# Groundwater Management in Sri Lanka

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### Introduction

Water from beneath the ground, or groundwater has been exploited for domestic use as well as for irrigated agriculture since the earliest times. Although the precise nature of its occurrence was not completely understood, successful methods of bringing water to the surface have been developed over the ages. Little is it realized that groundwater constitutes about two thirds of the freshwater resources of the world if the polar ice caps and glaciers are not considered.

Groundwater accounts for more than 85 percent of safe drinking water supply in the rural areas of most of the Asian countries including Sri Lanka. In neighbouring India it also accounts for as much as 47 percent of the total irrigation potential of the country. In contrast, in Sri Lanka the use of groundwater for irrigated agriculture has been traditionally confined to the karstic aquifer of the Jaffna peninsula. Agrowell development in the hard rock regions of the north central and northwestern provinces has been a more recent phenomenon.

Some of the very large cities in the world are totally dependent on their groundwater aquifers for their city water supplies. Many of the major cities of Europe, specially those in Denmark, Portugal, Germany, Italy and Switzerland are more than 75 percent dependent on groundwater supplies for the city requirements. Colombo city in contrast is primarily dependent on surface water reservoirs and river supplies from the Kelani river. A small proportion of city dwellers draw on the various groundwater aquifers for their domestic needs.

In comparison with surface water, groundwater is by its very nature, a hidden resource. As a result, users often have little or understanding of its location, its dynamics and its quality as well as its real nature and availability. Surface water on the other hand is visible and readily understood.

Since groundwater is a dynamic and replenishable resource, its availability for different use purposes has to be estimated primarily based on the annual recharge that is available. This annual groundwater recharge is largely dependent on hydrogeological and climatic conditions, chiefly the amount of rainfall received. In the wet zone of Sri Lanka this recharge takes place all round the year, while in the dry zone it takes place only during a part of the year in the wet season.

### Country Background

At the outset, it should be borne in mind, that despite its small size as an island nation, a great diversity of groundwater conditions could be identified among the different hydrogeological conditions encountered across Sri Lanka. More than seven different types of groundwater aquifers can be identified in the different regions of this country, each having its own distinctive management problems and its special characteristics.

Extraction and demand for some types of groundwater have grown rapidly in recent times as a result of population increases in the semi-urban areas, the hotel and tourist industry in the coastal regions, shrimp farms in the northwest coastal plain, and agrowell development in the small tank cascade region of the north central and northwestern dry zone.

The preferred low cost source of water for most rural and semi-urban population is the groundwater from dug wells that are distributed across the country. Under the low population pressures that obtained in the past, these wells were constructed and maintained by the rural population with a balance between supply and demand in normal rainfall years. With the rapid expansion in rural and semi-urban population that has taken place over the last few decades, there has been an increasing stress experienced in both the quantity and quality of water in these shallow aquifers. This is being reflected in the increasing drying up domestic wells during the dry season as well as in the deterioration of the quality of domestic well water.

Subsidies have been provided indiscriminately for shallow agrowells in some areas, and groundwater exploitation has been actively promoted by some politicians often without adequate knowledge of the availability and sustainability of the groundwater resource that is being currently exploited, especially in areas where there has been no longstanding tradition of the use of groundwater supplies for agriculture and other purposes.

The Water Resources Board (WRB) and the National Water Supply and Drainage Board (NWSDB) are currently engaged in groundwater resources investigations and development. There is no legislation for the proper assessment, planning and control of groundwater utilization. Many tube wells continue to be constructed by the private industry and commercial organizations without concern to

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the sustainable groundwater capacities and environmental concerns. Several tube wells constructed in the recent past in the dry zone have been abandoned because of the high iron content or fluoride content of the groundwater.

There is no public information or awareness program regarding groundwater, nor is there any coordinated groundwater information program. Several studies have been undertaken and considerable data exists, but these have not been properly assembled, published and disseminated to the main users of groundwater, or even to professionals. As a result, the resource is widely misunderstood even by decision makers.

