GROUNDWATER RESOURCES
OF
SRI LANKA

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ABSTRACT

Six main types of groundwater aquifers have been identified and characterized in this country. The geomorphological and hydrogeological setting of these six types have been adequately characterized and their distribution patterns mapped.

The shallow karstic aquifer of the Jaffna peninsula has been the best studied and characterized over the last 40 years. It is also the most intensively used groundwater resource in this country. The least utilized, yet adequately studied are the deep confined aquifers, which occur within the sedimentary limestone and sandstone formations of the northwest coastal plain. Seven distinct aquifer basins have been identified and mapped within this deep confined aquifers region.

The shallow coastal sand aquifer that occurs on the coastal beaches and spits are intensively used and occupy a total extent of approximately 125,000 ha. The alluvial aquifers of this country constitute one of the most diversified forms in the tropical region, and occur on both coastal and inland flood plains, inland river valleys of varying size, and old buried river beds. These are fully used at present specially in the wet zone of this country.

It has now been recognized that the groundwater in the hard metamorphic rock in this country is found in the weathered rock zone, or the regolith, as well as in the deeper fracture zone of this hard rock region. This shallow regolith aquifer is mainly confined to a narrow belt along the inland valley systems of this undulating mantled plain landscape, and despite its low yield and transmisivity, it has provided the basic minimum water needs for village settlements over several millennia. Recent developments in agro-well farming in the north central provinces of the country are wholly depended on this shallow ephemeral groundwater.

The laterite formation or cabook, which occur in southwestern Sri Lanka have considerable water holding capacity depending on the depth of the cabook formation.

According to the present state of knowledge and understanding, the effect of human impact is the most observable in the shallow regolith aquifer followed by the coastal sand aquifer and the shallow karstic aquifer of Jaffna. Policy guidelines have been developed for the safe extraction of this regolith aquifer in 1997.

There are two state organizations mainly the Water Resources Board (WRB) and the National Water Supply and Drainage Board (NWS&DB) involved in groundwater studies, investigations and preparation of consultancy reports for over the past 30 years. Databases represent more than 30 years of collection effort and they contain information for more than 30,000 well sites including data on tube wells, water levels and water quality.

In Sri Lanka, groundwater resources are widely used for domestic, commercial and industrial purposes, small scale irrigation, water supply schemes and other purposes.

About 80 percent of the rural domestic water supply needs are met from groundwater by means of dug wells and tube wells.

The NWSDB produces over 310 million m^3 /year of treated water to cater for a population over 5.3 million. There are over 300 urban and rural water supply schemes across 23 districts under the NWSDB and very few are under the WRB.

At present, information on groundwater resources of this country is not readily accessible. There is no single publication available within the country that lists and summarizes the present state of knowledge of the different aquifers in this country. There is, therefore, a compelling need to compile and make available to the general user a publication that sets out, in a readily understood and interpreted form, the body of presently available information.

Chapter 1

Groundwater Types in Relation to Physical Features – Special Characteristics

[1]In Sri Lanka, six main types of groundwater aquifers have been identified and demarcated according to the studies carried out over the last 25 years mostly by the Water Resources board (WRB) and the National Water supply and Drainage Board (NWS&DB). Pioneering studies in field have been carried out and reported Sirimanne 1952, 1968 and Arumugam 1966,1974. These six types of aquifers are

1. Shallow Karstic Aquifer of Jaffna Peninsula
2. Deep Confined Aquifers
3. Coastal Sand Aquifers
4. Alluvial Aquifers
5. Shallow Regolith Aquifer of the Hard Rock Region
6. South Western Lateritic (Cabook) Aquifer

The geomorphological and hydrogeological setting of all these six types have been adequately studied and characterized, and their location and distribution patterns have also been delineated and mapped at different levels of intensity. A map showing the approximate regions of occurrence of these main aquifers is in Figure1.1.

1.1. Shallow Karstic Aquifer of Jaffna Peninsula

The whole Jaffna peninsula is underlain by Miocene limestone formations which are generally 100 to 150 m thick and which are distinctly bedded and well jointed and are highly karstified. The shallow aquifer of the peninsula occurs in the channels and cavities (karsts) of this Miocene Limestone as shown in Figure 1.2 and hence this nomenclature for this aquifer. All the shallow groundwater found within the karstic cavities originates from the infiltration of rainfall, and this shallow groundwater forms mounds or lenses floating over the saline water. These water mounds or lenses reach their peak during the monsoon rains of November –December.

Of the annual recharge of rainwater which is between 10 to 20 X 10^7 cu.m, around fifty percent eventually drains out to sea according to Balendran et al. (1968) and the remainder is used most intensively for agriculture and domestic purposes. The aquifer boundary itself expands and contracts through the wet and dry seasons respectively. Monitoring studies have confirmed a significant inbalance between the draw-off and recharge rates as reported by Balendran (1969).
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Approximately 80 percent of this groundwater is being used for high-value agriculture and the remaining 20 percent for domestic use including flushing demands of toilets in urban areas of Jaffna. Water quality studies have shown enhanced levels of nitrate pollution in domestic wells situated in the more densely settled Municipal areas of the peninsula as reported by Nagarajah et al 1988.

