Groundwater Potential Mapping In Ado Ekiti, Nigeria Using GIS And Remote Sensing Techniques

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Abstract: Water is an age-long inevitable resource of life of man and is available in limitless quantity in man's environment ranging from the salty oceans to the fresh-water Rivers, underground water and rainfall. This study x-rayed the mapping of groundwater potential of Ado Ekiti, the using Remote Sensing & GIS techniques. Various thematic layers were produced from different datasets using Erdas Imagine and ArcGIS 10.3 software. The six (6) thematic maps that was prepared were reclassified, weights assigned to the various maps according to their degree of influence from 0 to 100%, and integrated to produce the groundwater potential map of the study area. The result showed that the groundwater potential is mostly high at the South-West to the North-West and North central of Ado Ekiti. Low groundwater potential was indicated in the south eastern part.

Keywords: Groundwater, Mapping, ArcGIS, Remote Sensing, DEM

1. Introduction

Groundwater is an essential source of drinking water in both rural and urban part of Nigeria. Groundwater accessibility has been a serious major challenge to some developing countries especially in Africa. Since it is the major source of drinking to developing countries like, efforts are been made to secure and manage the groundwater available within the country. About 1.1 billion people lack access to safe, clean water and the underlying cause of water scarcity is not absolute scarcity; water scarcity is manufactured by institutional and political practices that disadvantage the poor [4]. Groundwater can become contaminated either naturally or because of numerous types of human interaction by, residential, municipal, commercial, industrial, and agricultural activities. Contamination of groundwater (resulting from human activities or from inherent aquifer material composition) reduces the supply of safe drinking water, posing a threat to public health and a challenge to water managers and strategists [6]. The occurrence of groundwater depends on several factors which include geology, surface drainage pattern, slope, topography, land use/ land cover and geology data. The best methods in the estimation of aquifer thickness and the preferable location of borehole are groundwater pumping test/drilling test and stratigraphy analysis, they are cost and time intensive as well as often require skilled manpower [8]. Kumar et al on the other hand, the integrated use of remote sensing, GIS, and satellite data is time and cost effective means to assess and manage groundwater resources [9].

2.0 Study Area

Ado Local Government area is the capital city of Ekiti State in Nigeria. It lies between Latitude7º 34' and 7º 44' North of the Equator and Longitude 5º 11' and 5º 18' East of the Greenwich Meridian. The people of Ado Ekiti are mainly of the Ekiti sub-ethnic group of the Yoruba. The state is majorly an agrarian state where most people are mostly farmer. Most educated people are civil servant and traders. The economics of the city is thriving, there is very prosperous agricultural and farming sector, and also has a very high potential for industry. The farmers in the state are mostly known for subsistence and commercial farming. They are known for cocoa farming and planting of food crops.

3.0 Methodology

Several datasets were used for estimating groundwater potential. Arc-Map 10.3 software was used to prepare the slope map, topographical map and flow accumulation map of the study area from Digital Elevation Model (DEM) using several GIS techniques. Lineament map was extracted from the Ikonos satellite imagery using Erdas Imagine software. Ikonos image of the study area was used to digitize fractures and faults features after several filtering techniques (3*3 Laplacian filter, high pass filter etc) were applied. The digitized data was exported to ArcMap software to calculate the lineament density using Spatial Analyst tool. The Landuse map was prepared Ikonos imagery coverage of the study area. The ikonos imagery used was enhanced using various filtering algorithms in ERDAS Imagine. The land use characteristics of the area were extracted using

supervised classification approach. Some GCP's were used for proper sample set preparation and Maximum Likelihood method was adopted to generate the landuse map. The geology map of the study area was prepared from the geology map of Nigeria. The geology map of Nigeria was geo-referenced in ArcGIS software, the subset of the study area was clipped and the geological features especially the rock formation were digitized [1]. Reclassification was done for the various thematic layers and weighting of the thematic layers was assigned based on the existing literature. Reclassify tool in ArcMap was used to converted vector data to raster format using the vector to raster too. The thematic layers were each reclassified into 5 classes, 1 being the least suitable and 5 the most suitable. The reclassified layers were then weighted based on their degree of significance in a scale of 0 to 100%, where 0% indicates little or no influence and 100% indicates very high degree of significance (See table 1.0). The sum of weights equals 100% and reclassified layers were then integrated together in ArcGIS software to generate groundwater potential. For this project, the model below modified from [8] model was used to produce the groundwater potential.