The growing complexity of modern society puts an increasing stress on groundwater. In a situation characterized by the phenomenal growth of groundwater use, it is of utmost importance that the groundwater regimes in the different hydrogeological conditions in the country are monitored regularly with respect to quantity and quality. In this regard, a small beginning had been made in this direction two years ago when the Water Resources Board in collaboration with the Agricultural Development Authority commenced a monitoring program for 100 agrowells located in twelve DS divisions of the Anuradhapura district. This is confined to only one of the seven recognized types of aquifers in this country, namely the shallow "regolith" aquifer in the inland valley system of the small tank meso-cascade basins of the North Central Province.

Similarly, during the early seventies, the Water Resources Board conducted a detailed and systematic monitoring of the groundwater in the Jaffna peninsular over a period of ten years up to the early eighties, which showed a growing imbalance between the draw-off and the recharge, and also an enhanced level of nitrate pollution in the domestic wells in the peninsula. Although the remedial measures that were proposed by the Water Resources Board studies could not be implemented due to the absence of an institutional authority with necessary powers to carry out such remedial measures, a very successful awareness program was achieved.

**Groundwater Conditions in the Country**

Based on studies conducted chiefly by the Water Resources Board (WRB) over the last twenty five years, seven main types of groundwater aquifers have been identified, and characterized in Sri Lanka. The recharge characteristics of some of the more well known groundwater aquifers such as those of the Jaffna peninsula, the north west sedimentary basins and some deep aquifers have also been systematically evaluated by the WRB.

The following main types of groundwater aquifers and their type locations are given in Table 1 below, and the main groundwater regions of the country are shown in Figure 1.

The present utilization in respect of six each of these main types of groundwater are briefly outlined below -

**1. Shallow Karstic Aquifers of the Jaffna Peninsula** - This aquifer has been, until recently, one of the most intensively utilized groundwater resource in this country. Approximately 80 percent of this groundwater is being used for high value agriculture, and the remaining 20 percent is being used for domestic requirement including septic tanks flushing demands. Water quality studies carried out during the mid 1980s have shown enhanced levels of nitrate pollution in the domestic wells in the more densely settled areas of the peninsula.

**2. Deep Confined Aquifers** - A number of distinct and confined aquifers exist in the sedimentary limestone and sandstone formations of the north western and northern coastal plain. These are relatively deep aquifers and therefore cannot be exploited by shallow, smallholder tube or dug wells. This also have relatively high recharge rates. Aside from use of two of these aquifers in the Puttalam area for agriculture in Vanathavillu and prawn production, these aquifers have been relatively little developed.

**3. Coastal Sand Aquifers** - Shallow and moderately deep aquifers are found in unconsolidated sands around a major part of the country's coast line. These aquifers consist of "lenses" of fresh water floating above denser saline water. The volume of freshwater in these aquifers usually expands during the rainy season and contracts during dry seasons, with fluctuating brackish and saline boundaries. Heavy exploitation cause contraction or depletion of the aquifer and may leave some wells in the brackish or saline zone.

The Kalpitiya peninsula is one of the best examples of a shallow aquifer on coastal sands which has, over the last two decades, been subjected to intensive exploitation mainly for agricultural purposes. There has been a gradual build up of salinity and high rates of leaching of various agro-chemicals due to intensive agricultural practices on the peninsula.

Coastal sand aquifers have traditionally been used in a very sparing manner by homestead settlements. Many of them are now being exploited by tourist resorts and hotels that have started to over-extract the limited supply.

**4. South-western Laterite Region Aquifer** - The laterite formations of south western Sri Lanka have considerable water holding capacity, depending on local depth. In general, these laterites support relatively shallow aquifers that are accessible to private dug and tube wells. The laterite region aquifer of the southwest wet zone today faces the most severe over exploitation, especially in the area of outer Colombo and between Gampaha and Kalutara districts. The rapid expansion of industrial estates, urban housing schemes and other developments taking place in this area are exerting a tremendous pressure on this groundwater resource.