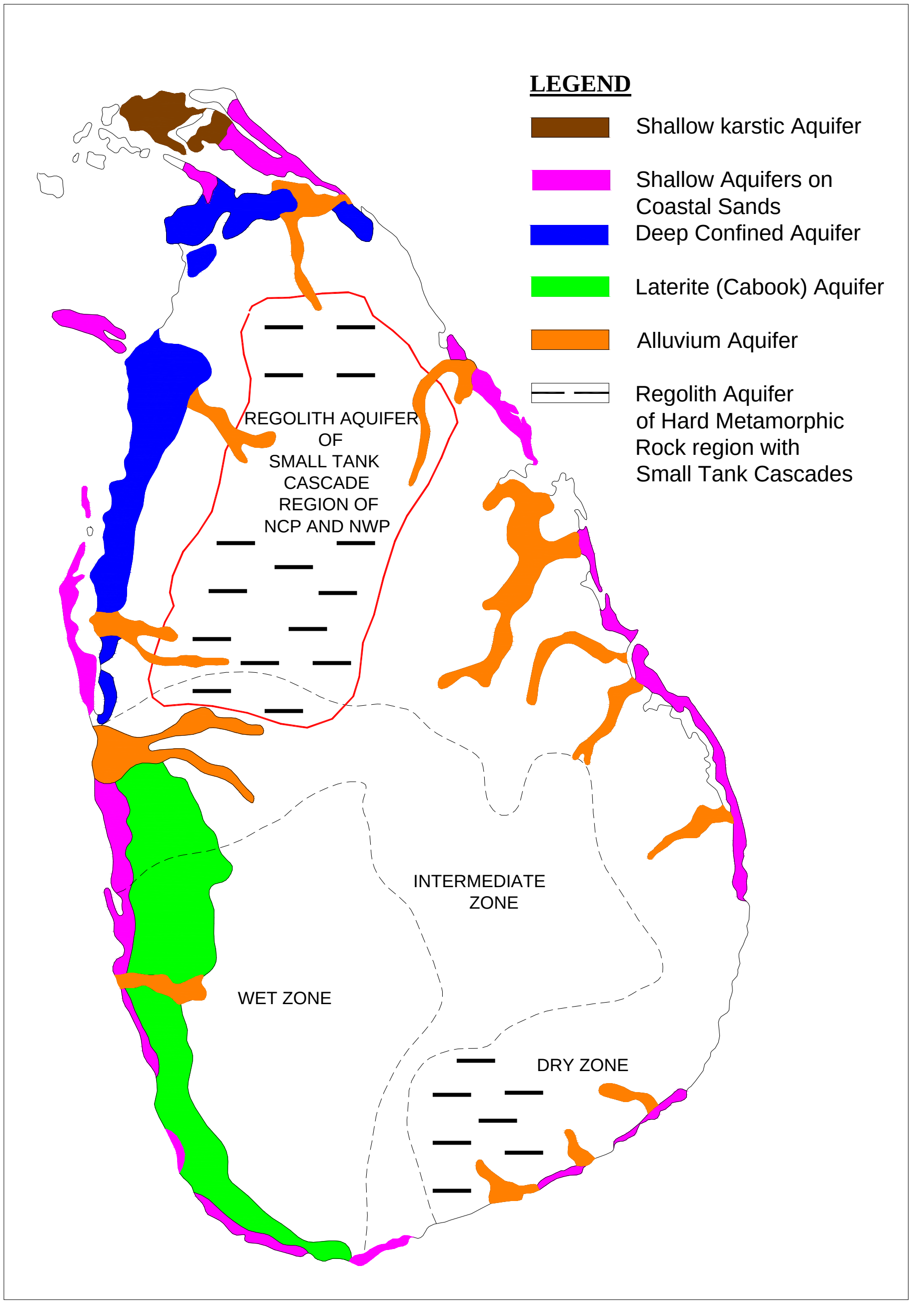


Figure 1.1 : Different Types of Aquifers in Sri Lanka

1.2. Deep Confined Aquifer

A number of distinct and confined aquifers occur within the sedimentary limestone and sandstone formations of the northwestern and northern coastal plains. These are relatively more than 60 m deep aquifers which have a relatively high recharge rate. The sedimentary limestone is highly faulted and it separates the aquifer into a series of isolated blocks thus forming a number of separate groundwater basins. Seven distinct aquifer basins have been identified, studied and mapped at different scales from the late sixties to the early eighties. These are shown in Figure 1.3.

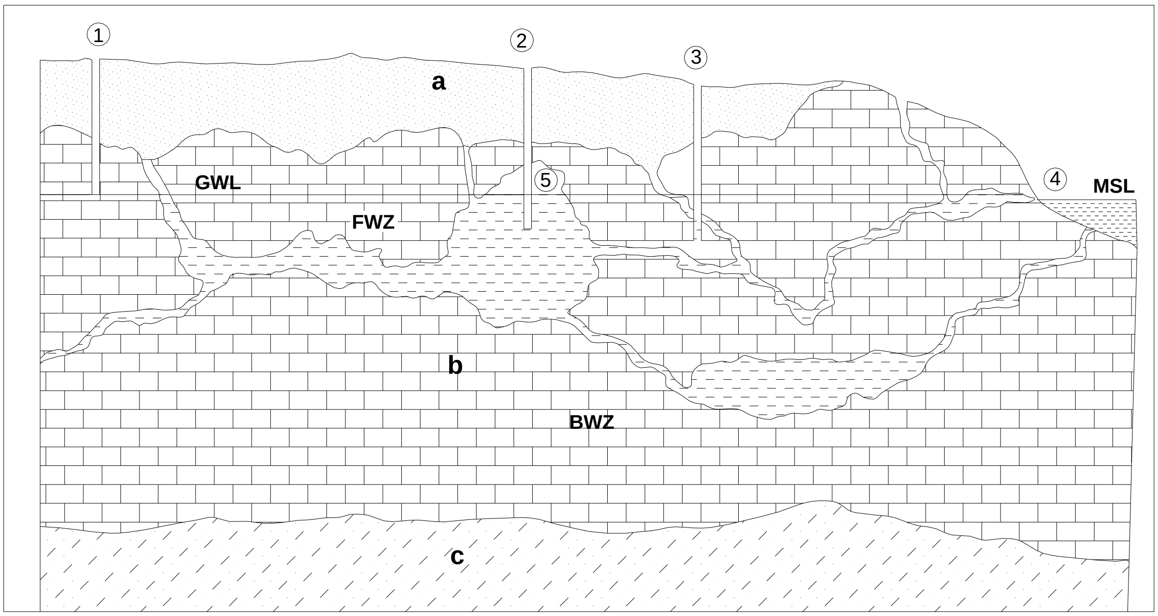
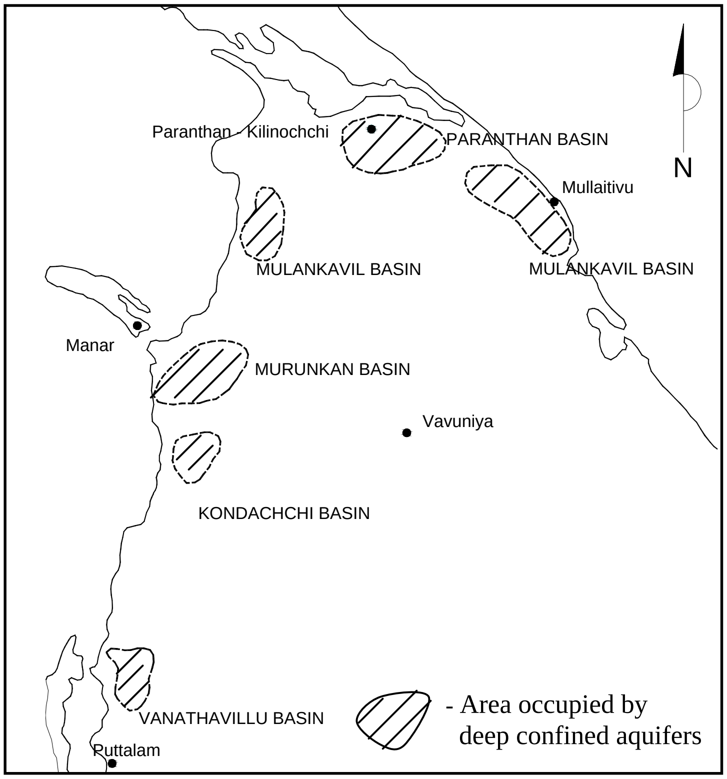


Figure 1.2 : Groundwater conditions in the Peninsula (After C.H.L. Sirimanne, 1952) (a) Red Earth, (b) Jaffna Limestone, (MSL) mean sea level, (GWL) groundwater level, (FWZ) zone of fresh water saturation, (BWZ) probable zone of brackish water ;(1) Dry Well (2) Well of Puttur type, (3) Ordinary successful well, (4) Spring of Keerimalai type , (5) Solution cavern

Aquifer boundaries have been approximately demarcated in respect of the Vanathavillu, Murunkan, and Mulankavil aquifer basins. The average depth of wells reaching the artesian aquifer in the well defined basins is from 30 to 50 m; and the yields of these wells is around 3-10 liters /sec. This aquifer dips towards the sea, and the depth to the aquifer is around 70 –90 m in some places close to the sea. Wijesinghe (1974).

In the Vanathavilluwa basin which has been more intensively used for irrigated agriculture of high value crops since 1978, a twenty percent increase in the conductivity of the deep tube well water has been observed by 1993. This has been caused by a leaching of salts from the cultivated soil overburden to the groundwater table.

Due to the unsettled conditions that have prevailed in this region since the mid-eighties, there has been a reduction in the exploitation and utilization of these very productive aquifers.



Scale (1 : 2,000,000)

Figure 1.3 : Deep Confined Aquifers of the Sedimentary Limestone and Sandstone Formations.

1.3. Coastal Sand Aquifers

Three main types of coastal sand aquifers have been recognized and characterized in Sri Lanka, of which two are discussed in this paper. These are

1. Shallow aquifers on coastal spits and bars as found in the Kalpitiya peninsula and the Mannar Island in the north west of Sri Lanka.

