ASSESSMENT OF GROUNDWATER RECHARGE ZONES USING GEOSPATIAL TECHNIQUE IN NORTH CENTRAL PROVINCE, SRI LANKA.

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Groundwater is a vital natural resource which provides water for all over the country and it varies in distribution across different regions. However, lack of sustainable management practices such as overexploitation and unplanned projects have depleted groundwater resources, while population growth and industrialization have increased the demand for groundwater. In North Central Province (NCP), most people rely on groundwater to meet their water needs since surface water varies spatially as well as temporally. Hence, sustainable management of groundwater resources is important to meet the demand while assuring the sustainability of this valuable natural resource. To identify suitable locations for groundwater exploitation and artificial recharge, this study employed a GIS-based approach. Seven thematic layers based on factors influencing groundwater recharge; geomorphology, geology, soil type, slope, lineament density, drainage density, and land use were taken to analyse the potential. Multi-influencing factor approach was used to determine the weights of each layer for the overlaying analysis. The created groundwater recharge map was divided into high, moderate, and low potential zones and the NCP region has 20.8%, 53.1%, and 26.1% in high, moderate, and low recharge potential zones, respectively. Further, the study demonstrates that there is ample opportunity to implement aquifer recharge programs to reduce groundwater stress in NCP. Since the accuracy of the study depends on the classification criteria and weights assigned to the thematic layers, suggested to have an accuracy assessment, using groundwater level data in NCP.

Keywords: GIS, Groundwater recharge, Multi influencing factor

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INTRODUCTION

Groundwater is defined as subsurface water that fills all the pore space of soils and geologic formations below the water table (Freeze and Cherry, 1979). It is the largest natural resource of water storage. Several factors affect the occurrence and movement of groundwater in a region including topography, lithology, geological structures, depth of weathering, the extent of fractures, primary porosity, secondary porosity, slope, drainage patterns landform, land use/land cover, and climate (Ramya *et al.*, 2018). Distribution of groundwater in the country differs from region to region as well as from place and time. Groundwater is a major source of water for domestic, irrigation, commercial, and industrial purposes. The world's demand for groundwater increases due to the rapid growth of population, urbanization, industrialization, and increasing water requirement for agricultural purposes. At present time, groundwater resources are depleting considerably due to over-extraction, ongoing development projects, the global impact of climate and weather changes, and unplanned development of ground resources like unplanned groundwater withdrawal, random drilling of bore wells without assessment, pumping of groundwater than the recharge or replenish rate and overexploitation.

Sri Lanka is enriched with groundwater resources. The rapid increase of urban-rural water supply, increasing number of housing schemes, irrigation of agriculture, shrimp aquaculture, and small enterprises are increasing the demand for groundwater in Sri Lanka. In Sri Lanka, high consumption of groundwater occurs due to the low cost of available water resources for rural and semi-urban domestic water supply by tube wells, dug wells and fitted with a hand pump. Inadequate hydrological data analysis and investigations of groundwater and aquifers in Sri Lanka are a major constrain (Foster *et al*., 1976) for sustainable management. Further, there are not enough policies to regulate groundwater. Nowadays, Geospatial technology emerged as a better spatial analysis tool for decision-making. Geographic Information System (GIS) is a collection of software, hardware, data and people for capturing, storing, checking, and displaying spatial data. Nowadays, many researchers use geospatial techniques for groundwater resource management for better decision-making.

METHODOLOGY

The North Central Province (NCP) of Sri Lanka is made up of the two districts of Anuradhapura and Polonnaruwa which are situated entirely within the dry zone. Although the mean annual rainfall in this region is around 1,400 mm, the major rainfall season (maha) has a 75% rainfall expectancy of around 650 mm. The total annual evapotranspiration is around 1,750 mm. This area falls within the Agro-ecological Region of DL_1 (Panabokke, 2003).

Available data for soil type, geology, geomorphology, land use and digital elevation model (DEM) were collected and non-digital data were converted to digital format, by georeferencing and digitizing.

Table.1 Collection of Data

Data	**Source**
Soil type	NRMC
Geology	Geological Survey and Mines Bureau of Sri Lanka
Geomorphology	
Land Use	Landsat 8 satalite image (https://earthexplorer.usgs.gov/)
Digital Elevation Model (DEM)	Downloaded from Alaska Satellite Facility (ASF) in Earthdata website(https://asterweb,jpl.nasa.gov)

Seven different themes such as geomorphology, geology, soil type, slope, land use/land cover, drainage density, and lineament map were prepared for the analysis. To generate a groundwater potential zonation map of the area, all seven different thematic layers were integrated with a weighted overlay in GIS.

The weights of seven layers were computed statistically by using Multi Influencing Factor (MIF) technique followed by ranks assigned to features within the layer based on local knowledge and from literature. Based on past studies, geology, slope, land use and geomorphology features play a major role in determining the availability of groundwater. Sensitivity analysis showed that excluding the land use and geomorphology layers other factors have a higher impact on the delineation of groundwater potential zones. The MIF method has gained more attention recently as it is comparatively simple and reliable (Anbarasu *et al.*, 2019). The MIF method was carried out in a GIS environment using ArcGIS.

