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Urban Groundwater Management Issues in Sri Lanka

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Abstract: The demand for ground water in Sri Lanka has grown rapidly over the past few decades, mainly as a result of population growth, economic development, and shortages of rainfall. Recent estimate show that over 55 percent of the population now relies on groundwater for their domestic water requirements. As a free and easily tapped commodity, groundwater today is utilized in a wide variety of uses. In some parts of the country including many locations in Kandy and Colombo, high pumping rates have lowered the groundwater table, causing the wells to go dry and affecting the natural water courses including those used for drinking. If these situations get worse, water shortages could become severe, especially during the more frequent extended dry spells being experienced, possibly due to climatic changes. Further, water pollution from domestic, agricultural and industrial sources is contaminating the surface water and groundwater and affecting the environment and further placing more pressure on the available water resources. Therefore this paper identifies several critical issues as urgent challenges to be immediately addressed and proposes policy recommendations to achieve sustainable groundwater resources in Sri Lanka.

Keywords: Groundwater, Hydrogeology, Land use, Management policy, Sri Lanka, Water pollution

Introduction

The *"EarthTrends"* countryprofile on Sri Lanka (2003) estimates the total renewable water resources available within the freshwater ecosystems of Sri Lanka as 49 km3 surface water, 8 km3 groundwater and a further 7 km3 as overlap water making a total internal renewable water resource of about 55 km3 a year. This is received mainly from the annual rainfall (volume of 120 km3) of which more than 50% is lost through evapotranspiration and a further 20% infiltrate down to replenish the groundwater leaving only about 30%, or about 35 km3 available as surface runoff. This estimated internal renewable water determines the available per capita freshwater volume as 2,900 m3 for the population of 2001. Though Sri Lanka is blessed with good water resources when one considers the total aggregate water availability, the variations over space and time, from the historical perspective, demand a proper management strategy.

In terms of the amount and pattern of the rainfall received, Sri Lanka can be divided mainly into three different climatic zones. These zones are referred to as wet zone, intermediate zone and dry zone. The average annual rainfall varies from 1,000 mm in some parts of the dry zone to over 5,000 mm in parts of the wet zone. This precipitation is brought mostly from and inter-monsoons and inter-monsoons. However with recent climatic changes experiencing, the average rainfall iso-lines from

1911 to 1940, compared with the average rainfall iso-lines from 1961 to 1990 show that the rainfall has significantly reduced all over the country, specially around Kandy (Ratnayake and Herath 2005). Further it is revealed that the lengths of dry periods have increased all over the country and the lengths of wet periods have decreased. These irregularities and uncertainties in rainfall together with the increasing demands of population growth have made the competition and water shortages to increase in Sri Lanka. In addition pressure from population growth is causing degradation of watersheds, resulting in soil erosion, sedimentation of reservoirs, landslides and more serious floods and droughts further limiting the available resources.

As a result demand for groundwater is increasing throughout the country specially in urban and agricultural regions raising doubts on its sustainability in the longer run. Water pollution from domestic, agricultural and industrial sources is contaminating the surface

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water and groundwater affecting the environment and public health has further aggravated the problem. These concerns have demanded immediate counter measures and strategies for proper management of the available water resources in the country.

To assess the current status, a study was initiated mainly focusing the groundwater management practices in two urban centers. The selected study areas are; urban water supply from groundwater in Colombo and Kandy. The Colombo study area includes twenty divisional secretariat divisions while the Kandy study area is limited to only five divisional secretariat divisions (figure 1).