2. Shallow aquifers on raised beaches as found in the Nilaveli-Kuchchaweli, Pulmoddai and Kalkuda in North Eastern region.

Although the total extent of these two types of aquifers is estimated at around 125,000 ha, it yet constitutes a limited but very precious resource of a renewable groundwater supply that supports an intensive human settlement, high value intensive agriculture and flourishing tourist industry.

These aquifers are re-charged mainly during the 3-4 months of rain in the wet 'maha' season and water in these aquifers then get collected in the form of a fresh water 'lens' floating above the denser saline water. The volume of fresh water in these aquifers usually expands during the rainy season and contracts during the dry season with fluctuating brackish and saline boundaries. Any over extraction from these fresh water lenses results in the coning or entering of the underlying brackish water in to the fresh water.

The aquifer in the Kalpitiya peninsular on a coastal spit as shown in Figure 1.4(a) has a thinner lense of fresh water and it is more easily subject to depletion or eutrophication than the Nilaveli type aquifer, which is located on a raised beach type of landform and is thereby of a more robust nature as shown in Figure 1.4(b).

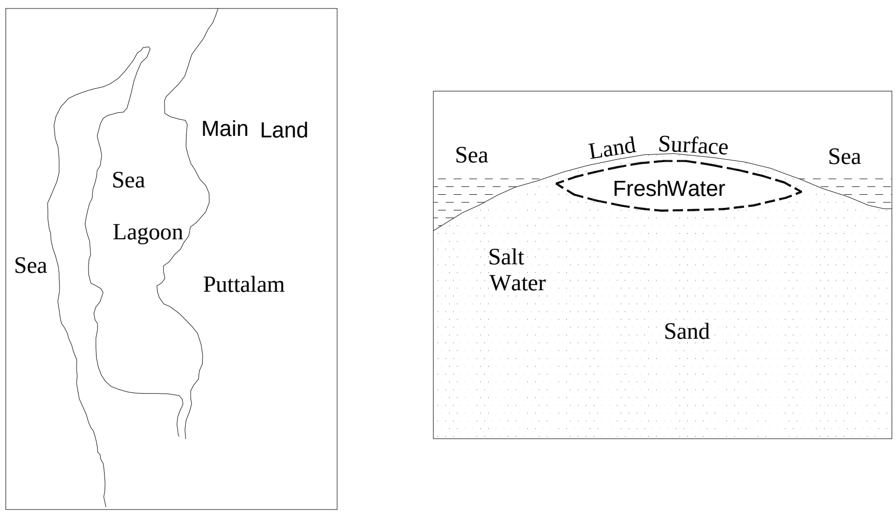


Figure 1.4(a) :The aquifer in the Kalpitiya Peninsular on a coastal spit

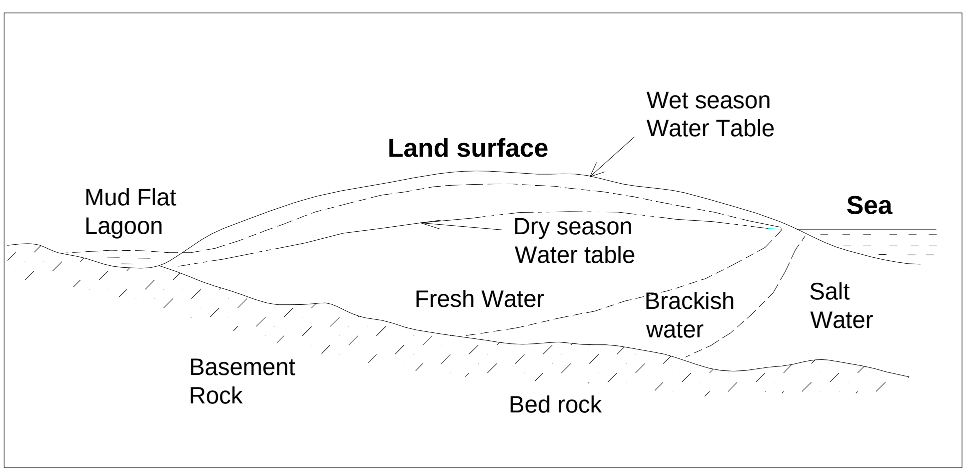


Figure 1.4(b) – Schematic cross section of Nilaveli coastal aquifer.

1.4. Alluvial Aquifers

The set of alluvial aquifers of Sri Lanka constitute one of the most diversified forms in the tropical region. These alluvial deposits occur over 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 materials. 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 Mahaweli Ganga, Kelani Ganga, Deduru Oya, Mi oya, Kirindi Oya, and Malwathu Oya have broad and deep alluvial beds of variable texture and gravel content in their lower reaches. Old buried riverbeds with high groundwater yields are present in the lower Kelani river aspects. The alluvial formations of these larger rivers may vary from between 10 to 15 m and up to 35 m in thickness, and may extend to several hundreds of meters on either side of the riverbeds. A reliable volume of groundwater can be extracted from these alluvial aquifers throughout the year.

In the wet zone, the shallower and smaller alluvial aquifers occur within the alluvial deposits of the minor rivers (Oyas) and streams. These aquifers are generally shallow and are directly connected to the surface water in stream and rivers. Even in periods of low surface flow, these aquifers are quickly recharged.

In sum, it could be stated that at present a major proportion of the various types of alluvial aquifers in the country are being exploited to varying degree without experiencing major draw-down hazards.

1.5. Shallow Regolith Aquifer of the Hard Rock Region

Geologists have recognized that the groundwater potential in the hard rock region of this country is limited because of the low groundwater storage capacity and transmissivity of the underlying crystalline basement hard rock Sirimanne 1952. It is also recognized that there is no continuous body of groundwater with a single water table in these metamorphic rocks, but rather separate pockets of groundwater.

It has been recognized that groundwater in the hard rock region is found both in the weathered rock zone, or the regolith, as well as in the deeper fracture zone of the basement rocks. The weathered zone generally ranges from 2 – 10 m in thickness, while the fracture zone is located at depths of more than 30 – 40 m Panabokke 2003. It is now referred to as the shallow ‘regolith’ aquifer on the one hand, and the deep fracture zone aquifer on the other.

The shallow regolith aquifer is mainly confined to a narrow belt along the inland valley systems of this undulating mantled plain landscape as shown in Figures 1.5 and 1.6. It is now recognized that this shallow groundwater benefits from the presence of several small tanks cascades that are situated within these inland valleys. The average thickness of the regolith is, not more than 10 m in this region, and the traditional hand-dug wells have been abstracting water from this basement regolith aquifer for village domestic requirements for more than 2000 years in the ancient Rajarata landscape. Despite their relatively low yields of these aquifers as reported by C.S. de Silva 2002 they have provided the basic water needs for innumerable human settlements over several millennia. The recent development of agrowell farming in the north central and north western provinces is dependant on this shallow groundwater resource as shown by Karunaratne & Pathmarajah (2002).

The deeper fracture zone occurs at depths of around or beyond 30 to 40 m in this hard metamorphic rock region, and the groundwater in this fracture zone is referred to as the deep fracture zone aquifer. The groundwater present within this deep fracture zone is tapped by bore wells or tube wells that have been installed at various locations in this dry zone districts under both state and donor aided auspices.

