Groundwater Potentiality Assessment for Sustainable Agriculture in Selected Farm Settlements of Southwestern Nigeria using Electrical Resistivity Tomography

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ABSTRACT

Agricultural productivity in the southwestern part of Nigeria has experienced limitations during the dry seasons due to heavy dependence of the farmers on rainfall, fluctuating surface water and rainfall unpredictability due to climate change. Therefore, the need to explore alternative water sources for all-year-round agriculture becomes highly imperative. This study was conducted to assess the groundwater potential of Ajegunle farm settlement in Ogun State, as well as Akufo and Eruwa farm settlements in Oyo State. Two-dimensional (2-D) Electrical Resistivity Tomography (ERT) data were collected using pole-dipole and dipole-dipole arrays for a combination of deep probing and high resolution. A total of six ERT profiles were acquired within each settlement using an 8-channel SuperSting R8 resistivity/IP meter attached to 84 stainless steel electrodes via multi-core cables, powered by a 12V battery. The acquired data were processed using the EarthImager 2-D and 3-D software. Three of the 2-D profiles acquired parallel at 20 m apart were combined to produce a 3-D profile for each of the farm settlements. Generally, the resistivity obtained ranged from 1 to 10000 Ωm, revealing the subsurface to be composed mainly of sandy clay/clayey sand, weathered/fractured basement, and fresh basement, with good groundwater potential zones. Development of the groundwater resource in these farm settlements will greatly enhance mitigation against climate change as well as adaptation to its effects while improving all-year-round agricultural productivity of the settlers, who are predominantly farmers.

Key words: Climate change; EarthImager; groundwater potential zones; hydrogeological; weathered/fractured basement.

INTRODUCTION

Groundwater is a renewable water resource which is widely distributed within the subsurface of the Earth. As part of the Earth's natural hydrological cycle, the principal sources of natural recharge of groundwater are precipitation, and seepages from stream flow in channels, lakes, and reservoirs (Ayoade, 2003).

Groundwater is a dependable source of water supply, which is often less contaminated due to restrained movement of pollutants through the soil profile (Lamb, 1985). It is an economic resource which has great potential for drinking, domestic, industrial, recreational, and agricultural purposes. For most countries around the world, agricultural practices such as irrigated farming and livestock farming are the principal user of water resources (OECD, 2006).

Successful exploitation of groundwater for domestic or irrigation purposes require proper understanding of the hydrogeology (Abdullahi *et al.*, 2016). This is particularly important in basement complex terrains owing to the non-continuous nature of basement aquifers (Satpathy and Kanungo, 1976). However, groundwater exploitation in basement complex aquifers comes with a lot of challenges (Akintorinwa *et al*., 2020). The rocky formation and deep nature of the aquifers make it economically difficult to dig wells without certainty of the extent and yield of aquifer in the area of interest (Ariyo and Oguntade, 2009). As a result, detailed geophysical investigation usually precedes borehole drilling, especially in areas underlain by basement complex terrain (Akintorinwa *et al*., 2020; Ariyo and Oguntade, 2009).

Electrical Resistivity Tomography (ERT), also referred to as Electrical Restivity Imaging (ERI) is a geophysical imaging technique which has developed rapidly. It is a non-invasive method which provides high-resolution spatial information that reveals the structure of the subsurface (Chambers *et al.*, 2008). One factor that makes electrical resistivity methods very useful in groundwater geophysics is the sensitivity of resistivities of rocks to their ionic contents (Alile *et al.*, 2011). ERI has been applied in groundwater exploration as reported by several authors. Dutta *et al.* (2006) in their survey delineated water-bearing fractured zones in the hard terrain of the Maheshwaram watershed using ERI method. Kumar *et al*. (2010) and Shamaun *et al.* (2011) have also used ERI to evaluate potential aquifer zones and for characterization of the near surface variation in geologic formation as well as soil strata in Bangladesh. Samgyu *et al.* (2016) used ERI to explore the groundwater contamination occurring near an uncontrolled landfill in South Korea. In this study, the authors juxtaposed the ERI results with the piezometric and hydrochemical data obtained from observation wells and they were able to establish a good agreement between the ERI results and groundwater monitoring results. Riwayat *et al.* (2018) remarked that ERT has become an established tool in groundwater exploration.

Geophysicists employ the ERT method by creating 2-D or 3-D models of groundwater reservoirs from resistivity data. Ratnakumari *et al.* (2012) used the 2-D ERT technique to delineate deeper aquifers in a part of the Chandrabhaga River basin in India. They confirmed the effectiveness and accuracy of the 2-D ERT model above the

1-D model of resistivity variation in subsurface model where resistivity changes in the vertical and horizontal directions were presented. The combined use of multi-electrode electrical resistivity imaging meter, effective data processing software and effective data inversion techniques guarantee the simultaneous study of both lateral and vertical variations of resistivity as well as enhances resolution of the computed images of the subsurface geological formation (Griffiths and Barker, 1993; Loke, 2000).

The Farm Settlement Scheme was a government intervention introduced in Nigeria in 1959 by the then Western Regional Government to improve the socio-economic status of the people. The scheme was established for the transformation of the traditional farming system and education of peasant farmers on how to produce food and export crops through the application of modern agricultural methods for multi-purposed agricultural activities (Iwuchukwu and Igbokwe, 2012). It was also to demonstrate that through careful planning and reasonable governmental assistance (in form of professional advice or finance through loans), young, educated farmers could establish and operate farms which would provide a comfortable standard of living comparable with or even higher than that of their mates in other forms of employment (Iwuchukwu and Igbokwe, 2012).

There has been an increasing interest in irrigation and all-year-round agricultural activities as part of the drive to meeting food security goal in Nigeria. Despite the potential for highly productive all-year-round agriculture, farm settlers have been struggling with lack of access to reliable source of water for irrigation and livestock production, especially during dry seasons. Therefore, the use of groundwater as an alternative source of water for agricultural purposes is gaining more attention. However, the major limitation to groundwater uses among small holder farmers generally and in the government farm settlements specifically has been little information on the groundwater characteristics and potentiality.

This study assessed the groundwater potentiality for agricultural purposes in Ajegunle farm settlement in Ogun State as well as Akufo and Eruwa farm settlements in Oyo State, Southwestern Nigeria, using Electrical Resistivity Tomography (ERT) method.

MATERIALS AND METHOD

The Study Areas and Geomorphology

This study was conducted at the Ajegunle farm settlement, Mile 6, Ajebo road, Obafemi Owode Local Government Area of Ogun State; Akufo farm settlement, along Ibadan-Eruwa Road, Ido Local Government Area of Oyo State and Eruwa farm settlement, not far from Eruwa town in Ibarapa-East Local Government Area, 60 km northeast of Abeokuta and about 72 km southwest of Ibadan, Oyo State. The three study locations are within the Ogun River basin, located in the southwestern part of Nigeria (Fig. 1).

