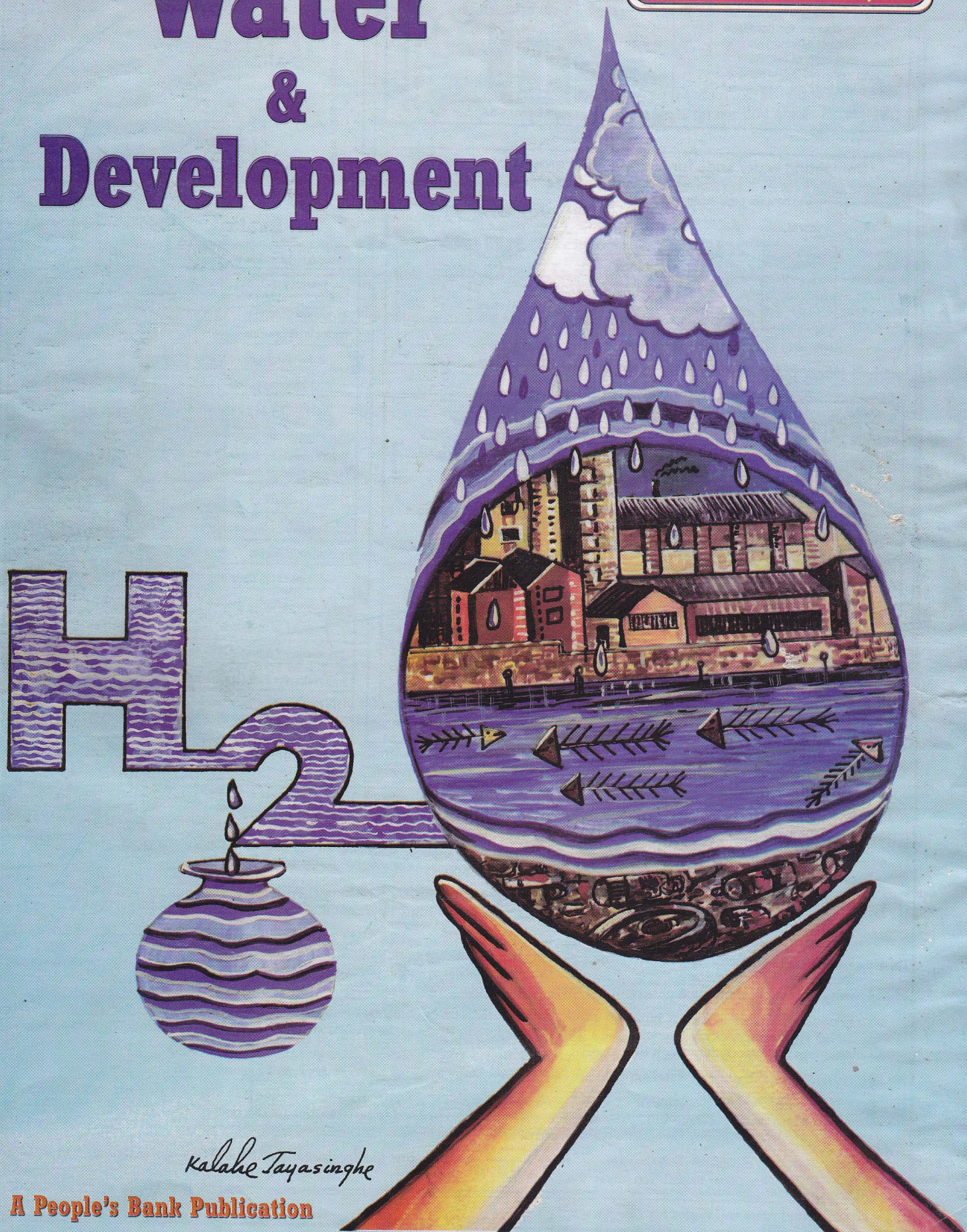


**ECONOMIC  
REVIEW**

June/ July 2009

# Water & Development



*Kalake Jayasinghe*

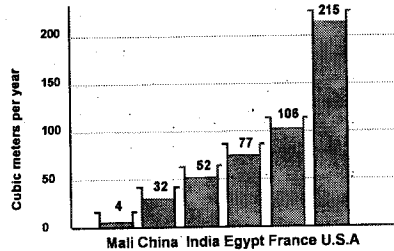
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# WATER FACTS

## Per capita use of water

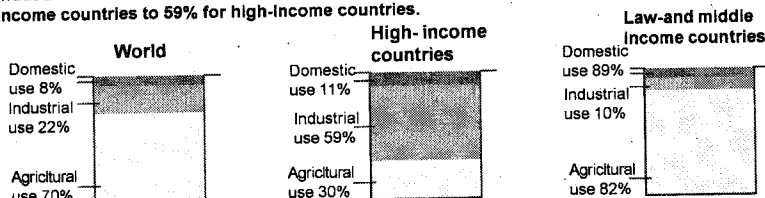
The adjacent chart derived from Aquastats data shows the wide variation in average per capita water withdrawals for domestic use from different nations. Humans need a minimum of two liters of drinking water per day to survive, which is less than one cubic meter per year.



Source: AQUASTAT-FAO's information System on water and agriculture (10-2-2003)

## Competing water uses for main income groups of countries

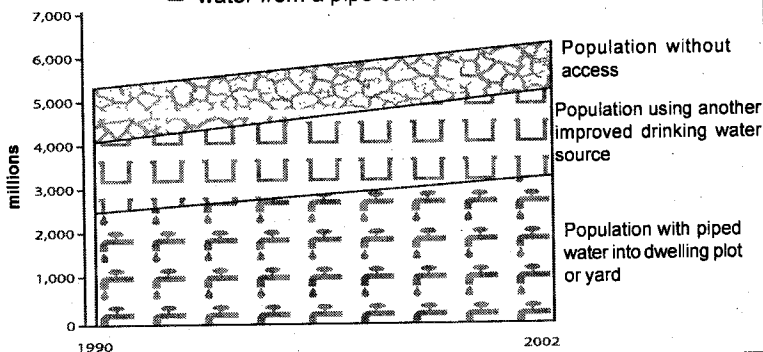
Industrial use of water increases with country income, going from 10% for low- and middle-income countries to 59% for high-income countries.



Ref. 8. "Water for People, Water for Life" United Nations World Water Development Report, UNESCO, 2003

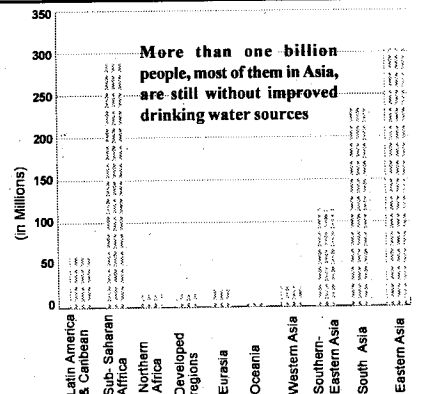
## Trends in service levels for drinking water

In 2002, more than half the world's population used water from a pipe connection at home



Source : World Business Council for Sustainable Development

## People without improved drinking water, 2002



Source : World Business Council for Sustainable Development

## Sri Lanka - Water Resources

Natural Renewable Water Resources	
Total, 1977-2001 (cubic km)	50
Per capita, 2002 (cubic meters per person)	2592
Water Withdrawals	
Total withdrawals (cubic km)	12.6
Withdrawals per capita (cubic m)	574
Withdrawals as a percentage of Actual Renewable Water Resources	22.1 %
Withdrawals by Sector (as a percent of total)	
Agriculture	96 %
Industry	2 %
Domestic	2 %
Freshwater Fish Species	
Total number of species	65
Number of threatened species	8
Freshwater Seafood Production	
Freshwater Fish Catch	
1990 (metric tons)	26765
2000 (metric tons)	36700

Source: World Resources Institute -www.earthtrends.wri.org

## Water Facts at Glance

- There are 1.1 billion people, or 18 per cent of the world's population, who lack access to safe drinking water. About 2.6 billion people, or 42 per cent of the total, lack access to basic sanitation.
- Only one per cent of the total water resources on earth is available for human use. While 70 per cent of the world's surface is covered by water, 97.5 per cent of that is salt water. Of the remaining 2.5 per cent that is freshwater, almost 68.7 per cent is frozen in ice caps and glaciers.
- Water withdrawals for irrigation have increased by over 60 per cent since 1960. About 70 per cent of all available freshwater is used for irrigation in agriculture. Yet because of inefficient irrigation systems, particularly in developing countries, 60 per cent of this water is lost to evaporation or is returned to rivers and groundwater aquifers.
- In parts of the United States, China and India, groundwater is being consumed faster than it is being replenished, and groundwater tables are steadily falling. Some rivers, such as the Colorado River in the western United States and the Yellow River in China, often run dry before they reach the sea.
- Up to 30 per cent of fresh water supplies are lost due to leakage in developed countries, and in some major cities, losses can run as high as 40 to 70 per cent.
- About 90 per cent of sewage and 70 per cent of industrial wastes in developing countries are discharged into water courses without treatment, often polluting the usable water supply.
- Every week an estimated 42,000 people die from diseases related to low quality drinking water and lack of sanitation. Over 90 per cent of them occur to children under the age of 5.

Source : United Nations/Water for Life - www0.un.org

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Owing to the importance of the subject of our Special Report, this Review comes out as a Double issue. Subscribers Please note that this Special 73 page issue on the Water and Development will be regarded, for subscription purposes, as two separate issues.

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**Next Issue : International Trade**

# Significance of Water in the Sri Lankan Context: A Sociological Perspective

## Introduction

All over the world, almost all the great civilisations started with river valleys. Those societies and their magnificent cultures produced diverse identities which are still in existence with identifiable characteristics. Water is a basic human and animal need, and is the life blood of all living organisms. This short article aims to discuss the sociological values of water, and how it was significant to the development of a unique water culture in Sri Lanka.

## Ancient River Valley Civilisations

Before we discuss Sri Lankan water culture, we have to be aware of the nature of global water-based civilisations and their contributions to the social and cultural development in the global context. For the first time in our history, the Neolithic period began with agriculture. Agriculture-based villages originated in about 9000 B.C. (Saure, 1957). The area, today known as Israel, Jordan, Syria, Lebanon, encompassed the Fertile Crescent in the Euphrates and Tigris river basins. Early forms of agriculture included the irrigation practices of Mesopotamia, Egypt and American South West other parts of the world (Storal, 1979). However in the Fertile Crescent, people had started agriculture and animal husbandry, sowing wheat seeds in hilly terraced area by 7000 B.C., and the wheat culture was started. However, water culture-based agricultural cities appeared in those two locations, originally. They are Mesopotamia and Meso America (Sjoberg, 1960).

In the second stage, additional hydraulic societies independently developed in the valley of Nile or the Indus and the Huang - Ho. The available evidence provides

information on the evolutionary process of water cultures in the global context as follows (Sjoberg, 1960):

- i. The first stage was in Mesapothemian river basins of Euphrates and Tigris.
- ii. The second stage near the Nile river area of Egypt.
- iii. The third stage in the Indus valley, Harappa in Panjab and Mohenjodaro in valley of the Indus.
- iv. Parallel to the third stage or before, the Sri Lankan hydraulic civilisation had started.

In the above-mentioned river valleys, civilisations flourished with a sound ecological basis, comprising climate, soil and water resources, and these three factors were favourable for the development of plants and animals. The qualities of life of the people under those civilisations were mainly dependent on availability of water resources. Especially, irrigation facilities were developed through human activities, paving way for good living conditions, and simple technological development enhanced stability of those civilisations.

## Water and New Settlement in Ancient Sri Lanka

At least by the 5<sup>th</sup> century B.C., Sri Lankan civilisation had started with the North Indian migration. Anuradhapura citadel archaeological excavations disclose, before the Indian migration, there had been an agricultural society with simple technologies, but which rapidly underwent changes with the North Indian migration. The migrants started new settlements, mainly in Malwathuoya river basin, Anuradhapura, Upatissagama,

Prof. H.M.D.R. Herath

Department of Sociology,  
University of Peradeniya.

Uruwelagama, Udenigama and later immigrants who settled in on the mouth of Walave river, Rohanagama and Mahagama (De Silva, 2005).

## Water and Sri Lankan Environmental Value System

Sri Lanka, as an agricultural society, was inspired by Buddhism and an environmental value system that evolved with the nature-based ideology. This ideology symbolises that the monsoon rain-associated air possesses divine power. It considers that the rain god can initiate prosperity in the country. Water is regarded as very pure and sacred by its own nature, and once it is polluted, it is the end of the nation.

The stanza below indicates that water is a central element in societal values.

*Devo Vassathuc Kalena  
Sassa Sampaththi Hethucha  
Pitho Bhavatu Lokocha  
Raja Bhavatu Dhammiko*

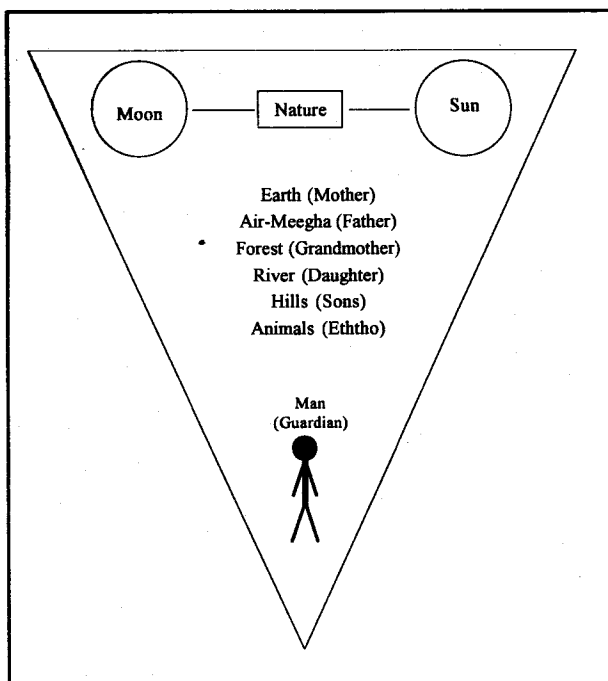
The meaning of this stanza is:

May there be rain in due season  
May the crops be bountiful  
May the king be righteous  
And may the country become prosperous  
(Dissanayake, 1992).

This stanza says; the god can make rains, then prosperity will be there, king will rule the country with justice (Dhamma). According to that, all values of the society are centred on water.

The water-based environmental value system in Sri Lanka considers care for water as a part of the civilised human





Earth (Mother = *Maheekanthawa*) provides love, kindness, mercy. She procreates her sons and daughters. Air (*Meegha* = *Wessawalahaka deviyo*) is the father who enable breathing and also provides shelter and has a capacity to provide rains in association with the procreating mother. Forest (Grandmother = *Kiriamma*) symbolises the grandmother who is

- i. Water fountain - *Diya Ulpatha*
- ii. Flowing water from the fountain - *Diya Kadiththa*
- iii. Flowing water through muddy water - *Diya Madiththa*
- iv. Flowing water in a small stream - *Ela* (Tributary)

According to the norms governing in those areas, up to the *Oya* level, whatever the water stream should not be used for cultivation, or should not be diverted for another purpose by force, because at that level, water stream behaviour is very similar to a girl before her puberty. She is still young (up to *Ela* level) and when the water reaches a stream (*Oya* level), it will be regarded as a main tributary to the river, and then farmers can divert that water for whatever purpose; she is mature after her puberty.

Then, all rivers are considered as daughters, because they have the reproduction capacity. They can marry with dams, anicuts, small village tanks, big reservoirs, storage tanks and finally they can

produce water for irrigation purpose. The service of those daughters can be utilised by creatures in the world who are called *eththo*, e.g., Birds are *Kurulu eththo*, Elephants are *Botakandaya eththo*. Finally, man is also a part of the nature; he can grant everything under sun and moon.

The above description shows how Sri Lankans respected water through an indigenous central value system that operates with social needs (Herath, 2004).

**Figure 1 : Indigenous environmental value system** the genuine protector of the water fountains in the earth. To enter the forest, people are expected to get permission from their grandmother (Herath, 2004). In

**Table 1 : Symbols for representation of the nature**

Unit	Symbol	Meaning
Earth	Mother ( <i>Mahikanthawa</i> )	Love, Kindness, Mercy and every bodies existence
Air ( <i>Meegha</i> – <i>Wessawalahaka deviya</i> )	Father	Shelter, breath, water giver, rain maker
Forest	Grandmother	Protection
Rivers	Daughters	Fertility / Procreation
Hills	Sons	Energy / Strength
Animals	Brothers / Friends	They are part of the system
Man		Guardian

Source : Herath (2004).

will be provided by the god; these will make way for prosperity.

The total environmental value system of the country focused on water. Figure 1 shows that the indigenous environmental value system in the country was based on water.

Figure 1 shows that the culture made rules and regulations to control the Sri Lankan agricultural society that has given symbolic meaning to the entire nation. Table 1 provides some symbolic meanings of the nature.

Anuradhapura, Matale, Kegalle and Nuwara, Eliya rural people say that all water fountains are belonged to the *Kiriamma* (Grandmother).

If any body needed to drink water, that person has to get permission from the grand mother. Then he/she worships to the grand mother who provided drinking water.

In addition, there are a number of water use patterns operating in those areas. The following are some examples:



## Social Functions of Water

Water has diverse functions in the Sri Lankan society, and its two types of ceremonies, namely, life cycle ceremonies and social reformations ceremonies, are associated with water. The life cycle ceremonies are those performed at different points in the life cycle, normally, at birth, puberty, marriage and death.

Some functions of water in the life cycle ceremonies include, life giving, purification, fertility improvement, medium of transfer and destroying evils, acknowledgement, etc. There are various rituals that are performed with water in different stages of life cycle, symbolising some beliefs that exist in the society. Value of water in social transformation ceremonies which are performed as common functions include, making transactions at New Year ceremonies, irrigation rituals, water cutting ceremonies in Kandy *Perahera*, etc.

Some of these functions of water in the Sri Lankan society are briefly explained in the following sections:

### Functions of water in life cycle ceremonies

*Life-giving Function* : Just after birth of a child, a drop of water mixed with milk and gold is put on the lips by midwife and women who are dealing with childbirth activities. By doing this, the society considers that water gives life to the new-born baby, i.e., water serves as a "life giver to a creature".

After birth, human beings expect to have a long life with prosperity, and the society expects to protect the infant. Water serves to protect the life of the people, and giving water to any creature is a merit-earning activity. In most of the dry zone areas, road-side people keep water pots known as *Pinthaliya* which has water for quench thirst for any person pass by. It is believed that any person who refused to offer water to a thirsty person to

quench his/her thirst, in his next birth, he will be born as a *Kendeththa* long-beaked bird, which cannot drink water properly (Dissanayake, 1992).

*Purification Functions* : Purification functions of water are the most significant in the life cycle ceremonies. For example, just after a childbirth midwife and women who are gathered at the scene purify the baby by washing with water. This gives lifetime purification norm as a social animal. After that, everybody should get purified themselves daily during his life time. In very special occasions, the person before enters sacred places requires purification with sacred water; otherwise, it is considered as a mark of disrespect.

The second stage, i.e., puberty, is considered as making pollution (*Killa*), and certain rites (*Diyawakkarana Mangallaya*) are performed to overcome this pollution. When a young girl attained puberty, society considers that the girl should get purified with sacred water consisting of different types of leaves and flowers. At the function of puberty, she must carry a pot full of water and drop and break the pot at the back door of the house. When she enters the ceremonial premises, she has to look her face through water *Koraha*. At the death ceremony again, water plays a major role. At the death bed of a person who is thirsty requires a bit of water to drink. Traditionally, if the son of the dying person is available, he has to drop five drops of water to quench the thirst of the dying person (Dissanayake, 1992).

In the life cycle ceremonies, a person has to pass different stages in his life. This passing process cannot be reversed. Therefore, the changing process is known as Rites of passage. To overcome this process, water is considered as a purifying agent. During marriage, sacred water performs a significant role. The bride as well as bridegroom who leaves the home to participate the wedding on an auspicious time, she or he has to come

in front of a person who is carrying a glass of water with a white flower in it. The Sri Lankan society considers water as very sacred social artefact. In wedding ceremonies, when bride and groom are on the "ceremonial pedestal" (*Magul Poruwa*) and at the bonding ceremony, they exchange water among each other as a lifetime bondage.

*Fertility Function* : Another social function of water is its value as a symbol of fertility. In the Sinhalese society, water is considered as a symbol of fertility and prosperity. In the marriage ceremonies, milk and water is consumed together by the newly-wedded couple. A female who brings a glass full of water to a wedded couple who comes out of the house at the auspicious time. At the homecoming ceremony, the couple before enters the bridegroom's house, bridegroom's mother brings a pot of water and hand over to the new bride. Two things are expected from this activity. First fertility and procreation, secondly, prosperity that carries to the house by the new bride. She is considered as a treasure to the house that brings prosperity.

*A Medium of Transfer* : Fourthly, water functions as a medium of transfer. In the traditional society, the most sacred wealth of the people was transferred through water. Liquidity of water has uncountable value. Normally, in any transaction, there will be a mediator either cash or any other symbol. But in the traditional society, all the merit-earning transactions were symbolised through water. Even in marriage ceremonies, bride givers hand over their daughter to bride receivers, bride's left hand and last finger put in bridegroom's right hand and last finger tied up and pouring water indicates the bride is handed over to the bridegroom including bride receivers. Sometimes, tusk, elephants, land, paddy field grants, etc. are handed over through offering water to symbolise the event.



Always recipients hand kept on givers hand that symbolises the merit-earning transaction in the religious domain.

In the death ceremony (*Pansakula pinkama*), living people give merit to the dead person by pouring water in to a cup till it overflows. All these water-associated activities symbolise the role of water as a medium of transfer.

**Acknowledgement Function :** Another social function of water is considering it as a symbol of acknowledgment. In any special social function in the family life, offering water is considered as invitation to the feast. Any wedding or other ceremonies, head of the family or his representative invite guests, including his own close relations for taking part in feasts, by offering a glass full of water. This indicates water is the most prestigious invitation system and acknowledgment system in Sri Lankan society.

**Medium of Destroying Evils :** Most of the societies in the world, consider water as a medium of destroying evils in different religious contexts. In Sri Lanka, Buddhists, Hindus, Christians, as well as Islamic religions consider chanted water has power to destroy evils. Among Buddhists, they believed that chanted (*Pirith*) water has the power to expel or destroy evil spirits. In all religious occasions, they distribute chanted water to overcome the ill effects of evils.

### Functions of water in social reformation ceremonies

**In Annual New Year Ceremonies :** The most important social reformation ceremony in Sri Lanka is the annual event called the New Year ceremony. According to annual New Year ceremony, the old year is considered as a passed year that is related to the sun's transition from Pisces (Meena) to Aries (Mesha); all normal transactions are concluded stopping human interrelationships. That means all human relationships stop immediately

(separation). They are stopped assuming transit from Pisces to Aries the sun's rashi relationship. The second step of transition period has no auspicious times (no *neketh*), and is considered as *Sankranthi* period. In the third stage, society reforms with new transactions for the forthcoming New Year. This is reintegration of the whole society with new transactions. All new transition commence with water. Society is awaking with water. This social reformation festival is led by women who deal with earth mother (*Polowamahee kanthawa*). Earth mother gives water to the society. Family-level mothers have the courage and power to integrate with whole society through water transactions, because water gives life to the society.

All individual-level mothers, before start annual transactions for the forthcoming new year, first visit the well and hand over a package which consists of salt, rice, charcoal, a copper coin, a little bit of chillies, wrapped in a pieces of cloth. Then, the mother gets pot of water for the survival of family. Then she starts transactions with her husband and other sons and daughters. In the country-level, whole society is awaking, and they start transactions for another year. After few hours or few days, societal people transactions extend to the plant world which is dependent on the solar system. Human world is always dependent on the plant world, then every year they anoint chanted water and oil, keeping leaves of a selected plant for the head and leaves from another plant for the foot. This ceremony is oil anointing festival or in Sinhala, *Hisathelgame Mangallaya*. This shows that the whole society's solidarity, unity and integrity throughout the New Year are based on water associated transactions.

**Irrigation Rituals :** Most of the irrigation rituals were designed to create collective consciousness and human spirit among peasants, based on irrigation water. In North-Central

province, farmers perform some irrigation rituals of which, manifest functions are very common and understandable, although latent functions are providing water-associated collective mind in that particular community.

*Kiriethreema* is an annual ritual based on irrigation, and farmers collectively expect water from the sacred *Bo* tree and the *Kaludevatha Bandara* god. There are two types of *Muttimangallaya* ceremonies (Pot ceremony) performed annually to get the support of god *Ayyanayake* and *Kadawara* guardian gods of the *Nuwarakalwiya*. After seven years, they organise *Mahadana*, again this ritual is to regenerate collective spirit of the community. All these rituals are based on irrigation water, and finally those rituals enhance common unity and community spirit among peasants in the region.

**Rain Making :** According to the Sri Lankan central value system, there are a number of rain makers that contribute to making rains. In general, people say monsoon rains received are carried by monsoon winds. The value system introduces the first rain maker is *Vessavalahaka Deviyo*, who brings rains to the country. Mother earth's procreation is dependent on the *Vessavalahaka* god's rains which help to begin fertility (Hearth, 2004). In dry seasons, people pray for the god, asking for rains to protect the plants, animals and human beings. In some areas, people chant "*Vehi Piritha*", after listening to his particular *pirith*, the gods are assumed to become happy, and then somatically give rains.

People, before go to bed, used to say the stanza, *Devo Vassath Kalena....* mentioned under Water and Sri Lankan Environmental Value System, asking rains from the god. This stanza says, another rain maker is the king of Sri Lanka. From the ancient time, kings performed rituals for citizens to get

*Contd. on page 15*



# Perspectives on an Overarching Water Policy for Sri Lanka

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Director,  
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Water policy defines the "rules of the game," guiding those actions governing the management, administration and procedures used to implement and direct a formal water planning process by which water rights, water uses and water diversions are evaluated, ranked and allocated on the basis of specific public policy goals and objectives. Such policies may be designated, either by legislative mandate, regulation or administrative fiat<sup>2</sup>. An inadequate understanding of the purpose of a water policy

has created a lot of avoidable myths and fallacies. Consequently, Sri Lanka's past efforts at water policy formulation have been perceived as a "conspiracy to sell water". This is not surprising when one considers the confusion arising from a plethora of policy documents in the sectoral and sub sectoral areas in the domain of water.

Figure 1 presents such diverse fields for which policy development is taking place in the blue water domain.<sup>3</sup> For blue water, there already exist sub-sectoral policies on major irrigation, minor irrigation, anicut systems, urban water supply, small towns water supply, rural water supply, community water supply, rainwater harvesting, wetland systems etc. In the green water domain, land use, soils, agriculture and watershed management are policies that impinge on the overarching water policy.

Ideally, the water policy should consist of an overall and overarching policy document which should stand on top of the activity specific collection of sectoral

and sub sectoral policies.

The objectives of this paper are to: outline briefly the experience to date with formulating a formal national water resources policy; clarify the meaning of a few widely misunderstood terms, such as, "ownership", "user rights" and "human right to water"; analyse several water policy themes and issues such as "bulk water entitlements", "ground water management", "user conflicts" and "roles of institutions"; suggest elements that should constitute a future water policy.

narrower mandate of engaging in hydro geological investigations and the development of ground water through the drilling of tube wells.

In 1980, a Water Resources Bill was drafted by the Ministry of Irrigation,

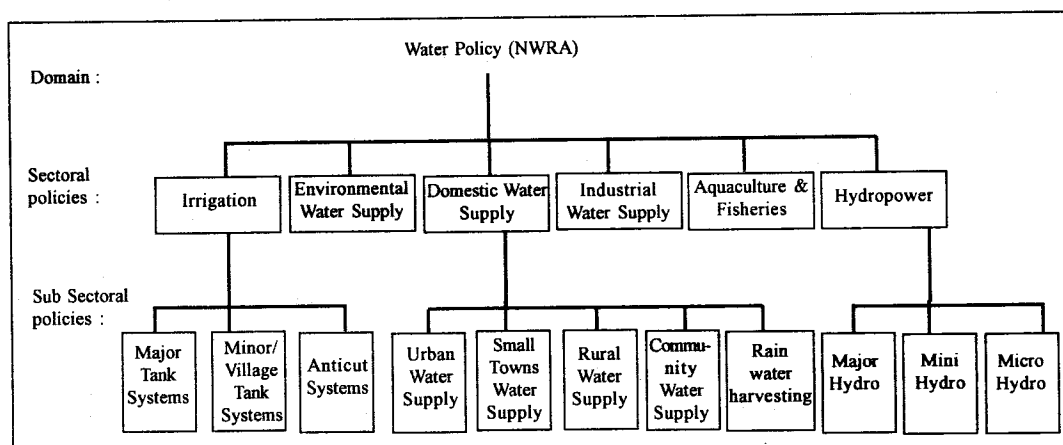


Figure 1: Policy Areas in the Domain of Water

## Historical Context<sup>4</sup>

Does Sri Lanka have the right water resource policies for the 21<sup>st</sup> century? Such concerns prompted policymakers to attempt several policy reforms in Sri Lanka's water sector during the last five decades. One of the earliest attempts at developing a national water resources policy was the establishment of the Water Resources Board in 1964 to advise the Minister responsible for irrigation on the formulation of national water policies, integrated water resources planning, river basin and trans-basin development, coordination and project coordination in general and the prevention of water pollution. Despite its mandate, the Water Resources Board has not functioned as an overall policy formulator. At present, it carries out a

Power and Mahaweli Development. This draft legislation made provision for bulk water allocation to various sectoral agencies (and further allocation by those agencies) and for the establishment of a National Water Resources Council as an advisory body under a "minister in charge of water resources planning." However, the legislation was never submitted to Parliament due to a lack of Cabinet support. With the formal approval of the policy of "Participatory management of irrigation systems" in 1988, the Government of Sri Lanka called for substantial devolution of authority and responsibility to Farmer Organizations. In order to facilitate the implementation of this policy, the Irrigation Management Policy Support Activity (IMPSA) was designed and implemented by the



International Irrigation Management Institute (IIMI) with USAID assistance. It executed a systematic and analytical planning process to assess experiences and formulated policies and guidelines for implementation of the new irrigation management policy. The outcome of IMPSA was expected to be a broadly participatory activity involving a wide range of stakeholders including specialists, policymakers, irrigation managers and farmer representatives with an emphasis on achieving a broad consensus on future directions. The project highlighted the need to address competing demands for water in the light of limitations of available water resources. IMPSA was initiated by the Ministry of Lands, Irrigation and Mahaweli Development and the Ministry of Agricultural Development and Research.

In its 1992 summary report the Irrigation Management Policy Support Activity (IMPSA) made recommendations on land, watershed and water resource management. That report recommended that the government should establish a high-level, advisory National Water Resources Council and a Secretariat. The functions of the proposed Council would include the development of national water resources policy and law and a national water resources master plan. The IMPSA report also recommended "a comprehensive water policy that looks at water in a holistic way, to put water to the most beneficial use at the least cost, as to conserve it without degrading the environment, sustaining it for future generations as well."

In 1992, a proposal to carry out a water resources master plan was presented to external support agencies. As a result, in late 1993, the Asian Development Bank funded the "Institutional Assessment for Comprehensive Water Resources Management (IACWRM) Project" to assess the institutional capacity for water resources management. Its outcome was a strategic frame-

work and an action plan for comprehensive water resources management. The action plan focussed mainly on the need to develop a **National Water Resource Policy**, to establish a permanent institutional arrangement for water sector co-ordination, prepare and enact "The National Water Act" and amend other related legislation, establish a system to provide information and data to decision makers and carry out comprehensive planning in selected watersheds. The Technical Assistance (TA) included broad consultation with the government agencies, water-related private sector groups and NGOs and other donor agencies. A strategic framework and an "Action Plan for Comprehensive Water Resources Management" were drawn up to establish the improved institutional framework over a three year period. The project recommended the formation of a temporary **Water Resources Council (WRC)** for a period of three years to oversee the implementation of the Action Plan and to recommend permanent institutional arrangements for water resource management.

Concurrently, the second TA project funded by ADB, "Institutional Strengthening for Comprehensive Water Resources Management" and the FAO/Netherlands funded "Water Law and Policy Advisory Programme" were developing water legislation and assisting groundwater policy development. On the basis of these recommendations the Cabinet of Ministers approved in 1995, the implementation of the Strategic Framework and Action Plan for the "Institutional Strengthening for Comprehensive Water Resources Management" (ISCWRM) project. As a result of these recommendations, the Government of Sri Lanka established a **Water Resources Council (WRC)** and a **Water Resources Secretariat (WRS)** in 1996. The Asian Development Bank approved funding of the project over a 30 month period beginning in April 1996. Parallel funding for legal and policy assistance was pro-

vided under the FAO/ Netherlands "inter-Regional Water Law and Policy Advisory Programme" over approximately the same time period.

In 2000, the Government of Sri Lanka signed a loan agreement with the ADB to obtain financial assistance for capacity building in integrated water resources management. The work programme to be funded by this loan agreement under the said Water Resources Management Project included the establishment of a National Water Resources Authority (NWRA) and formulate capacity building and sector reforms. The formation of the NWRA as a legally constituted body after the passage of Water Resources Management Law by Parliament was a precondition for the loan effectiveness.

These efforts resulted in producing the documents, i.e., the "National Water Resources Policy and Institutional Arrangement" and the "National Water Resources Authority Bill". The National Water Resources Policy was approved by the Cabinet of Ministers in March 2000. The draft National Water Resources Authority Bill was released by the legal draftsman's department in September 2000. However, this was subsequently revised due to public concerns expressed on certain sensitive issues.

In the year 2004, two policy documents were prepared by the Ministry of Agriculture and a Presidential Task Force. On 21 December 2004, the Cabinet approved the water resource policy contained in the Cabinet Memorandum No.04/1702/013/020. This national water resources policy recognized water rights, with regulations governing allocations. It also provided for transferable water rights and sought to introduce appropriate ground water management measures to regulate use. Yet, public concerns expressed on certain sensitive issues and the lack of consensus due to changing hands of the subject of policy development amongst

various successor Ministries resulted in the demise of this water policy formulation effort.

### Ownership or User Rights

One of the most contentious issues in the national water resource policy process was the question of ownership. Skeptics alleged that the ownership would pave the way for sale of the water resource which should be freely available to the people as a human right. Can water be owned? Ownership connotes a right to prevent others from using a "resource". Yet water is a common property resource which is always in a state of flux. In the course of its movement in the hydrological cycle it can only be owned when captured in a receptacle. Hence, it is best defined as a common property resource, not as a state or a private property. Unlike land, water is hard to "capture". What is the value of expressing ownership for a fugitive and constantly changing asset? Therefore, what is important is the right to use and acknowledge a human right to a basic water requirement. Under the Roman law, the air, the rivers, the sea and the seashore were incapable of private ownership. This concept of common property, called, the Public Trust Doctrine maintains that the state holds navigable waters and certain other water resources as common heritage for the benefit of the people.<sup>5</sup> The doctrine can prevent the continued destruction of public waters (Stevens, 2003).

Water rights are linked to land ownership. In Sri Lanka, a landowner is regarded as owning the water underneath his land and consequently a right to pump all the water from the common aquifer, lowering the water table. Further, he may use or abuse all the rain which falls on his land. In Sri Lanka, all the streams that flow across a private land fall within the public domain. A right to abstract and use surface and underground water should be subject to a right of reasonable use with-

out a permit. Extraction of water by mechanized means may not be a reasonable use for which, a permit requirement should be recognized. A water right entitles a holder of the right to the exclusive use of surface or subsurface (underground) water for a specified purpose. It does not, however, endorse a right to own the river or underground water. Consequently, a water right only permits the use of water up to the permitted quantity. Being a property right, its infringement by external parties can be prevented.

People may have an exclusive right to the use of water, but it can never be "owned" as it passes through a particular point on its continuous journey through the water cycle. The government is the custodian of the island's water resources, as an indivisible national asset and has ultimate responsibility for and authority over water resources management, the equitable allocation and usage of water and the transfer of water between catchments. This principle recognizes that where resources are limited and the competition is increasing, some party has to have oversight and custodianship over water. This means that the government is not the legal owner of water but the overall manager of water. Ownership is a difficult legal concept. Property rights can vary significantly in nature and degree. There is a difference between right to access / right to use and the ownership of water.

Water rights can be broadly categorized into public, common or private property on the basis of the decision making rights of allocation (Caponera, 1992). Public water is considered to be the property of the State. They are non-prescriptible, i.e., in spite of long use they do not confer upon the user any prescriptive right. In public water rights, state asserts its rights over water by controlling the allocation directly through government agencies. People get water rights by acquiring water permits, which allows them to

use but not own water. Common waters are those waters considered as the common entitlement of the whole community. In common water rights people can use water in ways that are specified by some community as seen in many farmer-managed irrigation systems in Asia. Private rights emanate in respect of those waters which the law recognizes to be the possible object of private ownership. They are held by an individual or legal personality such as a corporate body. In some cases, private rights go beyond just user rights to include a sale or lease to others as in Chile's tradable water rights systems. (Mainzen-Dick et. al., 2007). Is there a human right to water? In 1948, when the Universal Declaration of Human Rights was adopted, no explicit recognition of a right to water was made as water like air is so fundamental to preserve life. The International Covenant on Economic, Social and Cultural Rights (1966) recognized this right under two articles, namely, article 11- the right to an adequate standard of living and article 12- the right to health. The Committee on Economic Social and Cultural Rights adopted general comment No. 15 in November 2002 in which water is recognized, not only as a limited natural resource and a public good but also as a human right.<sup>6</sup> Although not legally binding, the right to water requires governments to increase progressively the number of people with safe, affordable and convenient access to drinking water. Access to basic sanitation is also included in the right to water. It is noteworthy that the right to water does not mean water is free, but rather that it be affordable and accessible to all.

