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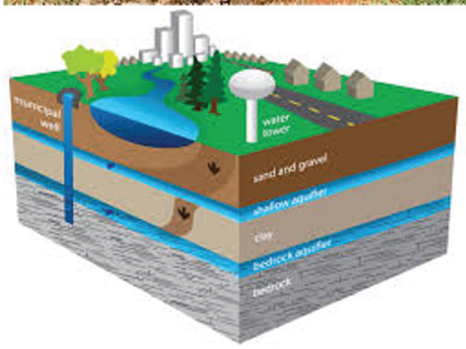

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அறிக்கை இல. : பீஈஆர்/பீ/2020/05
Report No : PER/B/2020/05

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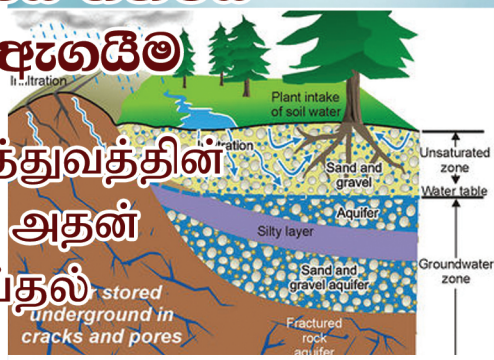

Evaluating the Legal Mechanism and Its Functionality of Ground Water Management in Sri Lanka

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தேசிய கணக்காய்வு அலுவலகம்
NATIONAL AUDIT OFFICE

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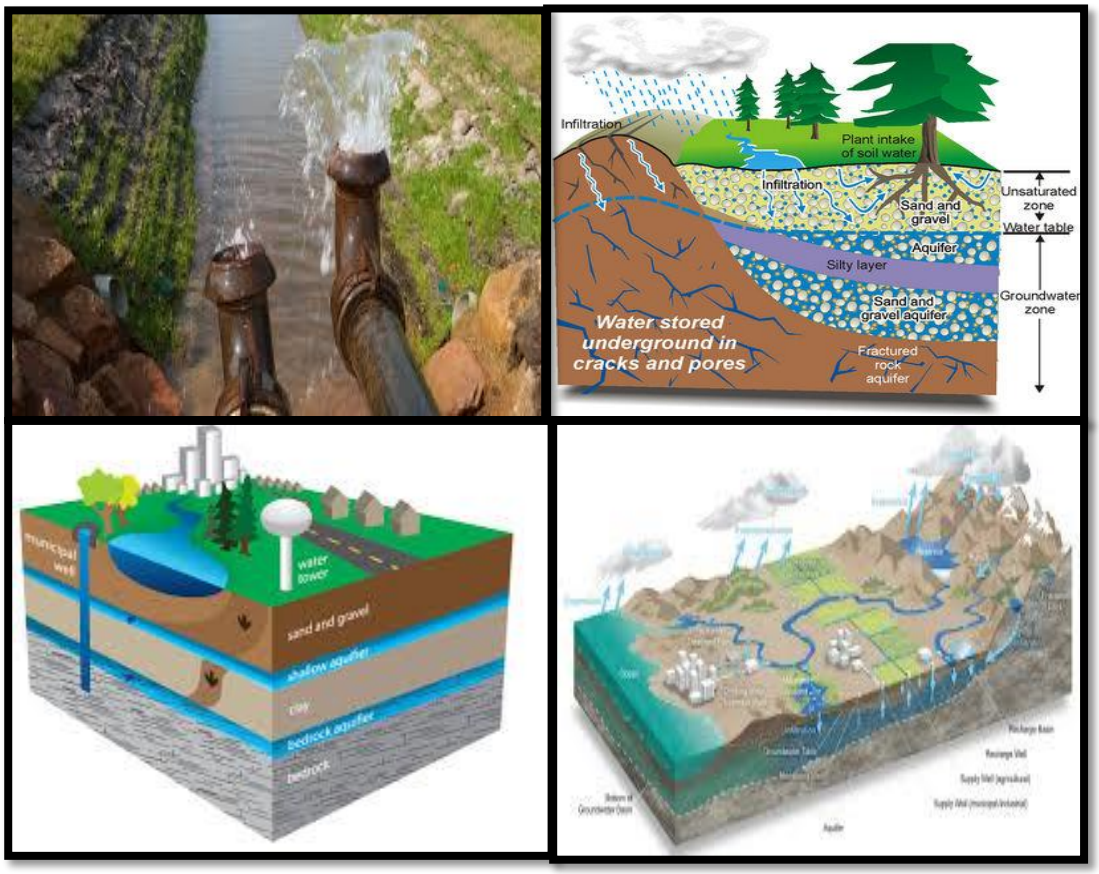

Report No: **PER/B/2020/05**

National Audit Office

Content

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1. Executive Summary

Groundwater is water that stores approximately 30 percent of the freshwater that has accumulated below the surface of the earth for millions of years, but has a very low annual precipitation rate. One of the reasons for maintaining the surface water and sustainability of the groundwater, is the high availability of sustainable water resources in the Central Hills and the increase in annual moderate rainfall in Sri Lanka is higher than the other countries in the world. Natural and human activities affect the quality and quantity of groundwater, and currently a growing trend of adverse effects from human activities can be observed. There are 06 main types of groundwater classification in Sri Lanka and these aquifers are found in various parts of Sri Lanka.

Recharging of groundwater is also an important area of concern in groundwater conservation. The purpose of the audit was to assess the institutional, legal background, monitoring, assessing the quality of groundwater and assessing the measures taken to the conservation of groundwater in relation to groundwater management in Sri Lanka. As the scope of this audit, the attention had been paid in assessing the legal provisions and their relevancy related to groundwater management, assessing the role of government institutions which are responsible for the sustainable groundwater management, assessing the groundwater and aquifer management policy planning and performance , and climate change mitigation and identifying the risks associated with the increase in nitrate and chloride levels in groundwater due to the climatic changes and the techniques used to minimize the climatic changes. .

Although the Water Resources Board was the institution that had been identified as the Groundwater Management Authority, in accordance with the National Policy on Protection and Conservation of Water Resources in Sri Lanka, their beneficial Areas and reserves through the Gazette Notification No. 1894/3 dated 24th December 2014, it had not been prepared and activated, a National Policy on Groundwater Management up to the date of audit.

The Water Resources Board Act No. 29 of 1964 was amended by Act No. 42 of 1999 and the functions of the Board were replaced by the new Act. It is observed that groundwater development has been given priority over groundwater conservation in the elimination of issues such as afforestation and control of the soil erosion which have affected the conservation of groundwater. It was observed that despite the implementation of several national programs, designed for the conservation of groundwater, the achieving of the desired performance indicators, was not sufficient. It was observed that evaluating the contamination of the waterways, salinity, and maintenance of the sources of water and also the post reviewing of laboratory analysis reports, which are important in the conservation of groundwater, was inadequate.

Although various experiments have identified the need for action plans as a long-term management strategy for identifying point and non-point sources of groundwater pollution, it was observed that the results are limited only to the relevant research papers. It was observed that the use of groundwater also is high in rural water supply schemes and export processing zones, and it was observed that taking actions was minimum for the recharging of groundwater.

Accordingly, it was observed that the establishment of a legal system that prioritizes the need for groundwater development as well as the need for water conservation could contribute to the achievement of sustainable groundwater management by the year 2030.

2. Background and nature of the report

2.1. Background

2.1.1. Groundwater

The water obtained from the rainwater and irrigation to the earth, is leaked down and trickled through the soil. There the gravity water stays between the microspheres of the soil and gravity water flows further down vertically and horizontally to rivers, streams, creeks and other reservoirs depending on the potential of water. Vertical downstream and runoff water is restricted to further downstream when it encounters any impermeable soil layer or rock in the ground and is deposited in holes and openings in the soil and rock above that impermeable layer. The water thus deposited is called groundwater.

Groundwater is considered to be the water reservoir of the earth. This water is the source of water in wells, springs and aquifers. If groundwater comes to the surface of the earth without interruption, it is called a spring, and when the groundwater flows down very fast, it is called a geyser. The upper limit of groundwater is the water table. Below groundwater level is the Saturated Zone, which fills all the soil space with water. There is an unsaturated zone above the groundwater level and groundwater moves from the saturated zone to the unsaturated zone by capillary lifting. In the unsaturated zone, the soil space in the upper soil retention areas is partially filled with water and the rest is filled with air, so that particular zone is also called the aeration zone.

There is no specific depth for groundwater level. It varies depending on the structure of the soil layers, the amount of water that falls on the ground, the geographical location, and the rainfall. For example, groundwater levels rise during the rainy season. Also, the groundwater level is higher in humid areas and deeper in arid areas. The amount of groundwater is also not certain. Groundwater levels are high in areas with high rainfall. However, due to the high evaporation in the arid areas, the amount of groundwater available in those areas is less as the excess water from heavy rains is less likely to leak as groundwater.

2.1.2. Definitions of groundwater

There are several definitions in this regard. Groundwater is the water in the ground, in cracks and spaces in soil, sand, and rock. It has been stored and moves slowly through the geological formation of soil, sand and rocks.

[The Groundwater Foundation]

Groundwater is the water in the ground, in saturated zones beneath the earth's surface.

[USGS Science for Changing World]

Approximately 30 percent of all freshwater on Earth is stored as groundwater. The amount of water that has accumulated in the form of groundwater is 100 times of the amount that has been collected in rivers and lakes. Most of the groundwater has accumulated in the aquifers below the Earth's surface for millions of years. The aquifer slowly replenishes due to precipitation. It then replenishes at an average charge rate of 1 to 3 years. Approximately 23 percent of the water used all over the world, is currently supplied by groundwater aquifers.