The Ogun River basin is bound geographically by the following coordinates: longitudes 2º 28' E and 4º 8' E and latitudes 6º 26' N and 9º 10' N. It has a low relief, with the slope pointing in the north-south direction (Oke *et al.,* 2013; Oke *et al.,* 2015). Ogun river basin has two distinguishable seasons; a wet season from April running through October, followed by a dry season from November to March. The watershed is characterized by two major vegetation zones: the swamp/mangrove forests that cover the southern coastal and floodplains, next to the lagoon and the high forest vegetation in the north and central parts (Oke *et al.,* 2013; Oke *et al.,* 2015).

The Southwestern Nigeria is predominantly underlain by the Precambrian Basement rocks of the Dahomey Basin, which is characterized by granite gneisses, banded gneisses and migmatites with low grade metavolcanic and metasedimentary schists, intruded by Pan-African age granites and charnockites (Oyawoye, 1972). Oluyide *et al.* (1998) remarked that the migmatites and gneissic metasediments are frequently thrust by pegmatite veins and dykes. The Precambrian Basement Complex also includes older granites, granodiorites and syenites, with dolerite dykes. This formation is the reason for low porosity and permeability essentially needed for the presence of large groundwater resources (Adelana *et al.*, 2008). However, significant porosity and permeability may have evolved through weathering and fracturing processes which contribute to groundwater resources in the basin (Nur and Kujir, 2006).

Ogun river basin is underlain by the Precambrian Basement Complex rocks such as granite, hornblende-biotite, quartzite, gneisses, biotite schist and Sedimentary rock sequence which range from Cretaceous to Recent sediment. The stratigraphic succession in the Dahomey basin from the top generally begins with the Coastal Plain Sands which consists of alternation of sands and clay. This Formation is underlain by sands of the Ilaro Formation. Underlying the Ilaro Formation is Ewekoro Formation which comprises of shale and limestone, while the oldest of all, the Abeokuta Group which consists of grey sandstones intercalated with clay underlies the Ewekoro Formation.

The selected farm settlements lie within the basement complex terrain; Ajegunle is underlain mainly with the Abeokuta Formation and migmatite, Akufo with quartzite and Eruwa with undifferentiated gneiss (NGSA, 2010) (Fig. 2a and b).

The farmers within the Ajegunle farm settlement are majorly into livestock farming: piggery, poultry, and fish farming while the predominant crops in the settlement are cassava, maize, and vegetables. Akufo farm settlers are both crop and livestock farmers: mainly cassava, yam, oil palm, kola nut, timber, cocoa, and vegetables as well as poultry and cattle rearing. Crop farming in cassava, vegetables, and fruits such as watermelon and cashew is predominant in the Eruwa farm settlement while few farmers also rear pigs.

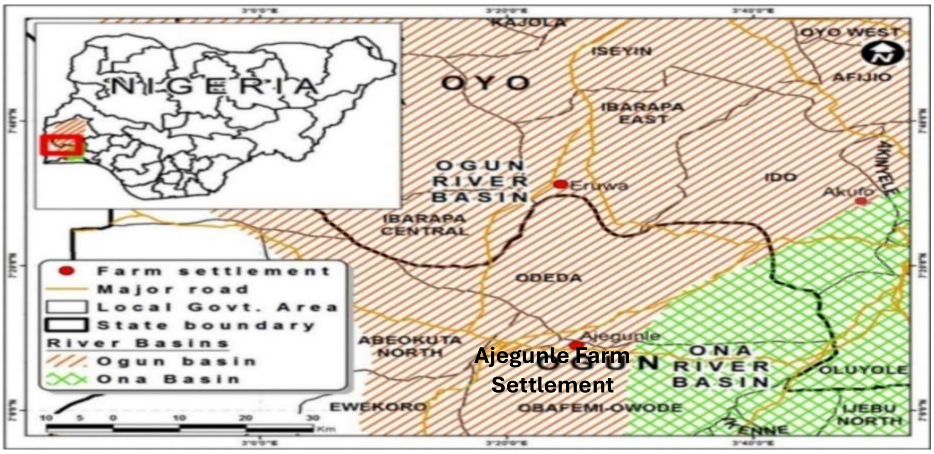
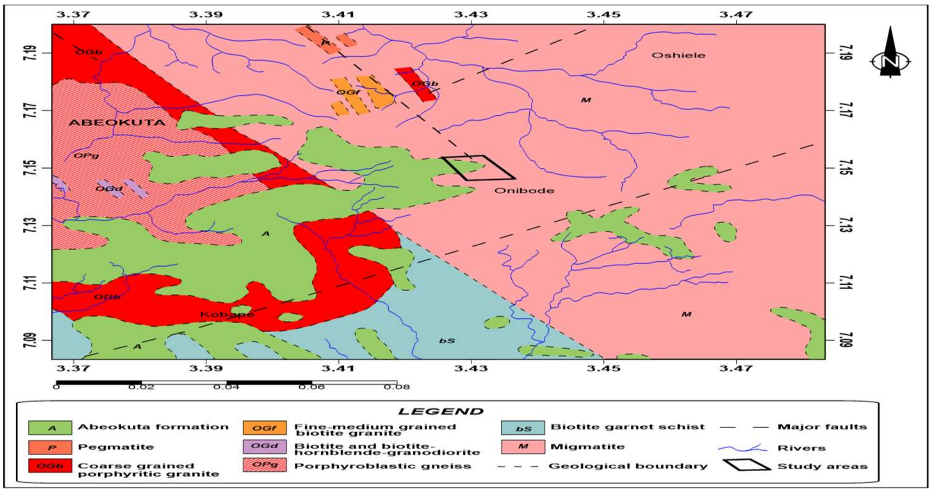
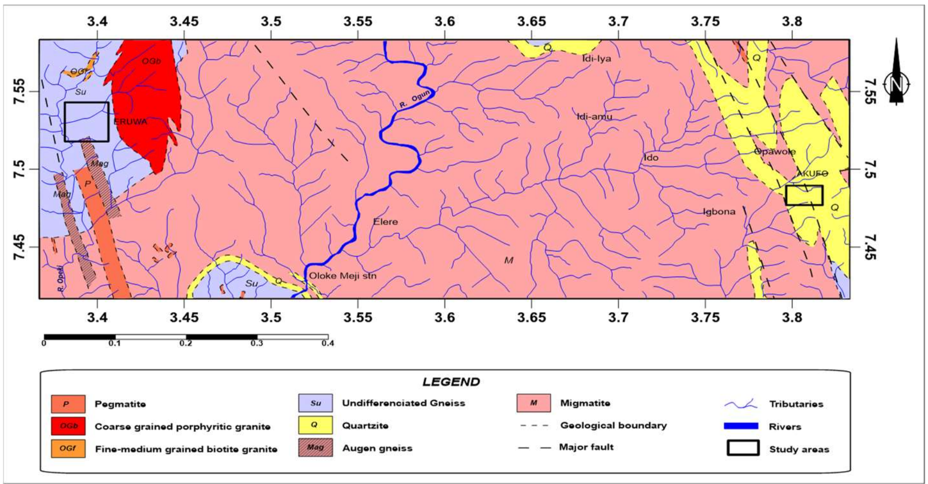


Figure 1: Location map of Ogun and Oyo States showing the selected farm settlements and river basins.