Table 3.2 Relative rates and scores for each influencing factor calculated using the MIF techniques

Factor	Major factor (A)	Minor factor (B)	Proposed relative rates(A+B)	The proposed score of each influencing factor
Geology	1+1+1	0	3	18
LD	1+1	0	2	12
Geomorphology	1+1	0.5+0.5	3	18
DD	1	0.5	1.5	9
Slope	1+1	0.5	2.5	14
Lu	1+1+1	0.5+0.5	4	23
Soil	1	0	1	6
Total			17	100

Table 3.3 Rank assigned for each feature within a thematic layer

Factor	Weight	Class	Rank
Slope(Degree)	14	21.67 – 73.09	1
		11.53 – 21.67	2
		5.72 – 11.53	3
		2.57 – 5.72	4
		0 – 2.57	5
Geology	18	Undifferentiated highland series	1

		Charnockite	2
		Calc granulite or gneiss minor marble	
		Gneissic rock (Granite gneissic/Augen gneissic/Biotite gneissic)	3
		Highly weathered rock(Hornblende gneiss)	4
		Water bodies	
		Quartzite	5
		Carbonatite	
		Alluvial and logoonal deposits clay ,silt and sand	
Geomorphology	18	Low plantation surfaces with inselberges and thin soils(Dry zone)	1
		Same, Dissected	2
		Lowe level of intermediate plantation surfaces ,dissected	3
		River plains and adjacent coastal plain	4
		Water bodies	
		Up warped Pleistocene coastal plain	5
Drainage Density	9	1.11 - 2.11	1
(Km/Km sq.)		0.78 - 1.11	2
		0.48 – 0.78	3
		0.17 – 0.48	4
		0 – 0.17	5
Lineament Density	12	0 – 0.14	1
(Km/Km sq.)		0.14 – 0.42	2
		0.42 – 0.76	3
		0.76 – 1.21	4

		1.21 – 2.79	5
Soil Type	6	Rock Knob plain	1
		Red yellow latosols, flat slightly undulating terrain Eroded land Erosional remands	2
		Alluvial soils of variable drainage and texture, flat terrain Reddish brown earth and solodized solonets undulating terrain Solodized solonetz and solonchaks, flat terrain	3
		Water bodies(Tanks)	4
		non-calcic brown soil, soils on old alluvium and solonetz undulating terrain Reddish brown earth non-calcic brow soils and low humic gley soils undulating terrain Reddish brown earths with a high amount of gravel in subsoil and low lumic gley soils, undulating terrain Reddish brown earth non calcic brown soil and low humicv gley soils undulating terrain Reddish brown earth and immature brown looms rolling hilly and steep terrain	5

Land use	23	Built up	1
		Other	2
		Forest	3
		Agriculture	4
		Water bodies	5

To differentiate the groundwater potential zone, scored maps of all the seven thematic layers after assigning weights were integrated using the spatial analyst tool in ArcGIS.

Results and Discussion

Groundwater availability depends on several surfaces and subsurface features. The accuracy of predicting the groundwater potential zone depends on the quality of thematic layers and the number of features considered in the study.

Geomorphology gives information about the description and genesis of its landforms which depends upon the structural evolution of the geological formation. Geology controls the recharge and storage of the rock aquifers through the porosity and permeability that controls the ability of the rock to transmit water and the rate at that groundwater flow.

Lineaments control the movement and storage of groundwater. Both minor and major lineaments in the study area were delineated which include faults fractures cracks. Drainage density (DD) is another geomorphic measure of groundwater potential. A drainage network can be expressed as drainage density indicating the total length of streams relative to an area (Km/Km^2). Lower drainage density indicates a highly permeable rock with high infiltration and less surface runoff while higher drainage density indicates low permeability less infiltration and more runoff.

Some land cover makes a great impact on infiltration and runoff. Vegetation can slow down the runoff water to seep into the ground while agriculture and cultivated lands also change infiltration patterns. Land use adjust recharge volume, time for recharging, amount, and effect of groundwater resources.

Soil is one of the fundamental natural resources that is the basis of agriculture. It is the mixture of some organic material, rocks and minerals different types of gasses and liquids and a large number of microorganisms that can maintain life on the planet

Slope plays an important role in groundwater potential. As well as terrain parameters expressing the steepness from the ground surface which provide important information on the nature of geologic and geodynamic processes operating at the regional scale.

The groundwater potential of this study area was divided into three classes namely poor, moderate and high groundwater potential zones (Fig.01). About 20.8% of the study area was covered by the high groundwater potential, while 53.1% of the total area falls under the moderate groundwater potential zone. The low groundwater potential area occurs around a high degree of slope, built up, high drainage density and low lineament density areas and it is 26.1% of the study area.

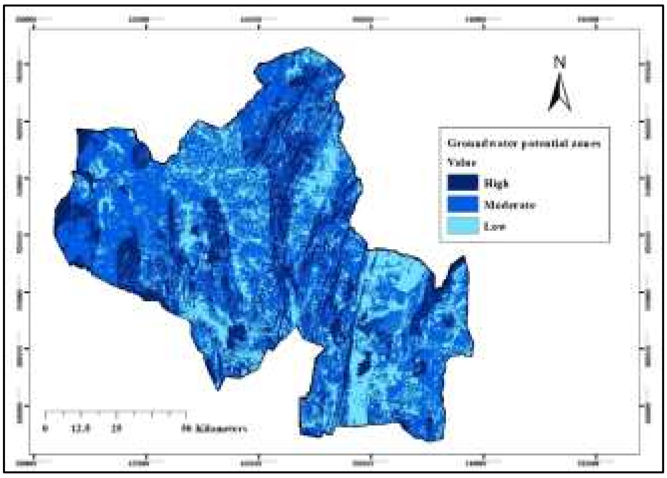

Figure 01: Groundwater potential zones

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