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RESEARCH ARTICLE

An Insight Into the Importance of Application of Geophysical Methods In Agriculture For National Economic Development

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Abstract
One of the keys to national development in developing countries like Nigeria is the diversification of economy. Nigeria's economy depends majorly on crude oil. The oil sector continue to face challenges like price drop in international market, corruption, reduced quantity of production as forecasted (although new oils are been drilled). These among others makes it necessary for the country to diversify its economy. Agriculture is one of the areas Nigeria have started investing into. New methods are necessary for fast improvement in the sector among which is geophysics. The need for Agricultural Geophysics to be considered for national economic development is discussed. Geophysics as a branch of science that deal with physical processes and phenomena occurring in the earth and its vicinity is applicable to many fields that contribute to the development of the economy of any nation. Such fields include oil, Agriculture, natural resources among others. Geophysical methods applicable in Agriculture like resistivity, electromagnetic induction, and Ground penetrating radar are discussed with their applications in agriculture. The various geophysical methods that are useful in agriculture are reviewed and necessity of their application is also emphasized.

Keywords: Geophysics; Agriculture; Economy; Development

Introduction

Many factors are responsible for decrease in production of Agricultural products. These include water erosion, poor soil biology, decreased yield reduced plant growth, reduced sustainability and soil degradation among others (Newell and Ken, 2014). An effort to address the aforementioned problems will have positive influence on all matter and living organisms on earth including soils and plants which are the main interest for agriculturists. Soil properties are of high importance in many human activities, such as agriculture, forestry, landscaping, environmental protection, recreation, and civil engineering.

Soil survey for different applications requires quick and non-disturbing estimations of numerous soil properties, such as salinity, texture, stone content, groundwater depth, and horizon sequences in soil profiles. A perfect assessment of properties of soil is convoluted due to their variability. Measurements of soil with a high sampling density is expensive and consumes time because conventional methods of analysing soil for precision agricultural mapping requires mostly disturbing the soil through removal of soil samples and subjecting them to laboratory analysis. This implies that, through the aforementioned practice, the sampling costs would exceed the potential benefits. Geophysical methods, conversely, tolerate quick measurement of soil properties, such as electrical conductivity, resistivity, and potential, from surface of soil straight to any depth without disturbing the soil. Precision Agriculture is the modern practice that allows farmer to make measurements so that he will know the exact deficiency of his land and plants.

Literature review

Little practice of Geophysical methods is done in Nigeria for Agricultural practice specially to observe soil fertility. Some of the available researches include Oladunjoye that used Ground Penetrating Radar (GPR) to characterize valley bottom soil at ilora (Oladunjoye et al., 2021), Yusuf that employed geophysical and geochemical aproaches to investigate ground water quality and soil cultivation viability in mokwa (Yusuf et al., 2018) among others. Leti described Agro geophysical methods to identify soil pipes (Leti et al., 2021). We still need to know more about the field and its impact in agriculture. This paper simply focused on describing the commonest geophysical methods applied in Agriculture. The choice of method depends on one's interest. Perhaps, some researchers may decide to use multiple methods, interestingly, using multiple methods will add more certainty and efficiency to the result (Alhassan et al., 2021).

Electrical Geophysical Method

Electrical resistivity is a geophysical method that uses the electrical properties of soil to infer about the temperature, water content and salt content of the soil. Such properties include resistivity and conductivity. There is a relationship between electrical conductivity measured with four-electrode probe and conductivity of soil solution (Nadler, 1982). These are given in equations 1 & 2.

By ohm's law, $$ER = K\frac{\Delta U}{1} \quad (1)$$

U=elecrical potential

$$EC = \frac{1}{ER} \quad (2)$$

The method of four-electrode probe was also used for the calculation of further soil properties such as soil water content, soil structure, bulk density, porosity, and texture, stone content, etc. (Larisa et al., 2007; Oladimeji et al., 2014; Yusuf et al., 2018; Kayode et al., 2022).

In conditions where one or two soil properties have influence on measured electrical properties, electrical conductivity (EC) method can be used to estimate such properties. The resistivity of rocks is much higher (about 104 -1012 ohm m) than that of soil horizons with any texture. Therefore, high ER will designate the presence of stones in soil profiles irrespective of soil type and geographical region. Vertical electrical sounding (VES) method can be used in studying several processes for instance melting, freezing, wetting-drying and solution transport in soils (Yusuf et al., 2018). The mobility of electrical charges can increase significantly when the topsoil materials have higher water holding capacity, such as clay and silt, and especially water logging conditions which can also cause significant decrease in ER. This implies that complex soil properties influencing plant growth, plant health and yield can be identified and mapped with electrical geophysical methods. (Yusuf et al., 2018). The electrical geophysical methods when Compared with conventional methods of soil analysis allows the evaluation of groundwater table, salt and stone content, depth and thickness of soil horizons, polluted/disturbed layers in soil profiles, and content with an estimation error (Kayode et al., 2022).

