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Identification of Groundwater Potential Zones by using Satti's Analysis Hierarchy and GIS Technology (with special reference to Kolugala Pahalagama GND)

L. A. Ranasinghe and K. P. L. N. Patabandi

Department of Geography and Environmental Management, Sabaragamuwa University, Sri Lanka

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*Corresponding author
E-mail address:
amandaranasinghe6@gmail.com

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ABSTRACT

This study utilized Geographic Information Systems and Sati's Analyzing Hierarchy to identify and safeguard groundwater potential zones in the Kolugala Pahala Grama Niladhari division. In this study, a comprehensive analysis of the research area was facilitated by integrating primary data, which included the geographic coordinates of 50 sample wells, with secondary data encompassing digital, Contour data and geology data. According to the created groundwater potential zone map, the best groundwater potential zone is spread over 8 ha (9.64%), and a good groundwater potential zone is spread over 35 ha (42.17%) in the study area. Also, it is confirmed that there is a moderate groundwater potential zone in an area of 33 ha (39.76%) and a poor groundwater potential zone can be identified in 6 ha (7.23%). Through the research, it was concluded that the slope angle contributes more than the geology in the formation of groundwater potential zones and it was concluded that Geographic Information System is the most appropriate tool in assessing groundwater potential zones.

1. Introduction

Water, composed of one oxygen molecule and two hydrogen molecules, is fundamental for the survival of both human and animal life, as well as the environment. But, presently, water is a scarce resource. Population growth has led to an increased demand for water, resulting in water scarcity where the available water resources are insufficient to meet the rising needs. Hydrologists predict that by 2025, water consumption requirements will surge to six times the current levels, with almost half of the global population residing in regions grappling with persistent water shortages (Dhanapala, 2021). Population growth, climate change, expansion of human water requirements as well as excessive pollution of water sources, and problems in water management related to the non-protection of groundwater potential zones can be identified as the reasons for the water scarcity. Thus, water scarcity emerges as a global risk to confront in the future. Therefore, it is crucial to identify new potential groundwater zones as a primary solution, while also safeguarding existing groundwater reservoirs through the implementation of updated rules and regulations.

About 138 million cubic kilometers of the earth's surface consists of water. But, out of this amount, 96.5 million square kilometers is salt water. A very limited amount is available for human consumption. This limited water resource is suitable for humans because it is the whitest, and contributes to sustainable ecosystems (IGRCA).

The Food and Agricultural Organization (FAO) of the United Nations points out that the extremely limited and extremely important groundwater aquifers are geological formations consisting of pores and impermeable layers that can store fresh water in the earth's interior. Groundwater can be identified as a part of the hydrologic cycle itself, 10% - 20% of the rain water that reaches the earth's surface, flowing through rock gaps, and is deposited in water-saturated zones. According to rough estimations, between 0.1% - 3% of water is recharged as groundwater annually.

Across the globe, the demand for fresh water extends beyond mere daily activities. According to the current estimations, 70% of water is required for agricultural purposes, 22% of water is required for industrial purposes, 8% is required for domestic consumption, and some amount of fresh water is used for recreational activities (Dhanapala, 2021). It takes about 2000 – 3000 liters of water to meet the daily food requirement of one person alone. By 2023, when the world's population exceeded 8 billion, such scarcity of water is inevitable. When considering the utilization of groundwater for industries, large amounts of water have to be used in the production process of mobile phones, metal mining, and polishing. In total, the production of one mobile phone consumes approximately 910 liters of water. At a time when the number of mobile phones exceeds the world's population, it is predicted that 6.7 trillion liters of water will be required for the production of mobile phones alone, and it will not be funny that there will be war conditions for water in future (Dhanapala, 2021).

Regarding Sri Lanka, there is more tendency towards using groundwater at present. Although more groundwater is used for agriculture which is the main livelihood of Sri Lanka as an Asian country, that situation is currently changing. Although tanks, and ponds were used in ancient societies, groundwater has gradually replaced them as the main source of drinking water due to the influence of Western colonization. By 2022, 39.6% of people fulfilled their daily water requirements from groundwater (Premathilaka, 2022). In the last few months of 2023, the cost of piped water increased due to economic recession thereby compelling more people to rely on groundwater through wells. Although developed countries use drilling technology to identify groundwater zones, it is a difficult task for our country due to the economic decline. But, in view of the decrease in water yield due to the establishment of wells without selecting a groundwater potential zone, abandoning those over time might destroy even the existing small water potential. Therefore, it is timely to identify the groundwater potential zones by using Geographic Information System (GIS) technology.

