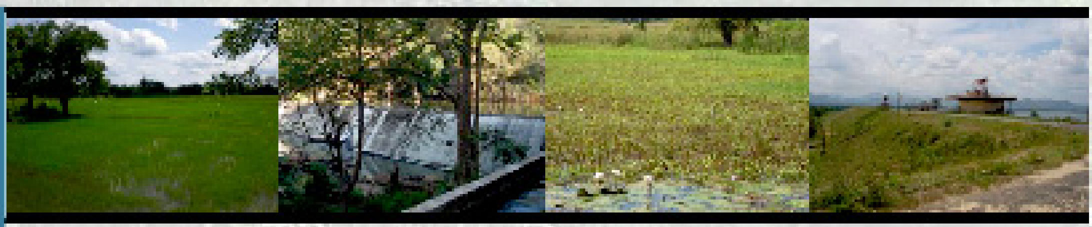
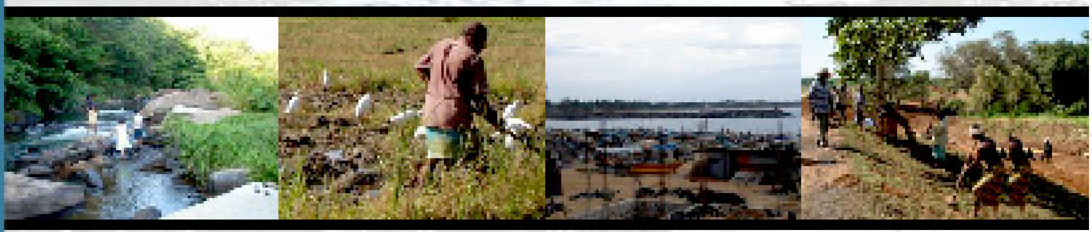


CASE STUDY:

Walawe Basin, Sri Lanka

MINISTRY OF AGRICULTURAL DEVELOPMENT AND AGRARIAN SERVICES, SRI LANKA



A contribution to the United Nations World Water Asessment Programme

United Nations Educational, Scientific and Cultural Organization

World Water Assessment Programme

UN WATER

The United Nations World Water Assessment Programme

Case Study:
Walawe Basin, Sri Lanka

Editors

K.A.U.S. Imbulana
U.R. Ratnayake
G.B.B. Herath
E. Koncagül
B.R. Neupane

The Ministry of Agricultural Development and Agrarian Services of the Government of Sri Lanka seeks to manage the country's water resources efficiently, focusing on developing and promoting sustainable agricultural practices and making maximum use of water resources for the benefit of the community. The ministry dedicates its services to developing Sri Lanka's water sector through projects of various scales, serving the community and encouraging their participation towards securing growth and sustainable development of the nation.

Sri Lanka has worked in partnership with the United Nations World Water Assessment Programme since its inception in 2000. In the first stage, this contribution led to the development of a case study assessing the water resources in the Ruhuna Basin to include in the first edition of the World Water Development Report, published in 2003. The second stage extended the study to the entire country to report on the status of its water resources and on its water resources needs, uses and governance. Sri Lanka is pleased to contribute to the third editon of the UN World Water Development Report with the present case study of the Walawe River Basin. The study offers an in-depth analysis of the water resources of the Walawe River Basin and of water-related issues and their impacts on the social and physical environment in the basin region.

Editors: **K.A.U.S. Imbulana, U.R. Ratnayake, G.B.B. Herath, E. Koncagül, B.R. Neupane**

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Message of the Hon. Minister of Agricultural Development and Agrarian Services

It is a great pleasure to send a message to the Walawe Basin Case Study Report prepared for the World Water Development Report of the United Nations.

Sri Lanka is one of the pioneer participants of the World Water Assessment Programme and had involved enthusiastically with the programme since its inception. In 2006 we prepared the Sri Lanka National Water Development Report which took stock of the outlook of water resources of the country. This study goes into the basin level and studies how the agencies and the community respond to the water resources management issues. We have completed the Walawe Left Bank Development Project recently and as such, selection of Walawe basin is of special significance. At a time we are implementing major water related development projects such as Moragahakanda and Kaluganga projects, Dam Safety and Water Resources Planning Project and campaign to grow more food locally under the theme "let us cultivate and uplift the nation" ("Api Wawamu, Rata Nagamu"), it is important to assess the impact of such projects on the water resources.

I wish to thank the United Nations World Water Assessment Programme for assisting the Ministry of Agricultural Development and Agrarian Services to carry out the studies that were necessary for this publication.

Maithripala Sirisena
Minister of Agricultural Development and Agrarian Services

Message of the Hon. Minister of Agriculture

I am very pleased to send a message to the report on Walawe Basin Case Study carried out under the World Water Assessment Programme of the United Nations.

From the ancient Sinhala king's days, our prosperity and development was based on agriculture. Agriculture is also the main user of water resources in Sri Lanka. Therefore the conservation and sustainability of water resources is vitally important for the food security. The studies carried out by our scientists have enabled us to have a closer look at our water resources and assess seriousness of the challenges faced by the sector.

Walawe river has special significance for agriculture. From the ancient times, it had helped to sustain life in the southern zone. The government is planning to further develop agriculture and industries in the south. As such, an assessment of water resources management issues in Walawe basin is very timely.

I wish to congratulate the scientists who contributed to this study.

Hemakumara Nanayakkara
Minister of Agriculture

Message of the Hon. Deputy Minister of Agrarian Services

Water is essential for sustaining life. It is the major input to agriculture. From the ancient times, our forefathers diverted water and made reservoirs to store it, so that the man, animal and the environment could have access to water. Even today, our agriculture depends on such achievements.

To face the modern challenges in the water sector, a periodic assessment of the resource is very important. Therefore, I wish this Walawe basin report to be a success, contributing the enhanced knowledge in water resources.

Siripala Gamalath
Deputy Minister of Agrarian Services

Message of Secretary, Ministry of Agricultural Development and Agrarian Services

I am both pleased and privileged to be invited to send a message to the Walawe basin case study report.

We completed a national level study on water resources in 2006, under the World Water Assessment Programme. In that study, we noted that the availability of water as a well managed resource is emerging as a challenge for national development. Therefore, the Ministry decided to have a closer look at the water resources management, at the basin level, to understand the major problems and how they are addressed. The findings of this report further consolidate the conclusions made in the Sri Lanka National Water Development Report of 2006. As we are implementing several major water resources development projects such as Moragahakanda and Kalu Ganga development projects, it is important to learn lessons from the responses made at the basin level.

It is my conviction that the Walawe basin Case Study Report will provide valuable insights into the management of water resources at the basin level, useful for future water resources development and management. I wish to thank the United Nations World Water Assessment Programme (WWAP), the authors and editors and others who contributed to this report.

J. Ranjith Wijethilake
Secretary
Ministry of Agricultural Development and Agrarian Services

Message from the WWAP Coordinator:

The World Water Assessment Programme (WWAP) works with 26 UN agencies and a number of country partners to prepare a triennial World Water Development Report (WWDR) with comprehensive coverage on the state of global freshwater resources. The country studies have always formed a pivotal part of the WWDR.

Sri Lanka has been a reliable partner of the WWAP Secretariat since its establishment in 2000. In the space of nine years, Sri Lanka has been revisited three times, with a different focus for each case study. The Ruhuna Basin case study which was included in the 1st edition of the WWDR was extended into a fully fledged national case study for the 2nd edition of the WWDR. The 3rd edition of the WWDR, to be released on 16 March 2009, will include a study of the water-related challenges in the Walawe River Basin. This case study report, for which I take the pleasure of writing a foreword, will be launched in parallel to the WWDR3.

In this long journey since 2000, the activities of WWAP have established a solid basis for the dissemination of freshwater-related information, and in so doing have helped provide supportive content for policy formulation in the water sector, while creating an incentive for national research. In fact, the Research Committee on Hydrology of the National Science Foundation is currently planning a discussion forum to identify gaps in water-related research so as to steer research activities towards speficic areas. Gaps identified through case study activities have helped donor countries to spot potential areas for investment.

WWAP case studies in Sri Lanka have also witnessed the destructive power of nature as evidenced in the 2004 tsunami. While the Sri Lanka National Water Development Report in 2006 reported on the sheer scale of destruction, the current case study report highlights the success achieved in recovery efforts.

The WWAP Secretariat takes pride in this time-tested collaboration with Sri Lanka and commits itself to following up progress in Sri Lanka's water sector in future editions.

Olcay Ünver
WWAP Coordinator

Editors' Note/Preface

The World Water Assessment Programme was initiated in response to recommendations made in several global forums on water. By 2000, the need for scientific assessment of the progress made towards achieving sustainable water use was apparent. Therefore, the main focus of World Water Assessment Programme was the assessment of whether the world is achieving the twin goals of serving society while ensuring the sustainable use of natural resources. The reporting mechanism consists of producing a World Water Development Report (WWDR) every three years. There are 24 UN organizations involved in the programme, with UNESCO carrying out a coordinating role.

The case study collections offer an important cornerstone of each report. Sri Lanka became a case study country in 2000 and contributed to the first WWDR, which was published in 2003. This was followed by a national level study in 2006 for the second WWDR. The WWAP case studies highlight the state of water resources in different physical, climatic and socio-economic conditions, and show the diversity of circumstances and different human needs.

The Walawe basin was selected for this case study, which is the third such study carried out in Sri Lanka since 2001. The study had the objective of assessing the state of freshwater resources in the basin and progress towards addressing a number of identified issues. The study describes the uses of water, pressures on the resource, and driving forces that impact water resources and use. Such driving forces shape the state of the resource, and the state of the resource in turn leads to responses from society in general and from key stakeholders in particular. The report ends by addressing the questions:

- What is being done (to address the issues)?
- What more is to be done?

We wish to gratefully acknowledge the immense contribution made by many agencies, officials and individuals in making this effort a success. A sincere effort was made to include all the names of those who supported the study in numerous ways; however, there may be omissions for which we apologize in advance. Invaluable support and encouragement extended by the Honorable Ministers and the Ministry of Agricultural Development and Agrarian Services of Sri Lanka, UNESCO and the WWAP Secretariat, UNESCO-New Delhi and UNDP-Sri Lanka are especially noted.

K.A.U.S. Imbulana
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G.B.B. Herath
E. Koncagül
B.R. Neupane

List of Acronyms

ADB	- Asian Development Bank
CBO	- Community based organization
CBSL	- Central Bank of Sri Lanka
CEA	- Central Environmental Authority
CEB	- Ceylon Electricity Board
CWSSP	- Community Water Supply & Sanitation Project
DAD	- Department of Agrarian Development
DANIDA	- Danish International Development Agency
DCS	- Department of Census and Statistics
DSD	- Divisional Secretary Division
EC	- Electrical Conductivity
EIA	- Environmental Impact Assessment
FIM	- First Inter Monsoon
FO	- Farmer Organization
GDP	- Gross Domestic Product
GND	- Grama Niladhari Division
GWh	- Giga Watt hour
Ha	- hectare
ID	- Irrigation Department
INGO	- International non-governmental organization
IUCN	- International Union for Conservation of Nature and Natural Resources
IWRM	- Integrated Water Resources Management
LB	- left bank
MAIMD	- Ministry of Agriculture, Irrigation and Mahaweli Development
MASL	- Mahaweli Authority of Sri Lanka
MSL	- Mean Sea Level
MDG	- Millennium Development Goal
MHP	- Mini hydropower
mm	- millimeter
MW	- Mega Watt
NEM	- North East Monsoon
NWSDB	- National Water Supply and Drainage Board
O&M	- operation and maintenance
OFC	- Other Field Crops

SIM	-Second Inter Monsoon
SLS	- Sri Lanka Standards
SWM	- South West Monsoon
TDS	- Total Dissolved Solids
UNDP	- United Nations Development Programme
UN-ESCAP	- United Nations Economic Commission for Asia and Pacific
UNESCO	- United Nations Educational, Scientific and Cultural Organization
UNICEF	- United Nations Children's Fund
USAID	- United States Agency for International Development
WHO	- World Health Organization
WRB	- Water Resources Board
WSS	- Water supply scheme
WWAP	- World Water Assessment Programme
WWDR	- World Water Development Report

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

The total land area of Sri Lanka is 65,600 km^2. The temperature is evenly balanced throughout the year, without any significant differences of temperature from month to month in temporal terms. The annual variation of temperature is from a maximum of 4.6^{O}C at Vavuniya to a minimum of 1.4^{O}C at Ratnapura. The average annual nighttime relative humidity in the country varies between 74% and 95%, while the daytime variation is between 53% and 86% (Imbulana et al, 2006).

Based on the data from 1961-1990, the average annual rainfall of Sri Lanka is estimated as 1861 mm. This results in a total rainfall volume of 120 BCM, which is distributed unevenly over the land. The average annual rainfall in the wet zone and dry zone are respectively 2,900 mm and 1,500 mm (ID, 2003). This rainfall results an annual surface water resources availability of about 43,000 million m^3 (ID, 2003 and Seckler et al, 1998). This is approximately 35% of the total rainfall volume, which is highly variable with respect to the river basins.

1.1 Location of the case study

There are 103 distinct river basins demarcated in the island, all draining to sea, ranging in size from 9 km^2 to 10,450 km^2. The Walawe River basin, one of the major river basins, with an area about 2,500 km^2, covers 4% of the total landmass of the country (Imbulana et al, 2006). It is situated in the southeast quadrant of the country (Figure 1.1). Administratively, Hambantota District covers the lower part of the basin, while Moneragala and Ratnapura Districts cover the middle region and the major part of upper reaches is located in the Badulla District. Figure 1.2 illustrates the network of rivers, streams, and irrigation reservoirs, lagoons and salterns that constitute the hydrologic features of this basin. In addition, hydropower plants in the basin have an installed capacity of about 130 MW, which is about 10% of the total hydropower installed capacity of the country. The basin is also reputed for high productivity in agriculture, having several major irrigation schemes and numerous small reservoirs and diversions. The multiplicity of water related issues prompted the selection of Walawe basin for the case study.

The recent water resources development activities in the region have resulted in some other river basins to be linked to the Walawe basin. They include the streams named Malala Oya, Kachchigal Oya and Karagan Oya. Therefore, the basins of Walawe River, Malala Oya, Karagan Oya and Kachchigal Ara are considered as one congruous unit for this study (Figure 1.2). Total area including the three linked basins, is 3,240 km^2 comprising as follows:

Walawe basin	–	2456 km^2
Kachchigal Ara	–	206 km^2
Karagan Oya	–	134 km^2
Malala Oya	–	444 km^2

1.5 Topography, Geology and Soils

Sri Lanka is topographically divided into three categories; lowlands, uplands and highlands. The lowlands are at elevations below 100 m altitude, uplands vary from 100 to 500 m, and highlands are at higher elevations. Walawe River has all three elevation categories in its Basin. It originates at an elevation of about 2,400 m above MSL and is about 85 km long. The upper reaches of Walawe basin falls within the highlands and contains mountainous terrain with steep slopes. The majority of the basin belongs to flatter lowlands of the downstream. (Figure 1.3)

1.2.1 Geology and geo structures of Sri Lanka and the Walawe basin

About 90% of the land area of the country is underlain with pre-cambrian metamorphic rocks. This “hard rock” region is further subdivided into a highland group, Vijayan complex, the south-west group and north-western group with former two types being the dominant types. The Highland series occupy a broad belt running across the centre of the island from southwest to northeast. It is mainly composed of charnockitic gneisses and meta-sediments. The Vijayan group located in northwest and southeast comprise of gneisses, migmatites and granites (Dissanayake and Weerasooriya, 1985).

Figure 1.1. Location of the case study

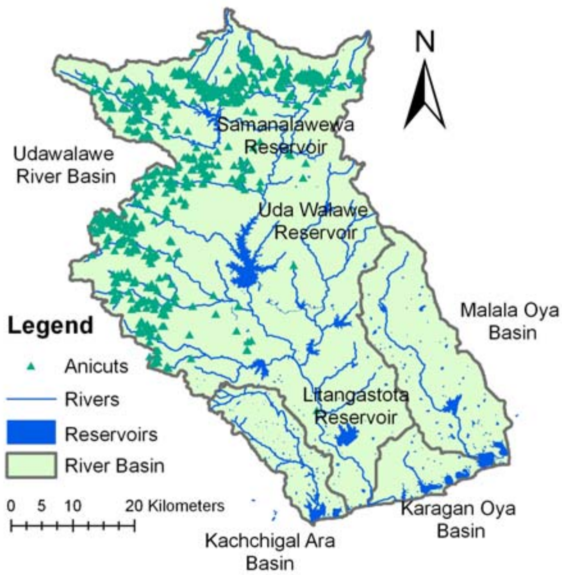


Figure 1.2 Selected basins of the case study

The rock types of the study area can be divided into three main groups, the Highland series, Vijayan complex and quaternary deposits based on the geologic time scale of their origin. In the Southern regions, the Highland series is present on the Western side from Timbolketiya to Hambantota, running out to sea near Ambalantota. The

Vijayan complex occupies the greater part of the lowest peniplain, both northwest and southeast of the Highland series. The lithology is made up of a varied group of gneisses, granites and small bodies of granite. Dolerite dykes have also been intruded into the crystalline rock from times between the Precambrian and Tertiary eras (Cooray, 1984). The Vijayan complex has the largest aerial extent within the study area (Seneviratne, 2008).

The entire Walawe catchment shows regional structural trends in a NNW-SSE / NW-SE direction. An axial trace of the regional fold system is also similarly aligned. Major shear zones that run either sub parallel or oblique to the regional strike, dissect the whole basin into several blocks. Among the brittle structures, two prominent joint systems developed in NW-SE and E-W orientations are significant. Geology and the geo-structures of the area are shown in Figure 1.4.

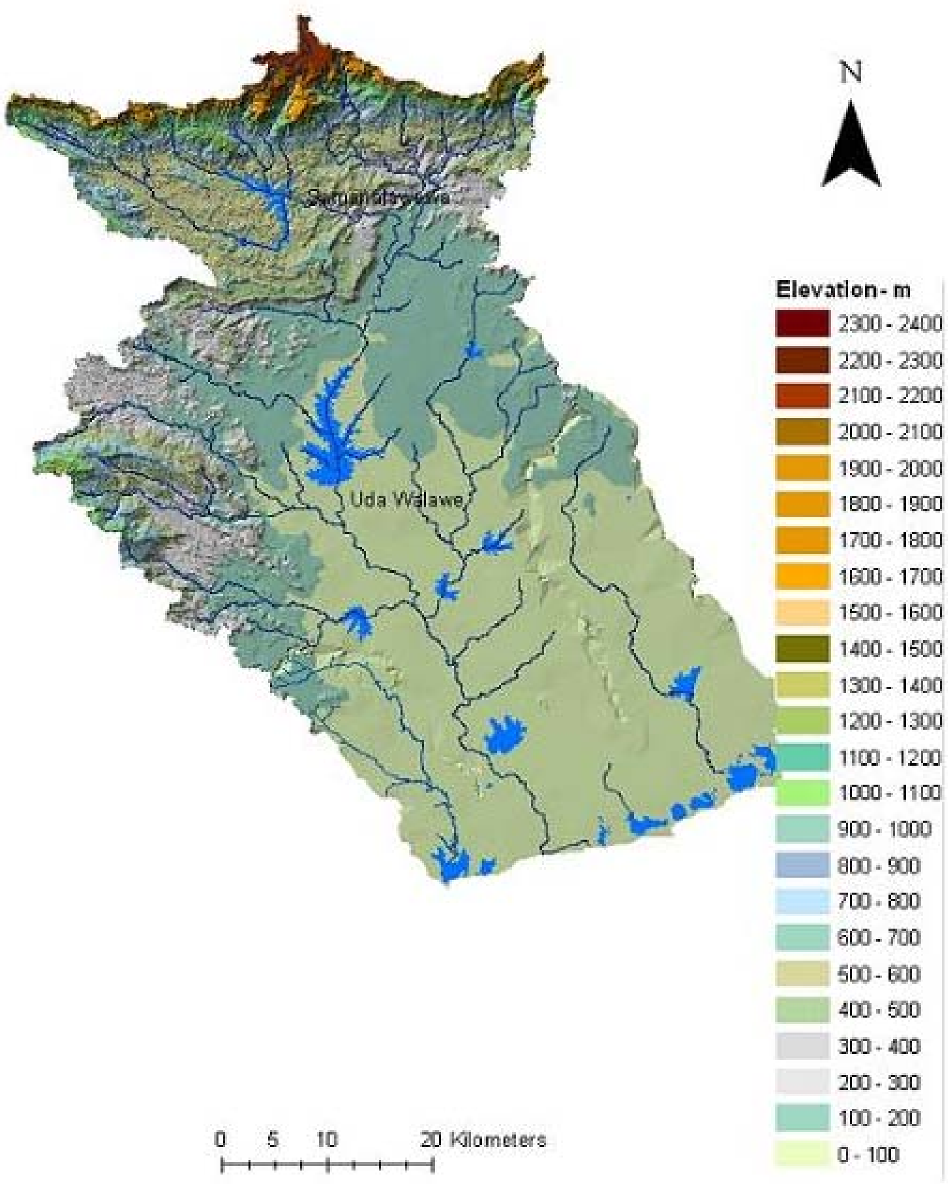
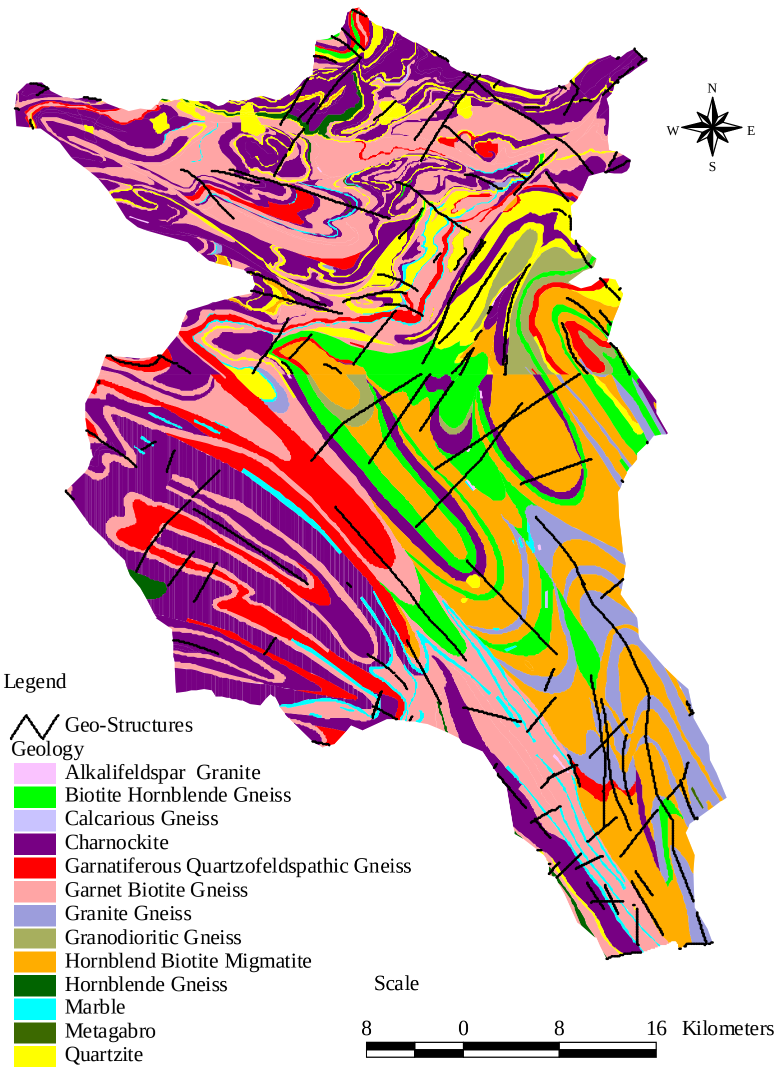


Figure 1.3. Topography of Walawe and adjacent basins

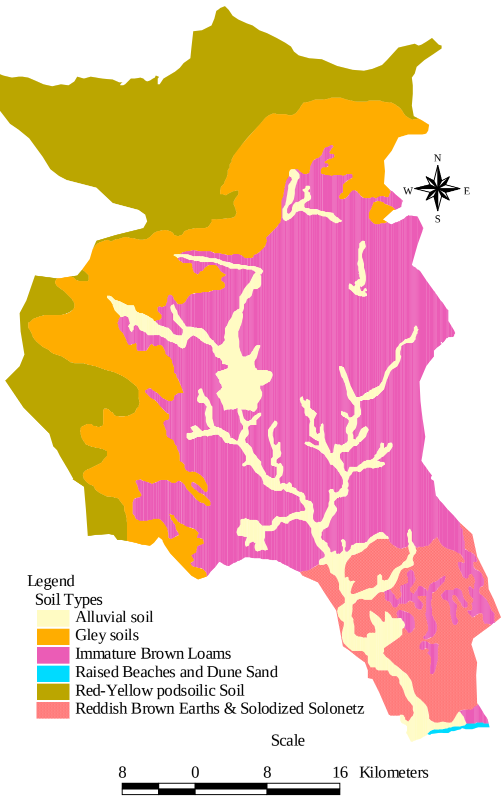


Source: Seneviratne, 2008

Figure 1.4. Geology and geo Structures of Walawe basin

1.2.2 Soil characteristics of Walawe Basin

Soil types and thickness of the soil cover vary with the climatic and topographic variation as well as the parent material because it is mainly a product of rock weathering. Immature brown loam is dominant in the upper part of the catchment associating with charnockitic gneiss. High rainfall associated with the area influence the formation of such soil. Reddish brown earth solodised solonetz is well developed in the lowest peniplain area with the association of Vijayan complex rocks (Cooray, 1984). It occurs close to the sea and this part receives relatively less rainfall compared to the other part of the study area and it is characterised by the presence of salt in parent material. Alluvial soils can be distinguished along the river and surface water bodies, while beach sand and dune sand are limited to the coastal area. Soil map of the catchment is illustrated in Figure 1.5.



Source: Seneviratne, 2008

Figure 1.5 Soils of the Walawe basin

1.3 Major socio-economic characteristics

1.3.1 Administration and population

The Walawe and the three adjacent basins are spread over three Provinces; Southern, Uva and Sabaragamuwa. The study area includes parts of Ratnapura, Badulla, Moneragala and Hambantota administrative Districts (Figure 1.6). There are 17 Divisional Secretary Divisions, within to the above mentioned Districts which are fully or partially included in the study area.

Total population in Sri Lanka was 19.9 million in 2006 (CBSL, 2007), out of which about 78% of people live in rural areas (Vidyaratne and Nigamuni 2006). Based on the population in Divisional Secretary areas and growth rates (DCS, 2007a), the study area has a population of about 0.65 million. The population densities of Ratnapura, Badulla, Moneragala and Hambantota Districts are 308, 271, 69 and 201 persons per km^2, respectively (based on 2001 census). These values indicate that the population densities are high in the upstream portion and lower basin. High population densities are observed in the lower basins where major water resources development investments have been made.

Some selected social indicators of Sri Lanka are given in Table 1.1:

Table 1.1. Life expectancy, Birth and Death Rates, Literacy, Labour Force participation and Unemployment among the population of Sri Lanka

Year	Mid Year Pop ('000)	Birth Rate (per 1000)	Death Rate (per 1000)	Life Expectancy		Literacy Rate%	Unemployment Rate%		
				Male	Female		Total	Male	Female
2000	18,467	18.4	6.1	-	-		7.6	5.8	11.1
2001	18,732	18.9	5.9	71.7	76.4	90.7	7.9	6.2	11.5
2002	19,007	19.1	5.8	-	-	-	8.8	6.6	12.9
2003	19,252	18.9	5.9	-	-	-	8.4	6.0	13.2
2004	19,462	18.5	5.8	-	-	92.5	8.3	6.0	12.8
2005	19,668	18.1	6.5	-	-		7.7	5.5	11.9
2006	19,886	n.a.	n.a.	-	-	-	6.6	5.0	9.5

Source: CBSL, 2007

Table 1.2: Population by Districts ('000 Persons)

District	1981	1999	2000	2001	2002	2003	2004	2005	2006
Hambantota	424	563	568	525	529	533	538	542	547
Badulla	641	800	826	775	787	801	813	825	837
Moneragala	274	394	399	396	401	405	410	415	420
Ratnapura	797	1,033	1,053	1,008	1,020	1,036	1,049	1,060	1,073
Sri Lanka	14,847	19,043	19,359	18,732	19,007	19,252	19,462	19,668	19,886

Source: CBSL, 2007.

Table 1.2 shows the population distribution in the major districts of the Walawe Basin in comparison to Sri Lanka from 1981 to 2006. The last national census was carried out in 2001 and the population in later years was estimated using natural increase in population and net migration statistics of 2002. Based on the population composition in the main districts, the majority of the people in the basin can be classified as rural population (DCS, 2007a). The important towns in the basin include Hambantota in the downstream and Embilipitiya in the middle of the basin.

Figure 1.6 Districts and Divisional Secretariat Divisions of the Basin

The Walawe basin consists of several ancient settlements associated with village irrigation systems, as well as new settlements associated with major irrigation developments and tea plantations. The restoration of major irrigation schemes was started in late 19th century and there had been continuous inward migration since then. Some families have migrated for 'chena' (shifting or slash-and-burn)) cultivation and later settled in the irrigated areas.

1.3.2 Economy and poverty

About 19.2% people in Sri Lanka are classified as poor, while the unemployment rate was 6.5% in 2006 (CBSL, 2007). However, slightly different estimates are made by different agencies and researchers. Although population with income less than USD 1 per day was only 5.6% during 2001, 41.6% of the population lives below USD 2 per day. In the poorer areas of the country such as east and in the south, where the Walawe Basin lies, the poverty incidence is higher than the national average. High percentage of poverty is reported from rural areas.

The per capita GDP was US$ 1,355 in 2006. The major contributors to the GDP include services sector constituting trade, transport, communication and public administration etc as the highest contributor followed by the industry and agriculture Sectors. The share of agriculture in GDP is steadily decreasing from mid 1950s and it was 16.8% in 2006 (CBSL, 2007). Sri Lanka’s economic growth had fluctuated in the recent years. It has been in the rise since 2001, and the GDP growth rate in 2006 was 7.4% (CBSL, 2007).

The average monthly income per household in the Badulla district was the lowest in the country in 1995/96. However, the situation has changed now, although all the main districts of Walawe basin record lower income levels than the national level. Recent surveys found that poverty is still high in the region (DCS, 2008) as given in Table 1.3. Considering the social, economic and political significance of the south, the government is keen to develop the region, and more attention is now being paid to industrial and commercial development (CBSL, 2007). The major occupations in the study area are shown in Table 1.4. Water resources of Walawe are vitally important for all kinds of development activities.

Table 1.3: The basic parameters related to poverty

District	Headcount Index	Population below poverty line	Monthly median household income (Rs.)
Badulla	37%	303,000	14,804
Moneragala	37%	155,000	12,320
Ratnapura	34%	364,000	14,356
Hambantota	32%	179,000	16,784
Sri Lanka	23%	3,841,000	16,735

Source: DCS, 2008 and Tilakaratne and Satharasinghe, 2002
Note: Head Count Ratio: the percentage of the population living below the National Poverty Line.
National poverty line: Minimum Expenditure per person per month to fulfill the basic needs (http:\www.statistics.lk)

Table 1.4: The major occupations in the Study Area

D.S. Division	Total Employed	Agriculture	Fishery	Mining	Manufacturing	Construction
Suriyawewa	13,775	66.5%	0.2%	0.2%	7.8%	3.0%
Lunugamwehera	8,295	56.2%	2.5%	0.3%	7.8%	2.5%
Hambantota	15,041	26.3%	6.0%	0.6%	15.1%	3.4%
Agunakolaplessa	13,912	62.1%	0.0%	0.2%	8.7%	2.5%
Ambalantota	20,478	42.1%	2.2%	1.3%	11.0%	2.3%
Haldummulla	14,520	61.9%	0.0%	0.3%	4.6%	1.8%
Thanamalvila	8,931	71.6%	0.6%	0.2%	5.4%	1.1%
Imbulpe	20,467	57.5%	0.0%	1.8%	8.0%	3.2%
Balangoda	28,190	45.3%	0.0%	1.2%	10.2%	3.1%
Godakawela	23,134	40.7%	0.0%	2.7%	10.3%	4.0%
Weligepola	11,548	71.1%	0.0%	0.9%	5.7%	2.2%
Embilipitiya	41,415	44.6%	0.3%	0.8%	10.7%	3.0%
Kolonna	14,952	66.1%	0.0%	0.7%	9.0%	2.4%

Source: Census of Population and Housing 2001, Department of Census and Statistics, 2007

Land holding size within the village irrigation systems is fairly small. A sample survey of cascade systems from Walawe and Kirindi Oya found that the land holding size ranges from 0.32 ha to 0.44 ha (Somaratne et al 2005). The land extent is vital for the people as a livelihood resource. The land fragmentation in old irrigation schemes such as Kaltota in Walawe Basin is forcing people to migrate outwards from the irrigation schemes. Some have resettled in downstream areas such as Uda Walawe scheme, where new irrigated lands were allocated (Molle et al 2005). However, still agriculture remains as the main occupation in the study area. The D.S. division wise occupation distribution is shown in Table 1.5.

1.3.3 Cultural background of the case-study basin

There is evidence that homo-sapiens appeared in the island of Sri Lanka about 500,000 years ago. Experimentation with rock crystals found in the upper Walawe basin has established that human being were here 5000 BC±700 years ago. The origins of the civilization in Walawe basin can be traced back to about 500 BC. During ancient times, Southern Sri Lanka commonly known as Ruhuna served as a haven for kings and princes fleeing foreign invasions from the north. As a result, food production (particularly paddy) was important for the national security. Therefore, water resources development from the early times was centered on irrigated agriculture.

While the northern parts of the country were subjected to frequent invasions, the southern part of the country remained by and large unexploited by the foreign influence, until the arrival of Europeans in the 16th century. Therefore, the culture and tradition in the deep south are still of ancient origin.

The existing irrigation works of ancient times include Kaltota (Uggal Kaltota) diversion (Anicut), Ridigama, Mahagama and Hambegamuwa reservoirs in Walawe basin and Bandagiriya and Maha Ranawarana Wewa in the Malala Oya basin (Brohier, 1934). There is however, a large number of ancient irrigation works that have been destroyed or abandoned, which were later restored.

After the 13th century, the irrigation systems and associated civilizations deteriorated. Irrigated agriculture was mostly abandoned after 15th century in the Walawe basin and population was sparse. Malaria was rampant until mid 20th century. The first attempts to restore irrigation under the British rule in the middle of the nineteenth century in Sri Lanka included irrigation systems in Walawe and adjacent river basins. These were followed by heavier investments by independent Sri Lanka in the same field.

1.3.4 Education

Literacy rate in Sri Lanka is high in comparison to her neighbors and other developing countries. The Table 1.5 gives the education status of the population of the basin based on the Divisional Secretary Divisions. It can be seen in Table 1.5 that though nearly all of the schooling population attend the school, only a limited number goes through to the higher education streams in search of vocational education.

1.3.5 Health services

The impact of Government policies on health and personal well being are highlighted by the health statistics of Sri Lanka shown in Table 1.6. Though a considerable portion of the population lives below the poverty line, high life expectancy is seen among them. Table 1.7 shows the situation within the basin.

Diet

In 2005, the per capita average calorie intake of a Sri Lankan was 2,363 per day. In the past decade, there has not been an appreciable change in the calorie intake. In the past, the per capita calorie consumption was 1,990 per day in 1950, and the increase can be partially attributed to the increased food production through water resources development. The major components of a person's diet include cereals followed by oils and fats and sugar. The consumption of fruits and vegetables were inadequate, and hence, the government initiated a national food drive to increase local food production with a special emphasis on home gardens where fruits and vegetables are grown.

1.4 Resources

1.4.1 Land Resources

Agricultural land in Sri Lanka is 28% of the total land area. Inland water bodies constitute 4.4%. Closed canopy forest cover is about 22% and total forest cover including sparse forest and mangroves is about 30%. The forest cover rapidly declined during the last century, but the decrease seems to be arrested during the last two decades (Imbulana et al, 2006).

1.4.2 Land use

In the study area, the dominant land use types are Chena (shifting cultivation), paddy lands, tea cultivations, forests, scrub lands, homesteads and nature reserves. Scrutiny of the land use types show that land is mainly developed for agriculture. The land use for chena cultivation is still prominent. Considerable extent of lands is occupied by forests and scrublands. Paddy cultivation is concentrated on the lower part of the area where water resources development has taken place. Areas with high elevation are associated with other plantations such as tea, rubber, coconut and teak. A small area in the upper catchments is used for tea plantations while sugar cane cultivation occupies considerable area in the central basin. Parts of ecologically important Horton Plains are located in the upper catchment. Areas designated for wildlife protection include Uda Walawe National Park. Bundala national park and a coastal national park famous for the migrant birds are located at the sea outfall of the Malala Oya. It is also the first Ramsar site in the country.

Major land use categories of the four administration districts of the Walawe Basin are given in the Table 1.8. Forests constitute about 18.7% of the land area (Weerasinghe et al, 2008). Other major land uses include Chena (shifting cultivation) (26%), scrub land (15%), homestead (13%), paddy (6.5%) and tea (4.5%) (Weerasinghe et al, 2008).

