Groundwater potential modelling: A comparative assessment of NigeriaSat-X and Landsat ETM+ satellite data

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Introduction

• Mapping and monitoring of existing groundwater assets and estimation of future resources are major issues in basement complex environments.

• The complexity and erratic nature of groundwater occurrence in these areas usually make groundwater development in the form of boreholes/wells expensive and arduous.

• Precise targeting of groundwater resources depends on quality information on the nature of underlying rock formations and their structural fabric, the thickness of weathered material, the topography and climatic conditions.
Introduction ...

• Many conventional methods such as geological, hydrogeological, geophysical and photogeological techniques have been employed to delineate zones of groundwater potential.

• Examples of such works are: Edet and Okereke, 1997; Taylor and Howard, 2000; Martin and van de Giesen 2005; Srivastava and Bhattacharya 2006; Anomohanran, 2013; Okogbue and Omonona 2013
Introduction ...

• Several works in different parts of the world have used satellite data from sensors like Landsat, Spot, IRS, etc. and multi-criteria decision-making techniques for delineating and mapping areas of groundwater potential


• Despite the availability of NigeriaSat-X data and the continuous operation of the platform, little or no studies have used NigeriaSat-X image data for modelling groundwater potential zones.
Introduction ...

• The aim of this study is to compare the performance of NigeriaSat-X data for groundwater potential modelling, using GIS-based multi-criteria decision analysis with that of Landsat ETM+ data.
About NigeriaSat eXperimental satellite (NigeriaSat-X)

• NigeriaSat-X is a training model (TM) satellite sensor developed as part of the Know-How Technology Training (KHTT) on the NigeriaSat-2 satellite project (Ikpaya et al. 2017).

• Used to give the KHTT’s hands on experience in the requirements specification, project management, system engineering, manufacture, test, assembly / integration and final system testing of a spacecraft.
About NigeriaSat eXperimental satellite (NigeriaSat-X) ...

• The microsatellite was launched alongside with NigeriaSat-2 on 17 August 2011, built primarily for resource management and mapping of the Nigerian territory.

• It was designed to:
  • (1) provide 22m multispectral (R, G, NIR) imagery data for mapping, agricultural monitoring, and disaster relief;
  • (2) provide data continuity and interface with NigeriaSat-1; and
  • (3) enhance national human resources to use space applications and to develop Nigerian capability in space science and technology.
The groundwater potential zones (GWPZ) was computed by converting all the thematic maps into grid (raster format), and the layers combined using Weighted Linear Combination (WLC) aggregation method (Malczewski 1999; Malczewski and Rinner 2015).

The results were validated with borehole yield data. The aquifer of the different locations were characterised with Vertical Electrical Resistivity (VES) survey data collected at 35 different locations using Schlumberger Electrical Resistivity technique spread over the study area.

Figure 2: Workflow diagram
Results and Discussion

Figure 3: Groundwater Potential Zones derived using Landsat ETM+ and NigeriaSat-X Satellite data
Results and Discussion ...

• The groundwater potential maps of the two satellite data show that lineament density and geomorphological pattern are the ultimate contributing factors to the occurrence and movement of groundwater in the study area.

• In addition, areas underlain by migmatite and migmatite gneiss which are characterized by relatively low lineament density have moderate groundwater potential.

• On the other hand, areas underlain by quartzite and quartz-schist, being more deeply weathered and fractured exhibit higher groundwater potential, while areas underlain by granitic rocks have moderate potential.
Results and Discussion ...

• The findings corroborate Murthy and Mamo (2009) and Fashae et al. (2014) who found the groundwater potential zones of crystalline basement terrain to be poor in the migmatite and migmatite gneiss formations, and very good to moderately good potential in the areas underlain by migmatite and quartzite rock units.

• The generally high percentage of low to very low groundwater potentiality of both NigeriaSat-X and Landsat ETM+ is a confirmation of the generally limited aquiferous capability of Basement Complex terrain (Fashae et al. 2014; Talabi and Tijani 2011).
Results and Discussion ...

Analysis of the differences between NigeriaSat-X and Landsat ETM+ for groundwater potential modelling

• Thus, NigeriaSat-X satellite data can be used, together with other ancillary data, to generate groundwater potential zone variability of up to 96.72% of what Landsat ETM+ can do, and vice versa.

Figure 4: Correlation of groundwater potential of Landsat ETM+ and NigeriaSat-X satellite data
Conclusions and Recommendations

• Qualitative and quantitative evaluation of results derived from NigeriaSat-X and Landsat TM+ data showed significant similarities exist between them.

• The two imageries are very similar in quality and spectral bandwidth, though NigeriaSat-X has better spatial resolution. The similarity of the band ranges and high-resolution images could make NigeriaSat-X a better substitute for Landsat ETM+ images for groundwater potential modelling.
Conclusions and Recommendations ...

• The overall results demonstrate that there is no significance difference in the performance of NigeriaSat-X and Landsat ETM+ for groundwater modelling.

• In all, the study found that the use of satellite imagery and GIS provide potentially powerful tools for design of suitable exploration plan and water resources development in general. Further study is needed in the areas of band to band correlation between NigeriaSat-X and Landsat ETM+ and assessment of the potentialities in other areas of applications.
Thanks for Listening

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