With a growing population, the amount of groundwater pollution will also increase rapidly. But pollution can be brought to a minimum level by identifying and protecting the groundwater potential zones. According to the estimations of the Palmer development group, one person in developing countries disposes 0.3 – 0.6 kg of waste per day, while in developed countries, this amount rises to 0.7 – 18 kg. On the other hand, groundwater pollution will increase with the increase in the disposal of wastewater. According to the reports of the World Health Organization, arsenic, and fluoride are the major contributors to groundwater pollution. Additionally, excessive use of fertilizers and pesticides, and disposal of water from mines, alkali pits, and underground oil storage tanks contribute in various ways. Organic chemicals such as trichloroethylene released from sewage tanks have a strong impact on groundwater pollution (Kandy and Suburban water supply project, 2016).

Groundwater should be protected as a natural resource that has a strong contribution to human health and environmental sustainability. Thus, it can be identified that the factors of geology, land use, soil, elevation, slope angle, and drainage density are the major factors affecting the identification of potential zones in protecting groundwater (Kumar et al., 2019).

Geological data is widely used to understand landform evolution and study groundwater movement (Machiwal et al., 2011 cited in Raju et al., 2017). Groundwater potential becomes poor in hard rock and high elevation landforms. High water potential exists in places with large alluvial deposits (Raju et al., 2017).

Soil data is an important factor for determining groundwater potential zones. Soil permeability, soil effectiveness, and soil structure strongly affect groundwater potentials (Punmia et al., 2005 cited in Raju et al., 2017), and soil is an important factor in the groundwater recharge and discharge process (Anuranga et al., 2006 cited in Berhanu et al., 2020). Alluvial soil provides a huge contribution to recharge. Surface flow contributes more than subsurface flow because compact soil environments and fine-textured soils have low permeability (Rukundo and Dogan, 2019 cited in Berhau et al., 2020).

Land use in an area plays a significant role in groundwater recharge (Krishnamurthi et al., 2000 cited in Raju et al., 2017). Land is important in collecting essential information about groundwater through water infiltration, soil moisture, etc. (Arulbalagi et al., 2019). Agro-ecologies, anthropogenic activities are also strong influencing factors for groundwater recharge (Hussain et al., 2016). Land use contributes to major processes in the hydrological cycle such as infiltration, evaporation, and surface runoff. Groundwater storage capacity is high in forest areas and low in urban areas (Waikar and Nilawar, 2016).

The slope is a significant factor in groundwater potential zones. In slope areas, water absorption into the stream is very limited due to the rapid subsidence. Rainwater retention time in flat areas is high (Ramu et al., 2014). Slope (elevation change) is also a major factor in the identification of groundwater potential. Slope can be used as an indicator for the demarcation of groundwater zones. Slope is a direct contributor to the rate of groundwater recharge and the percolation time is less due to the rapid downward flow of water in sloping areas (Pathmanandakumar et al., 2021).

Thus, sustainable management is essential in this decade by identifying groundwater potential zones with the help of different thematic layers. Accordingly, GIS information technology plays a significant role in the assessment of groundwater potential zones by reducing time and cost. GIS is one of the most efficient modern technologies used to take spatial multi-criteria decisions targeting potential groundwater zones (Aziz et al, 2018). As stated by Pathmanandakumar et al., (2021) GIS is an effective tool for storing georeferenced data from multiple sources and manipulating them in a short period, analyzing and conserving groundwater potentials. GIS creates platforms for monitoring groundwater sources as well as building conceptual models. It is the most appropriate tool to integrate primary and numerical data sets that can be used for rapid estimation of natural resources (Arulbalaji and Sreelash, 2019). Further, GIS is a suitable tool for linking spatial data as well as for identifying the most suitable groundwater potential zones (Pande et al., 2021).

Accordingly, this research was conducted to identify and manage the groundwater potential zones in Kolugala Pahalagama Grama Niladhari Division (GND) by using the most appropriate technology and Satti's analysis hierarchy.

2. Materials and Methods

Kolugala Pahalagama Grama Niladhari Division (GND) was taken as the study area. This GND consists of two villages, namely, Pulleniwatta and Kolugala Pahala.

When considering the relative location of the study area, it is located in Hatharaliyadda Divisional Secretariat Division (DSD) of Thumpane jurisdiction of Kandy District. Kolugala pahalagama GND is bounded to Eramuduliyadda GND in North, Kithuldora GND in East, Kolugala Ihala GND in South and Weliwita GND in West. When considering the absolute location of this GND, it is located between 7018’47” NL – 80031’6” EL. This GND covers 83 Hectares of land and home gardens, and paddy fields are the major land use practices in this GND (Resource profile, 2023).