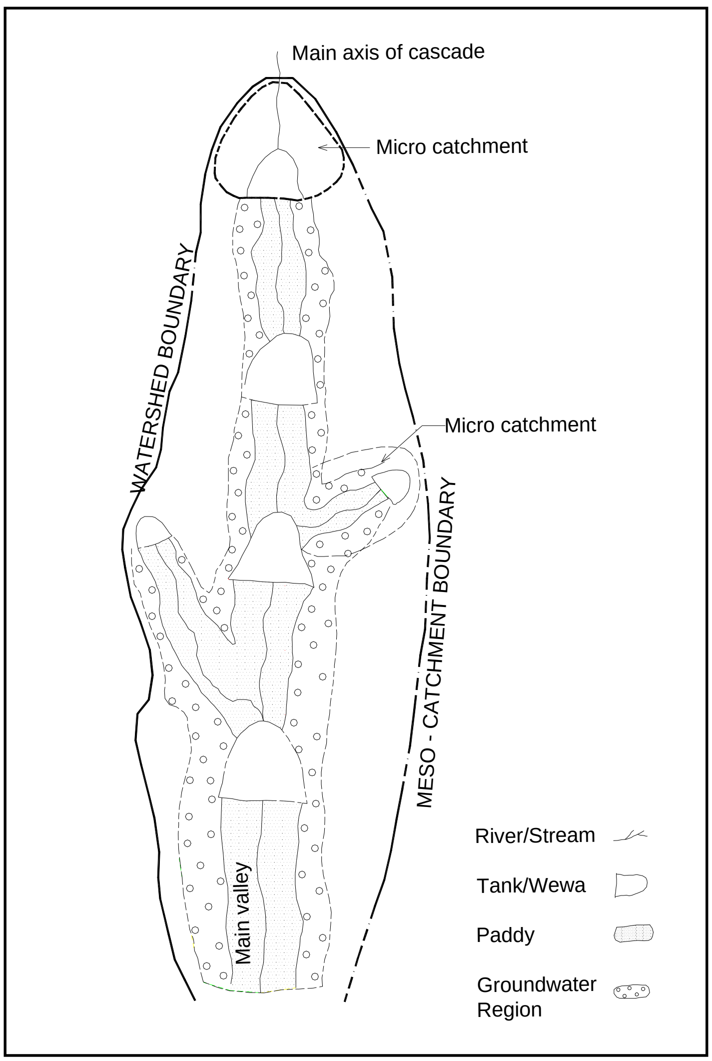


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Figure 1.5- Schematic representation of Groundwater area within a cascade

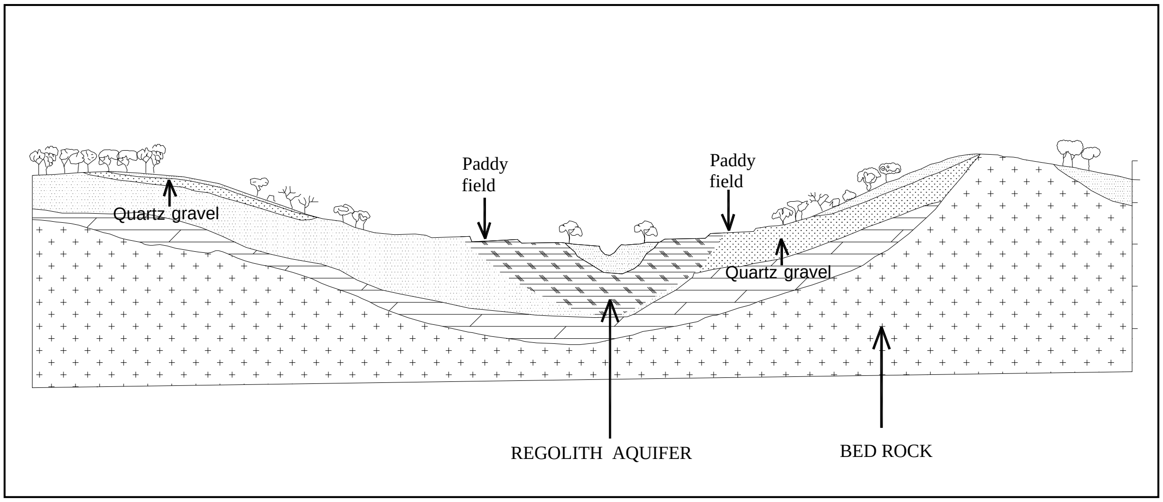


Figure 1.6 – Cross sectional view of regolith aquifer

1.6. South Western Lateritic (Cabook) Aquifer

The laterite formations called “cabook” of south-western Sri Lanka have considerable water holding capacity, depending on the depth of the cabook formation. The aquifer found within this vesicular laterite responds very rapidly to the initial rains following the usual dry season of February – March, and then keeps filing up with the monsoon rains.

Due to the highly dissected nature of the macro landscape in this region, the water table or the aquifer itself is highly fragmented into a number of discreet, low mounds, within the residual landscape which is separated from each other by intervening valley floors. As such, one could demarcate and map out a mosaic of interconnected aquifers in this landscape rather than a single continuous aquifer as shown by Sirimanne 1964.

In general, these vesicular laterities support relatively shallow aquifers that are easily accessible to dug wells as well as shallow ‘tube’ wells. However, this vesicular laterite aquifer of the southwest wet zone faces the most severe over exploitation especially in the area of outer Colombo and adjacent districts. The rapid expansion of industrial estates, urban housing schemes and bottled water projects in this area is causing a tremendous pressure on this limited resource. Enhanced nitrate levels have been observed from some of the domestic wells around Colombo and its suburbs.

Chapter 2

Groundwater Resources – Variation in Time and Space

In the previous chapter the main pattern and characteristics of the six types of aquifers together with their mode of occurrence was briefly discussed. This chapter outlines their known patterns of variation in time and space as well as their response to extremes of droughts.

2.1. Shallow Karstic Aquifer of Jaffna Peninsula

This aquifer is the most intensively utilized as well as the best studied one in this country and, as a result, much is known in respect of its variation in time and space. This aquifer gets fully recharged by the November – December rains of the North East monsoon. No appreciable rainfall occurs after February, and the volume of stored water within the mounds of the karstic cavities tends to drop rapidly within less than three months. This significant loss of groundwater is because of the considerable karstification which intensifies the sub surface flow. This is the main problem in the Jaffna peninsula aquifer, especially around the coastal region, where the fresh water lens gets rapidly reduced in thickness thus limiting water supplies in the dry season which extends up to August – September. With rapidly increasing demands both for agriculture as well as urban and domestic use within the peninsula in the nineteen eighties, even by June –July the amount of good quality water available for domestic use had become restricted.

Monitoring studies conducted in the seventies have confirmed a significant inbalance between draw off and recharge ratio. Water quality studies conducted in the mid eighties have shown enhanced levels of nitrate pollution in the densely settled Municipal areas within the peninsula. The number of open dug wells in the Jaffna Peninsular, had exceeded 100,000 by the early eighties.

2.2. Deep Confined Aquifer

The safe abstraction rates have been studied and estimated for three of the aquifer basins. The safe rates range from 3.0 MCM per year for the Vanathavillu aquifer basin to 8.0 MCM per year for the Paranthan aquifer basin. The value for the Mulankavil is provisionally estimated at 9.0 MCM per year.

A semi-quantitative measure of the potential of each of the aquifer basins could be obtained from the data presently available in respect of the depth to limestone and depth to hard rock. The values for the respective basins are as follows.

Basin	Depth to Limestone (m)	Depth to Hardrock (m)
Vanathavillu	15	225
Kondachchi	15	60
Murunkan	5	167
Mulankavil	0	240
Paranthan	6	76

Up to the mid eighties there were approximately 200 functioning tube wells, and over 800 open wells using this groundwater for both agricultural and domestic use. The average depth of wells reaching the artesian aquifer in well defined basins is from 30 to 50 m. Yields of these wells range from 0.5 l/s to 25 l/s.