Table 1.5: Education status of the population

D.S. Division	Total population aged 3 years and over	Educational institution				
		Attending pre school	Attending school	Attending university	Attending Vocational Technical institution	Attending other educational
Suriyawewa	33,586	863	10,036	34	78	191
Lunugamwehera	23,758	714	6,696	23	87	203
Hambantota	43,865	1,333	10,559	80	168	324
Agunakolaplessa	40,306	886	11,182	47	124	254
Ambalantota	61,008	1,385	15,911	146	340	373
Haldummulla	35,933	763	8,396	37	76	232
Thanamalvila	21,875	777	6,271	22	61	117
Imbulpe	52,748	882	12,729	912	139	323
Balangoda	73,284	1,564	18,355	125	203	462
Godakawela	65,583	1,113	15,950	49	456	405
Weligepola	27,755	543	7,302	48	83	162
Embilipitiya	113,598	2,420	30,607	269	412	797
Kolonna	41,436	810	11,107	60	56	162

Source: Census of Population and Housing 2001, Department of Census and Statistics, 2007

Note: Refer Figure 1.6 for the location of DSD Divisions

Table 1.6 Island wide statuses of health services

	2003	2004	2005	2006
Hospitals	606	598	606	606
Central Dispensaries	387	375	397	397
Doctors	9,631	10,025	10,290	10,893
Hospital beds	61,808	60,328	61,835	61,835
Nurses	16,711	17,316	20,332	20,549
Aurvedic Doctors	16,799	17,038	17,503	18,503
Government Expenditure (Rs million)	27,475	34,419	44,851	58,038

Source: Fernando, 2008 (Base data from Quarterly Health Bulletins)

Table 1.7 Present status of health Services in the basin

Category	**Institute**	**Bed Strength**		
		2005	**2006**	**2007**
Base Hospital	Embilipitiya	233	297	297
	Balangoda	226	226	226
	Kahawatta	159	163	166
	Kalawana	65	65	65
District Hospital	Kolonna	98	122	128
	Chandrikawewa	81	81	81
	Weligepola	36	50	45
	Rakwana	106	106	113
	Kaltota	23	75	55
	Godakawela	74	82	82
Peripheral units	Gallella	32	43	38
	Pelmadulla	38	33	42
	Pothupitiya	26	26	26
	Mahawalathenne	55	46	46
	Gilimale	44	50	50
	Nivithigala	90	91	90
Rural Hospital	Belihul Oya	4	16	16
	Omalpe	1	14	14
	Udawalawe	27	27	27
	Hinguralakanda	23	30	30
Estate Rural	Sooriyakanda		9	11
	Endana	30	30	30
	Alupola	27	27	27

Source: Fernando, 2008

Table 1.8 Land developments for major uses in the constituent districts of the study area (ha)

District	Built up Lands	Homestead	Tea	Rubber	Coconut	Perennial	Paddy	Abandoned
Badulla	870	35230	36020	960	0	520	20010	84430
Moneragala	280	47380	1130	2770	70	750	14930	186330
Ratnapura	350	52480	35830	35830	3730	4220	23200	101750
Hambantota	2430	38290	70	0	8850	1660	32010	69330

Source: Statistical Compendium on Natural Resources Management – Sri Lanka 2000, Planning Division, Ministry of Forestry and Environment

In the Malala Oya basin, the major land use is scrublands, which occupies nearly 54% of the area. Other major uses are forests (20.5%), chena (20%), homestead (10%) and paddy (3.2%). In the Kachchigal Ara basin, homesteads occupy the largest area (37%) followed by paddy (35%), chena (12%) and scrublands (4.7%).

Table 1.9 Irrigated Agricultural Land use in Uda Walawe Scheme (ha)

Crop	Maha 2003/04	Yala 2004	Total	Maha 2004/05	Yala 2005	Total	Maha 2005/06	Yala 2006	Total
Paddy	8,547	8,607	17,154	8,883	7,325	16,208	9,904	9,484	19,388
Other Crops	8,659	7,501	16,160	7,334	5,940	13,274	6,704	6,689	13,393
Total	17,206	16,108	33,314	16,217	13,265	29,482	16,608	16,173	32,781

Source: Mahaweli Authority

Table 1.9 shows the fluctuation of land use for irrigated agriculture in Uda Walawe scheme. It can be noted here that the fluctuation of the irrigated cultivation is more for ‘Yala’ cultivation season (April to September, the Southwest Monsoon). Shortage of water is the main reason for reducing the cultivated area.

1.4.3 Water Resources

Studies carried out for the 3rd WWDR in Sri Lanka indicated changes to the rainfall volumes over time. The Figure 1.7 taken from Sri Lanka National Water Development Report (SLNWDR, 2006) clearly shows the change of the position of rainfall contours. The area receiving rainfall more than 2000 mm has significantly shrunk, increasing the area of dry zone. The upper and middle catchments of the Walawe basin are affected due to these changes in the rainfall patterns.

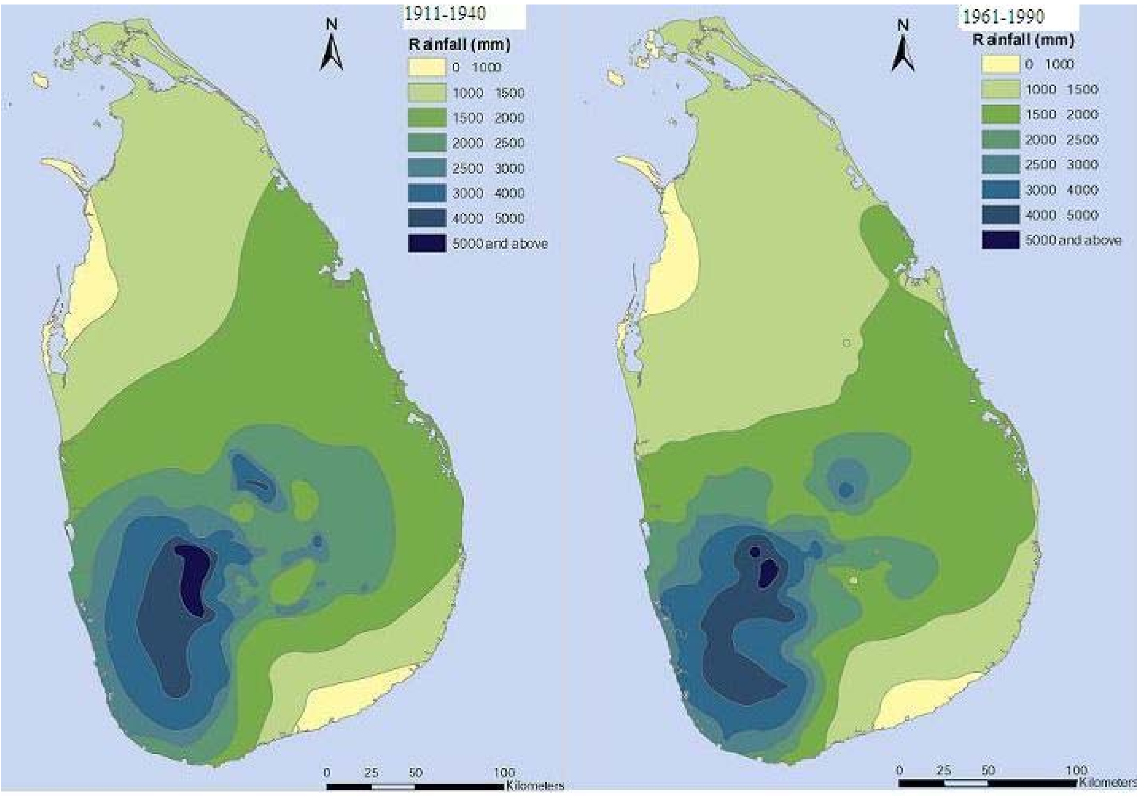
The observations by Jayatillake et al (2005) are compatible with these findings. In their studies it was found that rainfall in first inter-monsoon and north-east monsoon had substantially reduced when the averages of 1911-1940 are compared with the averages of 1961-1990. These two rainfall seasons bring the bulk of rainfall to the dry zone.

The upstream reaches located in the high altitudes of the Walawe basin receives rainfall from both north-east and south-west monsoons. As such, there are two rainfall peaks; one in April and the other in October-November. This rainfall distribution is illustrated as the average rainfall of upstream gauges and the average rainfall of downstream gauges in Figure 1.8. Such rainfall distribution creates favorable climate conditions for the cultivation of rice in two seasons, with rains during the land preparation and dry weather during harvesting.

The average annual spatial average of the rainfall of the four basins of the study area is 1768 mm for the period 1949 to 2002. The highest annual average rainfall of 4374 mm is recorded in the upper catchment, while the lowest annual average rainfall of 937 mm is recorded at Ambalantota gauging station in the lower catchment. The average annual runoff varies with the period of assessment and the assumptions used. Statkraft Groner, (2000) estimated the average annual runoff in Walawe basin as about 1650 million m^3. Ratnayake and Herath (2008) estimated this as 1550 million m^3, using data from 1949 to 1999. The annual pan evaporation in the upper catchment is about 1400 mm while that in the lower catchment is about 1800 mm. The above mentioned values show a high spatial variability of the rainfall and its inadequacy meet the evaporation needs in the lower catchment, emphasizing the need to develop water resources to meet the demands.

Main tributaries, lakes, reservoirs

Walawe River has five main tributaries. They are Belihul Oya, Weli Oya, Thimbolketiya Oya, Katupath Oya, Hulanda Oya and Mau Ara. While the upper Walawe basin, the Weli Oya basin, the upper basin of Timbolketiya and the Hulanda Oya are in the wet zone, the rest including the Mau Ara basin are in the dry zone (Talagala, 2008).



Source: SLNWDR (2006)

Figure 1.7 Change of rainfall contours: 1911-1940 and 1961-1990

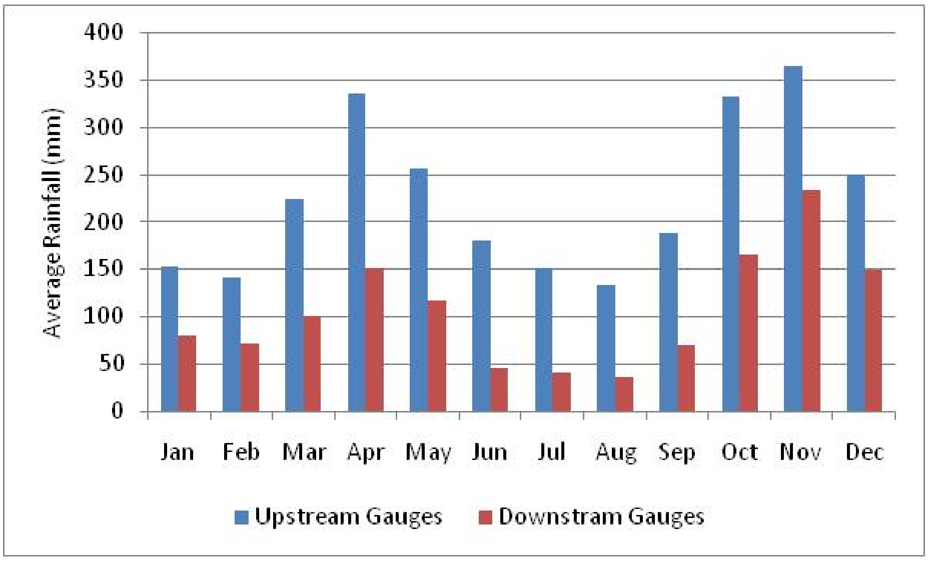


Figure 1.8 Average monthly rainfall distributions in the upper and lower basins

Out of the four river basins considered for this study, Walawe is the largest. Three smaller rivers, namely, Kachcigal Ara, Karagan Oya and Malala Oya receive water diverted from Walawe. The two major reservoirs in the river basin are Samanalawewa and Uda Walawe. Out of these, the former is mainly a hydropower facility, while the latter is primarily used for agriculture. Several coastal lagoons, which are rich in bio-diversity, are linked to the Walawe River. The tributaries, coastal lagoons, reservoirs and diversions are shown in Figure 1.2.

Climate

Climatically, the river basin is located around the transition zone of wet zone to dry zone. The rivers on the west of Walawe are comparatively wet and subject to frequent floods. The rivers in the east are dry and droughts are a recurrent problem. The ambient temperatures in the lowland range between 21°C and 35°C (Angunakolapellassa) and from 23°C to 25°C in the upper elevations.

1.4.4 Groundwater

Although surface water is the main source of water for agriculture, the region depends on groundwater for domestic purposes, small scale irrigation and water supply schemes. The water resources of the catchment are unevenly distributed along both spatial and temporal dimensions. During the dry season, (August -September) the basin is subjected to water scarcity problems affecting not only agricultural and industrial activities but also human consumption. Dry period ratio of service interruption or drying up is in the range of 80%. Studies suggest that the stability of the service by the water supply schemes highly dependent on their water sources (JICA, 2003).

Groundwater Recharge

The aquifers in the basin are recharged naturally by rainfall and indirectly by excessive irrigation. Meteorological and hydrological analysis and a macro water balance study were carried out to determine the potential recharge of the groundwater.

Water Balance of the basin

Macro water balance was carried out over the entire catchment assuming storage change is equal to zero under steady state condition. Long term average potential evapotranspiration is estimated as 1625 mm. As such, the annual groundwater recharge of the catchment has been estimated around 8% of the annual precipitation. Groundwater recharge calculated by chloride mass balance method was about 121mm and it is about 12% of the average annual rainfall of the study area.

The application of steady state hydrologic water balance (Seneviratne, 2008) is an approximate method that uses the water gains and losses in of the catchment. As it uses the lumped parameter approach, it reflects neither spatial nor temporal variations of precipitation, evapo-transpiration, groundwater recharge and surface water discharge. For a better accuracy of the water balance, it is necessary to have long term data.

1.4.5 Development of water resources

Water resources development in the river basin has an ancient origin. In more recent times major water resources development works were under taken in Walawe River basin on the downstream basin. The first large scale construction was under taken in 1889 with the construction of Liyangastota diversion and the associated right bank scheme. This scheme was extended in 1928 to cover 5300 ha by completion of Liyangastota left bank scheme and the Ridiyagama tank. It diverts water from Walawe River to Ridiyagama reservoir and the Liyangastota right bank scheme. The Ridiyagama reservoir has a capacity of 27.1 million m^3 and commands 2850 ha. The Uggalkaltota diversion (Kaltota scheme) upstream of Uda Walawe reservoir was reconstructed at the same ancient site in 1900. It diverts water directly to left bank and right bank canals with command area of 870 ha. All of these schemes are managed by the department of Irrigation (Talagala, 2008).

Chandrikawewa reservoir was completed in 1963 with a construction of a dam across Hulanda Oya, a tributary to the Walawe River. It was designed to provide irrigation facilities to 2020 ha of paddy during Maha season and to irrigate a limited extent during the Yala season. Yala extent depends on the availability of water in the reservoir. Construction of Uda Walawe dam was commenced in 1963 and by the end of 1967, work on dam and power plant and part of the right bank and left bank main canals were completed. The Chandrikawewa reservoir was supplemented with water from the Uda Walawe reservoir. The Mahaweli Authority of Sri Lanka manages Uda Walawe and Chandrikawewa Irrigation schemes (Talagala, 2008).

Samanalawewa reservoir has been built at the confluence of Walawe River and Belihul Oya. The dam is a rock fill type with a clay core and has a height of 100 m above the river bed. The power station has two turbine units with a total capacity of 120 MW. The underground power tunnel is 5.5 km long and after power generation, the flows to Diyawini Oya which is a tributary of Walawe River downstream of the reservoir.

Samanalawewa reservoir has a maximum capacity of 278 million m^3 and intercepts a highly productive catchment area of 333 km^2. In addition to power generation, it controls the irrigation releases to Kaltota scheme, which lies downstream of the reservoir. Samanalawewa hydropower complex is managed by the Ceylon Electricity Board.

Samanalawewa dam is located in a geologically complicated area and a major leak that began soon after the reservoir was impounded caused grave concern. Signs of possible leakage through the right bank were identified according to geologic conditions during construction of the dam. With 100m-deep, 1300m-long grout curtain and wet blanketing over the suspected ingress zones leakage is still continuing and the reservoir is operating with a continuous leakage of around1800 l/s. Recently, a number of sinkholes were found in an area far from the areas under consideration and preliminary studies have indicated a connection between these sinkholes and the main leakage (Talagala, 2008).

Walawe River is the main source of domestic and industrial water supply to the areas in and around Ambalantota. There are two raw water intakes maintained by the NWSDB at Ambalantota and Bolana with intake capacities 3000 m^3/day and 7500 m^3/day respectively. In addition to that there are numerous small scale water supply schemes abstracting water from natural springs in the basin (Talagala, 2008).

1.6 Policies and decision making in water sector

1.6.1 Policy framework

Studies carried out in early 1990s found that there are policy and institutional gaps in the water sector constraining optimum performance of the sector. Since 1996, there were several attempts to prepare a national water resources policy. The National Water Resources Policy proposals of 2000 recognized the institutional and policy gaps in the water sector and proposed an apex body for its management (WRS, 2002). It also proposed entitlements for allocation among sectors, which was opposed by many stakeholders. There were subsequent draft water policies developed by various Ministries. The policy development activities since 1996 came to a gradual halt around 2005, without producing a comprehensive policy (MAIMD, 2006). Though there has been substantial policy development in the allied sectors such as, environment, agriculture, watershed management and rainwater management, the policy gaps in such areas as water allocation and irrigation continue to affect the performance of the sector. Therefore, policy making in Sri Lanka’s water sector has experienced limited success.

The Ministries in charge of irrigation, agriculture and Mahaweli Development introduced a programme called “Granary Area Programme” (GAP) at the turn of the new millennium, with the intention of increasing the productivity of paddy agriculture in selected irrigation schemes and thereby increasing the income of farmers. Rehabilitation of irrigation infrastructure has been carried out with a substantial investment from international donors. Participation of farmers in irrigation management was promoted since late 1980s. Sustainability of such interventions will be enhanced by adequate policy and institutional support.

The current situation constrains adequately addressing some crucial issues such as deterioration of water quality, regulation of extraction and stakeholder participation in the management ((Imbulana, 2008). The polarization of opinions on some key water issues is one of the main reasons for the current status of policy development (Imbulana et al, 2006).

1.6.2 Decision making mechanisms for water management

In the irrigation sector, the decision making mechanisms operate at several levels. They include the committees at irrigation scheme level, administrative district and Provincial Council level. Farmer participation at scheme level decision making has improved over the years (Imbulana & Neupane, 2005). However, more active role is expected from national level forums such as Central Coordinating Committee on Irrigation Management, for which policy and institutional support is required.

A national forum bringing all the different water users does not exist. The Mahaweli Water Panel implements macro level water allocation in Mahaweli, Walawe and Kelani basins. Though the stakeholders such as farmers and domestic water consumers are not directly represented, their interests are usually covered by the service-delivery agencies.

1.6.3 Legislations

It is estimated that there are over 50 legislations relevant to water sector (Ratnayake, 2005). They can be broadly categorized in to two types: those which define the authority and the responsibility of institutions and those which are framed to protect the resource. While Irrigation Ordnance, Water Supply and Drainage Law, and Agrarian Development Act are examples for the former type, the Environment Act and Soil Conservation Act are examples for the latter type.

1.6.4 Institutions

Some of the major institutions were already mentioned in the preceding discussion. Major irrigation (inter-provincial) schemes are managed by the Irrigation Department and Mahaweli Authority of Sri Lanka. The Village irrigation systems are the responsibility of Provincial Councils according to the 13th Amendment to the Constitution of Sri Lanka. However, the Department of Agrarian Development also has a role to play in their management. The Provincial Councils relevant to the Walawe Basin are Sabaragamuwa, Uva and Southern Provincial Councils. The National Water Supply and Drainage Board (NWSDB) is the main state provider of drinking water, especially for the large towns. In addition, the NWSDB provides water for industries. Local authorities and community organizations manage a substantial number of rural water supply schemes. Water Resources Board is the state institution responsible for groundwater, and it is especially active in the groundwater development activities. Private sector is involved in all water sub-sectors; examples being groundwater irrigation, management of small scale irrigation and bottled drinking water.

Walawe River in its upper reach is regulated by Samanalawewa reservoir for Hydropower by CEB. In the middle reach Uda Walawe reservoir regulates the river for irrigation by MASL. At the lower reaches further downstream at Liyangastota flow is regulated by ID for irrigation. Further downstream at Bolana and Ambalantota river water is used for Water Supply for major parts of Hambantota District. Such existence of multi dam operators could be a great problem at times of major water scarcity and for optimum water utilization. Further during major flood events uncoordinated operations of reservoirs could endanger the downstream works. Therefore, there is a need for integrated operation and management of dams, anicuts etc especially at multi stakeholder basins such as Walawe River basin (Talagala, 2008).

Sri Lanka has a tradition of water resources development for human use, while paying due regard for the requirements of the nature. However, increased demand in the recent times is leading to conflicts among sectors. Except in few river basins in the wet zone, the predominant water use is for agriculture.

2.1 Trends in water use

Since 1950s, there was a rapid increase of water resources development for agriculture. However, since mid 1980s, the rate of expansion has decreased. Irrigation development is still a major tool in rural development strategies. But the new development proposals are usually designed to serve multiple purposes, such as irrigation, drinking water and industries (Imbulana and Neupane, 2005).

Until mid 1980s the water resources of the Walawe basin were mainly used for agriculture. Samanalawewa, a major hydropower reservoir was built in the basin in mid 1980s, and since then, hydropower also became a major user of water. In addition, substantial amount of water is used for drinking and industrial use as well. These demands are projected to increase in the future, with the implementation of a major harbour and an international airport in the region.

However, the water use for irrigation still remains predominant. The major irrigation systems include Uda Walawe scheme, Liyangastota (Walawe Left Bank (LB)) scheme and Walawe Right Bank (RB) scheme. Further large scale irrigation systems are not currently planned, and therefore, water resources development in the basin follows a trend similar to the national trend.

2.2 Water and land resources use for agriculture

2.2.1 Land for irrigation

The total irrigated area in the river basin is 44,900 ha. Therefore, about 14% of the study area is under irrigation. Out of this, 38,033 (85%) is under major irrigation and the rest is under village irrigation schemes. In a village irrigation scheme the command area is less than 80 ha. All the irrigation systems in Kachchigal Ara and Karagan Oya are village irrigation schemes.

Out of the 21 major irrigation schemes in the study area, 15 are located in the Walawe basin, having a command area of 36,610 ha. The largest schemes in the basins include Uda Walawe (23,700 ha), Ridiyagama (2,544 ha) and Liyangastota LB and RB schemes (6,600 ha).

Table 2.1 Village irrigation systems in the study area

Type of irrigation system	River basin				
	Kachchigal Ara	Walawe	Karagan Oya	Malala Oya	Total
Village Irrigation Tanks	51	92	10	52	205
Village Irrigation Anicuts	2	504	226	1	733
Command Area (ha)	988	4285	849	751	6873
Farmer Families	1582	15338	2151	1017	20088

Village irrigation systems, comprising village "tanks" and "anicuts" (diversions) support as many as 20,000 farmer families in the four river basins. There are several unique features of these systems: They are located in cascades, or hydrologically connected series of reservoirs. By this arrangement, the water use in village irrigation works is comparatively more efficient than some major irrigation systems. The irrigation systems are mostly managed by the farmers. They serve multiple purposes; drinking water, sanitation, livestock and irrigation. The tank density is high in the Malala Oya basins; about one tank per 7.5 km^2.

2.2.2 Water for irrigation

Of the total agricultural lands of Sri Lanka extending over 1.86 million ha, 630,000 ha are irrigated (Imbulana et al 2006). The total land under paddy was 742,000 ha in 2003, and 708,000 ha in 2005/06. About 30% of paddy lands are rain-fed, and this area shows a declining trend. However, irrigated area is increasing, less rapidly after mid 1980s. The average paddy yields were 4.2 tons/ha and 4.0 tons/ha in Yala and Maha seasons respectively in 2004/05 (DCS, 2007).

Yield (production per unit land per season) and cropping intensity are the major parameters influencing the agricultural production and productivity. The productivity in major irrigation schemes is generally higher than those in village irrigation systems and in rain-fed areas. In the major irrigation schemes of Uda Walawe, Katupath Oya, Kaltota and Panamure, where the records are available, the cropping intensity is between 190% to 200% per annum (Official records, MASL and ID). The cropping intensities in village irrigation and rain-fed agriculture in Walawe basin is also higher than the national average. Paddy yields in the Uda Walawe scheme are among the highest in Sri Lanka (DCS, 2007). Therefore, Walawe basin can be considered as a highly productive river basin with regard to agriculture.

Water use monitoring in irrigation

Water deliveries are regularly measured in most major irrigation schemes, but not in village irrigation schemes. Therefore, it is difficult to estimate an accurate value for basin-level water productivity. The water allocation in Walawe basin is monitored at the Mahaweli water panel, where decisions regarding water allocations for irrigation from hydropower facilities are made.

Water use in major irrigation schemes

The water used by major irrigation systems vary significantly across the schemes. The irrigation duty defined as water delivered at the reservoir outlet per unit area varies from about 1000 mm to 1,800 mm in the Maha season and from 1,200 mm to 2,500 mm in the Yala season. However, a portion of these releases is used indirectly by small irrigation systems for domestic use, lowering the actual irrigation applications (Wijesekera, 2008).

Water use and cropping intensity in village irrigation systems

The Table 2.2 shows the irrigation water use in major irrigation schemes. It can be seen that the water use in Kaltota and Katupath Oya schemes are very high. The water use in Uda Walawe scheme was also fairly high in the past, but it has been reduced due to better water management. High proportion of non-paddy crops also contributed to the low water use in the scheme.

There is no proper system of record keeping among the village irrigation systems, and as such, irrigation duty, cropping intensity etc are not accurately calculated. Studies by Somaratne et al (2005) show that the systems depending on their own catchment have low cropping intensities, while those are connected to major irrigation systems or which receive drainage water record nearly 200% cropping intensity. It is also noted that the major water uses are irrigation, washing and bathing, and livestock. Fishing is also practiced in some reservoirs. When the water use for domestic purposes from village irrigation systems before 1980s is compared with the present (around 2005), a reducing tendency can be observed (Somaratne et al, 2005).

In the Walawe basin, the withdrawals for irrigation account for about 95% of the total volume diverted (Jayatilake, 2002). Considering the wide variability of irrigation duty in similar agro-ecological regions of Sri Lanka, it can be seen that a potential for improving the water use efficiency exists. Ongoing programmes to improve efficiency rely on better scheduling, participation of stakeholders in the management and rehabilitation and modernization of irrigation system. Some improvements of efficiency due to these efforts can be observed.

With the realization of higher incomes resulting from cultivation of cash crops and the comparatively low water requirement, a significant portion of irrigated areas initially cultivated for paddy have been recently converted to other crops. Such changes are notable in the Uda Walawe scheme. Banana has been one of the popular crops and, now, a part of the Uda Walawe scheme is popularly known as the “banana kingdom.”

In addition to irrigated agriculture the Walawe basin also produces large amounts of marine fish, inland fish, and cow and buffalo milk. All these activities are directly supported by water collected in the village tanks. Inland fisheries are an important source of nutrition and income for the Walawe basin population. The fishing is practiced in irrigation reservoirs and coastal lagoons. In the Uda Walawe reservoir the total fish catch fluctuates but with the increasing number of fishing crafts, catch per craft has declined.

Table 2.2 Irrigation duty in village irrigation schemes of the study area

Scheme	Command area(Ha)	Average irrigation duty (m) Yala	Average irrigation duty (m) Maha
Kalthota	920	3.65	2.45
Katupath Oya	400	3.65	2.45
Uda Walawe-LB	12000	1.40	1.28
Uda Walawe-RB	11700	1.60	1.25
Kandiyapita	145	1.85	1.50
Hambegamuwa	270	1.85	1.50
Wellawa	200	1.50	1.20
Walalgoda	200	1.50	1.20
Hulanda Oya	198	2.00	1.70
Panamure	480	2.10	2.00
Liyangastota-RB	3200	2.20	1.60
Liyangastota-LB	3400	2.13	1.30

Village irrigation systems

Some time ago rain-fed chena cultivation was the main enterprise of the local population in rural areas. K*urakkan* and millet were extensively consumed in parallel with rice. Village irrigation systems contribute significantly to the rural economy and social well-being. The population served by the village irrigation systems is proportionately higher than that in the major irrigation systems and therefore the importance of cereals, other than paddy, may be underestimated in national programs. The landholding size under village tanks is smaller when compared to major irrigation settlements, which reduces the dependence of the benefited population in agriculture. The systems fall into two major categories; reservoirs (village tanks) and diversions.

2.3 Water for energy production

Electrical energy for Sri Lanka is now produced mainly using petroleum sources and hydropower. In 1990, almost all the electrical power was produced by hydropower. There was a rapid change in the following decade and the current share of hydropower is only about 40%. Frequent drought experienced during late 1990s and early 21st century made hydropower less reliable source (Imbulana et al, 2006). When there is adequate rain, the share of hydropower in energy generation increases. For example, the hydropower share increased to nearly 50% in 2006. Despite the decrease of relative contribution in power generation, it still remains the less expensive and indigenous source of importance for energy generation in Sri Lanka (Somatilake, 2008).

Walawe basin consist of one large scale hydropower station of 120MW and few mini hydro plants including Udawalawe power station(6MW), Belihuloya mini hydropower (MHP) (2.5MW), Kumburutheniwela MHP (1.4MW), and Seethagala MHP (0.8MW). Samanalawewa Hydro power station is the largest in the basin and it consists of a rock fill type dam with the height of 103.5 meters in the upstream of river Walawe. The dam has more than 300 meters of vertical difference from the water level of discharge after hydropower generation. The maximum water discharge for power generation is 45 m^3/s. The annual average present generation is 240 GWh. Approximately, 1.3 million m^3 of water is required to generate 1 GWh in Samanalawewa.

In the future, the expansion of power plant, increasing up to 240MW, is planned in order to meet the peak demand. The facilities are designed by taking this expansion into consideration.

To meet the demand growth in late 1990s, Samanalawewa power plant has made a significant contribution. In the first year after completion, Samanalawewa power plant supplied 8.83% of total supplied energy and 16.1% of peak demand in the country. These proportions have since then dropped as other power plants have been built to meet the growing demand; still Samalawewa makes significant contribution to energy sector and capacity to the grid (Somatilake, 2008).

The Uda Walawe power station built in 1964 has an installed capacity of 6 MW. However, the priority user in the Uda Walawe scheme is agriculture, and hence power generation is limited.

2.4 Water for ecosystems

The major ecosystems in Sri Lanka are identified as forest and related ecosystems, inland wetland ecosystems, coastal and marine ecosystems and agricultural ecosystems. Each of these ecosystems has different values and threats, and they are impacted by water availability and water use by other sectors. The extent of forests has been adversely affected by the development projects, especially for irrigation and hydropower. Inland aquatic ecosystems comprising freshwater marshes, streams and rivers, and reservoirs and ponds are both positively and negatively affected by water resources development. The creation of reservoirs has resulted in improved micro-climate, better habitat for wildlife and recharging and more uniform distribution of groundwater (Imbulana, 2008). On the other hand, development work has changed the hydrology and adversely affected flood plains and marshes. Coastal and marine ecosystems are threatened by unplanned tourism, coral mining, and discharge of agricultural, industrial and domestic waste to the sea (Weerasinghe et al, 2008).

Walawe basin and the three coastal basins are rich in bio-diversity. The major locations of ecological importance in the region are the part of the Horton Plains national park, Uda Walawe National Park, a part of Bundala National park, Kalametiya-Lunama sanctuary, Mandunagala sanctuary and Pallemalala sanctuary. Tea plantation has adversely affected the forest cover in the upper watershed, but recent re-forestation activities have had a positive impact.

Bundala National Park, comprising five coastal lagoons is a habitat for migratory water birds and is the first Ramsar wetland site in Sri Lanka. In the recent times, agriculture has been intensified in the areas upstream of these lagoons and drainage water from the newly developed agricultural settlement areas flow into them. The impacts of these developments are monitored by the researchers.

2.5 Major ecosystems found in Walawe basin

2.5.1 Forests and Related ecosystems

UdaWalawe national park is the one of major forests categorized under the dry monsoonal forest in Walawe basin. Major plant species found in the area are *Manilkara hexandra*, *Manilkara*, *Chloroxylon swietenia*, *Vitex pinnata*, *Sapium insigne*, *Grewia polygama*. According to department of wild life conservation (2001), *Hopea cordifolia* which found in UdaWalawe national park is highly threatened endemic species. Elephant (*Eliphs maximus*), *Herpestes vitticollis* *Melersus ursinus*, *Mus fernandoni* (endemic), *Paradoxurus zeylonensis* (endemic) are the mammals and *Ocyceros gingalensis* bird species found in the UdaWalawe national park are the threatened species.

2.5.2 Wetland ecosystem

The coastal lowlands in the basin consists of the estuaries and associated lowlands of the main rivers, and the lagoon studded wetlands between them (Handawela 2002). Most lagoons are open to the sea through a sand barrier. The distribution of lagoons from west to east and their extents are as follows; Kalametiya (604 ha), Lunama (192 ha) Karagan Lewaya (355 ha), Malala (437 ha), Embilikala (430 ha), Bundala (520 ha), Dorawa, Kirinda, Angunakolawala, Atulla, Palatupana Lewaya (160 ha), Palatupana Goda Kalapuwa (18 ha), Wilapaluwala, Uraniya, Buttuwa, and Gonalabba (15 ha) (Werasinghe et al, 2008).

2.6 Water for domestic needs

2.6.1 Access to safe drinking water

Provision of safe drinking water in adequate quantities is a challenge for both urban and rural settlements. The sources of safe drinking water include pipe borne water supply, hand pump and tube wells and protected dug wells. In the case of urban settlements, about 75% of people have access to treated, pipe borne water, while the access to safe drinking water is about 95%. In the rural settlements about 85% has access to safe drinking water, but the majority depends on sources other than pipe-borne, as a safe source. The estate sector is still lagging behind in these achievements, though there is an improvement over time. Statistics reveal that 38% has access to pipe-borne water in 2006 at national level (CBSL, 2007) and the population having sustainable access to safe drinking water in Sri Lanka was 85%. The sustainable access to safe drinking water and improved sanitation in 2006 can be explained by Table 2.3.

Table 2.3 District-wise access to safe drinking water in Walawe basin

Sector	National level Access to safe drinking water%	District	Access to safe drinking water (%)			
			Protected well	Tube well/ other	Pipe	Total
Urban	95.4	Badulla	28.2	10.3	46.9	85.0
Rural	84.6	Moneragala	40.6	14.5	25.0	80.0
Estate	57.8	Ratnapura	29.1	14.2	34.9	78.0
Sri Lanka	84.7	Hambantota	35.5	6.2	50.5	92.0

Source: DCS, 2008a
Note: There are differences in the estimates by CBSL, 2007, DCS, 2008b

Table 2.4 Major NWSDB schemes in Walawe basin and supply hours

Scheme	**Source**	**Estimated Water serving Population**	**Supply hours (hrs/day)**
Sooriyawewa	Reservoir	16560	
Amabalantota	Walawe Ganga	29254	20
Hambantota	Walawe Ganga	25602	20
Ranna/Hungama	Kattakaduwa wewa	41100	
Uda Walawe	Uda Walawe RB canal	18000	6 – 12
Embilipitiya	Chandrika wewa	42000	6 – 12
Balangoda	Walawe Ganga & Pettigala spring	25000	6 – 12
Kahawatta	Walawe Ganga	8400	6 – 12

Sources of safe drinking water include protected wells, tube wells or other protected means and pipe-borne supply. The ratio of population having access to drinking water from protected sources was 60% in the Ruhuna basins (where Walawe was a sub basin) in 2002 (Wickramage, 2002). The current access to safe drinking water and improved sanitation can be indicated by the District level values given in Table 2.3.

Based on the district values, the access to safe drinking water in the Walawe basin ranges from 73%-83%, and therefore the achievements are comparable with the national level. It can also be seen that the situation has improved from 2002.

However, as indicated by Table 2.4, the duration of water supply does not extend up to 24 hours in several pipe-borne water supply schemes and some schemes experience quality problems during dry periods. Another factor to be considered is the chemical properties of water, such as fluoride concentrations and agricultural pollutants are increasingly considered as an issue for concern especially in areas with no pipe water. The current indicators do not incorporate these important issues in assessing the access to safe drinking water. Therefore, the above percentages can only be considered as an optimistic upper limit of the current levels of access to safe water supply.

2.6.2 Institutional arrangement for drinking water supply

Key agencies involved in the water supply sector in Walawe basin are NWSDB, Community Water Supply & Sanitation Project Unit (CWSSPU), Plantation Housing & Social Welfare Trust (PHSWT) and local authorities (Fernando, 2008). In addition ADB assisted 3rd water supply and sanitation sector project, implemented through the NWSDB has significantly contributed for improvements to the rural water supplies in the Hambantota district. NWSDB is executing urban water supply schemes within the basin through Regional Support Centers.

Table 2.5 Access to improved sanitation at national and basin levels

Sector	Access to improved sanitation at national level%	Study area Districts	Access to improved sanitation at basin level%
Urban	91.5	Badulla	85.9
Rural	94.8	Moneragala	85.0
Estate	85.1	Ratnapura	88.1
Sri Lanka	93.6	Hambantota	89.7

2.6.3 Access to improved sanitation

Adequate sanitation could be regarded as having means for disposal of excreta and other domestic waste in a safe manner, without causing any pollution of environment or contamination of water sources (Fernando, 2008).