Sri Lanka is an island of sustainable water resources originating in the Central Highlands. The average annual rainfall of the island is about 1,900 mm, which is more than 2.5 times of the average rainfall value of the world, 750 mm. Thus, Sri Lanka as a whole has been identified as a country rich in water resources in terms of the capacity groundwater.

(Via the Internet)

2.1.3. Surface water and groundwater

There is a strong connection between surface water and groundwater. As the amount of water stored in the tanks decreases, the groundwater level in the areas far from the tanks also decreases. When the tank is completely filled with water, the associated groundwater level is close to the surface of the earth. The groundwater level is close to the surface of the lake as well as on both sides of the Ellangawa creek. Groundwater is abundant on both sides of the Axis stream at Ellangawa, where most of the water flows over a long period of time. There is also a very limited amount of groundwater along small streams that flow very temporarily into the upper reaches of the Ellangawaka valley.

Groundwater is one of the most valuable natural resources in Sri Lanka and a large number of people use groundwater. Groundwater is a hidden resource and also a more reliable source of water compared to surface water. Groundwater has been used for domestic use and irrigation in Sri Lanka since ancient times. Due to their high quality and sustainability throughout the year, about 80% of the rural population meets their domestic needs through groundwater. Activities in Jaffna, Ampara, Mannar, Puttalam and Vavuniya depend entirely on groundwater.

(www. Usgs.gov, www.britannica.com science, www.sciencedirect.com, www. Lenntech.com)

2.1.4. Aquifer

The permeable soil layer inside the crust of the earth, which is capable of retaining and removing water, is called aquifers. The spaces in a soil layer that can be considered an aquifer are quickly filled with water, and holes are drilled to allow that water to flow.

Aquifers are mainly divided into two parts.

(a) **Confined aquifers**

A layer of water-saturated rock or soil, bordered by impermeable layers above and below, is called a closed aquifer.

(b) **Unconfined aquifers**

An unconfined aquifer is a layer of rock or soil that is saturated with water above an impermeable layer. Surface of the earth these aquifers contain water that is deposited in the impermeable layer, which is first encountered when water flows down from. Most probably, this layer will be a layer of clay. The water level in these aquifers changes frequently due to rainfall or irrigation.

Depending on the location of the aquifer, it can be further subdivided into four types.

i. **Non-Artesian Aquifers**

These aquifers are open aquifers that are not located so deep. This water is present in shallow wells in watersheds.

ii. **Artesian Aquifers**

It is a closed aquifer where water is stored under high pressure. These aquifers are permanent and the water in such aquifers is present in deep wells.

iii. **Semi Confined Aquifers**

One of the upper or lower boundary layers of these aquifers is semi-permeable. These are also known as leaky aquifers and are permanent aquifers.

iv. **Perched Aquifers**

The water in the unique open aquifers known as perched auifers is above the groundwater level. A temporary aquifer.

2.1.5. Classification of groundwater

Groundwater is classified into Classes and Sub classes according to their quality.

Class I - Unique groundwater

Extraordinarily high-quality water sources are classified into this class. The total solids content of this groundwater is less than 500 mg per liter and has a very low concentration of pollutants. There is also a high level of contamination of this water.

Class II - Groundwater with drinking water quality

Groundwater belonging to this class is used for drinking as well as many other purposes. The total solids content of water is 500 - 3,000 mg per liter and can be contaminated.

Class III - Groundwater with limited uses

Groundwater that does not use as drinking water but can be used for other purposes belongs to this class. The total solids content of this water ranges from 3,000 - 10,000 mg per liter and is contaminated by natural as well as human influences. For example, water containing an element such as sulfur or iron has a bitter taste and is unsuitable for drinking. Also, not suitable for certain industrial activities.

Class IV - Saline groundwater

Groundwater belonging to this class contains a large amount of salts. The total solids content is more than 10,000 mg per liter and is not suitable for drinking at all. The most abundant salts in groundwater are calcium, sodium, and magnesium.

(en.m.wikipedia.org.wiki.aquifer)

2.1.6. Groundwater classification in Sri Lanka

Groundwater in Sri Lanka has been identified under 06 main types as follows.

(a) Shallow Karstic Aquifers in the Jaffna Peninsula

The entire Jaffna Peninsula is composed of Miocene limestone-like plateaus about 100 to 150 m of thickness. The shallow groundwater in the cavities of this plateau is generated by the infiltration of rainwater into it. About 80% of the ground water in Jaffna is used for agricultural purposes and the remaining 20% is used for domestic purposes. Studies on water quality have shown that the value of nitrate pollution is high in domestic wells located in densely populated urban areas of the Jaffna Peninsula.

(b) Deep Confined Aquifers

Most limited aquifers are found in sedimentary limestone and sandstone formations in the northwestern and northern coastal plains. These are water depths of approximately 60 meters and are highly regenerative. Sedimentary limestone is highly degradable, dividing the aquifer into a number of isolated parts. There a number of groundwater basins are created.

(c) Coastal Sand Aquifers

The shallow aquifer with coastal sand covers an area of approximately 125,000 hectares. Coastal sand dunes in Sri Lanka have been identified under 03 categories.

I. Shallow aquifers at coast lines and points

Ex: - Kalpitiya, Poonery and Mannar

II. Shallow aquifers on built beaches

Ex: - Pulmudai, Nilaveli and Kalkudah

III. Medium deep aquifers with are red and yellow sands in the coastal plains

Ex: - Katunayake, Chilaw

Coastal watersheds are fed by rainfall. Due to the high quality of rain water, there is high quality drinking water in the coastal aquifer. Offshore seawater, or saltwater, is naturally located at the bottom of the system because of its high density. When an aquifer is bordered by salt water, the outflow of freshwater from the aquifer is limited.

(d) Alluvil Aquifer

It is the aquifer in the sediment that collects from coastal and inland floodplains. This wetland is located in the lowlands along the main rivers with a thickness between 10 to 35 m and receives a significant amount of groundwater throughout the year.

(e) Shallow Regolith Aquifer of the Hardrock region

Due to the low groundwater retention capacity in hard rocky areas, there is only a limited amount of groundwater in those areas.

(f) South Western Lateritic (Cabook) Aquifer

This Cabook ground has the potential to retain a significant amount of water in the ground and is highly sensitive to rainfall that begins in February-March in the dry zone.

[Source- A framework for groundwater policy for Sri Lanka, E.R.N. Gunawardena, P.K.D. Pabasara]

2.1.7. Recharge of Groundwater

Deep Percolation or Deep Drainage is the process by which water moves down from the surface of the ground and joins the groundwater during the Recharge of Ground Water. In this process water can be obtained naturally or artificially. Rainwater, snowmelt, and water from reservoirs or rivers are used to replenish groundwater naturally, as well as through artificial irrigation and certain human activities. Thus, groundwater recharge occurs in two ways.

(a) Dispersion recharging / direct recharging

Leakage of water causes a large inflow of water into the unsaturated zone of the groundwater table.

(b) Focal recharging / casual recharging

This is where water flows from surface water sources such as reservoirs or rivers into the aquifers below those water sources.

2.1.8. Factors affecting the recharge of groundwater

(a) Rainfall or the amount of water supply

When rainfall is high or frequent watering, the amount of water that seeps into the soil increases and the soil becomes saturated. Accordingly, the ground water level is increased. The flood situations due to the increasing of the rainfall, the permeability of the river bed is increased and it is increased the recharge of the ground water associated with the water bodies.

(b) Location of the land

Sloping ground increases the slope and the ability of absorbing water. The flow of water in the plains is limited and the amount of water that seeps into the soil increases and the groundwater level rises.

(c) Nature of rocks and soil

If the soil firmness is higher, the amount of soil space will be greater available in the soil, and it will be an enforcement to the logging of water. Therefore, the groundwater level is risen. Soil stability is determined by the soil structure. Gravel, sand, loosely compacted sedimentary

sandstones, etc. are provided adequate permeability to the groundwater movement. Also, the nature of the minerals that make up the rocks and the way they are bound is also important here. For example, unlike igneous rocks, digested rocks allow water to seep out.

(d) Structure of rocks

Unlike a horizontal rock layer, a sloping rock layer facilitates leakage of water.

(e) Plant population and other organic substances.

Retains water and allows more time to drain through the soil. Due to the plant roots, the disaster is reduced and the soil is easily saturated with water.

(f) Human activities

Man-made development and urbanization are some of the activities that expose the soil and accelerate the surface disaster. This is adversely affected on the recharging of groundwater.

2.1.9. Major Government Institutions Related to Groundwater Management in Sri Lanka

(a) Water Resources Board

The Water Resources Board was established in 1966 under the Water Resources Act No. 29 of 1964. Functioning under the vision of "Adequate supplying of clean and safe water to all", the mission of this organization is to work closely with the general public, relevant government departments / authorities / institutions, national and international organizations and local as well as foreign expert and professional groups in Sri Lanka. Advising the Government and the people on the assessment, protection, development and use of groundwater resources.

(b) Water Supply and Drainage Board - Groundwater Division

The Groundwater Division was established in 1979 with the aim of quenching the thirst of the people living in areas where piped water is not available. This division conducts hydrogeological physical tests for various purposes of groundwater sources and groundwater activities, groundwater extraction, well development and supply and construction of water wells, groundwater extraction, pump tests, groundwater problems, activities such as hydrogeological mapping and groundwater management and environmental impact assessment.

2.2. Authority for Audit

Audited under my direction in accordance with the provisions of Article (154) (3) of the Constitution of the Democratic Socialist Republic of Sri Lanka and the provisions of the National Audit Act No. 19 of 2018.