Soil properties influencing Density of mobile electrical charges in summary are:

- Chemical properties (Salt content, humus content etc) stones and oil are intrusions of high resistivity.
- Physical properties (bulk density, water content, temperature, texture, water movement based on soil compaction or mixing)

Applications of ER/EC in Agric

Changes in one soil property can be monitored (drying-wetting, freezing-melting, solution transport)

Mapping of the soil properties which highly influence electrical parameters (salinity, stone content, hardpan, oil pollution, ground water table)

Evaluate complex effect of many soil properties on measured electrical parameter, develop management zones or study soil cover structure. (Richard and Dualem, 2014)

Electrical resistivity is Fast, Portable, Versatile, Affordable and In depth.

Ground Penetrating Radar

Ground Penetrating Radar (GPR) uses seimic method and serves as a quality control tool to determine the presence, depth and lateral extent of diagnostic subsurface horizons, Improve interpretations by providing estimates of different soil types composing a soil map unit and Characterize spatial and temporal variations in soil properties (Doolite, 2014).
GPR generates a sequence of trigger pulses which are sent via a control cable through the antenna. Each cable transmits into a bipolar transmit pulse. The transmitted pulses are the directed into the soil by the antenna which is fold below the surface. The energy is radiated in a pattern roughly 90° front to back and 60° side to side. It passes different materials with different properties. The dielectric constant changes when change in Electrical conductivity of soil is experienced. Some of the pulse bounces back to the antenna. The received signals are then sent back to the receiver where they are processed. The data are displayed on a coloured map and can be stored on internal hard drive for later play back.
GPR results depend mainly on two electrical properties of soil namely electrical conductivity and relative dielectric permittivity or dielectric constant. Electrical

conductivity (EC) is the ability of a material to conduct an electric current. It controls the signal penetration. EC increases with increasing water, clay and size of soil contents (Doolite, 2014). On the other hand, Dielectric constant is the measure of the capacity of a material to store charge when an electric field is applied to it. It controls the strength of the signal reflection. Different subsurface materials have different dielectric constant.
Three general soil/landscape factors affect water and crop growth :

- Available water storage (soil texture, organic matter)
- Rate of water infiltration and recharge (Soil surface porosity, layers of impermeability, slope)
- Water redistribution within the field (relative elevation, curvature, slope) Newell kitchen. (Barry et al., 2010)

Electro Magnetic Method

Electro Magnetic (E-M) wave creates sinusoidal E-M field that induces E-M current. E-M reaches 1km depth and exhibits both time domain and frequency domain techniques. (Richard and Dualem, 2014). Electromagnetic induction (EMI) possess the potential in assisting agricultural applications (Binley et al.,2015). The method has the ability to provide a suitable alternative by measuring apparent electrical conductivity of soil which can be used to estimate soil properties such as water content, textural properties, mineralization, porosity, and residual pore water content (Brogi et al., 2021).

Remote Sensinsing Method

Remote sensing acquires information about an object without making physical contact with that object. Remote sensing gives the soil moisture data and helps in determining the quantity of moisture in the soil and hence the type of crop that can be grown in the soil. Remote sensing technology plays an important role in the analysis of crop health which determines the overall crop yield. When all of this data is combined it gives almost accurate estimates of the crop yield. Because of the predictive nature of the remote sensing technology, farmers can now use remote sensing to observe a variety of factors including the weather patterns and the soil types to predict the planting and harvesting seasons of each crop. Remote sensing has also played an important role in crop identification especially in cases where the crop under observation is mysterious or shows some mysterious characteristics (Grindgis, 2018).

Conclusion

Characterizing soil spatial variability at immediate (field) scale is a major challenge in soil investigation. This paper brought on board the advantage of geophysical methods over other methods in precision Agriculture. Electrical Method, Ground Penetrating Radar and Electro Magnetic methods are discussed as the most commonly used Geophysical methods in Agriculture. This allows the observation and recommendation of using the methods more than it has been applied in the farm especially in Nigeria.

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