THE UGANDA GEODETIC REFERENCE NETWORK (UGRN) AS A BACKBONE FOR THE NATIONAL GEOSPATIAL INFRASTRUCTURE IN UGANDA

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Key words: Uganda National Land Information System (UgNLIS), Spatial Data Infrastructure (SDI), Geospatial Framework, Spatial Data, Uganda Geodetic Reference Framework (UGRN).

SUMMARY

Spatial data plays an important role in achieving Uganda's vision 2040. Spatial data is required for integrated spatial planning, implementation and monitoring of Government programmes. Spatial data facilitates efficient and optimal use of Uganda's land and natural resources such as forests, minerals, oil and gas, energy and wetlands. Furthermore, spatial data and its related applications and services promote efficiency and transparency in public management functions such as urban management, fair and equitable tax assessment, and monitoring and security, agriculture and farming.

The UGRN development is based on the current trends of Geodetic and Geospatial data integration and framework. The Geodetic Network is composed of the *Passive Geodetic Control Points, Active Geodetic Control Stations* and the *Geoid.*

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1. Introduction

The Uganda Government under the Ministry of Lands, Housing, and Urban Development has successfully implemented the Land Information System and is now in advanced stages of enhancing the key features and establishment of the Uganda Statistical Geospatial Framework (USGF) based on the social-economic datasets and the fundamental spatial datasets.

UgNLIS establishment which is based on Web Services to provide for the data exchange and pragmatic interoperability is becoming a big issue for data integration with Cadastral surveys among other geospatial datasets. Therefore in order to improve on data quality and exchange in the Land Information System, the system itself should provide for a given data exchange format understood by Surveyors and other system Users of the cadastral data in order to increase the productivity, efficiency and reliability of the cadastre.

UgNLIS development was based on current trends of Geospatial data integration and framework; thus the spatial datasets from the other controlling authorities have been exported to the UgNLIS for data quality control and in order to further support in the protection of the environment and other gazetted national protected areas.

2. The SDI and Geo Spatial Framework Components

A spatial data infrastructure is a framework for sharing geo-spatial data across government institutions, CSOs, the private sector and the entire geo-spatial community. The Infrastructure components include geo-spatial datasets, Standards, Metadata, Distribution Networks, people and policies governing use of data and related products. SDI is not a physical infrastructure but shares features of physical infrastructures such as roads. Infrastructures are meant to support other functions and are for the common good and are used by observing common rules. Almost all countries in the world are at various stages of developing spatial data infrastructures. Hosting framework for a spatial data infrastructure is necessary to motivate institutions to collaborate, to define rules for development and use of spatial data and to stimulate innovation and investment in geo-spatial services in addition to sharing the spatial datasets.

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Spatial data is important for managing natural resources, physical infrastructures and services that governments are responsible for, such as land, forests, roads, electricity, water, sewers, education and public health institutions. However, accessibility to spatial data is still a challenge for institutions in the process of using spatial technologies such as Geographical Information Systems, Location-Based Services, Remote Sensing Image Analysis, Global Navigation Satellite Systems (GNSS) aided by the SDI and web mapping in Uganda.

In Uganda, most of the spatial data is acquired and stored in analogue (paper) form by various MDAs, and the private sector, for achieving their organizational goals. There is a general lack of coordination in the capture and use of spatial data which has led to unnecessary duplications and overlaps in data collection, inconsistencies in data formats, lack of standardization (as each organization has developed its own standards), lack of harmonized policies for data sharing, lack of knowledge about availability of data, and a general inefficiency in the use of spatial data and geo-spatial tools for planning and decision making. A common Spatial Data Infrastructure will address the above problems by providing guidance on the actions required for coordination of spatial data collection, storage, management, accessibility and utilization in Uganda. This will help to avoid loss of Government revenue and also improve planning and management of the natural resources.

The planning and management of Uganda's resources requires spatial data as an essential part in mapping and matching the resources to the identified needs and priorities. Studies undertaken by Government about streamlining data collection and utilization, in the years 2001 and 2004 respectively, revealed several duplications and inconsistencies in spatial datasets. The studies further identified that government was making heavy losses through duplications in capture and maintenance of inconsistent spatial datasets. A recent study by the Government in the years 2010 and 2011 also outlined the need for SDI.

