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Investigation Of Groundwater Distribution In Ututu And Its Environs In Abia State Nigeria, Using Geo-Spatial Technique

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ABSTRACT
This paper aims at evaluating the groundwater distribution in Ututu and its environs, Abia State, Southeastern Nigeria using Geo-Spatial technique. Influential thematic maps of slope, geology, lineament, topography and drainage were prepared using Landsat 7 ETM^+ Imagery and ancillary geologic data of the area. These were integrated in ArcGIS 9.0 environment to produce the groundwater potential map for the study area. Groundwater distribution in this area was observed to be controlled by the underlying geology and geomorphology of the area. The study categorized the groundwater potentials of the area into poor, low and high potentials. A great portion of the shale dominated lowlands of the Abam communities and Amuvi fall within the poor to low groundwater category whereas the Sandstone dominated highlands indicated good hydro geological properties and were classified as good groundwater potential zones. Areas of good groundwater potentials include Eziama, Ihechiowa, and Ututu. These communities are therefore areas of sustainable regional groundwater resource development within Arochukwu watershed.
Keywords: Remote sensing , Ututu, Abam, Groundwater potentials, Landsat 7 ETM^+ ,

1. INTRODUCTION

Sustainable groundwater development has become a necessary need across countries, regions and cities if the increasing water demand for domestic and other purposes must be met. A good knowledge of groundwater potential status is however required for a successful regional groundwater resource development and management,. Groundwater potential of an area is controlled by the inter-relationship of many factors such as the geology, geomorphology, drainage, groundwater flow pattern, recharge and discharge processes among others. The use of these relationships and comparisons between other aquifer properties and geophysical parameters has yielded useful result in groundwater potential modeling (Okonkwo *et al*., 2016; Ezeh *et al.*, 2013).

Groundwater offers the most dependable source of quality water supply in Abia state, hence there is an increase in groundwater demand in Ututu and its environs. The study area is located in Arochukwu Local Government Area within latitudes 5° 22' 48" N - 5° 39' .52"N and longitudes 7° 30' 19" E - 7° 54' 17"E. Ututu is a principal historic city and is surrounded by Ihechiowa, Aro and the Abam communities. It falls within the south-eastern part of the Anambra basin, within the Deltaic marine sediment of Cretaceous to recent age. The three principal geological formations in the area are; the false bedded Ajali sandstones, the Imo shale and the Nsukka Formation. The inhabitants of this area are mostly farmers therefore, water resource development and management plays an integral role in the local economy of this region. However, there is a challenge to groundwater resource development in this area due to its characteristic Shale Formations, dense vegetation and insufficient hydrological data.

For areas where dense vegetation hampers geophysical surveys, remote sensing becomes a valuable tool for the assessment of the hydrological properties, which contribute to the groundwater prospect of the area. It provides useful information on terrain parameters such as drainage pattern, slope, and structures among others, which have bearing on permeability of soils and recharge conditions.

The concept of Remote Sensing and GIS application in groundwater exploration has been applied by many authors. Basavarajappa, *et al*., (2015), Obimba *et al*., (2017), Arulbalaji and Sreelash, (2019), Collignon (2020), Adindu *et al*., (2021) and Allafta *et al*., (2021) have utilized the integrated concept in targeting groundwater potential resources in different locations. They noted that the integration of the two techniques has the capability to identify potential areas of groundwater occurrence through delineation of groundwater terrain indicating factors. This study aims at using the integrated approach of Remote Sensing and GIS in the investigation of groundwater distribution and potentials in Ututu and environs.

2. METHOD OF STUDY

The study investigated the surface features contributing to groundwater prospect in the area such as slope, lineament, drainage, geology and geomorphology. Thematic maps of these factors were generated from Landsat 7 ETM^+ imagery and were integrated with geologic map of the study area using ArcGIS 9.0 software. The maps were overlaid and processed to produce the groundwater variability and distribution map for the area. This map was visually inspected, evaluated and used for the identification of groundwater distribution pattern and the possible groundwater potential zones in the area. Three categories of groundwater potentials were delineated. These are the poor, low and good groundwater potentials.

3. RESULTS PRESENTATION

The color distinctions in the thematic maps of the groundwater potential indicating factors reflect variations in sediment formations, topography and complexity in structures that affected infiltration, runoff, recharge potentials, storage and possibly the potential distribution of groundwater in the area. These maps are characterized by distinct patterns and color gradations that reflects the impact of each factor on groundwater occurrence in the area. The individual maps were visually inspected and evaluated for groundwater potential zones and distributions in the areas.