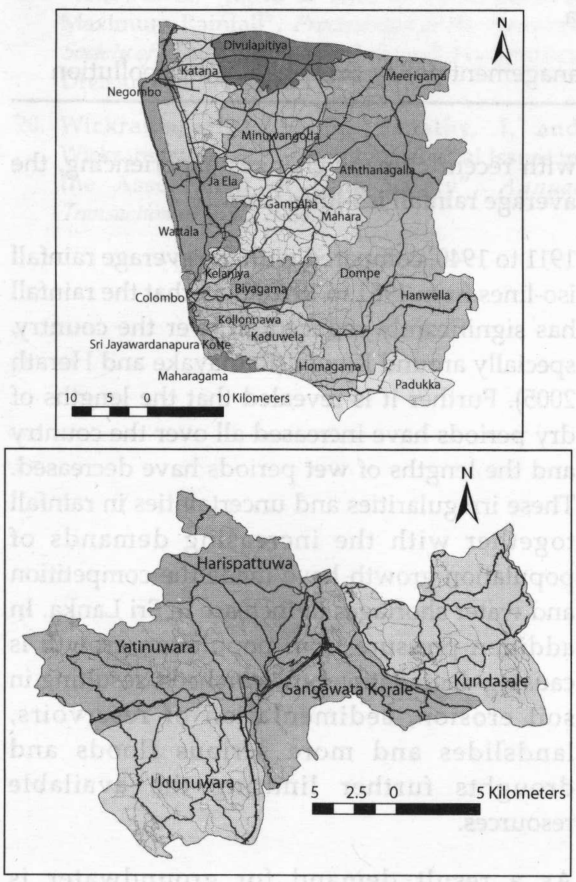


Figure 1: Colombo and Kandy study area extents

Of the two urban areas, Colombo is a coastal city of the western region where its terrain is of gently undulating plains with high density of drainage paths. On the other hand, the Kandy city is a plateau in the central mountains around 500 to 700 meters above sea level. The terrain in Kandy city area does not contain many steep, plunging slopes except in the surrounding mountains. The topography in this plateau consists of undulating plains with hillocks formed by drainage paths separating them.

Both the selected urban areas are located in the wet zone, which receive an average annual rainfall of about 2,000 mm. According to the historical rainfall data, the Colombo study area receives an average annual rainfall of 2376 mm (40-year average) while the Kandy study area, receives an average of 1841 mm (60-year average).

Groundwater Resource

Hydrogeological setting: There are six main types of groundwater aquifers demarcated and identified in Sri Lanka. They are shallow karstic aquifers, coastal sand aquifers, deep confined aquifers, lateritic (cabook) aquifers, alluvial aquifers and shallow regolith aquifers in the hard rock region (Panabokke 2003). In addition to these major aquifers, a large number of small groundwater pockets can be found throughout the country. These aquifers occur in either isolated patches of soil cover over the bedrock or in the fracture and weathered zones of the underlying metamorphic bedrock formation.

Colombo basin hydrology indicates that there is a fair amount of groundwater potential both in the alluvial aquifers and bedrock. The prominent aquifer bedrock types in the basin are quartzite and a few crystalline limestone (marble) bands. Though over 90% of the entire non-coastal area lie on metamorphic hard rock formation, there exists a weathered water bearing rock formation over the hard rock that accommodates a fair amount of groundwater resources. This formation having secondary porosity provides excellent conditions for deep aquifers. The alluvial sand/gravel aquifers in the basin are recharged by rainfall and seepage from the rivers. Due to laterite formation the northwestern region is rich in this resource. High-potential porous residual laterites also contribute to groundwater supplies. During droughts, river water and springs recharge most alluvial aquifers in the basin.

Groundwater in Kandy exists mostly in the form of semi-confined aquifers in the first 100 meters of the bedrock. Groundwater storage exits as small pockets of underground reservoirs or as fissure groundwater. The available amount of water in these aquifers is not very well known and is limited as the recharging of these aquifers is very slow. In addition, there exists high-yield groundwater resources along the alluvial flood plains of the Mahaweli River and are mostly recharged by the river water.

Groundwater Issues

Land use: The land coverage in Colombo and Kandy selected urban areas are 1575.6 km2 and 322 km2 respectively. The main land use change during 1987 to 1998 period in both areas is tabulated in table 1 below.

According to these land use data, the main land use change observed in both the study areas is the rapid increase in built-up areas. Colombo shows an increase of over 900% within the eleven years from 1987 to 1998. This increase replaces the domestic gardens, water bodies and marshes (a typical domestic garden in Sri Lanka mainly consists of mixed vegetation that surrounds the house). Also there is a significant decline in the extent of domestic gardens, mainly because of migration to commercial crops. Another, significant change in relation to this study is in the reduction of cropping intensity and cultivation area of paddy fields which cover nearly 20% of the area. This change is happening in both study areas and is not clearly reflected in the land use maps. Paddy cultivation in the late seventies compared to the last decade, has dropped and this has substantially restricted the amount of irrigation water in the paddy fields, thereby reducing the sub-surface flow and recharge, which in turn influenced the groundwater resources in the regions.