Spatial information plays a decisive role in promoting economically and socially feasible solutions to problems faced by various sectors of the economy, where a variety of information needs to be collected from a variety of sources and must be integrated to plan, monitor, and evaluate development programs. The current mechanisms for collecting and disseminating

spatial data are cumbersome and resource intensive and data is liable to become out of date very quickly. This leads to a lack of trust in its quality and usefulness. The result of this problem has been a proliferation in the number of data sets being kept – an inherently inefficient process and poor use of government resources.

As a compliment to the SDI, the Integrated Geospatial Information Framework (IGIF) fronted by the United Nations Geospatial Information Management Secretariat has come in as the new companion to SDI, incorporating the SDI and the four components of Innovation, Capacity and Education, Financial, Communications and Engagement, which are not catered for by the SDI.

The IGIF complements the SDI and allows for building of additional functions and strengthening the SDI in addition to offering a new paradigm and comprehensive mechanism for further strengthening of the nationally integrated geospatial information management and providing a holistic, integrated national information systems approach to the data life cycle and shows you how to do it.

Therefore, the UgNLIS will facilitate a platform for hosting and enhancing sharing of spatial data with other MDAs and the Private Sector. Due to its rich Base Reference Layers, the UgNLIS presents a formidable platform for the SDI.

a) The National Geodetic Network (NGN)

The Uganda Geodetic Reference Framework (UGRF) is core to the realization of the Geodetic Reference system for Uganda. This system is essential to provide reliable and fundamental Geodetic Reference Frame. The UGRF consists of active, passive stations and the National Geoid.

The Continuously Operating Reference Stations (CORS) form the active stations designed and built to achieve the best accuracy that modern GNSS technology provides and they provide Real Time Kinematic (RTK) services and Post Processing Positional Services (PPPS).

The CORS Network is designed to be the most accurate, Zero Order Network, that serves as a fiducial for the establishment of the Uganda Reference System, National Datum and modern,

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reliable and accurate National Coordinate Reference System and will be an integral part of the African Reference Frame (AFREF).

The passive stations are made up of the first and second order control points. These consist of the permanently monumented Geodetic Control Points distributed throughout the territory to provide accurate geodetic reference that uniformly merges with the active stations. The Figure1 below shows the Phase One and Two of Uganda Geodetic Network CORS.
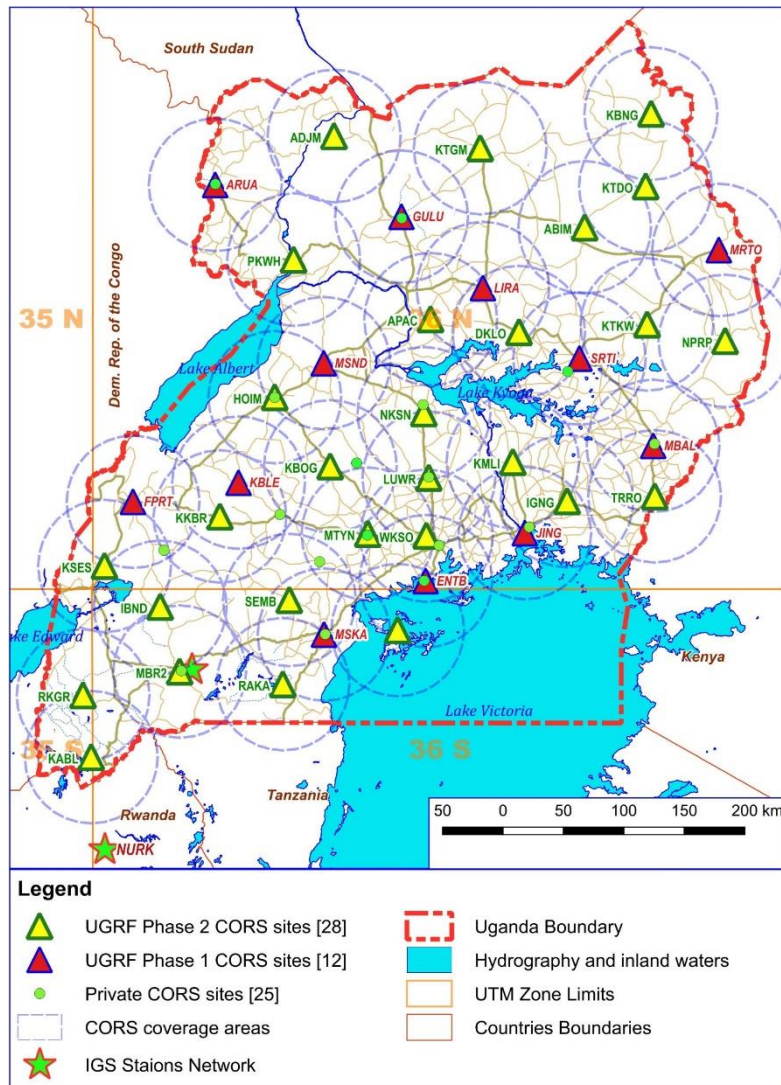