2.3. Objective of the audit

To evaluate the legal mechanism of groundwater management in Sri Lanka and its functioning in relation to the following processes in the proper discharge of their responsibilities by the relevant agencies.

i. Creating an appropriate institutional and legal background.
ii. Monitoring process related to ground water management
iii. Periodic testing of water quality
iv. Measures taken for ground water conservation
v. Inter-provisional arrangements between groundwater management agencies
vi. Analysis of Research done to use the ground water and evaluating the utilization of groundwater

2.4. Access to Audit

The following points were considered.

a) According to the existing groundwater studies, there is a risk of groundwater depletion in the future due to unrestricted groundwater abstraction.
b) There is a risk of increasing groundwater contamination by the use of agrochemicals and various other activities.
c) Inadequacy of the existing legal provisions for the protection of groundwater by applicable laws and regulations relating to groundwater management.

2.5. Scope and scope of the audit is limited

2.5.1. Compliance with international standards

My audit was conducted in accordance with the International Auditing Standards (ISSAI 5110 - ISSAI 5140) of the Supreme Audit Institutions.

2.5.2. Scope

In observing the findings of this report, the following points were taken into consideration.

i. Evaluating the legal provisions and their relevancy to the groundwater management.
ii. Evaluating the role of government institutions, responsible for sustainable groundwater management.
iii. Planning of groundwater and watershed management policy and evaluation of performance.
iv. Identifying the climate change mitigation strategies and the risks associated with increasing nitrate and chloride levels in groundwater due to climate change.

2.5.3. Limitations of the scope

a) It was not considered regarding the cultivation wells in this audit, as they require in-depth study.
b) There have been instances where no positive response has been received in obtaining information from the relevant parties to ascertain the contents of this report.
c) Due to the Covid 19 epidemic, in the year 2020, only a limited number of site inspections had to be carried out.

2.6. Audit methodology

2.6.1. Sources of Evidence

Relevant evidence was obtained from the following sources so that it could be considered quantitative and a reasonable conclusion could be drawn.

i. Inspection of the files
ii. Study of newspaper articles and journals
iii. Obtaining information from the Internet
iv. Study of research papers
v. Inter Reference of associated international Books

2.6.2. Other sources of evidence

Evidence was obtained from the following sources.

i. Discussing with the relevant officials
ii. Gathering and verifying various news items published through media notes
iii. Confirmation regarding the information submitted for the questionnaire

2.7. Audit Criteria

2.7.1. Compliance with the provisions contained in the policy ordinances under consideration

i. Water Resources Board Act No. 29 of 1964
ii. Water Resources Board (Amendment) Act No. 42 of 1999
iii. Irrigation (Amendment) Act No. 23 of 1983
iv. Water Supply and Drainage Board Act No. 02 of 1974
v. Chemical composition of water - SLAS 614 Drinking water quality standard
vi. . Extraordinary Gazette Notification No. 2010/23 dated 16th March 2017
vii. National Policy on Protection and Conservation of Water Resources, Their Wetlands and Reserves of Sri Lanka dated 22nd December 2014, 1894/3
viii. National Water Supply and Drainage Board (Amendment) Act No. 13 of 1992
ix. Agrarian Development Act No. 46 of 2000
x. National Environmental Act No. 47 of 1980

2.7.2. Criteria related to standard status and progress review

i. Reports of the Survey Board
ii. Project Progress Review
iii. National Action Plan to Prevent Land Degradation in Sri Lanka.

2.7.3. Comparisons, Criteria for trends

i. Increase in the number of tube wells established by the Water Resources Board
ii. Test data analysis of the water samples of 46 schools in Puttalam District

3. Audit observations

3.1 Legal background

3.1.1 National Policy on Protection and Conservation of Groundwater

Protecting rivers and streams is a first requirement for the sustainability of not only surface reservoirs and aquifers but also groundwater resources when observing the pattern of the usage of water in Sri Lanka. The Water Resources Management Project implemented with the assistance of the Asian Development Bank in 1992 had been stated the need to implement a Water Policy for Sri Lanka. However, the objectives expected from such a policy could not be achieved until 2014 and many years later, in 2014, the Ministry of Lands and Land Development drafted a National Policy. It was based on the protection and conservation of water resources and watersheds. Also, the need to formulate a water policy had also been raised at the workshops conducted by the Sri Lanka National Science Foundation in the years 2008 and 2010. However, it was observed that a groundwater policy based on the quantity and quality of groundwater in the provinces of Sri Lanka had not been formulated. As a result, the background has been prepared for further use of groundwater without proper management due to the inability to do so on the purpose in the formulation of plans and programs related to groundwater management.

3.1.2. Delegation of responsibilities and the ownership of groundwater

Following the enactment of the Local Government Act No. 42 of 1987 by the 13th Amendment, the responsibility for the management of groundwater areas came under the purview of the relevant Provincial Councils and through the 13th Amendment of the Constitution delegated management responsibility for other mineral resources. The 13th Amendment does not explicitly delegate groundwater management responsibilities, and it has been observed that many landowners determine the amount of groundwater available to them. Accordingly, the use of groundwater by landowners, investors and public places in an unrestricted and non-acceptable manner has been allowed to be used without regard to future environmental impacts on groundwater consumption.

3.1.3. Contribution of the Water Resources Board

Gazette Notification No. 1894/3 issued dated 22nd December, 2014 has been published the National Policy on the Protection and Conservation of Water Resources in Sri Lanka, their catchment areas and reserves. Although the Water Resources Board has been identified as primarily responsible for the use of groundwater or groundwater resources for drinking water projects and or for agricultural purposes under this policy, it has been observed that insufficient attention is being paid to groundwater conservation in the operational mechanism.

3.1.4. Obtaining a Chemical Analysis of Groundwater

Although the capacity of shallow groundwater reservoirs in the Kalpitiya Peninsula is sufficient to accomplish the drinking water requirement of a large number of people, according to the Extraordinary Gazette Notification No. 1894/3 dated 22nd December 2014 and in accordance with the paragraph 1.8 of the National Policy on Protection and Conservation of Water Resources, this water has become a condition of which the purification cannot be done ,due to the groundwater pollution caused by the addition of chemical fertilizers, agrochemicals and pesticides to the soil. Chemical analyzes of groundwater resources in this area in 2014/2015 and beyond were carried out until 2019 under the "Dam Protection Project". The Water Resources Board has recommended in 2015 to conduct a chemical analysis in this regard and minimize this situation. However, it was observed that it was not sufficient in identifying and the preparation of alternative methods of meeting those needs in relation to future groundwater demand.

3.1.5. Water Resources Board (Amendment) Act No. 42 of 1999

The Water Resources Board Act No. 29 of 1964 was amended by Act No. 42 of 1999 as an Advisory Board on Water Resources of Sri Lanka with an emphasis on groundwater in 1966, through the section 2 of the Water Resources Board (Amendment) Act No. 42 of 1999 was accommodated by Section 12(1) of Act No. 29 of 1964 and accordingly the functions of the Board had been stated as follows.

i. Preparation of detailed and interconnected plans for prevention of pollution of rivers, canals and other waterways and conservation, utilization, control and development of ground water resources of the country.

ii. Formulation of a national policy on the control and use of water resources in the country for the purpose of multi-purpose development and use of water resources, short-term and long-term supply of water for domestic and industrial purposes, and salinity control.

iii. Coordinate with Government Departments, Local Government Institutions and Government Corporations to carry out basic data analysis on hydrogeology, related researches there on, analysis of statistical survey plans and proposals based on proposals, coordinating upcoming projects in relations to , conserve, utilize and develop groundwater resources in the country.

iv. The capability usefulness of maintaining and economic feasibility of sustaining those projects had to be assessed.

The relevant observations were as follows.

(a) In terms of Sections 16 (1) and 16 (2) of the Water Resources Board Act No. 29 of 1964, the statutory powers pertaining to the functions of the Board in each case can be obtained by obtaining the necessary legal authority thereafter by drafting and publishing them in the Gazette. From 1964 until 1999, there was no legislation on groundwater conservation. In the 21 years from 1999 to 2020, only one legislature had been done in 2017. It was observed that a single legislation was not sufficient for the proper management and economic use of ground water and it was observed that the action to be taken by the Water Resources Board in this regard had not been taken up to the date of the audit.

(b) Imposing fines

Section 20 (1) of the Water Resources Board Act No. 29 of 1964 was amended by Section 04 of the Water Resources Board Amendment Act No. 42 of 1999. According to this section, the fine imposed on an offender under this Act, had been revised as Rs. 5,000.

Although a fine has been declared as above, it has not been observed under the Provisions Act for sentencing an offender for any offense. Also, by the year 2020, this penalty had not been revised for a period of 21 years. According to the information of Water Resources Board, no fines had been levied as at 12 October 2020.

(c) Utilization and control of groundwater

Section1 2 of the Water Resources Board Act No. 29 of 1964 was replaced by Section 2 of Act No. 42 of 1999. Among the functions of the Board which were expected to be included in the reclamation were the introduction of four main stages, namely the regularization and development of water resources, including the conservation and utilization of water resources in the country. However, it was observed that the Water Resources Board had not made adequate provisions for groundwater utilization and control.

3.1.6. Provisions of the Water Resources Board Amended Act No. 29 of 1964 and the (Amended) Act No. 42 of 1999

The new amendments to the Act removed the following points.

i. Improving afforestation and controlling the soil erosion
ii. Wildlife conservation, development of fisheries industry, aquatic flood control, land reclamation, supplying irrigation, hydroelectric power, liquefaction, industrial supply, supply of short-term and long-term water resources for supply, industrial waste and waste disposal and afforestation
iii. Preparation of Priority Scheme in the Development of River Basin and Road River Basin Projects

The following observations were made in this regard.

(a) Accordingly, it is observed that ground water development has been given priority than the ground water conservation, which is a major function of the Water Resources Board, in deviating from the Act on matters relating to afforestation and protection of the stability of soil.

