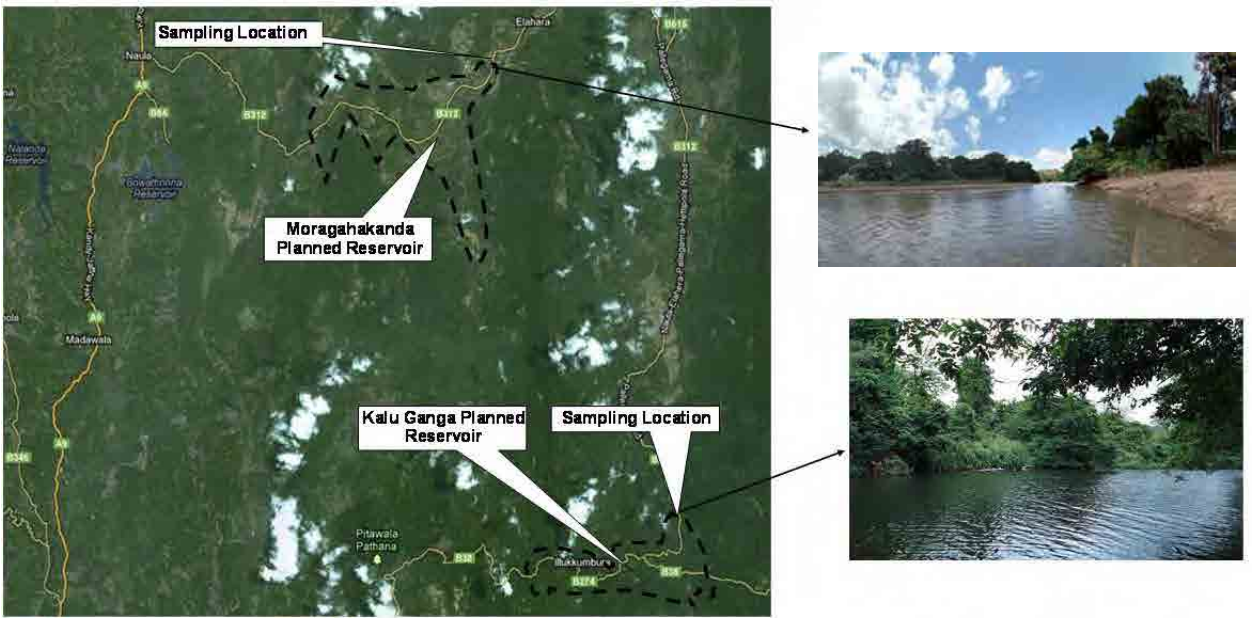


Figure 4.44 Planned Reservoirs of Moragahakanda and Kalu Ganga and Sampling Locations

Water quality results of the two water resources and the drinking water standards in Sri Lanka were compared. For Moragahakanda: a colour sample of 7.5 exceeded the desirable level (<5 Hazen Unit), a turbidity sample of 19 exceeded the permissible level (<8 NTU), a taste sample of "Objectionable" exceeded the permissible level ("Unobjectionable") and a nitrite sample of 0.07mg/l exceeded the permissible level (<0.01mg/l) of the Sri Lankan standards. For Kalu Ganga: a colour sample of 5 exceeded the desirable level (<5 Hazen Unit) and a taste sample of

Hazen Unit), a turbidity sample of 19 exceeded the permissible level (<8 NTU), a taste sample of "Objectionable" exceeded the permissible level ("Unobjectionable") and a nitrite sample of 0.07mg/l exceeded the permissible level (<0.01mg/l) of the Sri Lankan standards. For Kalu Ganga: a colour sample of 5 exceeded the desirable level (<5 Hazen Unit) and a taste sample of "Objectionable" exceeded the permissible level ("Unobjectionable") of the Sri Lankan standard. However, these will be reduced through the water treatment process, thereby these excess will be resolved.

In conclusion, both water resources which will supply water to Mahakandarawa wewa will not cause any adverse impact on the water quality of the said wewa.