### Bulk Water Abstraction

Water has to satisfy multiple needs as it flows through a catchment. Currently, there is no proper bulk allocation system in Sri Lanka. Some large consumptive users allocate water to themselves. In the current situation, the agency that operates the structures con-



trols the water allocation. For example, in the upper reaches of the Kelani River, hydro - electricity producers control the water releases. At the lower reaches at Ambatale, the National Water Supply and Drainage Board (NWSDB), who controls the intake structures, decides its allocation and consequently determines the balance flow for ecological purposes. In between, wherever Irrigation structures are found, the Department of irrigation controls the quantity for diversion. The most serious deficiency observed in water allocation has been the tendency by large water users to allocate water to themselves regardless of the needs of others.

Often, there are inter - agency conflicts, particularly during times of low flow. When consumptive users such as irrigators, urban water providers, industrial and commercial users appropriate the scarce surface water, who will ensure the minimum environmental flow for the preservation of river ecology, fishing and a host of other in - stream uses? The reasons for a neutral state authority involvement in managing water resources are to coordinate the sharing of water for the benefit of all existing and potential users, whether they obtain their water from watercourses, underground water or overland flow and to protect the environment. The challenge for the proposed authority is to establish a set of allocation principles that are rational and durable to accommodate the long term demands.

Do we need to establish a formal water allocation system? Can we meet all our water needs in the domestic, irrigation, hydropower generation, recreation and navigation and fishery development sectors? Can we guarantee a basic water requirement to all the people for all the above competing needs without managing the resource? The dilemma we face as a nation is how to manage our water bodies in a sustainable manner so that future generations too will inherit a healthy river system with the capacity to provide our drinking wa-

ter needs, capacity to support productive agriculture and preserve an ecosystem with a diverse range of flora and fauna.

When allocating water, at present, responsible agencies have to take into account many more competing demands than in the past. And to this day about 4.6 million out of the 20 million inhabitants in the country, predominantly those living in the rural areas, do not have access to safe drinking water (Wickramage, 2008). They have to meet their water requirements from wells and rivers, the quality of whose water is questionable. How can universal access to safe drinking water be ensured unless the freshwater sources are protected from *ad hoc* withdrawals by powerful vested interests?

Water use consists of three types:

- (a) intake uses
- (b) on site uses and
- (c) flow uses.

Intake uses for domestic, agricultural and industrial purposes, actually remove water from its source. Onsite uses include water consumed by wetlands, swamps, evaporation from the surface water bodies, natural vegetation and wildlife. Wetlands act as sponges during dry periods of the year and regulate run-off and recharge groundwater resources while purifying water supplies. Flow uses include water for estuaries, navigation, waste dilution, hydro-electricity, fish and recreational uses. What is important is to determine whether the allocation for such uses has to be permitted as a "free-for-all" or whether guidelines should be enforced by a neutral agency.

The use of water for primary needs like domestic use, and watering of plants and livestock should be free without the need for a permit. Any system of bulk water entitlements is likely to fail, if the "reasonable user" categories are not clearly specified in legislation. (Nanayakkara, 2003)

## User Conflicts

With less water available, the resource harbours a considerable potential for conflict which may occur amongst individuals or community groups who require water for drinking or for cultivation or for commercial/industrial purposes. While the irrigation sector's head-end-tail-end problems are well known and such conflicts are resolved at *Kanna* meetings there is no arbitrator for water conflicts between drinking or cultivation purposes. Furthermore, the share of the urban population in Sri Lanka is projected to increase to 45 percent by 2015 and 65 percent by 2030. (Presidential Task Force on Housing and Urban Development, 1988, p.4). Expanding water requirements of growing urban populations are making serious inroads into scarce water, previously devoted to agricultural use, particularly in the Dry Zone. A case in point is the Anuradhapura Water Supply scheme which competes with irrigation requirements of the Thuruwila farmers. (Aheeyar et.al., 2008). With economic growth, new appropriation of water for commercial agriculture, industry or hotels would injure the earlier appropriations.

Increasingly scarce irrigation water in many parts of Sri Lanka is used wastefully and excessively by some farmers to the point of causing water logging and salinization of soils, while other farmers in the same irrigation system suffer from water shortages and unreliable supplies. The water stress in Sri Lanka's South Eastern arid zone has communities fighting with one another for its dwindling water supplies. A recent HARTI study shows that the water sharing arrangement practised in the Kirindi Oya Irrigation and Settlement Project (KOISP) between the "old system farmers" and the "new system farmers" as a clear case of inequity, where the old system farmers are provided with 70 percent with only the balance for the new system users. While a large number of small tanks used by

the farmers in the new system area were demolished for the KOISP, they were denied equitable use, with a "prior appropriation" right taking precedence over "riparian" rights (Aheeyar et al: 2008). Further, it is observed that customary cattle watering places were not recognized in the development of the Kirindi Oya system. (Ruth Meinzen-Dick, 2001). Farmers and pastoral groups in Kirindi Oya area have totally different perceptions on water.

Admittedly, the Dry Zone is historically a water stressed region. But what is the situation in the water-rich Wet Zone? The following case illustrates an instance of conflict among the farmers depending on small tank/ anicut systems and the beneficiaries of rural village water supply schemes, for which water is drawn from the same supply source upstream of the small tank. The townships of Galaha and Deltota in the Kandy district suffer from a severe water shortage for domestic purposes. The rural water supply schemes are unable to cater to this fast developing area where human settlements have increased. In order to meet this demand for domestic water, extraction from Loolkandura Oya has been mooted. However, the farmers in Gabadagama area object to any diversion of water from Loolkandura Oya as water from this stream has been used to cultivate paddy in Gabadagama North and South. In addition the villagers in Gabadagama obtain their drinking water requirements from this source.<sup>7</sup>

The absence of any principles for sharing of water between the upper and lower riparians as well as between drinking and irrigation purposes has hindered the development planning efforts of both the Irrigation Department and the NWSDB. Should the "prior appropriation" doctrine prevent any beneficial use by later water users? Clearly, the rapidly growing population in Galaha and Deltota townships fosters fierce competition for the use

of scarce water of Loolkandura Oya placing a strain on a fragile and finite resource. Who should get priority of use during times of shortage? Where, in the balance of competing interests, does natural justice lie? Climate change and population growth may exacerbate the ever more complex problems of water abstraction.

There is no mechanism or institutional arrangement for decision making with regard to bulk water allocation as the above case illustrates. The absence of such a bulk water allocation policy compels *ad-hoc* decision making by reference to political authorities who are dictated by pressure groups rather than any decision making by obtaining a consensus amongst the stakeholders. It is essential to develop principles for equitable sharing of water between the upper and lower riparians.

### Ground Water Management

Although hidden from view, groundwater plays a central role in our environment, maintaining wetlands and river flows through prolonged dry periods. A water policy should address not only surface water but also the groundwater resource. Currently, a doctrine of territorial sovereignty is applied in groundwater extraction which means that "what is beneath our feet is ours to use". Groundwater, though not as visible as surface water, is ubiquitous in the Island's land mass and its use is rapidly increasing in Sri Lanka, intensifying cultivation and improving the standards of living of poor farmers in the Dry Zone. However, the Dry Zone farmers lament the lack of water for their crops at the end of the growing season- because over extraction has dried out aquifers. In some areas, like the Kalpitiya Peninsula, high concentrations of nitrates and agro-chemicals are already being found in the groundwater (IWMI Water Policy Briefing, Issue 14, p.2). Despite the intense use of agro wells during the last couple of decades, groundwater use has

so far been unregulated. Ownership of the overlying land should not permit the occupier to pump underground water through mechanical means. Guidelines should be established prescribing the spacing norms for pumps and wells.

Effective management of groundwater necessitates proactive intervention because high abstraction rates and uncontrolled developments require management policies which strive to balance the needs and interests of all water users and affected stakeholders in a particular region. A survey conducted by IWMI revealed that "...in Sri Lanka, some aquifers are already being pumped dry by the end of the dry season, and some communities have been left without drinking water." Furthermore, farmers in the lower reaches of the Hakwatuna scheme in the Deduru Oya basin, for example, are lamenting that heavy pumping upstream has reduced the availability of both groundwater and surface water in their area (IWMI, Water Policy Briefing, Issue 14, p.4). Water rights may offer a way for poor irrigators to protect their river water from being stealthily stolen by wealthy and powerful investors through induced seepage and reduced base flow caused by heavy pumping. Development of groundwater must ensure a sustainable balance between the proportion of the natural recharge abstracted for supply and the amount left to flow naturally from an aquifer to protect the aquatic environment. If groundwater is abstracted from an aquifer at rates that exceed the average long term replenishment from rainfall, water levels steadily decline and the yield of water will eventually decrease. Because Sri Lanka's aquifers are shallow, they are particularly vulnerable to pollution. Safeguarding water quality is vital - especially as 66 percent of rural drinking water comes from open dugwells (DCS, 2008). Additionally, other pollution problems have also emerged. Several deep tube wells constructed



recently to provide drinking water in the dry zone have been abandoned because of high iron and fluoride concentrations. (Panabokke, 2008)

The implications of stream-aquifer connectivity and the need for a conjunctive management approach are the most under appreciated issues in Sri Lanka. A management policy should clearly stipulate that groundwater should not be regarded as a resource separate from surface water. The policy should recognize that both surface and groundwater are hydrologically connected and are complementary components of a larger single system.

### Governance and Institutions

Water use planning requires that all the players – water users, policymakers and planners at all levels be actively involved in decision making, planning and implementation. Centralized and sectoral approaches to water resource development and management are insufficient to solve local management problems. The role of government needs to change to ensure a more active participation of people, local institutions, NGOs and CBOs. The fundamental principle of the management of the resource at the lowest appropriate level requires a decentralized approach to water management. Yet, such an approach would fail if it were to operate in an institutional vacuum.

The quasi-federal character of the Sri Lankan polity after the enactment of the 13<sup>th</sup> Amendment to the Constitution has some particular implications for water management. The confusion governing the allocation of the subject of irrigation within the provincial, central and concurrent jurisdictions is illustrated in Table 1 by juxtaposing the subjects and functions assigned to the centre and the provinces. The Provincial Council list empowers the centre to handle inter-provincial irrigation and land development projects which utilize water from rivers flowing through more than one Province. It also

empowers the centre to handle all schemes where the command area falls within several Provinces, such as the Mahaweli Development Project.

Definitive resolution of boundary problems is sometimes not possible because at any time there are several different and plausible approaches. For instance, the cultivation of tobacco and potatoes in the steep slopes in the Hill country poses a serious environmental problem. Soil erosion is a subject assigned to the concurrent list in the 13<sup>th</sup> Amendment while the Department of Agriculture which is a central functionary is entrusted with the responsibility. Land use planning on the other hand is a subject assigned to the Provincial list in the 13<sup>th</sup> Amendment. Who should intervene to improve cultural practices in steep slopes? It is very easy to “pass the buck” in such situations. The practical arrangements to deal with overlapping responsibilities are left to bureaucratic measures.

There is a need for an institutional arrangement at the national level, such as a proposed National Water Resources Authority (NWRA) capable of defining the overall water policy directions and adjudicating disputes. The complex functions of a national authority lie in the establishment of effective integration of the overall socio-economic and environmental decision making process. Figure 2 depicts the sectoral and sub sectoral areas dispersed in the domain of water with a need for a central apex body to provide a system of linkages between existing organizations, including basin authorities for harmonizing policy approaches.

Unfortunately Sri Lanka does not have a single water administration, which is responsible for the freshwater resource, as a whole. But, it does have multiple authorities for sectoral aspects of water administration. Where traditions of inter-jurisdictional jealousy and distrust preclude opportunities for

coordination and economy, fragmentation remains an impediment to productivity gains. Consequently, the responsibility for the development, apportionment and management of the freshwater resource is *ad-hoc*, tentative and confusing. What does the sectoral organization of society imply with regard to demands on water? The health authorities are interested in water supply and sanitation to protect against water-related diseases, high morbidity and mortality. To date, around six million inhabitants in the country, have to meet their drinking water requirements from wells and streams, whose water quality is questionable. How can universal access to safe drinking water be assured unless the freshwater resources are protected from ad hoc withdrawals by powerful vested interests?

The agricultural authorities are responsible for crop production, in generating increasing water requirements, often leading to land degradation. Irrigated agriculture claims the lion's share of the Island's water use, accounting for over 70% of total withdrawals. The Central Environmental Authority is responsible for habitat protection to avoid ecosystem degradation and maintenance of water quality. The economic development authorities are responsible for industrial production, generating increasing water requirements.

In-stream use of water also serves fisheries, transportation and recreation needs. Although hydro-power is a non consumptive use, it requires public water allocation through decisions to build dams and the operating rules that change the flow pattern of rivers. Public allocations to fisheries, wildlife and navigation are embodied in the restrictions on the development or withdrawal of water for other uses. The primary challenge in Sri Lanka is, and will be, how to cope with the rising competition for water between multiple kinds of users in ways which are equitable, efficient and sustainable.

At the national level, a large number of Ministries, Departments and Public Corporations have responsibilities impinging on water resource management. These institutions numbering over 30 perform various functions such as irrigation, drainage, water supply, hydropower and ecological purposes (Imbulana et al., 2006). Central agencies are separated by resource (irrigation, drinking water, hydroelectricity, forest, land), each with multiple functions (policy, regulatory, commercial and conservation). It is easy for an agency to compromise one function in favour of another. The tunnel view tendency in each of these sectoral bodies introduces incoherence in decision making that explains many of the difficulties in coping with emerging problems.

Responsibilities for management of the water resources are thus scattered over different agencies within provincial, district and divisional administration. Management of some of the major and medium sized irrigation reservoirs and minor tanks/anicut schemes has been entrusted to the Project Management Committees/Farmer Organizations with shared responsibilities. Some of

the large reservoirs serving multi-purpose objectives are also managed by agencies such as the Ceylon Electricity Board, Irrigation Department, National Water Supply and Drainage Board and the Mahaweli Authority of Sri Lanka. A multiplicity of institutions is sometimes unavoidable. Water resource, by its very nature is cross sectoral, whereas administrative arrangements of government are based on the sectoral approach.

The above institutions also fall into the category of water users when they function as service delivery agencies, playing a dual role at the same time. There is no integrated approach to water resources management or a system of separation of authority for management of the resources from development and service delivery functions. There is also no legally empowered authority or agency to allocate water for different water users although the Irrigation Department in certain critical situations undertakes such a responsibility.

## 6. The Way Ahead

What could be the elements of a comprehensive, integrated and sustainable

countrywide water policy? The ensuing policy directions present a number of principles that can be applied at all levels in the polity. We must acknowledge the doctrine of reasonable and beneficial use to mean that water must be allocated fairly and used efficiently. All users should avoid actions that impair the quantity and quality of water available for other users. This public resource must continue to be managed by the state to further the benefit of all who live in the country. Whilst there are multiple sectoral and sub sectoral policies, there is no clearly defined policy for the overall water resources sector.

Despite common public ownership there is no single custodian of the natural resource. A neutral agency should determine the appropriate balance between the demands for water for off stream consumption and the volume of water flows needed by the river system. The growing competition for water between irrigation use for food production and domestic use by both urban and rural dwellers needs resolution by a nonpartisan body at the apex, such as the proposed National Water Resources Authority (Bandaragoda,

**Table 1: Competence Jurisdiction relating to Irrigation in the Thirteenth Amendment**

List 1 - Provincial	List 2 - Reserved	List 3 - Concurrent
<p>9.2 Rehabilitation and maintenance of minor irrigation works</p> <p>19. Irrigation -</p> <p>Planning, designing, implementation, supervision and maintenance of all irrigation works, other than irrigation schemes relating to rivers running through more than one province or inter provincial irrigation and land development schemes.</p>	<p><b>National Policy on Irrigation</b></p> <p>Rivers and waterways; Shipping and Navigation: Maritime zones including Historical Waters, Territorial Waters, Exclusive Economic zone and Continental Shelf and Internal Waters; State Lands and Foreshore, Except to the Extent Specified in Item 18 of List 1.</p> <p><b>Inter-Provincial Irrigation and Land Development Projects</b></p> <p>2.1 Such projects would comprise irrigation and land development schemes :</p> <p>(a) within the province initiated by the State and which utilize water from rivers following through more than one province: a Provincial Council however, may also initiate irrigation and land development schemes within its province utilizing water from such rivers;</p> <p>(b) within the province which utilize water through diversions from water systems from outside the province; and;</p> <p>(c) all schemes where the command area falls within two or more provinces such as the Mahaweli Development Project.</p> <p>2.2 These projects will be the responsibility of the Government of Sri Lanka</p> <p>2.3. The administration and management such projects will be done by the Government of Sri Lanka.</p>	<p><b>17. Irrigation -</b></p> <p>17.1 Water storage and management, drainage and embankments, flood protection, planning of water resources;</p> <p>17.2 Services provided for inter-provincial land and irrigation schemes, such as those relating to rural development, health, education, vocational training, co-operatives and other facilities.</p>

Source : M K Nadeeka Damayanathi and V K Nanayakkara (2008), *Impact of the Provincial Council System on the Smallholder Agriculture in Sri Lanka*, Colombo HARTI, p. 21



<b>National Level</b>		
<b>Non Sectoral Players</b>		
♦ WRC (Proposed)	Policy formulating body for Water Resource Allocation	
♦ NWRA (Proposed)	Water Rights, Bulk Entitlements	
♦ CEA	Environmental Quality Standards, EIA Procedure (Tolerance limits for discharge of effluents into inland waters)	
<b>Sectoral Players</b>		
♦ Irrigation Department	Irrigation development and maintenance	
♦ CEB	Power generation, transmission and distribution	
♦ Mahaweli Authority	Water and related infrastructure development in designated basins; Water panel	
♦ NWSDB	(1) Regulator for Drinking Water : (2) Operator of Integrated Urban Schemes, Small Town schemes	
♦ Department of Agrarian Development	- Village irrigation	
♦ Department of Fisheries	- Aquaculture, marine fishing	
♦ NARA		
♦ Water Resources Board	- hydro geological investigations into groundwater	
♦ National Aquaculture Development Authority		
<b>Provincial Level</b>		
Provincial Ministry of Irrigation		
Provincial Ministry of Local Government		
<b>Divisional Level</b>		
♦ Divisional Secretary	Divisional Agricultural Committee, Kanna meetings	
♦ Farmer Organizations	O& M of field channels, and distributory channels, Village irrigation	
♦ Local Government Level		
Municipal Councils	Urban water supply systems	
Urban Councils	Unintegrated urban systems, small towns water supply schemes,	
Pradeshiya Sabhas	Rural Water Supply Schemes	
<b>Village Level</b>		
CBO/NGO*	Community water supply schemes (piped, gravity schemes, rainwater harvesting schemes.)	

**Figure 2 : Institutional Setting**

2006). It should determine the sharing and allocation of water between multiple kinds of users in ways which are equitable, efficient and sustainable. Currently, there is no administrator for the water rights system.

Like air, water is a resource that transcends society's boundaries. Watersheds and aquifers cross property borders as well as and national, sub-national and local government boundaries. At the national level, a dilemma has arisen concerning appropriate degrees of centralization and decentralization of water planning and administration. Water resources planning and management are frequently not based on the river basin as the natural unit for hydrologic management, resulting in inefficient use of water and inadequate concern with in-stream and ecosystem values.

Typically, environmental water is what remains after all other users in the system have taken their share. Most water laws in Sri Lanka were enacted to assist the abstraction of water for consumptive uses. The maintenance of stream flows in keeping minimum water levels for in-stream uses and protection of ecological uses has never been implemented in Sri Lanka. Consequently, environmental concerns such as the loss of biodiversity, salinity intrusion and seasonal drying up of wetlands have surfaced. A percentage of the flowing water in streams must be dedicated to the environment for fish and stream reservations. The purpose is not to return all streams to a pristine condition but rather to ensure that water dependent ecosystems are catered for in water allocation decisions. Therefore, it is imperative to recognize environment as a legitimate

Apart from the creation of a single new institution at the apex, the mandates of existing sectoral agencies need to be clarified in order to establish a clearer vision for the development of coordinating mechanisms to harmonize and reconcile policy differences. Further, the roles and responsibilities of the existing water agencies would have to be re-oriented to reflect their revised mandates of service delivery separated from resource management function as the institutional roles and responsibilities remain unclear and partly overlapping. The need for separation of the policy making and regulatory roles from the implementation, operation and service management is paramount. The mandates of sectoral agencies as structured at present, do not address some important gaps such as water sharing, conjunctive use and basin management.

user of water. Many water problems stem from a failure to take an adequately large "systems view-point" (like upstream-downstream relationships on major rivers), while day-to-day administration and public participation call for a more local approach. Appropriate resolution of this issue requires delineation of administrative boundaries to conform to river basins. This is a complex issue retarding the progress on implementation of devolved responsibilities as set out in the 13<sup>th</sup> Amendment.

A broad array of variables and their interrelationships has to be examined in the context of land and water management. Many land based activities have implications for water flows and quality. Water's capacity to trigger soil erosion has further impacts on land degradation. Therefore, a coordinated management of water and land resources offers the possibility of addressing the dynamics of an ecological system.

Can our land stewardship be separated from water stewardship? Since the mode of land use also helps determine the water balance, this means taking an integrated view of land and water use, and presupposes that management planning be watershed-based, which often cuts across administrative boundaries. Improved water governance will thus require a revision of the present system, which is a "free for all", through the development and enunciation of a shared, comprehensive vision of water resources. Integrated Water Resources Management (IWRM) assists communities to improve the ways they share, manage and protect water resources. Groundwater is inextricably linked, physically connected, to surface water and must be managed conjunctively and sustainably. The principle that the overlaying property owner carries with it no private ownership right to groundwater beneath his feet except for a reasonable user right has to be given legal recognition.

Because of a general perception of water abundance, Sri Lanka's laws from colonial times never reflected any urgency for conservation. Hence the policy has evolved over the last two centuries as if water had no cost and there were no limits to its availability. Despite Sri Lankans being profligate users of water, there is not enough water anywhere in the Island to permit every user to do with it as he pleases. Like other laws governing scarce things, a water law must encourage desirable activities and prevent or

discourage undesirable conduct. There is an urgent need for a comprehensive water resources legislation to fill this void. Water allocation priorities, particularly in water stressed situations should be established in consultation with all water user groups on a legal basis.

It is important to recognize that water is not simply a free "gift of nature". In all its competing uses, water has an economic value. Some form of cost recovery is evident in the domestic water supply sector which includes the recovery of operation and maintenance costs plus the greater of debt service or depreciation from revenues derived from tariffs. Managing water as an economic good (certainly not as a commercial good to be traded in the market) is an important way of achieving equitable and efficient use and encouraging conservation.

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#### Footnotes :

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<sup>2</sup>Webster's Dictionary defines "policy" as a definite course of action selected from among alternatives and in light of given conditions to guide and usually determine present and future decisions.



<sup>3</sup>Blue water is the portion of rainfall that enters into streams and recharges groundwater. Green water or soil water is the portion of rainfall that is stored in the soil and then evaporates or is incorporated in plants and organisms.

<sup>4</sup> This section draws heavily from an earlier paper. See Nanayakkara, V K (2003), "Sri Lanka's Efforts in Introducing Water Sector Policies and Initiating Related Institutional Development," International Water Management Institute, Project Final Report, Vol. 5, Appendix III.

<sup>5</sup> Issuing its landmark judgment on the Water's Edge Golf Course Case, in the matter of an

application under Article 126 of the Constitution in S.C. (F.R) No. 352/2007, the Supreme Court declared that the Sovereign lands of a state are held in trust by the state for the benefit of all the people of the country and ruled that the tract of land at Battaramulla acquired for the public purpose of providing water retention as a low lying area has "to serve needs of the general public as distinct from the elitist requirements of the relatively small segment of society in Sri Lanka."

<sup>6</sup> The comment provides guidelines for States Parties on the interpretation of the right to water emanated from and was indispensable for an adequate standard of living as it is one of

the most fundamental conditions for survival. The right to health entails the underlying determinants of health, *inter alia*, access to safe and potable water.

<http://www.unhcr.ch/html/menu3/b/a-cesr.htm>.

<sup>7</sup> Information obtained as per interview on 25 May 2009 with Ms Illangasinghe, Project Director, Towns South of Kandy Water Supply Project, National Water Supply and Drainage Board.

## Contd. from page 5

rains and then country was led to the prosperity.

It is considered that the sacred tooth relic has a power to produce rains, therefore, authorities annually perform Sri Dalada Perehera with four Devala pereheras. At the end of the perehera, the chief custodian of the Daladamaligawa •Diyawādana Nilame performs water cutting ritual with the assistance of four Devala Basnayake Nilames. Further, Anuradhapura sacred Bo-tree has the power to produce rains that is a traditional belief system in the country. To gain water, people perform different types of rituals for the sacred Bo-tree.

There are some regional-level rituals activities also performed to get water in different regions.

## Conclusion

Sri Lanka is an agricultural society, and its mode of production is heavily dependent on rain-fed agriculture, based on monsoon rains. According to Sri Lankan culture, water is considered as sacred. Because as a life blood, people do not urinate onto water or even do not spit onto water.

Therefore, water has a very special language structure which is a cultural form that has a unique hierarchy.

Delayed monsoon rains or low monsoon rains directly affect the socio-

economic life of the citizens. Therefore, people have given sacred and divine power to water. And people interpret, define and evaluate water in terms of sociological value in their Central Value System. Then water becomes an essential part of human survival and well being.

However, at present traditional water associated value system is facing challenges mainly due to the market-oriented capitalist value system that attributes a monetary value to water, thus making it a marketable commodity, similar to any item considered only for consumption.

Also all over the island, ruthless deforestation and construction of unplanned tube wells may affect underground water resources and water springs, and streams are adversely affected by removal of natural vegetation to produce potato and vegetables that generate some income for a few people while threatening the ecological and environmental conditions essential for year around water availability for humans, animals and plants.

Therefore, rules and regulations geared to protect water resources in a sustainable manner are urgently needed as the social value systems are losing the prominence and strength in the context of modern lifestyle.

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# The Multidisciplinary Approach to Water Quality Research

## Abstract

**O**ur earth is a water cooled planet. As a liquid, water exhibits some unique chemical and physical characteristics. Its remarkable ability to dissolve a very large array of inorganic and organic substances makes it a "universal solvent" with serious implications on contamination and pollution of the aquatic environment. Further, it transcends all spheres of the planet, and the complex interactions of the hydrosphere with the atmosphere, lithosphere and the biosphere helps in maintaining a dynamic equilibrium within the earth. It is the disturbance of this dynamic equilibrium, mainly by man, with his environmental polluting activities that results in serious global impacts, including human health. There is probably no scientific discipline that does not involve the study and impact of water on society. Religion, history and civilisation, public health and sanitation, town and country planning, agriculture and economics, war and other conflicts, hydropower and engineering, earth sciences and environment, chemistry and biology are among these subject areas. Clearly, a multidisciplinary approach is vital for any in-depth study of the role of water in society.

## Introduction

Water is a unique substance. Because of its uniqueness, it is the subject of extensive and intensive research. Paradoxically, water is both an absolute necessity for life and a poison responsible for the deaths of millions of people the world over. Its uniqueness stems from the fact that as liquid water has many chemical and physical properties quite distinct from many other liquids. Its relatively high boiling point, the wide liquid range (0° - 100° C) existence in three physical

states, namely, solid ice, liquid water and gaseous water vapour, hydrogen bonds, bent shape and polarity, high dielectric constants are some of these unique features. The exceptional behaviour of water as a good solvent, capable of dissolving a variety of inorganic and organic compounds makes it highly vulnerable for contamination, and hence, its status as a ubiquitous poison. Clear water is, therefore, clearly the need of the masses, and water quality research ranks very high in earth science.

The World Health Organisation (WHO), having realised the impact of water quality on health, has introduced guidelines (WHO, 1963) for water, indicating the maximum and permissible levels of the parameters and substances that may be present in the water. At best, these values should only be used as guidelines, since the values may not be applicable to all countries, in view of the fact that the daily consumption of water in the different populations will be vastly different, and also, in view of a variety of other factors such as the health status, lack of essential nutrients among others. People living in tropical lands are particularly vulnerable to diseases caused by changes in water quality.

Very broadly from a human perspective, chemical elements are classified as essential and toxic. Element irons such as calcium, phosphorous, potassium among several others are considered essential for human physiology, while others such as lead, mercury, cadmium, arsenic are classified as toxic. However, it is vitally important to bear in mind that, it is the dosage that matters, and that even a so-called essential element can cause ill health due to the inordinate amounts consumed (Dissanayake, 2005) The element iron necessary for the

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production of the all important body substance haemoglobin, may cause a disease if consumed in excessive quantities. Further, it should also be remembered that, it is not the amount of the total element that matters, but the chemical species of the element causing toxicity. Hence, water quality research places strong emphasis on species determination.

## Terrain Geochemistry

Water quality changes depending on the terrain. A study of the hydrological cycle (Figure 1) shows the close interaction of the hydrosphere with the lithosphere (rocks, minerals and soils) atmosphere and the biosphere. The quality of groundwater depends on the chemical composition of the rocks and soils with which the water is associated (water-rock interaction) the period of time during which the water-rock interaction takes place and the quality of any extraneous matter such as pollutants introduced into the groundwater system by man. The chemical composition of the rocks, minerals and the soils control, to a very large extent, the quality of the groundwater, and therefore, it is logical to assume that different terrain with varying rocks, minerals and soils will have different water qualities. For example, the water underlying the rocks strata of the Jaffna Peninsula will have high levels of calcium and magnesium owing to the abundance of their carbonates in the limestone-rich terrain. As against this, the water in the highly laterite-rich terrain in the south-western parts of Sri Lanka may have high iron contents in the water,

often imparting a poor taste to the water.

Problems of salinity, high dissolved solid contents, high fluoride levels, as observed in the dry zone of Sri Lanka, are closely linked to the terrain geochemistry and climate. The high salt contents in the groundwater of the dry zone are generally attributed to the accumulation of the dissolved salts getting concentrated due to the high rates of evaporation. By contrast, many elements are leached out from the rocks in the wet zone resulting in much lower dissolved solid contents. Further, the nature of the underlying rocks, their structures, fractures and fissures also play an important role in the quality of water deeper down. The higher fluoride levels in the dry zone water, notably in some tube wells, occur due to the chemical composition of the rocks, presence of fluoride-rich minerals, greater water-rock interactions and longer passage of water through the rock fissures. Groundwater in the Jaffna Peninsula, for example, tends to get contaminated quite easily from seepage of waste matter in septic pits and latrines through the cracks and crevices of the underlying limestones.

## Industry and Water Quality

Dumping of waste matter, particularly the industrial effluent, is one of the most important causes of water pollution. A large array of chemicals from substances such as paint, diesel, engine oil and lubricants, pulp, agrochemicals, detergents among many others pollute the water. Kelani River, due to its passage through the industrial regions of the western province, receives a significant quantity of industrial effluent. The danger caused by such chemical pollution is that toxic elements such as cadmium, lead, mercury, chromium, etc. accumulate in the sediments, and these find their way into plants and through the food chain into the human body. Several years ago, a study carried out by the Department of Chemistry of the University of Kelaniya highlighted the anomalous concentrations of chromium in the 'Keera' plants on the banks of the Kelani River, presumably caused by waste from leather factories. Further, some chemicals have a long residence time, and these may remain in the groundwater for decades. The extreme demand for land for housing coupled with the neglect of environmental concerns often cause serious water pollution.

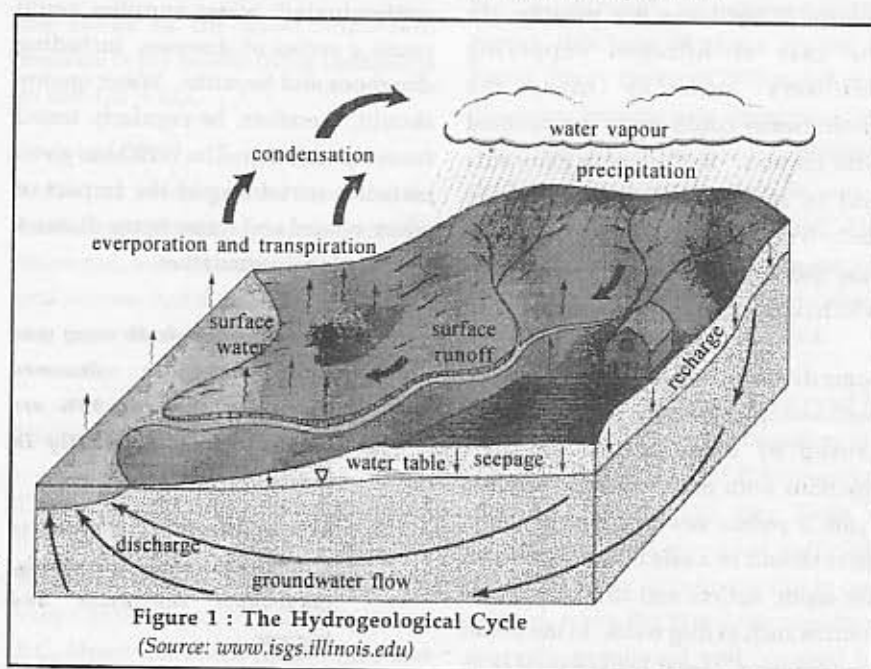
Stringent laws are, indeed, required for the prevention of dumping of toxic chemical into the aqueous environment. However, their implementation is emphatically more important.

## Algal Blooms and Algal Toxins

Stagnant water bodies such as lakes, reservoirs and drinking water wells often acquire a green to brown and cloudy appearance due to the growth of algae. Indeed, some lakes such as the Beira Lake and the Kandy Lake, both located in an urban environment, turn dark green due to the profuse growth of algae, of which, there are several varieties as classified by microbiologists. These algae, after extensive growth and reproduction, die and accumulate at the bottom of these water bodies, thereby releasing toxins to the water. Some of these toxins cause diseases, affecting the skin, liver, brain and the kidney. The algal blooms are ubiquitous, and have become a major pollution threat, notably in the tropics and in places where nutrients accumulate in excessive amounts. When lakes become badly affected by such algal blooms, they are termed eutrophic as against the lakes which have clear water, and where sunlight penetrates deep, termed oligotrophic lakes.

The sudden appearance of large quantities of dead fish in a lake is, very often, due to the highly eutrophic nature of the lake concerned with the concomitant release of toxins that had made the water uninhabitable for the fish and other forms of fauna.

Interestingly, some microbiologists consider these algal toxins which find their way into the drinking water of people in the North Central regions of Sri Lanka to be the cause of the chronic kidney diseases now spreading fast. More research is needed in this regard, and algal toxins may prove to be potent disease-causing substances in





the disease-prone areas of North Central Province.

### Agrochemicals and Fertiliser Inputs

In Sri Lanka, the agricultural sector uses the most amount of water. While the need for food production cannot be over emphasised, certain aspects in the agriculture sector is a matter of serious concern. Bearing in mind the extreme vulnerability of water to contamination and pollution, inputs from agrochemicals and fertiliser such as urea and phosphates do, indeed, cause significant damage to aquatic resources, mostly to groundwater.

The contamination of drinking water sources by potent agrochemicals, particularly those which have long residence times, poses a major health hazard. In the dry zone of Sri Lanka, where farming is the most dominant occupation, use of agrochemicals (haphazardly in most cases) is extremely common with the concomitant pollution of surface, ground and drinking water. Organophosphates are among the common compounds in these agrochemicals, and these are well known to cause a variety of neurological diseases.