When collecting data relevant to identifying the groundwater potential zones in Kolugala Pahalagama GND, required data were collected through both primary and secondary data collection techniques. Mainly, the primary data were collected to calculate water levels of sample wells according to quarters for the confirmation of the validity of the final map of the groundwater potential zones. Moreover, to achieve the objective of this study, secondary data were used for the creation of thematic maps of land use maps, geology maps, elevation maps, slope maps, soil maps, and drainage maps.

Table 1. List of data layers and their sources

Elements	Data	Source	Year
Administrative boundary of the study area	Sri Lanka boundary shape file	Survey Department of Sri Lanka	1999
Geology map	Georeferenced geological map of Sri Lanka	Geology Survey & Mines Bureau of Sri Lanka	N.D.
Map of drainage density	Contour data	Google Earth pro	2023
Map of Elevation	Contour data	Google Earth pro	2023
Map of Slope	Contour data	Google Earth pro	2023

Map of LuLc	LuLc Digital data	Land use & Policy planning department of Sri Lanka	2019
Soil map	Soil map of Sri Lanka	Department of Irrigation	2009

In the geographical realm, this research strategically utilized a georeferenced geological map as secondary data, employing it to create thematic layers through contour data encompassing elevation, slope, and drainage density. The integration of soil data further enabled the identification of distinct soil types across the study area. These thematic layers underwent a weighted analysis using GIS software, culminating in a thorough spatial examination of geographic factors that shape the study area.

3.1. Creating Thematic Layers

Arc GIS 10.4 software was used to create thematic layers. A georeferenced geology map was used to create the geology map. Next, it was digitized and converted into a raster layer. After that, the geology thematic layer was created. Five types of rocks have been identified in the study area through this thematic layer.

Contour data were used to create elevation, slope, and drainage density thematic layers. Here, GPS visualizer/elevation web and Google Earth Pro software were used. Then, the surface was created by using the IDW tool based on the data sets downloaded in GPX format. After that, it was converted into TIN data by using a 3D analyst tool. Next, the TIN data were converted into raster data and created DEM model. This was followed by the creation of slope thematic layer by using the DEM model which was created using the slope tool. Several steps were followed to create a drainage density thematic layer. The DEM model was used. The “Fill tool” was used to fill the sink of the DEM model and the “direction tool” was used to create flow direction. After that, flow accumulation of the flow direction data set was constructed through flow. Then the data were rearranged according to Strahler’s stream order and converted into vector data. Next, the “line density tool” was used to create drainage density. The land use thematic layer was created by using the data obtained from the Land Use Policy Planning Department of Sri Lanka and applying it to the study area map. When creating the soil thematic layer, digital soil data was generated on the study area map, and the relevant area was separated by using the “merge tool” and converted into raster data, and the final soil thematic layer was created.

3.2. Creating Reclassified Thematic Layers

After identifying the classification procedure needed to reclassify the map by studying the literature, the “reclassify tool” of Arc GIS software was used.

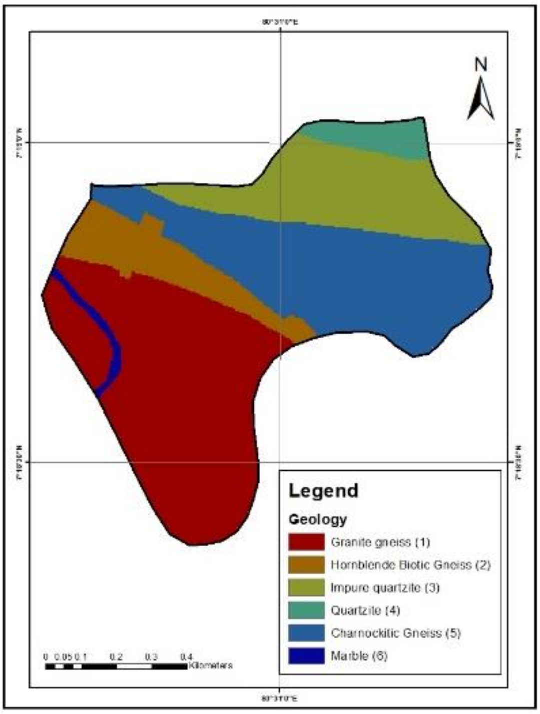
3.3. Building weights and map combining

When creating the groundwater potential zones map, weights were built by using Satti’s analyzing hierarchy as percentages based on the influence of reclassified all thematic layers on the creation of water potentials. Allocations of percentages are shown in the figure 1.