(b) Determining the extent and quantities of groundwater that can be absorbed for various purposes It was observed that no provision has been made for groundwater abstraction while protecting the soil layer aquifers.

Due to this reason, it is observed that the Water Resources Board, as the nearest authorized government institution capable of dealing with groundwater management, has shied away from its responsibilities in this regard, which has allowed groundwater to be used more loosely and irresponsibly.

3.1.7. Extraordinary Gazette Notification No. 2010/23 dated 16th March 2017

(a) In accordance with the provisions of this Gazette, the Orders under Sections 16 (1) and 16 (2) of the said Act relating to the matters referred to in Section 12 (1) of the Water Resources Board Act, No. 24 of 1964 Published by Special Gazette Notification No. 2010/23 dated 16th March 2017. Among the provisions made by the relevant gazette notification, the following matters were very important.

i. Submission of all small- and large-scale industries using agricultural wells and water for proper approval of the relevant project proposal board before commencement

ii. Regarding the approval and supervision of the Water Resources Board for the construction of tube wells in a manner that does not harm the environment and reporting the water level obtained during the use of the relevant tube wells and the details relating to the tube well every 03 months.

iii. Submitting a report once in every 6 months on the samples of those water sources obtained from a recognized laboratory to a water source or ground water utilizing institution (06 has been identified) in accordance with Order 3 of the Gazette Notification.

iv. It provides access to the Water Resources Board for monitoring the activities of the relevant water resources and details of provisions and provisions that may be legally enforced against institutions and individuals who violate the relevant terms and conditions.

(b) The following matters relating to the execution of the orders issued by the aforesaid Gazette are observed.

i. The implementation date of the above orders is 16th March 2017 and it is observed that prior to this date, there had not been evaluated in relation to the groundwater conservation and groundwater projects, activated in Sri Lanka. This gazette notification was the first order issued under Section 16 of the Water Resources Board Act No. 29 of 1964, which did not achieve the objectives of establishing the Water Resources Board and did not regulate groundwater abstraction in Sri Lanka.

ii. Although it is important to consider both the diameter and the depth of the well in relation to the volume of ground water, Article (1) (a) of the Gazette has focused only on the diameter of the wells to be constructed for agricultural purposes. This did not observe the regulation of the level of infiltration into the groundwater and the volume of water that could be removed from a well.

iii. It is the role of the Water Resources Board to issue the guidelines for the construction of tube wells in accordance with the directives issued by the above Gazette Notification. The Water Resources Board had not issued groundwater regulatory guidelines from 1964 to 2020. It was also observed that the construction of tube wells is being carried out by both the Water Supply and Drainage Board and the Water Resources Board. Accordingly, it was observed that the functions of the institutions conducting their corporate activities under 02 main objectives had not been carried out with a single guideline.

iv. Number of 443 tube well constructing institutions had been obtained the registration under the Water Resources Board As at 30th June 2020, the groundwater division established under the National Water Supply and Drainage Board was also operational as a tube well construction company in Sri Lanka but had not been registered with the Water Resources Board until 16 August 2020. It was thus observed that the intended objectives of this order had not been achieved.

3.1.8. Action plan to prevent land degradation

Following are the reveals in relation to the National Action Plan on Land Prevention in Sri Lanka, prepared by the Ministry of Environment and Renewable Energy.

(a) A groundwater related program was also identified by the National Action Plan for Prevention of Land Degradation in Sri Lanka prepared by the Ministry of Environment and Renewable Energy which was approved by the Cabinet on 24th July 2014.

(b) As the 16th program of this National Action Program, Sustainable Groundwater Childhood promotion has been identified. There are different types of water bodies in Sri Lanka and the availability of water depends on the nature of these reservoirs. In many parts of the country, water is traditionally used for domestic purposes using shallow wells. Groundwater has traditionally been used for irrigation only in a limited number of areas, such as the Jaffna District. However, over the past two decades, groundwater has been used extensively for irrigation in an unorganized manner. Government and non-governmental organizations have encouraged the construction of shallow wells and provided financial assistance.

(c) This tendency has led to a drop in the groundwater level in the dry zone where large number of wells have been dug. Some wells have been abandoned by now. It has been reported the brackish water sources and incidents of polluting. Groundwater density is very high in some areas. Chronic kidney disease (CKD) is also reported to be more prevalent in areas where well water density is high. An assessment of groundwater resources in Sri Lanka shows that this resource is being used on a scientific basis and prudently utilized to promote its sustainable use. The program will address the first two strategic objectives.

(d) The 16th program of this program promotes sustainable groundwater management, the objective of which is to prevent groundwater use and water pollution. Based on this, new trends in groundwater abstraction and water quality were identified as the underlying data and the expected impact of this program will be on the establishment of systematically managed non-polluted groundwater reserves in the country. Fair groundwater extraction and high quality water have been identified as the main impact indicators in this regard.

The following points were observed under each of the activities of the program.

i. The Water Resources Board is the main responsible body for its implementation under Activity No. 01 and the Supporting institutions are the Department of Irrigation and the Ministry of Water Resources Management. The estimated cost of this program is Rs. 108 million and was scheduled to be operational from 2015 to 2016. As at 31 December 2019, it was observed that the physical progress of this program was 88 percent and the overall progress was only 66.78 percent.

ii. The Ministry of Irrigation and Water Resources Management, the Central Environmental Authority and the Water Resources Board were identified as the main responsible institutions implementing it under Activity No. 02, while the Irrigation Department and the National Water Supply and Drainage Board acted as the supporting agencies. The estimated cost of this program is Rs. 0.25 million and was scheduled to be operational between 2016 and 2017. By the date of the audit, a legal framework had not been prepared and orders had not been issued.

iii. The Water Resources Board is the main responsible institution for its implementation under Activity No. 04 and the estimated cost of this program is Rs. 34 million. The program was scheduled to be implemented in the period 2016-2023. By December 2020, only observation reports had been identified as performance indicators.

iv. The responsible institutions implementing it under Activity No. 05 are the Department of Agriculture and the Provincial Department of Agriculture and the Agencies are the Department of Agrarian Development and the Department of Irrigation. The estimated cost of this program is Rs. 3.75 million and is scheduled to be implemented in the period 2015-2024. It was observed that the methodology for measuring this function was not clear from the indicators.

v. In implementing these programs, it is essential to maintain an up-to-date database reviewing the progress of all affiliated organizations within the National Active Program Management Directorate, but such situations were not observed during the audit.

3.2. Measures related to ground water conservation

3.2.1. Activity of the Water Resources Board

The following observations were made

(a) Prevention of contamination of waterways

Research studies on groundwater quality and quantity are carried out by the Water Resources Board as measures taken to prevent pollution of rivers, canals and other waterways, are the activities related to the development of ground water resources, activities required to prevent contamination of ground water resources, giving advice and recommendations and determining the water capacities that can be obtained from water sources without harming the environment, in terms of Section 12 (1) (b) of the Water Resources Board (Amended) Act No. 42 of 1998. However, it was observed that the measures taken to prevent pollution of rivers, canals and other waterways by the Water Resources Board were insufficient. Examples include the cemeteries constructed associated with the river banks, the unauthorized constructions along the Kelani River and the dumping of industrial waste into the river can be stated as several examples.

Diagram - No. 01 - Cemeteries and unauthorized constructions associated with the Kelani River

(b) Controlling the Salinity

Short-term and long-term investigation and reporting of the changes in salinity in the western, southern and northeastern coastal areas of the island had been stated as the measures taken by the Water Resources Board to control the salinity of water in terms of paragraph (c) (iii) of section 12 (1) of the Water Resources Board (Amended) Act No. 42 of 1999.However, it was observed that a follow up is not being done whether the recommendations are functioning , regarding the controlling of the salinity of water by the Water Resources Board.

(c) Maintenance of water sources supplying water to tube wells.

The Water Resources Board is required to maintain the water sources that supply water to the tube wells. Making necessary recommendations by design and evaluation in a sensitive area and implementing the recommendations of the relevant government agencies on the basis of the evaluation recommendations for informal commercial and gravel mining has been stated as the measures taken in this regard. It was observed that the Water Resources Board had not been given the authority to take action on unauthorized constructions and illegal land acquisition in areas with water sources that supply water to the above tube wells and it was observed that there is a possibility of the waterlogged areas would be threatened.

Diagram - No.-02

(d) Laboratory analysis reports

According to Order 03 of the Extraordinary Gazette Notification No. 2016/23 dated 16th March 2017, if any institution, organization or individual engaged in the bottling industry or beverage industry uses a natural water source or ground water for its production activities, it is a sample of the relevant water source and the analytical report of a test should be submitted to the Water Resources Board for approval by a government recognized laboratory every 06 months. There were 22 water bottling industries and beverage industries registered From 1 January 2012 to 31 December 2019 and out of that only 05 industries had submitted laboratory reports for the period from 01 January 2018 to 31 December 2019. Details are below.

Name of the Industry		Relevant Time Period	Name of the Laboratory
i.	Coca cola Beverage Sri Lanka (Water samples were tested on 03 occasions)	From 2018.06.12 to 2020.02.12	Industrial Technology Institute
ii.	Lion Bruere Ceylon PLC	From 2018.01.25 to 2019.02.09	SGS Lanka (pvt) Ltd
iii.	Air Force (Lagle spring water)	From 2018.03.05 to 2018.04.18	Industrial Technology Institute
iv.	Belt plantation	From 2018.09.26 to 2018.10.08	Water Resources Board
v.	Vihara natural products	From 2018.02.20 to 2018.03.26	Industrial Technology Institute

Table-01

According to this gazette notification, the government recognized laboratories are the Industrial Technology Institute, the Water Resources Board, the Water Supply and Drainage Board, the Sri Lanka Standards Institution, the Geological Survey and Mines Bureau and the National Building Research Institute have been stated.