Fertilisers, notably the phosphate types, carry a host of metals, among which, toxic elements such as cadmium, uranium and lead, are common. Even though some of them may be present in the original rocks, some others get introduced into the fertiliser material during the process of production. These are particularly common in some cheap imported phosphate fertilisers. The regular use of these poor-quality fertilisers in the paddy fields and other crops causes the accumulation of these toxic metals in the soils and water, thereby posing a major health hazard. In developed countries, all fertilisers used in plantations are subject to stringent regulations, and quality

**Table 1 : Diseases and problems caused by organisms and chemical substances in water to humans**

Causative item	Disease and problems
Bacteria	Typhoid, gastroenteritis, bacterial dysentery, cholera and tuberculosis
Virus	Poliomyelitis, meningitis, infectious hepatitis, respiratory diseases, diarrhoea and enteritis
Protozoa	Amoebic dysentery, diarrhoea and amoebic meningo encephalitis
Helminths	Hook worm, round worm, and threadworm infections
Fungi/algae	Colour, turbidity, taste, odour and toxins
Cadmium	Decalcification of the bones, protein and sugar in urine and kidney damage
Lead	Muscular paralysis, damage to nervous system, liver and kidney, lowered IQ, anaemia
Fluoride	Mottling of teeth (dental fluorosis), cracking of teeth and osteo fluorosis
Nitrate	Methaemoglobinaemia
Sulphate	Diarrhoea
Hydrogen sulphide	Taste and odour problems
Iron	Yellow colour, unpleasant taste and odour
Zinc	Unpleasant taste
Manganese	Unpleasant taste
Mercury	Affects kidney, nervous system, and causes brain damage
Chromium (hexavalent)	Kidney problem, lung cancer and skin diseases
Arsenic	Skin, bladder and lung cancer
Aluminium	Alzheimer (memory loss)
Pesticide	Kidney disease, reduced vision, joint pains and memory loss
Dissolved salts	Unpalatable if greater than 1200mg/ 1

Source: Sarath Amarasiri (2008).

control of fertilisers is a priority. In the case of nitrogen supplying fertilisers such as urea, the groundwater could easily get polluted with nitrates. In the Jaffna Peninsula and in the Kalpitiya regions, the underlying loose porous soils provide easy passage for nitrate-laden water which could enter drinking water wells.

Some diseases, notably bowel diseases, methaemoglobinaemia, and cancer are caused by nitrates through their reactions with other chemical species. From a public health point of view, there should be a safe distance between the septic outlets and drinking water sources such as dug wells. In the urban environment, faecal contamination is very often observed, and when

contaminated, water supplies could cause a series of diseases, including diarrhoea and hepatitis. Water quality should, therefore, be regularly tested for contamination. The WHO has given statistics pertaining to the impact of water-related and water-borne diseases on the global population.

- 1.8 million people die every year from diarrhoea diseases (including cholera); 90% are children under 5, mostly in developing countries.
- 88% of diarrhoea disease is attributed to unsafe water supply, inadequate sanitation and hygiene.

*Contd. on page 22*

# Traditional Village-based Hydraulic Culture

## Introduction

**G**reat King Parakramabahu stated "let not even a drop of water obtained by rain go to the sea without benefiting man". This implies the importance of water to the sustenance of the human civilisation and how the ancient culture appreciated the precious natural resources. Sri Lanka had a tank-based agrarian culture. It is well defined in the ancient food production system as "agrarian cultural system" than an "agricultural system". The reason for this is ancient, or more appropriately traditional food production, was not targeted at food production only, but also as an integrated system in which culture and the society were integral components. Therefore, the concept of "village-tank-field-temple" was evolved. Due to this culture, none of these components operated independently.

In the traditional food production system or agrarian system, the "tank" or the "man-made reservoirs" played a vital role to food production and to the society, and hence, the tanks were considered in a divine manner. The society showed great respect to the tanks, and some kings even considered the tanks as the most important treasure or the wealth (King Dathusena in 461-478 A.D.).

This article attempts to present historical evidences on how the Sri Lankan traditional agrarian societies respected, utilised and conserved water and lessons that the present generation can learn from them to sustain water resources and the environment.

## History of Water Culture

The author of Mahawansa has indicated that the hydraulic culture in Sri Lanka was initiated after the advent of King Vijaya and his group in the 6<sup>th</sup> century B.C. However, when King Vijaya lost his group, he found that they have gone

to a lake (may be tank) but never left it, while a (royal?) woman Kawanna or Kuweni, was knitting cotton on the dam (wekanda) of the tank. Sri Lanka is a country where there was no inland natural water bodies located, and this lake or tank has to be a man-made (at least some influence of man in constructing) water body. Therefore, this statement indicates that there had been a tank-based culture even prior to the arrival of King Vijaya.

The Kashmir text of history "Rajatharangani" by Kalhanayan, written in the 12<sup>th</sup> century A.D., clearly explains how the King of Kashmir invited Sri Lankan Irrigation technologist to Kashmir in the 8<sup>th</sup> century A.D. to construct irrigation channels to develop irrigation facilities. In addition, construction of a dam across the "Kaveri river" to divert water to a 'Shiva' temple, by using Sri Lankan irrigation technology and technicians is mentioned in the ancient Indian text written during the "Maurya" dynasty.

Another marvel construction in the local irrigation system is the sluice or the "Bisokotuwa". In nowhere in the world, this type of sluice system is found. Henry Parker in 1870 stated, that "Sinhalese have the great strength and the power in irrigation, because they possessed the technology in constructing the unique sluice system called Bisokotuwa". The "diyaketa pahana" is a vertically erected stone pillar with graduation to show the level of the water in the tank.

The rainwater reservoirs developed in the ancient kingdom of Anuradhapura (437 B.C.-845 A.D.) and Polonnaruwa (846 A.D.-1302 A.D.), Dry Zone of Central lowlands provided sufficient irrigation water to cultivate rice in two seasons, while the Wet Zone remained sparsely populated and covered by thick forests. Today, around 12,000

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ancient small dams and 320 ancient large dams, together with thousands of man-made tanks dot the lowlands, with over 10,000 reservoirs in the Northern Province alone.

Another marvel construction by the ancient irrigation technologist is the "Yodha ela" or "Jaya ganga" with a gradient of 6 inches to a mile, which carries water along 54 miles, from a lower elevated "Kalawewa" to highly elevated "Tissawewa".

Earlier many believed that this is only a water conveying canal. By looking up the surrounding agrarian culture both sides of the canal; it is very evident that this has served the purpose more than a canal. This collected spill water as reservoir from the village tanks and stored, then supplied the water to the other village tanks as required while flowing down.

A Sri Lankan historian R.L. Brohier stated "many are the instances where the modern engineer has frequently found himself anticipated by an unnamed predecessor".

## Management of Village Tank Culture

In Jethawana rock inscription, the following three types of tanks are mentioned during the reign of King Maluthissa (167 - 186 A.D.):

- Small tanks - (Danavavi) - a tank built by constructing a dam across a small stream. Usually such tanks are

privately owned, and the water is offered at a reasonable charge (fee).

- Large tanks - (*Mahavavi*) - due to its capacity and extents, individuals cannot afford to build; therefore, the state patronage is given and managed by officers / authorities appointed by the king.

- Village tanks - (*gamikavavi*) - village tanks are an integral part of the village system and satisfies the irrigation requirement of the village. Each village has a small tank. The control is by an appointed officer known as "*gamarala*" or *vidane*".

The tanks were owned by the king, the temples, village institutions or individuals. Among them, the large tanks and major canals were owned by the king. During the 3<sup>rd</sup> B.C. in a Brahmi rock inscriptions, it was noted that there were individuals with the ownership of private tanks and known as "*Vapihamika*". In addition, there are many ancient inscriptions such as "*Thimbiriwewa*" and "*Kahabiliyawa*" rock inscription which clearly mentioned about the ownership of the tanks either by individuals or families.

"*Samanthapasadika*" an ancient text of Sri Lanka, have described the rules and regulations in managing large and small tanks and also tanks owned by the private individuals.

For agricultural purposes, irrigation water was not offered free of charge. Therefore, when water was obtained from a tank, a charge was made. Until the 6<sup>th</sup> century B.C. this payment was known as "*Dakapathi*" and "*Bojiyapathi*". During the latter part of the Anuradhapura and Polonnaruwa era, they were known as "*Diyabedum*" and "*Diyadada*", respectively. Because of the payment have to be made for the water, traditional farmers realised the value of water, and they treated it as precious. The society, therefore, abides by the traditions, and laws and regulations imposed on water to collect, conserve

and respect, and utilise optimally to minimise waste and pollution.

In the traditional agrarian system, for every tank, there was a management system and management officials appointed by the king, regional ruler or the society. This is a paid position, and more than the payment, it is a social status. According to Paranavithana (1970), the words found in two very ancient Brahmi inscriptions, "*Ananika*" and "*Adikaya*" may be referring to an irrigation engineer and an officer-in-charge of canals, respectively. Another rock inscription by the King Sena II (853 - 887 A.D.) described of a supervising officer of tanks as "*Vevajeruma*" and in the 10<sup>th</sup> century A.D., an authorised organisation to take care of tanks as "*Dolos maha ve thena*". In Aththani inscriptions, the officers are mentioned as "*Viyavadaranuwan*" meaning the executive. However, "*Maha gamarala*" and "*Vidana*" are the common official persons existed until recent times.

### Water and Agriculture

Cultivation, especially the lowland rice cultivation was done two seasons per year. This was mainly determined by the availability of water. This was found in the Thonigala second rock inscription as; "*Pitadadahasa*" (*maha* season or north-east monsoonal season) where the rice cultivation is entirely done by rain water. The other "*Akalahasa*" (*yala* season or south-east monsoonal rains) where the rainfall is not sufficient to cultivate the total extent of land. During the "*yala*" or South-eastern monsoon season, cultivation is done by the collected water in the tanks during the rainy seasons. Often due to the insufficiency of water to cultivate the total extent of land, limited irrigation water is released to all rice farmers in the village to cultivate only a part of their fields and this system is called "*Bethma*" system. In certain part of the country where sufficient rainfall is available, an additional short season can be cultivated between the two main

seasons and known as "*Madehasa*" (mid season).

Irrigation water was supplied to the fields systematically. To organise irrigation facility, initially meetings were held between the authority and the farmers. Often the authority (*gamarala* or *vidane*) is also a farmer accepted by the society. Thereafter, the plan of cultivation and system of supply is discussed. With everybody's consensus, the available water is distributed on a given schedule and order.

The water to irrigate rice fields were obtained from irrigation tanks if not from direct rain. The traditional land use and the settlement system was organised that each village-based rice cultivation land lot (*yaya*) is fed with a small tank called "*village tank*" (*gam wewa*), and the villages were known as "*tank village*" (*wewugam*). Once the rice fields were filled with the irrigation water, the excess water was wasted. This excess water was then diverted to the next village tank through another type of small canal (*pahuela*) to replenish the water level and further use. This shows the concepts followed by the traditional agriculture in recycling and conservation of natural resources. Therefore, in traditional water management system, the irrigation system was designed not only to distribute water, but also to collect excess water and direct them for storage and conservation. The waste water that was recycled to the tank, if carries any deleterious chemical substance from the previous field, will be purified naturally through the action of "*natural phyto-remediation*". This has been a long-practised phenomenon in ancient tank culture. Natural perennial plants which are capable of absorbing such chemicals through their root system were grown in the bunds of the tank (*Kubuk*, *Wetakeya*, *Maranda*, *Mee*, etc). Traditional people knew about these plants and their different abilities.



## Tank and Local Traditions

Tank is the most important asset to the agrarian culture, because it provides many services other than supplying water for irrigation. It provided water for irrigation, livestock, drinking, washing and bathing and even for recreation. In addition, it was the source of fish, other food types (lotus root, seeds, stems, kekatiya and other edible aquatic plants), flowers for ornamental use, etc. Therefore, the tank was considered as a treasure to the village. Thus, it was everybody's responsibility to sustain this asset. Complete authority of the tank was given to the "maha gamarala" or the "wel vidane". Every individual in the village had to follow the set rules and regulations imposed on tanks. Anybody who violated such rules was penalised with heavy penalties despite his social status. The bans imposed on tanks by the wel vidane was called "ana bol bedeema". For this, he plant a long stick upright in the tank with few plant twigs tied on to it. When the villagers seeing this will understand that some ban has imposed for certain uses of the tank (fishing, letting livestock, irrigation, etc.).

When a tank is filled with water, entering the water is prohibited from, as they wish for any purpose. This is to conserve the tank and maintains the purity of the water. There are identified places for different uses of water. The place where bathing is allowed is known as "bathing port" (*nana munkada*), but separately for males (*pirimi munkada*) and females (*gehenu munkada*). Similarly, water to fetch for drinking is drawn at "*diya munkada*", for cattle bathing and drinking at "*gon munkada*" or "*bora munkada*", for washing "*redi* or "*radha munkada*". These social disciplines were maintained not for the restriction of water, but to maintain the high utility of water.

## Water and Worship

Water was venerated as a sacred element. This natural resource was

highly respected among the traditional agrarian society. Among the four ancient local tribes "Sivuhelayo", the "Naga" was considered to be more associated with water as they were known to be the ancient navigators, whereas the "Yakksa" as the "Irrigation specialists". In the tank-based culture "the cobra" had become an identical symbol in water-related culture. The three or five hooded cobra was regarded as the guardian of water resource. The "multi-hooded cobra" stone carvings found in ancient cultural sites can be assumed as the ancient belief of the "king cobra" (*Naa raju*) as the guardian of "water and wealth".

In the ancient culture, water was considered so precious, and the kings who have made large reservoirs, developed irrigation culture and done much service to hydraulic civilisation, were worshipped at the state of divines or gods (King Mahasen as "Mahasen Deviya", "Minneri Deviya", etc.). In ancient hydraulic culture, they found a place on the bund of the tank or its vicinity to perform offerings to the deities responsible for or guardians of water and agriculture (crop and livestock). Usually, they selected a very old wide spread perennial tree (*vanaspathy*), especially a *Ficus* species (*nuga, asatu*) or any other perennial (*mee, kumbuk, palu, weera, kon* etc.). This is called the "place of worship" (*sanhinda*), where they perform services, chanting, offerings, alms and make vows (*yaga homa*) for asking the blessings or thanksgiving.

Gods or deities for agriculture and water differ from place to place. It was believed that these gods guard the tanks and their fields and stocks. The genesis or the birth of some gods was also from the same area or related to the tank. Some were mythical and some were individuals in the society who were venerated as gods or devils after their death due to some heroism, behaviour or the service rendered to the society when they were alive or otherwise

(Kadawara, Mangara, Aiyanyaka, Gambara, Pulleyar, Kataragama, Saman, etc).

## Lessons from the Past

Sri Lanka ancient hydraulic culture and the agrarian civilisation around it are unique to this country. It cannot match with any other ancient technology or agrarian civilisation in the world. Irrigation technology adopted was far superior to what the present-day irrigation experts know and have performed. The technology used then was still a mystery. The type of equipment used was, though we thought primitive, more accurate than what we used today. Source of knowledge is still unknown to us. The accuracy, concepts and mythology are astonishing. Therefore, it is very essential for our present-day irrigation technologist to understand the concepts and systems used in the ancient hydraulic culture, when designing the future irrigation development activities in the country. Classic examples to this effect can be cited as the Samanala wewa sluice, Yoda Ela gradient, *relapanawa* concept on bank erosion, etc.

On the other hand, the culture that harmonised the society with traditions, norms and values were originated through the concepts of tank-based village civilisation and culture. It kept the community together and promoted collective frame of mind in their agrarian activities such as land preparation (*aththama*), weeding (*neluma*), and harvesting (*kaiya*). This sharing of labour was done without considering their wealth or social status. These collective activities kept the society together to sustain the harmony of the society. The leadership was given by the village leaders such as the priest of the temple (*loku hamuduruwo*), village headman (*muledeni / arachchila / gamarala*), village doctor (*veda aththa*), village school head teacher (*loku iskola mahaththaya*) and a village committee (*variga sabhawa*) led

by few respected elders of the village. Presently, the society is divided because there are no activities that are performed collectively; everything is hired or mechanised. The social norms and values are besmirched, culture is drained as a result of so called modernisation.

Finally, the value of this precious natural resource, water, is just not water alone; it is the origin of human civilisation, and the sustenance of human culture and life. Therefore, let's understand the future threat on this natural resource due to its scarcity, pollution, and learn to use it respectfully and resourcefully. Therefore, national programmes should be implemented among the Sri Lankans at all levels to educate them on the value of water and how we enjoy it now

because of our forefathers understood and conserved for future generations. It is our responsibility to conserve for the future generations.

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- There are 396 million episodes of malaria every year, most of the disease burden is in Africa south of the Sahara.
- An estimated 160 million people are infected with schistosomiasis
- 500 million people are at risk from trachoma.
- 133 million people suffer from high intensity intestinal helminth infections, which often lead to severe consequences such as cognitive impairment, massive dysentery, or anaemia.
- Over 26 million people in China suffer from dental fluorosis due to elevated fluoride in their drinking water.

Pipe-borne water systems in Sri Lanka are still confined to the main cities. The majority of the population (approx. 70%) still depend on groundwater and surface water for their domestic requirements, the garden well being the commonest water source. Even though industrial contamination of

these rural water wells is very rare, some natural causes often render the water unsuitable for drinking. From among these, salinity, excess fluorides, excess total dissolved solids are the most important (Dissanayake and Weerasooriya, 1989). In the Jaffna Peninsula, excessive use of fresh water for irrigation causes an influx of brackish water thereby rendering the water unsuitable for drinking. Table 1 shows the types of diseases and problems caused by organisms and chemical substances in water to humans.

### Conclusion

Water, due to its unique chemical and physical properties, dissolves many inorganic and organic substances, thereby, making it a 'Universal solvent'. It is, therefore, very easily contaminated. Due to the nature of planet earth, with its dynamic equilibrium between various spheres, water encompasses almost all disciplines. From among these, geology, chemistry, agriculture, medical science, industry, public health, town and country planning,

sociology, irrigation and power generation, engineering, microbiology, parasitology deal with various aspects of water. A multidisciplinary approach is, therefore, clearly required, and all stakeholders need to contribute their fair share of work aimed at keeping the environment clean and providing one of the most essential of all substance - pure water.

### Acknowledgements :

Ms. Jeewa Kasthuri is thanked for typing the manuscript.

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# Surface Waters, Their Status and Management

## Abstract

**S**ri Lanka is rich in its water resources, but there are water scarcity problems based on seasonal and spatial variations in rainfall. There are 103 rivers flowing from a central mountainous massif in a radial pattern through various directions of the country, and 18387 tanks are distributed within the river basins and in the Jaffna peninsula and in Taleimannar. The stagnant waters of Sri Lanka are threatened by eutrophication and blooming due to nutrient loading from their catchments. The rivers also receive pollutants from catchments via surface runoff. Proper water resources management criteria focused on river basins is needed with proper coordination among relevant organisations in order to achieve the management goals.

## 1.0 Introduction

*"Water is the most critical resource issue of our lifetime and our children's lifetime. The health of our waters is the principal measure of how we live on the land" – Luna Leopold. (This statement indicates the value of the water resources.)*

Sri Lanka is a tropical country<sup>1</sup> located between 5° 54' N and 9° 52' E and 79° 39' N and 81° 53' E with a surface area of 65,525 sq km, and it is rich in its water resources. It consists of one of the highest densities of the water resources of the world, with rivers, reservoirs, lakes, ponds and ground water resources (SOE, 2001). However, this picture of richness in water resources is misleading to a certain extent as there are water scarcity problems due to variations in seasonal and spatial distribution patterns of the rainfall.

The only source of fresh water in Sri Lanka is the rainfall received from monsoonal rains<sup>2</sup>. Nearly two-thirds of the country gets less than 1,500mm of rainfall in a year, and almost all of it comes during the short northeast

monsoon season. The mean annual rainfall ranges between 900mm to 6000mm, with an island wide average of about 1,900 mm, which is about two and a half times more than the world annual mean of 750mm. The country can be divided into wet and dry zones with a mean annual rainfall of 2424 mm and 1450 mm respectively.

## 1.1 The objectives

The objectives of the present paper is to discuss; (i) the types of surface waters, (ii) their status using a multidisciplinary approach to analyse the effect of human interventions on deterioration, and (iii) to discuss the management strategies to protect the surface waters as a response.

## 2.0 The Types of Surface Waters

Inland waters of Sri Lanka could be categorised into surface and ground water. Out of the total, land area of Sri Lanka, 4.43% (2905 sq Km) is covered by the surface water (Census and statistics data & SOE 2001).

There are two major categories of surface waters, namely, the stagnant waters or lentic waters (The reservoirs, lakes and tanks) and the running waters or lotic waters ("Oya"s and "Gangas"). Present paper deals only with the surface waters of Sri Lanka, Table 1 illustrates the statistics of the rivers, their basin areas and the number of stagnant waters located within each river basin of Sri Lanka.

The stars indicate the river basins greater than 1000 km<sup>2</sup>. As indicated by Ranaviraja (2000), the river basins could be categorized into five classes (Table 1 & Figure 1) based on their geographical location; (i) Northern river basin region, (ii) Mahaweli inter basin region, (iii) Western river basin region, (iv) South eastern river basin region and (v) Southern river basin

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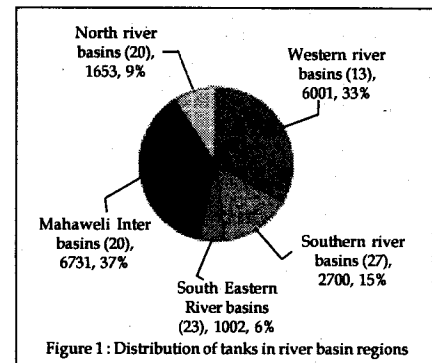


Figure 1: Number of rivers and distribution of tanks within each river basin region, their number and percentage

region. Table 1 illustrates the river basin included under each region. This type of a classification will be useful to describe issues in groups of river basins based on their geographic location.

## 2.1 Running waters

### The Origin

The water which enters via rainfall into groundwater (the recharge water) drains down through the soil, and in some places, may seep out as a spring thus forming a stream<sup>3</sup>. Such a series of streams degrades the land, and when it flows downhill, other streams or the tributaries join the major stream forming a river. There are 103 such rivers in Sri Lanka flowing from a central mountainous massif in a radial pattern through various directions of the country (see Table 1 for statistics). During rainfall, these rivers receive waters from respective catchments or basins, bounded by ridges located at their highest elevations.

Such basins are referred to as "drainage basins" "river basins" or "watersheds" (defined as the area drained by a river and all its tributaries). They differ in their sizes, shapes and elevation.



Table 1: Statistic of Surface waters of Sri Lanka

river Mahaweli is the only river which

River No.	Name of River Basin	Area (sq. km)	No. of TANKS		River No.	Name of River Basin	Area (sq. km)	No. of TANKS	
1	Kelani Ganga*	2292	20	Western River Basins	54	Maduru Oya	1559	231	Mahaweli inter Basins
2	Bolgoda Ganga	378	12		55	Puliyapotha Aru	53	11	
3	Kalu Ganga*	2719	6		56	Kirimechchi Odai	78	24	
94	Moongil Aru	44	0		57	Bodigolla Aru	166	45	
95	Mi Oya*	1533	1556		58	Mandan Aru	13	1	
96	Madurankuli Aru	73	105		59	Makarachchi Aru	38	8	
97	Kalagamuna Oya	153	189		60	Mahaweli Ganga*	10448	1003	
98	Rathambala Oya	218	291		61	Kantalai Aru	451	120	
99	Deduru Oya*	2647	3274		62	Palampotta Aru	70	101	
100	Karambala Oya	596	483		63	Panna Oya	145	12	
101	Ratmal Oya	218	15		64	Pankulam Aru	381	164	
102	Maha Oya*	1528	33		65	Kunchikumban Aru	207	95	
103	Attanagalla Oya	736	17		66	Palakutta Aru	21	4	
4	Bentara Ganga	629	2	Southern River Basins	67	Yan Oya*	1538	832	North River Basins
5	Madu Ganga	60	1		68	Mee Oya	91	40	
6	Madampe Lake	91	1		69	Ma Oya*	1036	366	
7	Telwatta Ganga	52	42		90	Aruvi Aru*	3284	1726	
8	Ratgama Lake	10	1		91	Kal Aru	212	14	
9	Gin Ganga	932	2		92	Moderagam Aru	943	509	
10	Koggala Lake	65	1		93	Kala Oya*	2805	1425	
11	Polwatta Ganga	236	2		70	Churian Aru	75	15	
12	Nilwala Ganga	971	16		71	Chavar Aru	31	24	
13	Sinimodera Oya	39	9		72	Palladi Aru	62	14	
14	Kirama Oya	225	206		73	Manal Aru	189	88	
15	Rekawa Oya	76	113		74	Kodalikallu Aru	75	59	
16	Urubokka Oya	352	182		75	Per Aru	378	156	
17	Kachchigala	223	150		76	Pali Aru	85	9	
18	Walawe Ganga*	2471	777		77	Maruthapillay Aru	41	8	
19	Karagan Oya	58	28		78	Theravil Aru	91	15	
20	Malala Oya	404	378		79	Piramenthal Aru	83	14	
21	Embilikala Oya	60	20		80	Methali Aru	122	22	
22	Kirindi Oya*	1178	334		81	Kanakarayan Aru	906	202	
23	Bambawe Ara	80	27		82	Kalawalappu Aru	57	4	
24	Mahasiliwa Oya	13	5		83	Akkarayan Aru	194	70	
25	Batawa Oya	39	18		84	Mandakal Aru	300	50	
26	Menik Ganga*	1287	294	South Eastern River Basins	85	Pallavarayan Kaddu	161	39	
27	Katupila Ara	87	45		86	Pali Aru	456	142	
28	Kurundu Ara	132	35		87	Chappi Aru	67	15	
29	Nabadagas Ara	109	9		88	Parangi Aru	842	425	
30	Karambe Ara	47	2		89	Nay Aru	567	282	
31	Kubukkan Oya*	1233	81			Jaffna Peninsula and Islands	1200	293	
32	Bagura Oya	93	19			Talaimannar	126	7	
34	Helawa Ara	52	7			TOTAL	65525	18377	
35	Wila Oya	490	65						
36	Heda Oya	611	55						
37	Karanda Oya	427	95						
38	Semana Aru	52	17						
39	Tandiadi Aru	22	15						
40	Kangikadichechi Aru	57	10						
41	Rufus Kulam	35	7						
42	Pannel Oya	106	21						
43	Ambalam Oya	117	11						
44	Gal Oya*	1813	191						
45	Andella Oya	528	47						
46	Tumpan Keni	9	35						
47	Namakada Aru	12	25						
48	Mandipattu Aru	101	29						
49	Pathantoppu Aru	101	46						
50	Vett Aru	26	9						
51	Unichchai Aru	350	52						
52	Mundeni Aru*	1295	138						
53	Miyangolla Ella	228	27						

Source : Survey Department

**Perennial, ephemeral and intermittent rivers**

Out of the 103 rivers of Sri Lanka, some are perennial having their flows throughout the year, with a base flow

even during non-rainy seasons, which depends on the water generated from the movement of ground water into the river channel.

According to the ancient nomenclature, perennial rivers are termed as "Gangas" and non-perennials as "Oya" or "Aru". The non-perennial<sup>4</sup> rivers are of two types, namely, ephemeral and intermittent. This classification is based on the flow regime of the rivers.

Some of the perennial rivers of Sri Lanka are river Mahaweli, Kalu, Kelani and Walawe. Most of them are located within the wet zone. However, the

flows through both wet and dry zones of the country, and due to its perennial nature, many hydropower and irrigation projects have been focused on it.

**2.2 The stagnant waters**

There are no natural lakes in Sri Lanka, and our stagnant waters are mainly man-made other than the flood-plain lakes. As illustrated in Table 1, there are 18,387 tanks distributed within the 103 river basins including the Tanks in Jaffna peninsula and islands and in Taleimannar. Out of that, there are 309 major irrigation reservoirs (serving over 80 hectares each), and nearly 18,000 minor irrigation reservoirs, of which, around 12,000 are presently operational. The major hydropower reservoirs; Kotmale, Victoria, Randenigala and Rantambe and the recent Maduruoya reservoirs

store waters of the river Mahaweli. Apart from that, many systems within dry zone reservoir waters of the Mahaweli River are used for cultivation.

Figure 1 illustrates the distribution of tanks within five geographic river basin regions of Sri Lanka. Number of river basins in each "river basin region category" is indicated within brackets. The Mahaweli inter-basin region contains the highest number (6, 731) of tanks. The lowest number (1, 002) of tanks is located within the South-eastern river basin region.

Coastal lagoons and estuaries also act as inland surface waters which also get

## GROSS DOMESTIC PRODUCTION BY SECTOR

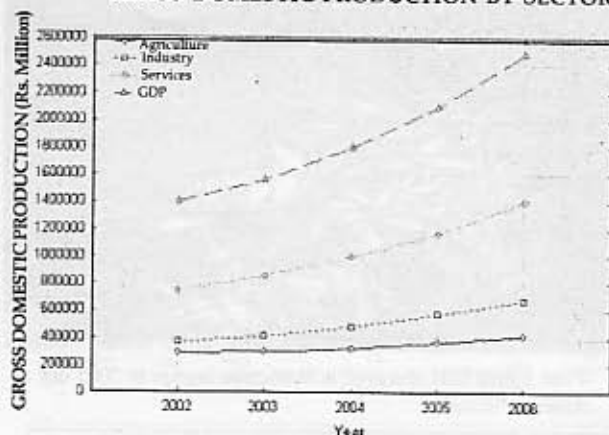


Figure 2 : Gross domestic production by sector  
Source : Central Bank of Sri Lanka

## Available data on Nutrient usage over the years

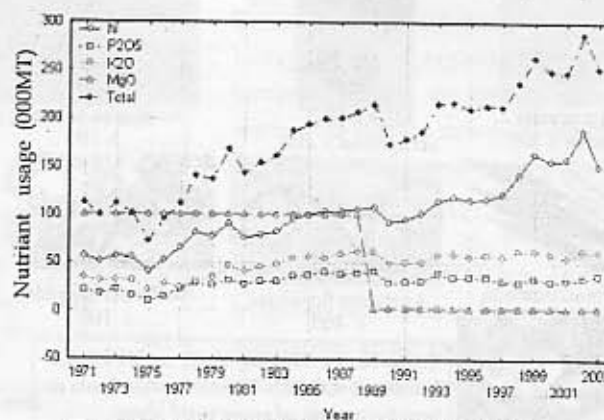


Figure 3 : Annual nutrient usage by year based on available data  
Source : National Fertilizer Secretariat

## Fertilizer consumption by crop (MT)

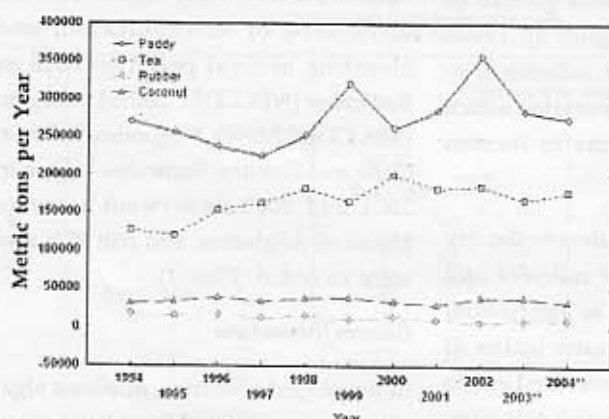


Figure 4 : Fertilizer consumption by major crops  
Source : National Fertilizer Secretariat

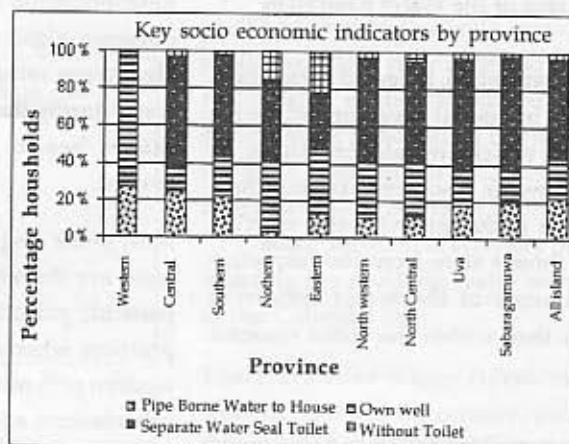


Figure 5 : Socio economic indicators which reflect fecal pollution

affected due to human interventions on running waters, which release their outflow at their down stream stretch.

### 3.0 Indicators of Pollution

Figure 2 illustrates the gross domestic product (GDP) of the country by sector. At present, Sri Lanka is not an industrialised country, but the GDP component is greater from industrial sector over the years and its contribution to GDP is greater than that of Agriculture indicating the trend towards industrial development of the country. Therefore, care has to be taken in management practices to avoid or minimise the water pollution due to industrial activities.

Figure 3 illustrates the annual use of nutrients by crops, and Figure 4 illustrates the consumption of fertiliser by major crops of Sri Lanka based on

available data from National Fertiliser Secretariat of Sri Lanka and Dept. of Census and statistics. The excessive use of fertiliser by agriculture is responsible for the elevated levels of nutrients in surface waters in agricultural areas. Paddy and tea are the major crops which consume highest amounts of fertiliser, and therefore, the catchments of the tanks and river basins dense with paddy or tea have threats of loading nutrients into the water bodies and rivers driving them towards nutrient pollution.

Over the years facilities for access to toilets for people was upgraded. However Figure 5 illustrates still there is a minor percentage (less than 1%) of the population without access to proper toilet facilities which is highly significant as a contributor to microbial pollution of water resources. As a result

there will be a threat on water resources due to release of sewer into water ways which ends up in stagnant waters. Recent study conducted by North East Coastal Community Development Project (Anon 2009 a & 2009 b) found high quantities over 2500 Colony Forming Units/100ml of E coli (Fecal coliforms) in Arugam Lagoon and in Batticaloa lagoon exceeding the threshold values of 50 CFU/100ml indicating similar threats due to poor sanitary facilities in the area. Therefore Figure 5 is a socio-economic indicator which indicates the fecal pollution threats to our waters and based on their geographical location, it has to be adequately addressed in water resources management by providing proper sanitary facilities for the community who lives mainly in shanties.

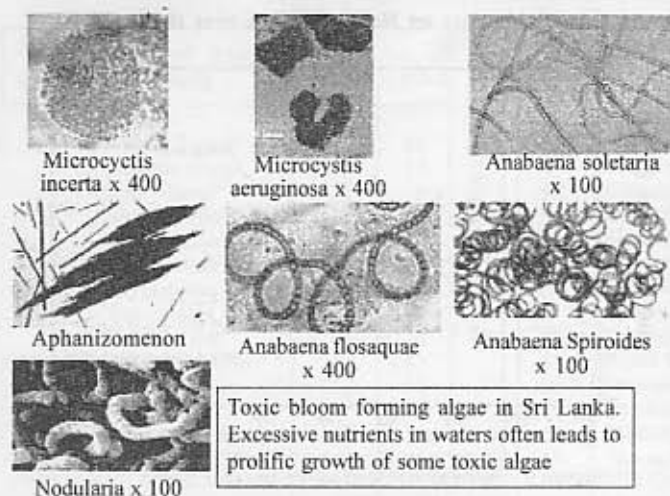


Plate 1 Fish kills observed in Batticaloa lagoon in 2003 due to Anabaena bloom

Figure 6 : Toxic Bloom forming algae in Sri Lanka

#### 4.0 Status of the Water Resources

The urbanisation, irrigated agriculture, and the industrial development are the factors which initiate pressures on inland water resources, driving them towards pollution and water scarcity. Such threats stem from the respective catchments of the water resources rather than within the water resource itself.

The major water pollution issues could be categorised as (1) stagnant water pollution (reservoirs and lagoons) and (2) running water pollution.

#### 4.1 Stagnant water pollution

##### Eutrophication

The common water pollution problem in stagnant water bodies of Sri Lanka is the eutrophication and blooming due to nutrient enrichments. High amounts of Nitrates and phosphates released from fertiliser applications of the relevant catchments in the agricultural zones or from wastes released from the urbanised areas cause the nutrient enrichments in stagnant waters. Status of such waters is referred to as "eutrophic" and the nutrient enrichment process is referred to as the "eutrophication". This condition occurs only in stagnant waters of Sri Lanka as our running waters move fast due to high elevation gradients.

Eutrophication accelerates growth of nuisance algae (See Figure 6). These algal types release toxic substances to water during their degeneration which causes health problems to human beings.

Most of the stagnant waters in the dry zone are threatened of nutrient and pesticide pollution due to agricultural practices whereas the water bodies of western province are threatened due to urbanisation and industrial activities. Some published information exists on waters threatened of eutrophication and blooming; Kotmale (1991), Victoria (2003), Maussakele, Castlereigh, Rajangana, Kandalama, Nachchaduwa, Nuwarawewa, Tisawewa, Venderasan, Parakrama Samudraya, Kantale, (1997), Girithale (1997) and Maduruoya (1997) reservoirs (Anon 2003a and 2003b, Silva and Schiemer 2001). Kotmale reservoir reached a severe blooming situation in 1991 and high densities later in 1994 (Piyasiri, 1995; Piyasiri, 2001).

The important stagnant water bodies of the western province; the Beira Lake (80 ha), Parliament Lake (95 ha), and the Bolgoda Lake also have indicated eutrophication. The Beira Lake suffers from high eutrophication and elevated levels of fecal coliform. Kandy lake underwent a severe bloom of *Microcystis aeruginosa* due to high nutrients from urbanisation.

Apart from that, many lagoons also are threatened of eutrophication and blooming or fecal pollution such as Batticaloa (NECCDEP 2009a), Arugam (NECCDEP 2009b), Negombo, Rekawa, Galle and Dondra. Batticaloa lagoon in 2001 and 2003 underwent a severe bloom of *Anabaena*, and fish kills also were recorded (Plate 1).