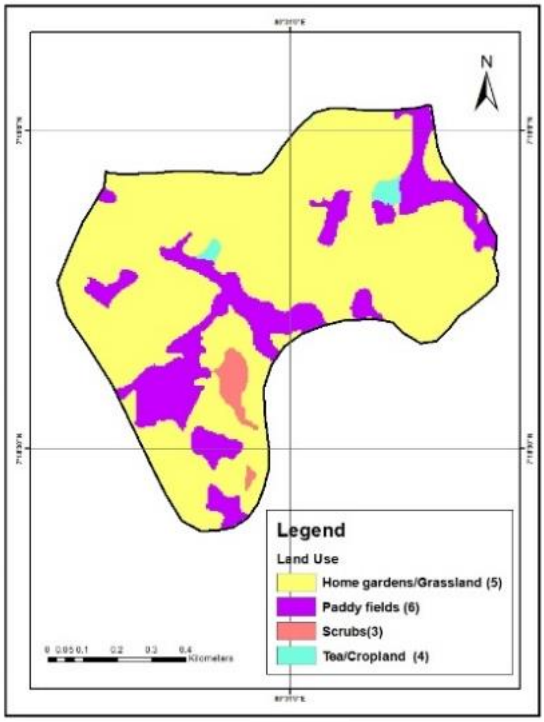
The following equation has been used to calculate the weights of the relevant factors.

$$Impact = \left(\frac{satie's\ scale}{sum}\right) * 100$$

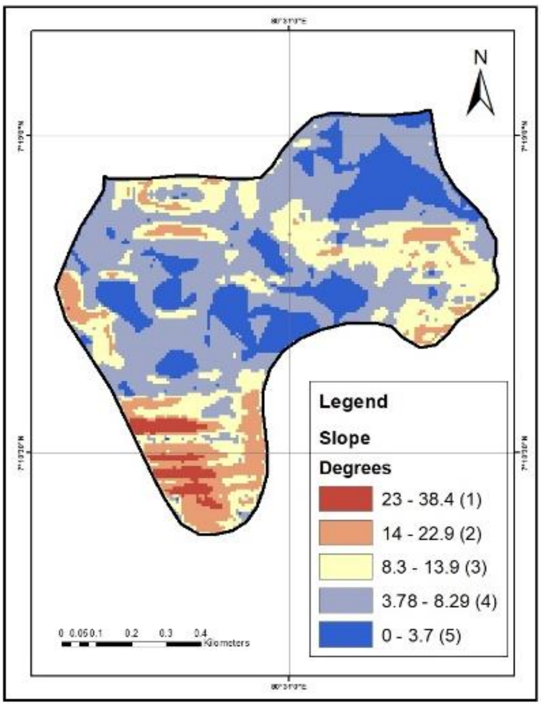
After the weighting as above, the groundwater potential zone map of Kolugala Pahalagama GND was created.


N
Legend
Geology
Granite gneiss (1)
Hornblende Biotic Gneiss (2)
Impure quartzite (3)
Quartzite (4)
Charnockitic Gneiss (5)
Marble (6)
0 0.05 0.1 0.2 0.3 0.4 Kilometers

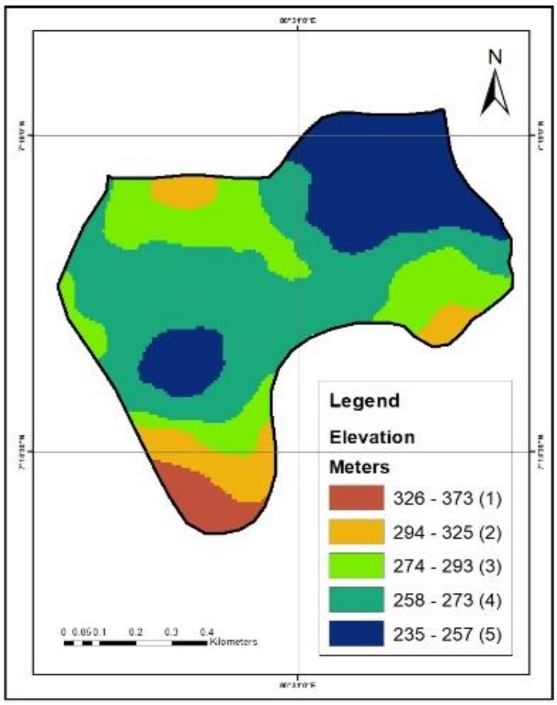
A


N
Legend
Land Use
Home gardens/Grassland (5)
Paddy fields (6)
Scrubs(3)
Tea/Cropland (4)
0 0.05 0.1 0.2 0.3 0.4 Kilometers