Thus, adequate sanitary facilities for toilet waste are the systems such as;

- Latrines with septic tanks
- Offset pit latrines (single or dual pit)
- Direct pit latrines with water seal
- Piped sewage disposal systems.

Therefore, inadequate sanitary facilities for excreta could mean the direct pit latrines without water seal, improvised latrines or having no latrines. Though pit latrines cause groundwater pollution, here it is not considered as an issue as the houses are located sparsely in the basin.

In 2006, about 94% of the population had access to safe sanitation at the national level. It was estimated that 71% of the population had access to safe sanitation in the Ruhuna basin in 2002. In 2006, 85-95% of the population had access to safe sanitation (Table 2.5). The values indicate a considerable improvement in access to safe drinking water and improved sanitation in the basin since 2002.

Within the study area, following methods of excreta disposal are used.

- Direct pit latrines without water seal
- Pour flush pit latrines (direct and off set)
- Latrines with septic tanks
- Defecation on ground (Fernando, 2008)

Table 2.6 shows the DS Division wise sanitation coverage of the Walawe basin.

2.6.4 Community participation in drinking water supply

The country is “on track” to achieve the Millennium Development Goals in access to safe drinking water and improved sanitation. However, in rural settlements, both drinking water and sanitation coverage is inferior. Community involvement schemes are put in place to ameliorate this situation.

It has been realized that managing rural facilities, which are relatively small and dispersed across a wide area, is difficult for centralized agencies. It is more appropriate to actively involve the beneficiary communities in the management of the schemes and in response, rural water supply schemes (i.e., schemes serving a population of 6000 or less) managed by Community-Based Organizations (CBO) have been established recently. These CBOs are voluntary and independent organizations managed by the community. They were formed at the planning stage itself and capacity building programs both in technical and management were carried out to strengthen their capacities to undertake the implementation and operation & maintenance (O&M) responsibilities.

Among the projects which rely on community management of rural water supply include, the Community Water Supply and Sanitation Project (CWSSP), and the Third Water Supply and Sanitation Project (TWSSP), both of which have activities in the Walawe basin.

2. USE OF THE RESOURCE

Table 2.6 Present sanitation methods

District	DS Division	Total Population	Total Housing units	Total No. of Latrines	Coverage
Monaragala	Thanamalvila	24725	9787	7959	81.3%
Hambantota	Ambalantota	68724	13797	12251	96.3%
	Hambantota	49929	10270	9305	90.6%
	Sooriyawewa	39993	7459	5261	70.5%
Ratnapura	Balangoda	82547	15009	11707	78.0%
	Embilipitiya	127674	23213	17340	74.7%
	Godakawela	73812	13420	9422	70.2%
	Imbulpe	59314	10874	7068	65.0%
	Kolonna	46657	8483	5190	61.2%
	Weligepola	31073	5649	3572	63.2%
Badulla	Welimada	51971	9449	7187	76.1%
	Haldummulla	40221	7513	4763	63.4%
	Haputale	21868	3976	2882	72.5%

Source: Fernando, 2008

There are programmes especially designed for the plantation sector, where the poverty is high and access to safe drinking water is low. CBOs fund the operation & maintenance of these schemes through a tariff structure formulated for the individual scheme. In rural & small town pipe water systems full O&M and replacement cost recovery is the main target. The scheme specific tariff structures prevailing at present in some cases are higher than the national water tariff. These CBO maintained water supplies cater for small towns (with served population of about 2,000 to 6,000) and villages (with served a population of less than 2,000) in the study area.

In the study area CWSSP was in operation in the Ratnapura and Badulla districts in nearly 5 to 7 years back and at present operating in the Hambantota district as the assistance for Tsunami. Third ADB assisted water supply and sanitation project with NWSDB as the implementing agency, was also in operation for the districts of Monaragala and Hambantota. Both projects were launched in par with the national rural water supply policy and the demand responsive approach was the main theme. Rural sub-projects were done with the active participation of the user groups and cost sharing model (about 20% capital cost contribution from the user community in kind and cash) was also introduced. Such cost sharing model had predetermined cost ceilings based on the technology options such as pipe systems or point sources.

Now almost all the rural water supply systems including small towns are managed by the respective CBOs. Few examples are Sevenagala small town WSS in Monaragala district and Vitharandeniya small town water supply scheme in Hambantota district. Legal recognition for CBOs are still lagging behind despite of several attempts made by the 3rd ADB project. Water quality surveillance is the other area need attention in CBO managed water systems.

Water vendors are not prominent in the study area. In the dry zone areas people mainly depend on shallow dug wells or hand pump tube wells with several hardships in the dry spells of the year. Rain water harvesting from roof catchments are also in practice at few localities. People who are living along the side of irrigation canals have wells with comparatively better success yields than the other places. In the hilly terrains unprotected streams and springs are the common alternatives in addition to rain water collection from roof catchment during the rainy periods.

2.7 Water for industry

The industry sector accounts for about 28% of the GDP, and is growing at 7.2% in the first half of 2007. The main sub sectors of industry in Sri Lanka include mining and quarrying, manufacturing, electricity, gas and water, and construction.

The major industries in Walawe basin include electricity, salt production, paper industry, ice plants, paddy processing and sugar cane processing. The main paper mill in the basin was re-activated recently after a period of inaction. At present, the industrial sector plays a secondary role in the Walawe and adjacent basins, and as such the water use for industry is not significant. However, as reported in Sri Lanka's WWAP case study in Ruhuna basins in 2002, several major industrial developments were planned in the Walawe and adjacent basins. Out of these, the construction of a sea port in Hambantota is being implemented. An expressway from Colombo and an extension to the southern railway line, both of which will run through Walawe basin and are in progress, will influence the industrial and urban development. Other planned development activities include a coal power plant in Hambantota.

2.7.1 Water and public health issues

The health care sector in Sri Lanka is organized as a mixed economy with little formal integration of public and private sector. The bulk of the Private sector is an essentially integrated national health service administered by both the Central Government and the Provincial Councils. The private sector consists mostly of ambulatory services provided by the medical practitioners with inpatient services provided by the private hospital sector. Most public services are delivered from hospitals including outpatient services.

The government health care system consists primarily of a network of more than 600 hospitals arranged in several tiers of increasing complexity and facilities ranging from maternity homes and dispensaries at the lowest level to Teaching Hospitals at the top. A referral system exists between the different levels. Government hospitals provide both in-patient and out-patient services.

Fernando (2008) describes the water and sanitation related infections using the following classification:

a) Water Borne Diseases
   When the pathogens are in water, which is drunk by a person (or animal) he may become infected.

b) Water Related Diseases
   This could further be divided into four groups:
   i. Water washed deceases
      When the infections can be controlled by higher personal hygiene and increased use of water
   ii. Water based deceases
      When the pathogens spend a part of their life cycle in aquatic animals such as water snails
   iii. Insect vector diseases
      When the pathogens are spread by insects which either bread in water or bite near water
   iv. Faecal disposal diseases
      Where the pathogens are spread with faeces mainly on land, i.e., due to unhygienic excreta disposal and pollution of soil

Cholera, typhoid and paratyphoid, shigellosis, amebiosis, diarrhea, intestinal diseases, hepatitis A and B are among the waterborne diseases encountered in the area. Dengue fever, dengue hemorrhagic fever, malaria, filariasis, Japanese Encephalitis and parasitic diseases are some of the water related diseases. The incidence of waterborne diseases is higher in Badulla and Ratnapura Districts, while the incidence of water borne diseases is high in Moneragala District. Due to data and time limitations, this study concentrated on malaria, cholera, dysentery, dengue fever, encephalitis, typhus fever, and viral Hepatitis.

Table 2.7 Change in malaria cases and related deaths

District	1990		2000		2006	
	New cases	Deaths	New cases	Deaths	New cases	Deaths
Badulla	3,690	0	5,757	0	2	0
Moneragala	20,455	0	40,885	0	1	0
Ratnapura	13,165	1	6,982	0	4	0
Hambantota	9,005	4	5,319	0	28	0
Sri Lanka	**280,981**	**14**	**210,039**	**76**	**591**	**0**

Source: DCS, 2008a

Waterborne and water related diseases

Malaria was a major health hazard in Sri Lanka as well as in the basin in the past (Molle et al, 2005). This disease is considered as a major reason for the destruction of hydraulic civilization in the area, and its depopulation. The anti-malaria campaigns in 1960s resulted in the control of the disease in the area (Molle et al, 2005). Recent surveys demonstrate the changes in malaria occurrence as shown in Table 2.7.

Recent studies found no clear seasonal pattern of malaria incidence. However, it is observed that malaria incidence is higher in the slash and burn (chena) cultivation areas compared to paddy areas; the reason could be lower socio-economic status of the people in former cultivation areas. It is also found that abandoned village tanks could be a possible source of breeding of mosquitos (Klinkenburg et al, 2003).

Japanese Encephalitis, Leptospirosis (rat fever) and dengue are some of the water-related diseases that have increased significantly in the recent past. News paper reports show that Leptospirosis resulted in 118 deaths in Sri Lanka during the first eight months of 2008, compared to 34 in 2007 Ceylon Daily News, 09-09-2008). This rose to 150 deaths by September (Lankadeepa, 22-09-2008). Patients have been found from Ratnapura, Moneragala and Hambantota in 2008 (Lankadeepa, 15-09-2008). 4,826 dengue patients have been reported in 2008 (up to September) which is a 35% rise over 2007 during a similar period. Deaths due to dengue were 18. Ratnapura and Hambantota districts in the Walawe basin are identified as a high risk area for dengue (Ceylon Daily News, 10-09-2008). Drying up of the paddy fields for about a day to control mosquito breeding has been practiced in some locations.

In addition, a disaster situation was declared in the Ratnapura District recently, due to a fever epidemic in April-May 2008. This fever was believed to be caused by stagnating water left in the abandoned gem mining pits. In some DS areas, the affected population was as high as 8% (DMC, 2008, official records).

Causes of water-related diseases

A research study was carried out in the Suriyawewa area to investigate the presence of two parasites causing diarrhea, which are more resistant to conventional water treatment than other pathogens. It was found that the parasites were present in the reservoir, irrigation canals and in wells. However, incidence was lower in the wells. Thermo-tolerant coliforms were also found in water, and the incidence in canals was higher than the standards for bathing water (Shortt et al, 2006). Water buffaloes using irrigation water bodies for bathing could be a reason for polluting irrigation water. The researchers note that shallow wells provide a better option for drinking with some treatment and for bathing. However, lining of canals could be a threat to recharging groundwater and replenishment of well water.

As many of the rural drinking-water supplies are self-managed, the management of health risk requires a high level of awareness among users. The

Ministry of Health specifies monitoring of drinking water quality as a regular activity for their field staff. Public water-supply schemes undertake monthly campaigns to promote the use of boiled water. In addition, promotion of sanitary latrines through education and enforcement, monitoring refuse-disposal and health standards in food production, work places, etc. are implemented by various agencies

There are several external factors which influence the management of water resources in Sri Lanka, which are reflected in the water resources management in Walawe basin. These factors include the trends in risk management, increasing demand for energy, impact of climate change on water resources, social and political developments and technological innovations.

3.1 Risk management in a changing world

Water related disasters make a pronounced impact on the life of Sri Lankans. Many recent disasters including the 2004 tsunami have initiated several actions, which will influence the management of water resources in the future.

3.1.1 Droughts, floods and landslides:

The major type of the disaster that influences water resource in lower Walawe basin is droughts. In addition the upper basin has several locations threatened with landslides. The floods are not frequent, but lower reaches are vulnerable to occasional flood events. The floods are associated with reservoir operations.

Hambantota district, where the downstream end of the basin is located, is classified as drought-prone. Some areas of the Moneragala district were also severely affected during the recent droughts. More than 52,000 families in Hambantota district were affected during the drought occurred in 2001. Drought management decisions in agriculture are taken in the seasonal cultivation meeting where farmers and officials participate. Typical decisions include the cultivation of a reduced proportion of the command area and sharing the land. In general, domestic water needs are given the highest priority during droughts.

3.1.2 Dam safety and risk management

The 103 m tall Samanalawewa dam was constructed with the intention of generating 462 GWh of hydropower, a 120 MW power plant is installed. The reservoir has a storage capacity of 278 million m^3.

The dam is located in an area broadly classified as consisting of the highland group of the pre-Cambrian metamorphic rocks. Detailed investigations found limestone formations in reservoir bed. During the construction which began in 1986, a high permeable zone was detected on the right bank of the dam and the foundation was grouted. After impounding the reservoir, heavy leakage was detected in the right bank of the dam. Further conventional grouting did not help to arrest the leakage, and safety of the dam was feared. Wet blanketing was carried out subsequently which reduced the leakage. Based on the recommendations of an international expert panel, Samanalawewa reservoir and power plant are in fully unrestricted operation since 1997. After the remedial measures, the restrictions on water level were removed in 1997. However, after heavy rainfall and a rapid rise in water level in 2007, the leak through the dam has increased, which raised fresh concerns about the dam safety. The management had to reduce the water level of the reservoir, fearing for its safety. The safety of Samanalawewa dam is one of the major issues to be addressed in a disaster management plan in the basin, and as such, dam safety related risk management is a major driver affecting the state of the resource in Walawe basin.

3.1.3 Present operation and management practices related to dam safety

At present there is no dam safety legislation available in Sri Lanka. Irrigation Department and CEB have internal circulars that provide instructions on how to monitor and collect flood data and operate gates in an emergency condition. In case of an emergency all dam owners inform the local police. The current practice in Sri Lanka for inspection of dam safety is the dam owning organizations adopt self regulation for dam safety assurance and dam safety management. However with conflicting demands for limited funding, dam safety has tended to be neglected or given low priority. This has sometimes led to gross neglect of essential maintenance of dams resulting in the exposure of the downstream public to danger. Hence there is a need to establish a mechanism to ensure that the dam owners input serious effort and commit sufficient dedicated funds to operating and maintaining their dams in a safe manner. World Bank funded Dam Safety and Water Resources Planning Project has addressed this issue and provision has been made for preparation of necessary framework, including provision and guidelines for establishment of an inter-organization arrangement for dam safety (Talagala, 2008).

3.2 Climate change as a driver influencing the state of the water resources

3.2.1 Variations of temperature

Average annual temperature of Sri Lanka is being increased at a rate of 0.01 to 0.03 per annum due to increase in both nighttime minimum temperature and maximum temperature. Basnayaka et al, (2003) have shown that increase in ambient temperature in Sri Lanka is more prominent in areas where land use has changed from agriculture to other uses than that of conventional agricultural regions.

3.2.2 Trends of ambient temperature in the Walawe basin

Punyawardena (2008) carried out a time series analysis of temperature, using average monthly minimum and maximum temperature values during the past 50 year period from 1957 to 2006, at Hambantota and Ratnapura. Hambantota lies in the downstream of the Walawe basin. However, there is hardly any reliable long series of temperature data recorded at the upstream Walawe basin and hence, a nearby location, Ratnapura which has a good record of data was used for the analysis. Even though Ratnapura does not fall within the Walawe basin, its exposure exhibits fairly similar characteristics of the upper Walawe basin.

Figure 3.1 shows the trend of annual average temperature during the period from 1957 to 2006 at Hambantota. It clearly reveals that ambient temperature at the downstream of Walawe basin is being increased at a rate 0.016 ^{0}C per year. Analysis has further shown that this increase in average temperature is mainly attributed to the increase in day time maximum temperature than that of the minimum temperature (Figure 3.2). Change in nighttime minimum temperature during the 50-year period is negligible and does not explain a significant proportion of the total variation (r^2 = 0.1813). The increase in daytime maximum temperature was evident in every season of the year (Table 3.1). Nevertheless, the magnitude and proportion of the variation to the total variation was highest during southwest monsoon and northeast monsoon seasons. This has a significant bearing to the Walawe basin as these two rainy seasons are conventionally water deprived periods of the year.

Unlike Hambantota, changes of ambient temperature regime in Ratnapura are highly erratic. Neither annual average (Figure 3.3) nor annual maximum/minimum (Figure 3.4) shows any discernible trend. Variations of ambient temperature in different seasons have also not shown any significant trend (Table 3.2). Thus, it cannot be assumed that global warming has a significant bearing on the temperature regime of the upstream of the Walawe basin without wide margin of errors. The lack of signatory of global warming in this region could be attributed to its terrain characteristics and state of the land use.

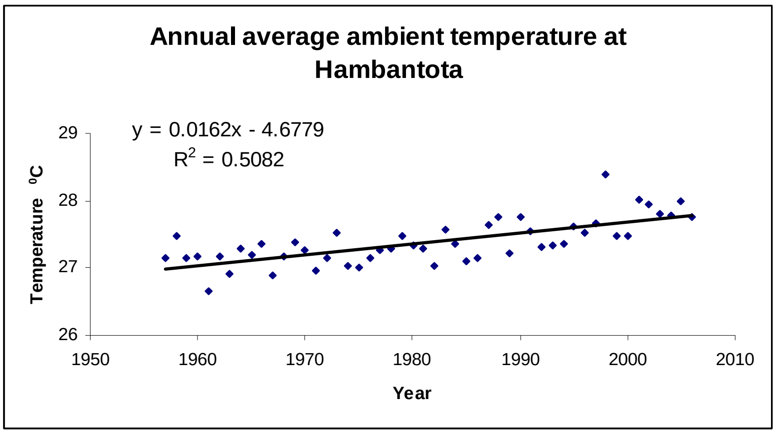


Figure 3.1 Trends of ambient temperature at Hambantota

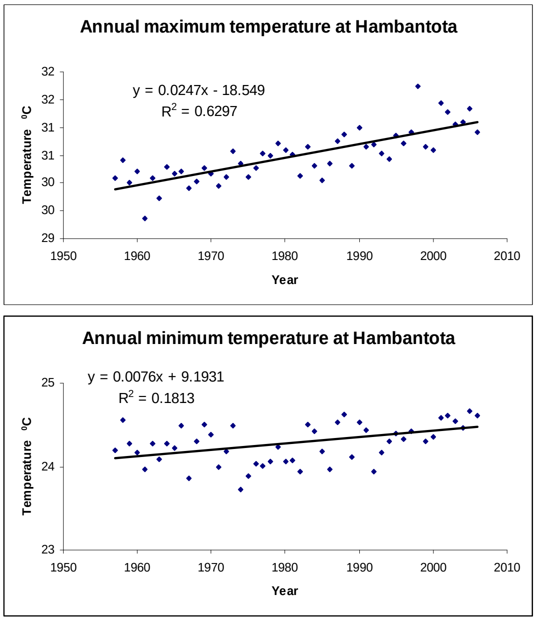


Figure 3.2 Trends of maximum and minimum ambient temperature at Hambantota

Table 3.1 Changes of seasonal temperature regime at Hambantota (1957 – 2006)

Season	Maximum temperature		Minimum temperature	
	Equation	r^2	Equation	r^2
FIM	Y = 0.0221X – 12.463	0.3494	Y = 0.0125X – 0.3627	0.1911
SWM	Y = 0.0255X – 19.937	0.4704	Y = 0.0029X – 19.166	0.0265
SIM	Y = 0.0221X – 13.369	0.3575	Y = 0.0081X – 7.9627	0.1554
NEM	Y = 0.0264X – 22.293	0.4983	Y = 0.0117X – 0.0689	0.1332
Annual	Y = 0.0247X – 18.549	0.6297	Y = 0.0076X – 9.1931	0.1813

Source: Punyavardena, 2008

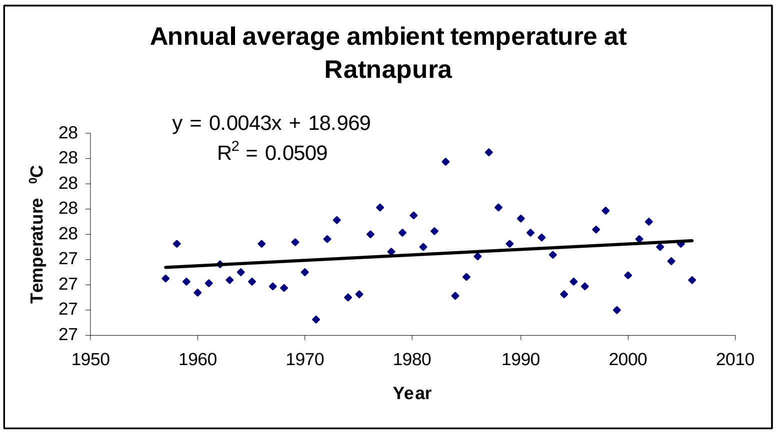


Figure 3.3 Trends of ambient temperature at Ratnapura

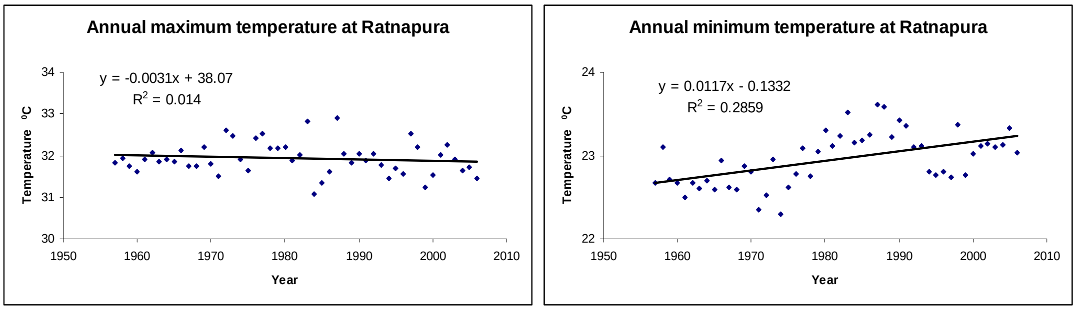


Figure 3.4 Trends of maximum and minimum ambient temperature at Ratnapura

Table 3.2 Trend of seasonal temperature regime at Ratnapura (1957 – 2006)

Season	Maximum temperature		Minimum temperature	
	Equation	r^2	Equation	r^2
FIM	Y = -0.0005X + 34.792	0.0001	Y = 0.0116X – 0.0086	0.152
SWM	Y = -0.0029X + 36.754	0.0095	Y = 0.0115X – 0.7665	0.2548
SIM	Y = -0.0072X + 45.694	0.0469	Y = 0.0116X – 0.1635	0.2504
NEM	Y = -0.003X + 38.497	0.0045	Y = 0.013X – 3.7544	0.178
Annual	Y = 0.0031X + 38.07	0.014	Y = 0.0117X – 0.1332	0.2859

Source: Punyavardena, 2008

3.3 Variation of rainfall-related parameters

Sri Lanka National Water Development Report 2006 described the changes of the climate and its impact on water resources. In effect, the changes to rainfall pattern have expanded the dry zone. In the case of Walawe basin, a reduction of the high rainfall region can be observed. Apart from the changes to the annual rainfall, there are changes to the within-year rainfall pattern also.

The current studies in the Walawe basin reveal substantial reduction of rainfall (Ratnayake and Herath, 2008) though there are concerns about the statistical significance of their trends.

3.4 Meeting the needs of energy

Based on the units generated in 2006, current annual electrical energy demand of the country is estimated at about 9,400 GWh. The average annual electrical energy production (from 2002-2006) is about 8,200 GWh. The main consumer of electricity is domestic sector, followed by industrial and commercial sector. The electricity demand is growing by about 7-8% annually. In 2002, 65% of the households had access to electricity. This was planned to be increased to 77% in 2006 and the achievement was78%. Government is providing subsidies for energy production using petroleum sources to keep the tariff structure at an affordable level for the consumers, mainly the domestic consumers. High prices of electricity could increase the use of bio-mass as an energy source, which can have adverse impacts on the environment. Currently, whenever there is a drought, there is a difficulty in meeting the peak power demand.

There are 13 major dams for energy generation in Sri Lanka. Share of hydropower in total generation decreased since 1990. However, there is a considerable increase, up to 49% in 2006 due to favorable weather conditions in that year, while the average share during 2002-06 was only 41%.

In the Walawe basin, Samanalawewa hydropower station is the largest hydropower generation facility. It is certified with ISO 9001:2000 quality management system since 2003 and ISO14001 environment management system since 2006. Though the target energy generation defined for the power plant is 462 GWh in 1992 it could produce less than that due to geotechnical problems and less inflows. The target is revised to 403 GWh/year in 1996 and later brought it down to 388 GWh/year. The recent average generation is in range of 240 GWh/year (Somathilaka 2008).

The Samanalawewa could be one of the last large scale dams to be built in Sri Lanka for hydropower. The environmental and social concerns have limited the options for more large dams. The remainder of the hydropower potential is mainly designed to be exploited through augmentation of the existing facilities, run-of-the-river type constructions and micro and mini hydropower generations. Though the share of hydropower has dwindled, it helps to contain the tariffs at affordable levels. The electricity tariff is already high compared to other countries in the region, and this is noted to be constraining the growth of industries (CBSL, 2007)

3.5 Challenges in the provision of safe drinking water

The water related challenges faced by urban and rural settlements are different. In the case of urban settlements, many drinking water supply schemes do not provide 24 hour supply. Some schemes experience quality problems during dry periods. New settlements in the periphery of major cities and shanties in cities are especially affected by such problems. As such, some people, mainly the poor, are likely to access water from unsafe sources, when the safe sources are inadequate.

Most commonly used drinking water sources within the basin are reservoirs, canals, streams, springs, dug wells, bore whole wells and hand pump wells. In the case of rural areas, which are mainly located in the dry zone, both the quality and quantity of water supply is reduced during the dry periods. As the majority of the rural people depend on groundwater (Fernando, 2008), the deterioration of its quality is a major concern. Quality problems have been arisen due to naturally occurring chemicals such as fluorides. Major quality problems observed in the groundwater of the basin are salinity, high iron concentration and high electrical conductivity. Fluoride is a significant hazard of the deep ground water in certain areas of in Moneragala District (Fernando, 2008, and Seneviratne, 2008).

Water pollution is caused by the heavy use of fertilizer and agrochemicals as well. The intensification of agriculture, which is promoted for uplifting the economic status of rural poor, is sometimes having adverse impacts on the water quality (Seneviratne, 2008). Many rural households draw water from wells dug in their own compound, and the lack of quality assessments delays the detection of water related health problems.

The following are some of the specific issues recorded in the urban water supply systems of the Walawe basin.

- Water production in Udawalawe scheme is insufficient during Udawalawe RB canal maintenance period.
- Balangoda scheme intake has been affected by sand mining in Walawe River. Production is therefore insufficient to distribute mainly during the dry season.

- Embilipitiya scheme - Rehabilitation is in progress at present but the present supply has several short coming both in adequacy and quality.
- Kahawatta scheme - There is no sufficient water at the source in the dry season.

Since the augmentations of Ambalantota & Hambantota water supply systems are ongoing at the preparation of this report, the current issues and constraints at the supplies will be settled in near future.

No routine source yield monitoring systems available especially in village and estate water supply schemes due to technical and financial difficulties. In certain pipe water schemes groundwater sources have fully or partly dried up few years after commissioning of the scheme. This has resulted in abandonment of the schemes. If a routine monitoring system has been in operation such problems would have been evaded.

Another issue is that there is no authority to control water abstraction from public water bodies such as rivers, springs, ground water etc. Over abstraction of water from these sources reduces both the quantity and quality of water that could be used for potable water. No proper mechanisms have been developed for co-ordination among the water sector actors to achieve the objectives and coverage targets of the sector. Various agencies operate in the basin without coordination with each other. When surface water sources are shared with irrigation for domestic water supply water right issues are becoming increasingly involved. In river basins the common competitors are the small scale farmers who use water for irrigation and those for domestic water supply.

Although certain amount of investment in drinking water supply is made by the NGO s, an accurate record of their level of investment within the study area could not be obtained (Fernando, 2008).

3.6 Current issues in the provision of sanitation

In the study area there are no central sewage disposal systems available even in major town centers. Private and public pit latrines either with septic tanks or direct pit are the available sanitary facilities. In the town limits the respective local authorities are assisting in emptying the septic tanks through their gulley-bowsers.

Moneragala & Hambantota districts were helped by the Third ADB Water Supply & Sanitation Sector Project to reach reasonable safe sanitation coverage. In addition a pilot intervention has been reported in Monaragala District by *Plan International*. But in December 2004, with the Tsunami hit a considerable number of household latrines were affected along the coastal belt of Hambantota District. With intervention of Donors this situation has been restored within a year.

A substantial input for providing safe sanitation was given in Ratnapura and Badulla districts CWSSP. Also there had been interventions in the estate sector in Ratnapura & Badulla Districts. All above donor assisted programmes were based on subsidy ceilings either cash or material for construction

In general, it has been noticed that the access to safe sanitation in Walawe Basin is in a satisfactory level but minor issues are still prevailing specially in some estate plantations. This causes the pollution of water sources especially during the rainy seasons.

3.7 Future water demands

The southern region of the country is regarded as a less developed region (ID, 2002). Currently the economic activities in the area are predominantly agricultural. For a substantial time the government was pondering a set of proposals to develop the area giving preference to industrial and commercial activities. This proposal envisaged the creation of a new industrial and commercial zone called "Ruhunupura". The major components of the proposal were the establishment of an airport, an oil refinery, a harbour and associated infrastructure.

In 2002, the Irrigation Department did a survey of water resources demand and possible supply sources for Ruhunupura. The assessment concluded that the water demand of Ruhunupura in 2030, when the envisaged developments are complete, would be 98 million m^3. It also estimated that 118 million m^3 could be developed from various sources. 88 million m^3 of this was expected to extract from Walawe and Kachchigal Ara Rivers (ID, 2002).

Since 2000, the water demand and supply situation in the basin has substantially altered. The new developments include diversion of Mau Ara to Malala Oya, diversion of Weli Oya to water scarce areas of Moneragala district and Walawe LB extension scheme. These developments have increased the extent of agricultural land and the cropping intensity of the already developed lands. The actual development has exceeded the plans at some locations, with encroached state lands and uplands being cultivated with unauthorized water extraction.

The annual increase of cultivated land under irrigated conditions will increase the evapotranspiration, and consequently the demand from surface water resources. On the other hand, there are new industrial and commercial development plans, which change the water demand (ID, 2002). Therefore, it is necessary to re-assess the water demand and supply situation in the lower Walawe basin, as it is very relevant to the future expansion of industrial and commercial activities.

3.8 Community participation in water resources management

Current deficiencies in management of water resources by the communities will drive the policy makers to adopt strategies to improve the situation. The studies revealed the following inadequacies:

CBOs in rural drinking water supply schemes were mainly developed through projects implemented with a fixed duration. Basic training to CBO's was provided by the implementing entities of those projects during the implementation. But there is no proper mechanism to train the CBOs on a continuing basis. As the CBO management and the operators are having limited knowledge & skills on the specific technical and management aspects of the water supply systems, refresher training is an urgent need. In addition, status of legal ownership of the CBO-maintained rural water supply schemes is not clear and it could create problems in the long run (Fernando, 2008).

In the case of irrigation management, farmer organizations (FO) have been formed in the programme mode. Therefore, the sustainability of FOs is unlikely to be affected by the closure of development projects. However, inadequate policy support and funds and affiliation with the Agencies that have created them could affect the long term sustainability of these organizations.

3.9 Demographic and social drivers:

3.9.1 Population and growth:

The present population in Sri Lanka is about 20 million. The population growth rate was 1.16% in 2005 and the rate is low compared to other developing countries. The current per capita water availability is about 2,300 m^3 per annum and this would decrease to 1900 m^3 in 2025. Though the water availability is not reaching critical levels in the foreseeable future, the population growth in cities will pose challenges to provide safe drinking water and sanitation.

Population density in the study area is low compared to national level of about 300 persons per sq. km. (in 2001). Moneragala, with a population density of about 49 people per sq. km. in 2001, is having one of the lowest densities in the island. However, the population growth rate in that district was 1.8% between 1981-2001, which is fairly high (DCS, 2008). This could be due to land availability and the state sponsored development activities.

3. DRIVERS FOR CHANGE

3.9.2 Land use changes

The changes to land use pattern influence the quality and quantity of water resources. Tea and rubber are grown as commercial crops in the upper basin, and rice is the major crop in the plains. The major land uses in the basins are agriculture, forests, and homesteads.

The reduction of forest cover is a major problem in Sir Lanka. However, the upper reaches of the Walawe basin, the forest and vegetation cover has increased. A study by Molle et al (2003) compared the land use in 1985 with 1956 in the upper Walawe basin and showed that area under tea and rubber plantation had reduced. The high population densities of the basin are associated with tea plantations. The forest area and paddy area has expanded. Savannah and scrub lands have been converted to forests. A study by Weerasinghe et al (2008) indicated that forest cover in the entire basin has reduced, while some forest areas were converted to scrublands. Therefore, it appears that the land use changes in the upper basin are different from that in the lower basin. Irrigation and more recent industrial and urban development in the lower basin may have contributed to the differing land use changes in the upper and lower basins.

Land use and vegetation distributions within the four basins of the study area are given in Table 3.3. Forests and scrub lands are the predominant natural vegetation in the area. Considerable area of the scrub lands have been converted to planted forests and in some cases this is done commercially for industrial purposes (Ratnayake and Herath, 2008). Excluding the reserves and currently cultivated lands, a further 58% are arable lands (comprising mainly scrub and grass lands) was available with a possibility for development in 1999.

The land use changes are influenced by the water resources development in the river basin. Irrigated area has expanded rapidly since 1950s. Liyangastota diversion in the downstream of the Uda Walawe reservoir commanded 5,300 ha while Uggalkaltota diversion commands another 870 ha of irrigated lands prior to 1967.

Table 3.3 Land use and vegetation of the study area

Land use type	Area (km^2)	Percent
Built up Lands	0.6	0.0%
Homestead	484	15.0%
Rock, Sand	14	0.4%
Forest	481	14.9%
Forest reservations	39	1.2%
Salterns	16	0.5%
Water	126	3.9%
Marsh	5	0.2%
Scrub	629	19.4%
Grass Land	35	1.1%
Tea	88	2.7%
Rubber	4	0.1%
Coconut	35	1.1%
Other Cultivations	171	5.3%
Paddy	355	11.0%
Chena	754	23.3%

Source: Prepared by U.Ratnayake; Base data Department of surveys, 1:50,000 maps, 1999
Note: totals of land area may not match with previous statements due to accuracy of maps.

The period after 1967 saw a major development of the irrigated agriculture in the Walawe basin. In 1967 the Uda Walawe Reservoir commenced its operation irrigating 9700 ha under its right bank canal and 6744 ha under its left bank canal. In year 2000 a new project is commenced to extend the command area under the left bank by another 5152 ha. In addition to above large scale developments many small reservoirs and diversions were developed in the basin. Since the commissioning of Uda Walawe scheme in 1960s, the irrigated area increased by 23,000 ha. Other developments in the recent times include Weli Oya Project and Mau Ara Project, each developing about additional 2000 ha.

Some adverse effects of man-made interventions on vegetation have been noted. Tea plantations replaced a part of the natural forests in the 19th century. While well maintained tea plantations can be environmentally beneficial, abandoned tea lands result in land degradation through soil erosion. In 1950s trees such as pines and eucalyptus were introduced as a part of reforestation. However, such trees were observed to have a negative impact on water resources, and believed to be responsible for drying up several small streams (Smaktin and Weragala, 2005).

Some of the recent developments have encroached in to the lands predominantly used by the wild life. The development has directly conflicted with the wild life in the area which is abundant. Elephants killed by humans or vice versa are happening frequently in the areas which were developed. The areas between Lunungamvehera, Udawalawe and Bundala together with Kaltota-Haldummulla area in the north of Udawalawe National Park are famous for such human-elephant conflicts. Department of Forestry and the Department of Wild Life Conservation have demarcated lands for wild life and forest. Live fences are used to control the wild life to minimize such conflicts.

3.9.3 Water and gender issues

The literacy rate of women in Sri Lanka is 90.5%, and it is considered high among the developing nations. In fact, in the 15-24 year group, the number of literate women is more than that of men (DCS, 2008a). Therefore, the literacy is likely to be improved further, in the future. The culture and tradition have not been a major hindrance to achieve equality in many fields. However, social and economic equality reduces from urban to rural, and affluent to poor, families (World Bank, 2007). The need to increase the participation of women in water related decision making is felt. The studies have shown that inadequate participation by women reduced the benefits of the post-tsunami rehabilitation activities. Women play a major role in providing drinking water and sanitation to the family. Delayed detection of some diseases such as kidney ailments in the dry zone, which are widely believed to be related to water, could be due to inadequate voice of the women.

3.10 Economic drivers:

3.10.1 Economic and social consequences of major water related disasters

The worst disaster of recent times is the Asian tsunami of 2004, which devastated the coastal regions of the Walawe basin. The assessments made prior to tsunami show that Hambantota District accounts for 5.5% of the fishing fleet and 12.9% of the total marine fish production. About 93% of the people employed in fisheries sector, which includes marine, lagoon and inland fisheries, lived in coastal areas (DCS, 2005). However, these people are also employed in other industries and provision of services in addition to fishing.

Hambantota district which forms the downstream portion of Walawe basin was badly affected by the Asian tsunami of 2004. The official statistics indicate that tsunami affected 16,994 families, caused more than 3067 deaths and further 963 people went missing in Hambantota

District. The total damage to the District was estimated as Rs. 23 billion (USD 220 million). Sector-wise, more than 90% of the fishing fleet and 386 ha of agricultural lands were affected (DCS, 2005). At the initial assessment, it was estimated that fisheries sector will take some time to recover, compared to wage-earning sectors (DCS, 2005.).