The following were the observations.

i. It was observed that an adequate program is not being implemented for regulate the 77% of industries which conducting water bottling or beverage manufacturing due to non-submission of the water samples to the Water Recourses Board .

ii. Out of the 05 industries where water sampling was reported, it was observed that the various parameters such as water depletion level, total iron content, manganese, chemical oxygen demand, alkalinity and aluminum in 03 industries had been reported, exceeding the limits of various parameters.

iii. Among the above 05 industries, Lion Bruere Ceylon (PLC) has tested water samples and obtained chemical reports from SGS Lanka (pvt) Ltd, a non-government recognized laboratory. Accordingly, it was observed that there was a problem regarding the acceptance of those reports and the adequate attention regarding this matter had not been paid by the Water Resources Board.

(E) Institutional or on-site inspections

The Water Resources Board reserves the right to enter and inspect these locations at any reasonable time of the day, with or without prior notice, at any institution or location where products or services are carried out using natural springs or groundwater. In the year 2019, the Water Resources Board had conducted 07 such tests and it was revealed that 4 institutions were using water without conducting water capacity tests and 03 institutions were using water without plumbing fixtures. Out of these institutions, 04 are in the Kurunegala District, one in the Puttalam District, one in the Ratnapura District and the other institution is in the Matale District.

Here are the following observations.

i. It was observed that only 07 tests have been carried out for the year 2019 and it was observed that these tests are not sufficient to confirm the sustainable use of ground water.
ii. In the above tests, it was observed that there is a possibility of excess water intake by the institutions which use ground water in the case of institutions which have not carried out water capacity tests and have not installed water meters.
iii. The above inspections were limited to Kurunegala, Puttalam, Ratnapura and Matale districts and it was observed that the inspections were not carried out covering all parts of the island.

(F) Updating data on construction of tube wells

Data on new constructions carried out by the Registrar for the Construction of Tube Wells should be submitted to the Water Resources Board every 03 months. However, these agencies have stated that they do not provide data on new construction every o3 months. The following observations were made in this regard.

i. It was observed that in the non-disclosure of information on new constructions carried out by the companies registered for the construction of tube wells to the Water Resources Board, there is an opportunity for the drilling companies to construct tube wells without proper technical procedures and also to construct tube wells in unsuitable places. It was observed that groundwater could be adversely affected.
ii. Although boreholes used by institutions registered under the Water Resources Board have to obtain a certificate of registration from the Water Resources Board annually, boreholes used by the Water Supply and Drainage Board had not met this requirement

(g) Identify the sensitive areas

The Water Resources Board has identified the Kalpitiya, Jaffna Peninsula and the Colombo-Negombo coast as sensitive areas for groundwater protection in Sri Lanka. These zones were identified as sensitive zones by a study based on their geological location and should have been declared as sensitive zones by a gazette notification. Although the opportunity to properly manage the identified sensitive areas and take steps to protect them was available through the publication of a gazette notification, but this had not been done accordingly.

(H) Water capacity testing

In water capacity tests, water is pumped continuously at selected speeds for 24 or 48 hours, 72 hours, and the water level in the surrounding wells and tube wells is monitored. After analyzing the data obtained in this way, recommendations are made for the safe amount of water that can be obtained without harming the environment and the number of hours that need to be pumped per day. Accordingly, it is essential to determine the amount and duration of water available per day experimentally in order to obtain groundwater in a manner that does not harm the environment and the aquifer.

The Water Resources Board conducts water capacity tests and makes recommendations on daily safe water availability and water availability periods. Here it is very important to install water meters and systematically follow up on the data to check whether the water is being taken in accordance with the relevant recommendations.

It was observed that out of the ground water aquifers registered with the Water Resources Board, water meters have not been installed for 256 establishments. It was observed that there is a risk of excessive water extraction in groundwater intake without the installation of water meters.

(I) Regulations for groundwater development

It was stated that regulations are being prepared for groundwater development and management at the river basin level. It was observed that, adequate regulations had not been formulated and implemented by the date of the audit.

3.2.2. Functioning of the Groundwater Division of the National Water Supply and Drainage Board

The Groundwater Division was established in 1979 by the National Water Supply and Drainage Board to provide drinking water to the people living in areas where piped water is not available. The Groundwater Division of the National Water Supply and Drainage Board has installed about 27,000 hands Pumps Island wide to meet the water needs of the rural population. Most of them were built during the 1980s - 1990s water decade and the Udagam period. The lifespan of a tube well is about 05 years and there are about 15,000 tube wells scattered throughout the island. Tube wells are maintained under the three-pronged approach of the Municipal Council, the Water Board and the public. The UNISEF institution has submitted project proposals for this purpose and Rs. 100 million has been given by the equipment and cash. That money was used to rehabilitate and repair tube wells in Moneragala, Kurunegala, Vavuniya, Mannar and Kalutara.

(Groundwater Division Information of National Water Supply and Drainage Board)

The following were the observations.

(a) The total number of tube wells constructed by the National Water Supply and Drainage Board covering 25 districts in 09 provinces of Sri Lanka during the last 05 years was 1,263 and the amount spent on construction was Rs. 727, 580, 802.

(b)) About 40 percent of the tube wells constructed in the 25 districts were confined to the 04 main districts such as, Kurunegala, Polonnaruwa, Vavuniya and Nuwara Eliya. Although, it was depicted that, the groundwater level that can be absorbed per day has increased in the 03 districts of Kurunegala, Polonnaruwa and Vavuniya over the past 05 years, a gradual decrease of that level in Nuwara-Eliya district was observed.

(c) The Mullaitivu, Mannar, Ratnapura, Moneragala, Kandy and Badulla districts also observed a gradual decrease in their daily water intake, compared to 2015.

(d) In the years 2015 and 2016, the Groundwater Division had conducted 03 researches and no research had been conducted in the years 2017 and 2018.

(e) Although Wariyapola had initiated groundwater recharge as an activity survey model, it was observed that this concept had not been implemented at a more widespread level as a groundwater conservation activity.

(f)) Gampaha, Puttalam, Moneragala, Hambantota, Vavuniya and Mannar districts are observed as having high monthly ground water production during the testing of 62 major water supply schemes implemented by the Water Resources and Drainage Board in 16 major districts. Jaffna, Kilinochchi, Gampaha, Vavuniya, Mannar, Ratnapura and Ampara districts were observed as the districts with higher demand within the next 05 years as forecasted.

(g) The Jaffna and Kilinochchi districts are expected to have a forecast demand of 649 per cent per month over the current capacity for the next 05 years, while in the Gampaha and Vavuniya / Mannar districts it was observed to be 251 and 230 per cent respectively.

3.2.3. Groundwater recharge

It has now been revealed that water consumption from aquifers on Earth is high, which is much higher than the rate at which groundwater recharges. Therefore, groundwater recharge is a very important process for sustainable groundwater management.

Groundwater is constantly being extracted for a variety of activities, most of which is groundwater. Examples include obtaining drinking water from wells for other human activities as well as gardening and farming. Groundwater is also extracted from tube wells in arid areas. Groundwater recharge is required if water is to be continuously available for these activities.

(a) Methods of improving groundwater recharge

Since groundwater recharge is a mandatory process and the rate at which it occurs naturally is insufficient, tactics have to be used to improve this process.

The following steps can be taken for this.

The action	**Ways to can be done**
i. Increasing water drainage and leakage	Improving soil structure, adding organic matter to the soil, improving soil texture.
ii. Cultivating plants	reduces surface damage and plant roots increase soil fertility and accelerate leakage
iii. Improving the flowing of water	Construction of water flowing ditches, basins, pits etc.

Table No. 02

The following observations were made in this regard.

(a) Rapid increase in the rate and volume of groundwater discharge due to population growth in Sri Lanka, increase in the use of irrigation water for agricultural purposes and use of groundwater for industrial purposes may occur and the rate of groundwater recirculation is relatively low. It was observed that the Groundwater Regulatory Authority of Sri Lanka had not laid down the regulations pertaining to the recharging of groundwater.

(b) It was observed during the audit that the inclusion of groundwater recharge methods should be a mandatory requirement in projects such as buildings and houses.

3.2.4. Conservation of Coastal Groundwater (Costal Aquifer)

Coastal aquifers with sandy or loamy soils have the potential to store large amounts of water. Therefore, coastal aquifers are of great importance in terms of productivity. Also, the permeability or the speed of flowing water is very high. And also, there are instances where the pollution takes place very quickly. The salinity was also very high. The following observations were made in this regard.

i. It was observed that regulations for controlling excessive groundwater discharge in coastal areas had not been prepared and published as regulations.

ii. Inappropriate application of approved fertilizers and pesticides and unapproved application of fertilizers and pesticides for coastal groundwater aquaculture can increase the nitrate concentration in the soil. Accordingly, there is a need to adopt organic farming methods in agriculture or to adopt approved practices that use approved chemical fertilizers and pesticides in approved doses or to minimize their use.

3.2.5. Functional projects related to ground water management

(a) As per the report on long term groundwater study prepared by the Water Resources Board for the year 2018, the details of each study program implemented under the aforesaid project and its recommendations are given in the table below.