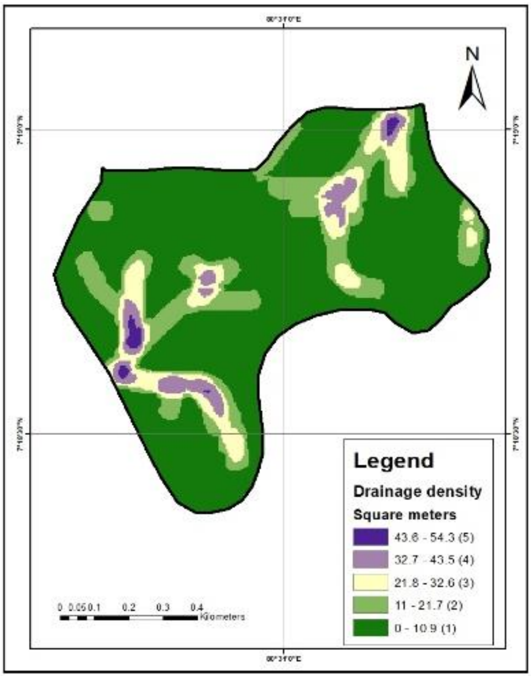
B


N
Legend
Slope
Degrees
23 - 38.4 (1)
14 - 22.9 (2)
8.3 - 13.9 (3)
3.78 - 8.29 (4)
0 - 3.7 (5)
0 0.05 0.1 0.2 0.3 0.4 Kilometers

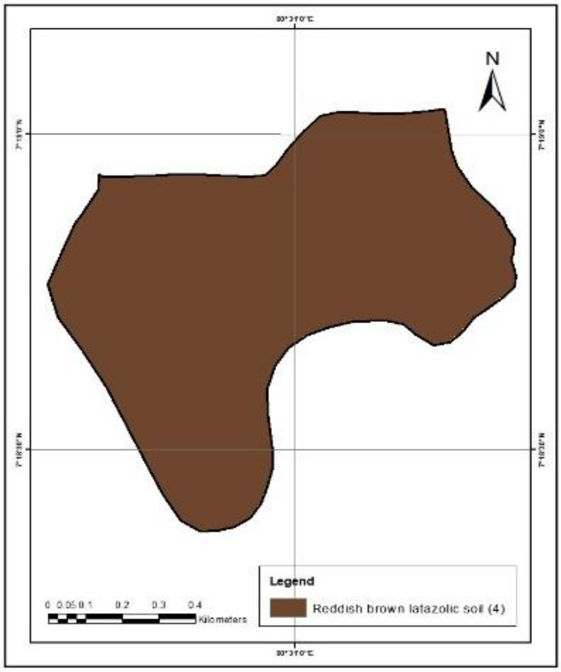
C


N
Legend
Elevation
Meters
326 - 373 (1)
294 - 325 (2)
274 - 293 (3)
258 - 273 (4)
235 - 257 (5)
0 0.05 0.1 0.2 0.3 0.4 Kilometers

D



E



F

Figure 1. Reclassify maps Note: (a) Reclassified geology map, (b) Reclassified land use map, (c) Reclassified slope map, (d) Reclassified soil map, (e) Reclassified elevation map, (f) Reclassified drainage map

Table 2. Percent weights of factors affecting groundwater potential zones in the study area.

Factor	Contribution to the creation of groundwater	Satie's scale (Fractions)	Satie's scale (Decimal)	Impact (%)
Geology	High	1	1	40
Soil	↓	1/2	0.5	21
Slope (Degrees)		1/3	0.33	14
Elevation (Meters)		1/4	0.25	10
Land Use		1/5	0.2	8
Drainage density (Meters/Sq Meters)	Low	1/6	0.16	7
Total			2.44	100

Source: Ramu et al, (2014). Identification of groundwater potential zones using GIS and Remote Sensing techniques: A case study of Mysore Taluk - Karnataka.