The current status is that most of the fishing fleet and housing is restored, together with public infrastructure. Being relatively free of conflicts and having better accessibility, Hambantota district fared better than the eastern part of the country in the recovery process. However, inadequate stakeholder participation is reported in some areas, which could be addressed in future policy development.

Impact on agricultural activities:

Farms located in the downstream end of Ridiyagama and Walawe Right Bank Irrigation System and some home gardens were affected by the tsunami. Most of these farmers receive water from drainage of the major irrigation systems. The adverse impacts included salinization of the soil and siltation of the drainage canals, erosion of the land and destruction of the crops. The farms with poor drainage facilities were the worst affected because timely flushing out could not be performed.

The solutions that were planned immediately after tsunami were flushing the irrigated areas with irrigation water, natural flushing with rain water in non-irrigated areas, and monitoring salinity levels. Ongoing studies in Uda Walawe Left Bank development area will provide some insight to the effectiveness of these interventions.

Impact on fisheries activities:

The vast number of people who died of tsunami was fishermen. The other physical impacts included damage to vessels, landing points and fishing gear. This has resulted in the loss of capital assets, livelihoods as well as household nutrition. Nearly 90% of the fishing fleet was damaged, bringing down the production to 10% of pre tsunami levels (Anputhas et al, 2005).

Impact on trade, manufacturing and services:

Many of the people engaged in agriculture and fisheries made an additional income by engaging in services and trade sector, especially in the tourist industry. The tourist hotels located on the beach were destroyed and tourist arrivals reached a very low value immediately after the tsunami. As such many people who were directly employed in the sector as well as people who provide various services such as selling curd and roadside vendors lost their income.

3.10.2 Economic value of water

The pricing policies differ from sub-sector to sub-sector. In the domestic water supply sector, pricing is based on operation and maintenance cost recovery. The capital cost is rarely recovered. However, in some rural water supply projects, the communities bear a portion of the capital cost. The tariff structure consists of step-wise increases to protect small scale users (Fernando, 2008).

The pro-poor tariff structure does not encourage people to save on water or resort to alternative supplies such as rainwater harvesting. Therefore, making it compulsory for new urban housing units to be equipped with rain water harvesting facilities is under consideration.

Attempts to introduce a fee for irrigation water made in mid 1980s met with failure. Due to social and political sensitiveness of the issue, it is unlikely that government imposes a fee on irrigation water. However, there is a limited success in farmers' participation in the management of irrigation systems. Among other benefits, this facilitates the effective and transparent use of public funds used for irrigation system management. Some farmer organizations collect a fee from their members and use the money for improved system management.

Public-Private partnership

The major role in both domestic water supply and irrigation is played by the State, as a service provider. However, the private sector is active in bottled water supplies and maintenance of infrastructure. It has contributes substantially to develop mini and micro hydropower. A prominent role is played by the private sector in hotels and restaurant industry, environmental conservation, fisheries etc, which has an impact on water resources.

Kikuchi et al (2002) observe that private investment in irrigation development, in terms of agro-wells, tube wells and irrigation pumps has increased rapidly, especially since 1980s. It is seen that agro wells and irrigation pumps allow more discretion to the farmers over water use, diversification to high-value crops and result in higher incomes. The advantage of these investments is that agricultural activities can be carried out independent of the surface-irrigated lands.

Public investment in water resources

The major state water institutions operating in the Walawe basin belong to the following Ministries:

a. Ministry of Irrigation and Water Management
b. Ministry of Agriculture Development and Agrarian Services
c. Ministry of Water Supply and Drainage
d. Ministry of Power and Energy
e. Ministry of Environment and Natural Resources
f. Ministry of Disaster Management and Human Rights
g. Ministry of Health and Nutrition

The national budget allocates funds for these Ministries which are subsequently allocated to different institutions for activities within the Ministry scope. As some of these activities are not strictly water related it is difficult to accurately estimate the investment in the water sector. The investments by Provincial Councils in the water sector further complicate the calculations.

The total of budgetary allocations to Ministries of Irrigation and Water Management, Water Supply and Drainage and Agriculture Development and Agrarian Services was about 5% of the total national budget during the recent three years up to 2008.

3.10.3 Social and cultural values:

The culture and traditions bestow a substantial cultural and social value on water. Research work shows that poverty reduces with better water availability. The direct impacts are observed in better incomes from agriculture and better drinking water and sanitation facilities. Effect is pronounced on women and children. As rural women are the main providers of domestic sanitation, provision of water supplies reduces their time spent on fetching water, and allows time for economic activities.

Low economic returns to agriculture are not reflected in land use changes in the rural areas. Therefore, the social and cultural values of water appear to play a major role in water use patterns in the rural areas. However, there is a significant reduction of rain-fed agricultural areas in the more urbanized wet zone.

Table 3.4 Water Charges as a Percentage of Income in the provinces relevant to Walawe basin (SL Rs.)

	Income	Average Water bill	Water bill as a% of income
All Island	15,400	253.46	1.65
Uva Province	10,765	200.68	1.86
Southern Province	12,422	200.68	1.62
Sabaragamuwa province	11,352	200.68	1.77

Source: Fernando (2008) (Based on Annual Reports of NWSDB)

Influence of irrigation infrastructure development on the value of water

The originally planned Uda Walawe Irrigation and Hydropower Project were completed in several stages. First part of the project was completed in 1967, with the dam, hydropower facilities, a part of the right bank and left bank main canals were completed. The developed irrigation area consisted of 12,000 ha on the right bank and 4,400 ha in the left bank. By 1993, 5,350 ha under the left bank main canal were developed with 2,450 ha allocated for sugar cane. From 1995-2007, a new area of 6,250 ha was developed on the left bank, together with improvements to the existing facilities.

The non-irrigation development activities in Uda Walawe scheme area included providing drinking water supply and rural infrastructure such as roads, schools and electricity supply. In addition, the Walawe Left Bank irrigation development involved several new concepts such as “dual canal system” which comprises of two parallel canals, one at higher level carrying water for non-paddy field crops and the other carrying water for paddy. This is supplemented with night storage tanks (ponds) to regulate the flow and to optimize drainage flow reuse.

The Project also introduced environmental mitigation measures and resources were allocated for monitoring environmental parameters such as water quality and soil salinity.

3.11 Poverty and human settlements

Poverty alleviation has been a high priority in Sri Lanka’s social welfare and development strategies. However, it remains a challenge to policy makers. Understanding the dimension of the issue at national level is important to formulate water resources management responses at river basin level.

Based on the per capita GDP Sri Lanka is now placed in the category of “Lower - Middle Income Countries”. Substantial gains have been made in the fields of rice production, infant mortality rate, life expectancy, and provision of health facilities, safe drinking water and sanitation in the last 50 years.

However, alleviating poverty remains a challenge. The percentage of poor households was 21.8% in 1990/91, 24.3% in 1995/96, and 19.2 in 2002 (CBSL, 2007). The MDG target for 2015 is to reduce this percentage to 13.1%, and the current statistics show that the process to achieve this is not on track (NCED, 2005). Despite good health coverage, malnutrition among poor is a serious problem. Poverty is higher in rural and estate sectors.

The surveys and studies carried out in Sri Lanka in 1940s revealed that about 75% of the village families were below the minimum subsistence level (in terms of food and nutrition). It was found that the main reason of the high rate of neo-natal mortality was maternal anemia resulting from an inadequate diet. The situation has changed now, especially in the dry zone where poverty was rampant.

The major challenges to poverty alleviation in Sri Lanka include the growing urban-rural gap in economic growth, stagnating productivity in agricultural sector and ongoing ethnic conflict (World Bank, 2007). These issues contribute to increased rural to urban migration. However, such migration could lead to further complication of the poverty issue. It is found that overcrowding in urban areas such as Colombo results in congestion and inadequate infrastructure results in reducing the potential for economic growth. The migrating poor often live in underserved settlements in the city or in the peripheral areas of the urban centers. A recent survey, which was also reported in Sri Lanka's WWAP case study of 2006, found that 43% of such households considered domestic water supply should be improved, and 27% considered sanitation and sewerage should be improved (Imbulana et al, 2006). Another study found that lack of safe drinking water and adequate sanitation makes poor households vulnerable to gastro-intestinal infections and diarrhea, and can result in deceases and infections that prevent absorption of nutrients, which is an important immediate cause of malnutrition. It is reported that poverty makes people vulnerable to malaria in the dry zone and malaria in turn makes a person's productivity low. To complete a vicious cycle, malnutrition in the long term constrains a child's ability to learn, and the statistics show that poverty incidence is high among the less educated.

To make the matters worse, water related disasters hit the poor the hardest, and their capacity to absorb the shocks is smaller compared to the affluent. The 2004 tsunami impacted the poorer areas of the country such as east and south, where the poverty incidence was higher than the national average (World Bank, 2007).

It has been found that inadequate access to towns and markets and facilities such as electricity also contribute to poverty. Considering that overcrowding of urban areas is already a problem, it appears that currently ongoing rural development activities should be given greater emphasis. Access to water could be one of the most important parameters of development.

The amount of money spent monthly on food required for a person to achieve basic nutritional requirement for good health is the lowest in the North Central Province (NCP), where 24% of the irrigated agricultural areas are located. Food poverty, measured in terms of percentage of people living below food poverty line, is again the lowest in the NCP, while the highest values are recorded in the plantation areas where the poor are mostly paid laborers.

Studies also show that poverty is higher where investment in water resources development is inadequate. A study carried out in Uda Walawe scheme shows that areas having water scarcity experience higher incidence of both chronic poverty and transient poverty (JBICI, 2002).

3.12 Threats to biodiversity of coastal wetlands in Walawe basin

Threats to the biodiversity can be divided into four categories. Destruction and degradation of habitats/ ecosystems, direct over exploitation of species, spread of invasive alien species and natural factors (Weerasinghe et al, 2008).

The Asian Wetland Directory notes 41 wetland sites of international importance in Sri Lanka including Lunama (212 ha), Kalametiya (200 ha) and Rekawa lagoon within the study area. The Lunama-Kalametiya area supports a variety of natural and man-made vegetation or habitat types, including terrestrial and wetland systems. Some of the threats to in Lunama and Kalametiya lagoons are described below (Weerasinghe et al, 2008).

i) Deforestation

The Kalametiya sanctuary is affected by deforestation. Villagers have cut down/burnt more than 50 ha of forests for their settlements, chena cultivation and shell mining. This has displaced forest dwelling birds from their habitats.

Mangroves have been cut down for human settlements and fuel wood. A mangrove patch in Lunama area has been cleared for illegal shell mining. Mangroves bordering lagoons and estuaries provide refuge for the larval stages of aquatic organisms such as fish and crustaceans. Random interviews with local fishermen indicate that there is a decreasing trend in fish and crustacean catches, over the past decade. The loss of mangrove refuge could be one reason for the decrease in fishery.

ii) Shell mining

Large-scale illegal shell mining was observed around the Kalametiya lagoon area. Shell mining has also caused the degradation of the mangroves and scrubland of the Lunama lagoon area.

iii) Drainage of irrigation water into the lagoons

The ecology of the Kalametiya lagoon has been adversely affected by defective irrigation structures and poor water management. Drainage of irrigation water into the lagoon has lowered the salinity of lagoon water. Silt brought in by drainage has filled up at least 40% of the Kalametiya lagoon within the last 15 years. Consequently the lagoon cover has decreased and filled area has been invaded by a monoculture of Sonneratia caseolaris. The Lunama lagoon is also affected by siltation. Decrease of salinity has aggravated the spread of invasive Typha angustifolia and Eichhornia crassipes mainly in the Kalametiya lagoon.

iv) Discharge of agrochemicals into wetlands

Large amount of agrochemicals, both biocides and fertilizers, are used in rice fields in the upstream areas of Lunama-Klametiya and has adversely affected the aquatic life associated with wetlands. The Kalametiya lagoon shows signs of eutrophication, possibly due to accumulation of chemical fertilizer residues. This condition has promoted the proliferation of invasive plants such as Water hyacinth (Eichhornia crassipes) in Kalametiya lagoon

In a study conducted with 162 randomly selected farmers by Arawinna (2004), it was documented that seventeen insecticides, nine fungicides and seven herbicides are widely used by them. More than 95% of farmers use pesticides to control pests on paddy cultivation. 44% of farmers had applied non-selective herbicides such as Glyphosate and Paraquat before the land preparation. After the cultivation, farmers use selective herbicides to control broad leaves weeds and grass type weeds. Most commonly used selective herbicide is Propanil at 94% and MCPA at 71%. Bispyribac-sodium, Clomazone, and Oxadiazon were used at less than 20% of farmers. Additionally, Diuron is used for weed control on sugar cane cultivation. Usage of insecticides is relatively lower compare to Kalpitiya area but 78% of farmers had used granular form of Carbofuran (at active ingredient of 30g/kg) as acaricides. Mainly used other pesticides are Fenobucarb (28%), Dimethoate (28%), Chlorpyriphos (22%), Phenthoate (34%), Profenophose (24%) and Imidacloprid (25%). Less than 20% of farmers use Diazinon, Fipronil, Malathion, Fenthion, Pirimiphos-methyl, Profenophos, Chlofluazuron, Prothiofos, Fenvalerate and Permethrin as insecticides. Very small number of fungicides was used at very low frequency. The main fungicide was Sulpha by 9% of farmers. Bitertanol, Captan, Chlorothalonil, Edifenphos, Mancozeb, Oxadixyl and Thiophanate-methyl were the other fungicides.

v) Unregulated animal husbandry activities

The grasslands of the Kalametiya area are overgrazed by cattle and buffalo allowed to roam freely. Several grasslands have been eroded due to overgrazing. These animals have also facilitated the spread of invasive alien plants such as Mesquite (Prospis juliflora) since they feed on the pods of the latter plant.

Unregulated animal husbandry activities facilitate the spread of invasive alien species of flora. A number of alien invasive plants and animals were documented in Walawe area. Among the invasive alien plants Prosopis juliflora (Mesquite), Lantana camara (Lantana) Eichhornia crassipes (Water Hyacinth) and Salvinia molesta (Selvinia) have invaded the aquatic ecosystem. The spread of juliflora is facilitated by feral/unmanaged domestic cattle and buffalo, and it is gradually displacing native Tilapia (Oreochromis mossambicus and O. niloticus) have stablised breeding populations in the lagoons, and the Garden snail (Achatina fulica), and feral domestic cats dogs and cattle have invaded terrestrial ecosystem causing negative impacts on native animals. The latter species are causing problems to terrestrial animals especially in Kalametiya. Feral dogs destroy turtle nests in the area and feed on turtle.

vi) Illegal encroachments and reclamation

Illegal encroachments and reclamation of wetlands have resulted in the fragmentation natural habitats. This is clearly visible in the Kalamatiya sanctuary area.

Present status and threats to biodiversity in Coastal areas in Walawe basin

Walawe basin including Malala and Kachchigal Ara basins are rich in bio-diversity. The major locations of ecological importance are a part of the Horton Plains national park, Uda Walawe National Park, a part of Bundala National park, Kalametiya-Lunama sanctuary, Mandunagala sanctuary and Pallemalala sanctuary. Tea plantation has adversely affected the forest cover in the upper watershed, but recent re-forestation activities have had a positive impact.

Bundala National Park, comprising five coastal lagoons is a habitat for migratory water birds and is the first Ramsar wetland site in Sri Lanka. In the recent times, agriculture has been intensified in the areas upstream of these lagoons and drainage water from the newly developed agricultural settlement areas flow into them.

In Walawe basin there are natural and manmade vegetations/habitats types including both terrestrial and wetland systems. Fresh water species mainly found in natural wetlands and anthropogenic wetland. Total of 209 plant species were recorded including 12 climbers, 113 herbs, 39 shrubs and 45 tree species. These include three endemic species and ten invasive alien species. According to the faunal diversity of the lagoons and channel in Lunama-Kalametiya area have three endemics and two threaded species. These include salt water dispersants, Marine forms, brackish water forms and fresh water forms. The area harbors 13 species of amphibians they include toads, narrow-mouthed frogs, common frogs and tree frogs. The wetland area of Walawe basin is rich in bird diversity, including many migratory species. There were 168 species of birds recorded in Lunama Kalametiya area. Those include 121 residents, 46 winter migrants and one off-shore marine bird. Among the resident birds five species are endemic and five are threatened.

Already existing human-elephant conflicts are expected to aggravate with further reduction of forest land due to agricultural expansion (Weerasinghe et al, 2008).

3.13 Technological drivers:

Rainwater harvesting

Rainwater harvesting is being promoted by the government. A rainwater policy has been adopted, which recommends making rainwater harvesting compulsory in new government buildings. It is expected that this policy will be implemented shortly. However, use of rainwater for agricultural purposes is not actively promoted by the government sector yet.

3.13.1 Technology improvements, awareness, dissemination

Technology for rural water supply systems

A large number of rural water supply projects located within the basin are operated and maintained by beneficiary organizations (CBOs) or local authorities. There is a need to build up the capacities of CBOs on aspects related to operation and maintenance since the sustainability of these schemes depends on the capacity of the organization. Basic training to CBOs has been provided by various development projects during their implementation but since then no refresher training on operational & management aspects have been done. As technical experts are difficult to be employed by CBOs, the refresher & replacement training have become an urgent need. (Fernando, 2008).

Database management on rural water supply systems is still at a preliminary level. Information on rural water supply is basically kept at the respective implementing agencies and the relevant CBOs. National or provincial council level data compilation and updating is not adequate and as a result information on rural water sector is disorganized and badly disseminated. Especially the small scale interventions were not recorded and the effect on rural water supply coverage from those interventions was under estimated (Fernando, 2008).

Urban water supply systems

Since 1975 the NWSDB operates in Sri Lanka as the key national organization for water supply. Most urban water supply systems are operated & maintained by the NWSDB through their decentralized setup. Their technical capacity and skills on planning, implementing and O&M of water supply systems is quite high. However, in certain instances management deficiencies has been reported in addition to the poor consumer relations (Fernando, 2008). Central & regional level data bases are available with NWSDB for their water systems and the performance data are published on yearly basis. In addition the corporate planning division of NWSDB is engaged in developing sector targets on national context.

3.13.2 Water quality management and use of technology

In general, the increasing pollution in rivers, reservoirs and streams both from liquid and solid wastes has resulted in severe impact to drinking water quality during recent times. In order to assess the extent of deterioration of raw water quality, a periodic monitoring programme has been launched by NWSDB in Kelani, Mahaweli, Nilwala, Gin, Walawe, Menik and Kirindi Oya river basins and in Kondawattuana, Inginiyagala and Weeragoda tanks for the presence of chemicals, metals and heavy metals (Fernando, 2008).

Water quality monitoring is regularly done in urban water supply schemes maintained by NWSDB with a view to maintaining the Sri Lanka standard (SLS) specifications for potable water established based on drinking water quality standards recommended by WHO.

Table 3.5 Water Treatment Process of NWSDB schemes in Walawe basin

Scheme	Source	Treatment Process
Sooriyawewa	Reservoir	Full
Amabalantota	Walawe Ganga	Full
Hambantota	Walawe Ganga	Full
Hungama	Kachchigalara	Full
Uda Walawe	Uda Walawe RB canal	Chlorination
Embilipitiya	Chandrika wewa	Full
Balangoda	Walawe ganga & Pettigala Reservoir	Full
Kahawatta	Walawe Ganga	Full
Godakawela	Rakwan Ganga	Full

Source: Fernando, 2008(Based on data from Regional Offices of NWSDB)

The Regional laboratories of NWSDB are well equipped to carry out the required water quality tests both Chemical & Biological in the water supply schemes operated and maintained by NWSDB to maintain SLS standards. The raw water quality of the source and the treated water is regularly measured at the following intervals.

- Full test - Once or Twice a month (depend upon the necessity)
- Turbidity - Every 6 hours or Every day (depend upon the type of treatment)
- Free residual chlorine - 4 times a day

Copies of these test reports are submitted to relevant NWSDB Regional Support Centers (RSC), District offices, and to the Officer in charge of the relevant scheme enabling them to take prompt action against problems.

The commonly recorded water quality issues with the surface water bodies were the rapid fluctuation of turbidity levels and the associated high colour. The effect is serious both at the high flows (flash floods) and the low flows at the dry spells.

As mentioned before the deep ground water quality is mostly problematic at the study area as a result of the behavior of the deep fracture zones. Hardness, Iron and fluoride are the prominent hazards but minor incidents were reported from high manganese. Comparatively the shallow wells have fewer problems with their water quality especially the wells located at the banks of the streams and the rivers.

However, the regional laboratories of NWSDB do not have facilities to undertake tests for residuals of pesticides & agro-chemicals in the raw water. The algal blooms are now prominent in the dry zone irrigation tanks and usually make complications at the conventional water treatment processes widely use in medium scale water supply systems. Though the implications on health from residues of pesticides & agro-chemicals were not specified there are suspicions on cancer causes from that. Hence it is vital to improve the laboratory facilities to undertake such tests in par with the seasonal farming cycles at the areas (Fernando, 2008).

Most of the village centers or small town water supply schemes constructed in the recent past and maintained by either CBO's or local authorities are provided with partial or full water treatment facilities. But still no routine water quality monitoring system is available with them especially due to technical and financial difficulties. This matter needs addressing since the quality of drinking water highly relates to the health and diseases.

Regular water quality monitoring is not practiced in the majority of the CBO water supply systems. At some schemes which are constructed under the third ADB Project, water quality was tested only at the commissioning stage of the schemes. Even the disinfection by chlorine is not being done in majority of these schemes and attention on quality is paid only when there is an alert or warning from the regional health authorities.

In order to address the issue, initial steps have been taken in 2006 for the implementation of island wide water quality surveillance system in collaboration with UNICEF and WHO. Local Government, NGOs, District Health Superintendents (DHS) and Provincial Directors of Health are other partnership for setting up of the system. The process is still in progress (Fernando, 2008).

3.13.3 Technology in irrigation

High yielding and short duration paddy varieties have been locally developed and such varieties are cultivated in major part of the agricultural land. These improved varieties substantially reduce the water use, due to their shorter growth period.

High emphasis was given to water use efficiency and productivity, especially in the irrigation sector, since 1980s. However, the emphasis shifted to infrastructure construction in the last five years. Policy and institutional gaps in these subject areas are evident.

There were several attempts to employ drip and sprinkler irrigation to agriculture. However, such attempts are only partially successful. The reasons include inadequate maintenance support and marketing difficulties for the produce which discourage farmers from investing in such techniques.

Recently concluded Uda Walawe Extension scheme provided several water management improvement techniques. The scheme had several water management problems; paddy cultivation in permeable Reddish Brown Earth (RBE) soils which are the main soil type in the scheme area, cultivation of both paddy and the field crops in the same canal command which results in over use of water by field crops, and deterioration of irrigation facilities were some of the reasons for high water use. Though an expansion of the irrigated area was envisaged as land resources were available, the water availability was a concern in mid 1990s (Navaratne, 2008).

The Uda Walawe Left Bank Extension project adopted several water management and agricultural measures to ensure water availability. They include the dual canal system and night storage tanks. In long distribution canals, the irrigation managers often have to provide a continuous supply even during the night, to avoid the lag time for water to reach the tail end of the irrigation system after an interruption. However, during the night a fair amount of water is wasted. A solution adopted by the project is the introduction of night storage ponds, which collect the drainage water and reduce the lag time of water to reach the tail end. Another water management problem faced in older schemes, which tried to promote the cultivation of field crops together with rice in the same command area, was that one irrigation rotation schedule had to be applied to both crops. This resulted in over irrigation of field crops. The project promotes cultivation of field crops parallel to rice, and the traditional canal systems could have resulted in wastage of water. The solution adopted was the construction of “dual canals”, one serving the paddy area and the other serving field crops (Navaratne, 2008). Such measures were complemented by improved agricultural methods. The interventions lead to significant water use efficiency improvements.

3.14 Governance and political drivers

A large number of institutions exist in water sector, sometimes resulting in overlaps. Attempts to restructure the institutions have not been very successful. The status of legal framework is similar, with many legislations dealing with water sector. The lack of policy support is felt considering the failed attempts to revive coordinating mechanisms that functioned well in late 1990s in the irrigation sub-sector. However, the momentum gained in the public participation in irrigation management is maintained, and this has resulted in better decision making, transparency in fund utilization, and better accountability.

The national goals in irrigation, domestic water supply and other related fields are defined in the 10 year development plan produced in 2007. The Millennium Development Goals are given the due recognition in government action plans and special units have been created to measure the progress of achievement. Department of Census and Statistics monitors 48 indicators on achieving MDGs (DCS 2008a), and 13 of them are water related.

Water policy proposals of 2000 recognized that the pollution of groundwater and salinity intrusion in coastal areas as a result of rapid development of groundwater is matters of concern (WRS, 2000). However, the current situation demands a closer look at water quality issues. The current discussion on water quality highlights on the chemical contamination resulting from soil-based chemicals, contamination by agro-chemicals and pollution by industrial and domestic waste. Policy and institutional support to monitor and control water pollution has been recommended in several scientific forums, recently. Therefore, it appears that academia, professionals and various stakeholders would play a major role in future policy dialogues.

The current state of village irrigation systems would be a driver for the better management of those systems. They were managed by the community for several centuries. The ancient management system and the subsequent state intervention have been studied by several researchers. In the past, a leader of the farmers directed the collective effort of the farmers for maintenance of the system. One of his main duties was to implement the decisions taken at the seasonal cultivation meeting. This system was disrupted during the British period (1832) and further changed after the introduction of the Paddy Lands Act (1958) and formation of Farmer Organizations in mid 1980s (Panabokke et al, 2002). The state intervention in the management, population pressure on land resources, changed social norms and modifications to the rural economy has made revival of traditional system difficult. However, no suitable alternative method has so far been evolved. In the recent times several State-sponsored and sometimes foreign-funded rehabilitation projects have contributed to improve the village irrigation systems. Despite such efforts it is noted that poor maintenance will deteriorate the village irrigation systems further. The major maintenance problems that are identified by the farmers are deteriorated bunds, sluices and spillways and silting in the tank bed due to upstream soil erosion (Somaratne et al, 2005).

The major issues that affect the functioning of village irrigation systems include:

- Expanding the command area of upstream irrigation systems have resulted in less inflow to downstream systems, and lesser cropping intensity and subsequent abandonment of such systems by farmers.
- Development of lands that were earlier used for chena (slash and burn) cultivation and scrub jungle has reduced the forest cover and grazing land for livestock.
- There are indications that water quality in the reservoirs have deteriorated. As such, the importance of village tanks as sources of domestic water is reducing.

Peace among communities is given recognition as a driver of equitable development of water resources. Incidentally, water played a role in sparking the current phase of ethnic conflict. In the recent times, some areas in the eastern part of the country, there is a situation more conducive for the development of water resources and irrigation, and managing water-related disasters. The water requirements of the east will be a deciding factor in framing the future water related developments.

3.15 Tools and instruments adopted for risk management

A substantial development in policy and institutional fields can be observed after 2004. A disaster management act was enacted in 2005, which provides the legal backstopping for related activities. The new institutional arrangements provided for the separation of pre-disaster mitigation planning (a responsibility of the Ministry of Disaster Management and Human Rights and the Disaster Management Centre) and post-disaster relief measures (a responsibility of the Ministry of Resettlement and Disaster Relief Services and the National Disaster Management Centre). The National Disaster Management Council is the apex governing body which is chaired by the President of Sri Lanka and comprised of the relevant Ministers. The newly created Disaster Management Centre (DMC) was assigned with the task of risk assessment and mitigation, technology development, early warning dissemination, preparedness planning and public awareness. While the management of some major disasters such as floods and landslides is assigned to some other national agencies with technical expertise, the DMC is responsible for their coordination. It is also equipped with a 24 hour emergency operations unit at the head quarters, and also staffed with District level officers (Sri Lanka is divided into 9 provinces and 25 administrative districts).

The decentralized structure of disaster management facilitates and stakeholder participation is done by coordinating committees' setup at provincial level down to the lowest administrative level. Preparedness plans, which provide information about risky areas, warning mechanisms, evacuation plans, roles and responsibilities of different institutions in the aftermath of a disaster etc, have been prepared with the participation of the community in several areas, and this work is ongoing. A ten year master plan for disaster risk management is also prepared.

In the field of technology development, major achievements are preparation of natural disasters database including historical data, resources information network, establishment of three tsunami warning towers and flood management plans in major flood-risk river basins. External support has come from the UNDP, UN-ESCAP Government of Japan (JICA), Italian Government, USAID, and World Bank.

The effectiveness of the disaster response mechanism was tested during the floods and landslides in December 2006 and January and the earthquakes in the vicinity of Indonesia in September 2007. While the public response has been good, shortcomings in the mechanisms were detected and rectified.

The responsibility of drought management lies with several institutions. The government initiated a range of measures to mitigate the impacts of future occurrences of droughts. These include short-term emergency measures, such as the development of groundwater for emergency domestic supplies; medium-term interventions such as introducing better water management practices; and longer-term studies on the possibility of inter-basin water transfers and integrated development of surface water and groundwater.

Recent government initiatives to mitigate the impacts of drought include the development of groundwater and surface water resources in an integrated manner with the objective of providing sustainable and reliable water supplies. Three major water resources development projects were completed in the recent past in Walawe basin. They include Mau Ara-Malala Oya diversion project, Weli Oya Diversion Project and Walawe Left Bank Development Project.

3.16 Impact of the 2004 tsunami on health, drinking water, sanitation and industries

3.16.1 The damages to water supply and sanitation systems

The area of Walawe basin affected by Tsunami on 26th of December 2004 falls under Hambantota District. Out of the 576 Grama Niladari Divisions (GND) of the District around 200 GNDs were fully or partly affected (GND is a village level small administrative unit). The most serious damages were reported along the coastal belt. Out of 11 Divisional Secretariat areas in the District Tissa, Hambantota, Ambalantota and Tangalle were the most affected areas.

The initial recorded damages to the water supply & sanitation facilities revealed that the damage to the water supply systems in the southern districts is mainly related to the distribution network close to the coast line. The head works (water intakes, water treatment plants and main transmission lines) of almost all the schemes are located at higher elevation and therefore they were not affected by the Tsunami.

Table 3.6 Summary of Tsunami damages to major piped Water Supply schemes in Walawe basin

Scheme	Damages to			
	Transmission Mains	Distribution Mains	Service connections	Other
Hambantota	250m	125m	1260	Approximately 25000m of service lines were washed away
Ambalantota		500m	25m	
Ranna-Hungama	100m	500m	200m	Small damages to ongoing pipe laying

3.16.2 Temporary water supply to tsunami refugee camps

Assistance was offered from various donors to provide water supply and sanitation facilities. Plastic water tanks, water bowsers, gully emptiers, assistance to empty and clean domestic wells, assistance to empty septic tanks and related activities offered at the time of need through NWSDB.

As an immediate remedial measure, package treatment units capacities varied from 15 m^3/day to 500 m^3/d were delivered by certain donor communities in order to treat the saline water. Those package plants had a facility for standby generators and it was suitable to the areas where electricity was also held up with the bad tsunami effects. However those package plants operations were not user friendly and were associated with high operating unit costs as well. Hence the operation of those plants was gradually curtailed.

The restoration of water quality of surface and ground water sources has become a challenge after tsunami, as to the resources had to come back to the original state naturally. It was difficult to artificially flush out the contaminants and salt. Several INGO's were actively engaged in cleaning of shallow wells at the coastal belt but the immediate rate of success was fairly less.

3.16.3 Donors for tsunami assistance

The GOSL has identified the areas for settlement of those who lost their residences owing to the Tsunami disaster. Some international/ local donors commenced house construction and water supply to theses housing schemes are planned accordingly.

Table 3.7 Donors for Tsunami Assistance

Agency	Currency	Amount pledged (millions)
KfW of Germany	US$	9.5
DANIDA	US$	8.0
JBIC	US$	20.0
JICA	US$	4.5
ADB	US$	10.0
Government of France	Euro	9.9
Government of Finland	Euro	6.0
UNICEF	US$	25.0
IFRC	US$	30.0
USAID	US$	2.0
World Vision	US$	1.75

Source: Annual report 2005 NWSDB

Table 3.8 Progress of restoration of water supply schemes affected by Tsunami

	Estimated Cost in Rs million	Progress
Improvements to Ranna WSS	91.8	11.61%
Improvements to Hambantota WSS	182	5.77%
Improvements to Wakamulla WSS	71.66	17.88%
Improvements to Ranna Distribution system	41.13	37.40%

Source: Fernando, 2008 (Based on the records of RSC/Matara, NWSDB)
Note: In Walawe basin as at 30.04.2007

Apart from several local agencies which extended support to provide water supply to the areas affected by Tsunami the following foreign agencies have pledged support. DANIDA & ADB were the main donors who assisted the restoration of water supply systems in the Hambantota district. In addition to the tsunami assistance, the ADB is assisting to augment the Hambantota water supply scheme to cater the current development trends at the urban area. At the preparation of this report the designs of such augmentations are completed and the contractors are being selected.

3.16.4 Current progress of restoration of WSS

Current progress of the restoration of water supply schemes affected by Tsunami is given in the table 3.8. It is clear that the progress is well below the acceptable levels.

3.16.5 Tsunami impact on coastal ecosystems

The tsunami has adversely affected the natural environment in the costal belt of the Sri Lanka, by destroying vegetation, changing landform, creating large amount of debris releasing pollutant and contamination soil and fresh water supplies. Unique costal ecosystem of wetlands, such as mangroves, salt marshes, sea grass beds, estuaries and coral reefs, were badly affected. Prominent are also the sand dune ecosystems.

The environmental damages caused by the tsunami are moderate at some places, but severe at others. Environmental degradation of the coastal zone therefore, poses a major hazard. Extensive damage has occurred marine algae and coral reefs, especially through sand mud and debris depositions. Sand dune vegetation, which is vital in the formation of sand dunes and harbors important fauna has been uprooted or destroyed completely at many places. Extensive damage to mangroves, which perform a multitude of functions, is reported at river mouths and estuaries.

Wetland ecosystems found in Walawe basin can be categorized as follows (IUCN, 2003),

1) Off-shore and marine systems
2) Coastal systems
   - Rocky seashores,
   - Sea beaches eg. Sandy beaches along coast
   - Mangroves swamps eg Kalametiya and Lunama
   - Costal brackish lagoons eg Rekawa lagoon
   - Saltpans eg. Karagan Lewaya, Mahalewaya

Threats resulted by tsunami to wetland sites in costal ecosystem reported in Hambantota district (de Silva 2007), are follows

- Lagoon fishery and marine fishery were affected by water quality changes.

- Possible effects on avifauna through water quality and flora were:

  - Destruction of large portion of mangrove vegetation at lagoon mouths (inter–tidal areas) and costal vegetation
  - Turtle landing sites were affected
  - Spreading of invasive species throughout the area
  - Damage to sand dunes
  - Sand deposition in the lagoon
  - Sea water intrusion through widening of lagoon mouths (Weerasinhe et al, 2008)

Tsunami damage in Rekawa, Kalametiya and Lunama lagoons

These lagoons represent a cluster of great ecological significance and were subjected to considerable damage from the tsunami. Landforms were highly damaged; most lagoon mouths have undergone changes. Lagoon fishery at Rekawa was affected, as was lagoon and marine fishery at Kalametiya. Possible effects on avifauna through water quality and flora were observed at Kalametiya Bird Sanctuary. Large portions of valuable mangrove vegetation at lagoon mouths (inter-tidal areas) and coastal vegetation were destroyed. Lagoon hydrology was altered. The popular turtle landing-sites at Rekawa were also affected, as were human habitations and inland vegetation. At many sites the spread of invasive weeds to new areas was observed.

The most important affected vegetation included the mangroves which consisted of the following species (abundance level before the tsunami: + common, ++ very common): Aegiccras cornicitlatum (+), Aviccnnia marina (++), Avicennia officinnlis (++), Bruguiem gytnnorrhiza (+), Bruguiera sexangula (+), Ceriops tagnl (+), Heritiern littoralis (+), Lumnitzera racemosa (++), Ni/pa fruticans (+), Rhizophora mucronata (+), and 14 mangrove associates. The investigation indicated severe damage to most of the species with the damage level ranging between 10-50 per cent (Weerasinhe et al 2008).

Mangroves form an important plant community at inter-tidal areas of rivers, streams and lagoons where they are known to play the roles such as provision of major habitat for fish and shrimps to complete their life cycles. Thus they form an important component in lagoon fishing minimizing bank erosion. Mangroves act as a protective barrier against erosive winds. Also provides firewood to the community.

The Lunama wetland and inland landscape were sheltered from the tsunami by the sand dune habitat. However, the tsunami waves were funneled into the Kalametiya lagoon through the manmade opening to the sea, causing the destruction of around 5% of the Sonneratia caseolaris dominated mangrove stand around the lagoon. The increase in salinity in the lagoon had a positive impact in destroying a high proportion of the invasive alien water hyacinth (Eichhornia crassipes) and cattle-reed (Typha angusifolia). Approximately 5 ha of grasslands salt mash vegetation has been destroyed, covered with sand and sludge transported inland by the tsunami waves.

3.17 Socio-environmental issues resulting from irrigation and hydropower development

One of the major social issues resulting from water resources development is the resettlement of people. In the recent times, such resettlement in Sri Lanka is guided by the Involuntary Resettlement Policy. Resettlement issues were experienced in the Samanalawewa project and Walawe LB development project.

Before impounding the Samanalawewa reservoir in May 1991, resettlement of residents was planned to be completed, with options of provision of alternative land or compensation. So far, no significant grievances toward resettlement were raised. Public facilities in newly settled areas have been constructed.