(a)



(b)

Figure 2: Geological map showing the rock types that underlie (a) Ajegunle farm settlement; (b) Akufo and Eruwa farm settlements (modified after *NGSA, 2010*).

Instrument, Data Acquisition and Processing

Electrical Resistivity Tomography (ERT) data were acquired with an 8-channel SuperSting R8 Resistivity/IP meter (manufactured by Advanced Geosciences Inc., Austin, Texas, U.S.A.) attached to 84 stainless steel electrodes via multi-core cables, which was powered by a 12-volts battery. Six (6) 2-D ERT data profiles were acquired on each farm settlement using two arrays (the pole-dipole and dipole-dipole arrays) for a combination of deep probing and high resolution (Aizebeokhai, 2010; Griffiths and Barker, 1993 and Okpoli, 2013). The signal-to-noise ratios of these configurations are known to be relatively low compared to that of others such as pole-pole (Samgyu *et al.*, 2016). Electrode spacing of 4 m or 5 m, depending on the available space, was used in the surveys. Three of the profiles from each settlement, which were acquired in parallel at 20 m apart, were combined to produce a 3-D profile (Aizebeokhai and Singh, 2013). The latitudes, longitudes and elevations of the start and end points of the profile lines presented in Tables 1-3 were taken using eTrex 10 Garmin handheld GPS device. The data acquisition maps showing the ERT profiles and land use features are presented in Fig. 3.

Table 1: Geophysical survey profile line coordinates at Ajegunle farm settlement

			Survey line Starting Point			**Survey line End Point**		
S/N	**Profile Tag**	**Survey line**	**Latitude (°)**	**Longitude (°)**	**Elevation (m)**	**Latitude (°)**	**Longitude (°)**	**Elevation (m)**
1	AJG01	A – B	7.15034	3.42708	167	7.15383	3.42589	191
2	AJG02	C – D	7.15028	3.42684	169	7.15381	3.42571	189
3	AJG03	E – F	7.15022	3.42647	166	7.15379	3.42552	192
4	AJG04	G – H	7.15169	3.43215	151	7.15452	3.43156	171
5	AJG05	I – J	7.14878	3.43514	170	7.14907	3.43139	153
6	AJG06	K - L	7.14563	3.43103	163	7.14933	3.43149	152

Table 2: Geophysical survey profile line coordinates at Akufo farm settlement

			Survey line Starting Point			**Survey line End Point**		
S/N	**Profile Tag**	**Survey line**	**Latitude (°)**	**Longitude (°)**	**Elevation (m)**	**Latitude (°)**	**Longitude (°)**	**Elevation (m)**
1	AKF 01	A – B	7.48132	3.81384	259	7.48375	3.81664	253
2	AKF 02	C – D	7.48146	3.81374	256	7.48388	3.81645	248
3	AKF 03	E – F	7.48119	3.81397	255	7.48362	3.81672	252
4	AKF 04	G – H	7.48702	3.81788	257	7.48890	3.81468	258
5	AKF 05	I – J	7.48108	3.80918	253	7.48116	3.81291	255
6	AKF 06	K - L	7.47786	3.81574	277	7.47992	3.81364	256

Table 3: Geophysical survey profile line coordinates at Eruwa farm settlement

S/N	Profile Tag	Survey line	Survey line Starting Point			Survey line End Point		
			Latitude (°)	Longitude (°)	Elevation (m)	Latitude (°)	Longitude (°)	Elevation (m)
1	ERW 01	A – B	7.52177	3.40589	148	7.52495	3.40355	144
2	ERW 02	C – D	7.52800	3.40019	143	7.53034	3.40343	145
3	ERW 03	E – F	7.54197	3.39313	145	7.54170	3.38917	148
4	ERW 04	G – H	7.54216	3.39319	142	7.54193	3.38914	147
5	ERW 05	I – J	7.5424	3.39322	178	7.54213	3.38914	146
6	ERW 06	K - L	7.53782	3.38242	122	7.53435	3.38408	112

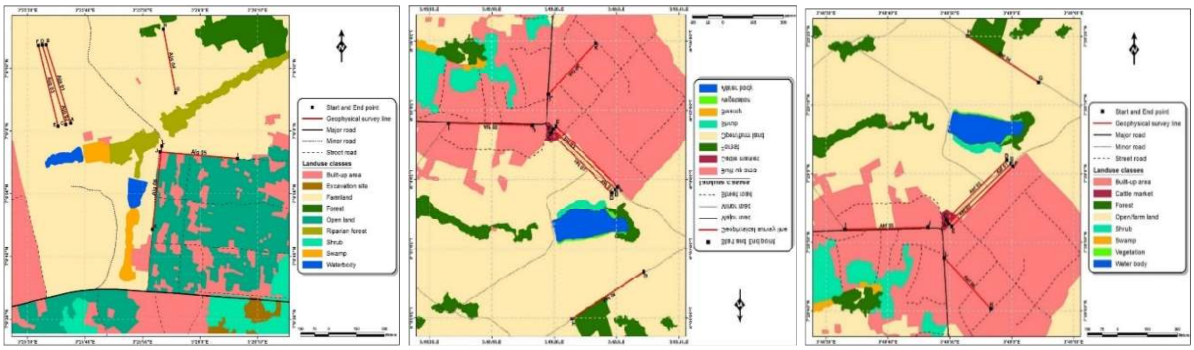


Figure 3: Data acquisition map showing land-use, for (a) Ajegunle farm settlement, (b) Akufo farm settlement, and (c) Eruwa farm settlement.

The 2-D ERT data acquired from the surveys were processed using EarthImager inversion software. Two-dimensional inversions were conducted on the survey data using same range of resistivity for all the profiles for easy interpretation. The bulk data was simulated by the EarthImager inversion algorithm which automatically divides the subsurface into series of vertical and horizontal rectangular blocks to create a 2-D model. The algorithm generates the depth inverted resistivity model for each line using an iterative smoothness constrained least-squares inversion technique. The inverted model gives modelling error in form of the Root Mean Square (RMS) error. EarthImager 3-D software was used to invert the data from the combination of the parallel 2-D ERT profiles to generate 3-D models as found suitable by Ayolabi *et al.* (2010).

RESULTS AND DISCUSSION

Figs. 4 - 12 show representative 2-D and 3-D ERT resistivity-depth models for the three farm settlements generated from resistivity inversions using EarthImager software. The subsurface resistivity distributions in the three locations showed similar patterns. Generally, the resistivity ranged from 1 to 10000 Ωm, covering a maximum distance of 415 m as well as maximum depths of 99 m and 141 m for dipole-dipole and pole-dipole arrays respectively. The results from the two arrays were similar, except for variations that arose due to their characteristic strengths and limitations (Binley and Kemna, 2005; Okpoli, 2013). Both arrays showed lithologies depicting sandy clay/clayey sand, weathered/fractured basement and a resistive material suspected to be fresh basement/bedrock covering mostly the lower parts of the profiles, with outcrops and groundwater bearing/potential zones.