Figure 1: The Uganda Geodetic Network CORS

In addition, Uganda has already acquired its Geoid Model, based on the airborne survey in the year 2020. The new Geoid is tied to the Khartoum height datum through 7 GPS-levelling points, fitting at 2 cm RMS and the new Geoid is by far the best Geoid Model for Uganda. The Geoid Model (Geoid) of Uganda is an integral part of the Uganda Geodetic Reference Frame consisting of the Horizontal Geodetic Network (CORS, Zero Order, First Order and Second Order Geodetic Control Points) and the Vertical Reference (Geoid Height).

Therefore, the implementation of the horizontal Geodetic Reference Framework and the Vertical Reference System including the CORS and the Geoid are some of the activities contributing to the improvement and consolidation of SDI and Geospatial Infrastructure and System of the country.

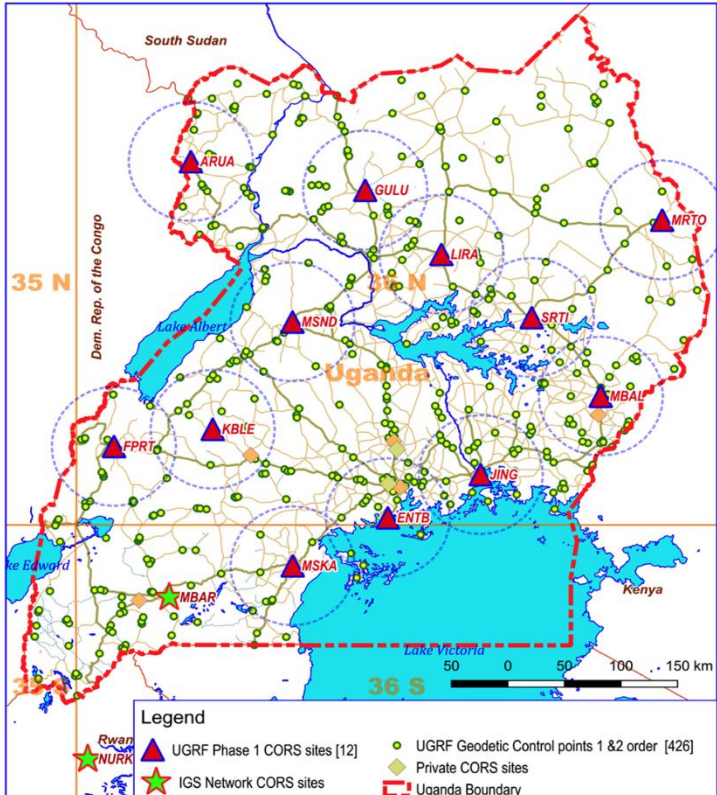The Figure 2 below shows the combined Phase One CORS and the Passive Network Control Points

Figure 2: Uganda Geodetic Network CORS and Passive Network Control Points

The implementation and functionality of the SDI and Geo-Spatial Framework in Uganda requires a fundamental Geodetic Reference Frame to comprehend the Spatial and Non-Spatial Information Framework of the SDI.

b) The National Spatial Reference Datasets -Digital Orthorectified Imagery (DOI)

As part of her spatial data reference system, Uganda acquired a National Reference Base Map as Orthophoto at the resolution of 40cm for the entire country and 15cm for 48 urban centers in the year 2018. The DOI for the country has come at the time the country is booming with a number of infrastructural and non-infrastructural projects that require orthophotos for preparation, analysis and presentation of the results.