392 households were targeted for resettlement. In addition, 22 households called for compensation. Although compensation was paid one or two cases occasionally come-up through the Divisional Secretary of the area. CEB is investigating the claims as applicable. All households agreed to the resettlement plan and sufficient lands were acquired for resettlement.

Compensation for lost assets was almost completed: however the payment is partially delayed for 49 families, which would be completed by 2009. This delay was mainly caused due to late identification (Somatilake, 2008).

3.17.1 Environmental impacts of hydropower development

Since the Samanalawewa project was designed to commutate the impoundment into another river and generate the power, it may cause the scarcity of water for domestic use or irrigation. This project was designed to discharge the necessary water to downstream through the tailrace and operation manual has been prepared taking this issue in to account. The follow-up project titled "Samanalawewa Second Stage with Diyawini Oya Reservoir" has been given up by CEB following the recommendations of various feasibility reports and hence the effect on downstream is well within the manageable frame of CEB.

Samanalawewa Power Station has been certified for Environment Management system (ISO 14001). It also follows the occupational safety and health standards and has been won the national safety awards too. According to the managers of Samanalawewa project, the environmental impacts of Samanalawewa project have been addressed (Somatilake, 2008).

The pressures created by different water uses and social, economic and technological drivers shape the state of the resource. The climate changes and their impact on water resources define the future state, and they play a crucial role in framing strategies for use and management of the resource.

4.1 Rainfall of the Basin

4.1.1 Annual precipitation and run-off

Long term temperature analysis indicates an increase in air temperature in the country, especially during the period 1961 to 1990. The rate of increase of mean air temperature in Sri Lanka during this period is of the order of 0.016 ºC per annum. Rainfall shows a reducing trend as well, and the reduction is more noticeable during the north-east monsoon and second inter-monsoon period (Imbulana et al, 2006). These two periods bring the bulk of the rainfall to the dry zone of Sri Lanka. Alternating dry and wet periods are noticed from 1880 until about 1970 with a significant reduction of rain thereafter (Ratnayake and Herath, 2008).

Following the WWAP research during the period of 2005-2006 under the subject of climate change, further activities were carried out addressing the same issues from 2007. The results show that rainfall had reduced in most of the rainfall stations in the Walawe river basin.

The field observations and farmer consultations are compatible with these research findings. A survey carried out by IWMI shows that farmers in the upper Walawe basin have experienced a decline in rainfall and water availability in the recent years (Somartne et al, 2005). Another survey showed that the people in the same river basin experienced a decrease of predictability of rainfall in the recent times (Molle et al 2003). In the upper Walawe basin, storage reservoirs are scarce and water is made available mostly by diversions structures. As such, decline of rainfall and surface water availability will have heavier impact on the water users in the upper basin, compared to the lower basin which is equipped with several large reservoirs. The rice cultivation seasons are designed so that cultivation starts during rainy periods and harvesting is carried out in the dry periods. The unpredictability of rainfall in the recent times has resulted in disruption of the cultivation and hence the production losses.

Ratnayake and Herath (2008) estimated that in some rainfall stations of Walawe basin, the reduction of rainfall is about 18mm per annum. On average, the annual change in the rainfall in the basin is about 0.36%. In some stations this is as high as 0.85%. Ratnayake and Herath (2008) concluded that within the last 50 years there had been an 18 ~ 42% reduction in total rainfall in the basin.

However, not all the research is so conclusive or the results of different research converge to similar conclusions. Researchers point out that though there are signs of rainfall reduction, the trends are not statistically significant (Punyawardena, 2008). The reductions in the rainfall in some stations could be due to cyclic changes of rainfall; that is, due to incidence of alternating wet and dry periods. In addition there are localized changes that are different from the general situation, which are difficult to explain. It is argued that longer time periods of rainfall and other parameters are required to identify such trends. The discontinuity and inaccuracy of data further compounds the researcher's dilemma.

The mean annual rainfall of the study area is 1768 mm; it has a bi-modal distribution along the time scale and the spatial distribution is uneven. Precipitation comes from the two seasons each year, the northeast monsoon from December to February and the southwest monsoon from May to September, with inter-monsoonal rains in some other months.

The annual rainfall pattern defines the two cultivation seasons, namely maha (wet season lasting from October to March), and Yala (dry season lasting from April to September). Maha rainfall is about 1.5 times that of the Yala season. The upper parts of the Walawe basin receive rain during both monsoon seasons (Jayatillake, 2002). However the middle and lower potions of Walawe receive the major proportion of the annual rainfall during the maha season. The spatial distribution of rainfall is shown in Figure 4.1.

The Ruhuna basins study for WWDR1

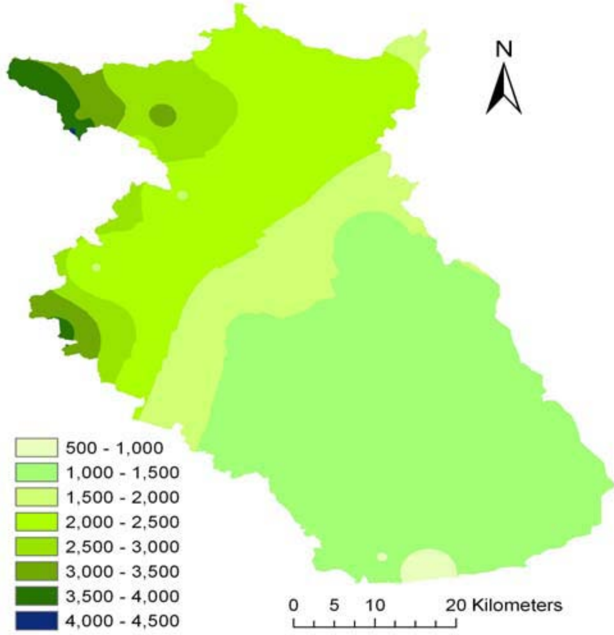


Figure 4.1. Spatial distribution of rainfall (mm)

analyzed the long-term trends of rainfall in two selected stations of upper Walawe from 1901 to 2000. The analysis did not reveal a definite pattern; one station (Holmwood) showed a decreasing trend, while the other (Campion) seemed to be static. The recent analysis using a larger number of rainfall stations indicates that the rainfall in the most areas of the basin is declining. The trends have become more significant since mid 1980s. The inflow at Samanalawewa shows a decreasing trend as well and on the average 1.7 million m^3/year (i.e. 0.3% of average annual inflow).

Figure 4.2 shows the rainfall trends of the rain gauging stations within the basin, based on the records of rain from 1950 to 2002. Ratnayake and Herath (2008) observed that the rainfall at almost all gauges in Sri Lanka have decreased over the time. The maximum reduction is seen as about 18 mm per annum while most stations show a reduction in the range of 5 mm per annum. The stations showing a reduction less than 5 mm per annum are not statistically significant; meaning the rainfall variation of the stations is large. The average rainfall ranges from 4374 mm to 997 mm per annum.

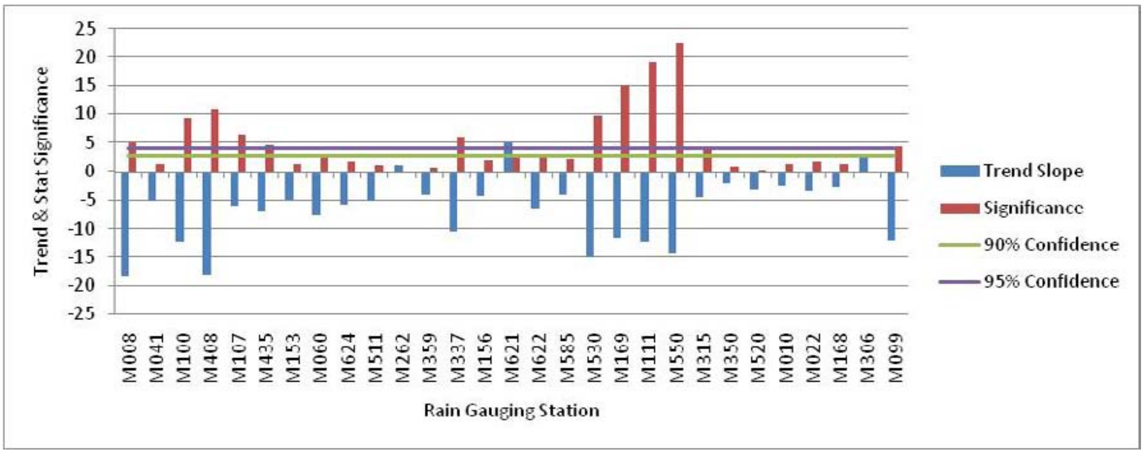


Figure 4.2: Annual change in rainfall in Walawe Basin from 1950 to 2002
Source: Ratnayake and Herath (2008)

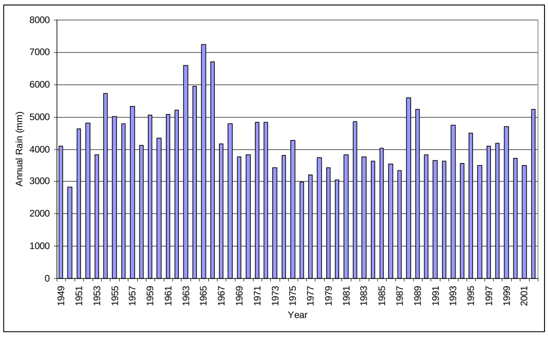


Figure 4.3. Annual rain at Alupolla Group

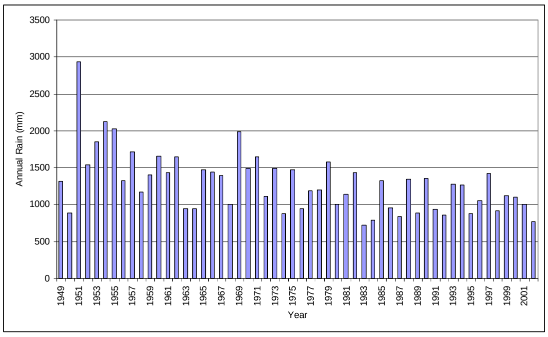


Figure 4.4. Annual rain at Suriyawewa

The above analysis is based on a linear trend analysis and such an analysis may not provide a clear explanation of the rainfall pattern changes, if the trends have been stabilized. Ratnayake and Herath (2008) conclude that in the case of Alupola, a change has occurred and then stabilized. However, in the case of Suriyawewa, the change is still continuing. These trends can be seen in the Figure 4.3 and Figure 4.4.

The average length of dry spells may not be giving a representative idea of the catchments as the counting has included single day events of no rain as dry spells. Among the other characteristics a drastic change is seen in the amount of rain within a spell. About three stations, Alupola, Balangoda and Suriyawewa, show changes exceeding 15% reduction implying a reduction in the rain per day in the basin. In most parts of the country the daily rain intensity has significantly increased except in the southwest and southeast areas (Ratnayake and Herath, 2008).

4.1.2 Changes in rainfall patterns and likely impacts

In the following section, two experiments carried out by researchers to identify the changes to the rainfall pattern, and the likely impact of such changes on the extreme events.

Ratnayake and Herath (2008) carried out a rainfall trend analysis in order to highlight the changes in the extreme events, using daily data. Seven stations were selected for this analysis. This selection was made based on the least amount of missing data and the distribution over the catchments. The missing data were filled using the standard methods based on observed values of the nearby stations. In this analysis various average characteristics before and after 1978 were compared. This year was selected as the breaking year because previous studies the same researchers have shown that a major trend variation had occurred in Sri Lanka during late seventies. The characteristics considered were the change of rain quantity with time, change of the consecutive number of rainy days, change of the consecutive number of dry days, change of amount of rain received in a spell of consecutive rainy days and the change of amount of average daily rain received during a spell of consecutive rainy days.

Out of the seven stations considered in the analysis, three were located in the upper Walawe catchments namely Alupola, Balangoda and Detanagala, three in the mid catchments, namely Nagarak, Suriyawewa and Embilipitiya, and one, namely Hambantota is located close to the sea in the lower catchments.

According to Ratnayake and Herath (2008), as given in Table 4.1 all the stations show similar changes in all selected characteristics except the Nagarak station where the rainfall during the rainy spells has increased while it has decreased in the other stations. In all stations the average rainfall after 1978 has decreased compared to the rain prior to 1978. Maximum decrease of 22.8% is seen in Suriyawewa data while the minimum decrease of 8.1% is seen in average daily rainfall at Nagarak. Here, the average length of the wet periods has decreased while the length of dry periods has increased. The maximum change in the wet length is about 16.8% reduction at Alupola while the dry length has increased by 21.9% at Nagarak.

It can be noted that at some other stations the change in wet length and corresponding change in the dry length is not reciprocal. This means that the number of spells within a year also has changed in addition to their lengths. However, the average length of dry spells may not be giving a representative idea of the catchments as the counting has included even a single day events as dry spells. Within the other characteristics a drastic change is seen in the amount of rain within a rain spell. Three stations, Alupola, Balangoda and Suriyawewa, show changes exceeding 15% reduction. This again may due to the splitting of the rain spells as well as reduction in rain as seen in the reduction in the rain per day.

This is in the contrary to the behavior of rain elsewhere in the country where the daily rain intensity has significantly increased.

Table 4.1 Rainfall trend parameters at the selected gauging stations

		Alupolla	Balangoda	Detanagala	Nagarak	Suriyawewa	Embilipitiya	Hambantota
Average rain per day (mm/day)	Before 1978	12.83	6.77	8.09	6.63	3.62	3.65	2.98
	After 1978	11.20	6.03	6.94	6.10	2.79	3.33	2.62
Average wet length (days)	Before 1978	5.08	3.30	3.52	3.00	2.10	2.20	2.29
	After 1978	4.22	2.91	3.24	2.82	2.10	2.11	2.17
Average dry length (days)	Before 1978	3.09	4.82	3.85	4.38	6.01	5.45	4.85
	After 1978	3.14	4.81	4.19	5.33	6.81	5.96	5.18
Average rain per spell (mm)	Before 1978	102.23	55.00	59.71	48.99	29.31	28.04	21.45
	After 1978	82.63	46.49	51.54	49.87	24.68	26.80	19.27
Average daily rain in a spell (mm/day)	Before 1978	20.23	16.61	16.85	16.32	13.95	12.71	9.36
	After 1978	19.57	15.97	15.90	17.62	11.66	12.64	8.89

Source: Ratnayake and Herath, 2008

Both wet spell length and average rain in a rainy day has decreased in the stations located in the upstream area, Alupola, Balangoda, Detanagala and Nagarak. Also they indicate the rain after 1978 has decreased compared to the period before 1978. It is clear that an increase in the drought lengths, reduction in rainfall per spell and per rainy day is occurring. Such changes directly affect the groundwater recharge and surface flows also.

Punyawardena (2008) also carried out an analysis on different aspect of the rainfall namely the variability, comparing 1962 - 1981 and 1982-2001 periods in Walawe basin using an arbitrary splitting point of the series. Four rainfall stations were chosen for the analysis, two from upstream and two from downstream. The results of this analysis, however, show no common change in variability of annual rainfall at the four stations.

Interpreting the results of Table 4.2 it can be observed that, the First Inter Monsoon (FIM) rains (March and April) which are convectional in nature that come as short duration, high intensity thundershowers, have shown an increasing variability in one upstream station (Detanagala) and reduced variability in one downstream station (Ambalantota). There is no change in the rainfall of other two stations. The variability of South West Monsoon (SWM) rains that last from May to September, has remained almost constant for the four gauges. Similarly the Second Inter Monsoon (SIM) in October and November also shows no variability. The North East Monsoon (NEM) from November to February showed an increase in the variability in the upstream, thus reducing predictability of rainfall.
In addition to the annual rainfall, its seasonal distribution also influences the state of the resource. The Figure 4.5 describes the seasonal distribution of rainfall.

Figure 4.5 shows the likely impact areas of these changes. Though the SWM and SIM periods bring the bulk of rainfall to the country, the NEM and SIM bring the major part of the rain to dry zone. As such, the reduced rainfall amounts and increased variability in those two seasons will have adverse impacts on surface flow diversions. The storage reservoirs, however, will cushion the impact.

The two studies described above were carried out for the WWAP. Apparently, the two studies do not converge to similar conclusions. Though Ratnayake and Herath (2008) identified a change in rainfall characteristics, the scientific reasoning for such a change has not been made. Overall, there appears a reduction of rainfall, but whether this is a statistically significant trend is not clearly defined.

Undoubtedly, reduced predictability of rainfall will affect the cultivations that depend on diverted water, especially in SIM and NEM periods, as this is the (Maha) season in which framers prefer to cultivate paddy. Similarly, reduction in rain can adversely affect mostly the rain fed cultivations and irrigation of diversion schemes which are ample in the upstream area. Upper basin could experience change in the surface flows if the rainfall changes in such a manner. As majority of the population in the country depends on agriculture the observed changes delivers a major blow to their livelihood.

Table 4.2 Variability of seasonal rains in the Walawe basin during the periods 1962-1981

Station	Coefficient of Variation of rainfall% (1) 1962-81 and (2) 1982-2001							
	First Inter Monsoon		South West Monsoon		Second Inter Monsoon		North East Monsoon	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Alupola	35.6	35.2	38.4	28.1	28.6	26.2	31.3	47.2
Detanagala	22.2	43.8	40.1	29.1	34.2	39.7	32.6	55.2
Hambantota	57.1	56.0	41.1	33.5	44.6	41.0	66.4	52.7
Ambalantota	76.1	45.7	49.5	57.9	49.5	57.9	77.0	71.6

and 1982-2001

Source: Punyawardena, 2008

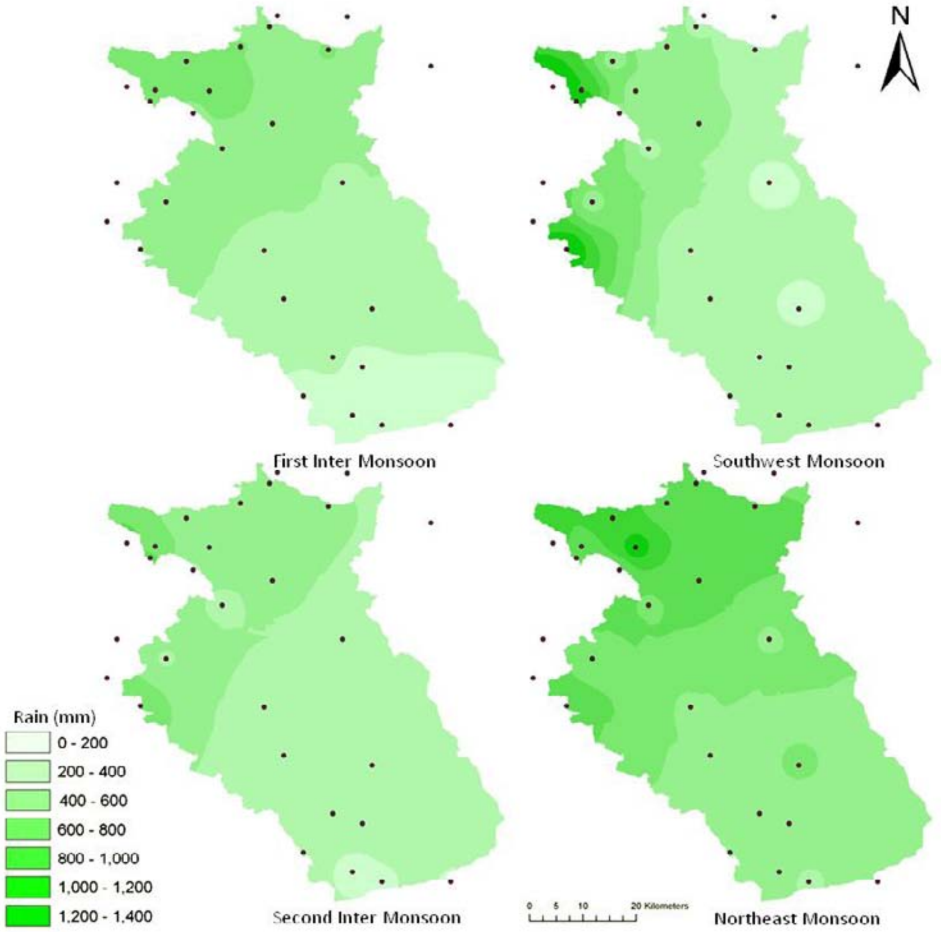


Figure 4.5 Seasonal distribution of rainfall in the study area

Source: Ratnayake and Herath, 2008

Regardless of divergence of research results, the general experience in the basin is that water availability for most of the sectoral uses has reduced. This is supported by surveys carried out with farmers (Molle et al, 2003 and Somaratne

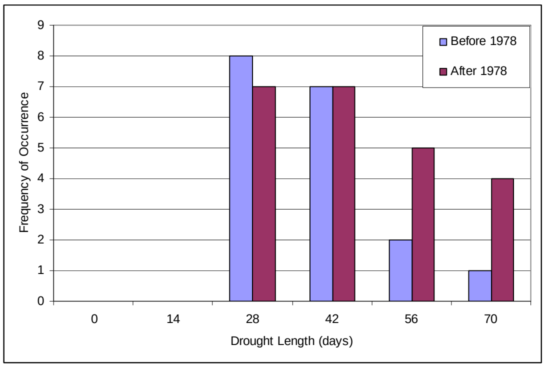


Figure 4.6 Change of frequency of annual drought lengths at Embilipitiya

et al, 2005). Furthermore, it has been observed that rainfall occurrence has become less predictable, especially for farmers. As the cultivation seasons are planned in accordance with rainfall pattern, this causes many hardships. Such a change of rainfall pattern could result in higher water use during the land preparation and greater crop loss during the harvesting periods, which had been observed in many parts of the island.

The fact that scientific research has not clearly explained the ground situation indicates a substantial knowledge gap. On one hand, the gap may be due to unreliability and inconsistency of data. On the other hand, weaknesses in the research design can be observed.

4.1.3 Observed extreme events

The reduction in the rainfall is expected to cause less peak rainfalls in the basin. This is confirmed by the observed peak rain with decreasing trend as given in Table 4.1. However, the peak reduction seen is less than the rate of reduction in the annual rainfall and it is in the range of -0.8 mm to 1.1 mm. In summary, though the rain has significantly reduced in the catchments, the flood threats remain more or less at the same level (Ratnayake and Herath, 2008).

Maximum rate of increase of drought lengths, in Table 4.1, is observed at Suriyawewa station where Ratnayake and Herath (2008) observed the maximum reduction in the average rainfall in a study concerning 7 stations. The rate of increase of the maximum dry lengths is 0.565 days/year which on the average results an increase of the maximum drought periods by an average of 22 days at the end of the considered 40 year period. Table 4.2 shows maximum lengths of droughts of 2-3 months occurred after the late seventies while most of the rainfall peaks were before. Figure 4.7 shows this distribution of the droughts on a time axis. The change of drought lengths with time is clearly evident in Embilipitiya taken as an example (Figure 4.6) which highlights the increase in the frequency of droughts after 1978.

In summary Ratnayake and Herath (2008) observed an increase in the drought lengths, reduction in rainfall per spell and per rainy day. Such changes directly affect the groundwater recharge and surface flows.

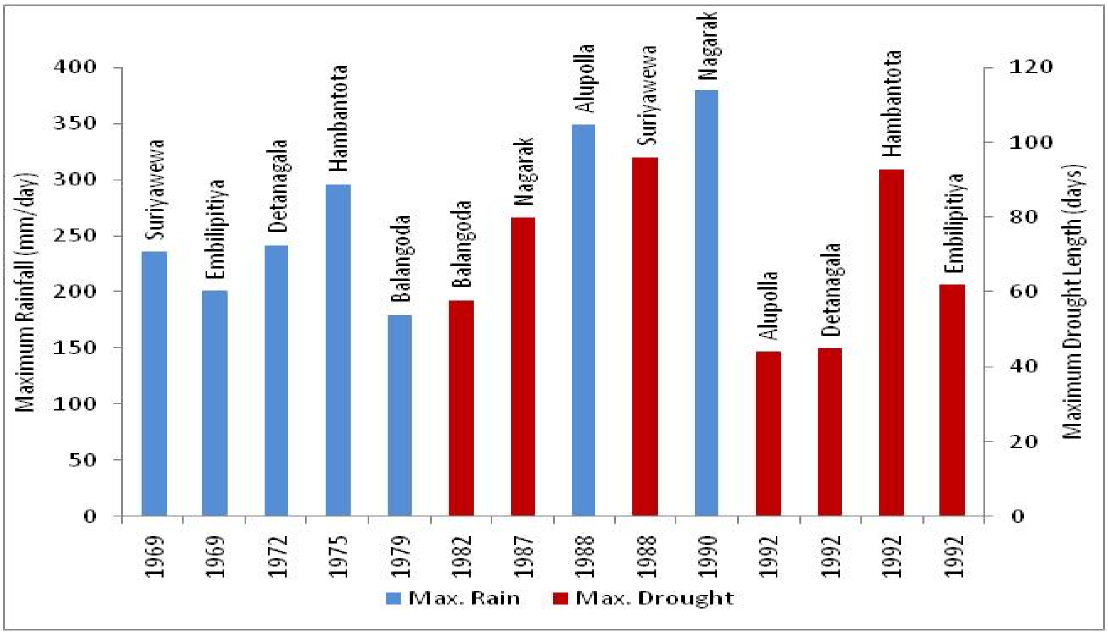


Figure 4.7 Occurrence of maximum rain and longest droughts

Table 4.3 Changes in the extreme events of the Walawe Basin

Station	Change in Maximum rain (mm/year)	Change in Length of Droughts (days/year)
Alupolla	-0.362	0.081
Balangoda	-0.809	-0.004
Detanagala	-0.930	0.146
Nagarak	1.105	0.077
Hambantota	-0.656	0.245
Suriyawewa	0.136	0.565
Embilipitiya	-0.822	0.374

Source: Ratnayake and Herath, 2008

Table 4.4 Maximum rains and maximum lengths of droughts

Station	Maximum Rain (mm/day)	Occurred in	Maximum Length of Drought (days)	Occurred in
Alupolla	350	1988	44	1992
Balangoda	180	1979	58	1982
Detanagala	242.5	1972	45	1992
Nagarak	380	1990	80	1987
Hambantota	296.9	1975	93	1992
Suriyawewa	236.2	1969	96	1988
Embilipitiya	201.9	1969	62	1992

Source: Ratnayake and Herath, 2008

An analysis of the results of the studies carried out by Ratnayake and Herath (2008) along with the study by Punyawardena (2008) can be summarized as follows:

- The annual average ambient temperature in the lower basin shows an increasing trend during the last 50 years. The rate of change is about 0.016^0 C/per year. The increasing trend of annual maximum temperature is more significant, while the change of annual minimum temperature is small in comparison.
- However, in the upper Walawe basin, the change of temperatures is not large in comparison to the lower basin.
- The analysis of rainfall is complex. Sometimes the trends are not easily recognized. Rainfall, like many other weather parameters, does not continuously change. Some stations of the basin show a change for a specific period and then it has stabilized.
- An analysis of the rainfall variability with respect to major rainfall seasons show that variability has increased in the upper Walawe basin during North East Monsoon. However, the variability had either reduced or remained static in the other rainfall seasons.
- One study shows a reduction of rainfall in the range of 18% to 42% in the last 50 years in some parts of the river basin. In other areas, however, the rainfall has stabilized after a gradual reduction. Therefore, a continuous and statistically significant trend of change is difficult to identify
- A detailed analysis of seven stations shows that the average length of wet periods (consecutive days of rainfall) has decreased. The average length of dry periods (consecutive days of rain-less days) has increased. However, the average decrease of the length of wet periods is more than the increase of the length of dry periods. This means the occurrence of alternating wet spells and

dry spell has increased, decreasing the predictability and reliability of rainfall.

- The rainfall intensity has decreased. This is compatible with the results of the studies carried out for WWAP case study in 2006, where it was found that rainfall intensity in the south and south east of the country has decreased.
- Annual rainfall peaks have not changed very much and does not show any definite pattern. However, the lengths of droughts have generally increased.
- The annual runoff at Samanalawewa shows a reduction of about 9% between 1949 and 2002. However, there is no significant change of rainfall/runoff ratios measured at Samanalawewa and Embilipitiya.
- It is apparent that there is a change in water availability for basic needs and livelihoods within the Walawe basin. The consultations of water users confirmed this. However, it is difficult to conclude whether this change is due to a change of the climate or other exogenous factors such as land use changes. Therefore, a more comprehensive analysis using a longer term data is necessary to identify the cause and to draw the strategies to cope up with the changes.
- Rain in upstream – both the wet spell length, average rain in a rainy day has decreased indicating the rain after 1978 has decreased compared to the period before 1978. Such reduction in rain can adversely affect the rain fed cultivations and irrigation of diversion schemes in the basin.

4.2 Trends of runoff through time

Figure 4.2 shows the trends of the rainfall and it is evident that nearly all stations show a decreasing trend. Hence it can be expected that the runoff will have a similar trend. Figure 4.8 shows the time series of monthly discharges to Samanalawewa reservoir. There it can be seen that very often the discharges fall below 20 m^3/s after late seventies. The trend line drawn has a negative slope of 0.011 for the monthly data. The line indicates the discharge has on the average has fallen from about 48.5 m^3/s in 1949 to 40 m^3/s by 2002, a 9% change.

At this point of analysis it would be interesting to know the behavior of the rainfall – runoff ratio. The Figure 4.9 and 4.10 shows the runoff ratios calculated for Samanalawewa Inflows and for Embilipitiya inflows respectively. There was no significant trend in these values indicating that the reduction of the flows is mainly due to the reduction seen in the rainfall. However the slight reduction of the ratio may be due to added water uses in the catchments from newly constructed irrigation schemes and water supply schemes.

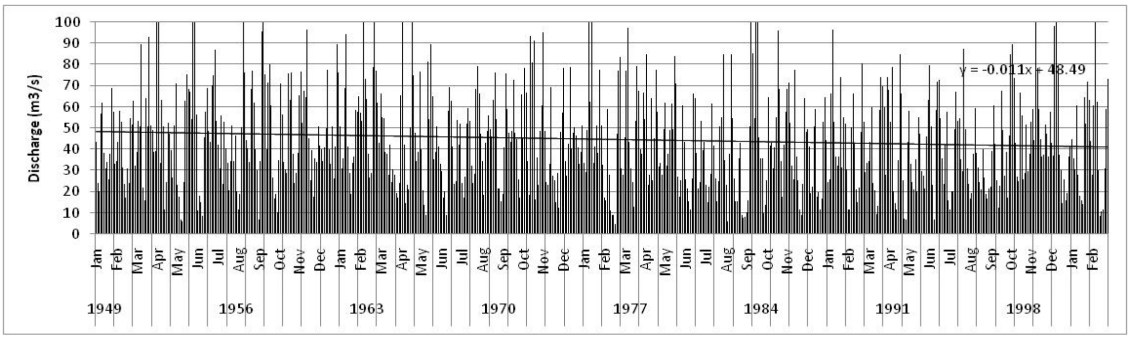


Figure 4.8. Discharge to Samanalawewa Reservoir

Source: Ratnayake and Herath, 2008

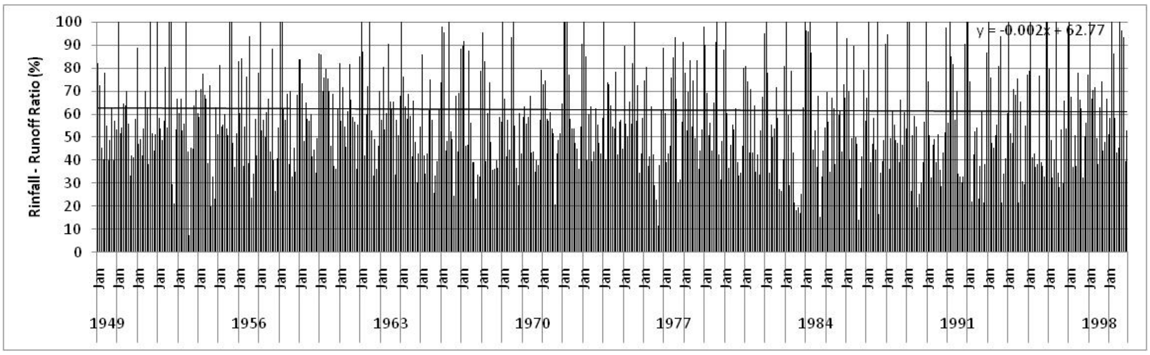


Figure 4.9. Rainfall – Runoff ratio at Samanalawewa

Source: Ratnayake and Herath, 2008

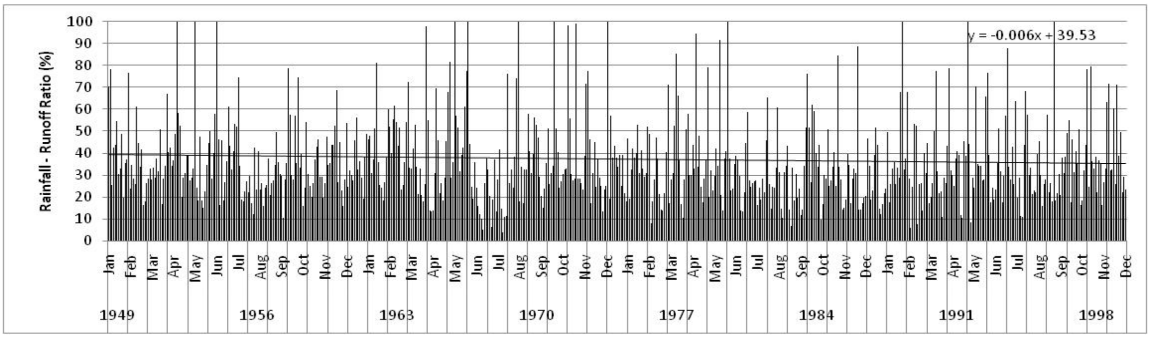


Figure 4.10. Rainfall – Runoff ratio at Embilipitiya

Source: Ratnayake and Herath, 2008

4.2.1 Surface water: current state

The annual flow in Walawe river is about 1550 million m3. The flow peaks in April and in November months and the discharge is low in August. Rainfall-runoff coefficient is high in the upper reach up to Samanala Wewa reservoir. Based on the Irrigation Department records, runoff/rainfall ratio is between 21-27% for the entire basin. However, the ratio varies for different reaches, with higher values being associated with upper catchment. The discharge to sea is gradually reduced due to several large scale irrigation and water resources development projects carried out since 1950s.

Surface water quality

Research study in the Suriyawewa area described in Chapter 3 indicates the presence of parasites causing diarrhea, in irrigation water (Shortt et al, 2006). The water quality in irrigation canals was found to be not suitable for bathing. Surface water quality is a concern in many other irrigation facilities also.

4.2.2 Impact of climate change on diversions

Diversions play a major role in water resources management in the upper Walawe basin. It can be seen that there is a high incidence of Anicuts in main Walawe basin. Most of these anicuts are in the upper region, in Badulla and Ratnapura districts.

The high incidence of anicuts in the upper basin indicates well distributed rainfall and runoff in the streams during their construction period. There are about 20,000 farmer families dependent on these irrigation systems. The changes to rainfall and runoff pattern are having a pronounced impact on the water availability and livelihoods of the farmers.

Figure 1.2 shows that diversion structures are the main method of water resources development for livelihoods in the upper catchment. As these diversion weirs have negligible storage, they depend on year-round stream flow. Any reduction in rainfall will severely affect the livelihoods and drinking water supply of the upper catchment population, though the area is not considered as the dry zone.

Surveys among farmers in small tank cascade systems in Walawe and Kirindi Oya basins indicate that reduced water availability is now a common experience. Farmers' opinion is based on water shortages for the irrigated crops and water springs that provide drinking water running dry (Molle et al, 2003). This could be due to reduced volume of rainfall as well as the changes to rainfall pattern as described in the preceding section.

4.2.3 Impact of changing hydrology on dam safety and power generation

Due to the leakage through the Samanalawewa dam, the reservoir water level was controlled from 1993 to 1996. Based on the recommendations of the international expert panel, Samanalawewa reservoir and power plant are in fully unrestricted operation since 1997. We can judge that the power station has been performing well: 284.8GWh in 2000, 210.4GWh in 2001, 185.5GWh in 2002, 318.3GWh in 2003, 233.6GWh in 2004, 240GWh in 2005, 291GWh in 2006 and 223GWh in 2007. The reasons the generated power of the station not reached the target are the changes of inflows, releases for irrigation and geotechnical problems.

Except in the years 1995 & 1999, since 1993 the hydroelectric generation in all power plants in the CEB system has been below average (Somatilake, 2008). However the hydropower stations have operated satisfactorily, although the original goals in energy could not be achieved. Main reason was the reduced inflow, and the increased demand for water by downstream irrigation.

4.3 Groundwater resources

Considering the hydro-geology of the basin the groundwater yielding aquifers can be divided in to two distinct groups. The first is the shallow regolith aquifers, which overlays the basement rock. The village tanks contribute substantially to recharge these aquifers. The shallow aquifers slopes gradually towards the southern coast, and therefore, it continuously drains to the sea under a positive hydraulic gradient. The well-distributed network of streams and river encourage the rapid interchange between river and aquifers.

The other is the deeper fractured aquifer which is associated with the fractured basement rock. It is mainly composed of charnockitic gneisses and meta-sediments. Generally the entire Walawe catchment shows regional structural trends in a north to northwest and south to southeast, and northwest and southeast directions. Major shear zones run either sub parallel or oblique to the regional strike; dissect the whole catchment into several blocks. Among the brittle structures, two prominent joint systems developed in NW-SE and E-W orientations are significant. The groundwater potential of this aquifer is mainly controlled by the associated geo-structural features of the study area.

