The weighted index overlay analysis (wioa)

[Science](#), [Geology](#)

The Weighted Index Overlay Analysis (WIOA) is one of the multi criterion decision making tool used to assigned weights and scores to each criterion and classes of each criterion respectively to determine the groundwater potential zones. All the criterion maps were converted to raster, assigned a weight (Wc) on a scale of one to ten depending on its suitability to hold water.

Different classes of each criterion map were also assigned a score (Scc) on a scale of one to ten according to their relative influence on the groundwater occurrence (Table 5. 1). With one being the least important and ten being the most important factor. The average score is given by; (Nag and Kundu, 2018) $?=(? Scc \times Wc)/(? Wc)$

Where ? is the average weight score of the polygon, Wc is the weight of each criterion map and Scc is the rating score of the class of the criterion map.

Individual criterion maps were reclassified and the reclassified map together with the weightage map were integrated using the raster calculator in the spatial analyst tool in ArcGIS software. The integrated map was then classified into; excellent, good, moderate, poor and very poor groundwater potential zones and lastly correlated and validated with the field groundwater data obtained from the article written by Meulenbeld & Hattingh, 1999 used as a reference.

Geology and geomorphology maps were identified to be classified maps, therefore the procedure followed to assign score to different classes of each criterion map is different from that of drainage density, lineament density and slope which were classified as continuous maps. Classified maps have

known and definable boundaries whereas continuous maps define a surface where each location is measured from a fixed registration point.

To assign scores to different classes of each criterion map in classified maps, each criterion map was first converted to raster, a table was added on the attribute table, then a suitable score corresponding to the influence of each class to groundwater occurrence was assigned. The vector and raster maps are joined, and the resulting vector map is then converted to raster with scores. For the continuous maps, each criterion map is reclassified into ten classes using the reclassify tool under spatial analyst tool, the method of classification used is quantile and a table was added as well as score.

Criterion maps were assigned weights corresponding to relative influence of each criterion to occurrence, origin and movement of groundwater, with geology given the highest preference (10), followed by lineament density (8), geomorphology (6), slope (4), and drainage density (2).

Sandstones are typically permeable and porous, therefore, can allow percolation of water and can store those large quantities of water, thereby making them good aquifers, However, those of the Wilgerivier Formation forms poor aquifers due to limited faulting, hence, it was assigned a score of 1 (by Meulenbeld & Hattingh, 1999).

Shales have very small interstitial spaces due to very small particle sizes, but can store large quantities of water, however, its transmission is limited due to low permeability, therefore, making it an aquiclude. The shales of the Ecca Group are very dense and should not be ignored as possible sources of

groundwater. The borehole yields are between 0. 5 to 2 l/s with a fractured or intergranular aquifer system, hence, shale was assigned a score of 2 (GCS, 2006).

The diamictite of the Dwyka Group is massive, with little jointing and shows stratification in some places. It has very low hydraulic conductivity ranging from 10-11 to 10-12 m/s and shows no primary voids. The Dwyka diamictite forms an aquitard with very small yield quantities of water ranging from 0. 5 to 2 l/s confined within narrow fractures and joints, hence it is assigned a score of 4 (GCS, 2006).

Diabase intrusion is highly fractured and weathered, yields appreciable quantities of water and therefore forms good aquifer. It was assigned a score of 10. The weight of 10 given to the geology was found to be suitable since the occurrence, origin and transmission of groundwater depends on the physical characteristics of the rock (Figure 5. 1. 1).

Lineament densities range from 0 to 140. 6 and were assigned scores from 1 to 10 respectively in accordance to its relative contribution to groundwater occurrence and storage and was also given a weight of 8. The higher the drainage density, the higher the score given. The classification method used to reclassify the densities is quantile method which assigns the same number of data values to each class, hence, there are no empty classes or classes with too few or too many values.

This method is best suited to linearly distributed data (Figure 5. 1. 2). The valleys, hills and steep inclines were assigned weights of 10, 2 and 1

respectively also according to its importance to groundwater occurrence and storage. Groundwater is usually found in valleys where percolation surpasses surface runoff than in steep inclines and hills where surface runoff precedes percolation. The weight of 6 assigned is well suited for it since it is the 3rd most important criterion to groundwater occurrence (Figure 5. 1. 3).

The slope of the study area ranges from 0 to 79º with the highest degree assigned a score of 1 and lowest 10. This is due to gentle slopes being good groundwater prospecting zones than steep slopes which favors surface runoff. Slope is dependent on geomorphology, therefore, has to be assigned a weight lower than that of geomorphology, hence, a weight of 4 was found suitable.

The classification method used to reclassify slope is also quantile method which assigns the same number of data values to each class, hence, there are no empty classes or classes with too few or too many values. This method is best suited to linearly distributed data (Figure 5. 1. 4). Drainage density is the inverse of lineament density, hence, the scores and weight assigned will be the opposite and lower than that in lineament density respectively.

The drainage densities range from 0 to 252. 4 and were assigned scores from 10 to 1. The slope is dependent on slope and geomorphology, therefore, a slope of 2, lower than them was found to be suitable. The classification method used to reclassify slope is also quantile method which assigns the same number of data values to each class, hence, there are no

empty classes or classes with too few or too many values. This method is best suited to linearly distributed data (Figure 5. 1. 5).

The classification method used for the output groundwater potential zones map is the geometrical interval. This classifier was found suitable to represent the generated data since it is a compromise method between equal interval, natural breaks and quantile. It creates a balance between highlighting changes in the middle values and the extreme values, thereby producing a result that is visually appealing and cartographically comprehensive.

It was observed that the majority of the boreholes are sited on excellent to good groundwater potential zones where the geology is mainly sandstone and close to contact zones with diabase intrusions. The rest of the boreholes are sited on poor to very poor groundwater potential zones with a diamictite rock mass.

According to Hattingh, 1996, the sedimentary rocks of the Wilgerivier Formation makes poor aquifers whereas, the cracks and fissures in intrusive rocks form the main aquifers, hence, groundwater occurs in fractured rock mass. The boreholes close to diabase intrusions make good aquifers irrespective of the groundwater prospecting zone.

Borehole yields are limited, especially in sedimentary rocks, they are below 0. 5 l/s, however, those sited on faults and fractures in intrusive rocks, can yield higher than 3 l/s. Typical borehole depth ranges between 40 and 120 m

while the average range of depth of water level is between 10 to more than

40 m below ground level (mbgl) (DWA, 2011).