Table 4.31 Water Quality Results for Moragahakanda and Kalu Ganga Reservoirs

Sampling location	Type of water source	Date	Odor	Colour	Turbidity	Taste	pH	Electrical C	Chloride	Free ammonia	Alkalinity
				Hazen Unit	NTU		-	µS/cm	mg/L	mg/L	mg/L
Moragahakanda	River	12/09/20	Unobjec.	7.5	19	Objec.	7.6	310	7	0.05	65
Kalu Ganga	River	12/09/20	Unobjec.	5	1.1	Objec.	7.5	118	6	<0.05	144
Sri Lanka Standards (Desireble)			-	5	2		7.0-8.5	750	200		200
Sri Lanka Standards (Permissible)			Unobjec.	30	8	Unobjec.	6.5-9.0	3500	1200	0.06	400

Sampling location	Type of water source	Date	Albminoid ammonia	Nitrite	Nitrate	Fluoride	Phosphate	Total residue	Hardness	Iron	Sulphate
			mg/L	mg/L	mg/L	mg/L	mg/L	mg/l	mg/L	mg/L	mg/L
Moragahakanda	River	12/09/20	0.06	0.07	0.85	0.08	0.31	215	78	<0.1	14
Kalu Ganga	River	12/09/20	<0.01	<0.01	<0.05	0.11	<0.2	82	153	<0.1	13
Sri Lanka Standards (Desireble)						0.6	-	500	250	0.3	200
Sri Lanka Standards (Permissible)			0.15	0.01	10	1.5	2	2000	600	1	400

Objec.: Objectionale, Unobjec.: Unobjectionable

4.3.9 Yan Oya Reservoir Project

(1) Outline

Yan Oya reservoir project is planned to provide irrigation water for the Northern and Eastern provinces and drinking water for people in the Anuradhapura and Trincomalee Districts.

Under this project, a reservoir will be constructed at Pangurugaswewa, across the lower side of the Yan Oya. Water from this reservoir will be diverted to another major reservoir in Padaviya and 4,780_hectares of land will receive irrigation water from this source. The project includes two main irrigational canals along the banks of the Yan Oya and an anicut dam to release surplus water to the nearly 20 kilometers of channels (See **Figure 4.45**).

Location of the Reservoir: east of Wahalkada Tank, Pangurugaswewa Village
Storage: 254 MCM（205,000 Acft）
Irrigation Area: 4,780 ha
RB Irrigation Canal discharge: 6 m^3/sec
LB Irrigation Canal discharge: 6 m^3/sec
Canal Length： LB Main Canal: 20.3 km
RB main Canal: 15.0 km
Secondary canal：40 km