Groundwater demand; The water demand in Sri Lanka is steadily increasing particularly for urban and rural water supplies, irrigated agriculture and in the industrial sector. This rapid increase in demand is exerting considerable pressure on the available groundwater resources. According to the WHO/UNICEF report on "Joint Monitoring Program for Water Supply and Sanitation-2000", only 76.1% of urban population was supplied with a piped supply compared to 11.4% in rural areas, while the urban and rural population using underground well-water was estimated to be 22.4% and 71.8% respectively. (urban and rural

Table 1: Land use change in Colombo and Kandy

Land-Use Type (km^2)	Colombo			Kandy		
	1987	1998	% Change	1988	1996	% Change
Agricultural land	572.5	799.1	39.6	109.1	104.4	-4.3
Built-up land	12.7	131.2	933.1	5.6	8.3	48.2
Forests	36.4	30.5	-16.2	22.1	46.5	110.4
Domestic gardens	848.1	560.9	-33.9	175.6	149.9	-14.6
Water bodies	53	21.5	-59.4	9.6	10.4	8.3
Mangroves and marshes	52.9	32.4	-38.8	-	-	-

Table2a. Water supply requirement according to sectors and sources

Water Resource	2001		2010		2020	
	Surface	Ground	Surface	Ground	Surface	Ground
Domestic supply	380,248	105,621	441,971	115,328	506,325	118,684
Industrial supply	158,445	6,970	181,508	7,129	198,898	9,465
Other	33,280	976	46,098	1,810	58,913	2,803
NRW	243,956		206,138		200,051	

Table2b. Water supply requirement according to sectors and sources

Water Resource	2001		2010		2020	
	Surface	Ground	Surface	Ground	Surface	Ground
Domestic supply	36,679	31,300	61,029	98,415	86,336	107,207
Industrial supply	5,972	804	15,157	1,684	16,690	1,451
Other					-	-
NRW	22,928		28,068		18,141	

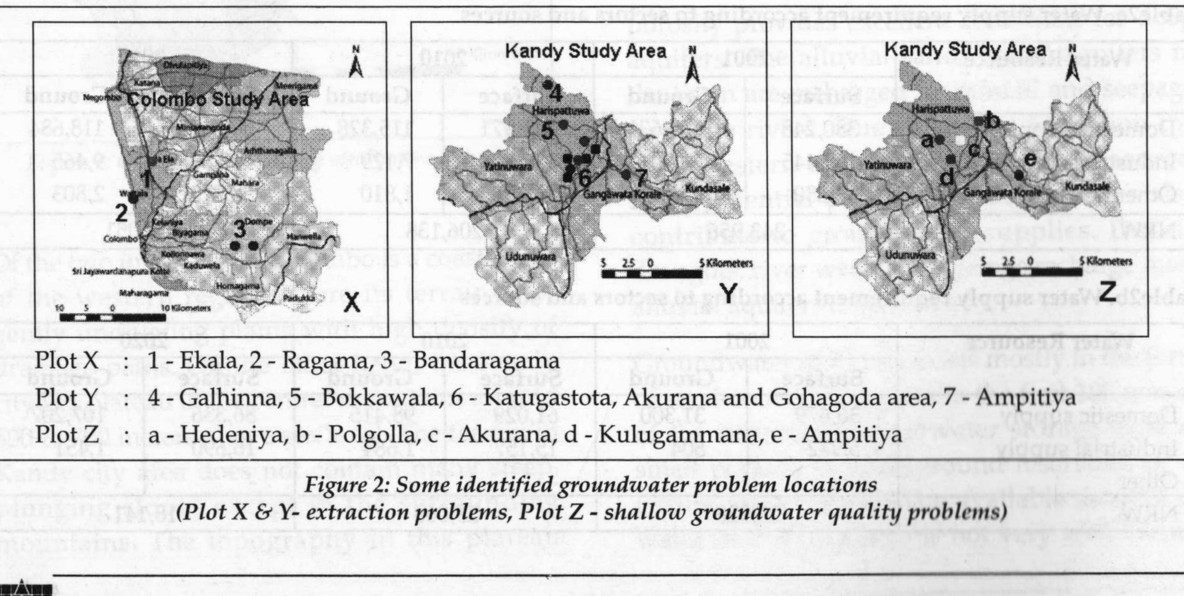
populations in 1999 were 5.86 and 13.05 millions respectively).

The sectoral water requirements for water supply within the two urban areas are given in Table 2a and Table 2b for Colombo and Kandy respectively. According to the Department of Statistics, the piped water coverage by 2001 was 64%, 22.2% and 40% in Colombo, Gampaha and Kandy districts respectively. Individual domestic groundwater consumers in the Colombo and Kandy study areas are estimated to be using approximately 34.5 and 10 million cubic meters a year. Due to limited coverage the approximate amount of groundwater used in piped water supply schemes in the Colombo and Kandy study areas are of the study area are 6,400 m^3/d and 18,100 m^3/d respectively for year 2001. The total groundwater extraction including the exploitation by the individuals using shallow wells amounts to 113,567 m^3/d and 32,104 m^3/d respectively. The total number of recorded deep groundwater extraction wells in the Colombo, Gampaha and Kandy districts is 342, 890 and 1754, respectively.