Geology of the area

The three major litho-stratigraphic units in Arochukwu are the Ajali sandstone, the Nsukka and the Imo shale (Figure 4 .1). The Ajali sandstone is delineated around the southeastern part of the area. It stretches from Amanagwu to Ututu area and also covers some localities at the Northeastern part; the Nsukka formation is observed to be the major formation in the region. It covers a larger portion of the area, stretching from the North-central region to the southeastern region. The third formation – the Imo shale is the least spread, underlying small region of the area around the Ameke and Omerenama and the Abam communities whereas the highlands of Amanangwu - Ututu are underlain by the Ajali Sandstones (Figure 4 .1). The underlying geologic unit and soil type have some influence on the rate of infiltration of rain water into the subsurface. Areas underlain by shale are expected to encourage more runoff than areas underlain by sandstones since shale materials are impermeable materials that do not encourage percolation of water (Deepa *et al.*, 2016).

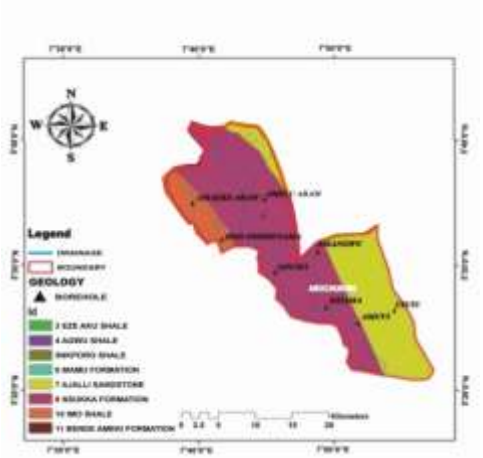

Figure 4.1: Geologic map of the study area

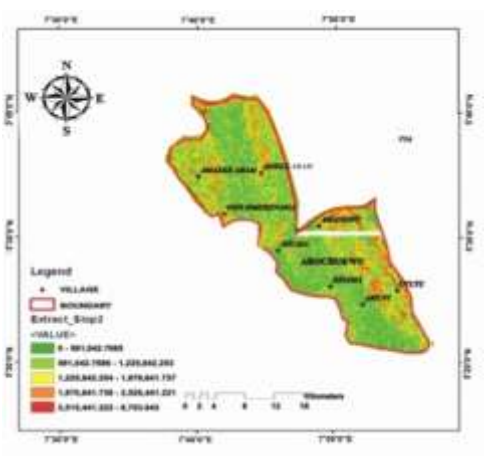

Figure 4.2: Slope map of the study area.

Steepness of the area

The steepness of the area is defined by low and high slopes. Low slope was delineated around Ahuma, Eziama and Amuvi in the southern region of the area, suggesting relatively low lying terrain (Figure 4.2). Low lying terrains are characterized by low runoffs, high infiltration and high groundwater recharge (Surayabhagavan, 2017). The delineated highlands stretching from Amanagwu to Ututu at the southeastern area implies steep terrain, high runoffs, low infiltration and consequently low recharge. High slope areas are probable areas of high runoffs, poor infiltration and consequently poor groundwater recharge (Raju *et al.,* 2017).

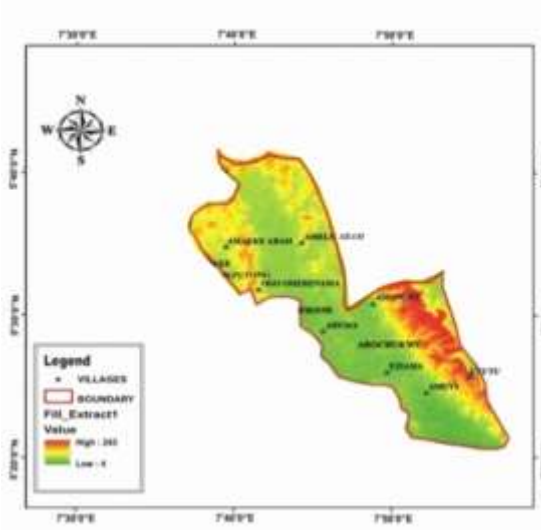

Figure 4.3: Elevation Map of the Study Area.