##### Bloom formation

In developed countries, nuisance algal counts are monitored in order to warn the general public about the suitability of waters for users. Three alerts levels<sup>5</sup> are declared by Australian water authorities for *Microcystis aeruginosa* cell numbers. It is advisable to introduce such a practice even in Sri Lanka as there are many water bodies in Sri Lanka subjected to blooms. Such blooms cause severe health problems due to algal toxins. Algal densities of *Microcystis aeruginosa* exceeding 15000 cells per ml was observed even in Kotmale reservoir in 1991 (Piyasiri 1995; Piyasiri, 2001).

All algal toxins are highly toxic and difficult to control, and should not be used for supply above the alert levels.

Toxicity is caused by:

- (a) contact with water containing blue-green algae;
- (b) consumption of fish taken from contaminated waters; or
- (c) drinking water with algal toxins.



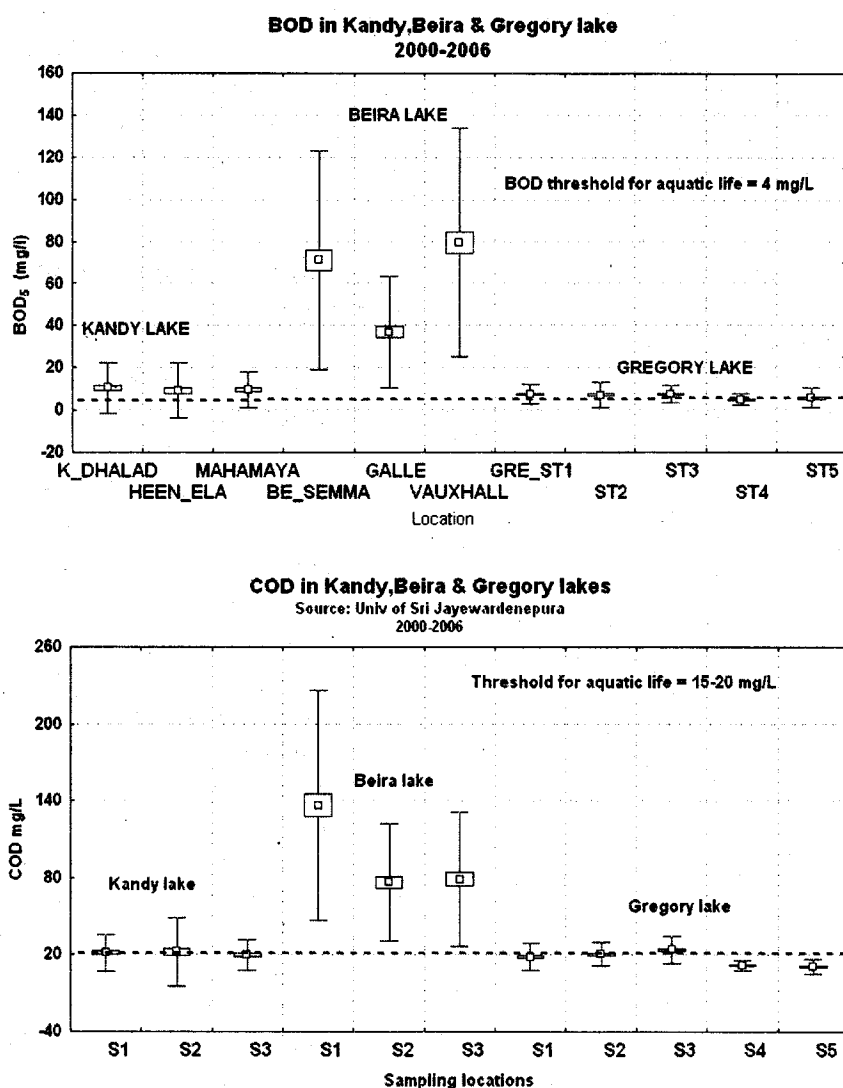


Figure 7 : BOD and COD levels in Kandy, Beira & Gregory Lakes

The toxins can kill fish and other biota, farm animals and waterfowl. The effects on humans is very serious causing a wide range of symptoms such as liver damage. The toxins produced by blue-green algae are varied, but include: (a) neurotoxins (mainly alkaloids) produced by species of the genera of *Anabaena* *Aphanizomenon* and *Oscillatoria*, (b) hepatotoxins (microcystin - peptides) produced by species of the genera of *Microcystis*, *Oscillatoria*, *Anabaena* and *Nodularia*, that mainly cause severe and often fatal liver damage. The World Health Organisation (WHO) has proposed a guideline value of 1 mg per liter for Microcystin-LR in drinking water.

#### Other Pollution Types

Other types of pollution in stagnant waters are; pesticide pollution, heavy

metal pollution, organic pollution, microbial pollution, sedimentation. A high level of organic pollution is indicated by the Biochemical Oxygen Demand (BOD<sup>6</sup>) and Chemical Oxygen Demand (COD<sup>7</sup>) levels. Available water quality data in such stagnant waters indicate that they exceed the guidelines published by the Central Environmental Authority (CEA) or other international standards, indicating their unsuitability for aquatic life and for other purposes such as consumption, swimming, etc. However the data available on such parameters are scanty. Figure 7 illustrates some available data on BOD and COD levels in three stagnant waters exceeding the CEA standards of 4 mg/l for BOD and 15-20 mg/L for COD.

## 4.2 Rivers

Rivers get polluted due to release of heavy loads of organic substances, fertiliser, wastes, etc into the running waters via surface runoff. Some of the river catchments are densely populated such as Kelani River. The Mahaweli river catchment is utilised for multipurpose activities such as irrigation, agriculture, homesteads, tea plantation, small industrial activities, etc., and also some parts of the river in its journey through the dry zone, are heavily populated.

Apart from that, many rivers face with problems due to excessive mining of sands from their river beds and due to soil erosion in the catchments. Sand mining in the Kelani River has lowered its beds, and the water level has dropped below sea level (SOE 2001). As a result, intrusion of seawater occurs affecting the drinking water supplies to the Colombo city.

There are four major rivers in the western region of the country, namely, Kalu Ganga, Kelani, Attanagalu Oya and Maha Oya. Out of these, the Kelani River is the second largest river in Sri Lanka, and its river mouth region is highly populated where city of Colombo is located, and most of its organic pollution is received in its last 50 km.

Water quality testing of the Kelani River has been carried out by National Building Research Organisation (NBRO) for National Water Supply and Drainage Board (NWSDB) since 1989. CEA also have conducted some water quality assessments of the river. The results indicated that the Dissolved Oxygen (DO)<sup>8</sup> levels in the range of 6-8 mg/l at Ambatale region which is used for distribution to city for drinking purposes (Anon, 1993). The COD ranged from 10-13 mg/l. Other parameters (Nitrate, Nitrite, Ammonia, Phosphate Sulphate, iron, etc.) tested by NBRO comply with the national standards (Anon, 1993).



However, at the downstream region close to the river mouth, the industrial pollution load discharged to the river was estimated from limited sampling industries in the Colombo area. A total of 25 industries discharged industrial process waste, with a BOD range of 80 – 405 mg/l at rates between 500 m<sup>3</sup> per day (Anon, 1993). The San Sebastian North and south canals were found to be the most heavily polluted, with BOD<sub>5</sub> of 165-180 mg/l more than twice the level found in the next most heavily polluted canals.

The river Mahaweli is the longest river of Sri Lanka which drains about 1/6<sup>th</sup> of the country's land area. While its journey through this large catchment area, it passes through densely populated regions, receiving large quantities of organic loads. In Kandy, at Meda Ela alone, it receives organic load of 712 1507 kg BOD/day (Anon, 2000 b). Apart from the city centers, the Mahaweli river waters receive large amounts of agro-chemicals via its catchment oriented towards agricultural activities, mainly through the paddy cultivation.

Some information exists on nutrient enrichments in the tributaries of the upper Mahaweli Catchment (Piyasiri, 1995; Piyasiri, 2001) and reservoirs via surface runoff due to excessive usage of fertiliser in the tea estates.

The 103 river catchments and the large number of tanks distributed over the country face pollution threats due to lack of proper water resources management criteria, and a coordinated mechanism is needed for water resources management.

## 5.0 Water Resources Management

### 5.1 Present status and required initiatives

Sri Lankans assume that the water is a freely available resource, but the demand is exceeding availability in some regions with the increasing

population, urbanisation and industrialisation. To achieve harmonious integration of the multiple uses of aquatic resources, proper plans for water resources management are essential.

There are many policy documents, legislations and institutions dealing with water issues. Over 100 acts of parliament exist with relevance to environmental management, and over 40 refer to water sector.

As a result of administrative units based on political boundaries, the activities of water resources management are diffused, and there is no proper coordination among institutions. Many organisations have the powers in controlling pollution, but none does strong law enforcement. Therefore, it is necessary to concentrate on basin-level management which will be more efficient and more scientific.

It is important to consider following in integrated water resources management (IWRM):

1. Consider a basin level management
2. Initiate proper water quality management criteria. Develop water quality Index (WQI) mechanism as in the other developed countries to classify the waters based on their quality. CEA and National Science Foundation can initiate the interest of scientists to develop the index.
3. The catchment management mechanism shall incorporate conservation of riparian zone, hyporhithic zone, 100m sensitive zones, wild life areas, etc. in IWRM.
4. Form River basin committees to integrate the water resources management activities. Administrators, the experts on water and catchment management, have to be incorporated into such committees to avoid problems encountered in lack of coordination among institutions.

5. Water policy document is already approved by the government, but it is important to consider the proposed water act with required revisions to omit or modify the sensitive issues such as water pricing.

### 5.2 Issues in water resources management

#### 5.2.1 Water quality, data bases and national guidelines

It is important to find out the status of the waters by proper water quality (WQ) monitoring programs. CEA, National Aquatic Resources Agency (NARA), National Water Supply & Drainage Board (NWSDB), National Building Research Organisation (NBRO) and some universities have undertaken water quality monitoring of surface waters for different objectives. As most of the available WQ data are scanty and not in a central database, such information is wasted and cannot be utilised properly in the management activities. Therefore, our waters are not yet quantified and classified based on status, and such data cannot be used efficiently to develop national guidelines or threshold levels for different water quality parameters. Therefore, a water policy or legislation should incorporate a mechanism to encourage the scientists to send their data to a common database for future use. Criteria could be adopted to have a database with a possibility to acquire information through internet, even by introducing a nominal fee for information.

It is essential to develop a basin-level database with other relevant information, including forest degradation, vegetation types, biodiversity, etc. for IWRM. It is suggested to include an administrative and an information unit in each river basin for handling such data and to develop a distribution mechanism for other users.

Table 2 : Water users categorised into simple groups		
User Category	Quality Requirements (Criteria)	Uses
1	water with highest quality and free of pathogens	drinking water supply, fishery, swimming and certain industrial processes such as food processing
2	water of lesser quality, but still free from toxins and pathogens	coarse fishery, amenity and recreation such as boating, also agricultural irrigation and certain industries
3	quality is unimportant, just quantity	cooling water and navigation

Union, Canada, Union of Soviet Socialist Republics (USSR) and the Environmental Protection Agency of the United States of America (USA).

#### *Water quality monitoring program*

Proper water quality-monitoring programs and research oriented towards major catchment issues also should be encouraged to obtain required information to develop national guidelines. A committee has to be formed, inviting water sector experts, to initiate research to develop national guidelines and Water Quality Index (WQI) for our waters to be used in water resources management.

Many developed countries have developed such national guidelines, and use them in developing WQI-values for their waters, integrating important physical, chemical and biological parameters to come up with a single value which will be very useful for water managers to develop relevant criteria for management of our waters.

### **5.2.2 Water quality monitoring**

Status of the water resources could be determined only through the water quality assessment of such waters. However, the water quality is very hard to be defined, and to a great extent, extremely subjective, and it is not simply a case of the cleaner or purer the better. For example, distilled water is extremely pure chemically, and its quality can be considered as being high as it contains no toxicants or pollutants. However, yet, it is unsuitable for potable use as it lacks the trace elements necessary for freshwater biota. Therefore, the water quality can only be defined in relation to some potential use for which the limiting concentrations of various parameters can be identified.

#### *Classification of user groups*

Classification of user groups was originally proposed by the World Health Organization (WHO). There are a variety of uses for water, each requiring their own set of specific quality requirements (criteria) as illustrated in Table 2.

In water management, decisions are based on the comparison of water quality data with criteria and standards. Sets of criteria exist for different categories of specific water use such as

- (i) drinking purposes
- (ii) recreational
- (iii) aquatic life
- (iv) agriculture and,
- (v) industry.

#### *Water quality standards and water users*

The proposed legislation by CEA is based on quality standards relating to suitability for a specific use and protection of receiving waters when waste water is released into water ways. However, Sri Lanka has not formulated the necessary legal and administrative procedures for adopting quality standards for surface water other than the proposed maximum allowable concentrations for selected water quality variables for different uses; nature conservation, drinking, bathing, fisheries, conservation of aquatic life, irrigation and agriculture proposed by the CEA. The proposed water quality standards are based on the existing international standards of the WHO, European

It is important to introduce a proper water quality monitoring program to investigate required water quality parameters to be used in IWRM. Water monitoring and modeling studies are important to analyse and predict pollution trends in major water resources. This should contribute to a national water quality database for decision making processes.

### **5.2.3 The water quantity management**

Surface water accounts for 98% of available water in Sri Lanka, of which, only about 25% is used. To get the maximum usage, we have to improve the efficiency of our water storage and usage mechanisms. As a result of competition among people for limited water for various purposes such as agriculture and industry, there are conflicts among competing water users. The irrigation sector alone accounts for about 96% of the national water consumption, and other users are competing with irrigation for water supply. Therefore, water managers have to develop an efficient water distribution mechanism.

### **5.3 Catchment issues in management practices**

Most of the water quality issues stem from the relevant catchments. As discussed under indicators, due to human activities in the catchment, most of the nutrients, pesticides, industrial effluent, sediment, microorganisms are sent to water resources with the surface runoff. Therefore, the water quality of the

surface waters indicates the symptoms of pollution of the relevant catchment. Therefore in the IWRM, it is necessary to look into the catchment issues responsible for water pollution, and criteria should be adopted to manage the catchment issues in order to protect the surface waters. It includes waste management from urbanised areas, control usage of excessive fertiliser in the agricultural areas, implement strategies to protect sensitive areas such as 100m sensitive area around the reservoirs, riparian zones, forest reservations, etc.

### **5.3.1 Controlling non-point source of pollution**

The non-point sources are the major source of water pollution in many surface waters, which are responsible for most of the suspended solids, oxygen-demanding loadings, nutrients, and bacteria counts. Proper management criteria should be introduced to manage the tea, paddy and home garden cultivations in the catchments where excessive fertiliser and pesticide applications occur.

The bare land should be minimised to reduce soil erosion. Performance standards could be introduced to place limits on the rate of pollution discharge to the water ways. Deforestation activities should be stopped in the catchments without proper environmental assessments.

### **5.3.2 Waste management**

Government should provide required infrastructure and support services for efficient removal and recycling of garbage collected within the sensitive catchments, as there is a high potential of water pollution threats due to garbage accumulation. Agro-based industries at the vicinity of the reservoirs should be encouraged to set up anaerobic digesters which are compact, low energy consuming and efficient for high organic wastewater. Instead of using imported technologies,

local institutions should adapt suitable cost effective technologies for this purpose. In the highly populated areas, the pollution of water ways through sewage (microbial contamination) should be controlled through a mechanism of bypassing the water resources by introducing proper sewerage canals (Piyasiri, 2008).

### **5.3.3 Conservation of 100m sensitive area**

If the developmental activity or any industry (minor or major) located within the 100 meter sensitive area of a reservoir or a water body, their outputs are very significant because the reservoirs receive the discharges in the concentrated form. (e.g. hotels may discharge organic waste; textile industry may release dyes, etc.). Therefore, it is recommended that the management of the 100m buffer zone in conservation of reservoirs according to the National Environmental Act.

### **5.3.4 Conservation of riparian zone around the reservoirs**

Riparian strips should be introduced to protect riverine areas saturated with river waters and the shoreline areas of the water bodies. This filters the nutrients and toxic substances, minimising their effects on the receiving waters. Riparian buffer zones are highly effective in nutrient and sediment removal, and are increasingly used to protect all types of water resources.

### **5.4 Awareness programs**

Farmers, general public and the schoolchildren should be educated through the awareness programs to minimise the pollution in neighboring water resources.

Media should be used as an effort to introduce awareness programs to educate the farmers about the nutrient traps (nutrient absorbing plant strips) in controlling the nutrient loading

effect via catchments where high fertiliser usage exist.

To accelerate the provision of sanitary facilities, the low income groups need to be educated on the importance of sanitation and its association with diseases. The current lack of trained and qualified health education personnel needs to be remedied.

## **5.5 Research and education**

Government agencies should cooperate with universities and other institutes to carry out research activities focused on environmental protection. It is recommended to focus research activities towards catchment management practices to avoid degradation of water resources.

## **5.6 Implementation and operation**

In Sri Lanka, the major problem in management is lack of proper coordination between the issue identifier and the implementing organisation. The catchment management criteria which are very weak within the existing institutional frame work of Sri Lanka, and it has to be refreshed. Links should be maintained among various organisations which involve in the studies on catchment issues to obtain information for this purpose.

## **Conclusion**

1. The surface water resources of Sri Lanka are threatened due to excessive usage of fertilizer and pesticides in their respective catchments. The statistics on nutrient usage by crops and over the years indicates increasing trends of their applications.
2. The recent water quality studies in Arugam Lagoon and Batticaloa lagoon indicates increasing rates of microbial pollution (Faecal coliforms) related to lack of proper sanitary facilities in the respective catchments. The 1% of the population in the country without access to proper toilet facilities will be a threat towards surface water pollution.

3. There is no proper coordinated water quality monitoring programmes in the country to use in water resources management. The available data are scanty and there is no national data base to be used in water resources management. The responsible authorities have to focus on this matter to formulate such a data base similar to available data bases of Census and Statistics Department.

4. The ambient water quality standards or national guidelines are lacking for some parameters in Sri Lanka. Such gaps have to be filled for the efficient water resources management.

5. In order to monitor the trends of water quality it is advisable to initiate water quality index programmes in the country. The research grants have to be focused more on this aspect as in the other developed countries of the world.

6. The water sector organizations have to form decision making bodies for conservation of surface waters with affective coordination.

7. Integrated water resources management has to be encouraged in all the policy documents and in water sector acts to be implemented.

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## Footnotes :

<sup>1</sup>The climatic condition of Sri Lanka is based on the generation of monsoonal wind patterns in the surrounding oceans

<sup>2</sup>There are four basic rainfall seasons in the country namely:

- (i) The South- west monsoonal period (May to September);
- (ii) The inter- monsoonal season of October November;
- (iii) The North-East monsoonal period December to February; and
- (iv) The inter-monsoonal period of March to April.

<sup>3</sup>The point of origin of the stream is termed as headwaters. Initially a stream is a temporary one and later, when the channel is cut below the level of ground water table (or when fed by streams), it becomes permanent.

<sup>4</sup>The ephemeral rivers flow only during or immediately after periods of precipitation. They generally flow less than 30 days per year. Intermittent streams flow only during certain times of the year and their seasonal flow usually lasts longer than 30 days per year.

<sup>5</sup>According to Land and water conservation Department of New South Wales, Australia, and the alert levels for blooming are as follows:

Alert level 1-500-2000 cells / ml of water- Does not indicate an algal bloom. But there may be taste or odour problems and an indication that an algal bloom be developed.

Alert Level 2- 2000- 15000 cells /ml of water- Still not considered as a bloom although water treatment using activated carbon or use of alternative water supply is recommended.

Alert Level 3- More than 15000 cells/ml of water- indicating of bloom. It is assumed at this stage that the bloom is toxic and action should be taken accordingly. Monitoring should be conducted monthly or ideally biweekly because two-week is the approximately minimum time for algal blooms. (Australia: State of Environment Report 2001).

<sup>6</sup> The BOD of natural waters is related to the dissolved oxygen concentration, which is measured at zero time and after 5 days of incubation at 20°C. The difference is the dissolved oxygen used by the microorganisms in the biochemical oxidation of organic matter. This indicates the rate of oxygen depletion in the water body and if its value exceeds 4 mg/L the water body is considered as polluted.

<sup>7</sup> COD is an indication of the proportion of organic material present in waters that is biodegradable, although some polysaccharides, such as cellulose, can only be degraded anaerobically and so will not be included in the BOD estimation. If the COD level exceed the threshold level established by the Central Environmental Authority (values of 15-20 mg/L), the water body is considered as threatened of pollution. The COD: BOD relationship varies from 15 to 20 depending on the type of organic substances present in the water.

<sup>8</sup> The amount of Oxygen Dissolved in water which is an indication of the health of the water resources.



# Groundwater resources in Sri Lanka and its importance towards economic development

## Abstract

Groundwater identified as an economic resource has a great potential to enhance productivity in agricultural and industrial sectors. In addition, use of groundwater as a safe drinking water for drinking purposes has great influence to improve human health and in turn enhance the socio-economic situation of the country. Due to limited water resources available in rivers, lakes etc, use of groundwater being gradually increased as a major source for many urban water supplies mainly for Industrial and domestic purposes. Groundwater was the only sources for water supplies in accelerated development projects implemented in recent past which gave enormous contribution to the economic development of the country. In rural areas groundwater is used in rural farming and drinking purposes. Abstraction of groundwater by means of *Agro-wells* (shallow open wells) and *deep tube wells* increase the productivity of the rural farming activities, specially in dry zone of Sri Lanka.

From these facts, link between use of groundwater and economic development, social welfare have to

be accepted without any doubts. However, intensive groundwater development may induce some negative effects such as groundwater level and storage depletion, saline water intrusion in coastal areas and sometimes deterioration of water quality. Therefore, systematic groundwater exploration and development is required to sustain the limited water resources in the country.

## Introduction

### What is groundwater?

Groundwater is that portion of the water beneath the surface of the earth that can be collected with wells or that flows naturally to the earth surface via seeps or springs.

### How ground water occurs in rocks

It is difficult to visualize water in underground. Some believe that ground water collects in underground lakes or flows through underground rivers. In fact, ground water is simply the subsurface water that fully saturates pores or cracks in soils and rocks. Ground water is replenished by precipitation and, depending on the local climate and geology, is unevenly distributed in both quantity and quality. When rain falls or snow melts,

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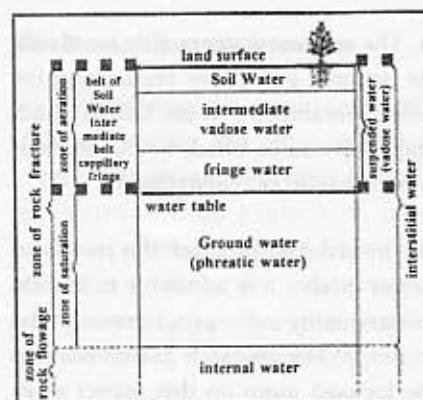


Figure 2 : Diagram showing divisions of subsurface water (from O. E. Meinzer)

some of the water evaporates, some is transpired by plants, some flows overland and collects in streams, and some infiltrates into the pores or cracks of the soil and rocks and move further downwards to reach the water table.

### Principles of groundwater occurrence and movements

As a starting point, it is intended to provide some basics of groundwater to assist readers who do not have background knowledge of this discipline. Therefore, the following discussion of the occurrence of ground water has been adapted from Meinzer (1923) to explain groundwater occurrence and its flow characteristics.

The rocks that make up the crust of the earth generally are not solid, but have many openings, called **voids** or **interstices**, which may contain air, natural gas, oil, or water. The many different kinds of rocks differ greatly in the number, size, shape, and arrangement of their interstices; therefore, the occurrence of water in any region is determined by the geology of the region.

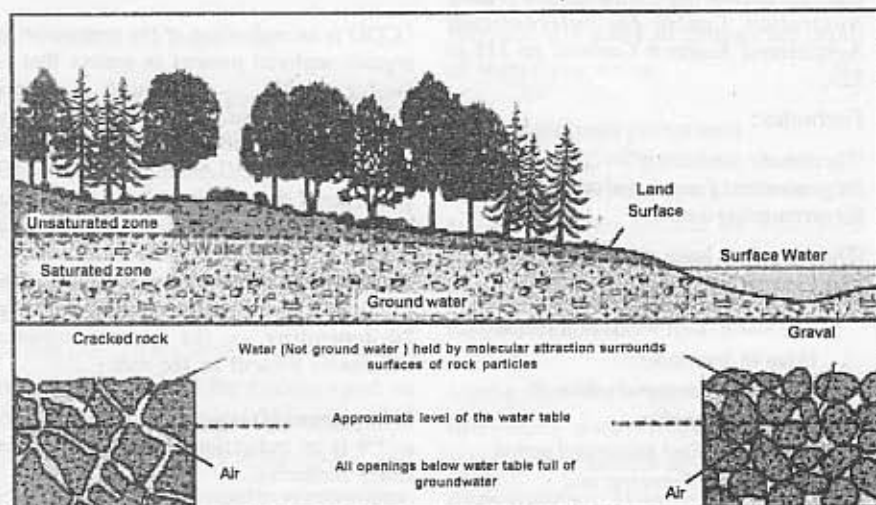


Figure 1 : How groundwater occurs in rocks

The interstices or voids in rocks range in size from microscopic openings to the huge caverns found in some limestones. The porosity of a rock is expressed quantitatively as the percentage of the total volume of the rock that is occupied by interstices or that is not occupied by solid rock material. Uncemented gravel deposits having a uniform grain size have a high porosity, whereas deposits made up of a mixture of sand, clay, and gravel may have a very low porosity because the smaller particles occupy the space between adjacent large particles. Relatively soluble rock such as limestone, though originally dense, may become cavernous as a result of the removal of part of its substance through the solvent action of percolating water. Hard, brittle rock may acquire large interstices through fracturing that results from shrinkage or deformation of the rocks or through other agencies.

The permeability of a rock is its capacity for transmitting water under pressure and is measured by the rate at which the rock will transmit water through a given cross section under a given difference of head per unit of distance. A rock containing many very small

interstices may be porous, but not very permeable; whereas, a coarser-grained rock may have a low porosity but will generally be much more permeable.

The permeable rocks that lie below a certain level are generally saturated with water under hydrostatic pressure. These saturated rocks are said to be in the zone of saturation (Figure 2).

The zone of saturation ordinarily extends down to a depth much greater than is reached by modern drilling methods. The term ground water is also used to designate that part of the subsurface water within the zone of saturation. The upper surface of the zone of saturation when not formed by an impermeable body is called the ground-water table, or simply, the water table. In most places there is only one zone of saturation, but in certain localities the water may be hindered in its downward course by an impermeable or nearly impermeable bed to such an

extent that it forms an upper zone of saturation, or perched water body, that is not associated with the lower zone of saturation. Figure 3 shows field situation of movement of groundwater in vertical soil profile with various aquifer types which are important in storing water (Chatterjee 1994)

**Aquifer:** A subsurface zone that yields economically important amounts of water to wells. The term is synonymous with water-bearing formation. An aquifer may be a porous rock, unconsolidated gravel, fractured rock, or cavernous limestone. Aquifers are important reservoirs storing large amounts of water relatively free from evaporation loss or pollution.

**Aquitard** is a geological formation that may contain groundwater but is not capable of transmitting significant quantities of it under normal hydraulic gradients. It may function as confining bed. **Aquiclude** is a geological formation not capable of transmitting water.

Figure 4 : Major hydrogeological regions of Sri Lanka (Cooray 1984)

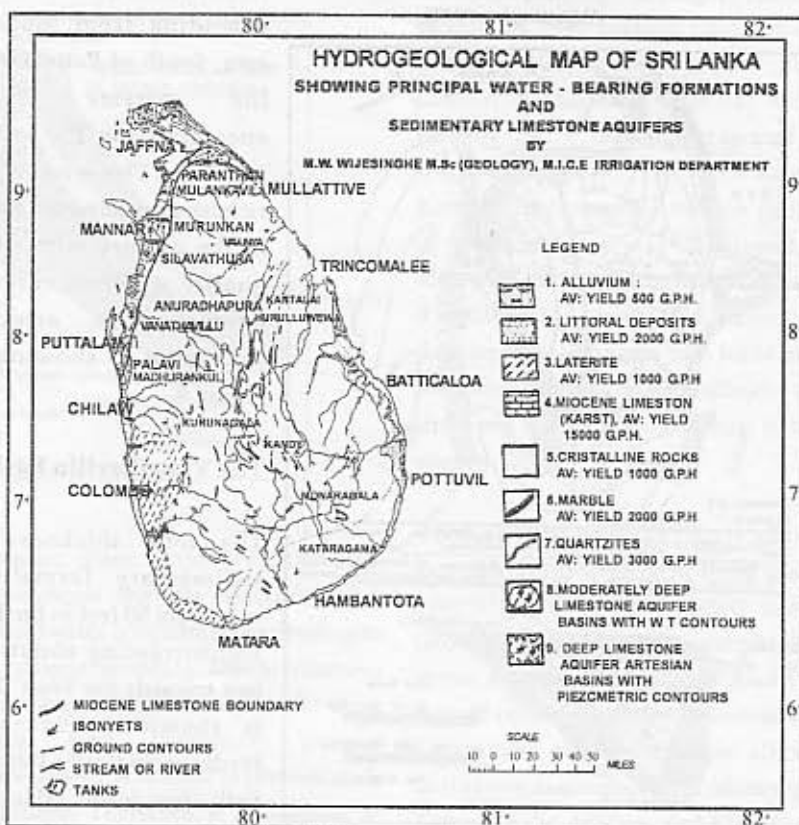
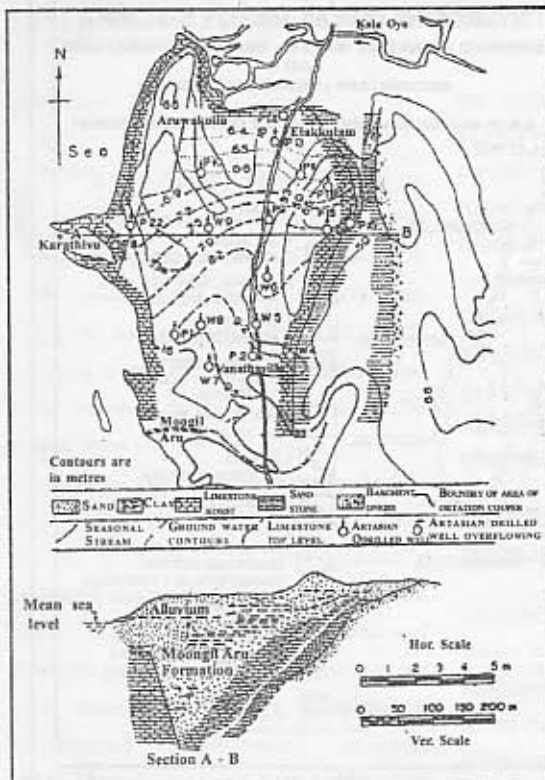


Figure 3 : Soil profile with different aquifers



Figure 5 : Vanathavillu basin  
(Wijesinghe 1973)



#### Groundwater Occurrences in Sri Lanka and development capabilities for economic development

In this brief description it is intended to provide general groundwater condition with its development possibility for economic development. Major groundwater regions (see figure 4) and aquifer basins summarized in the following chapter :

##### 1. North and Northwest Limestone Belt

This is the main sedimentary basin of the country and confined to the

Northwestern coastal belt extending from Mundal area, South of Puttalam, to the extreme North encompassing the Jaffna peninsula. This is one of the richest groundwater basin in the country with good quality water at varying depths with artesian conditions as showing in Figure 4.

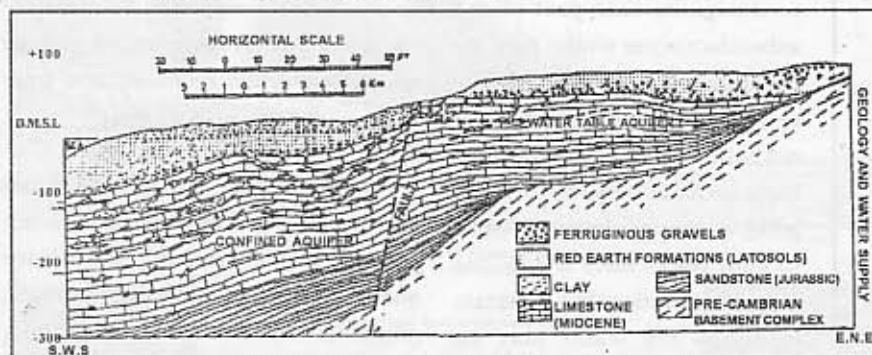
##### The Vanathavillu Basin

The total thickness of sedimentary formations vary from 50 feet in the East and increasing about 800 feet towards the West. This is shown in Figure 5. Hydrogeologically this has both free water table and artesian aquifer

characteristics.

According to the available data on deep tube wells drilled from 100 - 150 meters depth, safe yield of 20 - 35 gallons per minute with good quality water. Presently more than 100 deep wells have been constructed for agriculture and prawn culture purposes. Based on the findings of previous studies (Wijesinghe, 1973) nearly 1200 acres of land could be brought under successful agriculture crops and further development is possible.

Figure 6 . Geological condition of Murunkan basin



##### GEOLOGIC SECTION ACROSS THE MURUNKAN BASIN

Geological cross-section across the Murunkan Basin showing groundwater conditions in confined aquifer in limestone.  
(After M. W. P. Wijesinghe, 1977)

##### Murunkan - Silavatura Basin

This basin covers 310 sq km area and it has similar geological characteristics as in the Vanathavillu basin consisting of Jurassic sandstone, karst Miocene limestone and quaternary unconsolidated sediments (Fig 6). This is essentially water table aquifer with water table being 10 - 20 meters below the ground level.

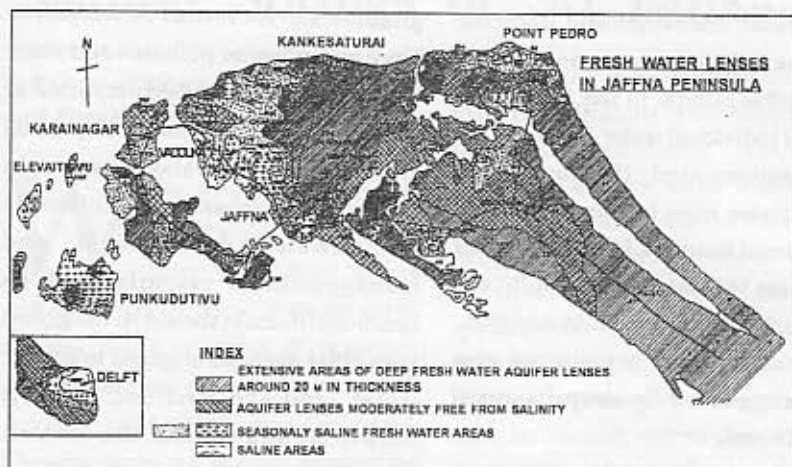
The water Quality is very high having an average salinity of 200 ppm. Well yield varies from 10 - 15 litre per seconds satisfactory for irrigating agriculture fields. Safe groundwater abstraction limit identified by previous studies (Herbet et al, 1988) was 4-5 Million Cubic Meters (MCM) per annum and can be used for development activities mainly towards agriculture development Within the Murunkan and Mannar area, groundwater is used to supplement the surface water supply using Giant's Tank for the irrigation of rice fields. Previous studies concluded that potable groundwater can be obtained from the top most zone of the aquifer at a depth of 20 meters below sea level and a further deeper zone contain very saline water.

##### Jaffna Penninsula

Groundwater in Jaffna in highly cavernous (karst) limestone formations that lie within shallow depth in most part of the area. Due to the dense network of caverns, fractures and fissures, the entire peninsula is subjected to sea water intrusion but, supports accumulation of freshwater mounds in the central part of the land units. Average groundwater recharge from seasonal rainfall have been evaluated over 10 years and usable groundwater has been evaluated roughly ranging between 10 - 25 MCM. Recent studies conducted (Wijesinghe 2002) in the area have indicated thickness of fresh water lens ranging from 20 - 30 meters in Putur, Pannikkudduwan and Uralli -



Figure 7 : Groundwater situation in Jaffna



Pokkanai areas. It has also found that productive groundwater lenses that covers a total area around 25 sq km extending up to Thirunaweli in the South and up to Vasavillan to the North. The updated map is shown in Figure 7.

More productive soils (red soils) occupy the major inland portions and crops originally cultivated are chillies, onions, potatoes, tobacco, vegetables,

bananas, these crops are cultivated throughout the dry season using groundwater irrigation contributing to our national economy. Due to intensive agriculture, high nitrate levels were found and therefore, proper management is needed to prevent such pollutions. Therefore, it is essential to undertake detail groundwater assessment to evaluate quantity and quality prior to implement new agriculture development projects.

#### Coastal Sand Deposit and River Alluvial Deposits

This aquifer systems also identified as a large carrier of groundwater.

