# Identification of Groundwater Potential Zones (GWPZS) using Remote Sensing (RS) and Geographical Information System (GIS)-A Case Study of Dodoma City

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## Abstract

Lack of proper knowledge accounting distribution of groundwater potential zones (GWPZS) has a negative implication on groundwater exploitation and management as the area will be explored with higher uncertainties. The study delineated the GWPZS using a Geographic Information System (GIS) and Remote Sensing (RS). Thematic layers which influence groundwater occurrence in an area such as lithology, lineament density, drainage density, slope and land use/cover maps were used. The final groundwater potential map was prepared by assigning appropriate weightage and theme classes' ranks to different thematic layers and integrate them into ArcGIS software. The integrated map shows different zones of groundwater prospects; very high, high, moderate, poor and very poor. Further studies should focus in verifying and enhancement of the results by introducing more verified values for weights as well as exploring other various factors that may contribute towards changing GWPZS.

## Introduction

Groundwater is the water that is found underneath the Earth's surface (Figure 1). Groundwater is a piece of the hydrologic cycle. Begins when a piece of the precipitation that falls on the Earth's surface infiltrates through the soil to wind up groundwater (Murasigh, 2014). GWPZS are areas where groundwater is highly likely to be available. The occurrence of groundwater is not the matter of chance, but largely influenced by geological and other conditions.

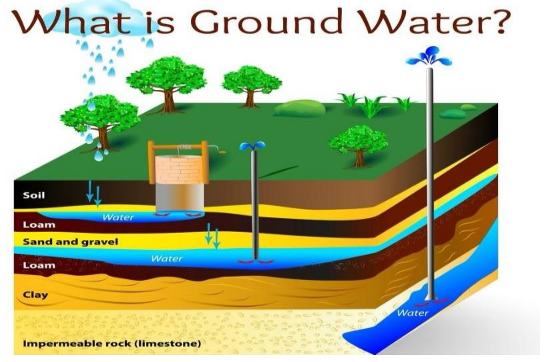


**Figure 1.** Groundwater circle (https://srcity.org/857/Groundwater)

Integration of the groundwater influencing parameters is best achieved through GIS and RS. RS provides data that are used to evaluate GWPZS.

Lack of proper knowledge on the distribution and variation in GWPZS has a negative implication on groundwater management as the area is explored with higher uncertainties. It is imperative to investigate the suitable areas for groundwater extraction in order to increase the freshwater availability and curb the water scarcity.

## Methods and Materials

Data used were ASTERDEM, Landsat satellite Image and Geological map. Thematic layers of land use/cover and lithologic units, slope, lineament and drainage density were generated and integrated in GIS environment to determine suitable zones for groundwater prospecting (Figure 2).