The wells located in Vijayan series rocks yield more water than the Highland series rocks. This is due to the high fracture density associated with the former rock type. Reported maximum yield (1200 l/min) belongs to the Vijayan series.

Therefore, the deep fractured aquifer on the Vijayan series rock types gives more groundwater potential.

Groundwater prospects

The pipe water coverage in basin is very limited and it covers only the main townships. As the majority belongs to rural population they rely on ground water and some on the irrigation water supplies. As stated before the regolith aquifer does not support high yield wells. Therefore, it is difficult to base watersupply schemes on the ground water. This is a constraint to supply the scattered rural population with teated or purified water.

4.3.1 Groundwater Quality issues in Walawe Basin

Water quality data obtained from the WRB, NWSDB and from database of comprehensive groundwater study on Hambantota and Moneragala District (JICA-2003) were analyzed to study the groundwater chemistry of the area. These data consist with the records of pH, EC, HCO3-2 F-, SO-24, Cl-, ,Ca+2,Mg+2,Na+,K+,Fe+2,Total Dissolve Solid (TDS) and Total hardness. (Senevirathne 2008)

To assure the quality of data reliability check was conducted to provide insight into the reliability of chemical analysis. The data were checked using standard methods and the percentage of samples that pass the attention value in each test are given in Table 4.5 and most of the samples did not fall into the category of satisfactory analysis. The comments are given in the same table.

Highly uneven spatial distribution of the fluoride can be observed over the catchment. The fluoride concentration is fairly low in the western and northwestern part of the basin while it exceeds the maximum permissible level (1.5 mg/l) in the Moneragala District (Hambegamuwa) and some areas in Hambantota District. High fluoride concentration has resulted in dental fluorosis among the school children.

Monitoring studies revealed that the fluoride concentration of deep aquifer is higher than the shallow regolith aquifer. That is due to the dissolved materials from rocks heavily influence the fluoride content. The concentration of fluoride in shallow aquifer is highly fluctuating with the rainfall, while the deep aquifer is not affected in the same manner.

Table 4.5 Reliability Check of Water Quality Data in Walawe Basin

Test	Attention Value	% of Samples satisfied	Comments
Balance (C-A)/(C+A)*100	<5%	12	The solution must be electrically neutral or sum of cations = sum of anions.
TDS Entered/Conductivity	0.55 < x < 0.75	41	There is a linear relation between TDS and conductivity within a range of 0.55 to 0.75.
$K^+/[Na^+ + K^+]$ $meql^{-1}$	<20%	61	Na >>K
$Mg^{++}/[Ca^{+2} + Mg^{+2}]$ meq/l	<40%	13	Ca > Mg, unless provided by the dissolution of dolomite.
$Ca^{+2}/[Ca^{+2}+SO4^{-2})$	<50%	36	Most SO4 concentration can be attributed to the dissolution of gypsum. Therefore the Ca/SO4 ratio must be 1:1 or lower, if some Ca is also provided by the dissolution of carbonate.
$Na^+/(Na^+ + Cl^-)$	>50%	66	Chloride is mainly provided by the dissolution of Halite (NaCl). Therefore the ratio Na/Cl is 1 or higher, if some Sodium is added to the solution by the solution of silicates or by ion exchange.

4. STATE OF THE RESOURCE

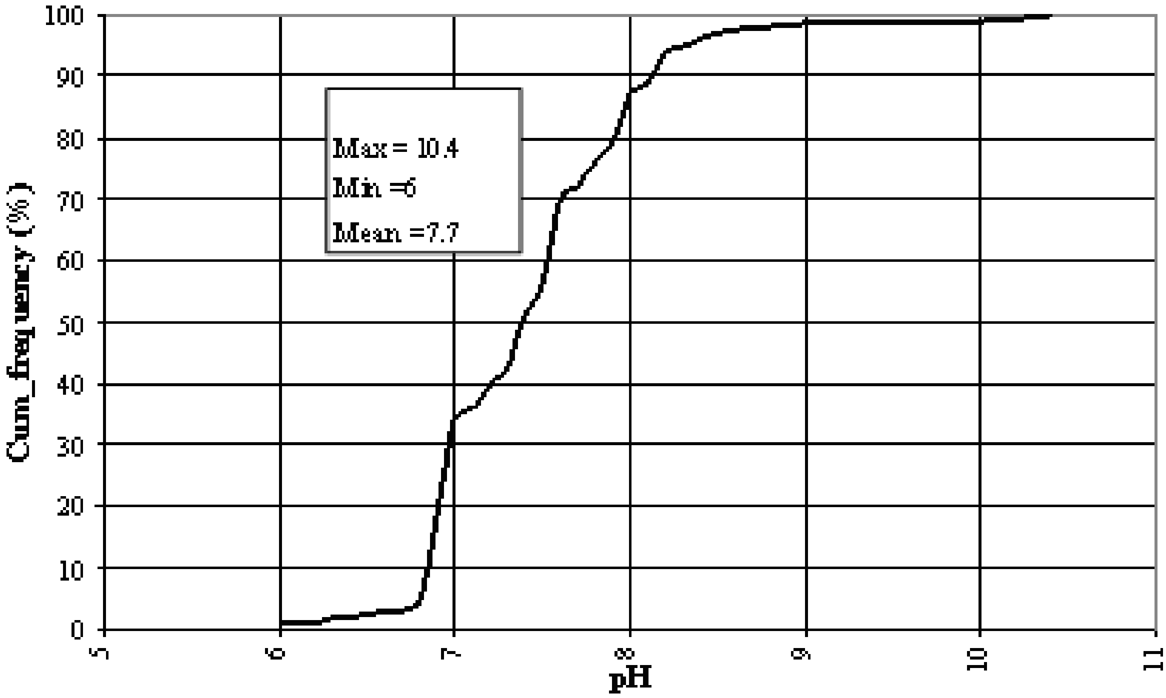


Figure 4.11. Statistical Distribution of pH

Source: Seneviratne, 2008

Table 4.6 Electrical Conductivity Groups

Electrical Conductivity ($uscm^{-1}$)	Group
>3500	High
1500-3500	Moderate
<1500	Fair

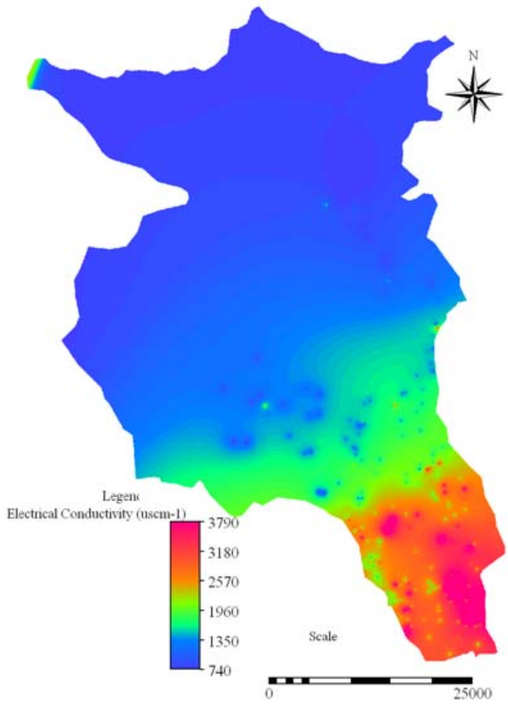


Figure 4.12. Spatial Distribution of Electrical Conductivity

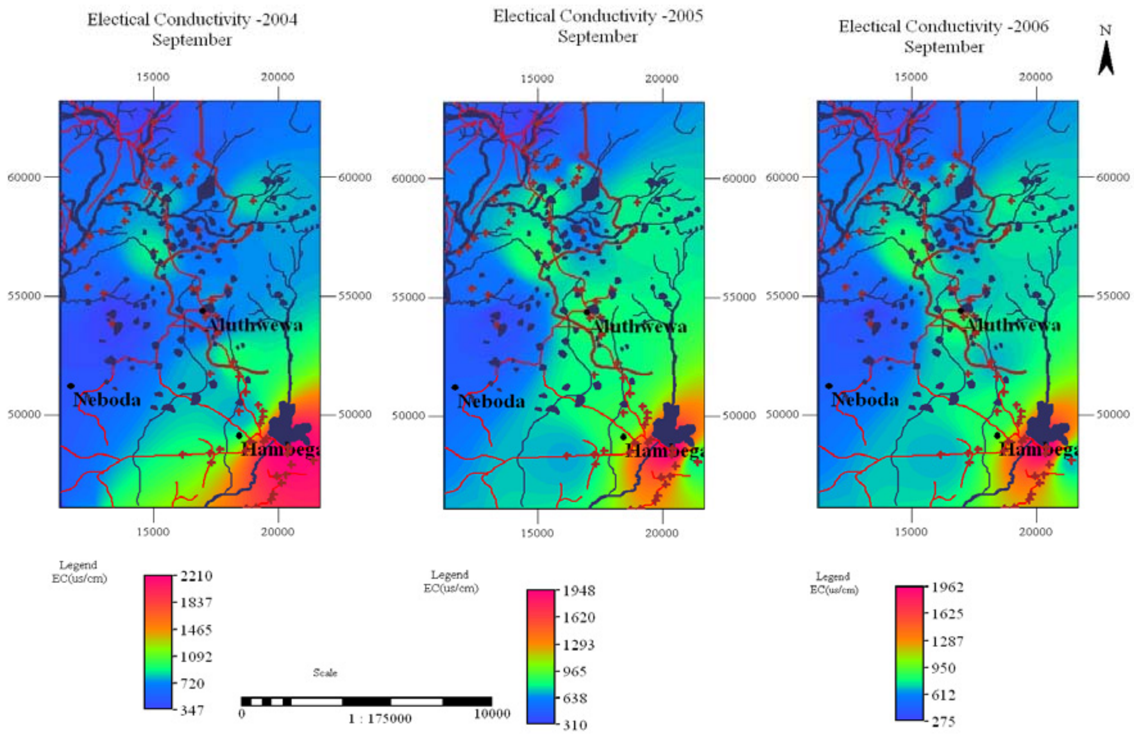


Figure 4.13 Spatial Distribution of Electrical Conductivity on Month of September in Years 2004, 2005, 2006

Source: Seneviratne, 2008

Ground water quality of the basin is determined by both natural processes such as chemical composition of infiltrating or recharging water; texture, hydraulic properties, and inorganic compositions of the aquifer and human activities. Groundwater hydro chemical facies of the basin belongs to mainly the Ca Mg type and the water quality is changed as the water passes through different geologic formations or different subsurface conditions (Seneviratne, 2007).

The measure of "acidity" in groundwater is pH and its distribution reflects the mineralogy of the area. Statistical distribution of pH in the study area is shown in Figure 4.11. The reported maximum pH of the area is 10.4 and the minimum is 6.0.

Since the EC is the primary indicator of the water quality, spatial distribution of the EC (Figure 4.11) was analyzed using the standard EC level of WHO standards for drinking water, and tabulated in Table 4.6. EC concentration is considerably high in the lower part of the basin due to the saline intrusions.

The groundwater quality improvement was seen due to the surface water diversion. Figure 4.12 depicts the spatial distribution of electrical conductivity on month of September in Years 2004, 2005, 2006 and reveled the areas with high electrical conductivity were reducing with time due to the presence of irrigated water.

Although EC does not give specific information about the chemical species present in water, it gives a measure of Total Dissolved Solid (TDS), which is an acceptable indicator for water quality. The physical and chemical properties of water highly depend on the TDS content. TDS has a fairly good correlation (R^2=0.83) with the EC of the area (Figure 4.15).When the TDS content of water exceeds 1000 mgl^{-1}, it is not recommended for drinking (WHO standard). Table 4.7 shows the TDS of water; degree of salinity and the percentage of samples which belongs to each group and the Figure 4.14 illustrate the statistical distribution of TDS of the study area.

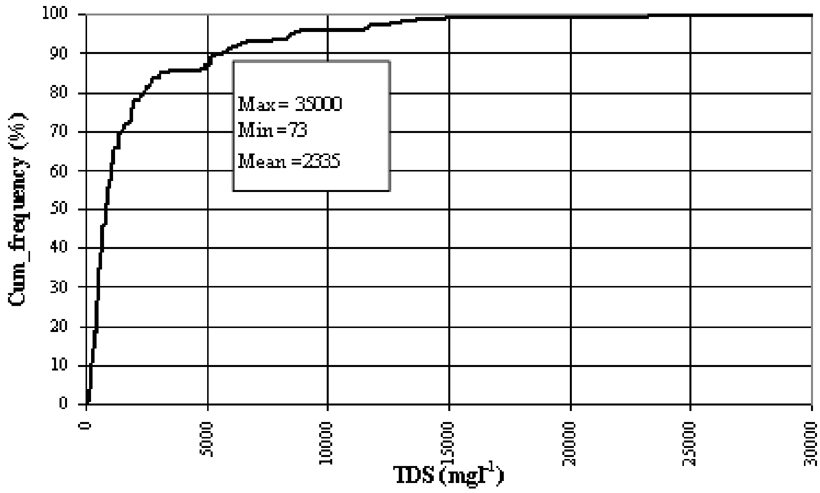


Figure 4.14 Statistical Distributions of TDS

Table 4.7 Salinity Groups

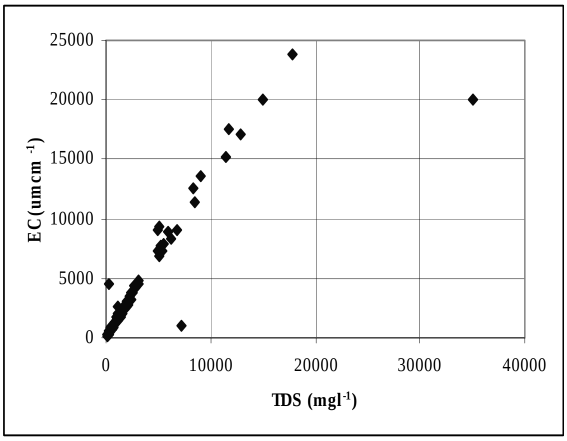
TDS (mg/l)	Degree of Salinity	Number of samples	% of samples
<1000	Fresh water	177	62
1000-3000	Slightly saline	65	20
3000-10000	Moderately saline	27	14
10000-35000	Very saline	08	4
>35000	Brine	-	-

Source: Seneviratne, 2008

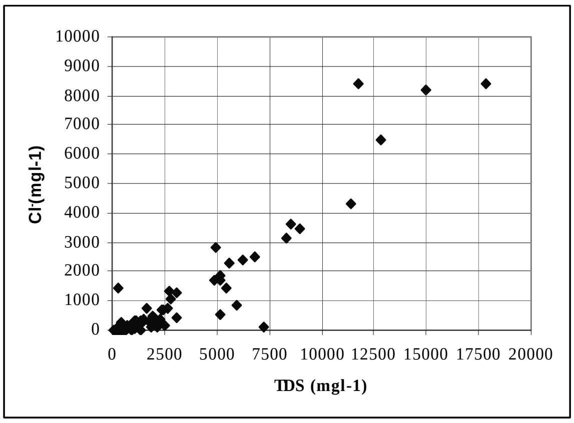
The most abundant and commonly analyzed cations and anions are Ca^{+2}, Mg^{+2}, Na^{+}, F^{-}, Cl^{-}, HCO_3^{-2}, SO_4^{-2}. Statistics of major anions and cations of the analyzed samples are given in Table 4.8. In addition to these major anions and cations Fluoride concentration of groundwater is also significantly high.

Correlations of ionic constituents such as chloride, bicarbonates and sulphate with the TDS of the area were shown in Figure 4.15 (a), (b), (c) and (d).

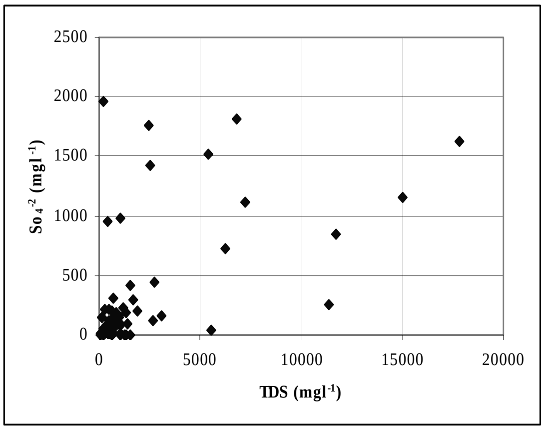
The maximum desirable level for fluoride is 0.6mg/l while the maximum permissible level is 1.5 mg/l (WHO Standard, 2004). Spatial distribution of Fluoride concentration of the deep aquifer in the area is illustrated in Figure 4.16 and it demarcated the fluoride concentration is considerably higher in upper part of the basin close to Hambegamuwa and Aluthwewa area.



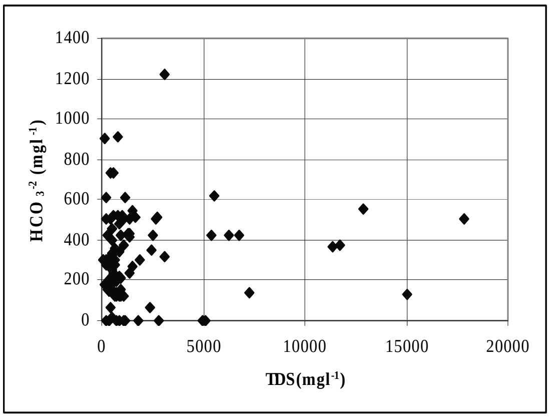
(a) EC



(b) Cl^-



(c) SO_4^{-2}



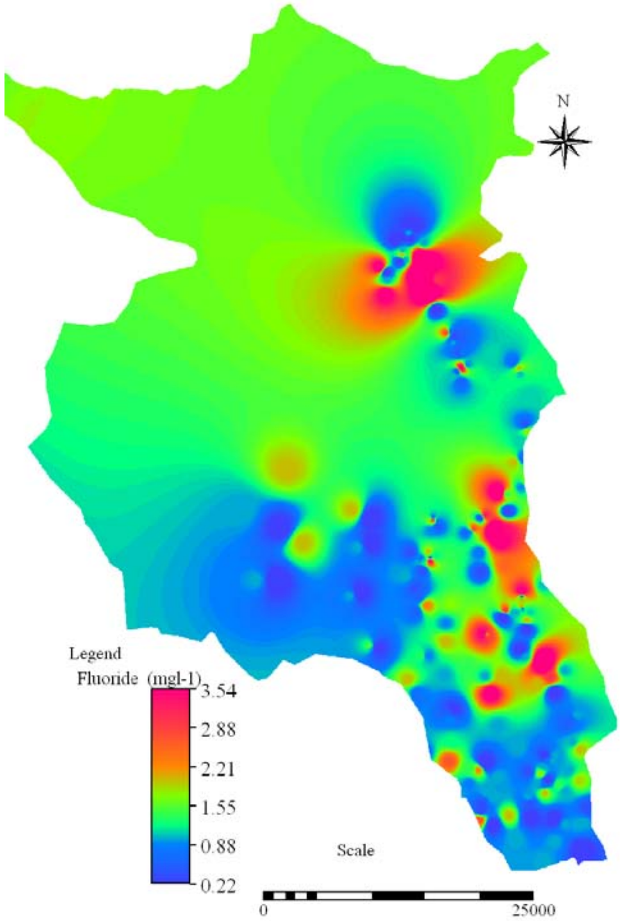
(d) HCO_3

Figure 4.15 Scatter Plots of TDS vs. EC and Major Anions

Table 4.8 Statistics of Major Anions and Cations

Parameter	Minimum	Maximum	Average
Ca^{+2} (mg l^{-1})	2.0	724.0	80.9
Mg^{+2} (mg l^{-1})	2.0	2064.0	112.6
Na^{+} (mg l^{-1})	5.0	24650.0	169
Cl^{-} (mg l^{-1})	0.1	135000.0	451.9
HCO_3^{-2} (mg l^{-1})	12	1220.0	312.7
SO_4^{-2} (mg l^{-1})	0.3	11616.0	484.6

Source: Seneviratne, 2008



Source: Seneviratne, 2008

Figure 4.16 Spatial Distribution of Fluoride

Results of groundwater study on Weli Oya Diversion Project Area (Seneviratne, 2007a) as well as Mau Ara Diversion Area (Panabokke, et al 2006) depicts the decrease of fluoride concentration of shallow groundwater with the rainfall of the area as well as along the downstream direction of the cascade system. The study shows that the fluoride concentration of deep groundwater of the area is considerably higher than that of the shallow groundwater of the area.

Geology of the area heavily influences the fluoride concentration of deep groundwater than the soil overburden of the area. With respect to the geology of the area wells located in the Hornblend Biotite Migmatite and Granodioratic Gneiss show high concentration of fluoride particularly in deep groundwater system while wells located in Charnockite formations shows less fluoride concentration. Groundwater extracted from the both the dug wells as well as the tube wells located on the quartzite give desirable water for the human consumption (Seneviratne, 2007).

4.3.2 Groundwater quality issues due to human impacts in the Walawe basin

In Walawe basin agrochemicals are used widely in order to enhance crop production. No study has recorded the groundwater quality data characterized by contrasting irrigated agricultural land uses and hydro geological properties. Frequently agrochemical contaminants can be leached specially to the shallow, unconfined aquifers. WRB carried out a water quality monitoring programme in Walawe left Bank Extension project Area in collaboration with Mahaweli Development Authority to understand the variation of water quality with natural and human impacts. The results indicate negative agro-chemical influence on water but with presence of heavy metals in the analyzed water samples (Seneviratne, 2008).

Results of “Bench mark groundwater study on Weli Oya diversion project area” described the increasing trend of the SAR value due to the fertilizer utilization in Aluthwewa area located in the upper part of the basin (Seneviratne, 2007).

Agro-chemicals considerably contribute to the deterioration of water quality. Carbofuran and diazinon are heavily used for controlling insects in the agricultural areas of Sri Lanka. Studies show that the degradation of carbofuran and diazinon is rapid in sandy soils, but less in clay and loam types. Carbofuran is used by 65% of farmers as an insecticide in Embilipitiya area and creates a high potential to contaminate groundwater (Watawala et al, 2005).

4.3.3 Surface Water Groundwater interactions

Walawe River as a major surface water body in the catchment has ample amount of water due to its large catchment area. Weli Oya supplies water to the main river in upper part, and Rakwana Oya and Mau Ara contributes in Western and Eastern part of the catchment respectively.

In addition to the Uda Walawe reservoir which is built across the Walawe River, Ridiyagama and Chandrika wewa reservoirs are the other main surface water storages in the downstream study area. Samanalawewa reservoir which has 216 million m^3 capacities is located in the upper catchment. In addition to these small, abundant irrigation tanks are also available within the study area. Rainfall runoff relationships have been developed by applying regression analysis at Liyangastota gauging station and the correlation coefficient was 0.66. Poor maintenance and the lack of the river gauging stations cause difficulties to quantify the surface water resources of the area (Seneviratne, 2008).

4.3.4 State of irrigation water use and productivity

Irrigation is the dominant water user in the basin and would remain so in the foreseeable future despite the increasing water demand from other sectors. As such, the current state of irrigation water use and productivity are of special importance to the water management of the basin.

Average yield in Uda Walawe scheme was 5.66 T/ha in 2007/08 Maha season and 5.64 T/ha in 2007 Yala season. These values are fairly high and higher than the national average for major irrigation schemes. It can be seen that the yields have increased over the years. Similarly, there is a marked decrease in the water use in the scheme, due to crop diversification and water management measures adopted in the recent modernization and extension projects. Accordingly, the current water productivity in Uda Walawe scheme ranges from around 0.41 kg/m^3 in Maha seasons (average of last three years up to 2007-08 Maha) and 0.27 kg/m^3 in Yala seasons. Based on the 1998 to 2001 values the irrigation water productivity was 0.27 kg/m^3 in Maha seasons and 0.21 kg/m^3 in Yala seasons. For the water productivity calculations, the water use was measured at the reservoir sluice. In the other schemes, the non-availability of scheme level yields makes it difficult to measure the water productivity.

4.3.5 Impacts of Dams and Diversions to the Aquifer System of Walawe Basin

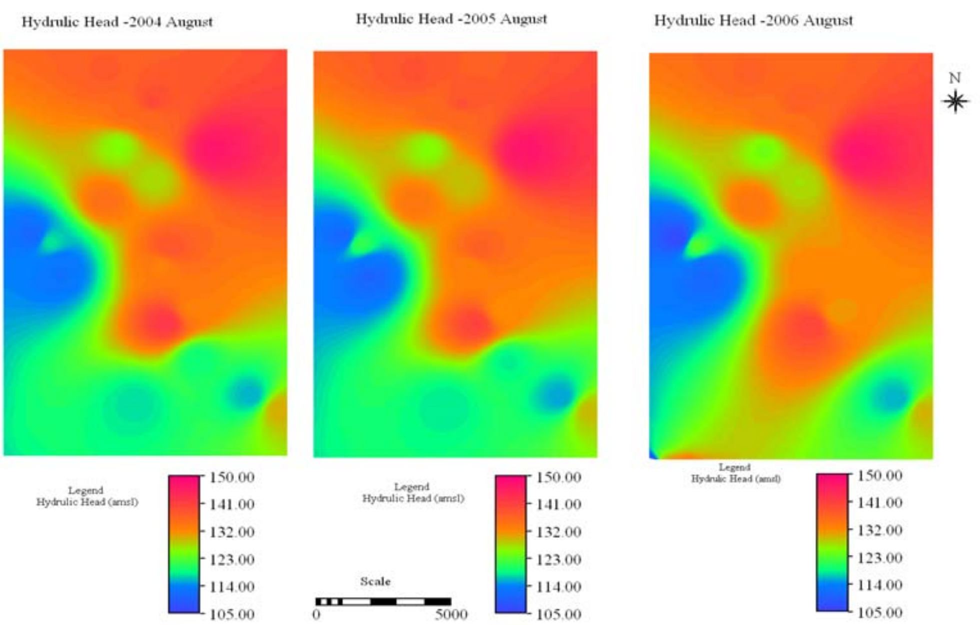
Except the major surface water storage there are number of small scale tanks and surface water storages available in the catchment. Among them number of small scale tanks are abandoned at present. Almost all the settlements areas of the basin are associated with these surface water bodies.

Generally replenishment and seepage losses from canal and inland reservoirs play a significant role in maintaining the shallow groundwater while rainfall and irrigation excess water that replenish the fractured and weathered aquifers in hard rock areas are limited (Seneviratne, 2008).

Two key studies carried out by the WRB in collaboration with the Irrigation Department at Weli Oya diversion project area and Mau Ara diversion (Malala Basin), located in the upper part of the basin and Eastern part of the basin respectively, have revealed the direct impact of the surface water diversion to the replenishment of shallow groundwater system. (Figure 4.17) Results of these studies provide evidence for the improvement of the quality of the shallow groundwater in the respective areas. But these studies do not discuss the replenishment of the deep aquifer system within these areas.

Study carried out along the feeder canal system associated with the Uda Walawe extension project area observed that whenever water flow takes place in these canals, the regolith aquifer domains within the irrigation scheme replenished with the infiltrating water, and the water table within the primary and secondary catchment basins rise to a specific height according to the lay of the landscape. But this water table recedes at a slow rate following the irrigation supply in the canals are cut off (Seneviratne, 2008).

Wells in the Walawe basin show a gradual rise in salinity from upstream to downstream, from wet weather to dry weather, and from within irrigated command area to outside from it. As reported by Handawela (2002), in irrigation systems of Walawe area water decline is generally from class II (0.275-0.750 dS/cm) in wet weather to Class III in dry weather (0.750-2.25 dS/cm)



Source: Seneviratne, 2008

Figure 4.17 Groundwater Level changes before and after Weli Oya Diversion

Table 4.9 Groundwater Supply of the Administrative Districts

Administrative District	Supply of groundwater Resources (m3 /day)	Percentage of groundwater supply (%)
Hambantota	1425	4.3
Moneragala	41	1.2
Rathnapura	12	0.8

Sources: JICA-2003

4.3.6 Present Groundwater Consumption and Future Needs in Walawe Basin

Although surface water is the main source of water for agriculture, the region depends on groundwater for domestic purposes and small scale irrigation and water supply schemes. About 80% of the rural domestic water supply needs are met from groundwater by means of dug wells and tube wells. Groundwater use is rapidly increasing in the area during the recent past, bringing several benefits to small farmers by allowing them to grow more crops and minimizing the impact of water shortages that occur during dry season. Over the last decade groundwater usage through tube wells has increased sharply in the area but groundwater is not properly managed as an additional source. Rural people who depend on the groundwater and other natural water sources are also facing hardships due to uncontrollable natural conditions such as drought experienced specially in the dry zone of the catchments in every year.

More than 75% of the urban population depends on the pipe born water supplied by the NWSDB. But these people are also experiencing water supply interruptions due to salinity intrusions in the lower reaches of surface water sources those are used for the water supply schemes.

The current groundwater supply carried out by the NWSDB and the WRB in the three main administrative districts which covers the Walawe Basin are given in Table 4.9. As the basin covers certain parts of the district's the supply is not represented only the basin.

4.3.7 Future water needs

Ambitious development plans of the Southern part of Sri Lanka indicate that the dominant role played by agriculture is geared to more industrial and service-oriented activities. Due to the major development projects such as construction of new harbor and air port in Hambantota area new settlement schemes as Walawe Left bank extension programme, and the proposed industrial zone, the water demand of the area will increase from 12 million m^3 currently to 100–150 Mm^3 million m^3 by the year 2025. The imbalance of the demand and the supply will have an impact on society as well as on natural resources and require the inclusion of issues of water management because currently, almost all water resources that diverted are used for irrigation with only a small percentage used for industry and drinking water.

Under this condition people tend to exploit both shallow and deep aquifer system of the area. Groundwater, because it is underground and hardly noticeable nature, it is often unacknowledged and undervalued resulting in adverse environmental, economic and social consequences. The over-exploitation of groundwater by uncontrolled pumping can lead to detrimental effects on neighboring boreholes and wells, land subsidence, saline water intrusion and the drying out of surface waters and wetlands.

Generally sustainable aquifer exploitation occurs when the rate of groundwater extraction is equal or less than the natural rate of groundwater replenishment for any level of aquifer storage. Thus to be able to exploit aquifer in a sustainable manner with minimal impact on the environment there is need to demarcate and evaluate the aquifer potential.

4.4 Water related risk management: current state of affairs

At present there is no dam safety legislation in Sri Lanka. Irrigation Department and CEB have internal circulars that provide instructions on how to monitor and collect flood data and operate gates in an emergency condition during monsoon. In case of an emergency all dam owners inform the police. The current practice in Sri Lanka for inspection of dam safety is the dam owning organizations adopt self regulation for dam safety assurance and dam safety management. However with conflicting demands and limited funding, dam safety has tended to be neglected or given low priority. This has sometimes led to gross negligence of essential maintenance of dams resulting in the exposure of the downstream public to danger. Hence there is a need to establish a mechanism to ensure that the dam owners input serious effort and commit sufficient dedicated funds to operating and maintaining their dams safely. World Bank funded Dam Safety and Water Resources Planning Project has addressed this issue and provision has been made for preparation of necessary framework, including provision and guidelines for establishment of an inter-organization arrangement for dam safety (Talagala, 2008).

A study carried out by the WWAP (2007-08) identified the inundation areas in the event of a dam break at Samanalawewa. They are demarcated as shown in the Figure 4.18.

4.5 State of ecosystems

4.5.1 Bio diversity in the coastal wetland systems

The shallow marine belt bordering Lunama-Kalametiya area harbours a coral reef as well as a sandstone reef. Small patches of sand dunes are located to the east of Lunama lagoon. Creeping vegetation such as Ipomoea pes-caprae and Spinifex littoreus occur on these dunes. Mangroves in Kalametiya are dominated by Sonneratia caseolaris, while those in Lunama are dominated by Excoecaria agallocha. Patches of scrubland are also located around the lagoons, dominated by thorny species such as Flueggea leucopyrus and Dichrostachys cinerea. The reed beds adjoining the lagoons are dominated by Typha angustifolia. The grasslands consist of species such as Cynodon dactylon and Panicum repens. The frequently inundated areas of the lagoon consist of salt marsh communities, dominated by salt-tolerant species such as Halosarcia indica (Weerasinghe et al, 2008). The dominant plant species occurring in natural terrestrial and wetland habitats of the Lunama-Kalametiya area are listed in Annexure 2.

4.5.2 Species composition of Fauna in Lunama-Kalametya area

A total of 283 species of vertebrates were recorded from the Lunama-Kalametiya area, of which 14 species (5%) are endemic, while 17 species (6%) are nationally threatened. The vertebrates are comprised of 35 species of fish, 13 species of amphibians, 43 species of reptiles, 168 species of birds, and 24 species of mammals. The invertebrates documented include 75 species of butterflies and 18 mollusc species.

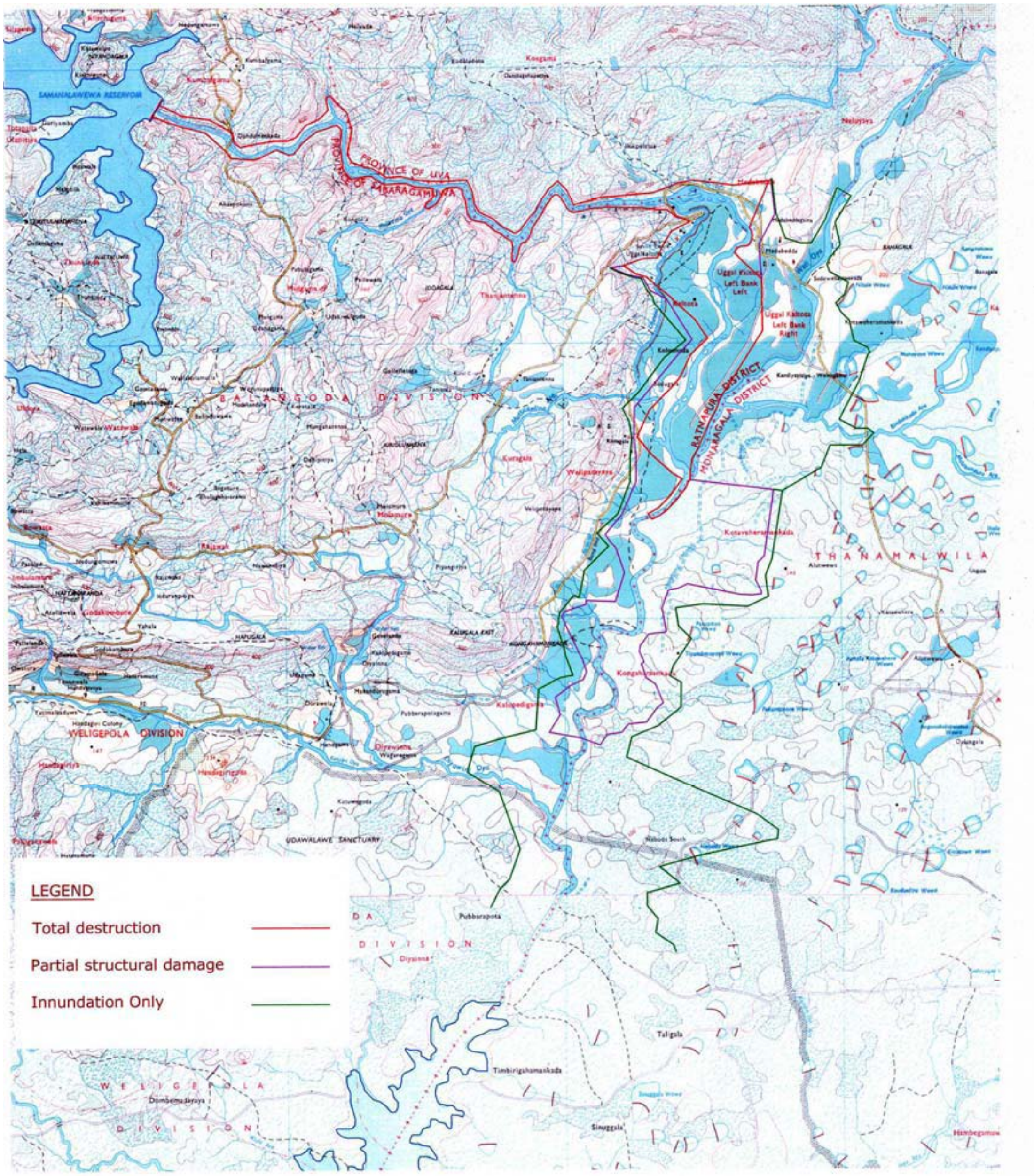


Figure 4.18 Inundation areas in the Walawe basin in the event of a Samanalawewa dam break
Source: Talagala, 2008.

A total of 35 species of fish were recorded from the lagoons and canals in the Lunama-Kalametiya area, including three endemics and two threatened species. These include salt water dispersants (e.g. Short-finned Eel - *Anguilla bicolor*), marine forms (eg. Bigeye Travally - *Caranx sexfasiatus*), brackish water forms (e.g. Brown gudgeon - *Eleophis fused*) and freshwater forms (eg. Murrel - *Channa striata*). The Deep body Silverbiddy (*Gerres abreviatus*), Dwarf panchax (*Aplocheilus parvus*), Blue Eyes (*Oryzias melastigma*), Bloch's Gizzard Shad (*Nematalosa nasus*} and the exotic Mozambique Tilapia (*Oreochromis mossambicus*) are abundant in the lagoons.