The spatial area covered by the DOI is the geographical location of Uganda with datasets inform of DEM and Contours (elevation data), orthophoto and spot heights. The DOI is an essential complement to the SDI and the Geospatial Framework since it is an integral part of the geospatial datasets mandatory for an SDI infrastructure.

The geospatial datasets acquired in form of elevation data, orthophoto and spot heights are essential in defining and maintaining a strong geospatial information which can be used by many spatial and non-spatial sectors/industries to provide precise spatial positioning, data harmonization and data integrity assurance in Cadastre, Agriculture, Mining, Oil and Gas, Forestry and Wildlife, Weather and Disaster Risk Management, Climate Change and Environmental Applications, and construction and engineering Government initiatives in Uganda.

3. Integration

The Web Solution has shown a great contribution to the development of the Spatial Data Infrastructure since there is available spatial and non-spatial data that can be shared with other private and Government MDAs based on clear exchange procedures. The UgNLIS business processes go beyond service use but focus on the compatibility issues of MDA Datasets,

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business rules in Geospatial systems, organizational policies, and the establishment and maintenance of trust and reputation of the MDAs. Logical support in cadastral service exchange has been seen as a key requirement to meet the desired efforts during data exchange for spatial systems infrastructure in Uganda. Pragmatic interoperability will focus on the ability of the Land Information System to exploit the use of other system datasets through the web Services at real data exchange level while leaning on the direct support of a spatial infrastructure framework.

The system integrates land registration, land administration, surveying and mapping, physical planning, and valuation and provides a daily case management system, a document management system, mobile office, and secure portals to access land administration and registration information for individuals within the general public and corporate portals providing more detailed access to banks, surveyors and legal institutions.
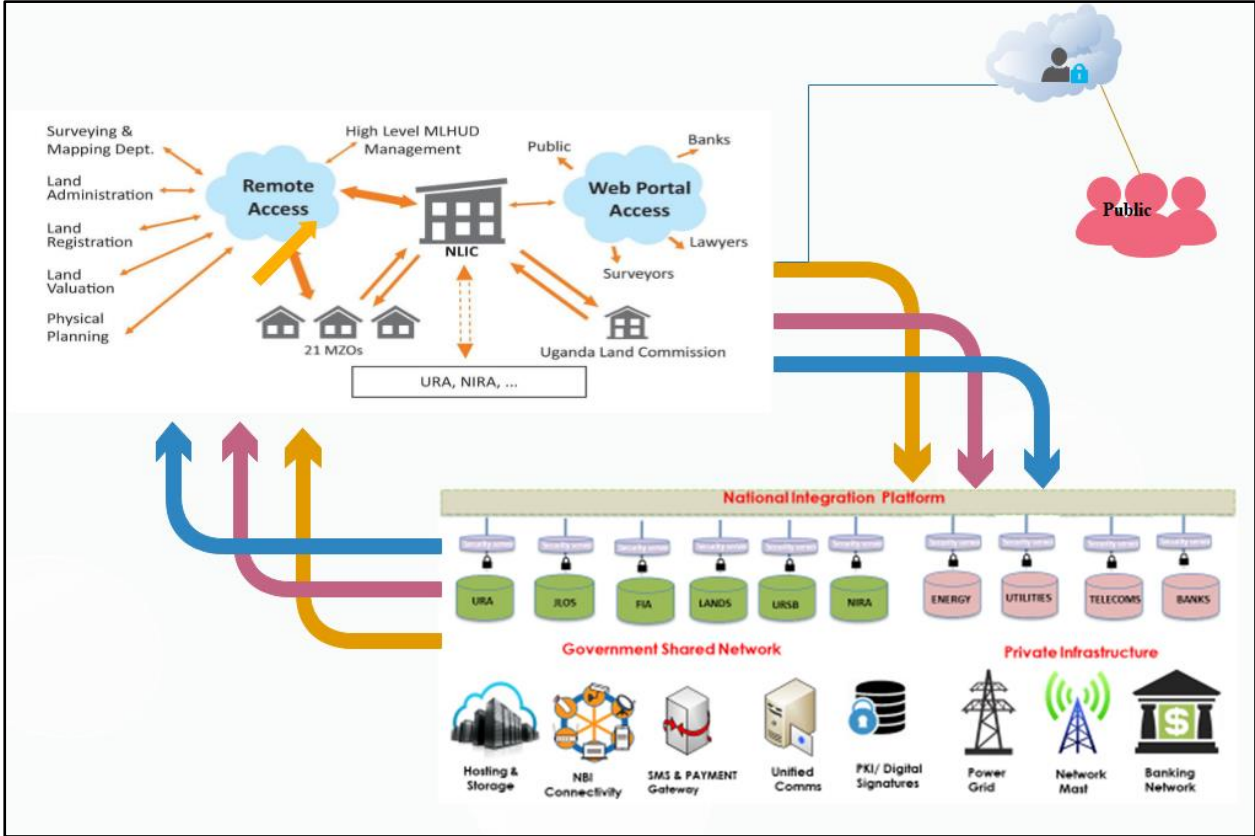