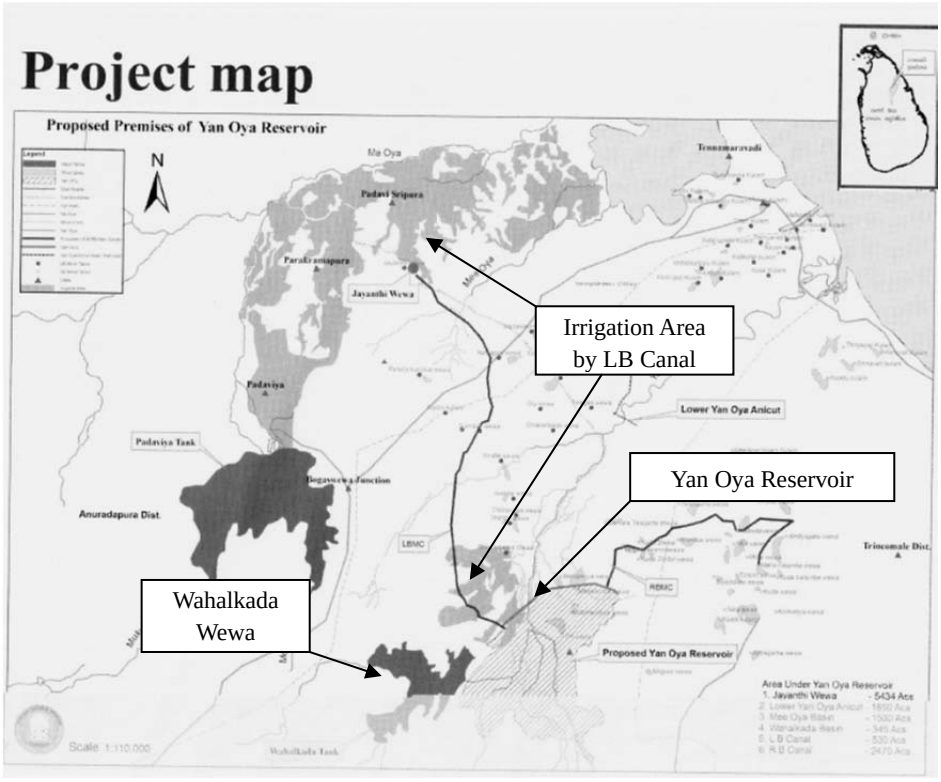


Figure 4.45 Yan Oya Project Location Map

(2) Relationship with Wahalkada Wewa

This project will be conducted in the Yan Oya river flowing eastern side of Wahalkada Wewa. New canals are planned as Right bank canal and Left bank canal, with the Left bank canal passing the irrigation area of the Wahalkada scheme. One of the objectives of the Project is to provide drinking water for Anuradhapura District.

(3) Project Implementation Schedule

Financial Award was signed between China and Sri Lanka in Nov.4, 2011(Project Cost Rp.19 billion).

The EIA report has been submitted to CEA and review of it is still in progress. After approval of

the EIA, construction is expected to start and around 4 years will be required for completion of the project.

(4) Water Availability for Water Supply

Yan Oya Reservoir Project will cover around 400 ha of the Wahalkada irrigation scheme, corresponding to 50% of existing irrigation area, by a reservoir with a capacity of 254 MCM. Therefore, required irrigation water supply from Wahalkada Wewa will be reduced almost 50%.

4.3.10 Measures against Global Climate Change

(1) Global Climate Change and Sri Lanka

According to "Climate Risk and Adaption Country Profile, Sri Lanka", made by the Global Facility for Disaster Reduction (GFDRR) and the Team of the Enviornment Department of the World Bank, the following is pointed out:

- Mean annual temperatures are projected to increase by 1.0 ℃. Mean rainfall is projected to change by 4%, with almost all models (Global Climate Models, etc.) showing a decrease compared to historical records, with accompanying changes in the quantity and spatial distribution of rainfall.
- Projections of future rainfall are less reliable under Global Circulation Models for island nations(in part due to their coarse spatial resolution, which fails to capture local processes driving rainfall dynamics such as feedback and convection). What is clear, however, is that climate variability and extreme events across Sri Lanka will increase in the future.

The hazard impacts of Floods and droughts across Sri Lanka are summarized below:

Historical records from 1974-2004 indicate that floods and droughts are increasing. The south-west monsoons (May to September) cause severe flooding in the western and south-western provinces; the north-east monsoon (December –February) cause flooding in the eastern, northern, and north-central provinces; while a huge part of the island is drought-prone from February to April and, if there is a subsidiary drought in the normal rainy season from May to June, drought can extend until September. In the past 30 years floods have been affecting more than 10 million people, while droughts have affected more than 6 million.

(2) Climate Change found in Anuradhapura District

Kotmale:	35%
Victoria:	14.7%
Randenigala:	18.4%
Castlereeigh:	14.0%

According to the Ceylon Electricity Board (CEB), a shortage of power from the Hydro-power plant is compensated for by the Geo-thermal power plant, therefore daily Rp.200 million is losing by this situation.

Concerning agriculture, the Ministry of Agriculture announced that a total of 150,000 acres of paddy field was damaged in Anuradhapura, Polonnaruwa, Jaffna, Kilinochchi, Puttalam, Kurunegala, Batticaloa, Ampara, Moneragala, Nuwara, Eliya Districts.

In the case of drinking water, the quantity of water stored in reservoirs is a concern. Additionally, when the villagers don't have piped water, they have a tendency to get damage. Because they usually use shallow wells, diameter is 1-2m & depth in 10m, and this draught makes water level lowering and drying water of the well. Therefore, they need to carry water from the place of deep tube well by CBO/NWSDB with small plastic container.