The groundwater bearing/potential zones were found where the original state of the rock has been deformed by deep fracturing, weathering, or faulting, among others (Akanbi, 2016; Nur and Kujir, 2006). Being that the selected farm settlements are within a basement complex terrain, the groundwater bearing/potential zones are suitable for groundwater exploitation since boreholes with sustainable high groundwater yields are obtainable where the weathered/partly weathered/fractured basements are significantly thick; and the groundwater storage and flow are significantly controlled by fractures, joints, or faults. This is in agreement with results from earlier studies, such as Clark (1985), Dewandel *et al*. (2006), Holdsworth *et al*. (2019), Olorunfemi and Fasuyi (1993), and Olorunfemi *et al.* (2020).

Hence, the probable locations of proposed boreholes along the profiles are indicated with vertical brown lines labelled as PBH.

2-D ERT for Ajegunle Farm Settlement

For profile AJG 01 (Fig. 4a and b), the resistivity values obtained ranged from 1 to 10000 Ωm probing a depth of about 99 m for dipole-dipole array and a depth of about 141 m for pole-dipole array. The inverted resistivity model for AJG 01 revealed sandy clay/clayey sand, weathered/fractured basement, and fresh basement with outcrops of widths 18, 10, 10 and 5 m at locations 250, 290, 305 and 340 m respectively along the dipole-dipole profile and widths 5, 5, 10, 10, 20 and 10 m at locations 10, 30, 60, 205, 305 and 345 m respectively along the pole-dipole profile.

A fractured zone delineated to a depth range of 25 to about 80 m was observed between locations 220 m and 340 m on the dipole-dipole model. The resistivity of this fractured zone ranges from 1 to about 320 Ωm and interpreted as sandy clay/clayey sand and weathered/fractured basement. Two groundwater potential zones were identified at positions 225 m and 270 m along the fractured zone.

The pole-dipole depth inversion model gives similar result with better depth resolution when compared with the dipole-dipole model. The pole-dipole model revealed three potential zones for groundwater exploitation at locations 225 m, 270 m, and 320 m along the fractured zone.

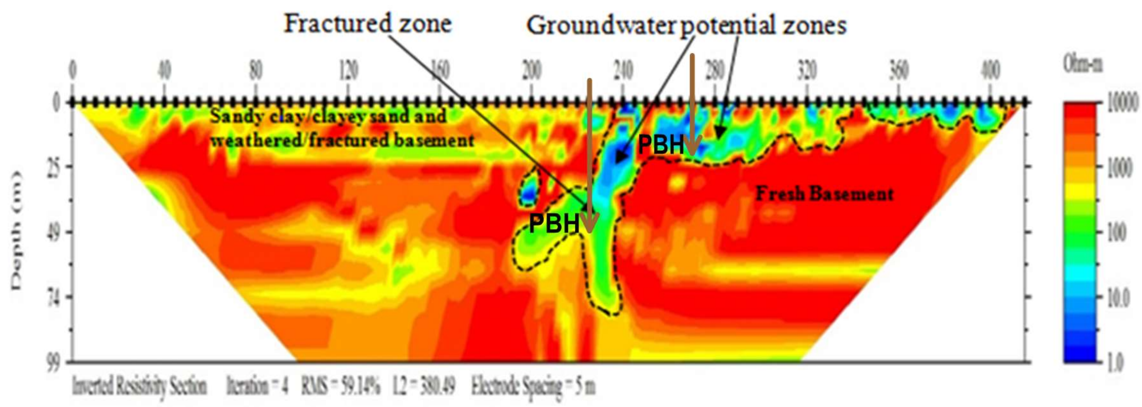


Figure 4a: 2-D ERT – Profile for AJG 01: Dipole-Dipole Array

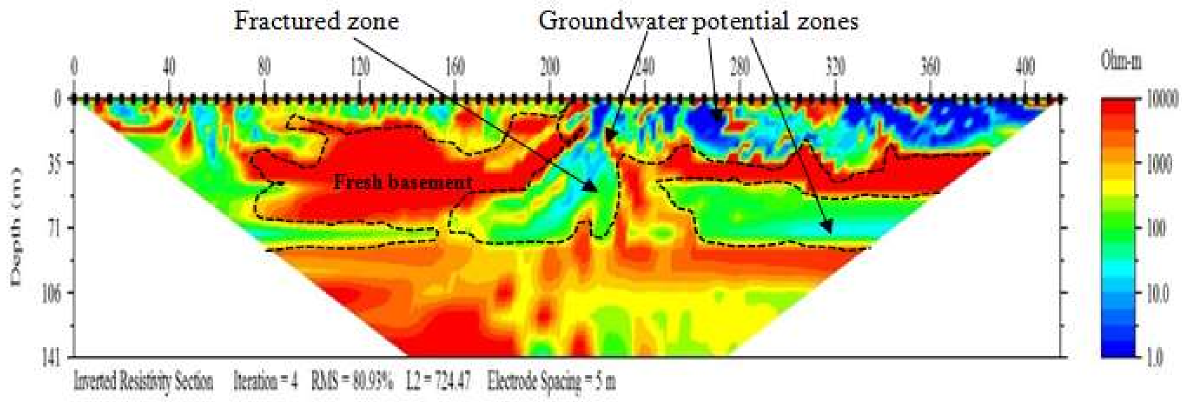


Figure 4b: 2-D ERT – Profile for AJG 01: Pole-Dipole Array

Fig. 5 presents the resistivity depth inverted model for profile AJG 05. The figure revealed resistivity values ranging from 1 to about 10000 Ωm probing a depth of 99 m and 114 m, for the dipole-dipole (Fig. 8a) and pole-dipole (Fig. 8b) array respectively. The inverted models revealed sandy clay/clayey sand, weathered/fractured basement (groundwater potential zones) and fresh basement.

A fractured zone delineated to a maximum depth of about 78 m was observed at horizontal distance 200 m and between locations 240 m and 290 m on the dipole-dipole model. The resistivity of this fractured zone ranged from 1 to about 320 Ωm interpreted as sandy clay/clayey sand and weathered/fractured basement. Three groundwater potential zones were identified between positions 80 and 160 m, 200 and 205 m as well as 240 and 280 m along the profile. The pole-dipole depth inversion model gave similar result. The probable locations of the proposed boreholes along both profiles are indicated at positions 205 m and 275 m.