Groundwater management; Over the past decades, the Water Resources Board (WRB), National Water Supply and Drainage Board (NWS&DB) and the Agriculture Development Authority (ADA) are all engaged in investigations into and development of groundwater resources in Sri Lanka. In addition, a few private drilling companies and donor-funded projects have also been engaged in the investigation and development of this resource. In terms of monitoring and data collection, these organizations collect data primarily for their own use, although certain information is shared with other agencies and public. These data collections are limited only to deep wells and in most cases, it is only the drill log including the initial water levels and the initial water quality. As there are no legislative requirements available for the assessment planning or management of groundwater, none of above agencies takes responsibility of the management of the groundwater resources of the country. Because of this at present there is no continuous groundwater-related monitoring data available. This makes it difficult to predict the recharge potentials and thus control the adverse impacts from the present developments taking place in groundwater extraction areas.

In regions of vesicular laterite aquifers, some are highly productive. So they are commonly used for medium-scale piped water supply schemes. Excessive abstraction that mostly occurs in the laterites located away from the flood plain results in the lowering of the water table. When these aquifers are used excessively, the aquifers themselves are subjected to localized groundwater table depletions affecting the groundwater wells in the surrounding areas.

At present the semi-confined rock aquifers are widely exploited for industrial activities, and for water-supply schemes which are generally in high volumes. Though these extractions are continuing, according to the NWS&DB, many of these deep hard-rock abstractions are experiencing a rapid lowering of water levels (over 40 m drop in Kandy region) or decreased yields or both. Some of these affected areas are shown in figure 2. In addition, personal



Plot X : 1 - Ekala, 2 - Ragama, 3 - Bandaragama
Plot Y : 4 - Galhinna, 5 - Bokkawala, 6 - Katugastota, Akurana and Gohagoda area, 7 - Ampitiya
Plot Z : a - Hedeniya, b - Polgolla, c - Akurana, d - Kulugammana, e - Ampitiya

Figure 2: Some identified groundwater problem locations
(Plot X & Y- extraction problems, Plot Z - shallow groundwater quality problems)

communication revealed that a number of groundwater wells in the study region, especially in Kandy, have been abandoned due to groundwater depletion. Most of the surviving schemes at present have curtailed supply of few hours a week. The actual causes for these failures are largely unknown both due to the lack of information and proper instrumentation for investigations, but may most likely be due to over extractions taking place.

Both in Colombo and Kandy, there is no continuous monitoring of groundwater quality being done. Based on the quality measurements taken from many bore-hole wells constructed in Kandy during test pumping, have shown high levels of hardness, iron and nitrite. Hardness as high as 1125 mg/l has been recorded in these areas, with the total iron at 18 mg/l, nitrites at 128 mg/l and sulphates at 500 mg/l. In Colombo except for the high iron content in some of the locations the groundwater quality is fairly good. However, an investigation by Gunawardhana et. al., (2002) shows that many shallow wells in southern Colombo was abandoned due to odor and taste problems caused by contamination of the groundwater with partially treated industrial effluents. Also high Mn (0.92 mg/l), Ag (0.58 mg/l), Ni (0.21 mg/l), Cr (0.13 mg/l), Pb (0.04 mg/l) and Al (5.62 mg/l) concentrations were observed in these wells. Although the present level of groundwater monitoring is poor, using the available limited monitoring it was found that many shallow groundwater wells in the study areas are contaminated with coliform (figure 2).

Conclusions

The rapid increase of population that has taken place in urban areas over the recent past, caused a deterioration of both the quantity and quality of available water. The data analyzed shows the shallow groundwater is contaminated with chemical in southern Colombo and with coliform in the Kandy region. On the supply side, lowered yield and water table drop is seen as the major issues to be addressed in the groundwater management.

Based on the findings in this study, following measures are recommended as possible options to be implemented to mitigate further deterioration of the groundwater resource.

- Location specific management program ensuring sustainability of the groundwater resource.
- Vested authority for coordinating the planning and the management of groundwater.
- Encourage more research and development in sustainable groundwater management and disseminating them effectively
- Initiate programs for monitoring of quantity, quality and replenishment
- Developing suitable guidelines for sustainable exploitation of the resource and disseminating the guidelines widely.
- Establish a registration program for heavy groundwater users to track groundwater development.
- Demarkation and protection of groundwater sensitive areas.
- A program to safeguard the rights of shallow well users while protecting from contamination.

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