To date there have been no reports of any over-exploitation of any of these aquifers, except in the case of the Murunkan basin where there has been an over exploitation of deep aquifer by many users who own and operate medium depth tube wells for irrigating paddy lands.

2.3. Shallow Coastal Sand Aquifer

Studies conducted by the Water Resources Board in the Nilaveli type aquifer with assistance from G.T.Z. in 1999 & 2001 have identified the extraction potential of this aquifer as compared with the Kalpitiya aquifer. The results of this study show that there is sufficient quantity of maha rainfall in the Nilaweli environment to leach out any solutes that build up during the dry yala season.

In the case of the more shallow aquifers as those of the Kalpitiya peninsula and the small aquifers situated along the south and south west coastal plain, they would be adversely affected both in volume as well as quality in extremely dry years.

2.4. Alluvial aquifers

The alluvial aquifers of the larger river systems, especially those that flow out to sea in the southwestern part of the country do not get significantly reduced during extremes of drought because they are deeper and have a wider alluvial fill. Considerable underflow of groundwater also take place in the very wide alluvial tracks of the Mahaweli ganga at Manampitiya as stated by Cooray (1984).

2.5.Shallow Regolith Aquifer

In general there is a recharge of around 100mm in this aquifer during the maha season, mostly in the north central and northwestern provinces. In the southern province the amount of recharge is not significant, especially in the more dry arid zone of the Hambantota district.

Recent studies Senaratna (1996) have shown that there is a limit beyond which the exploitation of the regolith aquifer would result in an irreversible degradation of this limited but very precious groundwater resource. These studies also support the view that at least 25 percent of the potential groundwater storage in an aquifer should be reserved to meet environmental requirement in areas where there is intensive agro well farming.

Severe droughts are known to cause a severe depletion of this regolith aquifer, especially in locations where there are no small tanks of appreciable size located along the inland valleys of the small tank cascade system.

2.6. South Western Laterite (Cabook) Aquifer

This aquifer gets recharged very rapidly with the first rains that follow the usual dry period. This takes place in April – May following the dry period of February – March. The water table recedes slowly and is recharged several times during the rest of the year with both inter monsoonal and north-east monsoon rains. However, in some areas with a high density of settlements as in some of the Colombo suburban areas, the water table could recede to depths of beyond 15m below ground level, during a prolonged dry period of more than 65 days.

Chapter 3

Human Impacts on Groundwater Resources

According to the present status of knowledge and understandings, the effects of human impacts is most observable in the groundwater areas of the shallow regolith aquifer, followed by the coastal sand aquifers, and the shallow karstic aquifer of Jaffna.

3.1 Impacts of Agrowell Development in Hard Rock Aquifer

In respect of the hard rock areas, the North Central Province region has been studied better than the other regions because of the rapid expansion of agrowell development that took place over the last fifteen years. These agrowells are usually 5-10 m in depth and 5-8 m in diameter. It was reported three years ago that there were as many as 10,000 agrowells are operating in the Anuradhapura district (Shanti de Silva 2002). This development of agrowells had taken place in an unorganized manner without a proper assessment of the hydro-geological properties of the basement rocks, spacing between agrowells, safe yield, and recharge potential. It was only after a symposium held in December 1997 on Groundwater Utilization for Crop Production in the Dry Zone of Sri Lanka under the auspices of the Food and Agricultural Organization (FAO) and Department of Agriculture (DOA) where all research findings to date were presented, that policy guidelines for groundwater use were enunciated for the first time in this country (Nagarajah and Gamage 1997). Policy guidelines for groundwater extraction and for groundwater use for irrigation were also developed. (Policy guidelines for groundwater use 1998).

In the absence of such guidelines, the indiscriminate expansion of agrowell farming under state sponsorship of the North Central Provincial Government would have led to severe environmental degradation in this province. Somasiri (2000) and Dharmasena (2002).

3.1.1 Impacts of Dams and Diversions

Almost all major irrigation reservoirs in this country are located within the hard rock region of the dry zone of this country. The associated major dams and diversion structures are accordingly all located within the areas occupied by these man made reservoirs. No studies have been conducted to date to study the direct impact of such man made reservoirs on the groundwater hydrology.

Some preliminary observations were, however carried out by the Water Resources Board (WRB) from 1999 in the irrigated command areas of two major irrigation systems. One system is located in the North Western Province which includes (Deduru Oya Project) and another is located in the North Central Province (System H of Mahaweli), both located on the hard rock basement area. These irrigated command areas are serviced by a main canal, distributary canals and field canals which cover most of the landscape located below a certain common elevation. It is observed that whenever water flow takes place in these canals, the regolith aquifer domains within the irrigation scheme get fully charged with the infiltrating water, and the water table within the primary and secondary catchment basins rise to a specific height according to the lay of the landscape. This built up water table is held up and retained as long as there is water flows in the canals. This water table recedes at a slow rate after irrigation supply in the canals are cut off.

Farmers in System H of Mahaweli are now beginning to exploit this shallow regolith water table to cultivate non-rice crops during the dry season. This practice has also spread to several medium scale irrigation projects where farmers could get a good price for these dry season crops.

3.1.2 Impacts of trans Basin Diversion

Studies on the impact of diversion canals on the small tank cascade systems commenced in January this year at two locations in the Southern dry zone namely, (a) the Weli oya diversion in mid – Walawe basin and (b) the Mau Ara diversion to the Malala basin which contains a large number of small reservoirs. Preliminary results, especially over the last seven month dry season show a distinct enrichment of the regolith aquifer within the studied sub-watersheds or small tank cascade meso basins. This enrichment would have a special significance to the small tank settlements in this arid zone environment which are so severely short of water during the usual protracted dry season from May to September each year.

3.2. Coastal Sand Aquifers

Until recent times the coastal sand aquifers in Kalpitiya and Nilaweli were sparsely utilized where water from these shallow aquifers were manually lifted for use by fishing village settlements. Chewing type tobacco was grown by small farmers in the Kalpitiya peninsula using simple lift irrigation devices.

Intensification of land use in these coastal sand areas began around the early seventies with farmers using small diesel operated pumps to lift the water for intensive lift irrigation for cultivation of chillie and onion which was becoming highly profitable. Small scale and medium tourist resorts also began to develop around Nilaweli which drew their water supply from these shallow aquifers. The water quality of the Nilaweli wells was of a very high quality.

In the Kalpitiya areas, the rate of groundwater extraction began to exceed the recharge rate, resulting on a high build up nitrate concentration often exceeding 22 mg/l by the end of the dry season in July-August.

In the Nilaweli aquifer the monitoring studies conducted by the Water Resources Board (WRB) with GTZ (German Technical Cooperation) assistance show that despite the high intensity of onion cultivation there is no build up of soluble salts or nitrates in the groundwater. It is reasoned that the amount of rainfall received during the 'maha' season is sufficient to leach out and dilute harmful concentration of solutes in this aquifer environment.

3.3 Shallow Karstic Aquifer

Human settlement has been taking place from the early Historical period in the Jaffna peninsula. Over this period of around 1,500 years, an intensive system of land use based on a frugal use of the underlying groundwater resource had been perfected. This intensive small scale irrigation farming was carried out using traditional methods of lifting the groundwater. By the late nineteen sixties, the overall picture indicated almost full development of the available groundwater resource. The annual replenishment in a normal period of rainfall was matched by the total consumption of groundwater for both domestic and agricultural uses.

With the increase in sub-urban housing together with rapid increase in use of water pumps for lifting water, a serous inbalance between consumption rate and replenishment rate has taken place as reported by Balendran 1969. The shallow aquifer is now stressed both in its quality as well as in its quantity.