**Coastal sands:** Three main types have been recognized (Panabokke et al 2002)

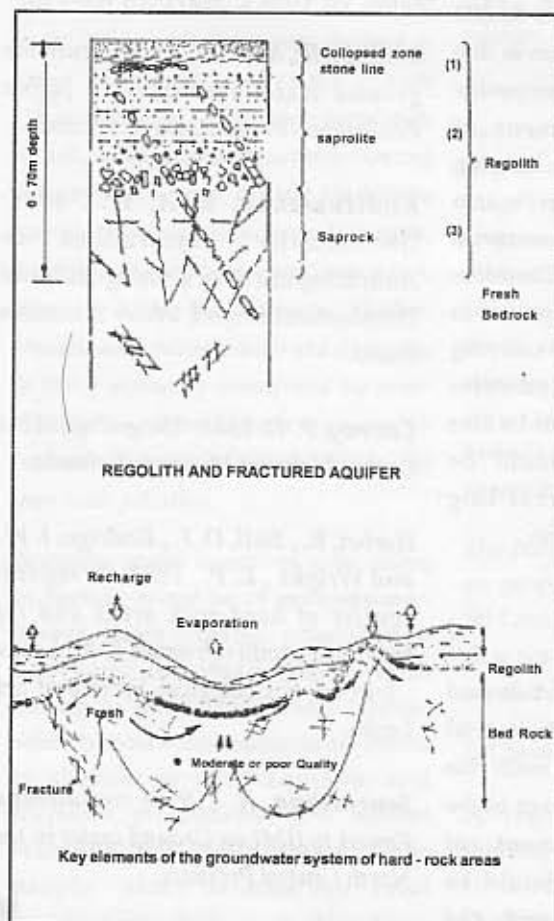
1. Shallow aquifers coastal spits and bars occupied in Kalpitiya, Poonaryn and Mannar Island
2. Shallow aquifers on raised beaches located in Pulmude, Nilaveli Kalkudah and Hambantota
3. Moderately deep aquifers on old red and yellow sands located in Katunayake and Chillaw

In these aquifers groundwater could be developed from shallow tube wells up to depth of 30 m for agricultural and industrial purposes with capacities ranging from 5-10 liters per second per well. For example, Free Trade Zone at Katunayaka, nearly 1 million gallons of water per day was developed by means of tube wells in early 1990 and it is still being expanded with industrial development. Koggala free trade zone is another example as groundwater was the only water source when it was started.

**River alluvial deposits :** River alluvial deposits are extensive in flood plains specially in river out-fall areas. Groundwater potential is very high in these aquifers and water could be tapped continuously for industrial and agriculture purposes. Major alluvial basins are associated with Mahaweli, Kelani, Kalu, Walave and Kirindi oya river basins.

#### Groundwater in Crystalline rocks

Nearly nine-tenths of Sri Lanka is underlain by crystalline rocks which is also called **Hard Rocks** (Figure 4). Granites, Quartzites, Charnockites, Marble (crystalline limestone) and Gneisses are common hard rocks in Sri Lanka. In previous studies (Herbet et al 1988) groundwater occurrence in weathered rock and soil overburden has been defined as **Regolith** aquifer (Figure 8) and below this a zone of fractures developed due to various deformations occurred in geological history. Development of fractures in crystalline hard rocks is mainly due to occurrences of tectonic events in geological history. These fractures are formed by geo-structures such as joints, faults, contact zones between different brocks and shear zones as these week zones have some open spaces capable of storing and transmitting water. Figure 9 shows generalized groundwater flow characteristics in fractured aquifer.





## Shallow Regolith Aquifer

Many agrowells (large diameter open dugwells) have been constructed mainly in regolith aquifer penetrating to the top of the saprock. Some studies (Panabokke; et al 2002) identified occurrence of favourable groundwater condition for agrowells in small tank cascade in Northcentral and Northwestern provinces. This productive groundwater zone is located mainly in saprolite (Figure 8) which include highly weathered and moderately fractured rock materials and some localities it has slightly weathered rock with open joints. It is reported that (Panabokke; et al 2002) 100 mm of groundwater recharge in upland areas and 150 mm in lowland paddy areas. Since these figures refer to the tank cascade system of Northwestern and Northcentral provinces of the country, it reveals possibility of development of agrowells to increase agricultural land area specially in dry seasons where surface water irrigation by small tanks are not sufficient. A methodology also developed (Senaratne 1996) to allocation of agro-wells in a tank cascade system to optimize groundwater abstraction by means of agro-wells.

## Deep fractured aquifer system

Groundwater abstraction in deep fractured aquifers is possible by means of tube wells having depth varying from 30 - 100 meters. Data on tube wells drilled so far in the country, well yields varies from 5 - 200 liters per minute, in general, but much higher yield have been observed under special hydrogeological situations. Low yielding tube wells (yield less than 5 litres per minute) can be used for rural water supplies using hand pumps and high yielding tube wells (yield not less than 20 liter per minute) can be considered as production wells and

suitable for development of agriculture, industrial and domestic water supply schemes using electro submersible pumps. In late 1980s more than 100 individual water supplies have been implemented (by abstracting groundwater from fractured aquifers) for garment factories. Intakes for water supply for Vavuniya town is fully met by deep fractures aquifer. In addition, several urban water supplies are now being augmented by deep fractured groundwater.

## South-western Laterite Region Aquifer

Laterite is a product of decomposition of crystalline rock occurs in Southwest region. Since the area is densely populated with increased industrial activities groundwater in Laterite aquifer is important for economic development. Reported well yields in Ragama area (Cooray 1984) 60,000 gallons per day (from 11 wells) and Gonitota a single well yields 80,000 gallons per day. The variation is due to filling of kaolin clay in permeable zone. The rapid development of industrial zones and urban housing schemes that are taken place in the area are exerting tremendous pressure on this groundwater resource. Therefore further groundwater development to be carefully undertaken after carrying out systematic groundwater exploration and groundwater monitoring net work should be developed to study the impact of long term ground water abstraction.

## Conclusion

Use of groundwater for urban and municipal water supplies, industrial and agriculture sector play a main role in socio-economic development in the country. Detail assessment of groundwater resources should be carried out to understand the

possibility of optimum use of groundwater for further development. Since groundwater pollution and water level depletion have been reported in some areas, attention has to be paid on groundwater conservation measures. In this regard a separate Institution for groundwater development and management is essential and its functional domain should be integrated with other agencies engaged in surface water, soil and land use, forestry, industrial and agriculture sectors. Community participation in groundwater management has to be further improved for effective and efficient development of limited groundwater resources.

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# Natural Springs of Sri Lanka: An Overview

## 1. Status of Water Resources: Past and Present

**W**ater is a unique gift of Mother Nature. Although water is the most widely occurring natural resource on the earth, covering nearly two-thirds of its surface, only less than one percent of fresh water is accessible and usable by man and animal. Therefore, water is a precious resource and a basic need for sustenance of all forms of life. From ancient times, water has been the focal point in our civilisation and early settlement schemes in the dry zone. Therefore, our ancestors treat water with reverence. Sri Lanka, compared with many other countries, is an island nation endowed with a high annual rainfall (avg. 1800 mm) and well distributed network of water bodies, making it rich in water resources, in terms of total aggregate available. For example, the per capita water availability was about 6000 cubic a meter per annum in the 1950 s' which has now declined to about 2100 cubic meters per annum (Yogarajah, 2002). However, population growth, rapidly increasing urbanization and industrialization over the past few decades have led to an increasing demand for water, creating a shortage of safe and clean water, especially during the dry season. Further, physical availability of water and its quality is being seriously threatened by over-exploitation of groundwater resources for intensive agriculture, climate change and man-made pollution.

Basically, water resources exist either as **surface water** or as **groundwater**. Rivers, lakes streams, ponds, large reservoirs and small village tanks belong to the surface water bodies, while groundwater resources are stored in shallow or deep aquifers, and therefore, groundwater is a hidden resource, not easily accessible to people. Many decades ago, rural people, particularly in the Dry Zone,

depended on surface water sources to meet their drinking water supplies and other domestic needs. But, today, almost all surface water bodies have become polluted due to man-made activities. Therefore, over 80 percent of rural population depends on groundwater sources such as dug wells, tube wells and agro-wells for meeting their water needs (Niyandagoda, 2008). But, in recent, years due to over-exploitation of groundwater in the Dry zone, many shallow wells either dry up during the dry season or water gets contaminated with toxic chemicals from agricultural inputs.

In some dry zone areas (e.g. North Central Province (NCP)), more than 40% of deep tube wells are reported to be contaminated with excess Fluoride (Perera et al., 2008) and unsuitable for drinking and cooking purposes. As a result, rural people face many hardships due to lack of safe and clean fresh water, especially in the dry season.

In this scenario, fresh water from natural springs which has remained largely an untapped resource, offers a huge potential as an alternate water source for the rural community. Natural springs are so vital to the country's well-being as they are the main water sources that feed the streams which in turn nourishes our river-system. However, our knowledge of the natural springs is somewhat meager.

The purpose of this article is to provide an overview of the natural springs in Sri Lanka and to highlight its potential as a water source easily accessible to rural communities.

## 2. Classifications of Springs

Springs are classified as **natural**, **thermal** and **mineral**, according to the chemical composition of its waters (Arumugam and Ranatunga, 1974). In

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the past, thermal or hot springs have attracted lot of attention, especially as popular bathing spots. Many such springs occur in the Eastern coastal region of Sri Lanka. By contrast, natural springs have not received much attention until recently. At present, there is a growing appreciation of their contribution in sustaining dry weather water flow in streams and water courses.

Some of these natural springs are large in size which is referred to as "**Bubula**" in rural areas (Arumugam and Ranatunga, 1974). They are mainly distributed in areas underlying the quartzitic rock in the Dry Zone and maintain water flow throughout the year (Perennial). The small sized natural springs are referred to as "**Ulpotha**" and most of them maintain a steady flow of water during the wet season and reduce water flow to a trickle or dry up completely during the dry season.

## 3. Occurrence and Distribution of Springs

A spring is a natural flow of groundwater from soil or rock surface and occurs wherever groundwater table intersects with ground surface (Arumugam and Ranatunga, 1974). The flow of water from a spring is affected by fluctuations of the groundwater table between the dry and wet season. Such springs are usually associated with three main types of rocks, Quartzite, Crystalline Limestone and Fissured gneisses or Schists (Arumugam and Ranatunga, 1974).

Back in 1970, Water Resources Board conducted an islandwide survey (Arumugam and Ranatunga, 1974) to collect basic information about the springs in the country, and they identified as many as 225 natural springs distributed throughout the country, either on Government land or Private land. The distribution of natural springs is shown in Table 1 and Figure 1. It is clear from the above Table that a large number of springs is concentrated in Badulla District (71 Nos.) followed by Anuradhapura (26 Nos.) and Matara (23 Nos.) Districts. We are fortunate that there are so many natural springs in this small country, yielding millions of gallons of fresh water to enrich our water resources. However, some of these springs may have been destroyed or damaged by human activities during the past few decades.

#### 4. Quality and Quantity of Spring Water

As the water flows out or discharged from a spring is well filtered through its passage of soil strata or rock fissures, spring water is of very desirable quality free of any pollutants. Spring water is therefore much safer to use, in contrast to other water sources. However, water quality would be entirely dependent on the chemical nature of the rock or soil strata through which it traversed. For example, spring water moving through crystalline rock appears to be well filtered before it flows out of the spring. In contrast, spring water flowing through laterite rock surface would show the presence of iron and appears turbid (Arumugam and Ranatunga, 1974). The Water Resources Board has recently analyzed several water samples collected from natural springs on few locations. The chemical data given in Table 2 clearly show that spring water is of very high quality and not contaminated with organic pollutants.

The quality and duration of water flow from a spring are dependent entirely on the amount and distribution of rainfall that recharge the groundwater, soil drainage and water holding capacity of soil. It has been estimated that the perennial large springs (Bubula) which are located in the Dry Zone areas underlying the Quartzitic rock are high yielding, producing about 100,000 gallons of water per day during the wet season and about 50,000 gallons per day during the dry season (Arumugam and Ranatunga, 1974). By contrast, those springs underlying the Crystalline Limestone rock are capable of producing a moderate yield of 25,000 - 50,000 gallons per day. Such springs occur in Badulla and Matale Districts. Spring water from these possesses a clear appearance free of organic pollutants.

#### 5. Use of Spring Water

Until recently, much less attention has been paid to derive the maximum benefit from these virtually untapped water resources. However, with the looming scarcity of safe and clean fresh water supplies, there is a compelling need to exploit natural springs as a potential water source for rural communities, especially in the Dry Zone.

One such highly productive fresh water spring is located on a temple land in Kebithigollewa DS Division in Anuradhapura District. This spring is popularly known as "Gonamariyawa" fresh water spring, yielding a copious flow of water throughout the year (Plate 1). Spring water from this site is being used for drinking and other purposes such as bathing, washing. Further, the overflow from the spring is being used for cultivation of paddy and vegetables by the local community. Similarly, there are few other popular springs in Embilipitiya (e.g. Sudugala in Panamure) and Polonnaruwa areas and other parts of the country, frequently visited by local people and public.

There are few springs utilized by local authorities for rural water supply schemes. More recently, few bottled drinking water companies have harnessed natural springs on private lands, for manufacturing bottled water which has a well-established ready market both locally and overseas.

Also, there are some perennial springs yielding copious flow of pure and clean water, which can be used for pipe-borne water supply schemes for the benefit of larger community in rural areas. In some areas of the NCP such as Padaviya, Kebithigollewa, Medawachchiya, Mahanuwara, Mahavilachchiya, Medirigiriya and Welikanda, many people, particularly farmers in the 40 - 60 years age group suffer from Chronic Kidney Disease (CKD), which is suspected to be due to the consumption of water contaminated with excess Fluoride and heavy metals such as Cadmium and Lead (Liyanage, 2008). So far, no permanent cure has been found to restrict the spread of CKD in this area. As an interim measure, medical specialists have advocated that switching to spring water may check the incidence of CKD in the NCP (Wijewardena, 2008).

Above all, fresh water springs play a very important function of sustaining the continuous water flow in river basins and catchment areas.

#### 6. Conservation of Natural Springs

The main objective of conservation of natural springs is to make maximum use of its groundwater storage capacity, while sustaining it as an actively functional spring for a long period. While no serious attempts have been made so far to conserve the majority of springs in the country, at least some have been conserved either by local authorities or local community or private parties. For example, source area of the popular natural spring "Gonamariyawa" at Kebithigollewa DS Division is completely covered with

Pandanus and rare medicinal herbs, which helps conservation of the springs (Plate 1). Some springs situated on private land have been conserved by private parties other than the land owner. Very often, private parties have conserved springs on crown land and allowed the public to use water for domestic and bathing purposes, while they used the overflow to cultivate paddy, etc.

Although, it is generally conceded that springs located on private land belong to the land owner who is entitled to use it all by himself, the local traditions restrict the owner from exercising his rights of ownership by allowing peaceful utilization of the available spring water by the local community and the public, for meeting their basic needs such as drinking, bathing and washing with the consent of the owner (Arumugam and Ranatunga, 1974).

With the development of the tea industry in the hill country, a large number of springs would have been destroyed or some have been damaged. Subsequently, with the afforestation program implemented on uneconomic tea lands, an extensive area of the hill country has been planted with *Pinus* trees, restricting percolation of rain water into the deep soil to recharge the groundwater. It is notable that the disappearance of so many natural springs and lowering of groundwater table has adversely affected the water resources in and around the hill country, experiencing severe water scarcities during non-rainy periods. Stripping soil or clearing natural growth in the vicinity of a spring could easily reduce the water flow to a trickle.

In certain areas, excavation of pits for gem mining could adversely affect spring water flow and in the hill country, many springs are threatened with extinction as their catchment area is being deforested for timber and fuel wood. In Badulla District, it was reported that water flow from 20

springs on crown land was fast dwindling, as a result of clearing the source area for cultivation by "Chena" farmers, causing great harm to the environment as well as large section of the community.

For the above reasons, source of the spring and its vicinity should be well protected by demarcating an area of about half to two acres as a reservation and fencing the area by barbed wire or live fence with an entry point and protecting it by maintaining a natural vegetation of trees and shrubs. The wet season overflow of water from the spring could be collected by constructing a "Wewa" or small tank to include all vents of a spring or by constructing a community well. This practice will maximize the underground water storage and reduce wastage and permits the use of spring water by the local community or public.

## 7. Need for Legislation

The enactment of legislation is needed for effective conservation of a spring and more equitable distribution of the available spring water. Unless effective measures are introduced to safeguard and protect our natural springs, we shall not be able to sustain our water resources in the future. All springs on private land must be declared by law to be the property of the State, as done by other countries.

The existing laws and government machinery seem to be adequate to provide protection to the springs and source area, as outlined below:

(a) Under the Crown Land Ordinance Section 40 (2), Ministry can declare source area of a spring as a crown reservation for the protection of a spring, and regulations can be made for the use of spring water.

(b) Section 70 of the Penal Code makes provision for a Police Officer to prosecute any person who intently

pollute the water of any public spring and render it unfit for use.

(c) Under Section 8 (9) of the Land Development Ordinance, crown land could be mapped out for the protection of a spring and grant authority to use water from the spring.

(d) Under the Land Acquisition Ordinance, it is possible to acquire private land for the protection of a spring and source area and declare it as a crown reservation.

(e) Under the Soil Conservation Act, it is possible to advise the private land owner to reserve an area for the conservation of a spring and to restrict the land owner from cultivating the land.

Therefore, practice of clearing the natural vegetation and cultivating the spring reservation area, encroachment, disturbing the soil and flow of water should be arrested. Furthermore, laws should be enforced to prevent people from blocking and suppressing the vents of a spring with stones or logs; removing soil, rock or other material from the vicinity of a spring; dumping refuse or other solid waste, illegal tapping or over-exploiting spring water by the industry and private parties; leasing the source area of a spring on private land for cultivation; and deforestation and land degradation of catchment area by "Chena" cultivators.

## 8. Conclusion

In rural areas, only about 10% of the households have access to pipe-borne water. Inadequacy of water supply and poor quality of surface and ground water are the main issues in rural areas. It has been revealed that the existing springs, which are so vital to the well-being of rural people, have been, in most cases, left unprotected and uncared for and not be exploited enough to address the scarcity of safe drinking water supplies to the local

*Contd. on page 67*



# Rain Water Harvesting in Sri Lanka

## Abstract

**T**here has been a significant increase in the use of rain water harvesting in Sri Lanka, which has proved to be a boon to rural people, particularly for domestic water supplies in water scarce situations. An estimated thirty thousand systems are presently in operation, scattered over a large number of districts. Interestingly, several large-scale projects have also been implemented in the urban context, and this too is likely to increase in the future. With a national policy on rainwater harvesting and other legislation in effect, Sri Lanka stands to benefit significantly by the appropriate use of this technology.

## Introduction

Many water problems in the world can be attributed to the uneven distribution of rainfall in time and space. Extremities of weather give rise to floods and droughts, often causing considerable damage to life and property. Countries subject to monsoonal weather patterns, such as, Sri Lanka, can experience flooding after a prolonged dry spell or a period of drought. There is also a growing concern globally about the implications of climate change on rainfall patterns, and about appropriate strategies to be adopted as far as infrastructure is concerned for proper management of rain water. In addition, globally, a Millennium Development Goal has also been set, which aims to halve the number of people who do not have access to safe drinking water by the year 2015. Thus, rainwater harvesting has emerged as an important issue in the international scenario, and was highlighted at the third World Water Forum held in Kyoto, Japan in 2003. In the context of Millennium Development Goals and

the issue of sustainability, the following conclusions are noteworthy:

- Harvested rain water is a major water supply option, as important as surface and groundwater
- That decentralised water utilisation and resource management uses rain water harvesting for the sake of the people and the Earth

Furthermore, at the Global Ministerial Environmental Forum held in Korea in 2004, it was concluded that alternative and cost effective technologies, such as rainwater harvesting, should be explored and promoted and the transfer of appropriate technology increased. Suggesting rain water harvesting as a new paradigm, Han (2004) suggests the building of a worldwide network to promote rain water harvesting.

## Rain water Harvesting Policy and Legislative Support

One of the earliest policy statements on water resources development and management in Sri Lanka, mentions rainwater harvesting. The famous proclamation by King Parakramabahu the Great (1153-1186AD), ".....let not even a small quantity of water obtained by rain, go to the sea without benefiting man" (Arumugam, 1969, quoted from Mahawamsa), shows the wisdom and commitment of ancient kings and people to conserve and efficiently manage water resources.

The ancient tanks of the dry zone and the complex water collection and distribution system of the Sigiriya rock fortress bear ample testimony to this fact.

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In June 2005, the government of Sri Lanka accepted a "National Policy on Rainwater Harvesting and Strategies" presented to the Parliament by Minister for Urban Development and Water Supply. The policy objective is aimed at encouraging communities to control water near its source by harvesting rain water. This results in minimising the use of treated water for secondary purposes, providing water for domestic use with adequate treatment, reduction of flooding, improving soil conservation and groundwater recharge, agricultural benefits and reduced energy consumption.

This policy document states the legislative changes needed in the Urban Development Authority (UDA) and Road Development Authority (RDA) by-laws on drainage and National Water Supply and Drainage Board (NWSDB) by-laws to incorporate rain water harvesting as a source of domestic water. Regulations have been gazetted on 17<sup>th</sup> April 2009, which make rain water harvesting mandatory in certain categories of new buildings in areas under municipal and urban council jurisdiction.

## Rain water Harvesting - Current Situation

Sri Lanka has used rain water for both domestic and agricultural purposes for many centuries. However, institutionalised rain water harvesting

became a practice in Sri Lanka in 1995, under the World Bank-funded Community Water Supply and Sanitation Project (CWSSP) which introduced rain water harvesting as a water supply option in the districts of Badulla and Matara (Heijnen and Mansur, 1998).

This project initiated the emergence of the Lanka Rain water Harvesting Forum (LRWHF), which is a non-governmental organisation (NGO) actively engaged in promoting rain water harvesting in the country. Since the CWSSP, a number of other organisations and institutions have adopted rain water harvesting as a means of supplying water to water

scarce households in both the wet and dry zones. Some of the noteworthy contributions in rain water harvesting for domestic use have been made by the Southern Development Authority, the Dry Zone Development Project funded by International Fund for Agricultural Development (IFAD), National Water Supply and Drainage Board 3<sup>rd</sup> and 4<sup>th</sup> Asian Development Bank Water and Sanitation projects and the 2<sup>nd</sup> CWSSP project. During the last 13 years, LRWHF has actively promoted the concept of rain water harvesting in all districts through demonstration projects, awareness programs, training, research and development, and networking. Presently, there are more than 30,000

domestic rain water harvesting systems recorded in 25 districts (Table 1). Most of these rain water harvesting systems are in rural areas, and have been implemented through government projects or by NGOs.

### Water Quality Issues

Rain water is one of the purest sources of water available, as it does not come into contact with many of the pollutants often discharged into local surface waters. It comes free and can be used to supply potable (drinkable) water and non-potable water. If collected properly, it can be used for all domestic purposes including drinking.

Rainwater from well-managed roof catchment sources is generally safe to drink without treatment. Except in heavily urbanised and industrialised areas or regions adjacent to volcanoes, atmospheric rain water is pure.

Any contamination of the water usually occurs after contact with the catchment system (roof). Regular cleaning and inspection of the catchment area and gutters are important to ensure good quality water (Heijnen and Pathak, 2006). Further treatment through boiling, exposure to sunlight and chlorination can be undertaken if there are concerns about water quality.

Insects breeding inside the tank can be prevented, by keeping the storage tanks and other openings sealed. Awareness and education are the two most important strategies to prevent water pollution.

**Table 1 : Distribution of rain water harvesting systems in Sri Lanka**

Province	District	No. of total number of rain water tanks		
		By LRWHF	By other organisations	
			No. of tanks	Organisations
Central	Kandy	10	2663	CWSSP
	Matale		994	CWSSP
	Nuwara Eliya	5	964	CWSSP, PALM
Eastern	Ampara	652	31	CI
	Batticaloa	11	36	Asia Onlus
	Trincomalee	19	-	-
North Central	Anuradhapura	13	3483	Plan, KOPBMO, ITDG, BLIA, NWSDB
	Polonnaruwa	-	1096	NWSDB, NCC
North Western	Kurunegala	51	577	GTZ, NWSDB, Sarvodaya, Plan
	Puttalam	14	1652	ORDE, PRDA, NWSDB
Northern	Jaffna	14	-	-
	Kilinochchi	09	-	-
	Mannar	11	98	IOM
	Mulathivu	03	-	-
	Vavunia	48	66	WV, IOM
Sabaragamuwa	Rathnapura	-	111	EC, HKLM
	Kegalle	8	1664	NWSDB
Southern	Galle	1397	-	-
	Hambanthota	1107	2811	Sarvodaya, WV, ADRA, OXFAM, NWSDB, ITDG, SDA
	Matara	629	1089	CWSSP
Uva	Badulla	1	5488	CWSSP
	Moneragala	40	1904	Sarvodaya, NWSDB, SDA, ITDG
Western	Colombo	5	41	USIP
	Gampaha	1	23	EC, CWSSP
	Kalutara	-	1443	NGOWSSDS, Asia Onlus, NWSDB
Total		4048	26234	
Grand total			30282	

Source: [www.lankarainwater.org](http://www.lankarainwater.org)

## Rain water Harvesting in Urban Buildings

Households in urban areas use pipe-borne water, not only for drinking and cooking, but also for gardening, car washing and all other activities. A close examination of Table 2 shows that apart from drinking and cooking, there is immense potential to utilise rain water to supplement household water supply for non-potable requirements, thereby reducing the use of treated pipe-borne water. Thus, authorities will be able to supply pipe-borne water to more households.

In view of the existing constraints faced by the authorities in meeting the increasing demand for water, it is vital that rain water harvesting be used as a supplementary source of water in urban areas where pipe-borne water consumption is very high.

A study indicates that, on average, in low income households in Sri Lanka, if

30% of the monthly water requirement was met by rain water, there will be a 34% reduction in water bill (Ariyananda and Gunasekara, 2004). In middle income households, if 30% of the monthly water requirement is met by rainwater, then the monthly water bill can be reduced by 61% at the present water rates.

The potential of rain water harvesting for large housing projects as a supplementary source and the required structural measures to be adopted have been studied and presented by Jayasinghe (2004).

Rain water harvesting in urban areas has many functions. It can supplement pipe-borne water for non-drinking purposes, thus conserving pipe-borne water, reduce energy cost of pumping, and also reduce flooding. Rain water collection in commercial and public buildings has particular advantages resulting from large roof areas.

Some examples of rainwater harvesting systems in commercial and public buildings in Sri Lanka are; Millennium Information Technologies Ltd., David Peries Motor Company and the Sabaragamuwa Provincial Council complex (Gunatilake et al., 2009).

Millennium Information Technologies Ltd. located in Malabe is a state of the art software company with about 300 occupants in a 12,000-sq.m. facility. Rain water from roof areas are collected and stored in ponds. The system which is designed for a 90-day dry period uses rain water for toilet flushing, gardening and washing and meets about 70% of the water demand, thereby contributing significantly to water conservation.

David Peries Motor Company which is a leading motor company has its assembly plant in Madapatha. Rainwater from roof and ground areas is effectively used for non-potable purposes with approximately 50% of the water demand being met, which also incorporates a treatment process.

The system is used to mitigate water scarcity from January to March and is also an example of a company's commitment to Corporate Social Responsibility of conserving natural resources.

The Sabaragamuwa Provincial Council Complex, which is located in Ratnapura, has 400 office staff and 200 visitors per day. The rain water harvesting system uses a roof area of 2842 sq.m., two storage tanks of 22 cu.m. capacity, an underground well and a sump, together with two three-phase motors for water pumping. It is reported that the annual saving due to harvested water is Rs. 120,000/-. Various technical problems faced were overcome with the assistance of the University of Moratuwa and the Institute for Construction Training and Development (ICTAD).

### Abbreviations

ADRA	- Adventist Development & Relief Agency Sri Lanka
Asia Onlus	- ASIA ONLUS
BLIA	- Buddha's Light International Association
CI	- Care International
CWSSP	- Community Water Supply & Sanitation Project (under the Ministry of Urban Development and Water Supply ( <a href="http://www.urbanlanka.lk/Agencies.htm#cwssp">www.urbanlanka.lk/Agencies.htm#cwssp</a> ))
EC	- Ekamuthu Cultivators
GTZ	- GTZ
HKLM	- HKL Menike
IOM	- International Organization for Migration
ITDG	- Intermediate Technology Development Group (Practical Action)
KOPBMO	- Kala Oya River Basin Management Office
LRWHF	- Lanka Rain Water Harvesting Forum
NCC	- National Christian Council
NGOWSSDS	- GO Water Supply and Sanitation Decade Service
NWSDB	- National Water Supply & Drainage Board (under the Ministry of Urban Development and Water Supply) ( <a href="http://www.waterboard.lk">www.waterboard.lk</a> )
ORDE	- Organization for Resource Development and Environment
OXFAM	- OXFAM
PALM	- PALM Foundation
Plan	- Plan Sri Lanka
PRDA	- People's Rural Development Association
Sarvodaya	- Lanka Jathika Sarvodaya Shramadana Sangamaya
SDA	- Southern Development Authority
USIP	- Urban settlement Improvement Project
WV	- World Vision

## Rain water for Drought Mitigation and Recharging Groundwater

### Domestic use

Rain water harvesting has brought much relief to people during times of drought, water scarcity and, more recently, to those affected by the devastating tsunami of 2004.

Even though Sri Lanka has a relatively high rainfall, it varies both temporally and spatially. Some areas can experience extreme dry spells between monsoons or on occasions even a total failure of the monsoons. Several dry zone districts of Sri Lanka experience prolonged drought, causing tremendous hardships to people. Rain water harvesting systems constructed in Hambantota, Moneragala and Anuradhapura were able to use rain water stored in the tanks for as long as 5-6 months during dry period. (Ariyanbandu and Aheeyar, 2000).

Research done by Kumari (2008) on rainwater harvesting for rural water supply shows that a 5 cu.m. tank with a roof area between 75 to 100 sq.m. can supply 300 litres/day to a household, with an overall probability of success of 50%, in the districts of Anuradhapura, Hambantota and Puttalam. However, this figure will reduce depending on the season. Substantially higher degrees of success can be obtained within the wet and intermediate zones (Ranasinghe, 2008). Further work on appropriate tank capacities for rainwater harvesting in the Jaffna district has been done by Gamage (2006).

### Agricultural use

The rural sector in Sri Lanka constitutes around 80% of the population and most of those in the rural sector depend on rainfall-based sources of income, such as, agriculture, livestock production and inland fisheries. Freshwater availability is a

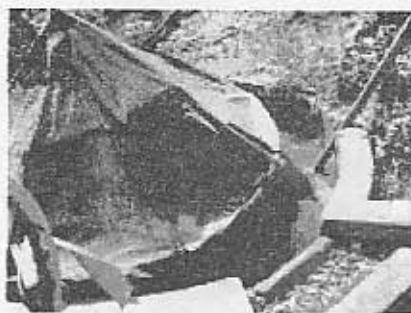


Figure 1:

Run-off tank at Kurundamkulama

vital element in food production and improvement of livelihood in these areas.

Lack of a dependable water supply is often a major limiting factor in our attempts to develop the rural sector. From the total rainfall, on average, around 50% of rain water is lost in the form of surface run-off, and conserving this water will promote crop growth in areas where water is limited. An effective and economical method of conserving this water is by storing it in surface tanks which are abundant in the dry zone. However, many small tanks are dilapidated and/or silted and need rehabilitation.

If the run-off water is stored in the land itself, it would be available to plants when there is a water shortage. In some parts of the dry zone, small ponds called "Pathahas" have been used to collect and store rainwater. Such a water collecting system on farm would enable farmers to cultivate crops during the dry seasons.

A study was carried out in Kurundamkulama (a village in Mihintale in Anuradhapura District) to



Figure 2: "Pathaha" at Nikawaratiya

harvest/collect run-off rain water in tanks. Water from the Maha season rain was collected in a 5 cu.m. run-off tank (Figure 1) and was used during Yala for crop production. As a result, the incomes of the families in the study increased substantially (Weerasinghe et al. 2005). Collection of run-off rain water, not only conserves water, but also reduces soil erosion and degradation of the land.

### Recharging groundwater

Water lost from the ground by way of evaporation, tube wells, etc. needs to be replenished. Collecting rainwater in ponds and pools in a manner where water percolates in to the ground, raises the water table. A study conducted in Nikaweratiya on the use of *pathahas* (Figure 2) (Shanthi de Silva, 2005), shows that these elevate the ground water level, thus increasing the quantity of water available for both domestic and agricultural use, even during the dry season.

In several Indian states, ground water recharging in urban areas through recharging structures (Figure 3) is encouraged and legalised to increase the exploitable quantity of groundwater, improve the quality of groundwater and to mitigate flooding.

### Social and Economic Aspects

As with any new technological intervention, rain water harvesting too needs changes in attitudes, perceptions and behaviour of the community, if the new technique is to be successful in terms of social, economic, cultural and environmental factors. Training and awareness are key factors to ensure quality construction, proper operation and maintenance, management of harvested water, and to change attitudes and wrong perceptions of the concept of rainwater harvesting.

Community mobilisation and training of beneficiaries are vital components,



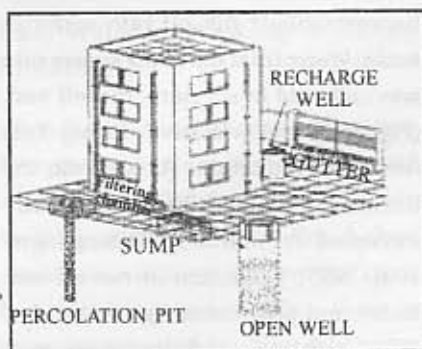


Figure 3 : Recharging structures  
( Raghavan, 2006)

since rain water tanks will ultimately be managed at private cost at the household level. Community contribution towards the project is recommended in order to increase the sense of ownership and motivate people towards sustainable management.

The beneficiaries can easily supply unskilled labour and local materials towards the project. The contribution of unskilled labour alone provides almost 15% of the total value of the system (Table 3).

Institutional and commercial-level rainwater harvesting in schools, government offices, hospitals and other public places is highly recommended due to their large roof areas, but proper institutional arrangements are vital for sustainable operation and maintenance.



Figure 4: Underground tank

One of the major disadvantages of roof rainwater harvesting technology is that it requires a higher capital investment initially for the construction of storage cisterns and other supplementary components.

The cost is much higher when the rainfall is low and there is a longer dry period, which results in the need for a larger cistern to ensure water security.

The success of any technological intervention also depends on the cost and affordability. The use of an appropriate tank size and suitable cost effective materials, less labour and simple construction aids are important factors for reducing the cost of construction.

Rain water harvesting system tanks can be placed above ground, underground (Figure 4-6) or partially underground.



Figure 6: Above ground Ferrocement tank

According to past research (Thomas and Rees, 2001), the unit cost of construction of rainwater tanks shows a negative relationship with the size of the cistern.



Figure 5: Partially underground tank

It is cheaper to go for a larger tank and to avoid using two smaller tanks, and larger communal systems compared to small individual units.

Table 3 : Cost estimates for different sizes of Ferro cement tanks

Cost of cistern	5 m <sup>3</sup>	7 m <sup>3</sup>	8 m <sup>3</sup>	10 m <sup>3</sup>
Material	24,305.50	26,919.50	29,719.50	35,370.50
Skilled labour	4,500.00	5,400.00	5,580.00	8,000.00
Unskilled labour	5,000.00	5,500.00	6,000.00	10,000.00
Transport of materials	2,500.00	2,500.00	2,500.00	2500
Reusable Frame/Miscellaneous	1427.5	1,500.00	1595	1750
	37,733.00	41,819.50	45,394.50	57,620.50
Pipes, First flush, Gutters (26 feet), other accessories & fixing charges	5,000.00	5,000.00	5,000.00	5,000.00
Total	42733.00	46,819.50	50,394.50	62,620.00

Source: Aheeyar (2009).

High initial cost has been a prohibitive factor for many poor households in adopting rainwater harvesting systems, though they are willing to collect rain water for their household needs.

Therefore, some supportive mechanisms such as loans and subsidies can be effectively used to promote the technology among poor families.

Use of subsidies in the past have shown positive results in introducing rain water harvesting systems among rural poor (Gould and Petersen, 1999).

Some of the social and economic benefits identified by households using rain water harvesting systems are -

- Easy access to clean drinking water
- Less time spent on collecting water
- Time saved (average 1.5 hrs per day) is used for social and economic activities
- Skills enhancement in the village
- Less reliance on external water providers
- More water security at household level
- Better sanitation due to more water availability
- Enhanced income through use of rainwater for home gardening, animal rearing, brick making, etc.
- Reduction in incidence of diarrhoea
- Better quality water, especially in areas with high levels of Fluoride in ground water, saline water (after the tsunami) and brackish water.

## Conclusions and Recommendations

Even though Sri Lanka presently has no water scarcity, except in some areas during the dry season, due to increase in population, urbanisation, pollution of water sources and climate change issues, it may face water problems in the future. Adopting rainwater harvesting and utilising it to the maximum will help the country to overcome this problem. The main recommendations are:

- Using rain water for drinking purposes should be encouraged in dry zone districts where the groundwater is both mineralised and contaminated, especially in areas where a high incidence of kidney problems due to polluted ground water has been reported.
- Rain water harvesting should be encouraged as a supplementary water source in urban areas to reduce water

bills, save on energy and water treatment costs, and reduce flooding in some areas.