GWP = Sl + Ld + To + Ge + Lu + Fa

Where

GWP = Groundwater Potential
S l= Slope map
Ld =Lineament density map
Lu = Landuse cover map
To = Topographical map
Ge = Geological map
Fa = Flow accumulation map

Table 1.0 *Weights assigned to each thematic map*

s/no	Thematic Map	Weight in %
1	Geology	25
2	Lineament	30
3	Flow accumulation	20
4	Topographic elevation	10
5	Land use	5
6	Slope map	10

4.0 Result and Analysis

4.1.1 The Slope Map

Slope or gradient of a line describes the direction and the steepness of a line. Slope can be expressed in angles, gradients or grades. The slope affects the rate and the direction of ground water flow. High slope was observed in Ofin village via North central and Ajebandele (the south-west). Low undulating lands were also noticed on the East part of the Ekiti state housing estate, (in the North-East). Approximately half of the study area in made up of low undulating land. Water also infiltrate into the ground in a low undulating land more than a hill top. See Figure 1

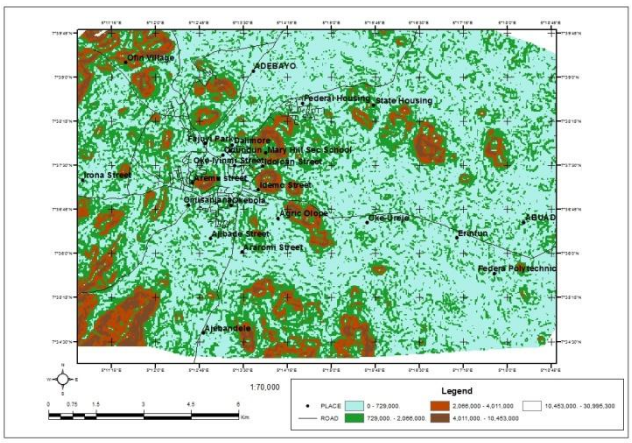

Figure 1: *Slope Map of the Area*

4.1.2 Lineament Map

Lineaments are straight or approximately linear landforms that are widely distributed across the surface of the Earth and are closely related to underground concealed faults. Lineaments are related to fractures and faults in slightly inclined stratigraphic regions. The direction and number of lineaments reflect rock mass fracture patterns and can provide valuable information related to geological structures, tectonics, hazard assessment, and natural resource availability. In this study, the lineament density tends to be high in the Ofin village, state housing estate, ABUAD and part of the town. The lineaments trend from NE to SE of study area and it extends over a length less than 1m to more than 9m as shown on the map. These Lineaments are the weaker zones of bedrock which are formed due to the movement of the Earth intersection of lineaments are considered as good occurrence of groundwater potential zones. Figure 2 shows the lineament density map of Ado Ekiti.