The area harbours 13 species of amphibians. They include toads (e.g. Common Toad - *Bufo melanostictus*), narrow-mouthed frogs (eg. Ornate Narrow-mouthed Frog - *Microhyla ornata*), common frogs (eg. Skipper Frog - *Euphlyctis cyanophlyctis*) and tree frogs (e.g. Chunam Tree-Frog - *Polypedates maculatus*).

A total of 43 species of reptiles were recorded from the area including 4 endemic species and 7 species that are nationally threatened. Among the reptiles are three species of globally threatened marine turtles that visit the sea shores of the Lunama-Kalametiya area for nesting, while the Mugger (*Crocodylus palustris*) and the Indian Python (*Python molurus*) are also considered as globally threatened species.

The complex system of wetlands and terrestrial habitats in the Lunama-Kalametiya area has contributed to rich bird diversity, including many species of migratory birds. A total of 168 species of birds were recorded from the area during the six month survey period. These include 121 residents, 46 winter migrants and one off-shore marine bird. Among the resident birds, five species are endemic, while 5 species are nationally threatened. Of the migratory species, 45 are regular migrants, while common-ringed plover is an occasional visitor or vagrant. The lagoons, inter-tidal mudflats and salt-marsh areas provide ideal resting and feeding habitats for numerous species of winter migrants, especially the wading birds. The vast numbers of migratory Stints, Sandpipers, Plovers, Terns, Gulls, and Ducks share the wetlands with resident wetland birds such as Herons, Egrets, Pelicans, Cormorants, Teals, Storks and Stilts.

The mammals recorded from the area consist of 24 species, including two endemic and three threatened species These include small mammals (Rats, Mice and Shrews), bats, large herbivores (Spotted Deer, Mouse Deer), carnivores (Fishing cat, Rusty-spotted cat, Mongoose, Otter), scavengers (Jackal, Wild boar) and arboreal species (Macaque, Grey Langur). Grey Langur (*Semnopithecus entellus*), Black-naped Hare (*Lepua nigricollis*}, Palm Squirrel (*Funambulus palmarum*), and Water Buffalo (*Bubalus bubalis* - mostly feral) are the most commonly seen mammals in the area.

About 75 species of butterflies were recorded from the area, including one endemic and 12 nationally threatened species (Annex 7). Majority of the butterfly species are found in the scrubland habitat. The three species of the Family Pieridae, Pioneer (*Belenois aurota*), Yellow Orange Tip (*Ixias pyrene*) and the Small Salmon Arab (*Colotis amata*) are among the commonest butterflies.

The molluscs recorded include ten land snail species and eight aquatic species (Annex 8). The land snails include five endemics and two nationally threatened species.

4.6 Impact of economic drivers on the water resource:

The economic drivers affect the water resource in several ways. In the rural areas, intensive agriculture and high use of agro-chemicals affect the quality of water. However, keeping large areas under irrigated conditions have favorable impacts on the environment. In the urban areas, the reduction of areas under agriculture, especially paddy, reduces the area available for temporary storage of flood water, and frequent inundation of urban areas due to local rainfall is witnessed. The ecological services provided by paddy lands are not formally recognized or compensated.

The Walawe Irrigation System is a success story in crop diversification. In addition to paddy cultivation and sugar cane plantations, about 35% of the irrigated area has non-rice field crops, especially bananas. This is a very high percentage for Sri Lanka. Crop diversification is one of the main strategies of the irrigation agency to save water and increase farmers income (Weerasinghe et al, 2008).

Most lagoons have had a sequence of two or even more manmade earth bunds across the valleys opening to them for storing fresh water in ponds both for conserving fresh water and for keeping the lagoons brackish. Human actions have resulted in the deterioration of water quality in these ponds possibly due to poor awareness on their significance, except in rare locations like Palatupana tank above Goda Kalapuwa (Handawela 2002).

Coastal lowlands located downstream of irrigation projects; Kalametiya-Lunama below the Walawe Project, and some lagoons of the Bundala Ramsar wetland located below Kirindi Oya Project are affected by irrigation backflow during cropping seasons. This is partly due to removal of traditional flood detention tanks during development in the upstream, and also by denial of the lowland share of water in drier than average Maha seasons (Weerasinghe et al, 2008).

The symptoms of coastal lowlands affected by irrigation development in immediate catchments are of two types. One is due to increased entry of water and the other due to reduction of supply (Weerasinghe et al, 2008). Increased entry has raised the ground water table in dry weather which has increased soil salinity making the soil too saline for cropping in the Yala season and has caused the natural vegetation associations e.g. Divul - Maliththan to give way to aggressive salinity resistant species, eg. Prosopis Juliflora. In wet weather or when irrigation is on in the immediate catchment, the wetlands get flooded more and longer than before, which makes paddy farming difficult. During such periods the affected lagoons become fresh water lakes seriously affecting the typical brackish water shell fish species, and associated fishing industry (Jayakody and Jayasinghe 1992). Subsequent construction for flood outflows in Kalametiya and Malala lagoons in 1985 and 1996 respectively have reduced flooding but has interrupted the shellfish biodynamic and hence worsened the plight of the fishermen.

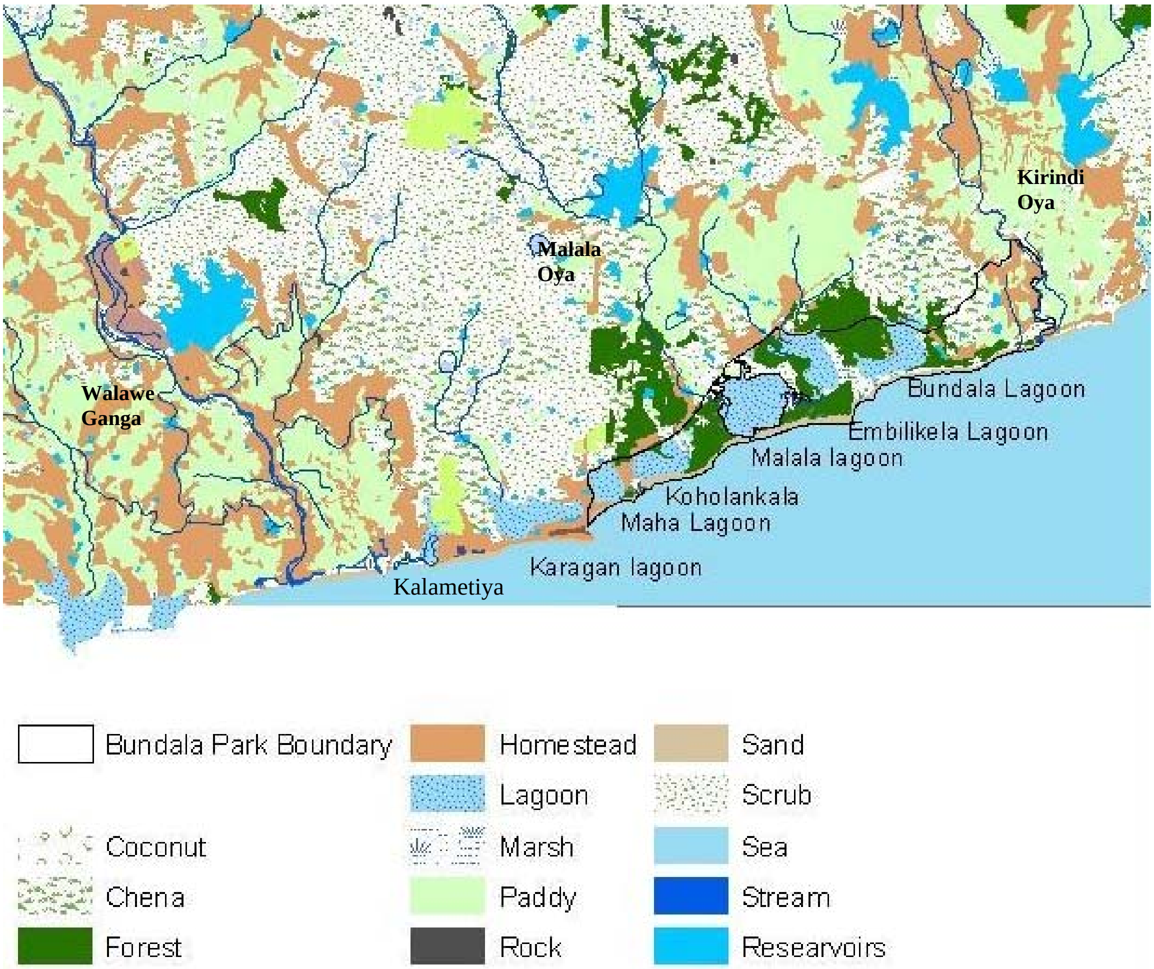


Figure 4.19 Location of coastal wetlands near Walawe sea outfall

Table 4.10 Summary of improvements to piped schemes: Hambantota/Ambalantota scheme

Phase 1	• Re assessed the Zonal Demands • Repairing damaged bridge crossings • Extension of existing distribution network towards Gannoruwa & Maurapura resettlement areas to cater for immediate drinking water needs • Modifications to transmission arrangements to cater for the immediate demands at the settlement
Phase 11	• Capacity Improvements to allocate 10,500m^3/day for Hambantota subzones • Re-arrange distribution system to suit 28km • Improvements to storage (3 towers, 2 GR) • Rehabilitation of existing Distribution network & expansion to resettlement areas and adjoining GNDs • Introduction of sewer network in resettlement areas

Source: Fernando, 2008

The Asian Wetland Directory described 41 wetland sites of international importance in Sri Lanka. Two of them are in Walawe basin namely Lunama Kalapuwa Kalametiya Kalapuwa (212 ha and 200 ha) and part of the Karagan Lewaya. The Lunama-Kalametiya area harbors a variety of natural and man-made vegetation/habitat types, including both terrestrial and wetland ecosystems.

4.7 The recovery of tsunami damaged drinking water and sanitation facilities

Most distribution systems were re-established through temporary repairs of main pipelines, river/bridge crossings and by capping damaged household connections almost immediately.

A stage-wise approach was used in restoring basic water supply and sanitation needs of the Tsunami victims.

1. Immediate sector support to the people while living in temporary / transit camps
2. Immediate medium term support when areas are restored and people are moved back to the restored original residential areas.
3. Immediate medium term support when affected people are resettled in new areas.
4. Support to meet the longer term needs of the population (10 years design horizon)

It can be seen that such drawbacks are being recognized by decision makers. A project titled Dam Safety and Water Resources Planning Project is launched in late 2008, with the World Bank funds. A major component of the project is to improve the hydro-meteorological information system through modernized equipment and capacity building in the sector.

The above information shows that drivers such as tsunami recovery effort resulted in new infrastructure catering for future needs, at some locations. The improvements to Hambantota and Ambalantota pipe water schemes are given in Table 4.10.

4.8 Data and information on water resources

A considerable amount of data and information on water resources are collected by the state institutions and private institutions. The lack of a forum to share water related information and difficulties to access data had been highlighted by several stakeholders in the water sector. In the recent times, especially since the tsunami event of 2004, some improvement in internet based information sharing can be observed.

The Walawe river basin is monitored with about 26 rain gauging stations with several stations providing reliable information for long periods. They are maintained by the Meteorological Department, Irrigation Department, Agriculture Department and some tea estates. Irrigation Department also maintains two stream flow gauging stations in Walawe basin, but they are located in two major tributaries. The smaller streams such as Kachchigal Ara, Karagan Oya and Malal Oya are un-gauged

4.8.1 Data on Deep Aquifer

Of the 5000 plus water tube wells drilled in Walawe Basin area during the past, more than 3000 have been inventoried and placed into the WRB and NWSDB groundwater database (Seneviratne, 2008). No common well numbering system has been assigned to these wells. The database contains well information including location (latitude and longitude), depth, well type, owner, driller, and construction and completion data, water-level and initial water quality data.

With respect to the groundwater quantity, ground water-level information with respect to the land surface datum, date of measurement and the flushing yield of each well after completion are consist with the databases of both agencies. Ground water-quality information includes the well number, date of sampling, lab-calculated pH, EC total alkalinity, hardness, total dissolved solids, and major anions and cations. But both data base are not completed and data gaps are available. The boreholes are drilled basically for fulfillment of the requests made by the privet parties.

The major problem associated with the groundwater information is the lack of records of the tube wells constructed by the private companies. Because bore holes drilled by the private parties are not inventoried in to the two main groundwater databases of the country. Therefore, no organization has the reliable figure of the extractions from the deep aquifers in the region. Also, due to lack of co-ordination among the organizations there is no method for the data sharing. Further such practice will create lots of data duplication. The inconsistency in the well numbering system, well coordinate system, structure of databases and GIS software used by institutions are causing the data duplication and it has been a major problem for the quantification of the deep aquifer in the region (Seneviratne, 2008).

4.8.2 Data on Shallow Aquifer

Although the majority of domestic water consumption of the region is fulfilled by the shallow regolith aquifer system of the area, institutions does not have proper reliable information on the state of or withdrawals from this shallow aquifer. The two main data bases of WRB and NWSDB also do not contains the details of the shallow aquifer of the region for the quantification of the groundwater abstraction of the area.

To avoid the difficulties for proper development and management of the groundwater resources in the area it is essential to have reliable and consistent national database, not only with the technical data and quality of the wells but also the studies carried out in the region. To achieve this target it is required to establish proper interconnection between the organizations who deals with the development and management of water resources in the country such as WRB, NWSDB, Irrigation Department, and Department of Agriculture etc. Also, there should be a way to get the information on the borehole drilled by the private parties and the groundwater abstraction of the area (Seneviratne, 2008).

4.9 Water and Ecosystems

4.9.1 Environmental impacts of irrigation

Irrigation drainage flow had been a problem for many of the coastal ecosystems in Walawe basin as well as adjoining basins such as Kirindi Oya. Kachchigal Ara was a seasonally dry stream prior to the construction of Uda Walawe project, but it became a perennial stream due to the irrigation water and drainage flow from Chandrikawewa RB main canal (ID, 2002). The lower-basin paddy lands also receive water from RB main canal of Liyangastota Anicut constructed in 1889. This has increased agricultural productivity in the Kachchigal Ara basin.

Kachchigal Ara carries a considerable drainage to sea via Kalametiya Lagoon. To avoid inundation of developed lands, drainage to sea had been ensured through opening the lagoon to the sea. Both actions affected the water quality and life in the eco system life adversely; the effects include decreasing the lagoon area due to siltation and decreasing the salinity affecting the fish population.

The research work by International Water Management Institute found several impacts of the irrigation development upstream of Bundala national park lagoon system, especially Embilikala and Malala lagoons. One is the flow of agricultural drainage to the system resulting in a drop of salinity levels. Consequently, a decrease in fish and shrimp populations in the affected lagoons had been observed. Another impact is caused by the loss of grazing land of livestock due to irrigation expansion. This resulted in cattle straying into the park area, and the agricultural drainage includes dung and urine from cattle. This, in combination with fertilizer in irrigation drainage, causes eutrophication (Matsuno, 1999). In addition, the breaching of the sandbar by farmers to protect upstream paddy lands results in fluctuating water levels. This in turn affects wading birds and other wildlife dependent on food sources in the shallow mud flats of the lagoons. High phosphorus and nitrogen concentrations in the Embilikala lagoon have been reported as well (Smaktin et al, 2004).

Loss of croplands within the coastal wetlands due to salinity and water logging is reported in the coastal areas. Another environmental problem associated with agriculture is the contamination of water resources by agro-chemicals. The increase of agrochemicals in irrigated agriculture is feared to affect biodiversity in the coastal wetlands and the livelihoods of fishermen (Smakhtin and Weragala, 2005).

4.9.2 Competing for a scarce resource

The Ruhuna basins case study report (2003) described the water sharing issue that emerged between the irrigation users and hydropower developers in the Walawe basin (Imbulana et al, 2002). The water stored in Samanalawewa is sent through a 5.5 km penstock to the power station at Kapugala, and released to Katupath Oya (a tributary of Walawe) sub basin.

The construction of Samanalawewa dam reduced the catchment area of Kaltota irrigation scheme from 410 km^2 to 56 km^2, which is 16% of the initial area. The average annual rainfall in present catchment area is 2,500 mm while the Samanalawewa catchment area has an average of 3,185 mm (Molle et al, 2005). Therefore, the construction of Samanalawewa dam resulted in cutting off the more productive portion of the catchment and irrigation is heavily dependent on releases from the Samanalawewa dam.

Current uncontrolled supply to Kaltota irrigation scheme comprise of the runoff from the catchment below Samanalawewa dam and the leak through the dam (described in section 3.1.2). It is estimated that this uncontrolled flow amounts to about 55 million m^3 (before the increase of leak in 2007). In addition, about 40 million m^3 is released from the dam (Molle et al, 2005), which otherwise could have been used for power generation.

Attempts made to reduce the cultivation and pay compensation to farmers in 1997-98 did not succeed. Subsequently arrangements were made to release water from the reservoir corresponding to irrigation demands. At present, the decisions are taken jointly by the Irrigation Department, Ceylon Electricity Board and the Farmer Organizations. Weekly decisions regarding the amount of release are made at the Mahaweli Water Panel in Colombo.

The issue of sharing water between Kaltota Irrigation scheme and Samanalawewa hydropower project involves many complex aspects. They include water rights, economic value of water, cultural and social values of paddy cultivation, attitudes, and reluctance to change. In addition, soil characteristics, geology, and deficiencies in infrastructure and irrigation water management play a role.

At present, the water use in Kaltota irrigation scheme is very high; at about 3 m. These high values are partly attributed to the high seepage and percolation in the paddy fields and the canals. Some traditional names of the villages indicate the presence of sandy soils, but a detailed analysis of soils has not been carried out. IWMI research indicates that the seepage and percolation losses are sometimes as high as 10 cm per day (compared to 5 mm per day adopted in the irrigation design guidelines). Field measurements carried out by ID (unpublished) in 2005 corroborate these observations.

The mandatory requirement to release water for irrigation schemes placed a constraint on the electricity generation capacity. Specifically, 50 million m^3 discharges to downstream was agreed with the Department of Irrigation during the project design but the water demand has now increased to 90 million m^3. Since irrigation has the first priority in Sri Lanka's water policy, the power plant has to respond to this requirement, which causes an estimated loss of 30GWh/year. (The estimated leak of 58million m^3 per year partially meets the irrigation requirement. The balance 40 million m3 is provided by opening irrigation valve causing an energy loss of 30 GWh/year) (Somatilake, 2008).

The issues arising from the industrial development would include competition for natural resources, mainly water and land. Already, the expansion of the agricultural area under Uda Walawe Project is constrained by the construction of a sea port. In the 1990s, the total water demand for all the envisaged development activities and resulting urbanization was estimated at around 100 million m3 per year. However, the actual demand would be less because all the planned development activities are not taking place. But at the same time the recent agricultural expansion will reduce the available water resources for urban and industrial uses.

5. RESPONSE OPTIONS

The current issues in the water sector have been recognized by the bureaucracy, international community, the academia and the professionals. While considerable advances have been made to address the issues, the stakeholders feel that there is more to be done.

5.1 Meeting the governance challenges

Bureaucracy has made several attempts to address policy and other governance issues. Policy and institutional development has been carried out in disaster management and environmental management; some of the activities were discussed in the preceding sections. In these fields, the approach has been a mix of policy development, strategic planning, establishment of institutions and stakeholder participation. However, further action is required in the fields such as resources management, water quality management and in the management of knowledge base. Integrated water resources management concepts are in line with the traditional approach to water resources management, and this has to be recognized in future plans and strategies.

Since there are a large number of institutions dealing with water, a coordinating mechanism plays a vital role both at national level and river basin level. There are some coordinating arrangements in the provincial and district levels which could adopt water as a major agenda item.

5.2 Recommended and ongoing responses to dam safety related risk management

As an initial step towards this direction in 2002 under the Dam Safety and Reservoir Conservation Program of Mahaweli Restructuring and Rehabilitation Project, an attempt has been made to establish an effective regulatory framework for planning, construction and management of dams in order to ensure dam safety and reservoir conservation systems management. Draft code of Practice for Safe Operation and Maintenance of Dams was an outcome of it. In order to address Dam Safety issues Mahaweli Authority of Sri Lanka, Irrigation Department and Ceylon Electricity Board who manage the most number of major dams, proposed to adopt a voluntary Code of Practice for safe operation and maintenance of dams in the country (Talagala, 2008).

In order to ensure safety in the operation and maintenance of dams, it is recommended that the owners of dams shall provide the following for each and every dam.

1. Standing Operating Procedures, for the use of dam operating staff
2. An Emergency Action Plan, to facilitate evacuation of communities at risk
3. A Dam Safety Officer, with responsibility for promoting safety on the dam and keeping breach of safety records
4. Training in safe operation and maintenance procedures for all managers and operating personnel (Talagala, 2008)

5.2.1 Standing Operating Procedures (SOP)

SOP for a dam and reservoir is prepared to establish one primary controlled document with all supporting documents and operating instructions for storage reservoir and its related structures. The purpose is to ensure adherence to approved operating procedures over long periods of time and during changes in operating personnel. The instructions will also permit responsible persons and also persons unfamiliar with the conditions at particular dam knowledgeable to operate the dam and reservoir during an emergency situation and at such other times when the regular operator is not available for his normal duties. The SOP is prepared primarily for the use of dam persons of who are assigned the responsibility for physical operation and maintenance of the dam and it contains all the information and instructions necessary for them to perform their duties correctly (Talagala, 2008).

SOPs are available for modern dams such as Kotmale, Victoria, Randenigala and Rantembe. But Emergency Action Plans (EAP) is not available. Attempt has been made during dam safety and Reservoir Conservation Program under Mahaweli Restructuring and Rehabilitation programme to establish SOPP &EAPP for 32 selected dams and these documents need further improvements. To achieve this it is necessary to make the dam personnel aware the need for a SOP&EAP. This should be done by a properly structured capacity building exercise (Talagala, 2008).

5.2.2 Dam-break modeling and Inundation maps

Methodology

As one of the capacity building efforts under WWAP, an inundation map has been prepared for a Dam break at Samanalawewa dam. HEC-RAS software package that is widely used for dynamic flood routing has been used for this purpose. Two days workshop on application of HEC-RAS for flood mapping has been organized at Samanalawewa for MASL and CEB officers. The input to the model is river cross-sections and Digital Elevation Model (DEM) indicating the topography of the river reaches. Since the river cross section data were not available, DEM was prepared based on 1:50,000 contour data (Talagala, 2008).

The preceding chapters described the technical issues related to the building of Samanalawewa dam, and the comparatively higher level of risk in the river basin due to its location. Several factors usually have to be evaluated whenever dam failures are postulated. The type of dam and the mechanism, which could cause failure, require careful consideration if a realistic breach is to be assumed. Size and shape of the breach, time of breach formation, hydraulic head and storage in the reservoir contribute to the dam failure hydrograph.

The researchers used CIRIA C542 method was used for the determination of dam break flood hydrograph. This helps to determine the potential impact that the failure of the structure might have on the downstream community. It was assumed that during the breach formation, the reservoir was at full supply level and the failure results in the complete emptying the reservoir (Talagala, 2008). The shape of the flood hydrograph was approximated to the triangular profile. This hydrograph was used in predicting flood levels downstream of the dam.

Impact assessment

Historical data shows that almost all fatalities caused by dam break occur within the first 30 km stretch of inundation downstream of the dam. Therefore 30 km distance has been taken as a cutoff length for the safety assessment. Reviewing the fatalities from past dam break events, it can be seen that half of the fatalities occur within the first 5 km reach downstream of the dam. Taking this into consideration, two valley areas defined for the assessment as follows:

- Near valley area – 0-5 km downstream
- Far valley area – 5-30 km downstream

Output from dam break modeling gives information on velocity and depth at various locations together with the predicted flood hydrograph. Map is plotted to show the zones of varying types of flood damage by using the depth and velocity of flow as parameters. It was assumed that:

- Velocities greater than 7 m/s – total destruction
- Velocities between 3 m/s & 7 m/s – partial structural damage
- Velocities below 3 m/s – inundation only

Roads and railway embankments often obstruct the flow. This may attenuate the flood wave during the flood. Further the estimation of flood discharge from the dam assumed to be a free flow. If there is a significant obstruction downstream or the valley slope, then the dam break flood discharge would not occur from the breach and reduce the peak discharge. Spill discharge corresponding to the various reservoir levels calculated using standard equations are tabulated in Table 5.1.

The floodwater from the breach of Samanalawewa will flow to the UdaWalawe reservoir. The prediction of the flood level was done up to 30 km downstream and dam break flood peak at this location is 7640 m^3/s. Uda Walawe reservoir is 33 km downstream of Samanalawewa dam and flood peak will be further attenuated when entering Uda Walawe reservoir. It can be seen from the Table 5.1 that even the flood peak of 7640 m^3/s could be easily pass through the spillways without overtopping the dam.

Dam break simulation results show that flood peak will reach Kaltota and Uda Walawe within 45 minutes and 6 hrs respectively. Hence there will be sufficient time for preparation for an emergency at Uda Walawe if there is a proper communication network among the main dam owners in the basin. Therefore, WWAP studies showed that dam break and inundation modeling is a viable technological response for the current concerns of dam safety in the Walawe basin.

Emergency Action plans and coordination

Despite the adequacy of the guidelines and their implementation, the possibility of dam failures still exists. To evaluate the effects of dam failure, maps should be prepared delineating the area which would be inundated in the event of failure. Whenever people live in areas that could be flooded as a result of operations at the dam, there is a potential for loss of life and damage to property. Having an emergency action plan would help to save lives and property damage in areas that would be affected by dam failure or operation (Talagala, 2008). The WWAP studies (2007-08) described in Chapter 4 prepared an inundation map with the available data, and demonstrated the importance of availability of data and funds for effective disaster management.

Table 5.1 Spill discharge of Uda Walawe reservoir

Water level (m MSL)	Maximum spill discharge (m^3/s)
88.39	2,527
89.0	3,011
89.61	3,829
90.22	4,841
90.83	6,004
91.44	7,296
92.04	8,702
92.65	10,212

Therefore provision has been made through Dam Safety and Water Resources Planning Project to establish Automated Dam Monitoring and Operational Early Warning System for selected MASL and CEB dams to improve operational efficiency of the major important reservoir by reaching the key operational information to the management level in and integrated manner (Talagala, 2008).

5.3 Stakeholder participation in the management of water

The participation of civil society in decision making has been promoted since mid 1980s in irrigated agriculture. There is a need to provide necessary policy and institutional support to make sustainable use of the momentum. At present, farmer organizations in irrigation schemes are registered under the Agrarian Development Act, providing them with legal recognition. However, there is no compulsion for stakeholder participation in decision making. Apart from the government auditing mechanism, the farmer organizations add some transparency to the government spending

MASL, CEB, ID & NWS&DB are the main stakeholders in the Walawe Basin and in case of an emergency, communication between the main stakeholders are vital. At present all dam owners are managing their dams in isolation and all dam managers are keen to establish a communication network.

in irrigated agriculture. Since the adoption of participatory management policy, the handing over of operation and maintenance responsibilities to FOs has taken place in many irrigation schemes. Later, the government adopted a policy of “joint management”. This policy was, however, less formal than the previous one.

During mid 1990s, farmers companies were considered as the main institutional strategy for improved irrigation management. Thus, Farmer Companies were established in several major irrigation schemes. Chandrikawewa Farmer Company was one of the first companies established in this manner. It has gained some successes with limited government support. Clearer policies on irrigation management could create a better environment for the sustainability of such interventions.

In the dry zone, the village irrigation systems were traditionally constructed and managed by the village community or individuals from the ancient times. The irrigation system was managed by a water headman (vel vidane) selected from the community. In late 1950s this system was replaced by “cultivation committees” where the representatives were elected. Subsequently, there was an intrusion of the party politics to the management system.

The studies have revealed that the management system consisting water-headman and rural courts were somewhat effective in enforcing the collective decisions made at the cultivation meetings. However, the present system requires that government officials have to sue the offenders using the normal legal procedure. Lengthy procedures (Somaratne et al, 2005), lack of incentives and motivation among government officials, and inadequate cooperation from the public result in weak enforcement of the collective decisions in village irrigation systems. As the government does not fund maintenance of these irrigation systems, the present situation could lead to rapid deterioration of infrastructure.

In many village tank cascade systems, the communities are closely-knit through social and economic ties. Therefore, the potential for community organizations to function as commercially viable management entities, which address irrigation, domestic water supply, inland fisheries etc, is present. Exploiting this potential could be a viable response to the current state of village irrigation systems and rural economy. This is especially important because provision of safe drinking water cannot be considered as the responsibility of an individual, in the light of current concerns about water quality.

In the case of major irrigation, the major challenge is to improve the productivity and the incomes of farmers. Several innovative methods of increasing the productivity have been tested in the Walawe basin. They include:

- Incorporating village irrigation systems in to major irrigation systems, in such cases as Mau Ara diversion project and Weli Oya diversion project. Records show the increases of cropping intensity and groundwater recharge due to such interventions.
- Uda Walawe left bank development project introduced several interventions such as dual-canal system, night storage tanks and canal system design for field crops. Increased water productivity and cropping intensities have been already observed.

The participation of stakeholders is promoted in disaster management and rural water supply, with policy support and institution building. Under the present disaster management setup, communities participate in disaster related decision making at appropriate administrative levels. In the Walawe basin too, such activities are pursued. The DMC identified six Grama Nildhari Divisions (smallest village level administrative unit) in the coastal areas of Walawe basin which face frequent flood threats. With the help of the community, 1311 families with 5613 members were identified as vulnerable. Activities are ongoing to mobilize the communities to face the disaster events, by forming disaster management committees and training them (Panditha, 2008).

Stakeholder participation in the management of drinking water supply has achieved several benefits as discussed in the previous chapters. Expanding the current level of beneficiary participation in the management and improving their technical capability to operate and manage water supply systems appear to be a viable response option for that sector.

The government recently initiated a programme to promote local food production under the slogan “Let us cultivate and uplift the nation”. This programme has identified 23 crops having potential to reduce imports and increase exports. There is specific attention on home gardens which had promoted greater participation by women. As there is sufficient emphasis on fruits and vegetables, it is expected that consumption of them would increase corresponding to lowering of prices. At present the consumption of fruits and vegetables in Sri Lanka is lower than the recommended, and as such, the programme would promote general nutritional status as well.

5.4 The Environmental Impact Assessment and compensating for the services by environmental systems

The EIA process applied to water resources development provides for the public, including NGOs to express their views about social and environmental impacts of such developments. Several development projects, including hydropower and irrigation projects, had to modify their plans or had to delay the implementation, until the environmental requirements were met. While substantial control of such issues is made at the implementation stage, long term monitoring of environmental impacts is inadequate.

A tendency to make provisions for the services of environmental systems can be observed in planning and execution of water resources development projects. Recently concluded Uda Walawe Left Bank Development Project made precautions to avoid environmental damage, through better water management. The Weli Oya project included a component to re-forest the area adjoining the headwork's and canal systems. Outside Walawe basin, the Upper Kotmale Hydropower Project made provisions to supplement the water flow to water falls from the hydropower reservoir. The Menik Ganga (situated east of Walawe) Development Project made provisions to supply water to maintain wildlife. The Moragahakanda Project (ongoing in the Central Province) will also incorporate similar provisions.

It may be noted that EIA process is supported by a policy framework and legislation. The deficiencies in implementation may be attributed to the defects in institutional framework.

Protection of ecosystems is vitally important for the sustenance of water resources. In the past 50 years, there was a considerable increase in the environmentally protected areas in the country. The forest cover has reduced drastically in the Walawe basin due to water resources development activities. The development of environmental policy and framing legislation has contributed to the arrest of this trend. About 4000 ha in the basin are designated as protected areas. They include Uda Walawe National Park, Madunagala sanctuary and Kalametiya-Lunama sanctuary.

5.5 Pollution control

Pollution of water bodies is a major concern in Sri Lanka and especially so in the Walawe basin. Pollution issues in the Walawe basin have arisen both from manmade development projects as well as from natural events. Controlling or minimizing impacts from manmade developments are much easier than that from the natural events. Water contamination from untreated sewage discharges, uncontrolled solid waste dumping and indiscriminate use of agro chemical and fertilizer is seen as the main anthropogenic pollution issues that need to be addressed immediately in the basin. Pollution from such sources is contaminating both the surface water and groundwater resource of the area. Unless immediate control measures are taken, water contamination will increase in the future increasing water stress further.

Several policy initiates already exist in the country for controlling man made pollution. Most pollution problems and necessary controlling measures are addressed in the National Environmental Act (NEA) of Sri Lanka. NEA stipulates the standard that must be maintained in releasing waste matter into the natural environment, the requirements to be followed in starting up new projects etc. The general standards for industrial

wastewater (effluents) discharged into inland surface waters under the NEA controls pollution from industrial sources. In new projects such as the water resource development projects, the mandatory requirements of EIA, IEE study before project start-up address the pollution control measures in large scale projects.
The existing EIA procedures address most of the pollution issues arising from new development projects including that from water resource development projects. However at present though most pollution control measures recommended in EIAs are addressed during the construction stage, they in most instances are neglected thereafter. Hence environmental management plans include monitoring and mitigation measures related to pollution controlling specified by the IEE/EIA studies are hardly implemented. Main reasons for this are identified as the lack of will, lack of properly trained personal and lack of financial resources.

Another major setback visible in the present NEA is that it does not clearly address the pollution issues occurring from domestic and agricultural sources. Controlling most domestic level pollution issues is rested with the local Public Health Office, than with the Central Environmental Authority (CEA). Lack of resources and inadequate training with these public health units is seen the major problems that need immediate attention. Unless as mentioned these issues are addressed, controlling pollution in the basin as well as in the country is difficult.

Central Environmental Authority

In 1980, the Central Environmental Authority (CEA) was established by an Act in the Parliament for the protection of any portion of the environment against waste discharges. Further this Authority was entrusted to conduct surveys, to conduct, promote and coordinate research on any aspect of environmental degradation, develop criteria and specify standards for environmental protection and powers to undertake investigations and inspections to ensure the regulations related. Again this Act was amended in 1990 such that many specified large-scale projects need necessary approval from the CEA for their construction and operations.

5.6 Financing water management

Financial resources allocation in several water related sub-sectors is inadequate for their sustainability. Irrigation management, water quality monitoring, pollution control and water related research, are some of the functions for which greater allocation of financial resources is urgently required. The shortfall can be compensated by the public-private partnerships and stakeholder participation in management. A substantial amount of international investment has been made in infrastructure development. A comparable investment in research and capacity building will make the earlier investments sustainable.

The need for capacity building to take up the challenges of water resources management is evident. Opportunities for international post graduate studies in the water sector are usually associated with donor funded development projects. Several local universities also conduct post graduate courses. A long-term arrangement and a programme for training water professionals at post graduate level will add quality and purpose to the ongoing training efforts.

5.7 Goals and programmes

The national goals relevant to water sector are specified in the 10 year development programme announced by the Government in 2007. Further, the development activities are related to the Millennium Development Goals. Targets have been set in domestic water supply and sanitation provision, poverty alleviation and food production in response to the MDGs. The government policy announced in 2004 pledged the development of an irrigation plan, which is currently being developed. In addition, there are short term and long term plans for drinking water supply, sanitation and hydropower generation. However, a national plan for water resources development and management and river basin plans, formulated on an IWRM basis, are not being prepared at present.

5.8 Responses by the civil society

Implementation of policies and legal measures to address such issues as pollution control are often hampered by lack of awareness and inadequate political will. Academic community and the professionals have to play a major role in addressing this challenge. Several initiatives in this direction were taken in this direction by institutions such as National Academy of Sciences, National Science Foundation, national universities and Institution of Engineers, Sri Lanka, which include workshops and seminars leading to recommendations to decision makers.

Poverty is a factor which affects the sustainability of interventions to prevent pollution, mitigate the impacts of disasters and water source protection. Attempts to address income-based poverty have been only partially successful. Civil unrest in some parts of the country further constrains uniform application of interventions. However, access to safe drinking water and the availability of water for livelihoods are important tools in alleviating poverty, and the gains in such areas are significant. Therefore current trend of multiple purpose water resources development will eventually help to conserve water resources.

5.9 Technology and development:

As irrigation uses about 90% of total developed water resources and demand management in irrigation considerably reduces the stress on the resource. Approach to demand management in irrigation sector includes cultivation of short-term paddy varieties, rehabilitation and modification of irrigation facilities and promoting stakeholder participation in management. In the domestic water supply sector, improved infrastructure and tariff system have helped in demand management.

The inadequacy of financial resources allocated for water related research is a challenge to make the technological responses. National as well as international support is required to face such challenges. Recently concluded Uda Walawe Left Bank Development Project allocated funds to assess the impact of the development work on water resources. However, generally the support ends after the end of the project.

The dam safety risk assessment study mentioned in the preceding sections was also affected by shortage of funds. The true water levels will always differ from the levels worked out from the above procedure due to topographic features and hydraulic conditions. Due to time and funding limitations it was not possible to carryout cross sections survey and could not take into account of site specific features which are likely to affect water levels. Selection of Manning's ***n*** value also affects the estimation of flow depth and rate of flow progression along the valley. As the dam break flood conditions are very different to normal river flow conditions, different ***n*** values has been selected for river reach and flood plain. This exercise could be further refined with training and working with experts who have experience in similar studies.