A fresh basement (with resistivity between 316 to 3200 Ωm) was observed to occupy the remaining parts of the dipole-dipole profile. High resistivity value above 1800 Ωm depicts fresh bedrocks with little or no groundwater potential (Akanbi, 2018; Olorunfemi *et al.*, 2020). Meanwhile, a fresh basement with resistivity ranging from about 425 to 3200 Ωm was seen extending downward from a depth of about 75 to 141 m on the pole-dipole profile. Fresh basement outcrops of resistivity ranging from 1800 to 3200 Ωm were observed, with widths of about 5, 5, 10 and 5 m at positions 225, 235, 255 and 390 m respectively along the dipole-dipole profile (about 5, 10, 10 and 10 m at positions 260, 275, 305 and 345 m respectively along the pole-dipole profile).

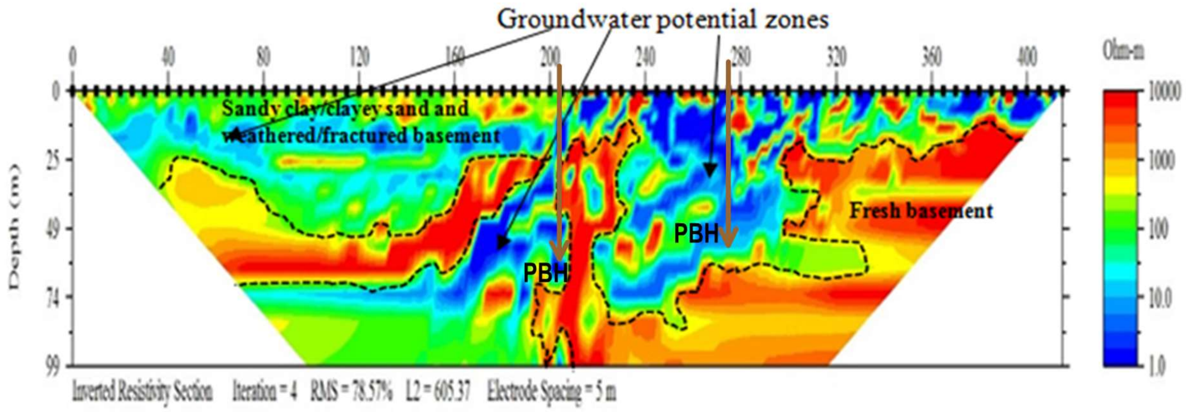


Figure 5a: 2-D ERT - Profile for AJG 05: Dipole-Dipole Array

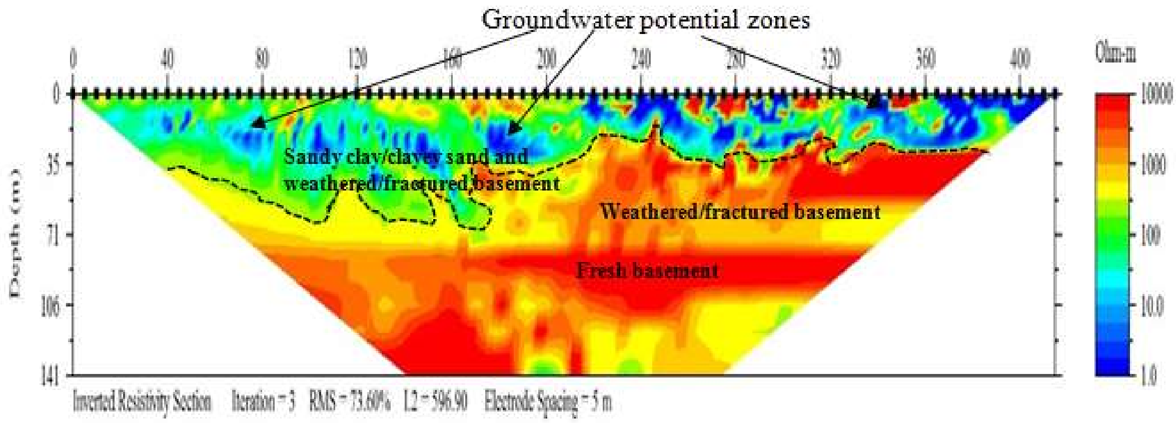


Figure 5b: 2-D ERT - Profile for AJG 05: Pole-Dipole Array

3-D ERT for Ajegunle Farm Settlement

The 3-D (dipole-dipole) image from the combination of parallel 2-D lines AJG 01 to 03 is presented in Fig. 6. The image showed resistivity variations across, parallel and perpendicular to the profile lines. The 3-D model reflects the presence of weathered/fractured basement (groundwater potential zones) sandwiched between sandy clay/clayey sand and fresh basement with outcrops from about 200 m along the profile. Groundwater potential zones are delineated between the lateral distances of about 235 to 330 m and depth range of about 35 to 60 m, and between positions 360 to 385 m and depth 0 to about 30 m. The observed features and groundwater potential zones were consistent with those on the 2-D profiles.

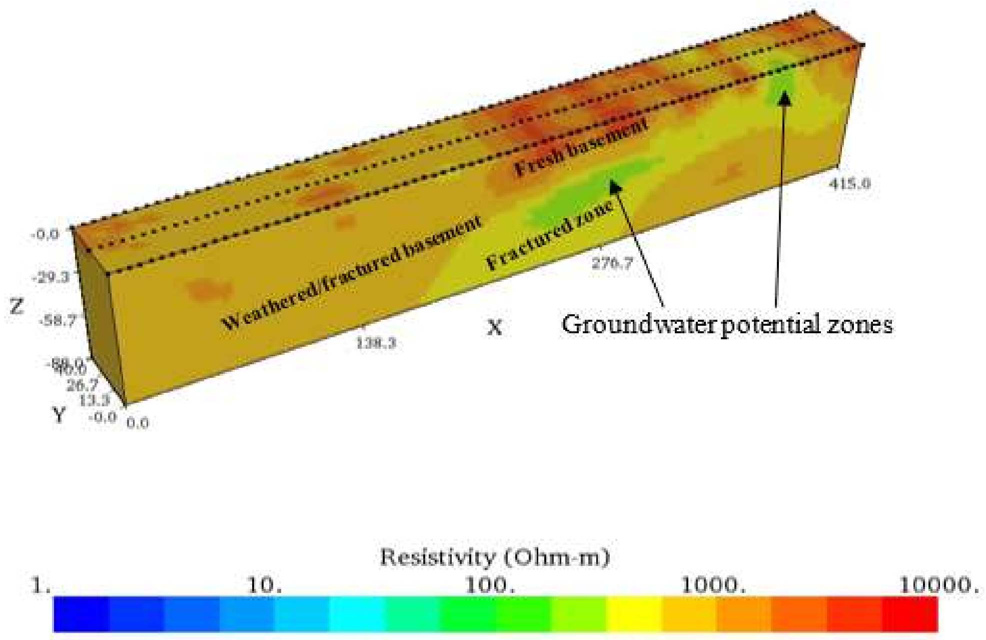


Figure 6: 3-D ERT (Dipole-Dipole array) for Ajegunle Farm Settlement

2-D ERT for Akufo Farm Settlement

The 2-D electrical resistivity depth structures for AKF 01 are presented in Fig. 7 with resistivity values ranging from 1 to 10000 Ωm probing a depth of 99 m for dipole-dipole profile and 141 m for the pole-dipole profile. The inverted image generally revealed sandy clay/clayey sand, weathered/fractured basement, and fresh basement. A suitable groundwater potential zone was observed along the dipole-dipole profile image between positions 60 to about 150 m and 185 to 210 m up to a depth of 61 to about 85 m.