Program	Recommendations
i. Detailed geohydrological study of the coastal aquifer system from Colombo to Negombo	• Sample testing should be continued to identify changes in the groundwater quality survey. • Except these 40 locations, further research should be done on locations that show high nitrate values, high electrical conductivity, and low alkalinity values. • The study network of Groundwater level should be continued. It can detect changes in groundwater patterns caused by climate change.
ii. Geohydrological study of limestone aquifers in Mannar district	• Higher capacity of Qualitative groundwater is in the areas such as Nanattan, Nagachetty and Iruvitwany and those wells had been recommended for irrigation schemes. • The construction of tube wells for paddy cultivation should be controlled for a long time as the ground water is polluted by salts. • It was recommended to take samples twice a year and perform all chemical tests (including sodium and potassium) to measure the quality of deep and shallow aquifers.
iii. Long term geological study conducted in Anuradhapura district	• Due to the geographical location of the fluoride-containing minerals, a high fluoride concentration in the chemical parameters is indicated. • High evaporation and salt accumulation can indicate high electrical conductivity. • The resulting salinity can be increased the hardness values, through that, the temporary hardness and permanent hardness can be occurred. • Monitoring will also be carried out during the dry and wet seasons of 2019 by an established monitoring network covering all sensitive areas in the district.
iv. Identifying the suitable areas for recharging groundwater	• Rainfall appears to be significant, when considering the changes in the water level of the shallow aquifer in the areas such as Kalpitiya, Bundala and Puttalam. Suitable areas for groundwater recharge can be identified in terms of electrical conductivity variation and

	total diffusion of iron. In some areas, the quality of water decreases as the rising of the level of water. • Artificially replaceable deep locations can be identified according to geological conditions and groundwater level variations. Areas suitable and unsuitable for groundwater reclamation should be identified taking into account variations in groundwater level and groundwater quality with rainfall patterns.
v. Geological study of Vavuniya district	• Data on water quality and water level in 2019 should be studied to identify the relationship between precipitation and chemical parameters of groundwater. • Excessive intake of groundwater from the tube wells in the study area should be controlled. • In order to identify changes in the chemical parameters and water level of the ground water and also to identify the problems related to the ground water, the network of wells in the area should be monitored regularly in order to cover this study. • The viability of different groundwater bodies should be assessed. • The long term objective of this project is to develop standards and guidelines for the sustainable development of groundwater.
vi. Geological study of Kilinochchi district	• This study has identified that there are a number of locations with ground water resources of good quality in the Kilinochchi District. Utilizing that groundwater for water supply schemes can provide such facilities to areas where drinking water is scarce. • Groundwater quality in agricultural areas should be closely monitored to detect the damage to the quality of water due to excessive water intake, low water levels and overuse of agrochemicals. • Long term groundwater monitoring should be carried out in the Kilinochchi District to identify changes in groundwater due to climate change and human activities.
vii. Groundwater Assessment in the	• According to the data analysis conducted in the study, no significant groundwater quality deterioration has been identified in the upper basin of the Kelani River in the year 2018. This may be

Kelani River Basin (Part I)	due to the declining population and declining industrial expansion in the area. • Groundwater contamination can be caused by local sanitation systems, landfills, sewage treatment plant leaks, sewer leaks, gas stations and overuse of fertilizers, pesticides and herbicides. In the future, if the above pollutants are added to the upper Kelani river basin, the quality of the water may deteriorate. • Therefore, a continuous groundwater monitoring program should be implemented to identify such situations and seek immediate treatment.
viii. Groundwater assessment in the Kirindi Oya basin	• The quality of the water may deteriorate due to the parameters such as alkalinity of water (PH), Electrical conductivity (EC), Total dependent solids (TDS), salinity, mainly in the upper reaches of the Kirinda in the Hambantota District and at the Lunugamvehera locations in the Moneragala District.Therefore, the majority of these areas are unsuitable for direct use of groundwater for drinking purposes and a suitable filtration system should be used to provide drinking water to the rural population. • Groundwater accumulated in the sand dunes of Kirinda coastal area shows good quality. Currently, groundwater is used for water supply schemes in the area and for domestic consumption in hotels. This valuable water resource should be protected and the continuous monitoring should be done to check whether the mixing of salinity water or the deterioration of the quality of water due to higher intake of water from the tube wells. • It is expected to implement a monitoring program in the Tissamaharama Divisional Secretariat Division in the Hambantota District where high salinity levels are reported in the near future. Here more water samples need to be collected to map the quality of the water and identify the reasons for it.

Table No. 03

Although the project cost of Rs. 2 million in the year 2019, the progress of implementing the recommendations for each project was not observed during the audit.

3.2.6. Pilot project to establish a groundwater survey network

Due to the rapid increase in the use of ground water resources and the potential for water resources to be endangered due to water pollution, proper management of groundwater in Sri Lanka has become an essential matter. This required the provision of timely data on the quantity and quality of groundwater, for which a pilot project was implemented to establish a "groundwater surveying network" in 03 selected districts of the island.

Under this project, an underground water treatment network has been constructed in three river basins covering Anuradhapura, Polonnaruwa and Moneragala districts where kidney disease has spread due to contaminated groundwater. The estimated cost of the project, which will be associated with the Malwathu Oya, Maduru Oya and Kumbukan Oya river basins, is 20.63 URO million, of which Rabo Bank of the Netherlands has been agreed to finance 85% of it.

Preliminary studies, the first activity according to the project action plan, are currently being carried out by a foreign company in conjunction with the Project Management Unit of the Water Resources Board, and about 60% of the preliminary studies have been completed.

The following observations were made.

(a) Groundwater control requirements in Mannar, Anuradhapura, Puttalam and Vavuniya districts have been observed in the year 2018 in accordance with the above research. It was observed that 38.64 percent of the total number of tube wells constructed by the year 2019 were related to those 4 areas.

(b) Due to the high salinity recorded in the ground water in the Tissamaharama Divisional Secretariat Division, the existing measures to expedite the necessary measures to manage that condition were not adequately observed.

3.3. Special status of the usage of groundwater in Sri Lanka

3.3.1. Establishment of wells by the Water Resources Board

By the year 2019, the Water Resources Board has installed 10,546 tube wells in 25 districts and the details are as follows.

District	Number of tube wells by the year 2015	2016	2017	2018	2019	Total number of tube wells by the year 2019	Number of tube wells belonging to each district as a percentage of the total number of tube wells by the year 2019 %
Ampara	372	10	2	6	0	390	3.70%
Anuradhapura	614	13	32	51	14	724	6.87%
Badulla	362	28	19	14	7	430	4.08%
Batticaloa	164	4	0	0	5	173	1.64%
Colombo	267	8	6	0	1	282	2.67%
Galle	176	3	0	1	8	188	1.78%
Gampaha	561	6	20	10	18	615	5.83%
Hambanthota	1019	2	8	6	3	1038	9.84%
Jaffna	269	103	23	4	2	401	3.80%
Kaluthara	91	9	4	0	2	106	1.01%
Kandy	92	0	3	0	2	97	0.92%
Kegalle	11	10	1	3	5	30	0.28%
Kilinochchi	90	10	13	15	9	137	1.30%
Kurunegala	501	4	13	15	12	545	5.17%
Mannar	269	18	26	19	0	332	3.15%
Mathale	296	48	17	40	2	403	3.82%
Mathara	27	0	5	0	0	32	0.30%
Moneragala	553	68	73	28	16	738	7.00%
Mullaitivu	112	25	18	11	16	182	1.73%
Nuwara-Eliya	57	2	1	1	1	62	0.59%
Polonnaruwa	310	5	12	14	2	343	3.25%
Puththalam	1843	25	17	22	20	1927	18.27%
Rathnapura	113	0	1	0	0	114	1.08%
Trincomalee	118	15	24	7	2	166	1.57%
Vavuniya	1030	22	3	16	9	1091	10.35%
	9317	438	341	283	167	10546	

Table No. 04

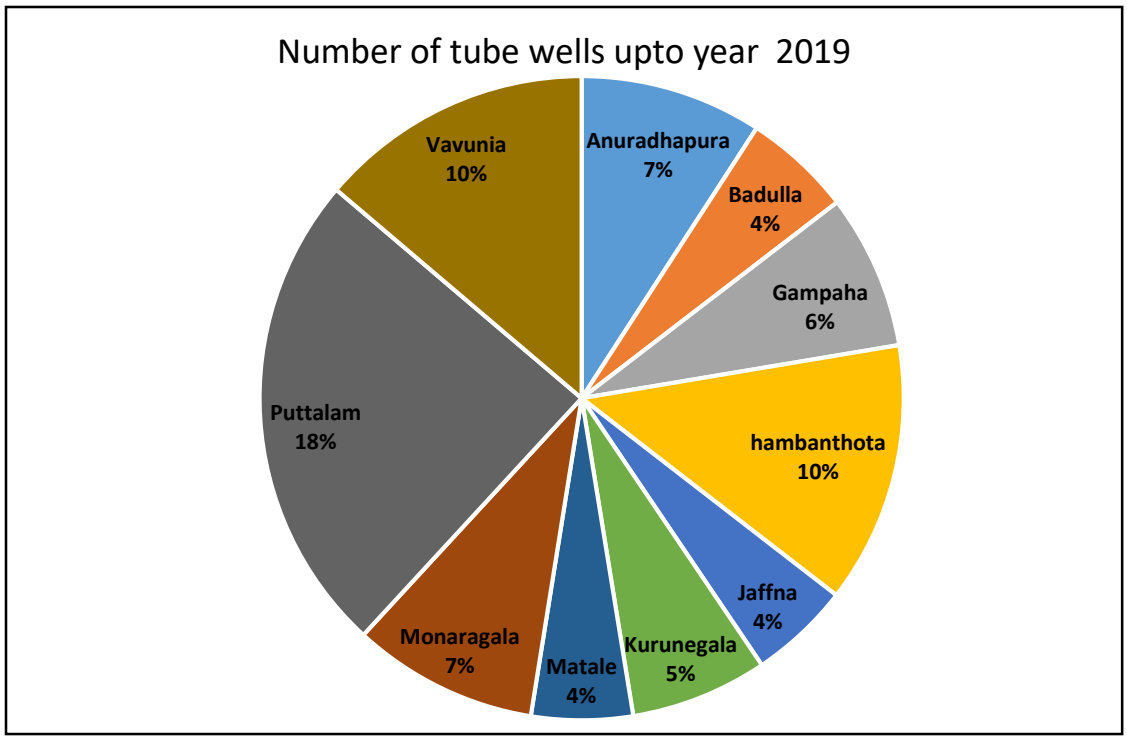

Diagram - No. 03

(A) Accordingly, the total number of tube wells constructed by the Water Resources Board by the year 2019 is 10,546 and it was observed that the highest number of tube wells had been constructed in Puttalam, Vavuniya and Hambantota districts respectively.