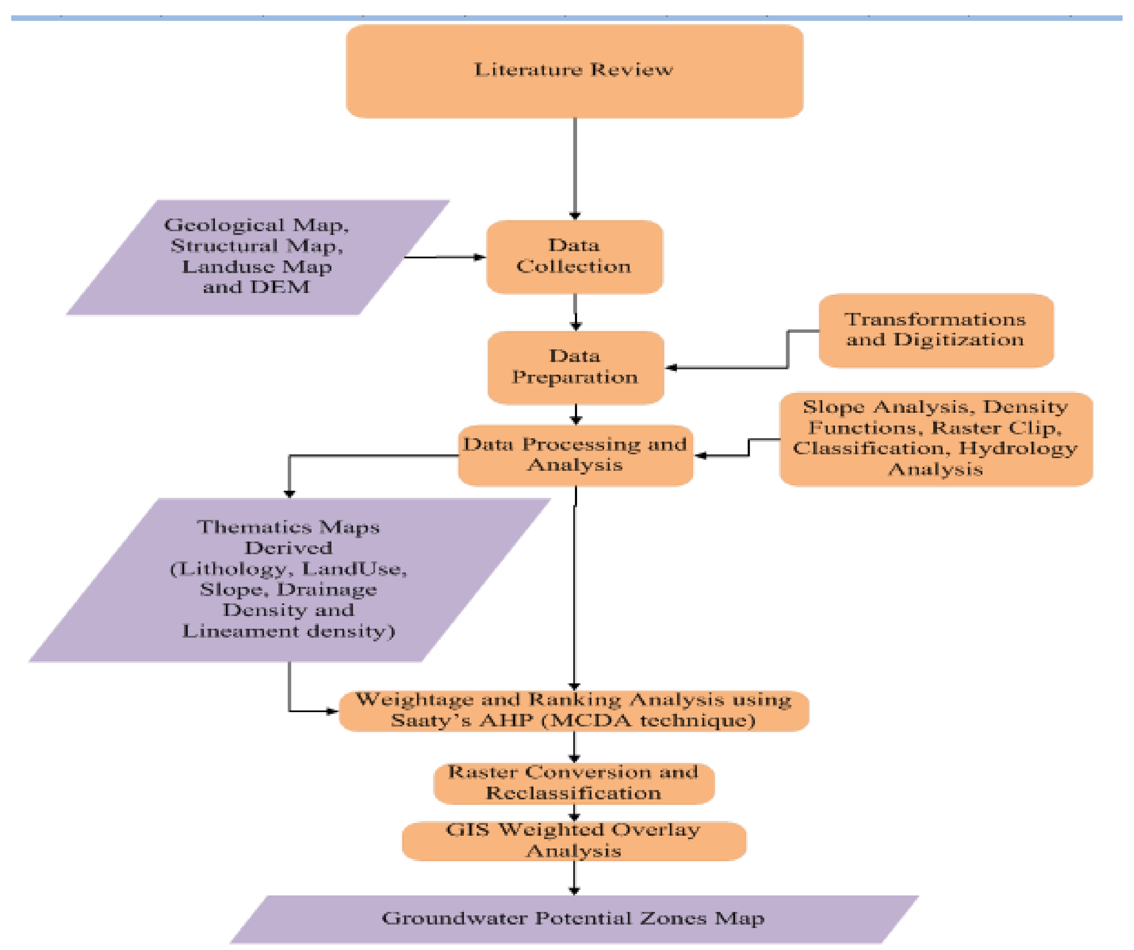


**Figure 2.** Methodoloy.

## Results

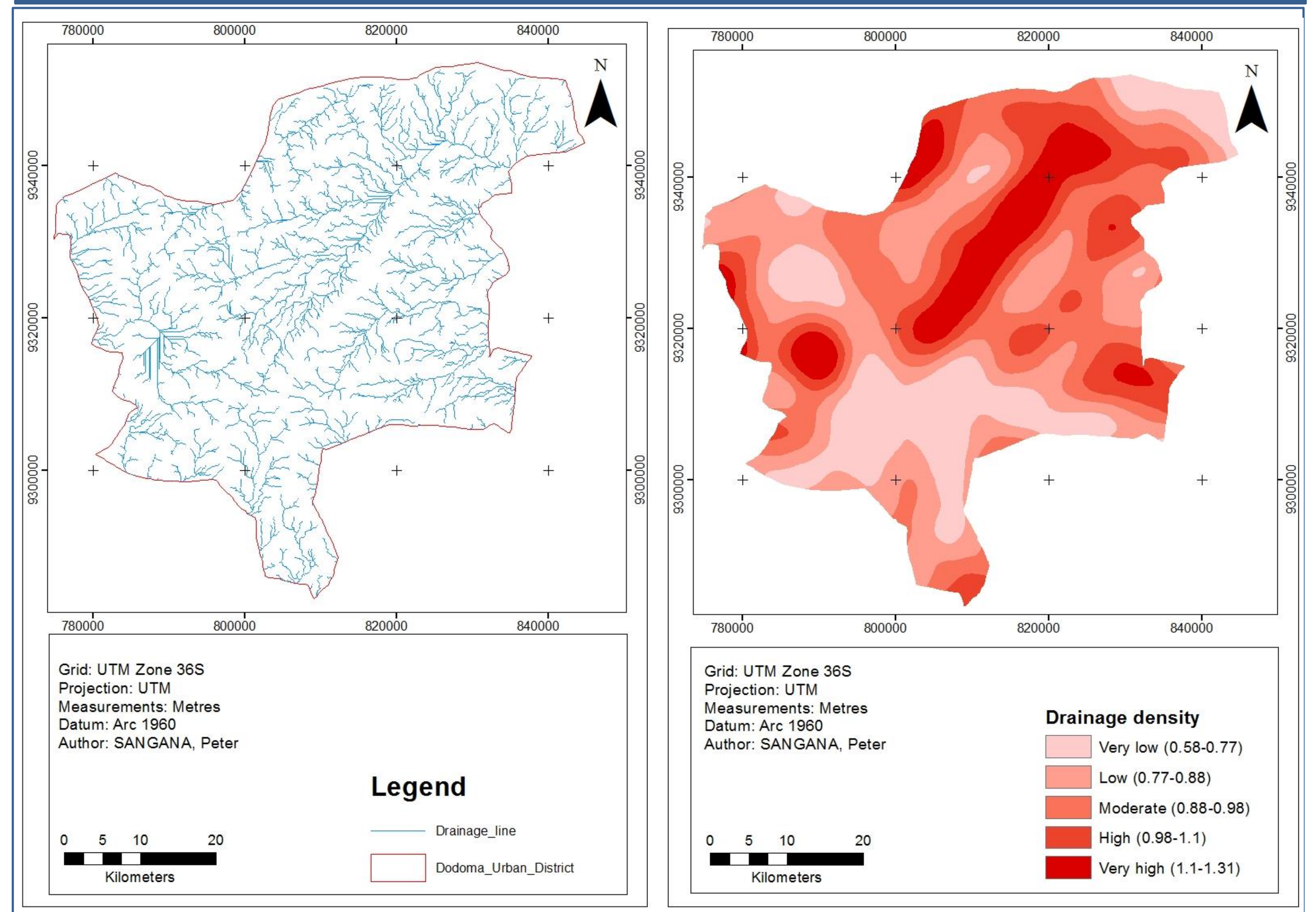


**Figure 3.** Drainage networks and density

## Results

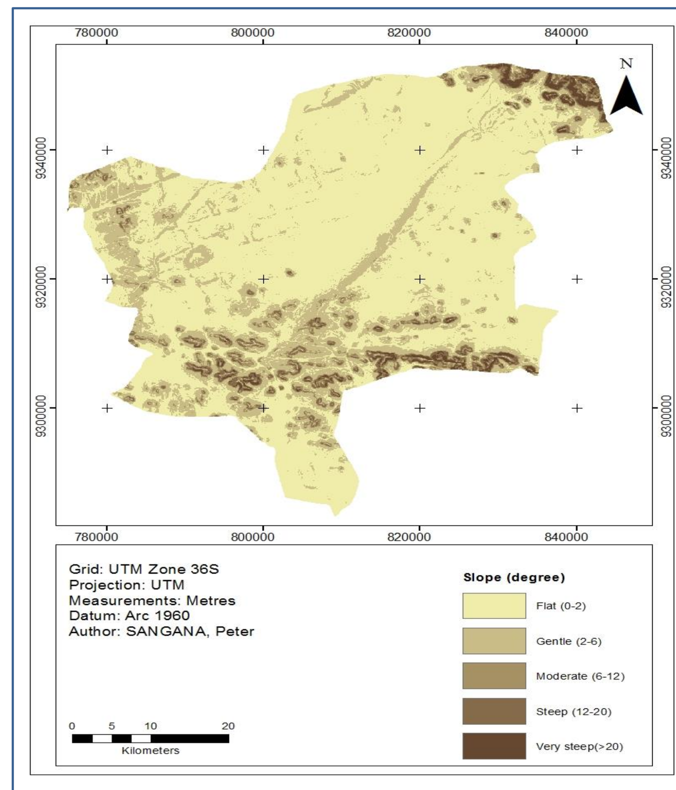

**Figure 4.** Slope amount

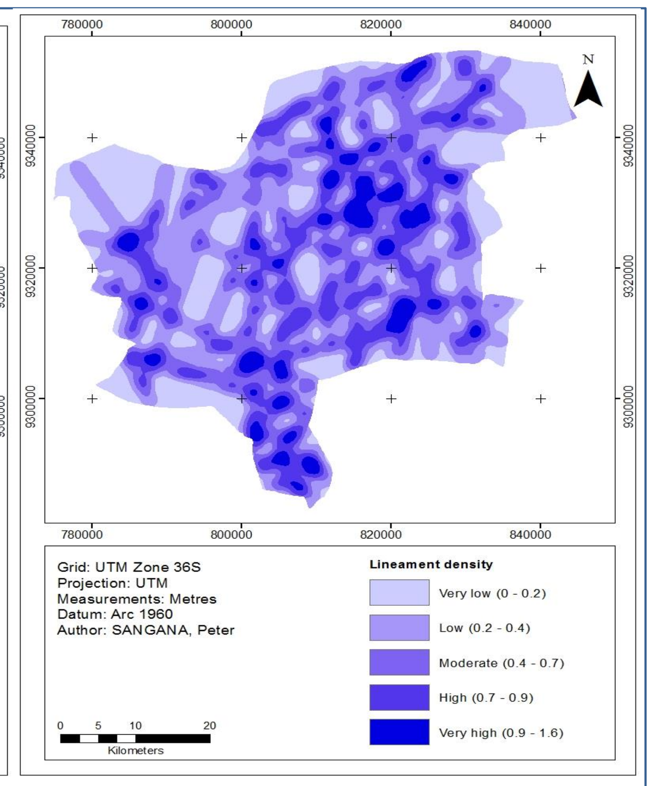

**Figure 5.** Lineament density

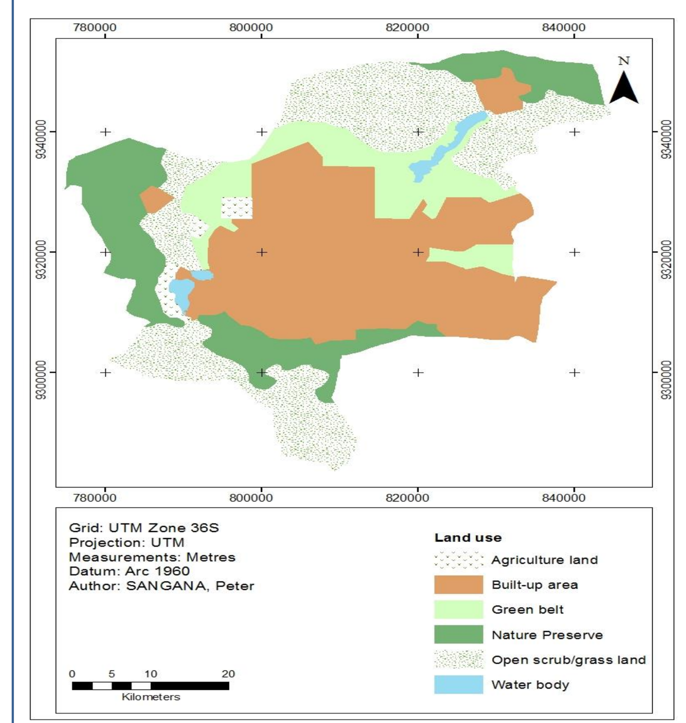


**Figure 6.** Land use/cover

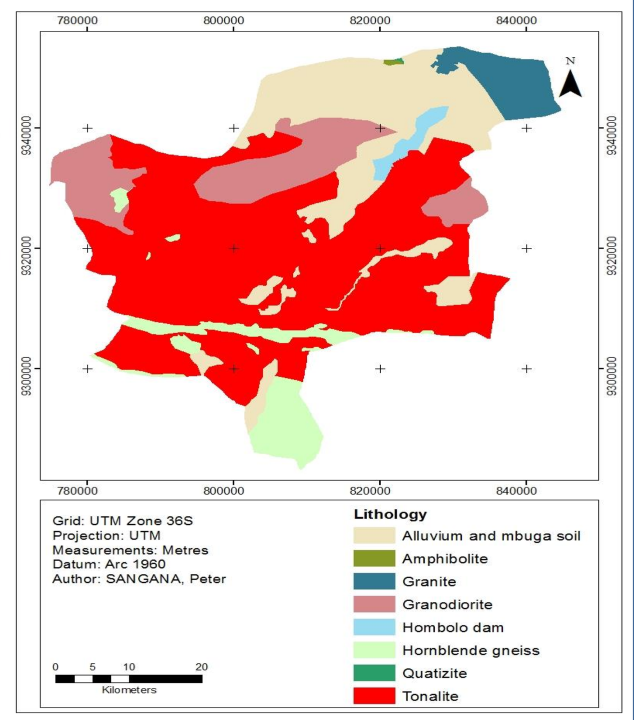

**Figure 7.** Lithology

| Thematic map | Class | Rank | Weight/Influence (%) |
|---|---|---|---|
| Lithology | Hombolo dam | 33 | 42 |
| | Alluvium and mbuga soil | 23 | |
| | Hornblende gneiss | 16 | |
| | Amphibolite | 11 | |
| | Tonalite | 8 | |
| | Granodiorite | 5 | |
| | Granite | 3 | |
| | Quartzite | 2 | |
| Lineament density | Very high | 49 | 26 |
| | High | 27 | |
| | Moderate | 14 | |
| | Low | 7 | |
| | Very low | 3 | |
| Drainage density | Very low | 50 | 16 |
| | Low | 26 | |
| | Moderate | 13 | |