Also, about three groundwater potential zones were observed on the pole-dipole image (Fig. 7b) between positions 0 and 135 m, 200 and 230 m, 330 and 355 m and up to a depth of about 88 m (with much higher potential up to a depth of about 35 m). This agrees with what was reported by Offodile (2002) that groundwater occurs at shallow depths in typical crystalline basement of Nigeria. The probable locations of the proposed boreholes along both profiles are indicated at positions 100 m and 210 m.

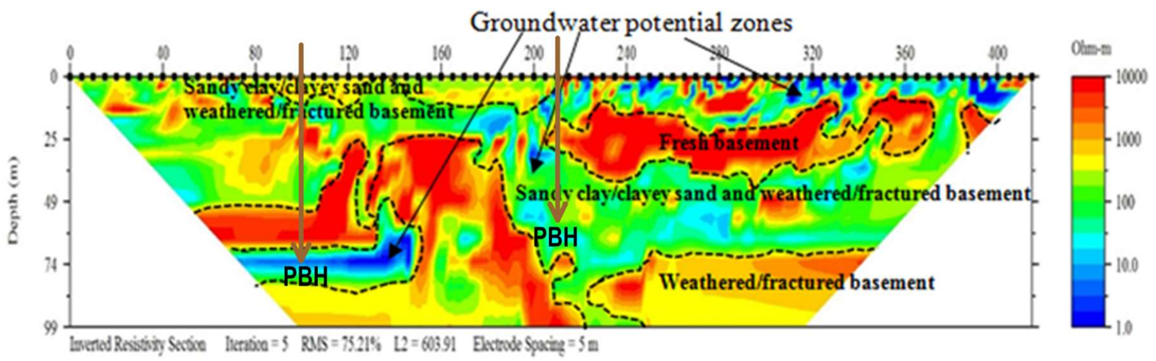


Figure 7a: 2-D ERT - Profile AKF 01: Dipole-Dipole Array

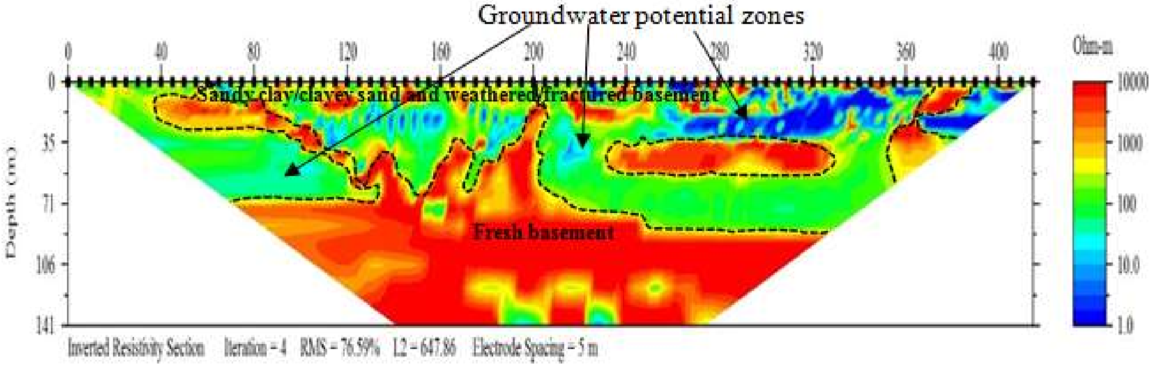


Figure 7b: 2-D ERT - Profile AKF 01: Pole-Dipole Array

The 2-D image obtained for profile AKF 05 (Fig. 8) showed resistivity values ranging from 1 to 10000 Ωm delineated to a depth of 99 m for dipole-dipole array, revealing sandy clay/clayey sand, weathered/fractured basement, and fresh basement. A Groundwater potential zone was identified between positions 41 and 50 m along the profile up to a depth of about 74 m. The probable location of the proposed borehole along AKF 05 is indicated at position 46 m.

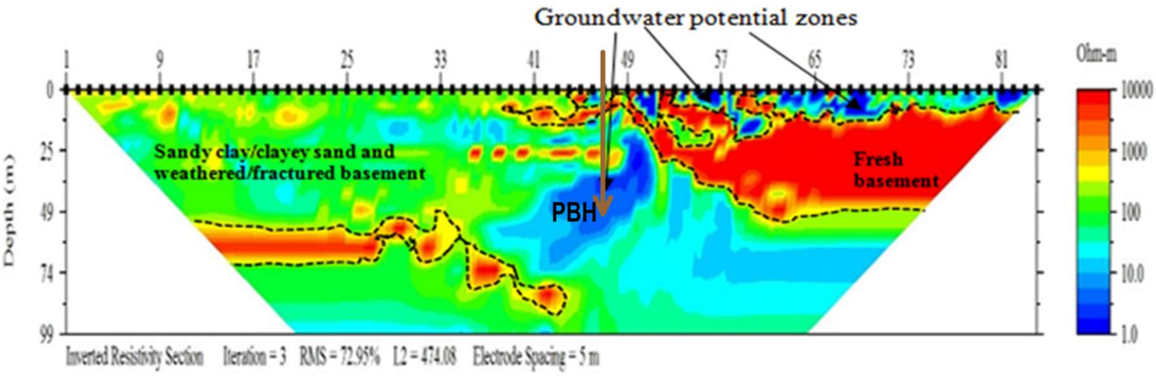


Figure 8: 2-D ERT - Profile AKF 05: Dipole-Dipole Array

3-D ERT for Akufo Farm Settlement

Fig. 9 presents the 3-D image from the combination of 2-D profiles AKF 01 to 03, using the dipole-dipole array. The figure showed resistivity values ranging from 5 to 10000 Ωm, up to a depth of 88 m, depicting sandy clay/clayey sand, weathered/fractured basement, and fresh basement with outcrops from about 200 m along the profile. Probable groundwater potential zones are observed to extend from 12 to 110 m between the depth of 40 and about 84 m along the profile, and about 205 to 350 m between the depth of 25 and 88 m.