There is no systematic monitoring of groundwater trends in this region, but

**Table 1. Main types of groundwater aquifers of Sri Lanka**

| | Type | Location - Distribution |
|---|---|---|
| 1. | Shallow Karstic Aquifer (Weathered Karstic Miocene Limestone | * Jaffna Peninsula only |
| 2. | Deep Confined Aquifer (Vanathavillu - Mulankavil - Mannar - Paranthan Basins) | * Sedimentary Miocene limestone basement of North-West coastal plain |
| 3. | Shallow to Moderately Deep Aquifers on Unconsolidated Coastal Sands<br>a. Shallow aquifers on coastal spits - Kalpitiya type | * Kalpitiya, Mannar Island |
| | b. Shallow aquifers on coastal sands - raised beaches - Nilaweli | * Raised beaches of eastern coastal plain - Kalkudah, Batticaloa, Nilaweli, etc. |
| | c. Moderately Deep aquifers of North-west coastal plain - Pleistocene deposits | * Chilaw, Negombo, Puttalam, Katunayake |
| 4. | Laterite Region Aquifer of South West Mid-coastal Plain (Cabook Region) | * Gampaha, Colombo, Kalutara and part of Galle-Matara |
| 5. | Alluvial Aquifers<br>Medium, Deep and High Yielding | * Kelani, Deduru, Mahaweli, Walawe, Kirindi Oya Alluvial<br>* Buried river beds - Kelani - high yield |
| 6. | Dry Zone Metamorphic Hard Rock<br>a. Shallow Regolith Aquifer of Small Tank Cascade System (STCs) | * NCP and NWP - Type locations. |
| | b. Deep Groundwater of Joints, Fracture Zones and Fissures of Basement Rocks (Bore-hole type) | * Sporadic<br>* Tube wells of NWSDB |
| 7. | Wet Zone Metamorphic Hard Rock<br>Water Tables of Variable Depth<br>a. Low Ridge and Broad Valley Land -form of Lower Peneplain<br>Shallow open dug wells (domestic) | * Low country wet and semi-wet zone |
| | b. Inland Valleys of Dissected Middle Peneplain<br>Shallow open dug wells (domestic) | * Mid country wet zone |
| 8. | Miscellaneous Types<br>a. Springs of high discharge | * Bandarapola - Matale<br>* Keppitigollewa - Anuradhapura. |
| | b. Springs of low to medium discharge | * Ubiquitous |

increasing complaints of rapid exhaustion of the groundwater aquifer are being made by residents located in the new housing estates and also by those in the densely settled areas, especially during normal dry weather periods.

**5. Alluvial Aquifers** – It should be noted that the alluvial aquifers of this country constitute one of the most diversified forms of aquifers in the tropical world. The alluvial deposits of this country occur in several diversified alluvial landforms such as coastal and inland flood plains, dissected and depositional river valleys, buried river channels, small rivulets and stream beds with shallow alluvial deposits, and inland valleys of varying shape, form and size with fine and coarse depositional in-fill material.

The deeper and larger alluvial aquifers occur along the lower reaches of the major rivers that cut across the various coastal plains surrounding the low country regions of this country. Rivers such as the Mahaweli Ganga, Kelani Ganga, Deduru Oya, Mioya, Kirindi Oya, and Malwatu Oya have broad and deep alluvial beds of variable texture and gravel content. Old buried riverbeds with high groundwater yields are present in the lower Kelani river aspects. The alluvial formation of these larger rivers may vary from 10 to 15 m to 35 m in thickness, and may extend to several hundreds of meters on either side of the river beds.

The shallower and smaller alluvial aquifers occur within the alluvial deposits of the minor rivers (Oyas) and streams. In the dry zone, the water table in them are recharged during the wet season, while in the wet zone they contain groundwater throughout the year.

In sum, it could be stated that a major proportion of the various types of alluvial aquifers in the country are being exploited at varying degrees of extraction without experiencing major drawdown hazards.