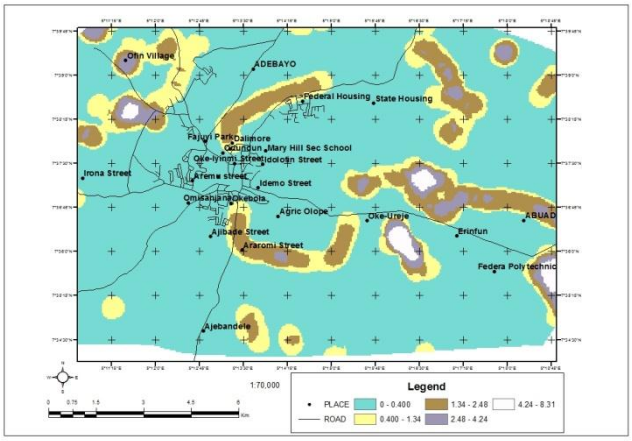

Figure 2: *Lineament Density Map*

4.1.3 Flow Accumulation Map

The Flow accumulation operation performs a cumulative count of the number of pixels that naturally drain into outlets. The operation can be used to find the drainage pattern of a terrain. The Flow direction operation determines the natural drainage direction for every pixel in a Digital Elevation Model (DEM). Based on the output Flow direction map, the Flow accumulation operation counts the total number of pixels that will drain into outlets. The Flow Accumulation tool calculates accumulated flow as the accumulated weight of all cells flowing into each down slope

cell in the output raster. In Figure 3, the flow accumulation is less pronounced in the NE. Also flow accumulations were more pronounced in the SW of Ado Ekiti, from Fajuyi Park to Ajebandele. The flow accumulation ranges from 0 to 2200.

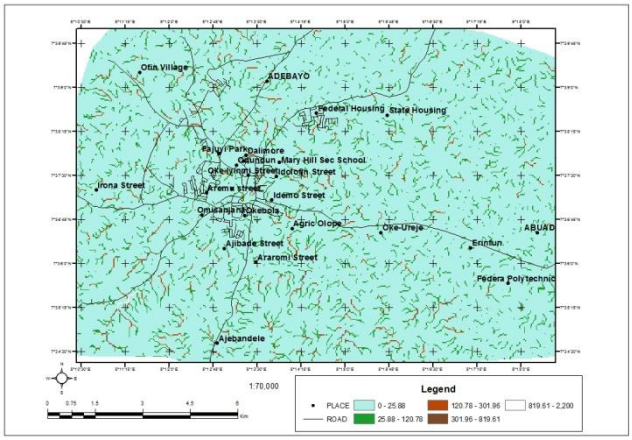

Figure 3: *The Flow Accumulation of the study area*

4.1.4 LandUse Map

Land use refers to man's activities in land, various uses which are carried out on land, whereas land cover denotes the natural vegetation, water bodies, rock due to land transformation[3]. The identified landuse are rock exposure, vegetation, built-up area and water body see Figure 4. Most rock surface exposure exists as a ground level land crop. The landuse influence the drainage network system and evapotranspiration.

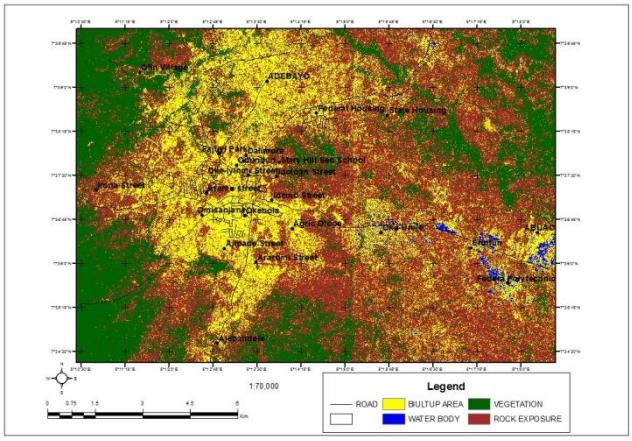

Figure 4: *Land use Map of the Study area.*

4.1.5 Topography Elevation Map

The topography of the area is made of a low level ground to a high hill top as shown in Figure 5. The low level area is located at Erifun, ABUAD, Federal polytechnic, to Agric Olope and Araromi Street (the North, North-East to the South-east). The South-west after Ajebandele is a made up of high hill. The whole area of the study area is moderately high-level ground. The topographic elevation is being derive by clipping out the area needed, and classify them base on height and it being depicted or differentiated by colour.