Chapter 4

Data and Information on Groundwater Resources

4.1 Data and Information available for Groundwater Studies, Investigations, Consultancy Reports etc. over the last 25 – 30 year period

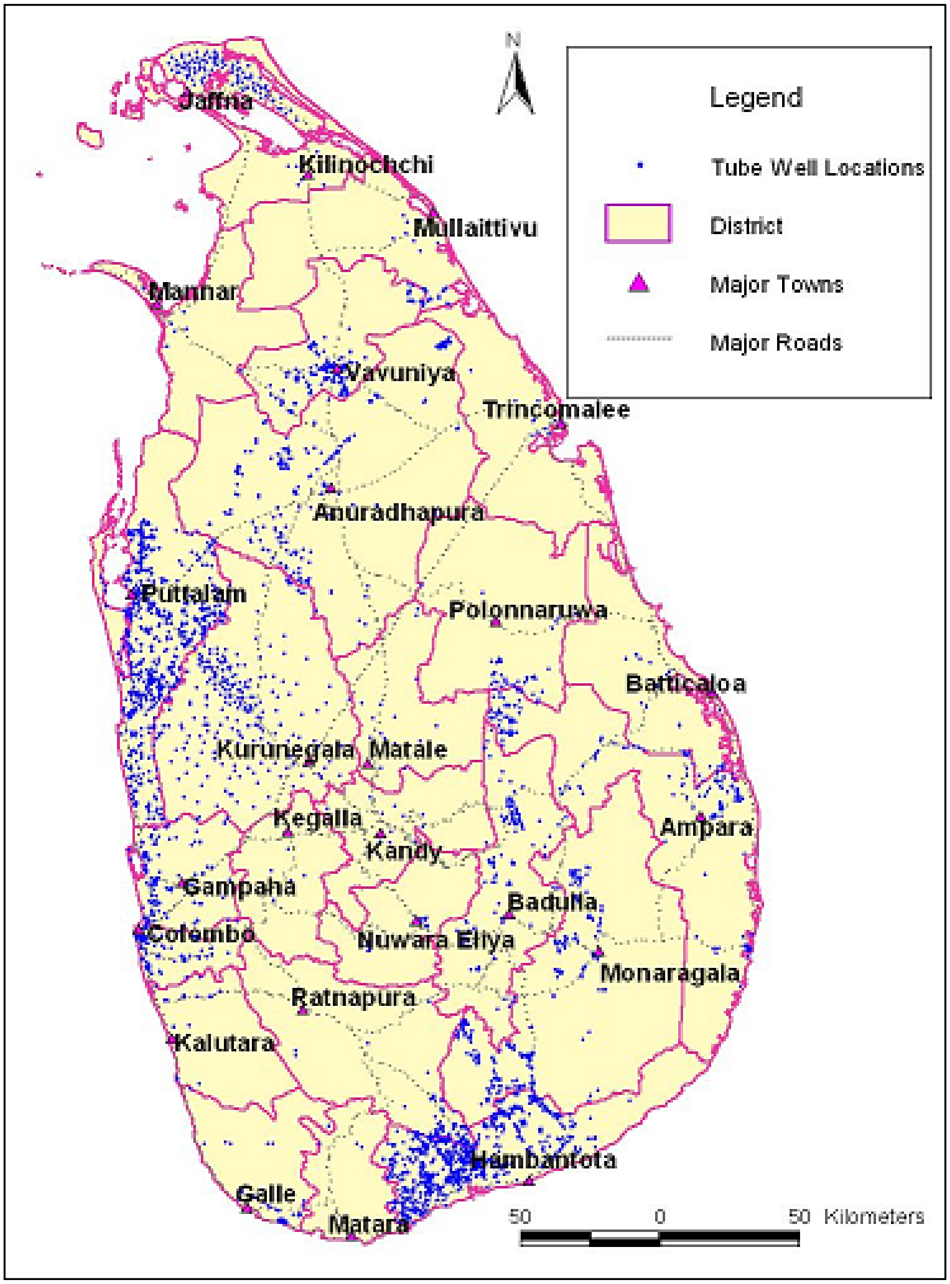
Data and information on groundwater studies, investigation and consultancy reports are essential for the effective management of the resource including groundwater policy development and planning, water management operations, project planning, public awareness and education and investment planning.

There are two state organizations such as Water Resources Board (WRB) and National Water Supply and Drainage Board (NWS&DB) involved in groundwater studies, investigations and preparation of consultancy reports for over the past 30 years. Few private drilling companies and donor funded projects such as DANIDA, FINIDA and GTZ have also been engaged in the investigation and preparation of consultancy reports pertaining to groundwater.

These organizations collect data, primarily for their own use as well as for some sharing with other agencies and release to the public. WRB and NWS&DB are the main institutions in Sri Lanka engaged in collection of tube well and water quality data. These data are collected and stored in their own databases. These databases represent more than 30 years of collection effort, and they contain information for more than 30,000 well sites including data on tube wells, water levels and water quality. Distribution of well sites having geographical co-ordinates from the Water Resources Board (WRB) database is shown in Figure 4.1. This does not represent all tube well sites existing in Sri Lanka because wells constructed by NWS&DB, private drilling organizations and overseas projects have not been included in this map. Table 4.1 shows the no. of tube wells constructed by National Water Supply & Drainage Board (NWSDB) and Water Resources Board (WRB) in the districts of Sri Lanka.

The data mentioned above has been collected and entered for a wide variety of projects and purposes over a long period of time and the resulting databases vary in quality and detail. The groundwater data and information system in water management agencies is inadequate in terms of consistent data standards, accuracy and reliability of data and information.

The data referred to above represents a combination of measured as well as reported information. Although many wells have accurate information (especially in recent projects), some problems are known to exist for the older entries. Known problems include inaccurate well locations and date of construction. Some of the wells in database have not been field visited but were entered into the database from well driller's reports. Also some coordinates of wells were entered into the databases using the general location information supplied by the driller. Information such as latitude and longitude has been entered into the WRB databases using maps and location information available at the time. Some locations have been updated where necessary, but some older ones have been not been checked or updated since the first entry.



Source: WRB (Water Resources Board) Database

Fig 4.1. Distribution of Tube Well sites

District	No. of Tube wells constructed by WRB	No. of Tube wells Constructed by NWS&DB	Total Tube Wells
1.Ampara	321	716	1037
2.Anuradhapura	329	4693	5022
3.Badulla	114	925	1039
4.Baticallo	136	9	145
5.Colombo	190	152	342
6.Galle	158	239	397
7.Gampaha	272	618	890
8.Hambantota	989	1494	2483
9.Jaffna	260	-	260
10.Kegalle	06	163	169
11.Kilinochchi	14	-	14
12.Kalutara	32	1099	1131
13.Kandy	23	1731	1754
14.Kurunegala	264	3420	3684
15.Mannar	99	34	133
16.Monaragala	371	1961	2332
17.Mulathivu	44	30	74
18.Matale	51	1509	1560
19.Matara	11	398	409
20.Nuwaraeliya	49	134	183
21.Polonnaruwa	189	1648	1837
22.Puttalam	1563	1705	3268
23.Ratnapura	70	1054	1124
24.Trincomalie	21	248	269
25.Vavuniya	503	498	1001
Total	6079	24478	30557

Source : WRB and NWS&DB databases

Table 4.1: No. of Tube wells constructed by Water Resources Board (WRB) and National Water Supply & Drainage Board (NWS&DB)

There is no consistency in the well numbering system, data contents/fields well coordinate system and GIS software used between institutional groundwater databases. To avoid difficulties such as data gaps, unreliability, fragmentation, inconsistency, unavailability for users, low value and low utilization, it is suggested that a centralized or co-coordinated data and information system in the groundwater sector can be set up.