| | High | 7 | |
| | Very high | 3 | |
| Slope | Flat | 49 | 10 |
| | Gentle | 27 | |
| | Moderate | 14 | |
| | Steep | 7 | |
| | Very steep | 3 | |
| Land use/cover | Water bodies | 40 | 6 |
| | Agriculture land | 25 | |
| | Open scrub/grass land | 18 | |
| | Nature preserve | 10 | |
| | Green belt | 6 | |
| | Built-up areas | 3 | |

**Table 1.** Weights and ranks

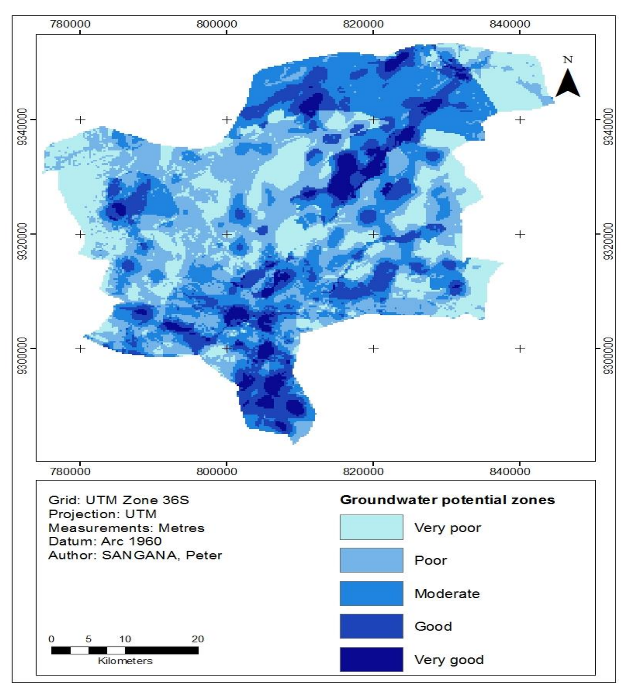

**Figure 8.** GWPZS

## Discussion

The higher the drainage density, the higher the runoff while the lesser the drainage density, the lower the run-off and the higher the probability of recharge or the higher is the potential for groundwater accumulation (Figure 3). In low slope areas (Figure 4) the surface runoff is low allowing more time for infiltration of rainwater, while high slope areas enhances high runoff with short residence time for infiltration and recharge (Magesh et al, 2012). The presence of lineaments may act as a conduit