**6. Shallow Regolith Aquifers of Hard Rock Region** – The inland valleys and small tank cascade systems (STCs) of the North Central Province and North Western Province, have shallow aquifers in the local valley alluvium. These aquifers are closely linked with the surface water in streams, canals and tanks. They are also ephemeral in nature – expanding and contracting in response to wet and dry season conditions. When properly located in areas with sufficient groundwater and transmissivity (potential for groundwater movement), shallow wells in this area can be an important source of water for domestic, irrigation and other purposes – either by themselves or in conjunction with surface supplies. Being shallow, however, these aquifers are susceptible to agricultural and other forms of contamination.

In some areas, well density and groundwater pumping has passed the sustainable limit, and, as a result, wells have failed and been abandoned. Not only does this deprive the owners of older wells from their share of groundwater, but it is also an inefficient use of public and private funds for well construction.

## Current Management Systems and Main Problem Areas

The Water Resources Board (WRB) and the National Water Supply and Drainage Board (NWSDB) are both engaged in groundwater resources investigations and development. But neither agency is responsible for the proper management of the groundwater resources of this country in terms of quality and quantity. Responsibility for investigation, development and regulation of groundwater is not assigned to any agency. There is no groundwater planning system, and problems and issues are being dealt with on an "ad hoc" basis.

There is no coordinated groundwater information program although many studies have been undertaken and a considerable body of essential and basic data exists. This data has not been consolidated and is not used to any significant extent in management decisions. There is no public information and awareness program regarding groundwater, and the resource is widely misunderstood even by decision makers.

Information on groundwater resources in this country are not readily accessible. The boundaries of aquifers are poorly defined except in the Jaffna peninsula and in the Northwest deep confined aquifers and some coastal sand aquifers. There is no single publication available that lists and summarizes the present status of the different kinds of aquifers in this country. Although records are usually kept for tube well drilling and pump testing, there is no ongoing program of groundwater monitoring. In the case of shallow domestic wells and agrowells in the dry zone there is little information on the number of functioning and abandoned wells.

Over the last two decades deep tube wells or bore wells have been provided by the NWSDB to villages and rural settlements across much of the dry zone's water short areas. While this has been a great boon to the remote and distant village settlements where people had to walk long distances during prolonged dry spells to fetch their essential domestic supplies, the quality and maintenance of these bore wells had not been uniformly satisfactory in the recent past. There are several reported instances where some tube wells have been abandoned because of the high iron or fluoride content of the water. In the future development of drinking water supplies there is a need for more selective approaches in location and servicing of the bore tube wells.

Since the shallow groundwater is the preferred low cost source of water for most rural inhabitants, around 80 percent of the rural drinking water needs are met from open dug wells. Because of the expanding settlements in these rural areas there is an increasing stress experienced in both the quantity and quality of the water in these shallow aquifers. Some measure of regulation and control of the well density is therefore essential in the future expansion of these settlement areas.

One of the most significant developments that has taken place at a very rapid pace in the north central and north western dry zone has been that of the construction of agrowells under the numerous small tanks. Each of these agrowells provide sufficient groundwater for irrigating between 0.5 to 1.0 acre of land by lift irrigation. Growing of high value cash crops during the main dry season is very profitable and has helped to raise farmer incomes. However, the main issue at stake today is how many agrowells can this region support based on the available groundwater supply. This issue has been addressed by several action research programs conducted by the Department of Agriculture, Agriculture Development Authority and IWMI over the last few years. In a sample of 50 small tank cascade systems located across 12 Divisional Secretariat Divisions it has been established that the maximum number of agrowells that could be safely accommodated within these 50 cascade systems was approximately 3,600. This critical figure has been already acceded in five of the 50 cascades that were studied.