A bibliography complied by Water Resources Board in December 2000 on groundwater studies in Sri Lanka is a database giving information on groundwater related documents. This database consists of 327 published and unpublished library materials on groundwater related studies for the period of 1955-1999. Based on the topics and content of the studies, these materials can be categorized in to 5 groups and the percentages of the categorized groups availability as shown in Figure 4.2.

1. Groundwater Quality, Groundwater pollution & Environmental effects : 35.8 percent
2. Groundwater behavior, Occurrence, Availability & Balance : 21.1 percent
3. Groundwater Exploration, Development and Management : 13.8 percent
4. Groundwater Demand, Deficits, Consumption & Groundwater Supply : 16.2 percent
5. Documents on Groundwater- Miscellaneous : 13.1 percent

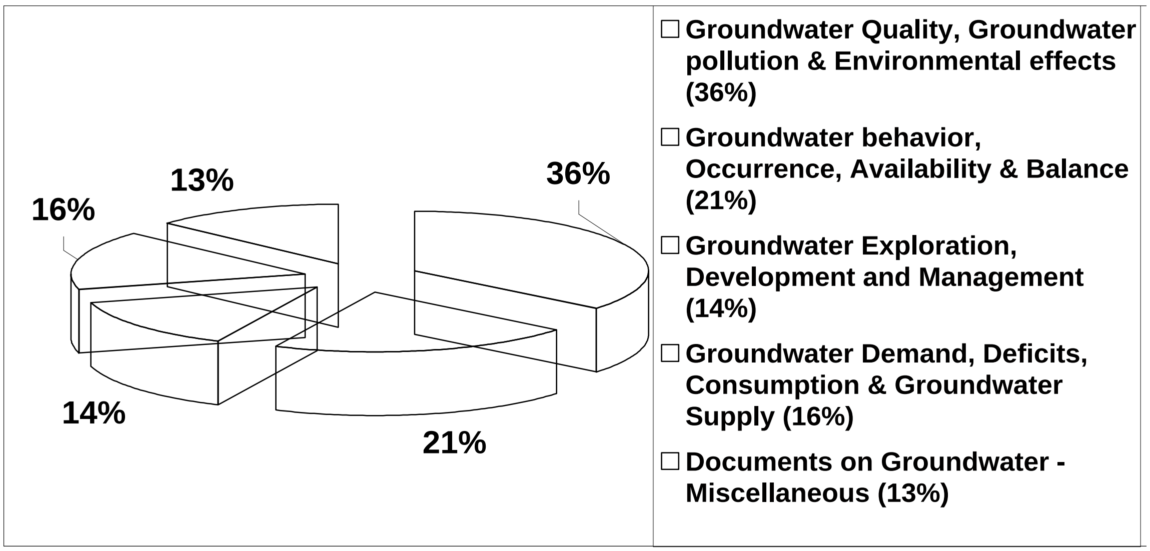


Fig 4.2: Percentages of categorized groups of library materials

Chapter 5

Present Groundwater Users and Needs

In Sri Lanka, groundwater resources are widely used for domestic, commercial and industrial purposes, small scale irrigation, water supply schemes and other purposes. About 80% of the rural domestic water supply needs are met from groundwater by means of dug wells and tube wells. In any many areas where surface water and pipe borne water systems are not fully reliable, groundwater provides industrial and commercial users with a margin of safety. Most of the industries in the country depend heavily on deep wells where groundwater is safe and of good quality, and can be self managed.

The demand for groundwater in Sri Lanka is steadily increasing specially in Urban and Rural Water Supplies, Irrigated Agriculture, Industrial Estate, Aquaculture, Small and Medium Enterprises and Urban Housing Schemes. The rapid expansion of these projects is exerting much pressure on the available groundwater resources.

On a nation-wide basis, piped water systems deliver safe water to almost 90 percent of the nation's urban population, and protected wells to approximately 60 percent of the rural population. A major portion of the urban water requirement of the country is treated and distributed by the NWSDB. The NWSDB produces over 310 million m^3 /year of treated water to cater for a population over 5.3 million. Many of the large urban centers along the coast derive their water supply through river systems. They are experiencing water supply interruptions due to salinity intrusions in the lower reaches of these rivers. Rural populations who secure water from dug wells and other natural water sources are facing hardships due to undependable nature of natural water sources.

There are over 300 urban and rural water supply schemes across 23 districts under the NWSDB and very few are under the WRB. One third of them are based on supplies from shallow and deep groundwater sources.

Town Water Supplies for towns such as Nuwara Eliya, Tangalle, Batticalo, Dambulla, Wennappuwa, Ahangama, Kataragama, Vavuniya, Puttalam, Chilaw, Anamaduwa, Nikaweratiya, Kuliyapitiya and Mihintale are being fully or partly operated by using groundwater from deep bore holes.

About 93 water supply schemes of which nearly 30% of the total number of water supply schemes distributed all over the country are operated based on supplies from shallow and deep groundwater sources. Fig. 5.1 shows the distribution of shallow and deep groundwater sources abstraction points scattered all over the country. The amount of groundwater abstraction of these points exceeds over 16 million m^3 /year which are used to cater to industrial zones and urban and rural water supply schemes distributed in the Island. The amount of groundwater and its percentages of supply over total supply in urban, rural and industrial zones supply in these districts are given in the table 5.1.

