ADEQUATE GEODETIC INFRASTRUCTURE: THE FIRST STEP TO SUSTAINABLE DEVELOPMENT

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Introduction

- Human beings love and desire comfort and in a bid to be comfortable, he utilizes the resources around him and his environment.
- Most of the resources he utilize are dependent on Land which can hardly be renewed without adverse consequences .
- Land is one of the most important economic assets, it supports all human activities and provides energy, food and raw materials needed for human existence and must therefore be judiciously and efficiently managed.

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- This judicious and efficient management of land is a matter of sustainability (Magel, 2001) .
- Most rural and urban areas of many developing countries are currently not being developed and managed in a sustainable manner; For this purpose, adequate Geospatial Information (GI) is needed on the location and quality of the existing infrastructural network as a starting point for initiating improvements (Atilola, 2003).
- Magel (2001) pinpointed that it is very clear from all indications that sustainable land development and management are not possible without the fundamental contributions of Surveyors (the Geodesist).

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Sustainable development

- Sustainable development is the development that meets the need of the present without compromising the ability of future generations to meet their needs (Akindoyeni, 2011).
- It is a dynamic process that it is difficult to define practically because it is a continuous process.
- To continually meet the needs of the present generation means that there must be continued economic growth, which in turn must ensure that minimum damage must be done to the environment.

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- Since Land is a major economic asset, the continued economic growth starts from an efficient Land Administration and Management.
- Efficient land administration and management requires continuous mapping and Surveying.
- Geodetic Infrastructure is the wireframe or skeleton on which continuous and consistent mapping and surveys are based (Carlson, 2003).

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ADEQUATE GEOSPATIAL INFRASTRUCTURE

- Infrastructure can be defined as the basic physical and organizational structure needed for the operation of a society or enterprise, or the services and facilities necessary for an economy to function (Rizos, 2009).
- Geodetic infrastructure includes technologies, techniques, facilities and services to address the mission of modern geodesy.
- This geodetic infrastructure includes what Rizos (2009) defined as Positioning Infrastructure: which is the passive ground marks and the active CORS to support positioning and mapping within a datum.

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- For geodetic infrastructure to be sustainable and in turn support sustainable development, it has to be adequate.
- Adequate Geodetic Infrastructure is efficient, precise and most importantly as pointed out by Rizos (2009) addresses the mission of modern geodesy.
- This indicates that for a geodetic infrastructure to be sustainable, it has to be time and cost conscious, yet achieve the desired purpose.
- A geodetic infrastructure that must meet the mission of modern geodesy, must be dynamic, improving with improving technologies and should be aiming at a transformation from classical to modern geodesy.

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THE GEODETIC ISSUE

- Surveying and mapping are very essential for effective management of land resources and this is why the most mapped countries today, are unarguably, the most developed.
- This assertion was made by Atilola (2010) stating that the reason the most developed nations in the world are the best mapped is because in those advanced countries, surveying is part of their culture.
- Geodetic infrastructural development has the responsibility of developing both the horizontal as well as the vertical coordinate system. However, the vertical coordinate system of most developing countries has been neglected.

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- Owing to the high cost of the establishment of the geodetic controls, especially the vertical system, they seem to be neglected and therefore the geodetic infrastructure becomes deficient.
- One of the certified ways of solving this geodetic problem is the development of a Geoid Model.
- The geoid is a measured and interpolated surface, and not a mathematically defined surface and the geoidal surface is measured using a number of methods (Bolstad, 2008).

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NUMERICAL EXAMPLE

- The GPS/Levelling method of Regional Geoid Modelling proves to be an efficient method of providing adequate geodetic infrastructure, especially with regards to the vertical system.
- Its relative cheaper cost and less tedious operation compared to the conventional geodetic levelling method.
- The GPS provides the Horizontal coordinates as well as the ellipsoidal height (*h*) while the Precise Levelling provides the orthometric heights *(H)*. Then the geoidal undulation *(N)*

$$h - H - N = 0$$

$$\therefore N = h - H \qquad (1)$$

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- This method was adopted for the realization of the Local geoid model of Nnamdi Azikiwe University, Awka.
- The Magellan Promark 3 Differential GPS was used in Static Differential Mode
- The Sokkia SDL30 Digital Level was used for the Differential Levelling owing to the unavailability of a Geodetic level.
- Two Interpolation Methods were used to test the possibility of generating the orthometric height *(H)* of new points whose Horizontal coordinates and ellipsoidal heights *(h)* are determined in future without carrying out further leveling operation.

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- The two methods used are the Geometric Interpolation Technique given by Heiskanen and Moritz (1967) as:

$$U_k = \frac{(x_2 - x_k)(y_3 - y_2) - (y_2 - y_k)(x_3 - x_2)}{(x_2 - x_1)(y_3 - y_2) - (y_2 - y_1)(x_3 - x_2)} U_1 + \frac{(x_3 - x_k)(y_1 - y_3) - (y_3 - y_k)(x_1 - x_3)}{(x_3 - x_2)(y_1 - y_3) - (y_3 - y_2)(x_1 - x_3)} U_2 + \frac{(x_1 - x_k)(y_2 - y_1) - (y_1 - y_k)(x_2 - x_1)}{(x_1 - x_3)(y_2 - y_1) - (y_1 - y_3)(x_2 - x_1)} U_3 \quad (2)$$

Where

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- **And the Polynomial Regression Method Model D given by Isioye and Youngu (2009) as:**

$$H_x = h - N_{EGM\ 96} + \delta N \qquad (3)$$

Where δN **= *corrective term*** $= \Sigma(N_{residual})/n$ **and**

$$N_{residual} = N_{local} - N_{EGM\ 96} \qquad \textbf{(4)}$$

Then (3) becomes

$$H_{(x)} = h - N_{EGM\ 96} + \sum (N_{residual})/n \qquad (5)$$

- **In place of the $N_{EGM\ 96}$, three different Undulations from Global Models EGM 86, EGM 96 and EGM 08 were used.**

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- **The interpolated values obtained from the four estimations were found to differ slightly numerically, but the root mean square error (rms) of ±0.003 was identical.**
- **With the realization of this model, it is easier to derive the orthometric height of further points and by extension, solve the problem of 3D Geodesy, which in turn creates a pedestal for Sustainable Development.**

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Conclusion/ Recommendations

- **Development simply means Causing to grow.**
- **Growth needs to be Sustainable since Resources are exhaustible.**
- **For this to be possible, an Adequate Geospatial Infrastructure, which serves as a foundation to other developments must be in place.**
- **It is therefore recommended that most Developing Economies understand and develop their Geospatial Infrastructure in order to make Sustainable Development a reality.**

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