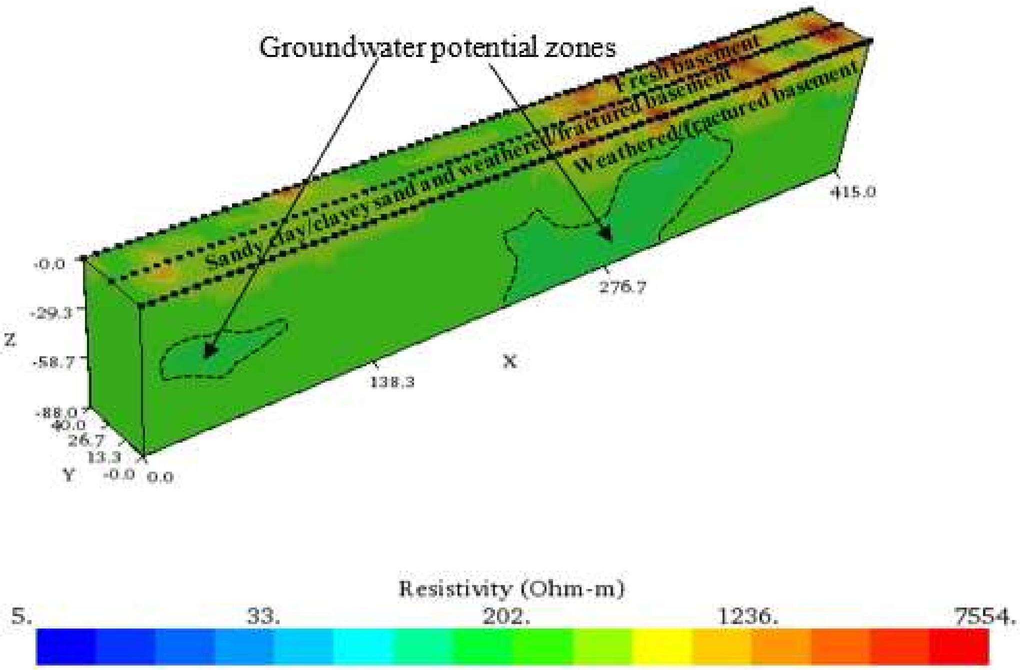


Figure 9: 3-D ERT (Dipole-Dipole Array) for Akufo Farm Settlement

2-D ERT for Eruwa Farm Settlement

Fig. 10 shows the 2-D electrical resistivity image obtained for ERW 02 with resistivity values ranging from 1 to 10000 Ωm probing a depth of 99 m for the dipole-dipole array and 141 m for the pole-dipole array. The image reveals sandy clay/clayey sand, weathered/fractured basement, and fresh basement.

Probable groundwater potential zones were observed to extend from position 120 to 150 m and position 230 to 260 m delineated to a depth range of 43 to 64 m along the dipole-dipole profile. Also, a good groundwater potential zone was observed between positions 190 to 250 m up to a depth of 72 m along the pole dipole profile. However, the probable location of the proposed borehole for ERW 02 is indicated at positions 230 m.

Fresh basement outcrops with resistivities ranging from about 2000 to 5623 Ωm were observed, with widths of about 5 m from 215, 230, 260, 285 and 300 m along the dipole-dipole profile. Also, a fresh basement with resistivity ranging from about 1000 to 10000 Ωm, was seen extending downward from depth of about 75 m on the pole-dipole profile.

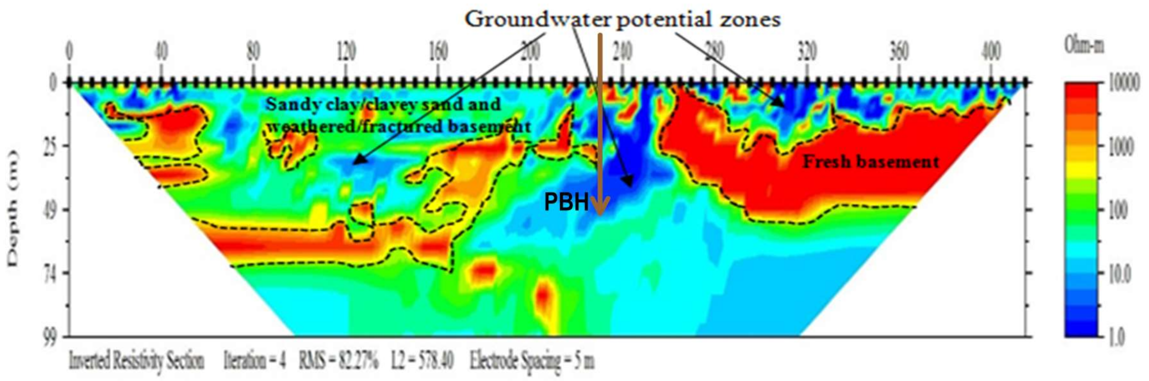


Figure 10a: 2-D ERT - Profile ERW 02 Dipole-Dipole Array

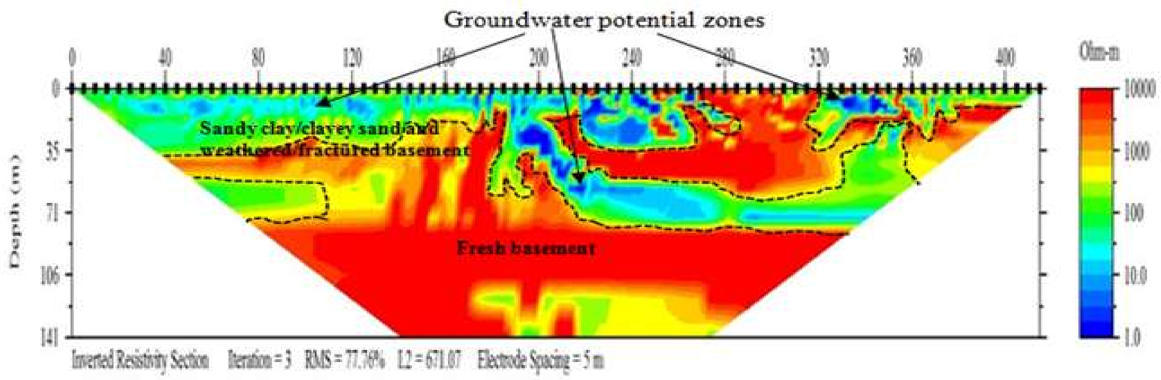


Figure 10b: 2D ERT - Profile ERW 02 Pole-Dipole Array

Fig. 11 presents the 2-D ERT image for ERW 06. The profile revealed resistivity values ranging from 1 to 10000 Ωm, delineated to a depth of 99 m for dipole-dipole array and 141 m for pole-dipole array, revealing sandy clay/clayey sand, weathered/fractured basement, and fresh basement.

A good groundwater potential zone was observed to extend from positions 170 to 360 m, between the depth of 25 and 99 m along the dipole-dipole profile. Also, two groundwater potential zones were delineated between positions 40 and 70 m as well as 250 and 260 m along the pole-dipole profile. The probable location of the proposed borehole for ERW 06 is indicated at positions 225 m.

Weathered/fractured basement of resistivity values ranging from about 600 to 5263 Ωm were observed from position 40 m along the dipole-dipole profile to about 190 m, from a depth of 10 m to a maximum depth of about 36 m. Also, a fresh basement was noticed between horizontal positions 230 to 400 m to a maximum depth of about 55 m.