- Incentives, such as tax rebates, should be offered to encourage householders to adopt rain water harvesting.
- Incorporate rain water harvesting in all public and commercial buildings with large-scale use of pipe-borne water.
- Encourage ground water recharge in potentially suitable areas.
- Rain water harvesting system components for urban houses should be made available locally.
- Professionals should use innovative designs incorporating rain water harvesting in new buildings.

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# Fluoride Problem in the Groundwater of Sri Lanka

## Fluorine - the Needy and Greedy Element

Fluorine, the most reactive and electro-negative halogen on the earth, is an element that virtually never occurs naturally in its free, gaseous form. In the form of fluorides, however, it is one of the most plentiful and wide spread of elements, standing seventeenth in order of abundance in the earth's crust. Fluorides occur in water, soil, rocks, dusts and the atmosphere. It is also present in most foods, many plants and virtually in all animal tissues. Fluoride is considered as an essential element for the human body for promoting growth of healthy bone and teeth. Although every food stuff contains at least a trace of fluoride, the total intake of fluoride from food is relatively small, and most of it is ingested through drinking water.

## Fluoride in Drinking Water and Health

The deficiency as well as excessive fluoride in drinking water creates a number of health problems. Prolonged exposure to low fluoride concentrations in drinking water causes dental caries, whereas continued exposure to higher (than optimum) levels in drinking water causes dental fluorosis (mottled teeth surface) (Figure 1) and skeletal fluorosis (stiffness of joints, crooked and or/brittleness of bones).

The world health organisation (WHO) has recommended a fluoride concentration of between 1.0 to 1.5mg/L in drinking water as the optimum level that promotes dental as well as skeletal health. Fluoride in drinking water is therefore, has become one of the most important geo-environmental and toxicological issues in the

world. During the last four decades, high fluoride concentrations in drinking water sources and the resultant disease "fluorosis" is being highlighted throughout the world. African countries, such as Morocco, Tunisia, Algeria, Sudan, Egypt, Somalia, Uganda, Tanzania, Kenya, Senegal, Nigeria and South Africa have high fluoride groundwater. Further, out side Africa, India, China, Japan, Canada and the united State of America (USA) also have high fluoride-bearing groundwater. In these countries, fluoride levels in the range of 10-60 mg/l in groundwater have been reported. In developing countries, especially in the tropical regions, rural communities, who mostly depend on groundwater sources for their domestic water supplies, face this problem seriously. In India alone, about 25 million people in 8700 villages are consuming water with high fluoride concentrations. Fluoride concentrations as much as 20.0 mg/l have been recorded in groundwater from these areas. Pampered et.al. (1997)

## Fluoride Problem in Sri Lanka

In Sri Lanka, endemic dental fluorosis was first described by Seneviratna et al.

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(1974) based on a survey conducted on the dental health of schoolchildren from three districts as shown in Table 1.

They also reported average concentrations of fluoride in groundwater in the 9 provinces of Sri Lanka (Table 2).

It is clearly seen that the areas of high fluoride-bearing groundwater show higher dental fluorosis, whereas those in the low fluoride regions suffer from dental caries.

## Sources and Causes

In Sri Lanka, when comparing the fluoride-rich and fluoride-poor areas with the climatic, geomorphological, and geological factors prevailing in the country, low fluoride concentrations in groundwater are common in the wet

Table 1: Fluoride concentration in groundwater and related dental health in three districts of Sri Lanka

	Anuradhapura District (Dry Zone)	Polonnaruwa District (Dry Zone)	Kandy District (Wet zone)
Dental fluorosis(%)	77.50	56.20	13.00
Dental caries(%)	26.20	26.50	95.90
Fluoride levels in Groundwater (mg/l)	0.10-4.70	0.50-13.10	0.02-3.70

Source : Seneviratna et al. (1974)

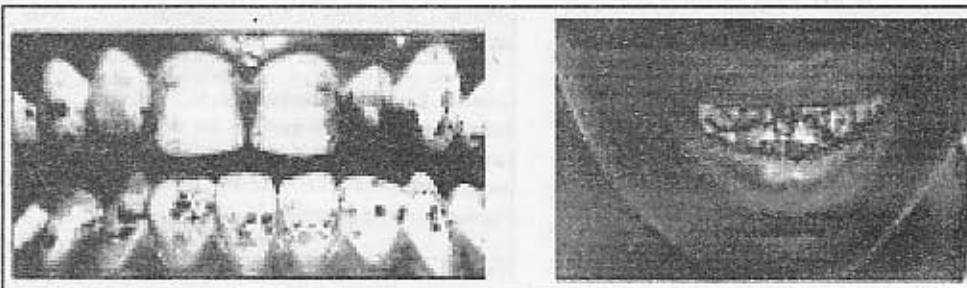


Figure 1: Dental Fluorosis



**Table 2: The average fluoride concentrations in the well water of different provinces of Sri Lanka**

Province	Average Fluoride Concentration (mg/l)	
Northern Province	0.65	Dry zone
Eastern Province	0.76	do
North Central province	1.40	do
North western province	0.78	do
Sabaragamuwa province	0.20	Wet zone
Western Province	0.20	do
Southern Province	0.30	do
Central province	0.50	do
Uva Province	0.40	Intermediate zone

Source: Seneviratna et al. (1974).

zone where annual average rainfall even some times exceeds 5000mm. High fluoride is common in the dry zone



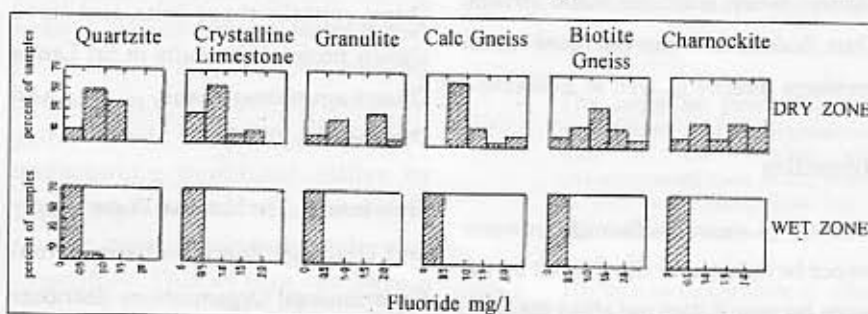
**Figure 2: Distribution of fluoride ions in the groundwater**

where annual average rainfall is less than 2000mm (Figure 2)

Physiographically, the high fluoride zones lie within the low plains of the island, whereas the low fluoride areas are mostly confined to the central highlands. This situation can be explained by the fact that leaching of fluoride from soil in the wet zone and transporting it with groundwater towards low lying dry zone areas take place in wet zone, whereas concentration

due to high evapo-transpiration and slow rate of ground water movement is taking place in the dry zone areas. Dissanayake, (1996). In wet zone, the saturated zone is replenished by the downward infiltration through the capillary zone during a large part of the year than in the dry zone, thus diluting the saturated-zone groundwater. Figure 3 compares the fluoride content in groundwater from the water supply bore holes (tube wells with hand pumps) located in six different rock types under dry and wet zone conditions as collected from the Matale and Polonnaruwa districts. Irrespective of the rock type, groundwater remains low in fluoride in the Wet Zone while in the Dry Zone fluoride reaches as high as 10.0 mg/l. The slow rate of groundwater movement in the low plains also tends to increase the fluoride concentration because the contact time of groundwater with a particular geological formation is comparatively long. Dharmagunawardhane and Dissanayake, (1993)

As stated before, fluoride is important, because it is essential for the growth of human, and in the same time, creates serious health problems due to either deficiency or to excessive intakes by the body. Since main ingestion path is through drinking water, it is important to know how it enters the water. A vast majority of the Sri Lankan population uses groundwater for their domestic water supply, and the groundwater which is always in contact with rocks and soils that contain fluoride-bearing minerals, upon weathering, release fluoride into groundwater. In Sri Lanka, a large number of county rocks contain fluoride-bearing minerals such as Biotite, hornblende, pyroxene, sphene, and apatite. Biotite is present in almost all rock types, and recent studies have revealed that average fluoride concentration in biotite is around 3400 parts per million (milligrams per Kilogram) Dharmagunawardhane, (2004). In addition to its high fluoride concentration and wide distribution, this mineral is also less resistant to weathering. Therefore, mineral biotite can probably be considered as the principal source of fluoride for groundwater. It should also be noted that rice-growing districts such as Kurunegala, Anuradhapura, Ampara, Polonnaruwa, Hambantota, etc. also receive a considerable amount of fluoride through application of rock phosphate as a fertiliser in the paddy fields. Although the solubility of rock phosphate is low, the continues application of rock phosphate in rice fields, residual accumulation in soil and subsequent leaching could release large fluxes of fluoride into groundwater of these areas.



**Figure 3: Variations of fluoride concentration in groundwater of water supply Bore holes located six different rock types under dry and wet zone conditions (Dharmagunawardhane Dissanayake, (1993))**



## Indirect Health Problems

Another serious health problem with growing concern in the recent past is the Chronic Kidney Disease (CKD) among many people in the dry zone districts of Sri Lanka. Statistically, it has been highlighted that this problem too, is common in the areas of high fluoride-bearing groundwater. Although it is a known fact that exposure to very high fluoride doses causes kidney failure, fluoride levels in groundwater of these areas are much lower than such toxic concentrations.

However, prolonged exposure to elevated fluoride levels in drinking water and possibility of its detrimental effects cannot be ruled out. Recent research conducted in Sri Lanka has revealed that dissolution of low-grade aluminium cooking utensils is enhanced when cooking with fluoride rich water. (Ileperuma, Dharmagunawardhane and Herath, (2004).

This situation is rather accelerated when acidic ingredients such as tomato, tamarind, vinegar and lime, etc. are used in cooking. Low-grade aluminium utensils release, not only aluminium ions, but also many other toxic metals, lead, and chromium.

All these released ions can form complex ions with fluoride and can damage the kidneys when enter the blood stream. Thus, fluoride in water can cause health problems directly as well as indirectly.

## Remedies

Presence of excessive fluoride in water cannot be detected or directly felt by the users, because it does not affect the taste, colour or the smell of water. It can only be detected by laboratory analysis.

Therefore, exposure is inevitable, especially in high-fluoride areas.

In general, it tends to occur in higher concentrations in groundwater (well water, tube well water) than in the surface water (stream, river, lake water). Also in low lying dry zone areas than in wet zone areas.

However, it should also be noted that surface water is often polluted and cannot be directly consumed. Therefore, removal of fluoride from water, using different techniques, is practised in the world. However, most of those, especially large-scale ones, are expensive and complex.

In the simplest (and more practicable at rural level) methods, the affinity of fluoride ion to hydroxyl (OH), Ferrous, or Aluminium ions is used. Fluoride ion tends to replace the OH ions in minerals and occupy its place in the mineral lattice. It also binds with Aluminium and Ferrous ions by surface adsorption, and tends to stay together under some favourable conditions.

If fluoride-rich water is percolated through a filter, material with above-mentioned ions concentration of fluoride can be reduced to a great extent (and to safe limits). Locally available brick chips, tile chips, Laterite (Kabuk) chips contain these ions and have shown promising results in Sri Lanka. Dharmagunawardhane, and Dissanayake (1996).

Time to time, The National Water Supply and Drainage Board and some Non-Governmental Organizations distribute such filters among the communities in the high fluoride areas of the country.

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# Use and Management of Wastewater in Agriculture

**W**ater quality will deteriorate in the coming years as a result of population growth, urbanisation, industrialisation and climate change. This will put even greater pressure on systems that involve wastewater or marginal-quality water for irrigation of food crops. The need to regulate and manage these systems will also intensify, but actions must not be at the expense of farmers who rely on these water sources for their livelihoods. Appropriate management options that take account of the economic and environmental benefits of wastewater use in agriculture, while minimising the health and environmental risks, are to be sought. For this to be possible, policymakers must acknowledge the importance of urban agriculture and seek pragmatic solutions based on policies and plans that have both measures that are feasible in the short term and longer-term aims.

## Introduction

Increasing populations, changes in human activities, urbanisation and climate change are expected to intensify water scarcity and contribute to the deterioration of water quality in many countries. Greater quantities of water will be generated in cities from households, commercial units and industries and the predicted increases in the frequency and severity of rain storms will increase the run-off from urban areas and farms (Qadir, 2009).

This marginal-quality or wastewater is already used by many farmers, knowingly or not, for irrigation. In future, the number of people irrigating with wastewater or marginal-quality water could increase, which would present an even greater management challenge than currently exists. Planning for wastewater irrigation will be critical to make use of the water and nutrients that it contains, while minimising environmental and health impacts.

Sources of wastewater include surface runoff, city drainage canals, grey water (such as domestic bathing water and kitchen wastewater), black water (from toilets, which contains urine and faeces), hospital and industrial wastewater, agricultural run-off and combinations of all of these (van Veenhuizen *et al.*, 2007). Wastewater generated by municipal and industrial activities contains a variety of constituents at levels higher than those usually found in freshwater, including salts, metals, metalloids, residual drugs, organic compounds, endocrine disrupters, active residues of personal care products and pathogens.

Exactly what the wastewater contains and in what concentrations depends on the local situations, and in general, the most problematic constituent for wastewater irrigation is pathogens from domestic sources. As a result, irrigation with untreated, partly-treated or diluted wastewater can result in multiple impacts on both the environment and health. Many farmers, consumers and policymakers are not fully aware of these implications and wastewater irrigation often takes place without adequate regulation or support for farmers to manage its use appropriately (Qadir, 2009).

The reasons for the use of wastewater for irrigation are multifaceted and include lack of access to other water sources and pollution of the existing sources. The underlying factor is that, in many instances, wastewater provides an opportunity for people to grow food and support their household's livelihood either by producing food for home consumption or cash crops, particularly high value vegetables. This in turn can have a positive impact on the wider economy and the health of the population through improved nutrition.

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Despite years of research and experience in many countries (Hamilton *et al.*, 2007), why wastewater irrigation occurs and how to manage it are still the topics of considerable debate around the world. Undoubtedly, the exact nature of the issue, the challenges that it poses and the potential solutions are country and even location specific.

Understanding the opportunities and constraints for wastewater use are therefore the first step in developing and initiating plans to maximise the benefits and minimise the risks. Several guidelines have been produced to assist governments in undertaking these reviews and developing policies and plans, of which the World Health Organization (WHO) Guidelines for the Safe Use of Wastewater, Excreta and Grey Water (2006) are arguably the most comprehensive, widely accepted and appropriate for all countries, since they provide guidelines that can be adapted to the local situations and either linked to existing country specific guidelines and regulations, or used to develop them.

Three major obstacles to attempts to minimise the risks of wastewater have been observed:

- ♦ The negative perceptions of consumers and policymakers, due to the health and environmental risks that it poses, as well as the difficulties that it can create for farmers;
- ♦ The lack of recognition of urban agriculture as an urban livelihood strategy, and thus the absence of appropriate associated policies; and

- ♦ The fact that many policymakers and government officials are unaware of the current extent of wastewater use, and therefore perceive that any interventions in the area of wastewater irrigation will actually initiate or increase wastewater use, rather than serve to regulate it and improve current conditions.

These views therefore fail to recognise the fact that the use of wastewater or marginal-quality water takes place, because at present, in some locations, there are no other options, or because wastewater is contaminating water bodies that are used for irrigation.

This paper reviews some of the recent findings on global wastewater use in agriculture and underlying reasons for its use. It presents some information about the Sri Lanka context and discusses how the opportunities and constraints associated with wastewater irrigation could be addressed here.

### The Current Extent of Wastewater Agriculture

Although it is difficult to estimate global wastewater use due to the lack of data and complications over definition, the most widely quoted figure is that 20 million ha of land were irrigated with undiluted or partially-diluted wastewater in 2001 (Future Harvest, 2001). It has also been estimated that in the early 1990s, approximately 10% of the world's population consumed food grown on wastewater irrigated land; a figure which has probably risen markedly since then (Lunven; cited in Smit and Nasr, 1992). Although such practices are a threat to human health, they do provide important livelihoods benefits and perishable food to cities (Raschid-Sally and Jayakody, 2008).

A global study of 53 cities undertaken by IWMI shows that the main drivers of wastewater use in irrigated agriculture are a combination of three factors:

- ♦ Increasing urban water demand and related return flow of used but seldom-treated wastewater into the environment and its water bodies, causing pollution of traditional irrigation water sources.
- ♦ Urban food demand and market incentives favouring food production in the proximity of cities, where water sources are usually polluted.
- ♦ Lack of alternative (cheaper, similarly reliable or safer) water sources (Raschid-Sally and Jayakody, 2008).

In 31 out of 41 cities that responded on the reasons for wastewater use, there was a clear indication that farmers have generally little or no alternative (safer) water source than diluted wastewater, polluted river water or untreated wastewater (Raschid-Sally and Jayakody, 2008). Farmers with access to other sources will rarely seek to use wastewater (although some value the nutrients that it provides).

to be relatively low, but the pollution of water bodies used for irrigation suggests that this is still an important issue for the country to address.

Anuradhapura, Kandy and Kurunegala were studied by Jayakody *et al.* (2006) to quantify the extent of wastewater use and the livelihoods' significance of the practice. They calculated, based on total abstractions and the percentage used for domestic and industrial purposes, that wastewater production in the country is approximately 273 million m<sup>3</sup> per year. In the three study cities, 70% of the water supplied is estimated to be disposed of as wastewater, amounting to approximately 1.3 million m<sup>3</sup> of per year (Table 1), and since the level of industrialisation is low in the three cities studied, this wastewater is predominantly of domestic origin, although there are a number of commercial properties and several hospitals.

Table 1 : Water supply and wastewater generation in the cities in 2003

City	Anuradhapura	Kandy	Kurunegala
Actual LPCD	290	335	260
Water supply % Pop Covered	90	95	90
Water supply % area covered	100	100	100
% unaccounted	30	32	30
Water <sup>1</sup> supply m <sup>3</sup> /day	20440	25000	6863
Estimated wastewater generation m <sup>3</sup> /day	14308	17500	4804

LPCD - Litres per capita per day

Source : Jayakody *et al.*, 2006

In South Asia, wastewater use is considered to be lower than in many other countries because of the high rainfall and consequent reduced necessity for alternative water resources (Hamilton *et al.*, 2007), however Raschid-Sally and Jayakody (2008) found the opposite; that wastewater agriculture was most prevalent in Asian cities, especially in Vietnam, China and India. Direct use of wastewater in Sri Lanka was found

Pipe-borne sewerage facilities are relatively limited in Sri Lanka, with Colombo having the widest network covering 80% of the city compared to just 5% in Kandy, and none in Anuradhapura and Kurunegala (Jayakody *et al.*, 2006). Here, blackwater from toilets is disposed of to pits and septic tanks, while greywater and stormwater drainage are directed to surface water bodies. Colombo and many other coastal cities

drain their wastewater directly into the sea. Anuradhapura city discharges wastewater to Malwathu Oya, Kandy to Meda Ela and Hali Ela, which flow into the Mahweli River, and Kurunegala drains into the Bue Ela, which flows onto Maguruoya (Jayakody *et al.*, 2006).

It was found that the available wastewater was used in two of the cities in the following way:

- ♦ In Kurunegala, irrigation water flows through the city and combines with urban drainage in Bue Ela, which is eventually used to irrigate rice. Irrigation releases are irregular, and in the dry season, wastewater is often the only water available.
- ♦ In Anuradhapura, wastewater enters the Malwathu Oya, is diluted and subsequently used for vegetable cultivation; greywater is also used directly for vegetable cultivation.

Compared to other countries where undiluted wastewater is used directly on crops, such as in Faisalabad, Pakistan (Clemett and Ensink, 2006), the situation in Sri Lanka seems to pose fewer risks because there is only a low level of industrial activity in the cities studied, and toilet water is generally not collected with the drainage water (although some illegal overflow connections exist). However, this does not mean that no risk exists, and that the situation should continue uncontrolled. This is because although risks are lower they are not absent. Furthermore, some specific locations may face more severe pollution that requires more regulation, and therefore there is the need for a policy and legislation to address such situations. Finally, urbanisation and industrialisation are likely to increase, which may create new or greater risks, for which the country should be prepared. The main concerns are the

exposure of farmers, their families and consumers to parasitic worms, and disease-causing viruses and bacteria. Other constituents in the wastewater may also impact positively or negatively on crop production, and pollute groundwater.

Not only is wastewater used locally around cities but, as already mentioned, this wastewater finds its way into open water bodies and is used downstream for a number of purposes, of which irrigation is one. This means that many farmers may be, knowingly or not, using diluted wastewater. This situation will only increase as population densities grow and there is reduced capacity for on-site wastewater management (such as septic tanks), and if wastewater treatment infrastructure cannot keep pace with this growth.

### Pragmatic Solutions and Opportunities

Preventing farmers from using polluted water sources or only disposing of wastewater to water bodies after treatment are the most comprehensive solutions to reducing the health and environmental risks associated with wastewater; but they are rarely practical. Firstly, the cost, planning, implementation and management implications of such a comprehensive treatment approach would be prohibitive. In India for example, it is estimated that investment in treatment capacity for the 73% of urban wastewater that is currently untreated would be US\$ 65 billion, which is ten times more than the Government of India proposes to spend on it (Kumar, 2003; cited in Scott *et al.*, 2004). Secondly, the negative livelihoods impact on farmers and their families, and the potential nutritional and economic impacts on society would be huge. Policymakers, considering such a ban on irrigation with marginal quality water or wastewater, would need to make provisions for the large numbers of

people who might be adversely affected. They would also need to ensure that they were able to enforce the related regulations (IWMI, 2003).

In the absence of alternative treatment and disposal options, using wastewater for irrigation is also a form of treatment, as it results in the removal of certain contaminants, thereby improving its quality. This option does not reduce the risks to farmers and consumers but the localised health risks may be more manageable than the dispersed public health problems (not to mention environmental and other livelihoods impacts) that arise in downstream communities if wastewater is discharged directly into lakes and rivers, especially if these are used as drinking water sources (IWMI, 2003).

Such an approach does not mean allowing the uncontrolled use of untreated wastewater, as this poses too much of a risk, but it can be part of a strategy that includes a number of components to improve water quality and protect health. The WHO recognised that such a "multi-barrier" approach could be a way in which to exploit local opportunities for addressing the complexities of wastewater agriculture. Their most recent Guidelines for the Safe Use of Wastewater, Excreta and Grey Water (2006) therefore provide a series of policy and management options that can be combined and developed into a comprehensive strategy. It is anticipated that the strategy would have short-term goals to protect health whilst maintaining the viability of livelihoods, whilst longer-term goals would be to improve the quality of the water being used for irrigation through upstream management (such as separating industrial and domestic waste and cleaner production options in industry) and improved sanitation infrastructure including appropriate wastewater and sludge treatment facilities for local conditions (Table 2).



**Table 2: Multi-barrier Options to Risk Reduction**

Approach	Description and who is protected
Crop restriction	Crops that pose less of a risk to health are chosen, for example any crops that are eaten cooked. Crops that are eaten raw or unpeeled pose the greatest health risk in terms of pathogenic organisms. The main beneficiary is the consumer.
Wastewater application techniques	The method by which the wastewater is applied can increase or reduce the degree of contact with the crop, and thus the risk. Drip or sub-surface irrigation are considered preferable to flood irrigation; ridge and furrow is also preferable if the wastewater does not make contact with the crop. Depending on the method selected both the farmer and consumer may benefit.
Pathogen die-off between last irrigation and consumption	Time, temperature and desiccation can all result in the death of pathogens (although helminth eggs can survive for many months). By withholding irrigation water for a few days before harvesting, the health risk to consumers can be reduced.
Food preparation measures	Careful washing, especially with detergents or vinegar; peeling; and cooking, can all reduce the risk to consumers from pathogens.
Human exposure control	Protecting fieldworkers and nearby communities from exposure to wastewater can reduce health risks. An obvious way of doing this is through the use of protective clothing such as shoes and gloves.
Appropriate wastewater treatment	Treatment will always be an important part of the solution as it protects fieldworkers and consumers, as well as the wider environment and the population as a whole. However treatment can be difficult to implement and manage, and may be costly. Locally appropriate solutions must therefore be sought.

Source: WHO, 2006

The key features of any policy and strategy related to wastewater irrigation are that:

- They must have both short-term and long-term objectives. Those in the short term need to address immediate health concerns, while longer-term objectives will be to improve wastewater management and treatment, and may be markets for wastewater produce.
- They should protect the livelihoods of those people who are dependent on wastewater agriculture, whilst also reducing health risks.
- They should not re-locate the problem, for example, by banning wastewater irrigation but without putting alternative measures in place, which will only result in greater pollution of water bodies.
- They must be practical and cost effective.

• They would benefit from considering all sources of wastewater as part of a comprehensive policy, although the approaches for each may be different. Industrial and hospital wastewater need particular attention.

### Conclusion

Wastewater agriculture is an existing practice that will only grow as human populations rise, and urbanisation and industrialisation increase. Unregulated wastewater agriculture is not acceptable, because of the health and environmental impacts. However, it is not feasible to prevent it, because this will have livelihoods impacts and wider implications for the economy and nutrition. It will also be costly and difficult to enforce, and will increase surface water pollution since application of wastewater to land is a form of treatment. It is therefore necessary to regulate and manage the practice, to be able to take maximum

advantage of the benefits that it can bring. This will require a suite of interventions as part of a holistic plan that provides barriers to risks to the health of farmers and consumers, and ensures water of an adequate quality reaches the fields and in turn open water bodies. Achieving the correct balance will not be an easy task, and there is likely to be opposition to approaches that appear to condone wastewater agriculture, but the reality is that, it takes place because there is a lack of alternative water sources for some farmers, and it provides food in a world where food security is an increasing issue. By managing the practice, pollution of water bodies can be reduced and in the longer term, as infrastructure for wastewater management improves, it will be a valuable component of the country's agriculture sector.

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# ARRESTING POLLUTION OF WATER

**W**ater can dissolve almost any substance because of the unique features of its molecule. Water is therefore very easily polluted.

*Pollution of water has been increasing due to the influence of the human during the last 125 Years. This is mainly due to increasing human population, unsanitary disposal of human wastes, burning of fossil fuel, release of harmful substances in industrial effluents, deforestation and agriculture. If unchecked, water pollution can become a major problem in the future as global warming has become at present.*

*To control water pollution requires public awareness of the problem, a human lifestyle that is respectful of the environment and a citizenry that is willing to actively undertake the role of custodian of the water bodies.*

Many chemicals pollute waterbodies. However, it is the concentration rather than the identity of the substance that is of much importance. For example, copper and zinc are essential nutrients for plants and animals, but are harmful to many organisms at high concentrations.

In fact copper and zinc containing compounds are used to control algal and fungal growth. For that matter, nitrogen and phosphorus are necessary for the synthesis of the very basic building blocks of life, but are also two of the key items that bring about excessive algal growth in water bodies.

Pollution may be defined as the entry of substances to a medium that brings about harm to living organisms, disturbs ecological systems and damages structures or amenities. Pollution can be sudden, intense and cause immediate ill effects or be slow, hardly noticeable, and cause harm over time.

Pollution can arise from natural causes or from the activities of the human. Natural causes include effects of volcanoes, earthquakes, tsunamis and underground minerals. The eruption of Mount Karthala volcano in Comoros in the Indian Ocean in 2005 left more than 175,000 people without drinking water due to entry of ash to the waterbodies.

Earthquakes pollute water from destruction of buildings, devastating landslides and ravaging floods. Tsunamis bring enormous quantities of sea water inland suddenly, making surface water, groundwater and soils saline in its path, as happened in Sri Lanka a few years ago. More than eight million tube wells constructed in a very short time to provide drinking water to people of Bangladesh created havoc in the country as millions of people who drank water from some of the deep wells developed bladder, lung and skin cancer owing to the presence of very high levels of arsenic. This event is considered the biggest poisoning of a human population in history.

The extent of pollution caused by nature however, if brought under a single unit and added up globally over time, may show up to be extremely insignificant compared to that by the human. This paper indicates why water is easily polluted, describes some examples of pollution arising from the acts of the human, indicates their influence on living beings and the environment, and makes a few suggestions on the steps to be taken in the future with regard to arresting the increase of water pollution.

## Why water is very easily polluted

A professor of chemistry once told the students that although sulphuric acid can dissolve a motor car and water cannot, water can dissolve many more substances than sulphuric acid. Some

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high-school chemistry is required to explain why water has the tag of universal solvent. The water molecule has two hydrogen atoms that are electropositive and one oxygen atom that is electronegative. The water molecule is not linear, but bent at an angle of 105 degrees.

These reasons make it behave as a dipole. As a result of its unique structure, the water molecule is attracted to other water molecules and to molecules of many other substances through what are known as hydrogen bonds. This makes water dissolve almost any substance. Consequently, water is very easily polluted.

There is a long list of items that are generally considered as water pollutants. The common pollutants are; human fecal matter, aquatic organisms, noxious gases, acidity, salinity, nitrogen, phosphorus, arsenic, cadmium, chromium, lead, mercury, nickel, uranium, chlorine, cyanides, radio nuclides, petroleum hydrocarbons, pesticides and their residues. Silt, clay, turbidity as well as high temperature of water bodies are also considered as pollutants.

Some of the diseases and problems caused by pollutants are given in the following Table:

## Incidents of water pollution

Almost every activity pollutes water. Some industries that are often mentioned in water pollution include the paper, paint, textile, leather, rubber and food industries. Fertilizer, weedicides, fungicides and insecticides also pollute water. A few examples of

**Table 1 : Diseases and problems caused by organisms and chemical substances in water**

Causative organism / substance	Disease and problems
Bacteria	Typhoid, gastroenteritis, bacterial dysentery, cholera and tuberculosis
Virus	Poliomyelitis, meningitis, infectious hepatitis, respiratory diseases, diarrhoea and enteritis
Protozoa	Amoebic dysentery, diarrhoea and amoebic meningo encephalitis
Helminths	Hook worm, round worm, tape worm and thread worm infections
Fungi/algae	Colour, turbidity, taste, odour and toxins
Aluminium	Alzheimer (memory loss)
Arsenic	Skin, bladder and lung cancer
Cadmium	Decalcification of the bones, protein and sugar in urine and kidney damage
Chromium	Kidney problem, lung cancer and skin diseases
Iron	Yellow colour, unpleasant taste and odour
Lead	Muscular paralysis, damage to nervous system, liver and kidney, lowered IQ, anaemia
Manganese	Unpleasant taste
Mercury	Affects kidney, nervous system, and causes brain damage
Zinc	Unpleasant taste
Fluoride	Mottling of teeth (dental fluorosis), cracking of teeth and osteofluorosis
Nitrate	Methemoglobinemia (blue-baby syndrome), gastric and prostrate cancer
Sulphate	Diarrhoea
Hydrogen sulphide	Colour and taste problems
Pesticide	Kidney disease, reduced vision, joint pains and memory loss
Dissolved salts	Unpalatable if greater than 1200 mg/l

pollution of waterbodies are mentioned here.

### Acid rain

pH is the measure of acidity or alkalinity. pH of pure water is 7.0. Pure water is neutral; meaning neither acidic nor alkaline. However, pure water hardly exists in nature, since on contact with the carbon dioxide in the atmosphere it becomes acidic. The pH of unpolluted rainwater in equilibrium with atmospheric carbon dioxide is about 5.6.

Much of the acidity in rain is caused by sulphur dioxide and nitrogen dioxide. Carbon dioxide and some other gases

formed by the oxidation of organic substances also contribute to rainwater acidity. It is correct to say that acid rain is mainly a result of burning of fuel and industrial activity.

The Taj Mahal in India, the Statue of Liberty in New York, the 2500 year-old wood carvings in Greece and the Coliseum in Rome have all suffered damage from acid rain. Rapid corrosion of bridges at many locations has been attributed to acid rain. In some industrialized parts in Poland, trains are not permitted to exceed the speed of 65 kmph because the iron railway tracks have been weakened from acid rain.

Although much of the atmospheric pollutants fall locally, some can be transported more than 1000 km before it falls as rain, sometimes in another country. In fact it has been reported a few decades ago that about 15% of the acidity in Norway is from emissions in Britain and about 20% falling in Sweden has had its origin in Eastern Europe.

Acid rain falling directly on to fresh water could lower its acidity immediately depending on the pH and the quantity of rain and the volume of the recipient waterbody. Almost all forms of life are affected by pH of water. Acid waters may contain high concentrations of cadmium, copper, zinc and other heavy metals which can cause skeletal deformities of fish. It is estimated that 200 to 400 lakes in USA may have lost their fish populations due to acidification.

Heavy metals can enter human bodies in high concentrations through drinking acidic water as their solubilities are higher in such waters. High intake of aluminium can cause bone wasting disease and Alzheimer's disease. Conventional water treatment plants are not set up for removal of heavy metals in water.

Acid rain harms forestry through slow growth, injury or even death of trees. It damages the leaves on direct impact, solubilises toxic substances to trees such as aluminium from soil and washes away plant nutrients potassium, calcium and magnesium from top soil to limit the growth of trees.

Although acid rain in Sri Lanka has been hardly reported, there is a possibility of this occurring in the future with increasing industrial activity. On the other hand Sri Lanka has to be mindful of the possibility of high quantities of acidifying atmospheric pollutants entering the Sri Lankan air space arising from the unprecedented industrial expansion in neighbouring India.

## Pollution of wells

Many shallow wells are contaminated with harmful microorganisms that bring about the hospitalization and death of millions of people around the world. The National Water Supply and Drainage Board of Sri Lanka has shown that many domestic wells are contaminated with human excreta. Hospital statistics reveal that a large number of patients, particularly children from rural areas suffer from water-related diseases. Household garbage and other wastes placed indiscriminately on the surface of the land, overcrowded households with wells and latrines in close proximity, overflowing septic tanks and leaking sewers contribute to contaminated water.

Nitrates have been identified as the leading cause of ground water pollution in forty nine out of the fifty States in USA. In some countries more than 10% of the population is exposed to nitrate levels in drinking water that are higher than the WHO guideline limit of 50 parts per million (ppm). Nitrate pollution arises mostly from addition of nitrogen containing fertilizers.

High nitrate levels in drinking water have been associated with a disease known as methemoglobinemia, or blue baby syndrome. Nitrate itself is not considered toxic but nitrate is reduced to the nitrite by bacteria in the intestinal tract which is then absorbed into the blood stream. Infants are unable to detoxify the nitrite which combines with hemoglobin and reduces the absorption of oxygen by blood. Infants drinking water containing high nitrate levels could become seriously ill and may die if not given medical treatment. In fact the Department of Environmental Quality in Idaho, USA has recently advised against giving water containing more than the WHO guideline limit to children younger than six months. They further advise pregnant women and nursing mothers to avoid drinking such water.

The nitrate levels in the water from many of the farm wells of Jaffna and Kalpitiya given above are higher than the Sri Lanka Standards Institute and WHO limits for drinking water. Studies conducted by the University of Jaffna in 2006 on the nitrate content in the water from 70 wells in Jaffna, have shown that high nitrate values exceeding the 50 ppm limit were present in many community wells, and in domestic wells where the water is used for drinking.

## Pollution of lakes and reservoirs

The Beira Lake in Sri Lanka is a good example of a water body which got converted slowly from a sparkling lake to a foul smelling eyesore with the advent of time by the activities of man. The lake was constructed by the Portuguese for military purposes over 500 years ago while the Dutch developed it to be the central point in the famous canal transport network connecting the Beira to Negombo and Panadura. The lake was such a beautiful spot that its banks were subsequently chosen to hold parties for the British elite. It is on record that a lavish celebration of the defeat of Napoleon was held at the Beira lake by the British government in 1815.

With respect to life on the lake, there is evidence that a well-known Botanist named Trimen made a systematic study of the aquatic plants in the Lake in 1879 and prepared a very long list of them that provided testimony to the health of the water body at that time. But twenty years later the lake got polluted as people began to settle down illegally on its banks. Human excreta found its way to the water, industries discharged their effluent and oil from garages and service stations went direct to the lake. The organic matter input to the lake increased rapidly over the years, their breakdown significantly increased the concentration of plant nutrients in the water and caused massive growth of algae, some of which had the property

of producing extremely poisonous toxins. Furthermore, the decomposition of the algal biomass reduced the oxygen concentration in the water, leading to the formation of bad smelling hydrogen sulphide gas and other harmful products. A combination of these factors led to frequent fish kills in the Beira Lake. A beautiful lake was destroyed by man.

The word eutrophication is derived from the Greek words *eu* and *trophe* meaning well nourished. Eutrophication may be defined as the enrichment of water by plant nutrients. Plants require seventeen elements, referred to as essential plant nutrients, for their growth and each has a unique role to play. While all the seventeen elements are equally important for plant growth, nitrogen and phosphorus stand out as the two nutrients that are commonly limiting productivity of plants in aquatic media. It is for this reason that aquatic plants often increase their growth significantly when the concentrations of these two nutrients in water are high.

Nutrients enter a waterbody in a number of ways. They include weathering of soil minerals, silt and clay from exposed land surfaces, soil disturbing agricultural activities, chemical fertilizers and organic manures. Plant nutrients found in cattle and buffalo dung near the water bodies find their way to the water by direct impact of rain and also by the rising water levels during the rainy season. Another way for nutrients to enter a reservoir is through the death and decay of fauna and flora found therein. Nutrients entering water bodies also come from domestic solid waste, sewage, sludge from sewage treatment plants and urban wastes.