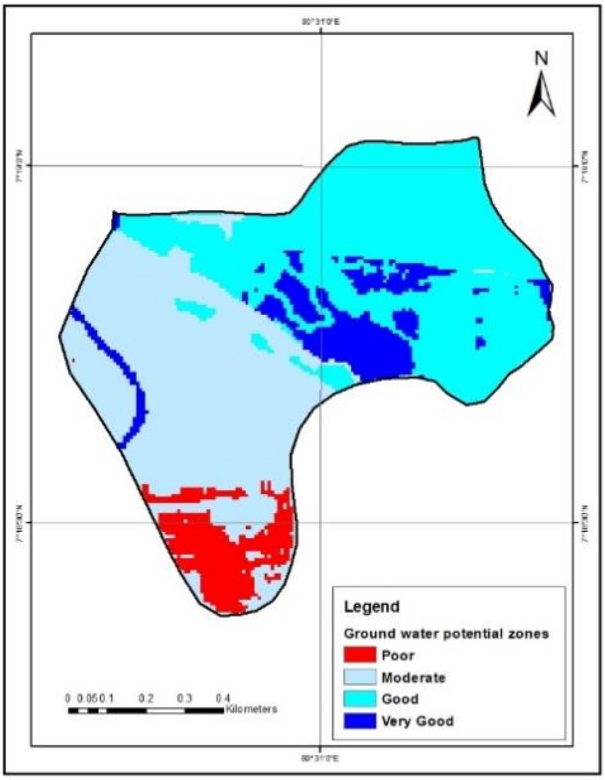


Figure 2. Groundwater potential zones in Kolugala Pahalagama GND

The validity of the created groundwater potential zone map was confirmed through two methods. The validity of the groundwater potential zones was measured by using 500 samples by "segmentation and classification tool". As the second method of measuring validity, the GPS values were obtained and 50 sample wells were selected as a random sampling method from 95 wells of the study area which were used by the community for their daily water requirements. "GPS waypoint" mobile App was used for that. Next, obtained locations were generated on the study area map by using the "GPX tool" of Arc GIS 10.4.

The quarterly water levels of those wells were calculated and the annual average water level was calculated by using Excel software and finally confirmed the validity.

Created all data are presented as maps created by Arc GIS 10.4 software and graphs created by Excel software.

3. Results and Discussion

3.1 Factors affecting the creation of groundwater potential zones in Kolugala Pahalagama Grama Niladhari Division

3.1.1 Geology

Geology is the major factor that influenced the availability of groundwater. When considering the geological formation of the study area, it has been formed by a combination of Granite gneiss, Hornblende Biotic Gneiss, Impure Quartzite, Quartzite, Charnockitic gneiss, and Marble. In the geographical context of the study area, the presence of high-grade metamorphic rocks with tightly interlocked mineral grains leads to the development of regoliths upon weathering. In this process, groundwater saturates the pore spaces within the regolith, indicating the formation of regolith aquifers. Therefore, geologically, the study area is characterized by the existence of regolith aquifers resulting from the weathering of high-grade metamorphic rocks. Although geological formation has occurred from different types of rocks, the ability to hold water varies from each other. Distribution of Marble which provides more contribution to creating groundwater potential zones is limited to a Hectare in the study area.

3.1.2 Elevation

When increasing the elevation, runoff becomes speed-up and percolation and infiltration become slow-down. But, runoff becomes slow-down and percolation and infiltration become speed-up in low-elevation regions. Therefore, elevation provides a significant contribution to the formation of groundwater potential zones. The elevation of the study area is in the range of 235 m-373m. A land portion of 20ha belongs to the elevation zone which provides more contribution to the formation of groundwater potential zone and it is in the elevation range of 235m – 257m.

3.1.3 Slope

In a geographic context, areas with steep slopes encounter reduced penetration levels as water rapidly flows downward, leaving insufficient time for infiltration. Conversely, flat surfaces enable effective groundwater recharge by retaining rainwater, enhancing the overall hydrological dynamics of the terrain. When considering the slope angle of the study area, it is located between the range of 0- 38.4 degrees. And also, the zone which provides a higher contribution to the formation of groundwater is located in the land portion of 16ha which belongs to a range between 0 - 3.7 degrees.

3.1.4 Drainage density

There is a high ability of groundwater saturation in zones that have high drainage density. Therefore, drainage density provides a significant contribution to groundwater potential. The drainage density of the study area is in the range of 0 – 54.3 Km^{-1} But, a zone with a higher drainage density range of 43.6 – 54.3 km^{-1} is limited to a hectare of the study area.

3.1.5 Land use

Home - gardens, Paddy fields, Scrubs, Grassland, Tea can be identified as the major land uses in the study area. Here, the distribution of home gardens can be identified in 63 ha of the total land of the study area. Specifically, home gardens provide a high contribution to groundwater because home gardens control the runoff through different human activities.

3.1.6 Soil type

The successful process of water percolation and infiltration is significantly influenced by soil permeability and porosity. In the study area, the predominate soil type, characterized by reddish-brown latosolic soil, particularly in the steeply dissected hilly and undulating terrains, plays a crucial role in shaping the groundwater potential zones. The distribution of these soils across the entire land area further underscores their unique contribution to the hydrological characteristics of the region.