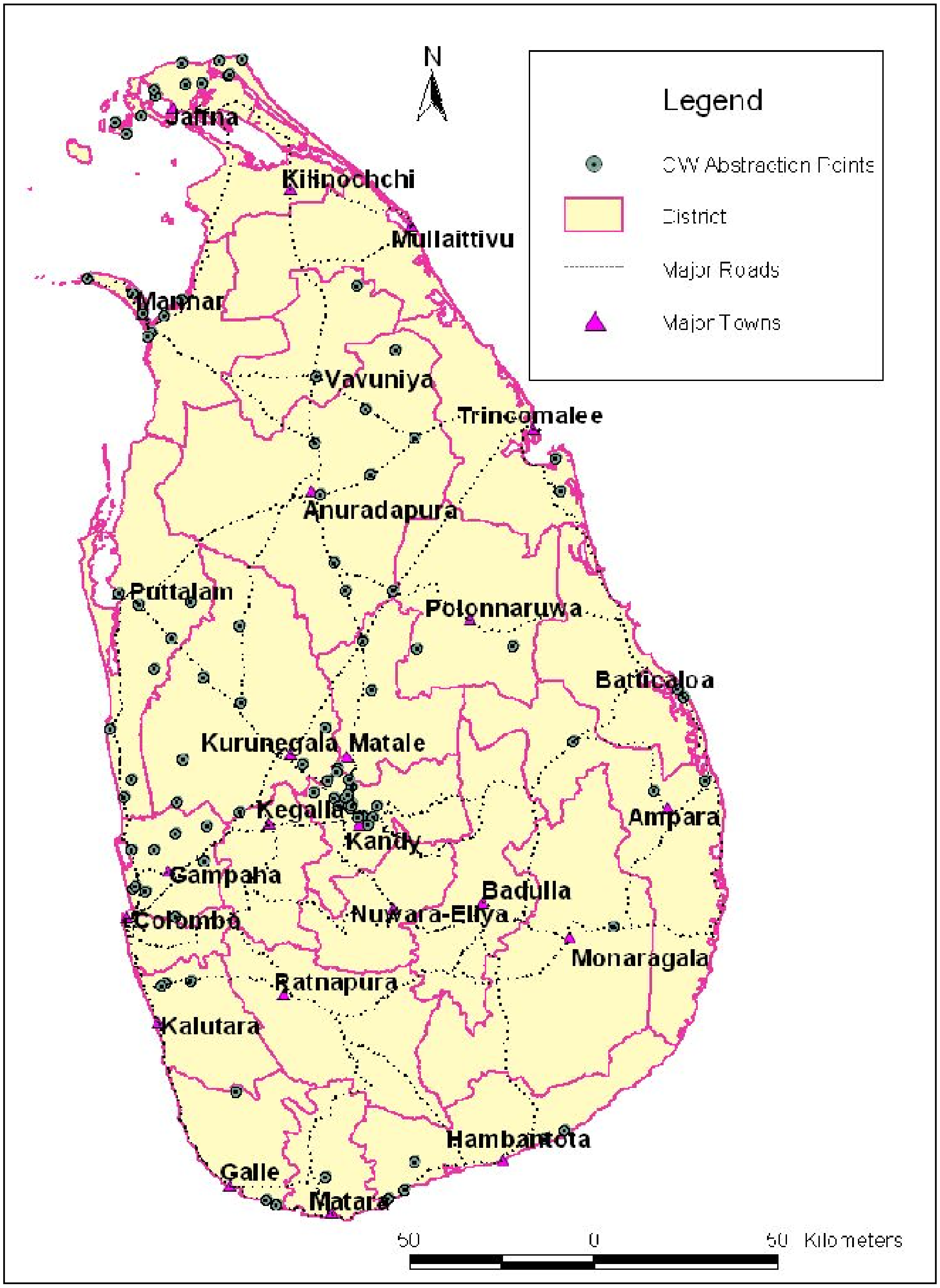


Figure 5.1 : Distribution of shallow and deep groundwater abstraction points used for urban, rural and industrial zone water supply schemes.

District	Total supply of surface and groundwater resources (m^3/day)	Supply of groundwater resources (m^3/day)	Percentage of groundwater supply (%)	Percentage of surface water supply (%)
1.Ampara	12457.0	329.0	2.6	97.4
2.Anuradhapura	20965.0	3285.0	15.7	84.3
3.Badulla	22223.0	0.0	0.0	100.0
4.Baticalloa	1449.0	1449.0	100.0	0.0
5.Colombo	561889.0	0.0	0.0	100.0
6.Galle	26247.0	987.0	3.8	96.2
7.Gampaha	51734.0	4859.0	9.4	90.6
8.Hambantota	27176.0	1021.0	3.8	96.2
9.Jaffna	209.0	209.0	100.0	0.0
10.Kegalle	15887.0	0.0	0.0	100.0
11.Kalutara	30604.0	555.0	1.8	98.2
12.Kandy	44075.0	13233.0	30.0	70.0
13.Kurunegala	11483.0	1800.0	15.6	84.4
14.Mannar	550.0	550.0	100.0	0.0
15.Monaragala	4228.0	12.0	0.3	99.7
16.Matale	13113.0	714.0	5.4	94.6
17.Matara	77482.0	1311.0	1.7	98.3
18.Nuwara-Eliya	8724.0	4500.0	51.6	48.4
19.Polonnaruwa	7655.0	355.0	4.6	95.4
20.Puttalam	8694.0	8424.0	96.8	3.2
21.Ratnapura	19650.0	0.0	0.0	100.0
22.Trincomalee	1433.0	9.0	0.6	99.4
23.Vavuniya	776.0	776.0	100.0	0.0

Source : NWS&DB and WRB databases
Table 5.1 : The amount of groundwater and its percentages of supply over total supply in urban, rural and industrial zones supply

Groundwater is the preferred low-cost source of water for most rural and peri-urban domestic water supply. Up to 80 percent of the rural drinking water supply needs are met from groundwater by means of dug wells and tube wells fitted with hand pumps. The shallow open dug wells that are distributed across the country provide the basic drinking domestic water supply to a major proportion of rural residents.

Groundwater is a main water sources for irrigation by small farmers, particularly during drought periods when tank storage is inadequate. Small farmers especially in the areas of north western and north central provinces used large – diameter agro wells. In coastal sand aquifer area like Kalpitiya Pennisular, there had been intensive use of the shallow groundwater for agriculture during the last two decades.

Shrimp aquaculture is being expanded in the Puttalam district of North Western province. In areas to the north of Chilaw, groundwater had been increasingly used for aquaculture ponds. The location of shrimp farms is close to the lagoon and stream mouths with availability of brackish water suitable for production. Some of these farms draw fresh or low salinity water from deep tube wells to balance the salinity levels of the water in the ponds filled from lagoon. Water Resources Board constructed more than 50 no of deep high yielding wells for these farms. The average yield of these wells is around 500 liters per minute and well depths are ranging from 80 - 150 meters.

Groundwater is a critical resource for the development of industry and the establishment of the export promotion zones, industrial estates and small and large enterprises. Industrial estates are not numerous. The more well known areas are the Katunayake and Biyagama industrial estates in the Gampaha district and Koggala industrial estate in Galle district. Amount of groundwater extraction in Koggala and Katunayake industrial estates is nearly 2670 m3 per day. Tourist Hotels along the coastal zone also depend primarily on groundwater present in the coastal sand aquifers.

Chapter 6

Future Needs

If an objective ranking according to the need with respect to groundwater is to be made, then the need for a public information and awareness program would occupy the topmost position. In the absence of a reliable information and awareness facility, the groundwater resource of this country is seriously misunderstood by decision makers and also by major groundwater users.

At present information on groundwater resources of this country is not readily accessible. There is no coordinated groundwater information program although many studies have been undertaken and a considerable amount of essential and basic data exists. This data has not been consolidated, and even in scattered forms it is not used to any significant extent in management decisions.

There is no single publication available within the country that lists and summarizes the present state of knowledge of the different aquifers in this country. There is therefore, a compelling need to compile and make available to the general user and district level managers a publication that sets out, in a readily understood and interpreted form, the body of presently available information.

Guidelines for safe and sustainable use of groundwater, on the same lines as that developed for the regolith aquifer by the National Resources Management Centre of the Department of Agriculture in 1997 should be framed for the other aquifers in this country and these should be widely disseminated to both local and district provincial agencies and other end users.

Another prime need at the present stage is the establishment of an ad-hoc working group under the aegis of the Water Resources Board that could be made up of a research or development professional from each of the related agencies such as NWS&DB, Geology Dept. of Peradeniya University, Geological Survey & Mines Beuro (GS&MB), National Building and Research Organization (NBRO), Department of Agriculture (DOA), and Department of Meteorology that will propose and foster both short and long term research and investigations programs. Funding for this could come from both government and donor agencies as well as from relevant UN agencies.

Groundwater development in this country has now reached a stage where the need for a sustained research and development effort on well identified national research and development agenda has become a ‘sine-qua-non’. It is useless to speak of sustainable development of the country’s groundwater resources without a supporting research effort to diagnose and trouble shoot both existing and emerging problems, and to also properly service and guide the on-going groundwater activities in the country.

The shallow open dug wells that are distributed across the wet zone’s metamorphic hard rock regions have provided the basic drinking and domestic water supplies to the innumerable rural dwellers from medieval times. With the rapid increase in population that has taken place over the recent decades, an increasing stress has been experienced in both the quantity and quality of this water. A few well designed case studies in some select hydrogeological land systems of the wet zone should be undertaken in order to ascertain the present status and their future sustainability. The Water Resources Board (WRB) has the capability to select such benchmark hydrogeological land systems and initiate the essential studies if some source of funding could be made available to it.

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