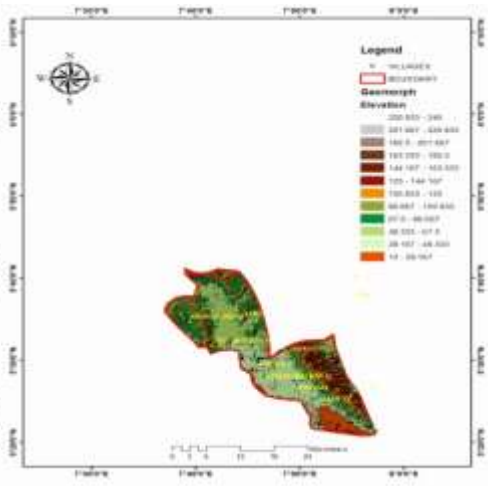

Figure 4.4: Geomorphology map of the Study Area

Geomorphology of the area

The geomorphology of the study area is characterized by two distinct features; a ridge stretching from the Amanagwu to Ututu at the southeast, highlands at some localities around the Ameke and the adjoining lowlands and valleys of Amuvi, Eziama and Ahuma (Figures 4.3; 4.4). The elevated areas with steep gradient are expected to exhibit high runoffs, poor infiltration and low groundwater recharge whereas the lowlands of are expected to exhibit low runoffs; high infiltration and high groundwater recharge (Shivaji and Nitim, 2014).

The drainage pattern

The drainage pattern in Arochukwu is characterized by both parallel and dendritic patterns (Figure 4.5). Dendritic patterns trends in the North - South direction reflecting the porosity, permeability and the litho-facies variation in the path of flow of the stream network (Shaban *et al.,* 2006). The parallel patterns are localized majorly to the Abam communities in the northwest of the study area. Parallel patterns are indications of structural controls by faulting and tectonics (Rajesh *et al.,* 2007).

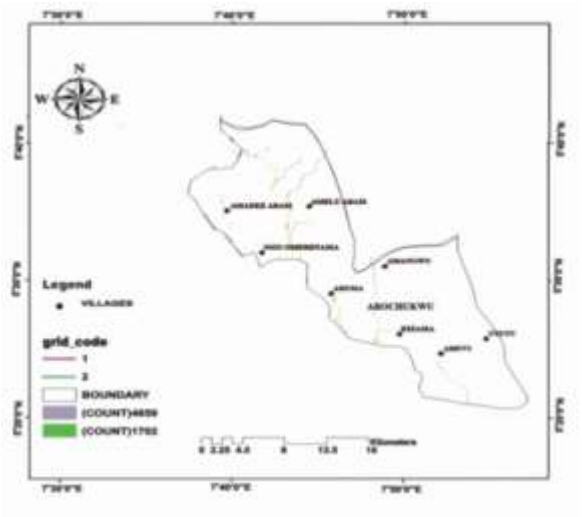

Figure 4.5: Drainage map of the study Area.

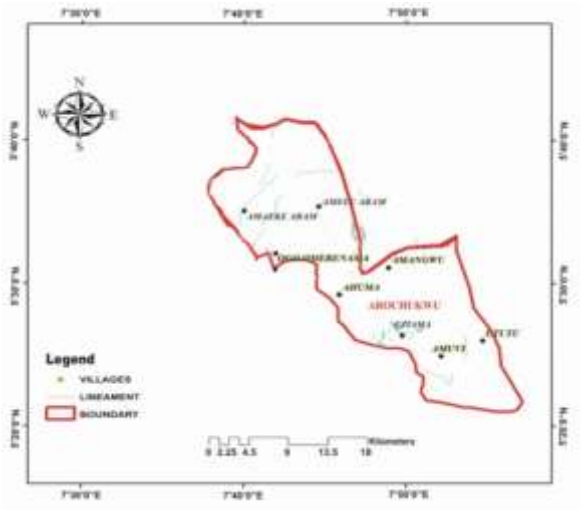

Figure 4.6: Lineament map of the study area

Lineaments

Lineaments in the area are majorly localized around the Eziama region. They trend **NE-SW and N-S** (Fig. 4.6). Lineaments are good guide to groundwater exploration. They give a clue to groundwater movement and storage, and also acts as channels for groundwater infiltration and recharge. Areas of high lineament densities suggest zones of high infiltration and recharge (Subba *et al*., 2001; Mulwa, 2005).

Groundwater potentials

After the weight of each terrain factors were evaluated using the analytical hierarchical process based on a scale of ten (10) in accordance with Badamasi *et al.*, (2016), areas of poor to low groundwater potential were identified as the Abam communities (Ameke, Ndi- Okereke, Nde Ite, Ndi-Ojiaku), Ahuma and Amuvi whereas good groundwater potentials were implied in Ututu Ihechiowa and Eziama communities (Fig. 4.7.).