3.1.7 Highest groundwater potential zones

The highest groundwater potential zone can be identified as a form of the belt in the middle portion of Kolugala Pahalagama GND, the eastern part of the study area, and the land between the northwestern and southwestern parts of the study area. This highest groundwater potential zone belt has been geologically formed by Marble rocks and central and eastern parts of the zone have been geologically formed by Charnockite gneiss. When considering the elevation of the highest groundwater potential zone, it is located in the elevation range of 258 – 273m which is considered as the elevation range which provides the best contribution to the formation of groundwater potentials. And also, the drainage density of the central and eastern parts of the highest groundwater potential zone is in a range between 21.8 – 32.6m per square meter and 11 – 21.7m per square meter. But, in a small part of the highest groundwater potential zone where there is a Marble geological base has a drainage density of range between 46.3 – 54.3m per square meter and is located in a drainage density range between 32.7 – 43.5 m per square meter and 21.8 – 32.6 m per square meter. When considering the slope of the highest groundwater potential zone, three slope regions can be identified from this zone. It can be identified that a slope between 0 – 3.78 degrees from the highest groundwater potential zone mainly and a slope between 3.78 – 8.29 degrees can be identified moderately. Moreover, the entire highest groundwater potential zone is covered by reddish-brown latazolic soil. When considering the land use practices of this zone, paddy and home gardens can be identified. It can be concluded that the belonging of paddy fields into wetlands and controlling the runoff in home gardens due to human activities are caused by the formation of the highest groundwater potential zone.

3.1.8 Good groundwater potential zone

Kolugala Pahalagama Grama Niladhari Division consists of Pulleniwatta and Kolugala Pahalagama villages. When considering the good groundwater potential zones, the location of the Pulleniwatta village and the location of Kolugala Pahalagama in the northeast part of the area can be mentioned. It can be pointed out as a specialty that the portion of Kolugala Phalagama village which has a moderate groundwater potential has a good groundwater potential of 1.024 ha. When considering the geological formation of a good groundwater potential zone, mainly the northeastern portion has been formed by Quartzite and impure Quartzite. It can be concluded that the zone formed by Charnockite gneiss rock has the highest and good groundwater potential.

The 1.024 ha good groundwater zone has been formed by Hornblende Biotic Gneiss. When considering the elevation of the good groundwater potential zone, an area of 1.63 ha towards the northeast of Pulleniwatta village belongs to the zone between 235 – 257 m which can be mentioned as a very good zone. Besides that, 274 – 293 m and 294 – 325 m are composed of good groundwater potential zones. When considering the drainage density, it is special that the area with good groundwater potentials zone consists of all five drainage density zones. 43.6 – 54.3 m per square meter, 32.7 – 43.5 m per square meter, 21.8 – 32.6 m per square meter, 11 – 21.7 m per square meter, and 0 – 10.9 m per square meter belong to the zones. Especially, it is specific to groundwater due to the higher ability to saturate water in areas that have high drainage density. Accordingly, the area with good groundwater potential consists of a 0.13 ha zone towards the northeast of Pulleniwatta village. The entire good groundwater potential zone consists of reddish-brown latazolic soil. When considering the slope of this zone, four slope zones can be identified.

They consist of slope angles of 0 – 3.7 degrees, 3.78 – 8.29 degrees, 8.3 – 13.9 degrees, and 14 – 229 degrees. A slope angle of 14 – 22.9 degrees is observed in an area of 2.304 ha between east and southeast and a 0.1268 ha area of the center of the good groundwater potential zone also belongs to it. When considering the land use of good groundwater potential zone, paddy, home gardens, and tea can be identified. It is special that tea lands are located only in the good groundwater potential zone.