(B) From 2015 to 2019, 1,229 new tube wells have been constructed and the growth of tube wells in Kegalle, Kilinochchi and Mullaitivu districts has increased by more than 50 percent as per the trend of construction of new tube wells. It was observed that the construction of tube wells in these districts could lead to long term groundwater shortages.

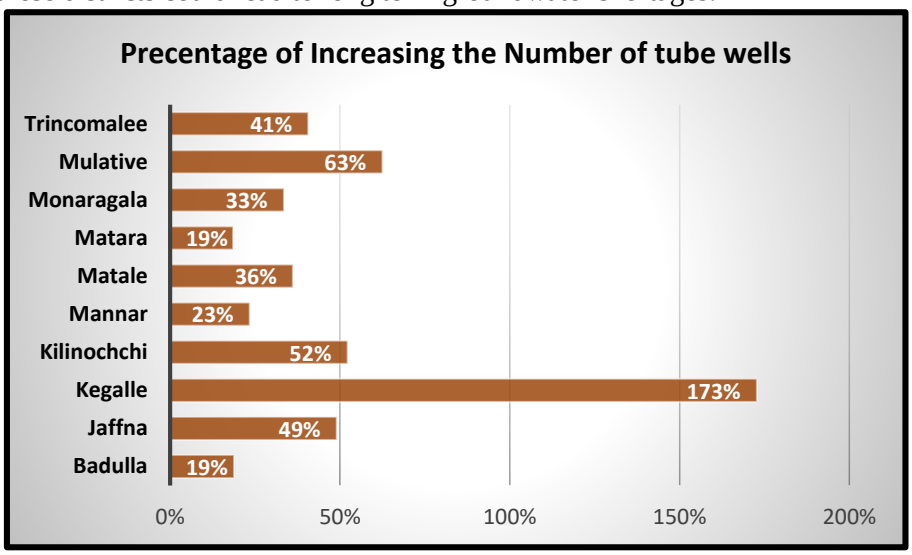

Diagram - No.04

3.3.2. Use of groundwater in export processing zones

Groundwater is also used for industrial production and consumption in 07 export processing zones in Sri Lanka. The 61 industries in the export processing zones that use groundwater use 32,605 cubic meters of groundwater per month and there are 14 wells in the export processing zones that are currently closed using groundwater.

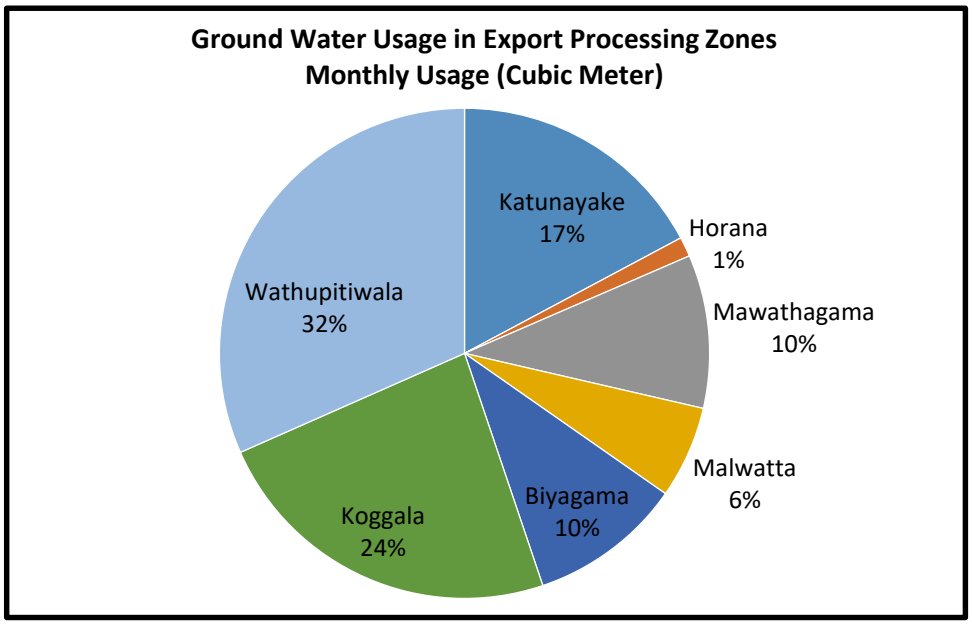

Diagram - No.05

None of the 61 industries which are used groundwater are being used groundwater with being registered with the Water Resources Board.

The following observations were made in this regard.

3.3.2.1. Wathupitiwala Export Processing Zone

(a) The Export Processing Zone in Wathupiyiwala is the main one accordingly. It was observed that 41 percent of the ground water, used for export processing zones is equipped for the Wathupitiwala industries. Accordingly, there is a tube well belong to the Board of Investment in the Export Processing Zone in Wathupitiwala and 05 tube wells belong to private factories, and 10,310 cubic meters of groundwater is used per month in the zone. However, the audit observed that there was a difficulty in obtaining sufficient water to meet the daily water requirement of the Wathupitiwala export processing zone.

(b) Out of the daily water requirement of 12070 cubic meters in the Export Processing Zone 230 is obtained from a tube well belong to the Board of Investment and 155 cubic meters of water is obtained from tube wells belonging to other factories. Although it was planned to obtain 550 cubic meters of water from the Ranpokunugama water project and 335 cubic meters from the Mirigama Export Processing Zone, the Water Supply and Drainage Board was unable to supply the required 550 cubic meters.

(c) It was observed that the tube wells belonging to the Board of Investment in the Wathupitiwala Export Processing Zone do not carry out adequate laboratory tests on ground water and it is observed that this ground water is collected along with the water supplied by the Water Supply and Drainage Board to the proper standard and distributed for the needs of the region. It was observed that by distributing water without daily testing of the quality of the groundwater, it is not possible to be satisfied that the water is at a suitable level for the drinking water requirement.

3.3.2.2. Katunayake Export Planning Zone

(a) The Katunayake Export Processing Zone will provide ground water at a cost of Rs. 10 per a cubic meter of ground water, and the industries will not be allowed to drill additional wells. One industry is working on a rainwater harvesting project and a volume of 70 cubic meter water storage tank. Groundwater consumption is around 1800 m3 per day for the Export Processing Zone. The need for systematic use and conservation of groundwater was observed during the audit as the Katunayake Export Processing Zone belongs to a coastal groundwater body and there is a possibility of salinization due to such high-water consumption.

3.3.2.3. Horana Export Processing Zone

It is also being implementing a 12 cubic meter rainwater harvesting project by 04 factories in the Horana Export Processing Zone, 04 factories in the Seethawaka Export Processing Zone and a factory in the Mawathagama Export Processing Zone. The need to encourage such projects was observed during the audit as the promotion of rain water management projects can lead to sustainable water consumption.

3.3.2.4. Koggala Export Processing Zone

The amount of water removed annually in the Koggala Export Processing Zone is 92,160 cubic meters and It was observed that an increase in this volume or the removal of excess water, could be occurred the risk of salinization.

3.3.3. Groundwater consumption in the Katunayake International Airport

The following observations were made in this regard.

(a) It is observed according to the information provided that 36 tube wells have been installed at the Bandaranaike International Airport, Katunayake and 26 of these tube wells have been gradually started since 1987.

(b) In accordance with the powers vested in it under Section 16 of the Water Resources Board Act No. 29 of 1964, the construction of tube wells shall be carried out in accordance with the instructions given by the Water Resources Board in accordance with Regulations 02 and the amount of water that can be obtained from it without harming the environment and the accurate assessment should be done under the supervision of the Water Resources Board and the relevant approval should be obtained. Accordingly, the relevant institution should install a flow meter to measure the amount of water obtained per day and should be maintained data on the amount of water received daily. Although the institution was obliged to submit this for testing whenever necessary, it was observed that none of the tube wells at the Bandaranaike International Airport premises were fitted with flow meters. Out of the 26 tube wells installed at the airport, 15 is said to be inoperable due to the current development work at the airport and poor performance.

3.4. Impact of groundwater pollution

3.4.1. Groundwater pollution

(a) Groundwater is a complex and ambiguous system with many uncertainties. That is, it is affected by various geological and hydrological factors. Risk assessment of groundwater pollution is an effective methodology for the protection of groundwater resource. Risk factors for groundwater pollution can be identified in several main ways such as sources, pathways, receptors, and consequences.

The U.S. Environmental Protection Agency has introduced the "DRASTIC methodology" instead of the traditional methods used to identify the risk of groundwater contamination. There, it is identified about the corruption based on the following parameters.

D - Diction of ground water

R - Net Recharge

A - Aquifer Media

S - Soil media

T - General Topography or slope

I - Vadose Zone

C - Hydraulic Conductivity of the aquifer

Here, groundwater pollution routes can be identified mainly under two types. That is, as target and non-target sources. Target sources include petrol or oil deposits buried in the earth's crust, mold systems, industrial sources, landfills, or accidental oil spills could be stated. Non-target sources can be caused by various chemicals and nutrients entering the soil. Contaminants in the places where the recharging of groundwater is taken place, sometimes flow in the direction of topography. In such cases, the amount of the transmitting of contaminants included in the groundwater depends on the strength of the soil layer.