Figure 3: UgNLIS Integration

The UgNLIS enhancement focuses on the integration of services from other Government systems as shown in *figure 3* above to support the establishment of a multipurpose cadastre and further provides full interoperability with external systems supported by an Open Application Programming Interface (API) for Organizations such as the National Identification and Registration Authority (NIRA), Uganda Revenue Authority (URA), Uganda National Bureau of Standards (UNBS) and already integrates data from other government institutions such as Uganda National Roads Authority (UNRA), National Forestry Authority (NFA) and the National Environment Management Authority (NEMA).

The UgNLIS is designed to integrate spatial data generated by ongoing initiatives to secure customary land tenure supported by Food and Agriculture Organization (FAO), UN-Habitat, and Civil Society actors including Gesellschaft für Internationale Zusammenarbeit (GIZ) and ZOA. It may also integrate spatially and non-spatial data associated with climate change and natural resources (including mining and the energy sector), soil topography, hydrology, and agriculture production. Upon the integration of these services through the central portal authority, users shall be enabled to access these datasets.

4. Current efforts at Regional level

The Ministry of Lands, Housing and Urban is further exploring the use of the Land Help Desk under African Union Development Agency (AUDA-NEPAD), Africa Land Policy for agricultural development, rural transformation, and equity to provide support to member countries in mainstreaming land governance issues into sectoral plans and strategies. This supports the existing efforts of the establishment of the National and Regional Data Infrastructure in the Member States.

5. Challenges

The implementation of the UgNLIS and establishment of the Geospatial Framework has been affected by various challenges including; the human and machine language understanding of the technical and administrative concepts, methods used during the data capturing and processing, data models, metadata and standards, and the political will. The complete establishment of the spatial data infrastructure and geospatial framework shall be based on the

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successful implementation of the UgNLIS and automation of the business processes in the entities with the fundamental Geospatial datasets in Uganda.

6. Conclusion

To ensure a successful implementation of the spatial data infrastructure and geospatial framework, it will be important to put in place an appropriate Information, Education and Communication (IEC) Strategy that provides for a public awareness campaign based on carefully developed messages targeting selected groups of stakeholders that should also include rural communities and traditional leaders, among others in which the key messages are delivered employing art and culture with appeal at the national level and to local communities as well.

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BIOGRAPHICAL NOTES

The authors' of this document have worked in the Land Sector for over 10 years with major specialties in the Land Administration and Management Sub Sector. Most of them are members of the respective Survey, ICT and Management Memberships in the Country. One of their key achievements is the transformation Land Administration in Uganda, from establishing a functional National Land Information Systems to Systematic Land Adjudication and Registration.

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