3.1.9 Moderate groundwater potential zone

The moderate groundwater potential zone is located in the northwest–south portions of the Kolugala Pahalagama village. Additionally, it consists of 0.9565 ha of good groundwater potential zone. The entire groundwater potential zone has reddish-brown latazolic soil. When considering the geological formation of the moderate groundwater potential zone, it has been formed by the combination of two types of rocks, Granite Gneiss and Hornblende Biotic Gneiss. Four elevation zones can be identified within the moderate groundwater potential zone. They consist of a 294 – 325 m zone of 1.59 ha, 235 – 257m low elevation zone of 3.82 ha, 258 – 273m of majority area, and 274 – 293m elevation zone. When considering the drainage density, it is specific that the area with entire good groundwater potential consists of five drainage density zones. They consist of 46.3 – 54.3 m per square meter, 32.7 – 43.5 m per square meter, 21.8 – 32.6 m per square meter, 11 – 21.7 m per square meter, and 0 – 10.9 m square meter zones. A zone between 43.6 – 54.3m per square meter which gave a high value in giving the weights is located towards the southwest and west and its size is 0.382 ha. Five slope zones can be identified from the moderate groundwater potential zone. But, the area belonging to the high slope angle 23 – 384 degrees is 0.00637 ha and it is located towards the west of the GND. In addition to the high slope angle, a moderate amount of degree 0 – 3.7 degrees, 3.78 – 8.29 degrees slope angle zones can be identified. Land uses provide a considerable contribution to the formation of groundwater potential zones. Focusing on a moderate groundwater potential zone, four land use practices can be identified. Paddy and home gardens are the major land use practices in the area and forests can be identified towards the western portion of GND. Additionally, cultivated land can be identified in an area of about 0.20 ha and woodlots can be identified in a small extent.

3.1.10 Poor groundwater potential zone

It is noteworthy that in focusing on the poor groundwater potential zone, it is not widespread across the GND. It can be observed that it is limited only to Kolugala Pahalagama village and the eastern portion of the study area. But, a poor groundwater potential zone can be seen in a very small land area of 0.00684 ha towards the west. When considering the geological formation of the poor groundwater potential zone, the entire zone has been formed by Granite gneiss. And also, when considering the elevation, this zone has been created along five elevation zones. Specifically, those elevation zones are created in the form of horizontal belts. In the lowest part towards the south is a very high elevation zone of 326 – 376 m and the elevation zones of 294 – 325 m and 274 – 293 m are located above that respectively. And also, a small land portion where towards the west includes the poor groundwater potential zone and an elevation zone of 274 – 293m is observed there. A high capacity to saturate the groundwater exists only in the zones with high drainage density, but, the drainage density of this poor groundwater potential zone is at a low level. Accordingly, 0 – 10.9 m per square meter has a wide distribution and 11 – 21.7 m per square meter has a small distribution. Regarding the soil composition, the entire zone consists of reddish-brown latazolic soil. The poor groundwater potential zone of 0.00684 ha towards the west is located in a slope zone of 23 – 38.4 degrees. Also, in the poor groundwater potential zone towards the south of the GND which is unable to hold rainwater, the runoff is mostly composed of 23 – 38.4 degrees and 14 – 22.9 degrees zones, while it consists of 8.3 – 13.9 degrees zone to a small extent. Forests can be identified in the small parts in the western part of the poor groundwater potential zone while home gardens are abundant in the rest of the zone, and paddy lands are observed moderately in the zone.

3.1.11 Inference regarding validity made using sample wells

In the geographical context of my research, the spatial distribution of sample wells indicates that 56% of them are strategically positioned within areas characterized by good groundwater potential, with 3 wells in the very good potential zone, 28 wells in the good potential zone, and 19 wells in the moderate potential zone. This distribution underscores a significant concentration of wells in regions with favorable groundwater prospects within the studied geographic area.

4. Conclusions and Recommendations

The existence of groundwater in any region is determined by the geological formation of that region. Accordingly, the geological formation of Kolugala Pahalagama GND has been formed by the combination of six types of rocks, namely; Granite gneiss, Hornblende Biotic Gneiss, impure Quartzite, Quartzite, Charnockite gneiss, and Marble. From that, it can be concluded that marble rocks mainly contribute to high groundwater potential. Slope angle is also a major contributing factor in the formation of groundwater potential zones. It can be concluded that the slope angle of the GND is located in a zone between 0 – 38.4 degrees. Accordingly, the zones between 0 – 3.7 degrees, 3.7 – 8.29 degrees, 8.3 – 13.9 degrees, 14 – 22.9 degrees, and 23 – 38.4 degrees can be indicated as zones. The area occupied by a very low slope angle is 16 ha, and a high slope angle can be seen in a small area of about 2 ha. It can be also concluded that the entire GND has reddish brown latazolic soil. In addition, the drainage density of the study area can be identified along five zones as between 0 – 10.9 m^2, 11 – 21.7m^2, 21.8 – 32.6m^2, 32.7 – 43.5m^2, and 43.6 – 54.3m^2. It can be concluded that one hectare of land belongs to the zone between 43.6 – 54.3 m^2 where water can be more saturated.

When considering the land use in Kolugala Pahalagama GND, six major land use patterns can be identified. Forests, tea, woodlots, home gardens, cultivated lands, and paddy can be indicated as the major land use patterns. Also, the home garden is the land use pattern that occupies most land in the study area. It can be concluded that apart from home garden land use, paddy land use occupies 16 ha of land.

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