for groundwater movement, therefore, can serve as groundwater potential zone (Figure 5) (Muralidhar et al., 2000). Land use/cover are ranked due to their capacity to infiltrate water and their characteristics to hold water on the ground surface (Figure 6). Lithology was studied with special reference to groundwater holding and conducting capacity of the individual lithology unit (Figure 7).

To compare the importance of two themes and theme classes in order to show that one of them has more influence to the groundwater occurrence than the other, the pair-wise comparison matrix technique was used(Table 1).

The GWPZS were grouped into five viz; very good, good, moderate, poor and very poor (Figure 8). Analysis of the potential zones shows that the very good GWPZS constitute just less than 3 % of the study area. Few patches of this zone were observed at areas associated with Hombolo dam unit.

## Conclusions

The presented results highlight the five thematic layers which influence groundwater occurrence which includes; lithology, land use/cover, lineament density, drainage density and slope amount. The percentage weight of each thematic map was established based upon its contribution toward groundwater availability. Lithology was found to have the highest influence on groundwater availability followed by lineament density, while the land use/cover was found to have the lowest weight. The resulting groundwater potential zones map was classified into 5 classes, namely; very good, good, moderate, poor and very poor. The poor zones were indicating the least favorable area for groundwater prospect; whereas very good zone indicates the most favorable area for groundwater prospect. This study provides the baseline information to local District authorities and planners about the potential sites for groundwater prospecting and exploration.

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