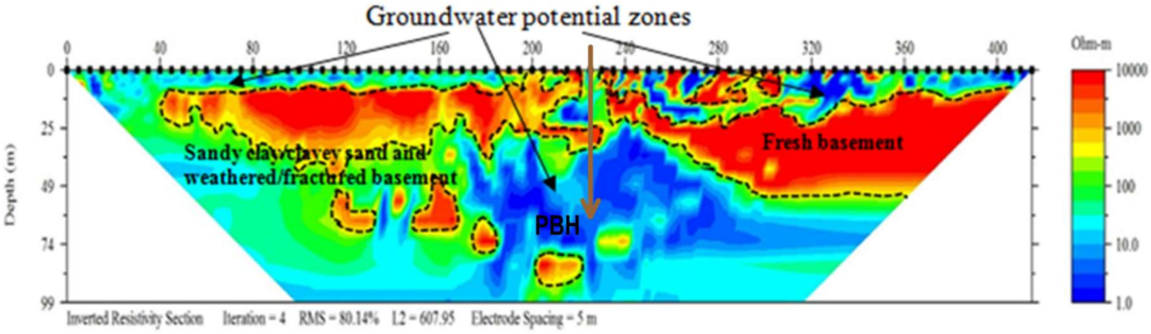


Figure 11a: 2D ERT - Profile ERW 06 Dipole-Dipole Array

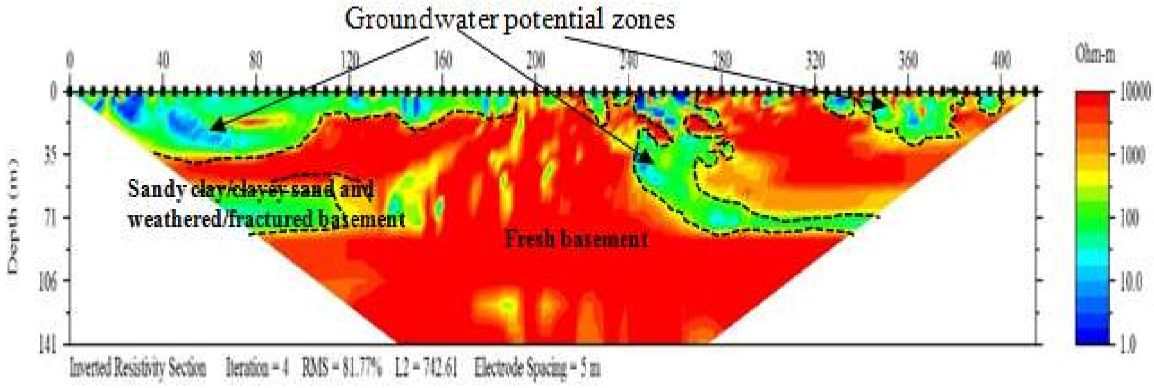


Figure 11b: 2D ERT - Profile ERW 05 Pole-Dipole Array

3D ERT for Eruwa Farm Settlement

The 3-D ERT (dipole-dipole) image from the combination of 2-D profiles of ERW 03 to 05 is presented in Fig. 12. The figure showed resistivity ranging from 1 to 10000 Ωm, up to a depth of 88 m. The figure revealed sandy clay/clayey sand, weathered/fractured basement, and fresh basement. From depth of about 30 m (with varying thicknesses over the length of the profile), a zone extended downward with resistivity range of about 80 to 100 Ωm, suspected to be a groundwater potential zone. The observed features and groundwater potential zones were consistent with those on the 2-D profiles.

The lithologies and groundwater potentiality revealed via this research agree with previous investigations in basement terrains of Southwestern Nigeria, as reported by Akanbi (2018), Aromoye *et al.* (2019) and Olorunfemi *et al.* (2020), etc.

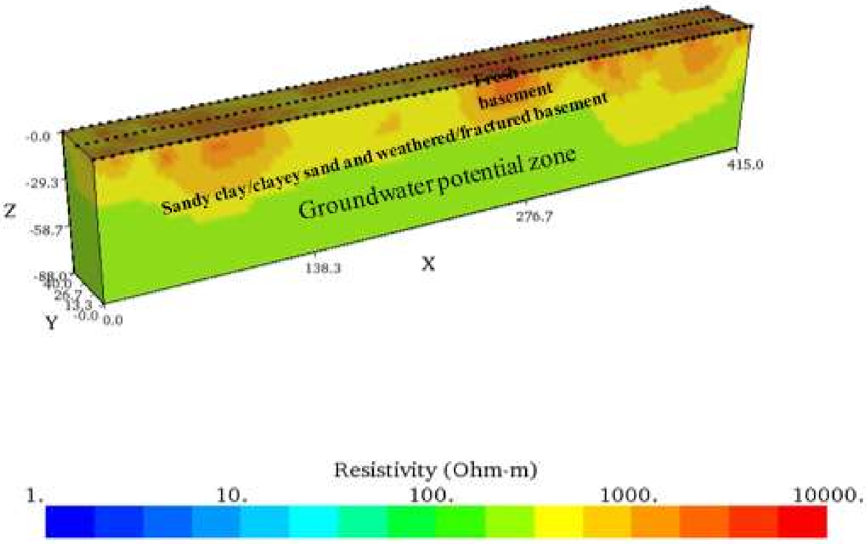


Figure 12: 3-D ERT (Dipole-Dipole Array) for Eruwa Farm Settlement

Potential for Groundwater Development

This research has shown high groundwater potentials within the selected farm settlements. The predominant lithologies are sandy clay/clayey sand and weathered/fractured basement, with water bearing formations. The aquifers have remarkable thicknesses from which groundwater can be exploited for agricultural purpose. There is a reliable quantity of groundwater reservoir within each of the settlements, from which government and interested investors can systematically and profitably tap for improved agricultural productivity. The observations from this research are in conformity with the reports of Oteze (1983), Offodile (2002) and Adelana *et al.* (2008) who reported that groundwater occurs at shallow depths in typical crystalline basement of Nigeria. The use of ERT in groundwater exploration has contributed significant data required for groundwater development in the three farm settlements.

CONCLUSION

The Electrical Resistivity Tomography (ERT) profile data were acquired using two arrays with complementary advantages of high resolution and deep probing. Both arrays (dipole-dipole and pole-dipole) revealed similar subsurface lithologies composed mainly of sandy clay/clayey sand, weathered/fractured basement, and fresh basement. This study revealed good groundwater potential zones for groundwater development in the study areas. The results from this study are consistent with others from basement complex terrains in southwestern Nigeria and beyond.

This research has demonstrated the capacity of 2-D and 3-D ERT in identifying regions of high groundwater potentials in the Ajegunle, Akufo and Eruwa farm settlements for all-year-round agricultural purposes. This will enhance agricultural productivity and alleviate the socio-economic problems of farmers as well as make food and other agricultural resources more available, even in the face of climate change.

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