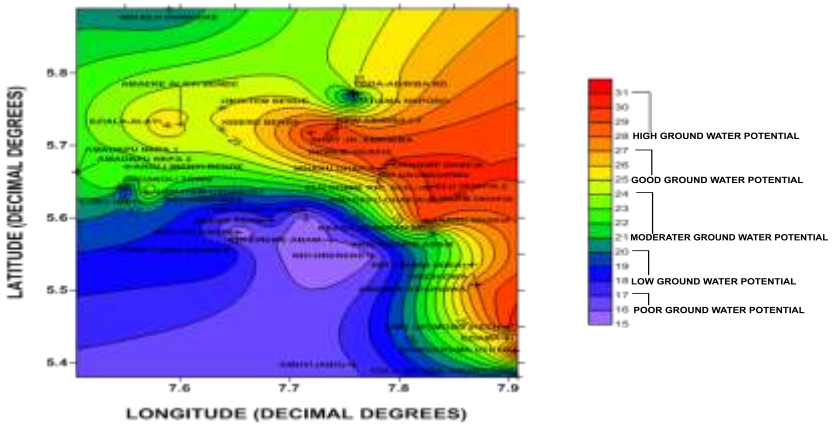

Fig.4.7: Groundwater Potential Map of the area.

4. DISCUSSIONS

The slope and geomorphology show highlands dominated by Ajali sandstones at the southeastern region, and also at some localities at the northeast region. These are flanked by shale dominated lowlands and valleys with characteristic poor infiltration and recharge. Steep slopes at the highlands enhance runoffs owing to insufficient residence time for percolation of surface precipitations into the subsurface. The runoffs are channeled to the shale dominated lowlands and valleys causing gully erosion in some communities. These lowlands and valleys are therefore categorized as poor – low groundwater potential zones. This result agrees with the observations of Deepa *et al*. (2016) which

reported that steep slopes are poor groundwater potential zones, but contrast the observation and Raju *et al*. (2017), that low slope areas are generally good groundwater potential zones.

Also, the highland dominated sandstones are characterized by relatively flat surfaces which reduce runoffs and enhance infiltration and recharge of rain water into the underlying formation. These areas are regions of good groundwater potential zones. However, these results contrast the observations of Deepa *et al*. (2016) and Obimba *et al*. (2017), which reported that areas of steep slopes are poor groundwater potential zones while less steep slope areas are good groundwater potential zones. These contradictions are attributed to the underlying geology of the study area which seems to have played an influential role in determining runoffs and infiltration. Shale formations are characterized by poor hydro geologic properties which encourage runoffs and low infiltration of surface precipitated water. It is therefore expected that within shale dominated regions of Ameke, Amelu and Ahuma and Amuvi, runoffs will be high, infiltration will be low and recharge will consequently be low. But the Ututu and Eziama communities which are underlain by the Ajali sandstones are characterized by permeable and porous Formation. Consequently, infiltration will be high whereas runoff is expected to be low hence groundwater recharge is enhanced.

High drainage frequency was delineated in the shale dominated regions whereas low drainage frequency is associated with the sandstone dominated highlands. Drainage frequency is a reflection of the impervious nature of the underlying formations. As such, shale dominated regions exhibit more drainage frequency than sandstone dominated highlands (Adeniyi and Anifowose, (2017); Obimba *et al*., (2017). Therefore in this study, poor to low groundwater potentials are associated with regions with more drainage frequency whereas good groundwater potentials are associated with regions of low drainage frequency.

Lineaments are related to surface drainage and serve as conduits for movement and storage of groundwater (Selvam *et al*., 2014). But this study observed by comparison of the drainage and lineament maps, that there is no apparent drainage that could be matched with the lineaments. This therefore suggests that these lineaments are not connected to surface drainages or subsurface flows implies localized weak zones through which surface precipitations are channeled down slope to the lowlands and valleys.

The produced groundwater potential zone map of the study area shows the distribution of groundwater potentials across the region. It delineated zones of good groundwater potential, zones of low and poor groundwater potentials respectively. Zones of groundwater potentials are underlain by Ajali sandstone formation. Such areas include the Ututu, Ihechowa and Eziama communities. Shale dominated regions of the Abam communities (Ameke, Amelu, Ahuma) and Amuvi in Aro indicated poor to low groundwater potentials. Borehole development will be unsustainable in these areas due to impermeable shale layers limiting the amount of water that percolates into the aquifers resulting to scarcity of water supplies in the areas (Adindu *et al., 2021).*

5. CONCLUSION

Evaluation of groundwater distribution in Ututu and its environs has been was carried out by analyzing the surface features contributing to groundwater prospects in the study area. The Influence of slope, geology, lineament, topography and drainage were used to determine the groundwater potential in the area. The geomorphology of the area signifies lowlands and valleys characterized by poor to low moderate groundwater potentials and highlands typifying good groundwater potentials zones. The study recommends that sustainable groundwater resource development should be carried out in this area.

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