Industrial effluents are also a major source of supply of nutrients to a water body. An important supplier of phosphorus to waterbodies has been detergents. The presence of phosphates



in detergents which was as high as 15% in the 1960s created a great public uproar in North America as it was attributed to the eutrophication of Lake Erie, the formation of algal blooms and the death of fish. At that time as much as 20,000 pounds of phosphorus per day was getting into Lake Erie from the use of detergents. Many citizen action groups were formed during this period to protest on the use of high phosphorus containing detergents. Among them the "The Student Council on Pollution and Environment" and the "Housewives to End Pollution" played a leading role. Consequently many countries placed limits on the phosphorus content of detergents. The Canada Water Act of 1970 placed a 2.2% limit on phosphorus in detergents while in the US many states banned phosphorus from detergents altogether. Most detergents in the developed countries are now phosphorus free.

When a mass of aquatic plants is sufficiently dense as to be clearly visible, it is referred to as a bloom. Most of the blooms are algal, hence the commonly heard term the algal bloom. Many small water bodies in the dry zone of Sri Lanka get covered by algae especially in the dry season. Animal dung may be primarily responsible for this situation.

Blooms are a hindrance to recreational activities such as swimming, sailing and angling. The water with an algal presence requires special treatment if it is to be used for drinking owing to the disagreeable colour, unpleasant odour and unacceptable taste. Two major problems with algal blooms are the likely drop in the level of oxygen in water and the possible production of algal toxins during their degradation.

While the desired oxygen level in water for fish is about 5 ppm, the oxygen concentration can drop below 3 ppm when an algal bloom is being decomposed. In this situation fish are

adversely affected as they have to breathe more rapidly, the movement of oxygen through the gills is restricted and their muscular performance significantly diminished.

While there are many types of blue-green algae only a few produce toxins. Some of these toxins are harmful to humans and other animals. Symptoms seen in humans after contamination include skin irritation, dermatitis, gastroenteritis, diarrhea and vomiting. Microcystin LR, an algal toxin has a toxicity 1000 times that of cyanide. These toxins are colourless and could remain active for several weeks after the algae have completely decomposed. They cannot be destroyed by boiling the water.

The first recorded toxic algal bloom occurred in 1878 in South Australia where cattle, sheep and pigs died few hours after consuming the scum. In Canada ten children fell sick in late 1950s after swimming in a lake covered with algae. There have been many similar instances of human illness after recreational use of water contaminated with poisonous algae.

In Sri Lanka algal blooms have been reported in reservoirs at Kotmale, Mausakelie, Castlereigh, Rajangana, Kandalama, Nachchaduwa, Nuwerawewa, Tissawewa, Giritale, and at Parakrama Samudraya. In 1991 the entire Kotmale reservoir had a dense thick bloom of a toxin containing alga. Fish kills have been reported from many water bodies in Sri Lanka over the years. They include Parakrama Samudraya, Pimburettawa reservoir, Tissawewa and the Beira Lake. In March 2007 about three tonnes of fish died in Rekawa lagoon. It is reported that the main cause was the dumping of large amounts of solid wastes by a Government organization near the lagoon that led to enrichment of the nutrient concentration in the water, excessive algal growth and the reduction of the dissolved oxygen during algal decomposition.

## Pollution of streams and rivers

Gem mining, quarrying, building construction, laying pipe lines underground and road construction and maintenance are activities which add soil particles to streams and rivers.

Coal mining pollutes water as the exposed pyrite mineral is oxidized to sulphuric acid. It has been established that about 16,000 km of streams were polluted in USA in this manner.

Several rivers in the world have been polluted. They include the Ganges in India, Rhine, Thames and Tyne in Europe, Rhone, Arno and Po from the Mediterranean and Darling from Australia. The largest algal bloom occurred in the Darling River in 1991 when 1000 km of the river was affected which led to New South Wales declaring a State of Emergency for a period of 21 days.

It is a fairly common sight in Sri Lanka for rivers to be muddied after a fairly high intensity rainfall. This is a direct result of transport of soil particles largely from exposed sloping land by moving water. A sizeable extent of sloping land without adequate soil conservation measures is planted with annual crops that do not cover the land during most times of the year, thereby subjecting it to erosion. Furthermore, in many commonly cultivated crops like potato, carrot, beetroot and radish the marketable portions are underground and at harvest the plant is uprooted disturbing the soil, bringing it up and spreading it on the surface, in sharp contrast to plucking few young leaves of a tea bush which does not disturb the soil in any way.

Particulate matter impedes the passage of light through water by scattering and absorbing the rays. This interference of light is referred to as turbidity which is a measure of cloudiness. High turbidity can hinder the effectiveness of disinfectants in public water systems. Turbidity of

water reduces photosynthetic activity of phytoplankton through reducing entry of sunlight. Turbid waters may allow the growth of disease causing organisms such as bacteria, viruses and parasites.

Clay particles in water can harm gills of fish. Furthermore, their spawning is adversely affected. Increase in sediment load reduces the water depth in many water bodies and at times adversely affects navigation.

### **Pollution of the ocean**

There is a serious misconception in the minds of some that the sea has an unlimited capacity to absorb anthropogenic wastes and biodegrade them quickly. Many rivers carry industrial pollutants to the sea. In some countries untreated sewage is pumped into the sea even at present. Massive algal blooms are a common site on the coastline of some European countries caused by the discharge of several hundred thousand tonnes of nitrogen by their rivers to the Baltic and North Sea.

The occasional red tides consisting of algae in the western coast of Sri Lanka with foul odour is ample testimony to the fact that the sea in some areas has reached its limit of waste assimilation, and a warning that pollution of the sea is taking place in and around Colombo.

The sea is also polluted by the acidifying effect of the increasing carbon dioxide content of the atmosphere since about one third of it is absorbed by the sea, alarms were raised by scientists of the Plymouth Marine Laboratory in England in 2005 that coral reefs could be dead within a few generations and that some of the fish that contribute significantly to human nutrition and the economy of many countries would disappear from the oceans owing to high acidity of the sea water in the next 35 to 70 years.

The current annual world oil production is about three billion tonnes. It is inevitable that some portion of oil used in almost any industry will get into water bodies. While the amounts entering fresh water bodies have not been fully assessed, the oil input into the marine environment is estimated at about 2.2 million tonnes a year. Much of this pollution comes from terrestrial discharge and in transport such as discharge of oil during tank cleaning and fuel oil sludge and other forms of waste oil.

There is hardly any evidence of a build up of oil residues in the seas as the marine environment is presently able to breakdown the anthropogenic introduction of oil. However, accidental oil spills amounting to about 400,000 tonnes a year can be extremely harmful in a localized environment because of its concentrated effect on a relatively small area.

The ship Exxon Valdez sank in Alaska in 1989 spilling 48 million litres (40,000 tonnes) of crude oil killing tens of thousands of sea birds, destroying the fisheries and harming many other living organisms. This is considered as the worst reported incident of marine pollution.

Oil spills can cause economic damage to the fishing industry. It can also hinder bathing, diving, boating and angling and other recreational activities and adversely affect tourism. Some power stations located close to the sea using sea water for cooling purposes can be forced to shut down if the water is highly polluted with oil. Likewise, desalination industry will be badly affected. Oil spills at harbours caused by accidents in loading and discharging can restrict the movement of ships.

### **Pollution of lagoons from fresh water**

Lagoons are shallow brackish water bodies with connections to the sea by

which sea water flows into the lagoon and vice versa. The basically brackish aquatic ecosystem has fish, shrimp, small plants and other forms of life adapted to the high salt content of the water.

The Bundala National Park which has several lagoons has international recognition as a bird sanctuary hosting more than fifty species of birds, mostly migrants who leave their mother countries during the winter season. They enjoy the food in the lagoons including salt water shrimp. However, two of the lagoons at Bundala namely, Malala and Embilikala, have lost their brackishness due to the entry of discharged irrigation water from the Lunugamwehera and Kirindi Oya irrigation settlement projects. In fact the salt content of the water has fallen to less than 10% of the value prior to the said irrigation projects. Consequently, the salt water shrimp has begun to decrease at Malala and Embilikala lagoons and may disappear in time to come. From the definition of pollution given at the beginning of this paper, fresh water is clearly the pollutant here.

Reduction of the salt level of the lagoons may drastically reduce the number of migrant birds visiting Bundala in the future.

### **Remediation of polluted waters**

The two basic steps to be taken in remediation are; reduction in the inflow of pollutants into the waterbody and a reduction in their concentration in the water. This is followed by selection of methods that are likely to succeed and cost effective. Remedial procedures often require much scientific input, long periods of time and enormous financial resources.

Many examples of restoration of large lakes and reservoirs have ended up in failure. China has spent more than 564 million US dollars over a 14 year period

to improve the water quality of Dianchi Lake in the Yunnan Province without much success in spite of decreases of external nutrient loading, owing to nutrient releases from lake sediments especially under low oxygen conditions.

There are examples of successful restoration as well. Lake Mjosa, the largest lake in Norway, was eutrophic from the 1970s giving an unbearable odour in the vicinity and an unpleasant taste in the drinking water due to a heavy algal presence. This led to the initiation of several programmes directed towards the remediation of the lake. A survey carried out on the source of pollution revealed that phosphorus was the main pollutant. A new sewage plant was accordingly introduced in 1980 that could remove phosphorus with 90% efficiency and its concentration which ranged from 0.015 to 0.018 mg/l decreased to 0.011 mg/l. The algal concentration was reduced as a result.

The phosphorus concentration in waters of Lake Zurich in Switzerland was less than 0.03 mg/l prior to 1950, increased to 0.09 mg/l in 1965 as a result of sewage discharge from the highly populated cities. This was decreased by more than 85% by addition of ferric or aluminium sulphate in the waste water treatment process. This in fact was the first lake in the world where phosphorus was reduced successfully by chemical precipitation.

A few years ago, the water in the Kandy Lake was highly polluted. The water was turbid, algae was present on the surface, a foul smell emanated from the lake, fish was scarce, birds were hardly present and human fecal matter was detected in the water. This state of affairs was caused mainly from the harmful materials brought in from the effluent of many of the industries operating nearby, and from the storm water coming into contact with animal

fecal matter and other harmful waste materials spread on the surface of the land.

Restoration activities of the lake were begun seriously about six years ago under the leadership of the Irrigation Department. The remediation activities included installation of corrective measures by the industrialists and hoteliers to reduce the levels of pollutants in their effluent and the dredging of the lake at a cost of Rs. 38 million. As of May 2009, the water is clear, algae is absent, fish is present and the birds are back.

### Concluding remarks

Rainwater, wells, lakes, reservoirs, streams, rivers and the ocean have been polluted by the activities of the human through human wastes, city garbage, sewage, industrial wastes, carbon dioxide emissions, deforestation, and agriculture. As a result of pollution millions are dying annually from water-related diseases, lakes are becoming fishless, waterbodies are getting eutrophied, and the acidity of the ocean is on the increase.

It can be said that almost all the major events that very significantly altered the environmental status of the earth took place in the last 125 years although the human has been in existence for about a million years. The printing, textile, leather and many other polluting industries began in the early 1900s. The world's first mass produced car, the Ford Model T, was developed by Henry Ford in 1908. The large scale chemical fertilizer industry commenced in the 1920s. DDT was used as a pesticide in 1945. Forest cover decreased by 75% after the 1900s. Human population increased by about the same amount during this period.

From chemical analysis of trapped air present in ice cores brought from the lower depths of the earth, scientists

have found what the carbon dioxide concentration in the atmosphere was as far as 600,000 years ago. Its concentration has risen from about 280 ppm during the pre industrial period to 387 ppm at present and is expected to reach 500 ppm within the next 50 years, if emissions continue to increase at the current rates. Although long term data on the content of other pollutants in air and water are not readily available, it could be assumed that many of them too must have progressively increased, for pollution is a result of human activity on several fronts, and the emissions of carbon dioxide only one of them.

If the recent past brought about a number of environmentally adverse changes at such alarming speeds, what of the future? The current world population of 6.7 billion is expected to rise to between 8 and 11 billion in 2050. Growing crops and raising livestock to meet human food requirements will incur a heavy environmental cost. Disposing of the trillions of tonnes of human wastes that will be generated will be a nightmare, given the struggle at the moment with the current levels of production of wastes. The number of motor cars that count 600 million at present will reach one billion in twenty years. Net forest losses exceed 10 million hectares a year, mostly in the environmentally fragile regions of Asia, Africa and South America. A range of chemicals, many whose effects on living organisms and the environment would not be fully known, will be developed and used to meet the ever increasing needs and wants of the human.

The future cannot be considered to be one of optimism given the rather lackadaisical nature of the human response in the past to some of the danger signals of environmental degradation. Although Professor Richard Revelle and Dr. Charles Keeling started measuring the carbon

dioxide concentrations in the atmosphere on a daily basis in Hawaii way back in 1957, the world hardly took notice of their pioneering work and the repeated warnings until the topic was raised at the United Nations meeting on Environment and Development held in Rio de Janeiro in 1992. Even today, while much attention is given to carbon dioxide increase and climate change, the world has still not begun to realize that this gas is not the only damaging pollutant, and that climate change is but only one item in the catalogue of environmental change.

Water pollution is basically due to two factors, the chemistry of the water molecule and the activities of the human. The former cannot be changed. Humankind will have to refrain from indulging in environmentally damaging activities that were undertaken in the past with abandon. This will not be easy but will require moral courage and utmost commitment. This is the responsibility of this generation to itself and to future generations. Some of the matters to be given consideration for Sri Lanka in this regard are given here.

### **1. Create public awareness on water pollution**

Public awareness programmes should be carried out regularly by issue of brochures, publication of newspaper articles, conduct of radio and television programmes and by other means to educate the public on the importance of water to humans, animals, plants and the environment, the reasons for water pollution, the damage it does and the methods and approaches to arrest it.

### **2. Improve public health and sanitation**

Public health programmes should be strengthened particularly in rural areas where public water supply schemes are scarce. Special emphasis should be

given to improving personal and food hygiene. Drinking water sources should be regularly checked for presence of disease causing organisms by the public health officers.

### **3. Monitor water quality of water bodies**

Many rivers and reservoirs are used as sources of public water supply at present, and more are likely to be used in the future for this purpose. Presence of a highly poisonous alga in a reservoir that is connected to other reservoirs can create havoc in the country. A countrywide continuous monitoring programme of rainwater, wells, rivers, streams, lakes, reservoirs and other water bodies should be initiated. Such a programme is absent at present.

### **4. Encourage citizens to act as custodians in protecting water bodies**

Sri Lanka cannot depend on its laws and law enforcement agencies alone to protect its water bodies. This is borne out by the water pollution that goes unabated notwithstanding the numerous Acts of Parliament, Gazette Notifications and Regulations that have been in force for more than forty years. The government should assist and encourage local bodies, community groups, schoolchildren and individual citizens to protect the water bodies in their habitats.

### **5. Promote demographic policies that can sustain the environment**

It is universally accepted that more people will bring about more pollution. In any given area the environmental status will depend mainly on the nature of the land, the quality and quantity of water available, the number of inhabitants and the activities they are engaged in.

A given locality may have reached the population limit that has exceeded its environmental carrying capacity. Yet the subject is hardly discussed owing to its sensitivity. The time has come however, to discuss the matter in earnest with all religious, ethnic, cultural and other social groups. In fact the Principle 8 adopted at the Rio Conference on Environment and Development held in 1992 states that appropriate demographic policies should be promoted to achieve sustainable development. The emphasis should be on controlling the populations in polluting areas rather than targeting changes on a national basis.

### **6. Follow a new path**

Almost all water bodies on earth were very much less polluted a hundred years ago as compared to the present. This was mostly because the population was less, living standards were modest and processes of self purification of water were in place. Sunlight, microorganisms, forest cover, filtration through soil and other natural mechanisms purified the water. The situation is very different now. Population is much higher and increasing, forests are felled more than established, soil erosion has increased, more fuels are burnt increasing the carbon dioxide content in the atmosphere, new substances are synthesized that are not easily degraded and have the ability to cause harm to living organisms. Much of the pollution arises from activities aimed at raising the standards of living of the humans.

An attitudinal change for the world, countries, governments and individuals to be much more environmental conscious in all their activities is urgently needed.



# Some Issues on Water Conservation and Water Quality in Sri Lanka

## 1. Water - The Most Important 'Limited' Natural Resource

The 'hydrosphere' is the collective term given to all different forms of water in the earth's surface, whether oceans, shallow seas, lakes, rivers, groundwaters or glaciers. Less than 0.5% of the total hydrosphere is present on the continents as lakes and rivers. About 70% of the earth's surface is covered by the oceans, thus, constitutes 98.8% of the hydrosphere as marine waters. The major part of fresh water (0.7% of the hydrosphere) is trapped as fresh water glaciers, and only 0.5% of hydrosphere is available to fulfil our needs such as drinking, cooking, agriculture, industry, etc.<sup>(1)</sup> This is an estimate, it may be less today.

The oceans are linked with other fresh waterbodies in the hydrosphere through the hydrological cycle, in which water evaporates from the oceans into the atmosphere and falls as rains or snow on the continent and returns via rivers and lakes to the oceans again. The average composition of fresh and marine waters in the hydrosphere remains unaffected. A major percentage of fresh water is stored in aquifers as groundwater resources.<sup>(1)</sup> Groundwater is the traditional potable water resource for about 70% Sri Lankans. Surface water stored in reservoirs ('wewas') is the main source of water used for agriculture in Sri Lanka<sup>(2)</sup>.

## 2. Historical Aspects of Water Conservation in Sri Lanka

The conservation of water in Sri Lanka commenced with the construction of the first reservoir by King Pandukabhaya (380 - 310 B.C.). He constructed the first 'wewa' (tank or reservoir) based on the knowledge of

Science and Technology during that period. Since then, there have been nearly 35,000 reservoirs constructed in Sri Lanka. The conservation and the subsequent usage of the conserved water in this manner are unique to Sri Lanka<sup>(3)</sup>, and are not found in Europe or American Continent. There are similar types of reservoirs in some Asian countries, but the scientific aspect is confined only to Sri Lanka. With availability of water for healthy living and for irrigated agriculture, the economic development was achieved during the Anuradhapura period. Subsequently, it was also evident in the Polonnaruwa period (King Parakramabahu the Great, 1153 - 1186 A.D.). 'Let not a drop of water be sent to the sea without utilising it for the benefit of man kind' said King Parakramabahu the Great, and constructed reservoirs. 'Wewa' and 'Dagaba' were the main theme of the ancient sociological village unit concept in Sri Lanka which led to sustainable development. Two main objectives in the conservation of water were:

- (i) to provide water of suitable quality for irrigation during the dry season such that an uninterrupted agricultural activity with the production of food is maintained,
- (ii) to improve the health of the people by making the water of suitable quality available for domestic purposes.<sup>(4)</sup>

It seems that an economic prosperity of ancient Sri Lankans was dependent on the conservation and subsequent continuous availability of water of suitable quality for human needs. Even though it is not the agricultural economy today, the conservation of water still plays a significant role in economy of the country. Therefore, the two terms "water" and "economic

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development" cannot be separated from one another. In his book on "*Environmental Aspects of Sri Lanka's Ancient Irrigation System*", Prof. C.G. Weeramanthri has stated that traditional wisdom has much to teach us. He further says that the concept of sustainable development was a part of our ancient culture associated with the irrigated agriculture. The modern international environmental law has only recently appreciated the necessity of this concept of sustainable development, and often discusses the concept as a modern invention.<sup>(5)</sup>

It is undoubtedly obvious that Science and Technology was directly responsible for the economic development of Sri Lanka during that era. Those who are not familiar with science wrongly argue that ancient Sri Lanka had only the technology without science. It is true that ancient Sri Lankans did not have the so-called modern science which is not more than 500 years old. The ancient technology was based on unwritten science, and is not the modern science. The survival of the ancient technology was possible for several years due to its association with this unwritten form of science which would have been in some cases a kind of family secrets. The survival of technology is dependent on science. The economic development through agriculture in ancient Sri Lanka was due to the application of 'Sciences' to the technological, needs during that period. The concept of 'sustainability', implies meeting human needs while preserving the environment and natural resources needed by future

generations.<sup>(6)</sup> Therefore, the technology based on the 'unwritten science' preserved the natural resources for us to use even after 2400 years, i.e., sustainability. The unwritten science which led to the sustainable economic development in the ancient period does not exist today. Therefore, a need arises to apply modern science to ancient as well as modern technologies to meet the **current human needs** which are quite different from the human needs of our ancestors. The development of the so-called modern science during 19<sup>th</sup> and 20<sup>th</sup> centuries led to the changes of the human needs. The highest priority during this period was to meet the human needs at any cost. This was not the sustainable development. It was only during last two decades, more emphasis was paid on the economic development by providing human needs without affecting the environment – sustainable development. The **sustainable development achieved during the ancient time** was completely ignored or disregarded. Often, the concept of sustainable development is taken as a modern invention. In fact, it is a concept regarded as a part of **our ancient culture**. It would be fruitful for us to have some understanding on the application of unwritten science to ancient technology in order to achieve economic development by the application of modern science which is familiar to us now for the existing technology.

### 3. Historical Aspects of Water Quality in Sri Lanka

"Respect water" is the concept introduced to me by my teachers in the village school in the early 1950's. This can be considered as the wisdom from the past relating to sustainable development - "Unwritten Science". The term "respect" included not spitting or urinating on water, i.e., not to pollute water. This was practised in Sri Lanka in the past 2,500 years in the domestic and agricultural use of water. The

ancient design of toilets was based on the concept "respect water", thus prevented the pollution of water in the past 2,500 years. Do we respect water today in our domestic usage? We have blindly followed the rest of the world in designing toilets without considering the **wisdom from the past**. The technology from elsewhere was copied without applying the science required to prevent the pollution of water. Urban population and also the village population today, disregard the ancient concept "Respect Water". This concept helped the ancient Sri Lankans to re-use water without any adverse effects, thus achieving the sustainable development.

The ancient science was also responsible for maintaining the irrigation water of suitable quality. After the reign of King Pandukabhaya, several successive kings constructed several thousand reservoirs ('wewa') mainly to conserve the rainwater. Very little evidence could be gathered on the construction of reservoirs by building dams across flowing streams or rivers. In such instances a **forest cover** was maintained in an around the streams carrying water to the reservoirs and also the canals which supplied water to paddy fields.<sup>(3)</sup> The belief such as divine being living in trees assisted to preserve the forest cover. In addition, powerful dictatorship and good governance prevented people even to clear a forest. One method of achieving **sustainability** in the ancient irrigation projects is by maintaining the forest cover. The modern science reveals that clearing of forest increases the sodium ion concentration of irrigation waters, thus making the water unsuitable, ultimately leading to loss of soil permeability. The ancient water management was based on this type of ancient scientific views (unwritten science) associated with the fact that large reservoirs had not been constructed to collect drainage waters from one irrigation system and to reuse the water to irrigate several thousand

hectares. The reuse of irrigation water was confined to a cascade system which involved the collection of drainage waters in small reservoirs with a subsequent use for irrigation of a small area less than 10 ha. The ancient science would have given the indication that the irrigation water quality is deteriorated after usage leading to the loss soil permeability. A small area affected in this manner can easily be abandoned without an adverse effect on the economy.

### 4. The Awareness of Water Quality

Nearly 2,400 years old irrigated agriculture, which was responsible for sustainable development of Sri Lanka in the ancient time, has not been given adequate consideration in the education system in Sri Lanka. Is the irrigation water quality a part of our school curriculum? No! Because there are no irrigation tanks (reservoirs) in the United Kingdom (UK) or in the United State of America (USA). Sri Lanka blindly follows the UK and the USA, and has taken no steps to incorporate irrigation water quality criteria in teaching even though we have about 35,000 irrigation water tanks. The Chemistry curriculum of the G.C.E. (A/L) is designed to maintain the international standard such that students of the affluent families who fail to gain admission to local universities may find places in foreign universities without sitting for another examination. At present, the course contents in all science subjects are geared for the minority (3%) who enter the universities. In many developed countries, the personnel who have written and published books for the secondary level are not allowed to participate in the designing or the revision of the course content. This is because the **vested interest** inadvertently predominates over the **National interest**. Since there is no such a rule in Sri Lanka, the students who offer science subjects at G.C.E.(A/L) do not find any usefulness of the subjects,

if they fail to gain admission to the universities. Sri Lanka suffers because the vested interest predominates over the national interest. A frequent revision of the curricula is essential to suit rapid changes in some aspects of scientific knowledge. It is suggested that a permanent body should undertake revision of the curricula of science subjects at G.C.E. (A/L) after conducting research on the aspects of catering to 97% of the students. This is cost effective since it helps in the development of the knowledge economy of the country. There is a very high resistance from many sectors in the revision of the curriculum suitable for local conditions such that about 97% students who could not gain admission to local universities are benefited.<sup>(7)</sup>

A report issued in advance to the Earth Summit, August 2002 in Johannesburg reveals that more than 76 million people, mainly children will die from water-related diseases by 2020 unless urgent action is taken to clean planet's water supplies. The World Health Organisation (WHO), in a report issued in 2000, estimated that, there are already 4,000 million cases of diarrhoea each year, killing as many as 5 million people. It has been reported that, the per capita availability of water in the Asian region has declined by 40-60 per cent from 1955 to 1990 (35-year period). If this trend continues, there would be a severe water problem in Asia in the year 2025. Water, like any other matter, cannot be created or destroyed, but water can be made unsuitable due to pollution. There is now a need to care water resources in Sri Lanka such that we will not face the anticipated water crisis in 2025. i.e. Preparedness! It has also been reported in the Sunday Observer of 26<sup>th</sup> June 2005 that, water shortages and water pollution cause four million deaths per year around the world. This means, one person dies every eight seconds. The science education plays a vital role in the preparedness for such a disaster. Our schoolchildren are well aware of

global warming, depletion of ozone layer, etc. There are no direct deaths due to these atmospheric effects, but these can affect developed (rich) countries. Therefore, developed countries ensure that these aspects are incorporated into teaching curricula by convincing the 'Educationalists' in Sri Lanka. Though a Sri Lankan student is well aware of the depletion of ozone layer, global warming, etc., he is not aware of the quality of water he deals with, in his day-to-day life. The water pollution does not affect the developed countries since they have very expensive modern methods to purify water. Since water pollution is a localised problem affecting us directly, our 'Educationalists' are not convinced by the 'Consultants' from developed countries to incorporate water into the teaching curricula. Can we have an indigenous curriculum suitable for Sri Lanka, taking all our aspects into consideration? The only way to increase the awareness of water quality is to incorporate it to school curricula disregarding the advice from so-called 'Consultants' from developed countries.<sup>(7)</sup>

In many important aspects of public life, the term "quantity" is always given a predominant position whereas the term "quality", applicable to the same aspect, is either ignored or not being given adequate consideration in Sri Lanka. This is true for water, which is the most important natural resource vital for life. However, some consideration is given for the quality of "potable" (drinking) water since there is an obvious undesirable effect of the potable water of poor quality, but little or no consideration is given for irrigation water quality in Sri Lanka, even though we have about 35,000 irrigation water tanks (reservoirs). An example for the priority for quantity is given below. In the past 1000 years, about 100 hectares of paddy fields have been cultivated using water from small tank ('wewa'). An irrigation scheme was introduced

to this area about 50 years ago. In this program, a canal was diverted into the tank to increase the 'quantity' which generally makes the cultivators happy. The poor quality of water in this canal led to loss of soil permeability, and the 100 hectares of paddy field were abandoned. The villagers in the area who lost their paddy fields due to an attempt to increase the 'quantity' at the expense of the 'quality' by engineers provide evidence for such disaster.<sup>(4)</sup> This necessitates the incorporation of water quality in all aspect of the use of water to prevent the anticipated water crisis in 2025.

### 5.The "Preparedness" to Prevent a Water Crisis

Daily News, Tuesday May 17, 2005

**"Tensions over water will increase as scarcity increases, but outright conflict can be avoided"** by Steve Loneragan

It is important take following steps to prevent the anticipated water crisis in 2025:

- (i) A gift from God - *Respect Water* - Not practicable today
- (ii) A suitable Legal framework - *Water Policy*
- (iii) The restructuring of economies away from water - intensive sectors - *A change of the crop pattern*
- (iv) The awareness of Water Quality - *Regular Monitoring*
- (v) Regulations on Re-use - *Industrial recycling*

All ancient civilisations in the world were associated with water bodies such as rivers. The anticipated water crisis in 2025 can be mitigated by regular water quality monitoring programmes which ultimately leads to the development of water quality criteria based on the human needs. These criteria will provide guidance for water

management problems. The modern methods of this nature could be guided by the history which provides evidence for the existed excellent sustainable water management system without any, so called modern scientific inputs. It was really the input of unwritten science ('Respect water') to water management technology. Good governance in the ancient period prevented people even from clearing a forest. One method of achieving sustainability is by maintaining the forest cover. The modern science reveals that clearing of forest increases pollution of water thus making the water unsuitable. The ancient water management was based on this type of ancient scientific views (unwritten science). The re-introduction of good governance is essential to prevent the water crisis in 2025. The strict implementation a water policy plays an important role. It should be mentioned that all stakeholders, including me, should be accountable for use of water. The accountability should be a part of water policy. The accountability should be associated with the water entitlement. Historical aspects on this could be considered, and a suitable modification could be made acceptable to all. The water quality

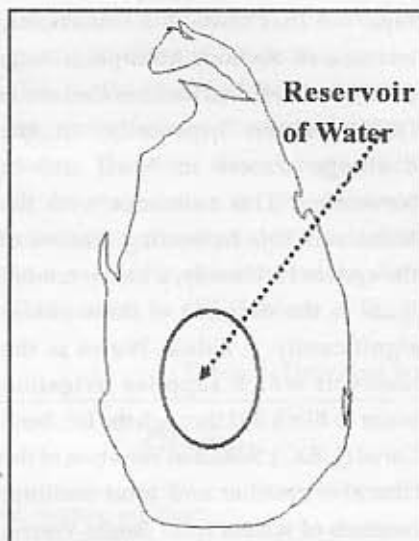


Figure 1 : Central hill country was kept as a reservoir of water in the ancient time

cannot be generalised as 'quantity'. The water quality should be associated with the purpose that water is used, e.g., potable water quality, irrigation water quality, industrial water quality, etc. Re-use of water, especially by industries, should be emphasised.

No historical records reveal that there were human settlements in the central hill country over 800 hundred years ago<sup>(3)</sup> (Figure 1). The hill country was the reservoir of water feeding most of the man-made wewas even during a severe drought.

The existing nine provinces (regions) have been demarcated by British rulers without any basis. If the watershed of rivers would be the major criteria for the division of the country into provinces, each province can take adequate steps for proper water management thus prevent the

pollution of water resources confined to it. The sustainable water management will thus be a reality. In this way, Sri Lanka can be divided into five regions (provinces). (Figure 2)

**The Mahaweli Region :** This includes the catchments of the Mahaweli river and Maduru Oya. The southern limit is the Morawewa catchments.

**The Ruhuna Rata Region :** This would be the region east of Mahaweli including the catchments area of Walawe Ganga and Matara district.

**The Maya Rata Region :** This is the region south to Maha Oya including the present Galle district with an eastern limit of Mahaweli region.

**The Raja Rata Region :** This comprises the area limited by Maha Oya in the south, Mahaweli region boundary in the east and the northern limit is the catchments area of Malwathu Oya.

**Yalpanam Region :** This comprises of Jaffna Peninsula and Manner area including the catchments area of Aruchi Aru.

There is also some historical evidence that the administrative division of the country was based on the water resources.<sup>(3)</sup> Each administrative division (province) can optimise the use of its water resources without being polluted. This would be the first step that should be taken to safeguard the country against the severe water crisis in the future. Preparedness leads to the prevention or mitigation of disasters. Prevention is always better than cure.

## 6. Irrigation Water Quality

The largest user of water in Sri Lanka is irrigated agriculture. The irrigation water flows through a system of tunnels, streams, reservoirs ('Wewa'), canals, etc. before it reaches the field where crop is grown. During this flow, some soluble salts



Figure 2 : Proposed demarcation of the provinces based on water-sheds of 103 river basins

are always dissolved in, and the water becomes saline, containing high dissolved salts. Man's activities such as industries, deforestation, etc. in and around water flow enhance dissolution of salts. In the fields, the water will undergo evapotranspiration, resulting in the accumulation of dissolved salts, which will affect the soil properties, especially the soil permeability and subsequently crop growth. It has been reported that in countries such as Afghanistan, Pakistan, Egypt, etc. millions of hectares of irrigated lands have been abandoned due to the loss of soil permeability which affected the crop growth<sup>(10)</sup>. The previous example is the abandoning of about 100 hectares of paddy fields in Sri Lanka due to the loss of soil permeability<sup>(4)</sup>. This may be possible in all the other irrigation schemes, if the priority is given only for the quantity rather than the quality. Therefore, it is essential to take adequate precautionary measures, especially in the areas irrigated by Mahaweli waters, in order to prevent any such salt danger caused by the increased utilisation of irrigation water resources<sup>(11)</sup>. **Prevention is better and less expensive than cure.**

The Mahaweli irrigation project involves utilisation of water of the Mahaweli Ganga to irrigate an extensive area of dry zone. When complete, the Mahaweli Development project is expected to supply water for the irrigation need of 900,000 acres for two crops a year. The master plan also envisages the generation of 2,037 million kilowatt hours of hydroelectric energy. The phase 1 of the project, (Kala Oya, Abanganga) covers 132,000 acres of existing lands and 91,000 acres of new lands.<sup>(13)</sup> A monitoring programme was initiated in 1978 to check the quality of irrigation waters in the system H of the Mahaweli diversion scheme.<sup>(12)</sup> The block 302 of the system H of the Mahaweli development scheme was selected for this purpose. It was

reported that there is a remarkable increase of Sodium Absorption Ratio (SAR) and Residual Sodium Carbonate (RSC) values, especially, in the drainage waters in April and in November. This coincides with the Maha and Yala harvesting seasons of the system H. Usually, a heavy rainfall leads to the decrease of these values significantly. Balalu Wewa is the reservoir which supplies irrigation water to Block 302 through the left Bank Canal (L.B.C.). Seasonal variation of the filterable residue and total residual contents of waters from Balalu Wewa, Left Bank Canal and at the beginning of D<sub>1</sub> Channel of Block 302 shows similar trends. It is seen that there is an increase in the filterable residue as well as the total residue of the irrigation waters in April 1978 and 1979. The Maha harvest starts in March and ends in April. During this period the water supply to the field being completely cut off and consequently, as a result of rapid evaporation of the existing water, the filterable residual content increases.<sup>(12)</sup>

The knowledge of the quality of irrigation water is important in judging its suitability for irrigation.

Suitability of irrigation water depends upon several factors associated with characteristic of water; soil, plant and climate.

It is difficult to suggest a single water quality criterion because of the interaction of several factors. The degree of adverse effects on soil properties is mainly related to the chemical composition of irrigated water. The adverse effect of water of poor quality on soil-plant system depends upon the total salt concentration, relative proportion of sodium to other cations, boron concentration and bicarbonate content. Waters of low electrical conductivity are generally composed of higher proportion of calcium, magnesium and bicarbonate ions whereas those of high electrical conductivity contain mostly of sodium and chloride ions.<sup>(14,15,16)</sup> The relative proportion of sodium to other cations is determined by the sodium adsorption ratio (SAR) (Equation (1)). Any increase in the SAR of irrigation water increases the SAR of the soil solution, which ultimately increases the exchangeable sodium by the soil leading to the loss of soil permeability.

**Table.1: FAO Guidelines for interpretation of water quality for irrigation<sup>(8,9)</sup>.**

Irrigation problem	Degree of problem		
	No Problem	Increasing Problem	Severe Problem
Salinity (affects crop water availability) ECw (mmhos/cm)	< 0.75	0.75 - 3.0	> 3.0
Permeability (affects infiltration rate into soil) ECw (mmhos/cm)	> 0.5	0.5 - 0.2	< 0.2
adj. SAR (or ESP)			
Montmorillonite (2:1 crystal lattice)	< 6	6-9	> 9
Illite - vermiculite (2:1 crystal lattice)	< 8	8 -16	> 16
Kaolinite - sesquioxides (1:1 crystal lattice)	<16	16 - 24	> 24
Specific toxicity (affect sensitive crops)			
Sodium (adj. SAR)	<3	3 - 9	> 9
Chloride (meq/dm <sup>3</sup> )	< 4	4 - 10	> 10
Boron (mg/dm <sup>3</sup> )	< 0.75	0.75 - 2.0	> 2.0



$$SAR = \frac{Na^+}{\sqrt{Ca^{2+} + Mg^{2+}}}$$

where ionic concentration of each is in mmol dm<sup>-3</sup> (1)

The degree of adverse effect on soil properties and crop growth is mainly related to composition of irrigation water. Food and Agriculture Organisation of the United Nations (FAO) forwards the guidelines given in Table 1 to evaluate water quality for irrigation using the problem approach. If the SAR value of the irrigation water is low there will be adsorbed calcium and magnesium ions on the soil exchange surface. If the adj. SAR is high most of the exchangeable sites which are initially occupied by calcium and magnesium ions will be occupied by sodium ions (Figure 3). However, two sodium ions are required to balance the charge initially balanced by a single calcium or magnesium ion. This results in the spread of charge distribution over the entire surface area.