5.9.1 Ongoing responses to dam safety improvement include the Dam Safety and Water Resources Planning Project.

With the increasing pressure on water and land resources, there is a necessity to increase the productivity of village irrigation. Recent water resources development initiatives resulted in incorporating several village tanks with a major irrigation system. In such systems, there is a need to develop integrated water management programmes. However, there is a fear that recent interventions in village tanks may have increased the dependence of the community on state. Such concerns have to be addressed through appropriate policies and strategies.

The studies for WWDR1 in Ruhuna basins predicted that a well-distributed system of small tanks would have contributed to a gradual recharge of the groundwater off-setting the inherent weakness of the regolith aquifer (Jayawardane, 2002). The more recent studies in Weli Oya and Mau Ara project areas confirm that the above assumption was correct. A better spatial and temporal distribution of groundwater was observed in the areas where water diversions augmented the village tanks. The ongoing WWAP studies will use GIS techniques to assess the impact.

A local food production drive has been launched by the government to bring all the cultivable land into production process. Special emphasis is given to home garden cultivation. Surveys revealed the high level of participation in the programme by women. Awareness in urban agricultural techniques has been promoted under this programme. The traditional technologies in fertilizing and pest management are also being promoted, and it is expected that an environmentally friendly agricultural system will evolve with the programme.

The impact of climate change could change the development priorities. As explained in the Chapter 4, (State of the resource) the people in the upper catchment will face severe water problems, due to reduction and changes to the pattern of rainfall. However, the water resources development for livelihoods is heavy in the lower catchment, which falls in the area designated as the dry zone. The decision makers will have to address the water needs of the upper catchments, while there should be better focus of research on the upper catchments of other major rivers.

5.9.2 Agriculture and technology

The studies carried out in Mau Ara - Malala Oya diversion project area revealed positive impacts of irrigation development on groundwater. This project was designed to augment a series of small reservoirs called “village tanks” through diversion of water from a stream. The village tanks are normally managed by the village community to obtain services such as drinking water, sanitation, water for livestock and irrigation, and main source of water is rain. They also recharge ground water, which is an important source of water during the dry season. The studies carried out in the project area show that groundwater levels deplete after May under normal circumstances (without irrigation). Irrigation water diversions help to maintain high water levels until July and August, which are the dry months (Panabokke et al, 2007).

The area developed by the Weli Oya (a tributary of Walawe) diversion scheme lies in the District of Moneragala, which is one of the least developed districts of Sri Lanka, severely affected by poverty. The project comprised diversion of water from Weli Oya to water scarce areas of Moneragala. The studies in Weli Oya area showed that water quality is considerably better in shallow dug wells compared to deep tube wells. (Seneviratne, 2004).

The common factor for the above mentioned diversion projects is the use of existing village tanks for storage of water, instead of new storage reservoirs. Considering the advantages in less construction cost and less environmental damage, this methodology constitutes a technological response option to the current water demand in the rural areas.

The water management measures adopted in Uda Walawe Left Bank extension project also provide the managers with some technology driven response options to water shortages. The improvement of water productivity over the years in Uda Walawe scheme is due to a combination of water management, agricultural and infrastructure improvement measures.

5.10 Knowledge base in water resources

Sri Lanka's knowledgebase in water resources can be categorized as the traditional knowledge base and the modern knowledgebase. The traditional knowledge is evolved from the ancient hydraulic civilization that flourished until 13th century. The remnants of this knowledge are still used by rural farmers in the management of village irrigation systems, soil conservation, non-chemical methods of pest control, and scheduling irrigation seasons. Documentation of this knowledgebase had been done in patches, and a comprehensive study and documentation could be useful for water management.

The modern knowledgebase comprises of incorporation of water sciences in general education, work carried out by the research institutions and researchers and databases maintained by various institutions. The Sri Lanka National Water Development Report identified that incorporation of water sciences needs to be improved. At the bachelor's degree level, the content of water subject ranges about 15-20%. Several universities have initiated post-graduate level water related education, which is encouraging.

The databases and use of the Internet to share data and information show improvement. The Science and Technology Management Information System (STMIS) database maintained by National Science Foundation provides information on science and technology sector, including the information on the scientific work in the field of water resources. Several databases have been created to share information in disaster management since tsunami of 2004. IWMI also provides much information about scientific work they do. The Ministry of Agriculture initiated a website to link water related institutions in 2008; the sustainability of this depends on the priority assigned to this kind of activities by the national institutions.

The Dam Safety and Water Resources Planning Project, inter alia, plan to improve the hydro-meteorological information system of the entire country. The project plans to improve the data collection, dissemination and access. Access to data had been identified as a major limiting factor to carry out research and it is hoped that the project will contribute sufficiently to narrow the gap.

5.11 IWRM and future management strategies

The future opportunities for major water resources developments in the Walawe basin are scarce. There are several options for the utilization of remaining water resources in the downstream, comprised mainly of agricultural drainage. Such options include using for irrigation expansion, industrial activities and urban water supply. An important factor to be considered during water allocation is the sustainability of ecosystems. In the upstream, climate changes are impacting the water availability for livelihoods and basic needs. Therefore, it appears that the Walawe basin is entering a phase where strategies based on IWRM principles are crucial for management. In such a situation, the decision makers and managers would find policy gaps a constraint.

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Annexes

Annex1 Major vegetation/habitat types found in the coastal lands of study area

Vegetation / Habitat Type	Kalametiya	Lunama
Natural Terrestrial		
Sand dune		X
Scrubland	X	X
Grassland	X	X
Natural wetland		
Mangrove Reed bed	X X	X
Salt marsh		X
Lagoon Coral reef	X	X X
Sand stone reef	X	X
Sea shore vegetation Seasonal pond	X X	X
Anthropogenic terrestrial	X	X
Coconut Plantation		
Home Garden/Chena	X	X
Anthropogenic wetland	X	
Paddy field		

X - Indicates presence

Annex II. Common plants in different habitats and vegetation types of Lunama - Kalametiya area.

Habitat/Vegetation type	Scientific Name	Family	Local name
Mangrove	*Sonneratia caseolaris*	Sonneratiaceae	Kirala
	Excoecaria agallocha	Euphorbiaceae	Thelakeeriya
	Avicennia marina	Avicenniaceae	Kadol
	Acanthus ilicifolius	Acanthaceae	Katu Ikiliya
	Acrostichum aureum	Pteridaceae	Karan Koku
	Ceriops tagal	Rhizoporaceae	
	Lumnitzera racemosa	Combretaceae	
Sand dune vegetation	*Spinifex littoreus*	Poaceae	Maharawana revula
	Hydrophylax maritima	Rubiaceae	Mudu geta kola
Habitat/Vegetation type	Scientific Name	Family	Local name
	Azima tetracantha	Salvadoraceae	
	Cyperus bulbosus	Cyperaceae	
Scrubland	*Dichrostachys cinerea*	Fabaceae	Andara
	Flueggea leucopyrus	Euphorbiaceae	Keen katupila
	Capparis sepiaria	Capparidaceae	Torikei
	Carissa spinarum	Apocynaceae	Keen karamba
	Azima tetracantha	Salvadoraceae	
	Randia dumetorium	Rubiaceae	Kukurumanna
	Cassia auriculata	Fabaceae	Ranawara
	Opuntia dillenii	Cactaceae	Katu Pathok
Gentle sea shore	*Spinifex littoreus*	Poaceae	Maharawana revula
Vegetation	*Ziziphus oenoplia*	Rhamnaceae	Eraminiya
	Launaea sarmentosa	Asteraceae	
	Opuntia dillenii	Cactaceae	Katu Pathok
	Capparis sepiaria	Capparidaceae	Torikei
	Cyperus bulbosus	Cyperaceae	
	Hydrophylax maritima	Rubiaceae	Mudu geta kola
	Ipomoea pes-caprae	Convolvulaceae	Mudu bimtamburu
	Evolvulus alsinoides	Convolvulaceae	Vishnukranthi
	Lantana camara	Verbenaceae	Hinguru
	Pandanus odoratisimum	Pandanaceae	Wetakeyiya, Mudukeyiya
Grasslands	*Cynodon dactylon*	Poaceae	Ruha, Belathana
	Cyperus rotundus	Cyperaceae	Kalanduru
	Eragrostis gangetica	Poaceae	Ela kuru thana
	Kyllinga nemoralis	Cyperaceae	Mottu thana
	Panicum repens	Poaceae	Etora
Salt marsh community	*Halosarcia indica*	Chenopodiaceae	
	Cynodon dactylon	Poaceae	Ruha, Belathana
	Cyperus stoloniferus	Cyperaceae	
	Prosopis juliflora	Fabaceae	Katu andara
Reed beds	*Typha angustifolia*	Typhaceae	Hambu pan
	Ceratophyllum demersum	Ceratophyllaceae	
	Cyperus rotundus	Cyperaceae	Kalanduru
	Eleochans geniculata	Cyperaceae	
	Cynodon dactylon	Poaceae	Ruha, Belathana

Source: Weerasinghe et al, 2008

Annex III. Status of bio-diversity in coastal ecosystems of Walawe basin

Costal area coves in Walawe basin	**Major ecosystems and Habitat**	**Floral diversity (Common Plants)**	**Faunal diversity**	**Threats**
Rekawa, Ussangoda and Kalametiya	*Beaches *Beach rocks / *Sandstone Beach Reefs *Rocky Shores *Coral Reefs *Mangroves *Sand dune vegetation *Scrubland *Gentle sea shore vegetation *Grassland *Salt marsh *Reed beds	*Inter-tidal habitat 23 Marine Algae species * seven Mangrove species * 4 species in Sand dune vegetation * 8 Scrubland species *11 species in Gentle sea shore vegetation *5 Grassland species *4 species in Salt marsh *Reed beds	Wetland Species # Vertebrates 283 (14 – endemic, 17 - threatened) Fish 35 amphibians 13 reptiles 43 birds 168 mammals 24 # Invertebrate butterflies 75 (1– endemic, 12 -threatened) molluscas 18 (5– endemic, 2 -threatened) Marine species #Vertebrates more than 200 Fish #Invertebrates more than 200	*Destruction and degradation of habitats/ ecosystems # Deforestation # Shell mining # Drainage of irrigation water in to lagoon # Siltation # Dischage of agrochemicals into wetlands # Unregulated animal husbandry activities # Unauthorized development activities #Direct over exploitation of species #Hunting and poaching of animals #Road kills *Spread of invasive alien species *Natural factors - Tsunami

Annex IV. Water supply schemes in Walawe basin and main characteristics (Apr 2008)

Source : 3rd WSSP Package C Final Report annex G, NWSDB, CWSSP

	Scheme	DS	District	Implimenting Agency	O&M Agency	Source	piped coverage	Water treatment	Water Serving Population	Supply Hours
1	Ambalantota Ekabadda	Ambalantota	Hambantota	FWSSP of NWSDB	NWSDB	Walawe ganga	Full	full	3935	
2	Ambalantota WSS	Ambalantota	Hambantota	NWSDB	NWSDB	Walawe ganga	Full		25319	20
3	Hambantota WSS	Hambantota	Hambantota	NWSDB	NWSDB	Walawe ganga	Full	full	25602	20
4	Hungama/Ranna WSS	Ambalantota	Hambantota	NWSDB	NWSDB	Kattakaduwa Wewa	Full	full	41100	
5	Hadawinna	Ambalantota	Hambantota	TWSSP of NWSDB	CBO	Borehole	Full		1970	24
6	Mulana extension	Ambalantota	Hambantota	TWSSP of NWSDB	CBO		Full		1918	24
7	Ihalagama	Ambalantota	Hambantota	TWSSP of NWSDB	CBO	Dug well	Full		1287	24
8	Walawetta West	Ambalantota	Hambantota	TWSSP of NWSDB	CBO	Borehole	Full		1801	24
9	Mamadala North	Ambalantota	Hambantota	TWSSP of NWSDB	CBO	Borehole	Full		1505	24
10	Athbatuwa	Ambalantota	Hambantota	TWSSP of NWSDB	CBO	Dug well	Full		1924	24
11	Mahajandura	Ambalantota	Hambantota	TWSSP of NWSDB	CBO	Dug well	Full		1451	24
12	Hadunkatuwa	Ambalantota	Hambantota	TWSSP of NWSDB	CBO	Dug well	Full		1098	24
13	Liyangastota	Ambalantota	Hambantota	TWSSP of NWSDB	CBO	Borehole	Full		2601	24
14	Deniya Pingama	Ambalantota	Hambantota	TWSSP of NWSDB	CBO	Kachchigal Ara	Full		2462	24
15	Rotte	Ambalantota	Hambantota	TWSSP of NWSDB	CBO	Borehole	Full		2445	24

	Scheme	DS	District	Implimenting Agency	O&M Agency	Source	piped coverage	Water treatment	Water Serving Population	Supply Hours
16	Hathagala	Ambalantota	Hambantota	TWSSP of NWSDB	CBO	Borehole	Partial	No	250	
17	Mamadala South	Ambalantota	Hambantota	TWSSP of NWSDB	CBO	Borehole	Partial	No	370	
18	Elegoda East	Ambalantota	Hambantota	TWSSP of NWSDB	CBO	Borehole	Partial	No	135	
19	Barawa Kumbuka	Ambalantota	Hambantota	TWSSP of NWSDB	CBO	Borehole	Partial	No	7570	
20	Bulathgama	Balangoda	Ratnapura	CWSPU	CBO	Spring, dug well	Partial	partial	1572	
21	Egoda Waleboda	Balangoda	Ratnapura	CWSPU	CBO	Spring	Full	partial	1932	
22	Kalupedigama	Balangoda	Ratnapura	CWSPU	CBO	Spring, dug well	Partial	partial	1278	
23	Kumaragama	Balangoda	Ratnapura	CWSPU	CBO	Spring, dug well	Partial	partial	864	
24	Kuragala	Balangoda	Ratnapura	CWSPU	CBO	Spring, dug well	Partial	partial	936	
25	Massenna	Balangoda	Ratnapura	CWSPU	CBO	Spring, dug well	Partial	partial	1338	
26	Mawela	Balangoda	Ratnapura	CWSPU	CBO	Shallow well	Non	partial	339	
27	Medakanda	Balangoda	Ratnapura	CWSPU	CBO	Spring	Full	partial	2028	
28	Mulgama	Balangoda	Ratnapura	CWSPU	CBO	Spring, dug well	Partial	partial	1242	
29	Pallekanda	Balangoda	Ratnapura	CWSPU	CBO	Spring, dug well	Partial	partial	1428	
30	Rajawaka	Balangoda	Ratnapura	CWSPU	CBO	Spring, dug wells	Partial	partial	2016	
31	Thelandiriya	Balangoda	Ratnapura	CWSPU	CBO	Spring, dug well, hand pump	Partial	partial	1020	
32	Udumullegama	Balangoda	Ratnapura	CWSPU	CBO	Spring, dug wells	Partial	partial	1220	
33	Vijinathkumbura	Balangoda	Ratnapura	CWSPU	CBO	dug well	Non	partial	900	
34	Vikiliya	Balangoda	Ratnapura	CWSPU	CBO	Spring, dug wells	Partial	partial	2154	
35	Yahalewela	Balangoda	Ratnapura	CWSPU	CBO	Spring, dug wells	Partial	partial	1026	
36	Kaltota	Balangoda	Ratnapura	CWSPU/NWSDB	CBO	borehole	Full	partial	1550	
37	Ellewatta	Balangoda	Ratnapura	CWSSP	CBO	Surface water			870	
38	Durakanda	Balangoda	Ratnapura	CWSSP	CBO	Surface water			1615	

	Scheme	DS	District	Implimenting Agency	O&M Agency	Source	piped coverage	Water treatment	Water Serving Population	Supply Hours
39	Kongahamankada	Balangoda	Ratnapura	CWSSP	CBO	Gr water			1650	
40	Thanjanthenne	Balangoda	Ratnapura	CWSSP	CBO	Surface water			1870	
41	Balangoda	Balangoda	Ratnapura	NWSDB	NWSDB	Walawe ganga/Pettigala spring	Full	full	25000	6 to 12
42	Detanagala	Balangoda	Ratnapura	PHSWT	CBO	spring	Full	partial	135	
43	Pettigala Lower	Balangoda	Ratnapura	PHSWT	CBO	spring	Full	partial	252	
44	Rye-Wikiliya	Balangoda	Ratnapura	PHSWT	CBO	spring	Full	partial	336	
45	Walaboda	Balangoda	Ratnapura	PHSWT	CBO	spring	Full	partial	112	
46	Maratotam	Balangoda	Ratnapura	PHSWT	CBO	spring	Full	partial	273	
47	Ukgaldoowa	Balangoda	Ratnapura	PHSWT	CBO	spring	Full	partial	240	
48	Culdeen	Balangoda	Ratnapura	PHSWT	CBO	spring	Full	partial	480	
49	Pettigala	Balangoda	Ratnapura	PHSWT	CBO	spring	Full	partial	112	
50	Rasagalla	Balangoda	Ratnapura	PHSWT	CBO	spring	Full	partial	140	
51	Meddakanda	Balangoda	Ratnapura	PHSWT	CBO	spring	Full	partial	116	
52	Meddakanda	Balangoda	Ratnapura	PHSWT	CBO	spring	Full	partial	544	
53	Nagrak	Balangoda	Ratnapura	PHSWT	CBO	spring	Full	partial	288	
54	Pettigala Upper	Balangoda	Ratnapura	PHSWT	CBO	spring	Full	partial	1254	
55	Darshanagama	Embilipitiya	Ratnapura	CWSPU	CBO	Spring	Full	partial	436	
56	Ketagalara	Embilipitiya	Ratnapura	CWSPU	CBO	Spring	Full	partial	2877	
57	Konkatuwa	Embilipitiya	Ratnapura	CWSPU	CBO	Spring, dug well, hand pump	Partial	partial	1860	
58	Modarawana	Embilipitiya	Ratnapura	CWSPU	CBO	Spring	Full	partial	1833	
59	Mudunmankada	Embilipitiya	Ratnapura	CWSPU	CBO	Spring	Full	partial	810	
60	Nindagampelessa	Embilipitiya	Ratnapura	CWSPU	CBO	Spring	Full	partial	2430	
61	Pallebedda	Embilipitiya	Ratnapura	CWSPU	CBO	Spring	Full	partial	1422	
62	Panahanduwa	Embilipitiya	Ratnapura	CWSPU	CBO	Spring	Full	partial	2016	
63	Panamura I	Embilipitiya	Ratnapura	CWSPU	CBO	Spring	Full	partial	2534	
64	Panamura II	Embilipitiya	Ratnapura	CWSPU	CBO	Spring, dug wells	Partial	partial	2108	
65	Ranchamadama	Embilipitiya	Ratnapura	CWSPU	CBO	Spring, dug well, hand pump	Partial	partial	1984	

	Scheme	DS	District	Implimenting Agency	O&M Agency	Source	piped coverage	Water treatment	Water Serving Population	Supply Hours
66	Sankapala	Embilipitiya	Ratnapura	CWSPU	CBO	Spring	Full	partial	2820	
67	Sudugala	Embilipitiya	Ratnapura	CWSPU	CBO	Dug well, hand pump	Non	partial	708	
68	Weheragama	Embilipitiya	Ratnapura	IRDP	PS	spring		partial	500	
69	Udawalawe	Embilipitiya	Ratnapura	NWSDB	NWSDB	Uda walawe RB canal	Full	partial	18000	
70	Embilipitiya	Embilipitiya	Ratnapura	NWSDB	NWSDB	Chandrika wewa	Full	full	42000	
71	Bibilegama	Godakawela	Ratnapura	CWSPU	CBO	Spring	Full	partial	1206	
72	Bibilegama West	Godakawela	Ratnapura	CWSPU	CBO	Spring	Full	partial	1849	
73	Bibilegama East	Godakawela	Ratnapura	CWSPU	CBO	Spring	Full	partial	790	
74	Dabawinna	Godakawela	Ratnapura	CWSPU	CBO	Spring	Full	partial	791	
75	Galahitiya	Godakawela	Ratnapura	CWSPU	CBO	Spring	Full	partial	1142	
76	Mahagama East	Godakawela	Ratnapura	CWSPU	CBO	Spring	Full	partial	1015	
77	Mahagama West	Godakawela	Ratnapura	CWSPU	CBO	Spring	Full	partial	1458	
78	Masimbula	Godakawela	Ratnapura	CWSPU	CBO	Spring, dug wells, hand pumps	Partial	partial	2279	
79	Meddegama	Godakawela	Ratnapura	CWSPU	CBO	Spring	Full	partial	905	
80	Thambagamuwa east	Godakawela	Ratnapura	CWSPU	CBO	Spring	Full	partial	1369	
81	Thambagamuwa west	Godakawela	Ratnapura	CWSPU	CBO	Spring	Full	partial	1809	
82	Werahera East	Godakawela	Ratnapura	CWSPU	CBO	Dug wells, hand pumps	Non	partial	819	
83	Werahera west	Godakawela	Ratnapura	CWSSP	CBO	Gr Water			1200	
84	Kompitiya	Godakawela	Ratnapura	CWSSP	CBO	Gr Water			1135	
85	Kauduwewa	Godakawela	Ratnapura	CWSSP	CBO	Gr Water			1560	
86	Werahera East	Godakawela	Ratnapura	CWSSP	CBO	Gr Water			870	
87	Makadura	Godakawela	Ratnapura	CWSSP	CBO	Rain water			445	
88	Hiramadugama	Godakawela	Ratnapura	CWSSP	CBO	Gr water			255	
89	Ematiyagoda	Godakawela	Ratnapura	CWSSP	CBO				815	
90	Rideewita	Godakawela	Ratnapura	CWSSP	CBO				1140	
91	Bambarapokuna	Haldummulla	Badulla	CWSPU	CBO	spring	Full	partial	1036	
92	Beragala	Haldummulla	Badulla	CWSPU	CBO	Spring, dug wells	Partial	partial	830	

	Scheme	DS	District	Implimenting Agency	O&M Agency	Source	piped coverage	Water treatment	Water Serving Population	Supply Hours
93	Gampaha	Haldummulla	Badulla	CWSPU	CBO	Spring, dug wells	Partial	partial	1174	
94	Hrankahawa	Haldummulla	Badulla	CWSPU	CBO	Spring, dug wells	Partial	partial	631	
95	Kalupahana	Haldummulla	Badulla	CWSPU	CBO	spring	Full	partial	940	
96	Kelipanawela	Haldummulla	Badulla	CWSPU	CBO	Spring, dug wells	Partial	partial	698	
97	Kitulgahaarawa	Haldummulla	Badulla	CWSPU	CBO	Spring, dug wells	Partial	partial	564	
98	Kolongasthenna	Haldummulla	Badulla	CWSPU	CBO	Dug wells, hand pump wells	Non	partial	875	
99	Kosgama	Haldummulla	Badulla	CWSPU	CBO	Spring, dug wells	Partial	partial	629	
100	Lenastota	Haldummulla	Badulla	CWSPU	CBO	Spring, dug wells	Partial	partial	460	
101	Madawela	Haldummulla	Badulla	CWSPU	CBO	spring	Full	partial	605	
102	Moraketiya	Haldummulla	Badulla	CWSPU	CBO	Spring, dug wells	Partial	partial	680	
103	Ranawanguhawa	Haldummulla	Badulla	CWSPU	CBO	spring	Full	partial	790	
104	Ranasinghegama	Haldummulla	Badulla	CWSPU	CBO	spring	Full	partial	671	
105	Uvathenna	Haldummulla	Badulla	CWSPU	CBO	spring	Full	partial	825	
106	Viharagala	Haldummulla	Badulla	CWSPU	CBO	spring	Full	partial	497	
107	Walhaputhenna	Haldummulla	Badulla	CWSPU	CBO	Spring, dug wells	Partial	partial	688	
108	Welanwita	Haldummulla	Badulla	CWSPU	CBO	Spring, dug wells	Partial	partial	597	
109	Pita Ratmale	Haputale	Badulla	PHSWT	CBO	spring	Full	partial	1645	
110	Nyabedda	Haputale	Badulla	PHSWT	CBO	spring	Full	partial	728	
111	Alakolaella	Imbulpe	Ratnapura	CWSPU	CBO	Spring	Full	partial	2099	
112	Atawakvala	Imbulpe	Ratnapura	CWSPU	CBO	Spring, dug wells	Partial	partial	2520	
113	Belankanda	Imbulpe	Ratnapura	CWSPU	CBO	Spring	Full	partial	2307	
114	Dewalagamagawa	Imbulpe	Ratnapura	CWSPU	CBO	Spring	Full	partial	1220	
115	Gurubewila	Imbulpe	Ratnapura	CWSPU	CBO	Spring	Full	partial	1260	
116	Halpe	Imbulpe	Ratnapura	CWSPU	CBO	Spring	Partial	partial	675	
117	Hatarabage	Imbulpe	Ratnapura	CWSPU	CBO	Spring, dug wells	Partial	partial	1305	
118	Ihalagalagama	Imbulpe	Ratnapura	CWSPU	CBO	Spring	Full	partial	1020	
119	Karadiyamulla	Imbulpe	Ratnapura	CWSPU	CBO	Spring, dug wells	Partial	partial	2285	
120	Karagastalawa	Imbulpe	Ratnapura	CWSPU	CBO	Spring, dug wells	Partial	partial	1427	

	Scheme	DS	District	Implimenting Agency	O&M Agency	Source	piped coverage	Water treatment	Water Serving Population	Supply Hours
121	Kumburutheniwala	Imbulpe	Ratnapura	CWSPU	CBO	Spring	Full	partial	1476	
122	Medathalawa	Imbulpe	Ratnapura	CWSPU	CBO	Spring, hand dug wells	Partial	partial	1691	
123	Minuanarawa	Imbulpe	Ratnapura	CWSPU	CBO	Spring, hand dug wells	Partial	partial	825	
124	Naluwela	Imbulpe	Ratnapura	CWSPU	CBO	Spring, hand dug wells	Partial	partial	980	
125	Niththamaluwa	Imbulpe	Ratnapura	CWSPU	CBO	Spring	Full	partial	874	
126	Pallewela	Imbulpe	Ratnapura	CWSPU	CBO	Spring	Full	partial	1316	
127	Pambagolla	Imbulpe	Ratnapura	CWSPU	CBO	Spring	Full	partial	2414	
128	Pandeniya	Imbulpe	Ratnapura	CWSPU	CBO	Spring	Full	partial	1495	
129	Passaramulla	Imbulpe	Ratnapura	CWSPU	CBO	Spring	Full	partial	1277	
130	Pidiligannawela	Imbulpe	Ratnapura	CWSPU	CBO	Spring	Full	partial	3147	
131	Puwaggahawela	Imbulpe	Ratnapura	CWSPU	CBO	Spring, hand dug wells	Partial	partial	1439	
132	Seelogama	Imbulpe	Ratnapura	CWSPU	CBO	Spring	Full	partial	1299	
133	Thotapalla	Imbulpe	Ratnapura	CWSPU	CBO	Hand dug wells	Non	partial	1327	
134	Udagama	Imbulpe	Ratnapura	CWSPU	CBO	Spring	Full	partial	1316	
135	Welanhinna	Imbulpe	Ratnapura	CWSPU	CBO	Spring, dug wells	Partial	partial	1546	
136	Wiharawela	Imbulpe	Ratnapura	CWSPU	CBO	Spring	Full	partial	706	
137	Pinnawala	Imbulpe	Ratnapura	PS	PS	spring	Full	partial	1500	
138	Belihuloya	Imbulpe	Ratnapura	PS	PS	spring	Full	partial	1500	
139	Hirikatuoya	Imbulpe	Ratnapura	PS	PS	spring	Full	partial	1800	
140	Rakwana	Kalavana	Ratnapura	CWSPU/NWSDB	CBO	stream	Full	partial	4480	
141	Ambagahayaya	Kolonna	Ratnapura	CWSPU	CBO	Spring, dug wells, hand pumps	Partial	partial	1465	
142	Boraluwageinna	Kolonna	Ratnapura	CWSPU	CBO	Spring	Full	partial	1345	
143	Buluthota	Kolonna	Ratnapura	CWSPU	CBO	Spring, dug wells	Partial	partial	1484	
144	Buthkanda	Kolonna	Ratnapura	CWSPU	CBO	Spring	Full	partial	1469	
145	Henakgoda	Kolonna	Ratnapura	CWSPU	CBO	Spring	Full	partial	443	
146	Iththakanda	Kolonna	Ratnapura	CWSPU	CBO	Spring	Full	partial	1799	
147	Kella	Kolonna	Ratnapura	CWSPU	CBO	Spring, dug wells	Partial	partial	1534	

	Scheme	DS	District	Implimenting Agency	O&M Agency	Source	piped coverage	Water treatment	Water Serving Population	Supply Hours
148	Koppakanda	Kolonna	Ratnapura	CWSPU	CBO	Spring, dug wells	Partial	partial	1190	
149	Maduwanwela	Kolonna	Ratnapura	CWSPU	CBO	Dug wells	Non	partial	1546	
150	Nanadanagama	Kolonna	Ratnapura	CWSPU	CBO	Spring, dug wells, hand pumps	Partial	partial	1299	
151	Ranhotikanda	Kolonna	Ratnapura	CWSPU	CBO	Spring, dug wells	Partial	partial	2559	
152	Ulinduwewa	Kolonna	Ratnapura	CWSPU	CBO	Spring	Full	partial	2392	
153	Walakada	Kolonna	Ratnapura	CWSPU	CBO	Spring, dug wells	Partial	partial	728	
154	Wawulpane	Kolonna	Ratnapura	CWSPU	CBO	Spring, dug wells	Partial	partial	409	
155	Omalpe	Kolonna	Ratnapura	CWSSP	CBO				1190	
156	Welewathugoda	Kolonna	Ratnapura	CWSSP	CBO	Surface water			680	
157	Habbeliyara	Kolonna	Ratnapura	CWSSP	CBO	Surface water			1770	
158	Kolonna	Kolonna	Ratnapura	CWSSP	CBO	Surface water			3320	
159	Wijeriya	Kolonna	Ratnapura	CWSSP	CBO	Surface water			2015	
160	Pupulaketiya	Kolonna	Ratnapura	CWSSP	CBO	Surface water			1250	
161	Heyes Lower	Kolonna	Ratnapura	PHSWT	CBO	Hulanda oya	Full	partial	464	
162	Heyes upper	Kolonna	Ratnapura	PHSWT	CBO	Gin ganga	Full	partial	252	
163	Heyes F-A	Kolonna	Ratnapura	PHSWT	CBO	Gin ganga	Full	partial	332	
164	Heyes F-B	Kolonna	Ratnapura	PHSWT	CBO	Hulanda oya	Full	partial	273	
165	Heyes Long ford	Kolonna	Ratnapura	PHSWT	CBO	Hulanda oya	Full	partial	229	
166	Lankaberiya	Kolonna	Ratnapura	PHSWT	CBO	Hulanda oya	Full	partial	387	
167	Ketaliyanpola	Ratnapura	Ratnapura	CWSSP	CBO	Gr water		non	1140	
168	Alupola	Ratnapura	Ratnapura	CWSSP	CBO	Surface water		non	1330	
169	Sooriyawewa Extension	Sooriya wewa	Hambantota	TWSSP of NWSDB	NWSDB	Reservoir	Full	full	3840	24
170	Sooriyawewa Ekabadda	Sooriyawewa	Hambantota	CWSSP	CBO	Dug well	Full	partial	14500	
171	Habarathwela	Sooriyawewa	Hambantota	CWSSP	CBO	Dug well	Full	partial	1575	
172	Hathporuwa	Sooriyawewa	Hambantota	CWSSP	CBO	Dug well	Full	partial	2000	
173	Andarawewa	Sooriyawewa	Hambantota	CWSSP	CBO	Dug well	Full	partial	3000	

	Scheme	DS	District	Implimenting Agency	O&M Agency	Source	piped coverage	Water treatment	Water Serving Population	Supply Hours
174	Wadiwewa	Sooriyawewa	Hambantota	CWSSP	CBO	Dug well	Full	partial	3000	
175	Sooriyawewa	Sooriyawewa	Hambantota	NWSDB	NWSDB	Sooriyawewa Res	Full	full	12719	
176	Arawanamulla	Sooriyawewa	Hambantota	TWSSP of NWSDB	CBO	Baragamawila	Full	partial	1326	24
177	Elalla	Sooriyawewa	Hambantota	TWSSP of NWSDB	CBO				1353	
178	Habarathwela	Sooriyawewa	Hambantota	TWSSP of NWSDB	CBO	RWT			4925	
179	Koholankala	Sooriyawewa	Hambantota	TWSSP of NWSDB	CBO	RWT			1476	
180	Abalagaswila North	Sooriyawewa	Hambantota	TWSSP of NWSDB	CBO				7290	
181	Suruvirugama	Sooriyawewa	Hambantota	TWSSP of NWSDB	CBO				3840	
182	Weliwewa	Sooriyawewa	Hambantota	TWSSP of NWSDB	CBO	RWT			1085	
183	Mahagalwewa	Sooriyawewa	Hambantota	TWSSP of NWSDB		Mahagalwewa Tank	Full	partial	3100	24
184	Sevanagala	Sevanagala	Monaragala	NWSDB	CBO	Walawe ganga				
185	Bambaragala	Weligepola	Ratnapura	CWSPU	CBO	Dug wells, hand pump wells	Non	partial	1890	
186	Galgodagama	Weligepola	Ratnapura	CWSPU	CBO	hand dug wells	Non	partial	1299	
187	Galpaya	Weligepola	Ratnapura	CWSPU	CBO	Spring, dug wells, hand pumps	Partial	partial	2996	
188	Medaganoya	Weligepola	Ratnapura	CWSPU	CBO	Dug wells, hand pumps	Non	partial	1210	
189	Palukgahawela	Weligepola	Ratnapura	CWSPU	CBO	Spring, dug wells	Partial	partial	2257	
190	Paragahamadiththa	Weligepola	Ratnapura	CWSPU	CBO	Spring, dug wells	Partial	partial	1305	
191	Ranwala	Weligepola	Ratnapura	CWSPU	CBO	Spring, dug wells	Partial	partial	1865	
192	Udagangoda	Weligepola	Ratnapura	CWSPU	CBO	Dug wells	Non	partial	1098	
193	Weligepola	Weligepola	Ratnapura	CWSPU	CBO	Dug wells, hand pumps	Non	partial	1467	
194	Pussathota	Weligepola	Ratnapura	CWSSP	CBO	Gr Water			1250	

	Scheme	DS	District	Implimenting Agency	O&M Agency	Source	piped coverage	Water treatment	Water Serving Population	Supply Hours
195	Udaranwala	Weligepola	Ratnapura	CWSSP	CBO	Gr Water			1170	
196	Ammaduwa	Weligepola	Ratnapura	CWSSP	CBO				950	
197	Panana	Weligepola	Ratnapura	CWSSP	CBO				480	
198	Madawalakanda	Weligepola	Ratnapura	CWSSP	CBO	Gr water			980	
199	Kalatuwakanda	Weligepola	Ratnapura	CWSSP	CBO				805	
200	Belimalliyedda	Weligepola	Ratnapura	CWSSP	CBO				811	
201	Kahawatta	Pelmadulla	Ratnapura	NWSDB	NWSDB	Manana Dola/ Nada Dola	Full		8400	
202	Hingura		Ratnapura	Samurdhi	PS	spring		partial	593	

Annex V. Sanitation coverage in Walawe basin

District	DS Division	Total Housing units	Type of latrine: Water seal	Pour Flush	Pit	Other	Total	Population 2007	Sanitation Coverage
Monaragala	Thanamalvila	9787	1786	1351	4822		7959	24725	81.3%
	Sevanagala	7659					4595	42126	60.0%
Hambantota		106461	33113	13203	50541	512	97369		91.5%
	Ambalan tota	13797	3998	2753	5500	0	12251	68724	88.8%
	Hambantota	10270	3340	2437	3528	0	9305	49929	90.6%
	Sooriyawewa	7459	85	706	4447	23	5261	39993	70.5%
Ratnapura	Balangoda	15008	6238	3345	2124	0	11707	82547	78.0%
	Embilipitiya	23213	5863	6752	4094	631	17340	127674	74.7%
	Godakawela	13420	3511	4138	1568	205	9422	73812	70.2%
	Imbulpe	10874	2304	3773	878	13	7068	59314	65.0%
	Kolonna	8483	1611	2756	302	521	5190	46657	61.2%
	Weligepola	5649	852	1534	1585	601	3572	31073	63.2%
Badulla	Welimada	9449	2315	3432	1412	28	7187	51971	76.1%
	Haldummulla	7313	1334	1143	1552	734	4763	40221	65.1%
	Haputale	3976	1689	531	662	0	2882	21868	72.5%

Annex VI. List if major irrigation schemes

River Basin	Scheme	Command Area(Ha)
Walawe Ganga (18)	Kalthota	920
	Katupath Oya	400
	Uda Walawe-LB	12000
	* Kiri Ibban Wewa	-256
	* Habaralu Wewa	-276
	*Mahagam Tank	-531
	Uda Walawe-RB	11700
	* Chandrika Wewa	-3,864
	Kandiyapita	145
	Hambegamuwa	270
	Weli Oya Anicut	1000
	Mau Ara tank	1018
	Wellawa	200
	Walalgoda	200
	Hulanda Oya	198
	Panamure	480
	Ridiyagama Tank	2544
	Liyangastota-RB	3200
	Liyangastota-LB	3400
	Total	36612
Malala Oya (20)	Maha Aluthgam Aru	223
	Ranmudu Wewa	81
	Pahala Andara Wewa	151
	Pallemattala	134
	Mahagal Wewa	164
	Badagiriya Tank	668
	Total	**1421**

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