(National Ground water Association - USA)

(b) The following factors were observed in relation to the zones and fields covered by the audit in relation to ground water pollution

i. Although the research paper experiments conducted by hydrologists so far have observed the need to formulate and implement a long-term action plan for the direct and indirect of identified sources of groundwater pollution in Sri Lanka, it had not been acted upon.

ii. An analytical study conducted by the Water Resources Board on groundwater in 06 districts has revealed that the nitrate concentration in groundwater in Jaffna is currently high. Also, the risk of salt water contact with groundwater was identified in the Chavakachcheri area. However, the audit could not identify any action to be taken in this regard.

iii. Groundwater in areas such as Samanthurai, Karativu, Valachchenai, Purankadu, Nainaveli, Kalpitiya and Wanathawilluwa in Ampara, where agro-economic activities are widespread, has been identified as being affected by the high use of herbicides and pesticides. However, the attention had not been focused on the governance, regulation or regularization.

iv. According to the Studies done in urban areas have identified that high levels of nitrate in groundwater, it had been revealed that the problems prevailing in sanitary conditions and the water flowing properties inside the soil had been caused for that. However, the attention on the causes of the increasing of nitrate composition and their control had not been focused.

3.4.2. Artificial recharging of groundwater

Following are the key findings of the research conducted by Ramya, R1, Nandakumaran, A1 and Senanayake, IP2 in 2019 in this regard.

(a) Although the extent of cultivable land in the Vavuniya District in the year 2015 for agricultural development activities is 21,016 hectares per year, but the extent of cultivated land is 16,599 hectares. It was observed that the main factor contributing to this was water scarcity. According to the above research paper on Groundwater Artificial Rechargeability Testing as a Remedy to alleviate this water shortage, areas with potential groundwater recharge in the Vavuniya District have been identified using modern technology. According to the study, it had been stated that the groundwater recharge had a potential of 44 percent, compared to 06 percent in the study area. However, an enough attention regarding this issue had not been paid through the annual activities of the institute.

(b) Areas of groundwater use in the Kilinochchi area were identified as a result of research conducted in the year 2016. According to the investigation it had been identified that groundwater was present at very good and moderate levels in nearly 66 percent of the total area under research. Accordingly, it has been identified that rain water should be used for recharging of ground water in this area as well. The conditions concluded by such research papers are very important in situations where there are financial and physical constraints on infrastructure development. Thus, it is observed that artificial rainwater harvesting can be used as a management tool to withstand climate change through project planning and development of guidelines for the use of rainwater for artificial recharging of groundwater in the identified areas associated with Kilinochchi.

3.4.3. The combination between chronic kidney disease and groundwater

Research into the link between chronic kidney disease and groundwater has revealed the following. Geochemical tests were carried out in the Girandurukotte-Ginnoruwa area, which is a high-risk area for chronic kidney disease, and the chemical parameters of the wells used to supply drinking water to patients with chronic kidney disease and the wells used by non-sick people in the vicinity were examined. There, 63 water samples were tested and about 1/3 (19) of them have been obtained from the wells used by chronic kidney patients. Samples obtained from wells used by chronic kidney patients showed significantly higher levels of chemical parameters such as alkalinity, total hardness, electrical conductivity, calcium, magnesium, fluoride, chloride, phosphate and sulfate.

[*Possible links between groundwater geochemistry and chronic kidney disease of unknown etiology (CKDu): an investigation from the Ginnoruwa region in Sri Lanka]*

Parameter	**The mean value of the sample mg / l**	
	Wells used by kidney patients	**Wells used by non-kidney people**
Sodium	33.8	23.1
Calcium	30.1	26.7
Magnesium	14.9	9.65

Table No. 05

This study suggests that the combination of fluoride in drinking water with water hardness may be one of the possible causes of kidney disease. Accordingly, it was observed that the findings of such research papers could be used to further address the issue of groundwater quality protection and alternative chronophers should be to be devised to provide sanitary water to the people of the affected and identified areas.

3.4.4. Groundwater quality and groundwater in use

Brackish water is scientifically known as the water, which is high in calcium and magnesium. Brackish water or hard Water is in two types. That is, as temporary hardness and permanent hardness. Temporary hardening is caused due to calcium and magnesium carbonate. It is difficult to remove. Hardness is the concentration of CaCO3 at 60 - 120 milligrams per liter, which is considered moderate brackish water, 120 - 180 milligrams, and if it is more than 180 it is considered as high brackish water. In most parts of the dry zone of Sri Lanka, the water is either high brackish water or brackish water. These areas include Embilipitiya, Hambantota, Moneragala, Anuradhapura and Polonnaruwa as well as Jaffna are included to these areas.

(a) The following are the water quality test observations made by the Water Supply and Drainage Board Laboratory on 14 Intake Bore Holes drilled in the area of Puttalam in February 2018 to obtain ground water as samples were tested.

According to the Sri Lanka Drinking Water Standards 614, the capacitance limits of the various water parameters at the respective water intake points are as follows.

parameters / **Number**	**Turbidity**	**PH value**	**chloride**	**Total Alkalinity**	**Ammonia**	**Phosphate**	**Hardness**	**Iron**	**Manganese**	**Total Coli type Bacteria**
Number of places where the bearing limit is exceeded	08	01	08	06	11	01	09	07	13	03

Table No. 08

(B) Chloride, alkalinity, phosphate, hardness and dependent total solids parameters are relevant as revealed in the sample water quality test data conducted on 02 bore wells of Puttalam Water Supply Scheme on 18th August 2020. In both samples, SLS 614 had exceeded the bearing limit.

(C) The parameters to be present in the drinking water have been introduced by the Standards No. 614/2013 of the Standards Bureau of Sri Lanka. Accordingly, according to the water sample test information obtained from 46 schools in the Puttalam District, the details of the schools which have exceeded the relevant parameters are given below.

Parameter / **Number**	**Coliforms**	**E. coli**	**PH**	**Turbidity**	**Electrical Conductivity**	**Chloride**	**Alkalinity**	**Ammonia**	**Nitrate**	**Fluoride**	**Hardness**	**T.Iron**	**TDS**	**Nitrite**
Number of schools out of 46 schools exceeding each parameter	15	09	08	06	13	13	05	04	05	04	19	05	19	31

Table No. 09

(D) It was observed while auditing that investigation reports which carried out by the Water Supply and Drainage Board on drinking water has been confirmed that the sewage waste and Coliform bacteria have been mixed with the drinking water of 09 schools, even though the sewage waste and Coliform bacteria should not be contained in the water according to the drinking water quality standards.

3.5. Achieving the Sustainable Development Goals

Sustainable Development Goals No.06 should work towards achieving the objectives of making water and sanitation accessible to all and ensuring their sustainable management by the year 2030.

According to Target 6.5, integrated water resources management should be implemented at all levels by 2030, making appropriate use of cross-border support.

Target 6.6 calls for the protection and restoration of aquatic life, including mountains, forests, wetlands, rivers, groundwater and lakes, by 2020.

3.5.1. Practices for the use of Groundwater

Water demand in Sri Lanka is steadily increasing. This rapid increase in demand, especially in the urban / rural water supply, irrigation, agriculture and industrial and industrial sectors, has put significant pressure on groundwater. By the year 2020, the number of tube wells constructed by the Water Resources Board was 10,545 and the number of tube wells constructed by the National Water Supply and Drainage Board was 40, 000. Accordingly,it was observed that the need for regulation of practices for the use of ground water in wells constructed to manage the rising demand for groundwater.

3.5.2. Rainfall changes

When it is observing the Annual rainfall patterns for 09 provinces of Sri Lanka during the last 30 years it showed that the 04 main provinces such as the North, North Western, Uva and North Central Provinces receive the lowest annual rainfall and the lowest continuous rainfall from 2009 to 2017 was observed in the North Western Province and the lowest rainfall in 2018 and 2019 was observed in the North Central Province.

3.5.3. Sustainable Groundwater Management

The International Water Management Agency (IWMI) has made the following recommendations to Sri Lanka for sustainable groundwater management.

- Registration of all ground water wells.
- Careful monitoring of coastal aquifers as there is a possibility of mixing the salt.
- Monitoring of agrochemical contamination of aquifers and identification of possible corrections and removal of soil salts especially in areas where groundwater is used as drinking water.
- Encourage and improve strategies and socio-economic relations on basic management and water use patterns in groundwater renewable areas.
- Taking necessary steps to coordinate and improve various government institutions and non-governmental organizations.
- Water scarcity arrangements to increase public awareness on the capacity of aquifer, usage of water and risk to the environment.

(iwmi.cgiar.org/publications/water policy briefs / PDF / wpb 14.pdf)

It was observed that further attention should be paid to the above points.

4. Recommendations

4.1. Establishment and implementation of a groundwater policy based on the nature and quality of groundwater levels in the provinces of Sri Lanka.

4.2. Ensuring the precise responsibility for groundwater management

4.3. Implementing and establishing objectives based on groundwater development and conservation

4.4. Increasing the focus on groundwater conservation as the Water Resources Board's contribution to groundwater management is important.

4.5. Giving priority to the Northern, North Western, Uva and North Central Provinces in planning groundwater conservation measures.

4.6. Obtaining chemical analysis of groundwater and implementing the relevant recommendations as there is an evolution of various human activities that change the chemical composition of groundwater.

4.7. Coordinates government departments, local authorities and public corporations to carry out basic data on hydrogeology, research, analysis of reports based on statistical survey plans and proposals, conservation, utilization and development of the country's groundwater resources and assessing the utility and economic viability of coordinating upcoming projects and the ability to sustain those projects.

Sgd./W.P.C. Wickramaratne
Auditor General

W.P.C.Wickramaratne

Auditor General

31 January 2022