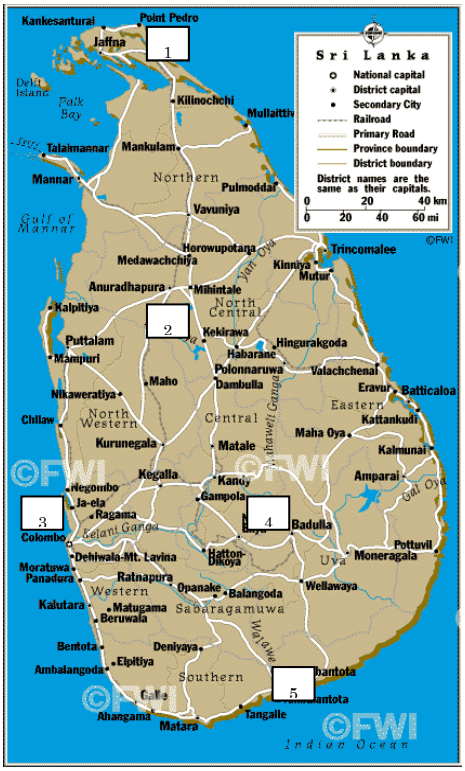


Figure 4.46 Location of the cities

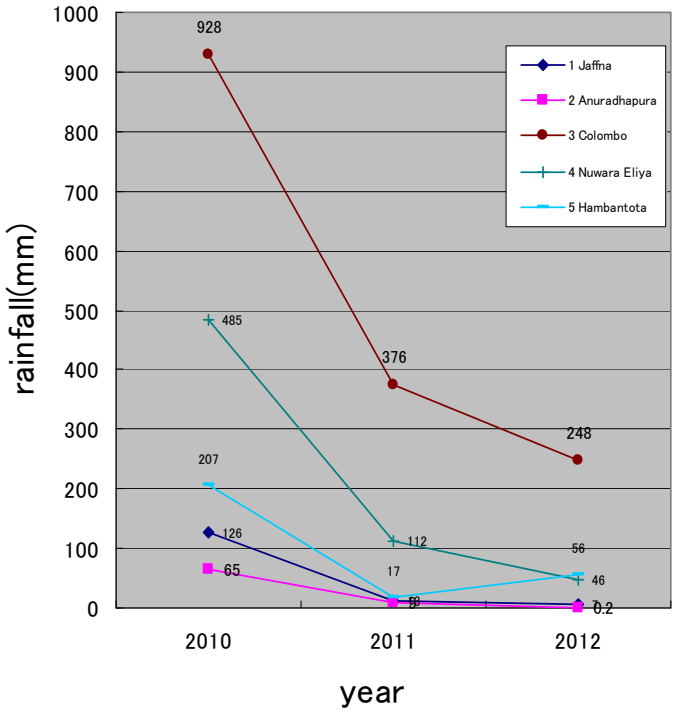


Figure 4.47 May-July Rainfall in 2010-2012

(3) Measures against Global Climate Change

Measures against Global Climate Change by the Project are expected on “Improvement of the rural water supply” and “Improvement of water resource management”.

1) Improvement of the rural water supply

The target area of the Project is in the Anuradhapura North area, covering a population of around 200,000 in 2012 and around 280,00 in 2034, a significant increase in the population from 2012.

From this population, the population served NWSDB’s water is estimated at about 50,000-60,000 (25-30%); therefore 70-75 % of population is using shallow wells constructed in the garden of their houses.

As mentioned above, dug well can get influence of draught, draw down of water level, and many villagers need to face bring water from other locations. If they have a water source from NWSDB nearby their houses they can bring water using plastic tanks. However if this source is not available, they have no choice but to use water from ponds or swamps.

The Project aims to distribute safety water to the local people in this area, via water treatment plant(s) using surface water from Mahakanadarawa wewa and Wahalkada wewa.

Therefore, this Project will contribute to avoid water supply problems which are caused by climate change in the Project Area.

2) Improvement of water resource management

In the Project, the water source will be from existing reservoirs Mahakanadarawa and Wahalkada. Supplementary water will be expected from the “Yan Oya Reservoir Project” and the “NCP Canal Development Project” in the future. Allocation of water between irrigation water and other uses will be an important issue for the Project when droughts occur. This allocation will be decided at a meeting of officers from ID, NWSDB, Divisional secretary and a representative of the Project Management Committees established under the irrigation ordinance and chaired by the District Secretary (from draft of memorandum of understanding between ID and NWSDB for extracting water from Mahakanadarawa wewa & Wahalkada wewa for the Anuradhapura North Water Supply Scheme).

Therefore, improved water management will be expected as a result of the Project.