The decrease in soil permeability is a result of an enhanced particle interaction with enhanced swelling and the development of diffused

electrical double layers. This leads to partial blocking of conducting pores of the soil thereby reducing the infiltration rate or downward entry of water. Therefore, the soil permeability is decreased due to the enhanced adsorption of sodium ions. Kalawewa is a reservoir constructed by King Dathusena (6<sup>th</sup> Century A.D.) by

for the shift is a crop failure due to the lost of soil permeability. The administrative failure during the period 6 - 9 century resulted the poor water management which ultimately led to the crop failure. The continuous irrigation with poor quality water and consequent crop failures affected the agricultural economy in the

Table 2: Drinking water standards (WHO)

Criterion	WHO Recommended Limit	International Acceptable Limit	Tolerance Limit
Total residue, mg dm <sup>-3</sup>	500	1500	-
Turbidity, NTU	5	25	-
Alkyl benzene sulphate mg dm <sup>-3</sup>	0.5	1.0	-
Arsenic (As) mg dm <sup>-3</sup>	-	-	0.05
Barium (Ba) mg dm <sup>-3</sup>	-	-	1.0
Cadmium (Cd) mg dm <sup>-3</sup>	-	-	0.01
Calcium (Ca) mg dm <sup>-3</sup>	-	200	-
Carbon: chloroform extract, mg dm <sup>-3</sup>	0.2	0.5	-
Chloride (Cl) mg dm <sup>-3</sup>	250	600	-
Chromium(Cr(VI)) mg dm <sup>-3</sup>	-	-	0.05
Copper (Cu) mg dm <sup>-3</sup>	1.0 - 2.0	1.5	-
Cyanide (CN) mg dm <sup>-3</sup>	-	-	0.2
Fluoride (F) mg dm <sup>-3</sup>	1.5	1.0 - 1.5	-
pH	6.5 - 8.5	6.5 - 9.2	-
Iron (Fe) mg dm <sup>-3</sup>	0.3	1.0	-
Lead (Pb) mg dm <sup>-3</sup>	-	-	0.05
Magnesium (Mg) mg dm <sup>-3</sup>	-	150	-
Manganese (Mn) mg dm <sup>-3</sup>	0.1 - 0.5	0.5	-
Nitrate (NO <sub>3</sub> ) mg dm <sup>-3</sup>	50	45	-
Phenolic compounds (as phenol) mg dm <sup>-3</sup>	0.001	0.002	-
Selenium (Se) mg dm <sup>-3</sup>	-	-	0.01
Sulphate (SO <sub>4</sub> ) mg dm <sup>-3</sup>	250	400	-
Zinc (Zn) mg dm <sup>-3</sup>	3 - 5	15	-

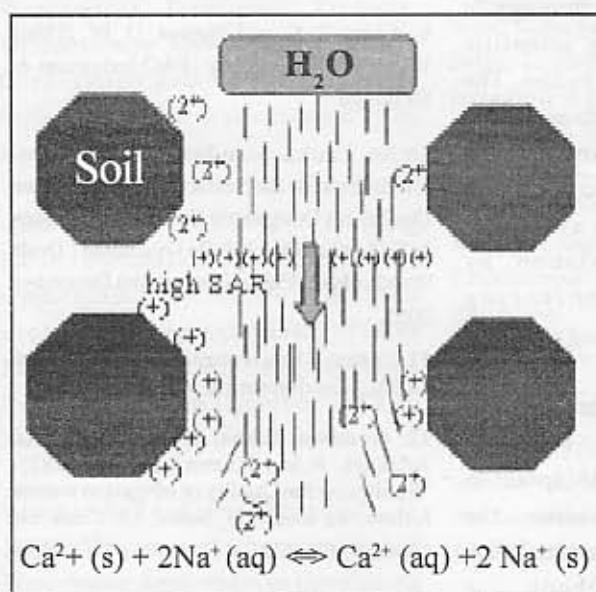


Figure 3: Illustration of the loss of soil permeability if waters of high SAR are used for irrigation

building a dam across a stream (presently Dambulu Oya - Kala Oya). He may have constructed this to fulfil his wishes and may have gone against the opinion of his advisors in making the decision. Three or four hundred years after the continuous use of Kala Wewa waters for irrigation, the Anuradhapura kingdom was shifted to Polonnaruwa. One could attribute reason

Anuradhapura area resulted the shift of the kingdom to Polonnaruwa in the 10<sup>th</sup> century.<sup>(17)</sup>

The recurrence of large-scale crop failure can not be ruled out today. However, it is now impossible to shift the population in the affected area unlike in the 10<sup>th</sup> century. A possible crop failure today will lead disasters and the destruction of the development achieved during last two decades.

A proper water management programme guided by the results of continuous monitoring programme and water quality criteria undoubtedly, prevent such disasters.

## 7. Potable Water Quality

The healthy living is directly related to the availability of potable water of suitable quality. Groundwater is the main source of drinking water for about 60% Sri Lankans.<sup>(18)</sup> The water in the reservoirs, rivers and streams also provides drinking water for healthy life. River water is the main source of water in water supply schemes to many cities in Sri Lanka. In the past, the reservoirs (Wewa) also supplied drinking water during long droughts. Hydro-geological study shows that the nature of rocks affects the quality of groundwater. The groundwater in some areas of North-Central Province contains excessive amounts of fluoride.<sup>(2)</sup> The health effects of these have been studied extensively.<sup>(19,20)</sup> It is generally assumed that water is purified and becomes suitable for drinking by boiling. Boiling only makes the harmful pathogens inactive and occasionally reduces hardness due to the precipitation of calcium/magnesium carbonates. However, boiling cannot remove the ions listed in the WHO guidelines (Table 2).<sup>(4)</sup>

The concept "Respect Water" helped the ancient Sri Lankan to re-use water without any adverse effect. It is now clear that the re-use of water today in domestic, agriculture and industrial spheres will lead to adverse effects. This is true for irrigation waters (the increase of SAR values and subsequent

loss of soil permeability). It is also applicable to potable and industrial waters as well. A requirement thus arises to carry out continuous monitoring of water quality of all spheres of human activities. It is essential to incorporate 'Water Quality' in school curricula, and water quality testing can become a part of school projects.

## 8. Conclusion

The operation of the "water cycle" in the earth is affected and will be affected due to anthropogenic inputs. The regular monitoring of the quality of water in all parts of the island will be helpful to take timely remedial measures leading to a meaningful integrated development in the 21<sup>st</sup> century. It is suggested that the water quality testing should be carried out at provincial levels even as a part of school curriculum. The data, even through may not be very accurate, will be useful in the water management programmes.

It was revealed that the per capita availability has declined to alarming levels affecting the future generations. To maintain the sustainability without curtailing the current human needs, it is essential to develop technologies on the reuse or recycling of water, effluent treatment processes, etc. (Figure 4). The development of such technology is impossible without the scientific knowledge on the water bodies. The immediate requirement is to assess the

availability. The recycling of water should be a law.

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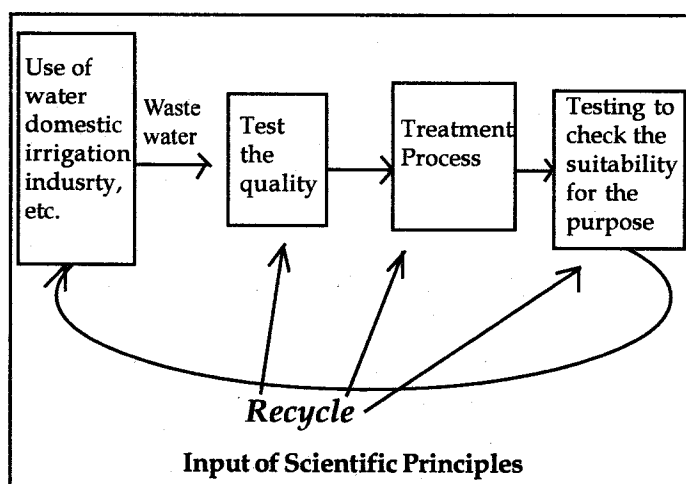


Figure 4 : Recycling of water

water quality and its seasonal variation by monitoring programmes and subsequent use of scientific principles to monitor the sustainability without a decrease in the per capita

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community. Therefore, more attention should be focused (Niyandagoda, 2008), in the future, on natural springs as a potential water source for the rural community. In this regard, the Water Resources Board has initiated a program titled "Restoration of Clean Water Centers and under this program, action has been taken towards the conservation and protection of natural springs and other potential water sources.

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<sup>1</sup> This value includes the actual supply by the water supply board and the amount of water estimated to be used by the households from other sources such as wells.

# Water Pricing for the Urban Poor

This article is the eleventh in a series of articles by the Centre for Poverty Analysis (CEPA) exploring various dimensions of poverty in Sri Lanka.

In Sri Lanka, access to water for domestic purposes has reached 84.7% of the population, while in urban areas access to water is as high as 95.4% (DCS, 2008). While these statistics indicate that access itself may not be an issue in urban areas, it makes disparities in terms of the quality and equal access to services that exists among urban populations. For the urban poor, many of whom reside in Under Served Settlements (USS), water services are provided mainly through public facilities such as stand posts, common toilets and bathing areas. This provides them with a lower quality service that can limit their quality of life. From the point of view of the service provider, in this case the National Water Supply and Drainage Board (NWSDB), public water is considered "free water" that they are obligated to provide so that communities are not denied access to a basic need. The NWSDB see individual household connections as a means to provide better water services to urban poor by also allowing them to recover their costs. However, in order to reach a larger number of urban poor who are unable to connect through the regular process due to financial, legal or infrastructure limitations, an alternative strategy needs to be devised and water pricing methods are commonly used for this purpose.

## Theoretical approaches for water pricing

Developing a pro poor water delivery strategy, including a suitable water pricing structure for urban poor, needs to consider what factors determines per capita water use and affordability. This includes monetary and non monetary characteristics such as household composition and living conditions, water supply and use patterns, income and expenditure status and available infrastructure that influence the decisions and actions taken. "Willingness to pay" (WTP) is a concept that can be used to understand how individuals of a population value goods or services. The concept of "willingness to pay" generally refers to the economic value of a good to a person (or a household) under given conditions (Gunetilleke et al, 2007). It theorises that if people are willing to pay for the costs of a particular service, it is an indication that the service is valued based

on factors such as felt need, existing conditions, as well as on affordability. Contingency Valuation is a methodology that is used to capture WTP for goods and services that are not already on the market. It specifies a set of conditions for a good or service for which the consumers are asked to indicate their willingness to pay. This is an accepted method of gathering information to assess economic viability, set tariffs, evaluate policy alternatives, and design socially equitable subsidies (Gunetilleke et al, 2007).

## Capturing willingness to pay for individual water connections

In a recent study carried out by the Centre for Poverty Analysis (CEPA) with support from Environmental Cooperation-Asia (ECO-Asia), a regional programme of the United States Agency for International Development (USAID), the concept of willingness to pay was applied to understand potential demand for individual house connections among urban poor, specifically the willingness and ability to pay for connection fees and water charges for piped water services. ECO-Asia's aim in supporting this study was to assist the NWSDB in the development of improved strategies for providing piped water supply to the underserved urban poor.

The sample for the study consisted of 248 households in 15 USS across the three municipalities of Moratuwa (MMC), Dehiwala-Mount Lavinia (DMMC) and Colombo (CMC), prioritised based on high concentrations of USS without individual connections and use of public facilities. The USS were selected to show maximum variance of characteristics such as size, users per stand posts, legal status and geographic locations. All the households interviewed were using water from public stand posts.

## Living conditions and water use patterns

The households in the USS that were sampled showed considerable diversity in terms of housing conditions within the same USS and in comparison across USS in different Municipalities. About half (46%) of the households have permanent structures with brick walls, tile/asbestos roofing and cement floor while about 20% had poor quality housing with plank walls and tar or metal sheets for roofing (most of

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the poor quality houses were located in 3 of the sampled sites situated in 64 Sri Saddharama Mawatha and 185, Stace Road, in Colombo, and Madamgahawatta in Moratuwa)

Plot sizes tended to be less than 5 perches, with limited space being more pronounced in the CMC area where a majority of the plot sizes were less than 2.5 perches. Number of rooms in houses also varied with 1-2 being most common in the Colombo and Dehiwala-Mount Lavinia areas while in Moratuwa there tended to be 3-4 rooms. The limited space issue is reflected in the toilet facilities available; 60% of the households in Colombo and Dehiwala Mount Lavinia Municipalities used common toilets, while a similar percentage had private toilet facilities in Moratuwa Municipal Council area.

Interestingly despite not having piped water in their homes, 75% of the households in Colombo and Moratuwa had metered electricity connections. The ability to afford electricity bills indicates that could meet the cost of the monthly water bills. In contrast in Dehiwala-Mount Lavinia the percentage was lower (45%) possibly due to the temporary nature of the sites captured in this municipality, as several of the sites were along the coastal belt and were affected by the tsunami and now faced uncertainty about their living space. All households interviewed were reliant on public facilities as their primary water source for all their water needs. Use of alternative sources such as wells was not common and when used it was for bathing and washing or at times when there was no water in the public stand posts. All households have easy access to at least 1 stand posts within 10 minutes walking distance from their homes. The close proximity of the stand posts has led to a use pattern of making several trips to the stand posts, as well as choosing to go at particular times (mid morning, late at night) to avoid having to queue for water. Despite easy physical access however, all households store water, mainly for cooking and drinking, while households that stored water for bathing and washing had household members such as babies, young children, women, elderly and disabled



persons who either needed extra care or privacy. The limited storage space also indicates that these communities are curbing their water needs and therefore having individual connections could lead to higher water consumption patterns.

### Establishing the demand and capturing willingness to pay

The study found that demand for individual connections, was high, especially in Colombo and Moratuwa where over 90% of those sampled expressed willingness to connect, while the demand in Dehiwala-Mount Lavinia was slightly lower (77%). The expressed value of individual connections was in terms of added convenience, time saved, more privacy, and better security. The benefits were seen as greater for women, who are usually tasked with fetching water to the house, and households with elderly, disabled and young children.

"I would not need to wake up at night to fill water if we have an individual household water connection."

—Female, Colombo, age 48

"Everyone in the community will benefit from getting an individual connection. Even though these are slum areas, women still prefer privacy. They prefer filling buckets of water to a tank in the house to bathe inside over bathing outside in public in the common tap."

—Community Leader, Moratuwa, Male

Furthermore, the problems experienced while using common facilities, such as wastage of time, lack of privacy, and problems with neighbours were expressed as reasons for why individual connections were preferred over free public facilities.

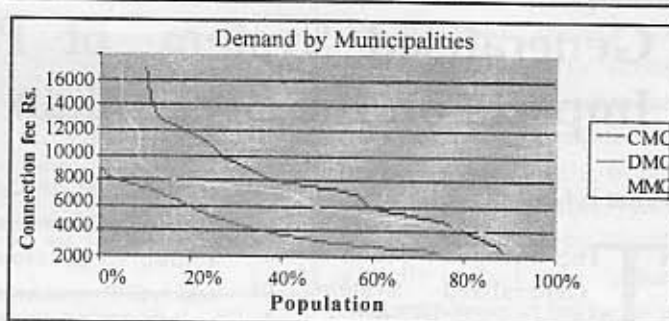
Evidence of their felt need is also supported by the fact almost half (46%) of the sampled households had tried to get connections but have not been successful. Reasons given for failure to connect ranged from not being able to meet the upfront costs, the process of having to submit as a group not working in their favour, and lack of follow up from the NWSDB. Among those unwilling or unsure about getting an individual connection, issues of space, cost and uncertainty regarding their place of living were the main deterrents. In Colombo, lack of space to construct facilities inside the house as well as for drainage was the main limiting factor while in Dehiwala-Mount Lavinia, the temporary nature of the unconnected settlements is the main reason for their unwillingness to incur the expense at this point in time. This brings us to the crux of the matter; are households who have a high demand for individual connections willing to pay for such

connections. The survey asked households to state levels of preferred amounts as what they can pay within set intervals of Rs. 0 – Rs. 15,000/-, where Rs. 15,000/- was the amount for general connection fee charged by the NWSDB.

The results revealed sharply downward sloping demand curves with a small percentage indicating willingness to pay at the asking rate of Rs.15,000, while many congregated at lower amounts. At the range of around Rs 5,000, 54% of unconnected households in Colombo, and almost 40% of unconnected households in Moratuwa are likely to connect, while only 13% of unconnected households in Dehiwala-Mount Lavinia would connect. The Graph below illustrates the demand curves by municipality that are indicative of the general trends in these municipalities. The demand curves also showed that willingness to pay differed across municipalities, USS and households, revealing that for different locations there are different levels of preferred payment amounts. In terms of what drives their willingness to pay, the regression outputs showed that the amount reported strongly correlated with income and proxy variables of income, but were not found to be highly correlated with factors that affect demand, such as having elderly, disabled and young children in the household or problems faced when using public utilities. Therefore the willingness to pay was capturing how much people could afford to pay rather than their perceived need or value for the service, showing that many were unable to translate their demand into a market-visible amount.

### Recommendations for developing pro poor strategies

The willingness to pay study is showing is that there is gap between affordability and expected utility from a household connection. Therefore strategies which are genuinely pro poor need to cater to both the affordability and the demand for better water services among the poor. In order to bridge this gap, concessions and subsidies, support services and implementation strategies must be able to reach out to households at different income brackets, and therefore affordability of individual connections. This would increase coverage and accessibility of better water services, while also allowing for cost recovery over time. In addition the varying conditions of



Source : CEPA 2009 (Based on household survey results from willingness to pay study)

the USS indicates that there is a need for a customised approach to deal with the various problems facing the urban poor, and that a one-size-fits-all approach may not result in maximum benefits for the communities or the service provider.

Another important factor to be considered is that the provision of individual pipe connection alone may not be adequate for households to make full use of an individual water connection. Issues of drainage, space for toilets and bathing areas, and other infrastructure needs (at household and site level) also have to be addressed in order to have an impact on the living conditions of the urban poor. Therefore a more holistic approach to water service delivery that takes into consideration other infrastructure needs of USS, and collaboration or coordinated efforts with other service providers such as the municipalities can result in increasing the benefits to the community.

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# Generalised System of Preferences (GSP+) and Its Impacts on the Sri Lankan Economy

## What is GSP +?

The European Union's (EU) Generalised System of Preferences (GSP) is a trade arrangement through which the EU provides preferential access to its market to developing countries, in the form of reduced tariffs when goods of developing nations enter the EU market. This trade arrangement is non-reciprocal in nature<sup>1</sup>.

Under the EU GSP scheme, there are three separate preference regimes (European Commission web site):

- The standard GSP arrangement, which provides preferences to 176 developing countries and territories on over 6300 tariff lines.
- The special incentive arrangement for sustainable development and good governance, known as GSP+, which offers additional tariff reductions to a selected number of countries.
- The Everything But Arms (EBA) arrangement, which provides duty-free and quota-free access for all products (except for arms and ammunition) for the 50 Least Developed Countries (LDCs).

As a developing country, Sri Lanka gets preferential access to the EU market, based on the standard GSP system. Over and above the GSP accorded to all developing countries, special incentives are provided under the GSP+ regime for countries that ratify and implement 27 international conventions in the areas of human rights, core labour standards, sustainable development and good governance. GSP+ provides duty free access to over 7200 products in the European market. Sri Lanka, together with 14 other countries, qualified for GSP+ for a period of three years, from December 31<sup>st</sup>, 2005 to December 31<sup>st</sup>, 2008. All beneficiaries are evaluated by the EU Commission, every three years, before an extension of the trade

arrangement. In December 2008, the European Commission listed Sri Lanka among 16 developing countries to which GSP+ was awarded from January 2009 till December 2011<sup>2</sup>. Nevertheless, Sri Lanka's status as a GSP+ beneficiary is currently subject to the outcome of an eligibility review<sup>3</sup>.

The overall value of imports to the EU under each of the three GSP regimes mentioned above, and an approximate value of the preferences provided to countries, in terms of nominal duty loss for the year 2007 are given in Table 1<sup>4</sup>. Understandably, more imports come into the EU under the standard GSP scheme, as this has been awarded to 176 developing countries. The beneficiaries of GSP+ have competitive advantage over most developing nations other than the LDCs, given the fact that, this is enjoyed by only 16 countries.

## Sri Lanka's Trade with the EU

Given Sri Lanka's high dependence on trade (with a trade: GDP ratio of 54 per cent) and the size of its domestic market (small economy of 20 million people) export markets like the EU have been vital for Sri Lanka's economic sustainability. The EU is Sri Lanka's largest trading partner, and having duty free access to the world's largest market through the GSP+ scheme, gave impetus to the Sri Lankan exporters to increase trade with the EU. Sri Lanka currently exports goods and services worth over US\$ 3 billion (37 per cent of Sri Lanka's total exports) to the EU. It is also Sri Lanka's second major source of imports, accounting for 12 per cent of the country's total imports. The importance of GSP+ to Sri Lanka has also been highlighted in the wake

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of the economic crisis. The impact of the GSP+ on Sri Lanka's exports to the EU has been substantial, and the industries, especially, the garment industry has been vociferous about the need of securing GSP+ concessions. Sri Lanka's exports to the EU increased significantly in the recent years. The main factor that can be attributed to this development is the concessions extended through the GSP+ scheme, since it came into operation in 2005. Under this non-reciprocal preferential trade arrangement, Sri Lanka is eligible to export more than 7,200 products duty free to the EU.

The scheme has helped boost exports to the EU, by enabling local manufacturers to remain competitive despite an increasingly competitive global environment. As a result, the value of exports to the EU increased from US\$1.8 billion in 2004 to US\$2.9 billion in 2009. In 2006, when Sri Lanka had zero duty access to the EU market, exports increased substantially, with a growth of 24.7 per cent compared to a growth of 2.7 per cent in 2005 – this higher growth trend since 2005 is clearly shown in Figure 1.

Table 1: Trade Volumes under GSP and value of preferences

2007	GSP Preferential Imports (€ millions)	Nominal Duty Loss (€ millions)
Standard GSP	49.390	1.542
GSP+	4.927	0.501
EBA	4.321	0.505
Total	58.637	2.548

Note: These figures would vaguely under-estimate the value of GSP for developing countries, since they do not factor in all reductions in tariff preferences applied to specific duty rates.

Source: European Commission web site.

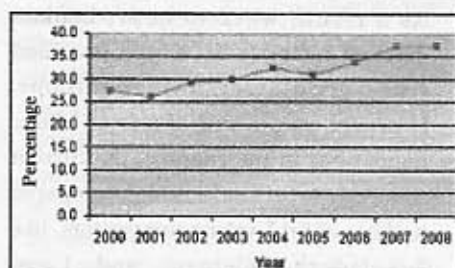


Figure 1: Exports to the EU as a percentage of total exports

Source: Central Bank of Sri Lanka, Annual Report (various issues)

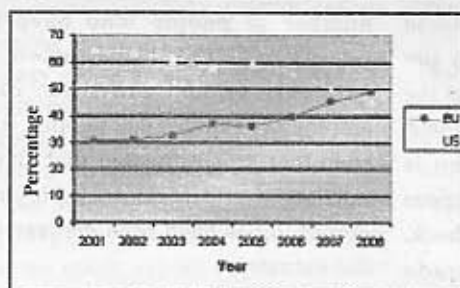


Figure 2: Garment exports to the EU and USA as a percentage of total garment exports

Source: Central Bank of Sri Lanka, Annual Report (various issues)

Like in all preferential deals that offer tariff concession, in GSP and GSP+, there are certain conditions, such as the Rules of Origin (ROO) criteria, that have to be met. Rules of Origin require a certain percentage of domestic value addition to take place for a product to be eligible for concessions. Challenging rules of origin criteria, requiring high levels of domestic value addition, have been a constraint for better utilisation of the GSP scheme. There have been proposals to relax ROO, so that the beneficiary countries can make better use of tariff preferences. As a result of high ROO, the utilisation of preferences has been an issue, especially for sectors, such as the garment industry. Nevertheless, Sri Lanka has been able to improve its utilization rate gradually over time (see Table 2).

The majority of Sri Lanka's exports to the EU are garments; garments account for over half (51 per cent) of Sri Lanka's total exports to the EU (Central Bank of Sri Lanka, 2008), and the local ready-made garment industry has been the largest beneficiary of the GSP+ scheme so far. In this context, GSP+ is of particular importance to the garment industry. The 24.7 per cent growth in exports to the EU in 2006 was led by garment exports which grew by 21.2 per cent (IPS, 2008). It is possible to identify some key changes in the trends in several sectors of the economy as a result of GSP+. Sri Lanka's garments exports to the EU have been increasing rapidly after it was awarded GSP+, while Sri Lanka has been losing its market share in the USA. As illustrated

in Figure 2, in 2008, the EU for the first time surpassed the USA, to be the largest market for Sri Lanka's garment exports, with the EU absorbing 49 per cent and the USA, 45 per cent of total garment exports. The importance of GSP+ to Sri Lanka has emerged strongly during the times of the economic crisis.

Although there was an initial decline in garment exports in December 2008, the garment sector appeared to be fairly resilient recording positive growth rates in 2009 till March this year: textile and garment exports to the EU grew by 18.4 per cent in March while exports to the USA declined. Interviews with some key players in the industry revealed that the growth of the garment sector was sustained in Europe in the first few months of the year, owing mainly to the concessions of GSP+. These concessions helped Sri Lankan garment exporters to offer competitive prices in the EU<sup>6</sup> compared to its competitors, and this had led to an increase in demand for Sri Lankan garments in the first 3 months<sup>7</sup>.

#### Importance of GSP+ Concessions to Sri Lanka

In the event Sri Lanka loses the GSP+ concessions, Sri Lanka would still continue to enjoy general preferences under the GSP arrangement (i.e., 20 per cent margin of preference on garment exports) but it would be less competitive without duty free access vis-à-vis countries like Bangladesh and China. LDCs, like Bangladesh, currently receive duty free access under the EBA initiative. Countries like China and Vietnam, who are recipients of the normal GSP concessions with a

20 per cent margin of preference on Most Favoured Nation (MFN) rates, are more price competitive compared to Sri Lanka due to their lower production costs. Therefore, loss of the GSP+ scheme would directly affect the price competitiveness of Sri Lanka's garments. Simple average tariff (MFN) for garments in the EU is 7.4 per cent. The highest band is 12 per cent.

Under the standard GSP arrangement, Sri Lanka will continue to get a 20 per cent marginal preference on garment exports to the EU, and would therefore, pay an average tariff of 5.9 per cent and at the highest band a tariff of 9.6 per cent on garment exports – a major shift from the current zero duty currently enjoyed under GSP+ (IPS, 2008).

This would put Sri Lanka in a vulnerable position with stiff competition from China, especially after the China safeguards on exports to the EU were lifted from December 31<sup>st</sup> 2008 as a result of the expiration of the EU agreement with China. During the period of safeguards, the annual growth of Chinese textile and apparel imports in 10 categories were limited to growth between 8 and 12.5 per cent.

However, it has to be noted that between the expiry of the MFA in January 2005 and the agreement to enter into quotas in June 2005 the annual growth rates were massive in categories, like sweaters (534 per cent growth on the previous year), men's trousers (413 per cent) and blouses (186 per cent) (IPS, 2008). It is clear that the

Table 2: Total utilisation rate of GSP by Sri Lanka<sup>5</sup>

Year	Total Utilisation Rate (%)
2004	42.1
2005	51.3
2006	64.5
2007	67.1

Source: From data collected by the Department of Commerce (DOC)

China safeguards suppressed Chinese export potential. In addition to the expiration of these safeguards and the current slow down of the world economy, if the GSP+ concession is withdrawn by the EU, this will expose Sri Lanka to a major external shock. Given Sri Lanka's high trade dependence, this will have substantial impacts across the entire economy.

It is important to note that, although, the benefits of GSP+ on the garment sector have been substantial, it has also had a considerable impact on other industries as well (Table 3).

GSP+ covers almost all the goods Sri Lanka exports to the EU, and industries, such as prepared food, leather products, gems and jewellery and fisheries, are also reaping benefits from the scheme. According to the Department of Commerce of Sri Lanka, one of the strongest beneficiaries of GSP+ has been the fisheries sector, while new industries, such as the bicycle exports, have also benefited from the GSP+ concessions. During 2005-2006, the plastics and rubber industry exports grew by 13 per cent. Processed food exports also grew by 13 per cent in the same period, while machinery and mechanical appliances exports grew by 29 per cent and transport equipment exports grew by 26 per cent. As a result, most non-garment product exporters of Sri Lanka have been able to find new markets and expand their existing market shares through GSP+. It is clear that GSP+ has supported and encouraged the diversification of Sri Lanka's overall export basket - a key requirement for the sustainable development of Sri Lanka's economy. The GSP+ scheme encourages increased value addition within Sri Lanka, and thereby promotes backward integration, resulting in the setting up of new industries, and creating new employment opportunities in the country. It is difficult to estimate the exact

number of people who have jobs related to GSP+. Nevertheless, the garment sector provides direct employment to 280,000 people. Apart from that, it is estimated that about a million indirect employment opportunities have been generated by the industry.

The local agriculture sector has also started to export under GSP+ with vegetables, like gherkins, and fish like tuna, being sent to the EU. The concessions under GSP+ are likely to have assisted the financially less privileged farmers who are engaged in agriculture and fisheries industry in Sri Lanka. It is also noteworthy that Sri Lanka maintains high labour standards. Compliance with labour laws has helped by developing their livelihoods and raising income levels, ensuring better working conditions, especially, in the Sri Lankan garment factories when compared to those of many other developing countries. The use of child labour is non-existent in Sri Lankan garment factories. Special projects have been initiated by associations, such as the Joint Apparel Association Forum (JAAF), in order to uplift the social status and image of garment workers.

As a result, workers in Sri Lankan garment factories have been provided with good working conditions. However, as a result of strong labour regulations in the country, the current wage rate in Sri Lanka is high compared to those of Sri Lanka's competitors, like Bangladesh, Vietnam and Laos. Therefore, the prices of Sri Lankan garments are relatively high, and in this context, Sri Lanka is already at a competitive disadvantage. Inter alia, with GSP+ concessions, Sri Lanka has been able to offer competitive prices while engaging in ethical garment manufacturing. This has helped keep buyers from shifting to producers in competing countries that offer cheaper but has more lax labour standards.

If GSP+ is withdrawn at any stage, it is likely that it would lead to numerous job losses, with the possibility of foreign investments being pulled out and factories being closed down. Although, the large and more established garment sector firms will be in a better position to meet greater price competition given their established buyer relations, differentiated products and marketing capabilities, the small players would

Table 3: Sri Lankan exports under the GSP scheme 2004-2006

Product	2004		2005		2006	
	€ '000	Utilisation (%)	€ '000	Utilisation (%)	€ '000	Utilisation (%)
Textiles and garments	822,289 (70.4)	30.4	819,005 (68.3)	40.5	992,988 (66.4)	57.1
Plastics and rubber	142,843 (12.2)	77.7	166,540 (13.9)	83.7	189,135 (12.6)	83.4
Live animals and animal products	4,310 (0.4)	92.9	4,900 (0.4)	96.3	74,644 (5.0)	98.6
Machinery and mechanical appliances	33,296 (2.9)	47.4	38,409 (3.2)	54.7	48,657 (3.3)	64.3
Prepared foodstuff	38,529 (3.3)	25.5	38,795 (3.2)	31.3	43,571 (2.9)	41.0
Transport Equipment	15,827 (1.4)	80.0	26,592 (2.2)	82.4	33,388 (2.2)	69.9
Total	1,167,979	42.1	1,199,317	51.3	1,495,357	64.5

Source: IPS (2008)

Note: Figures in parentheses are percentages of total value.

be forced to close down their factories<sup>8</sup>. This could result in increased unemployment and possibly increased poverty. It should be noted that the garment factories have been one of the major sources of employment for young women in the rural areas where employment opportunities are limited. Ninety per cent of workers directly employed in the garment sector are women (<http://jaaf.eureka.lk/newsView.cfm?nld=40>). Majority of these workers come from already impoverished households.

Given that the unemployment level among Sri Lankan women (8 per cent in 2008) is high (Central Bank of Sri Lanka, 2008), more than double that of men, withdrawal of GSP+ would further aggravate this problem. Livelihoods will be lost and job opportunities reduced for young women, especially those in the rural areas who are fighting poverty. Large-scale unemployment may well lead to social unrest, as seen in countries like China, in the recent past, as a result of the global economic downturn. Another concern is the ability of the government to support industry and workers in the event of a downturn. The outstanding public sector debt in the country already amounts to 81 per cent of GDP (Central Bank of Sri Lanka, 2008). Given the constrained fiscal position of the Sri Lankan government, in the event of large-scale disruptions to production due to a loss of GSP+, the government may not be in a position to provide meaningful support to affected firms and workers through financial bail outs and unemployment benefits.

Furthermore, in the year 2008, Sri Lanka's trade deficit expanded by 60.6 per cent (Central Bank of Sri Lanka, 2008). Therefore, if there is any further pressure on foreign exchange earnings due to the withdrawal of GSP+, there is a possibility of Sri Lanka being faced with a Balance of Payments (BOP) crisis. In this context, continuity of GSP+ is vital for the Sri Lankan economy. Given that the garment sector is the largest contributor to the local economy (contributing 8 per cent to GDP, 40 per cent to total industrial production and 40 per cent to total export earnings<sup>9</sup>), the withdrawal of the GSP+ scheme would have ripple effects on the economy. The local garment industry has been greatly affected by global economic downturn and credit crunch, with its largest export markets, the USA and the EU, being severely hit. As a result, export orders from

these major markets have fallen and are expected to fall even further with time. Factory closures and job losses have already been recorded in the garment sector, as a result of falling orders due to the global economic crisis. Losing GSP+ concessions at this juncture would not only have crippling effects on the garment sector, but also on other export sectors and the economy as a whole. A decrease of the number of orders from the EU, following the withdrawal of the GSP+ scheme will force some garment factories to close while others would move out of the country, seeking lower cost destinations.

In 2008 when there was doubt on the extension of GSP+ to the country, the government offered to provide a bail out package to exporters so as to cushion the impact of losing GSP+ concessions. Although such bail out packages would provide temporary relief to the industries, it would not be a long-term solution. Given the sheer size, especially of the garment industry, and its contribution to the economy, the loss of GSP+ will have a substantial impact on the entire economy.

Sri Lanka continues to receive preferential access during the course of the investigations. If it is decided to withdraw the GSP+ concessions, the country will be given a six-month notice period prior to the withdrawal. Therefore, according to government and industry sources, GSP+ will be available for Sri Lanka at least till October this year.

## Conclusion

With the GSP+ concessions in place, Sri Lanka has been able to beat price competition and expand its market share in the EU in the recent past. Although Sri Lanka is listed as a GSP+ beneficiary for the period 2009-2011, and continues to enjoy the concessions, its status as a beneficiary depends on the outcome of the current investigations on the implementation of the relevant international conventions. The garment industry has been the largest beneficiary of the GSP+ scheme, and if the scheme is withdrawn, its impact on the industry as well as the entire economy will be substantial. The importance of GSP+ has been highlighted in the wake of the economic crisis as well, with the garment exporters fairs better in the EU market rather than in the USA. Nevertheless, the current situation underlines the need for Sri Lanka to

diversify its export products and markets and seek alternative markets so as to reduce its over-dependency on the EU and the US and on the garment industry. Moreover, it highlights the need for the country not to rely on such schemes which are non-reciprocal in kind and the urgent need to find other means of remaining competitive.

## References:

*Institute of Policy Studies (2008), Sri Lanka State of the Economy 2008.*

*Central Bank of Sri Lanka, Annual Report (various issues).*

## Footnotes:

<sup>1</sup> Non-reciprocity means, that the countries that get the benefits (in this case the developing countries) are not required to offer similar preferential access to their markets in return for the access concessions they are granted to the EU market.

<sup>2</sup> The other 15 countries that have qualified for GSP+ are Armenia, Azerbaijan, Bolivia, Colombia, Costa Rica, Ecuador, El Salvador, Georgia, Guatemala, Honduras, Mongolia, Nicaragua, Paraguay, Peru, and Venezuela.

<sup>3</sup> According to the EU, the Commission's investigation will try to establish whether the national legislation of Sri Lanka incorporating the International Covenant on Civil and Political Rights, the Convention against Torture and other Cruel, Inhuman or Degrading Treatment or Punishment and the Convention on the Rights of the Child is effectively implemented.

<sup>4</sup> This is the duty that could have been earned by EU if the products were imported and if the duties were paid under the EU's standard MFN conditions of access.

<sup>5</sup> The utilisation levels of GSP+ are not calculated separately and are included in this calculation of the total utilisation rate of GSP.

<sup>6</sup> From stakeholder interviews.

<sup>7</sup> Garment exports to both EU and USA declined in April and May. However, the situation may have been worse if GSP+ was not in place. In May, exports to the USA fell at a higher rate than that to the EU.

<sup>8</sup> Many small-scale factories were hit by the MFA expiration and were forced to close down.

<sup>9</sup> Calculated using Central Bank of Sri Lanka, Annual Report statistics.



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