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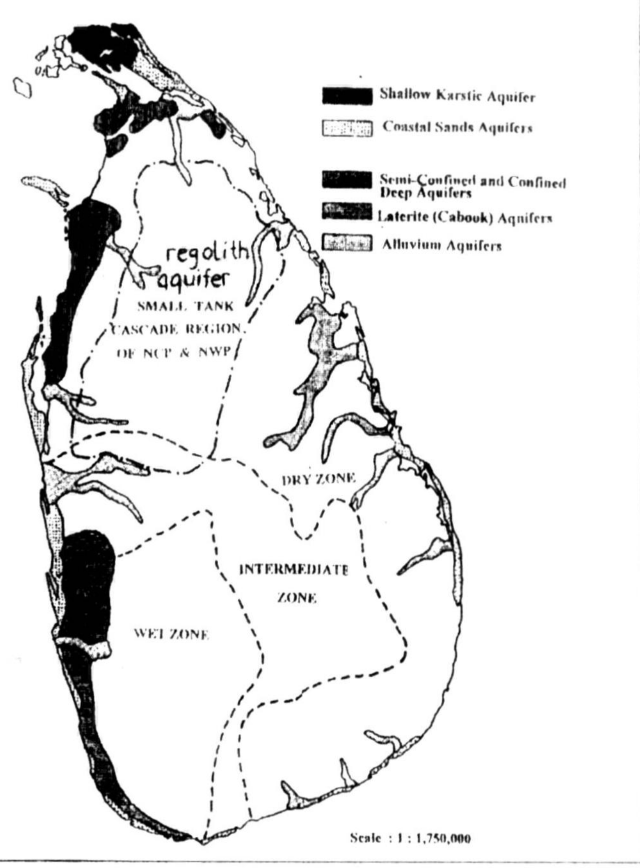
Figure 1

MAIN GROUNDWATER REGIONS OF SRI LANKA



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Rapidly increasing demands for the presently untapped sources of groundwater are being experienced by new industrial and commercial enterprises in export promotion zones and industrial estates. Groundwater supplies in some areas cannot cope with this rapidly increasing demands. Shrimp aquaculture in the northwest coastal plain is also placing an increasing stress on the deeper groundwater supply in this region and is also affecting the quality of several domestic wells located in this region.

**A Rational Approach Towards a Strategic Management of some Groundwater Resources in Sri Lanka**

In this section a management strategy in respect of five of the more important groundwater aquifers is briefly outlined.

***(a) Shallow Karstic Aquifer*** – Registration of shallow wells by local government agency, minimum distance separation between domestic wells and sanitary facilities and minimizing present high level use of agrochemicals should receive high priority.

***(b) Coastal Sand Aquifers*** - Same as for the preceding aquifer but with more attention given for ensuring optimum well density and pumping rates in the agricultural areas, combined with control in heavy use of agrochemicals. Creating a better public awareness of the limited capacities of these aquifers both for agriculture as well as for the hotel industry, and prevention of point-source pollution in the recreational areas.

***(c) South West Laterite Region Aquifer*** - Because of the increasing exploitation and local depletion caused by rapid urban and industrial development there is a high potential for chemical and bacteriological contamination of the aquifer. Documentation of all points of extraction including domestic wells by local government authorities should be given high priority, as well as the enforcement of well spacing guidelines according to the aquifer properties. Planning of land use with combined use of open domestic wells and pipe-water water supply systems should be given special consideration in the rapidly expanding urban housing settlement schemes promoted by the private sector.

***(d) Shallow "Regolith" Aquifers of the Small Tank Cascade Systems of the NCP and NWP*** - It is now recognized that the shallow regolith aquifer is confined to a narrow belt along the main axis of the cascade valley and agrowells should therefore be restricted to this restricted portion of the landscape. There is also an interconnection between the regolith aquifer and the surface storage water of the small tanks located within the cascade. Both critical agrowell spacing, and conjunctive use with tank water supply should receive high priority.

***(e) Deep Fragmented Aquifers of Hard Rock Region*** - Groundwater occurrence in the deeper joints, fractures and fissures is sporadic in its distribution pattern. Because of the increasing exploitation that is now taking place with the use of deep well drilling rigs and modern equipment, it is essential to depict in a reliable form the current state of exploitation of these fragmented aquifers, and to plan future development on the presently proven resource base.