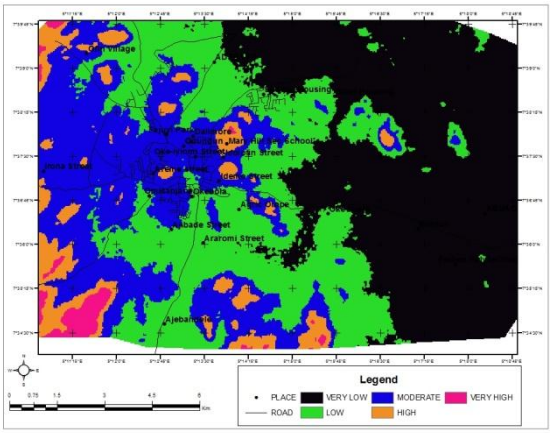

Figure 5: *The Topographical Map of the area*

4.1.6 Geology Map

The rock is generally even textured and homogenous with mineral aggregates mainly of biotite and feldspar phenocryst. The superficial deposits are clay, quartzite rumbles and fine sand (Si_{O2}). The clay is believed to have be formed from the weathering of feldspar mineral present in charnockitic rocks due to alteration of igneous rocks by hydrothermal process and the quartzite rumbles due to high degree of cyclic weathering. See Figure 6 below.

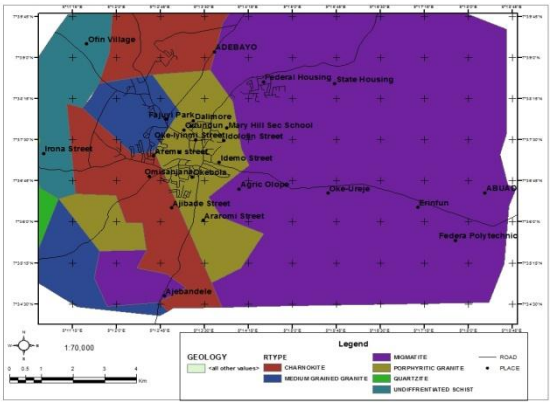

Figure 6: *The Geology of the study area*

4.2 Groundwater potential map

Figure 7 below showed that the flow accumulation area with high flow accumulation of fluid delineate/indicate high equipotential surface moving from the south-western and northwest crossing at right angle to area with low potential in the north east. The groundwater potential was mostly high at Extreme edge of Ajebandele of Ado Ekiti. This is due to the high slope, and high topography of the area. High elevation and high slope usually allow the ground water to run down the slope rather than infiltrating into the ground. There is a low ground water potential in federal and state housing estate to south eastern part of the study area. This is due to low slope and low elevation in the area.

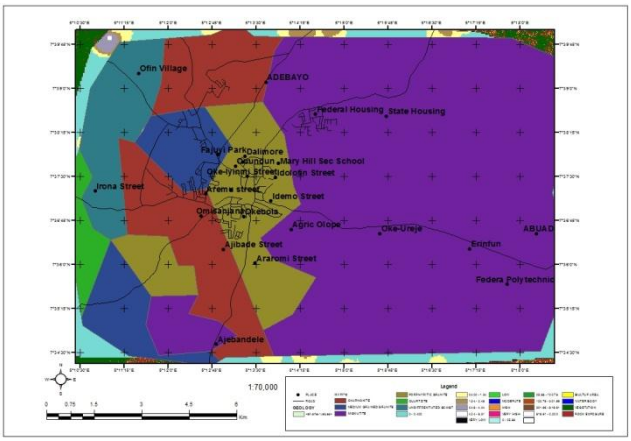

Figure 7: *Groundwater potential composite map of the study area.*

5.0 Conclusion

The integrated use of GIS and Remote Sensing for mapping the groundwater potential in this study area proved the efficiency of this technique in terms of time, labour and cost reduction. the ground water potential is mostly high at Extreme edge of Ajebandele (in the Soutwest to the north west and north central) of Ado Ekiti. This is due to the high slope, and high topography of the area. High elevation and high slope usually allow the ground water to run down the slope rather than infiltrating into the ground. There is a low ground water potential in federal and state housing estate to south eastern part of the study area. This is due to low slope and low elevation in the area.

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