The National Spatial Data Infrastructure of Zambia

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Key words: National Land Audit, GIS, LIS, Common Spatial Data

SUMMARY

One of Zambia's important challenges is to recognize the title of property owners on their land. The Ministry of Land, Natural Resources and Environment Protection (MLNREP) is in charge of managing the country's land resources. To begin a LAND AUDIT and to be efficient in charging the revenues, the Ministry has installed ZILMIS – the Zambia Integrated Land Management Information System. The MLNREP has contracted Sivan Design D.S Ltd to design and implement the system. One of the deficiencies in obtaining an ideal system is the absence of a good quality and up to date national map. To that end, Sivan Design is leading a joint venture together with another Israeli company – Ofek Aerial Photography and with Ground Force Land & Engineering Services, a surveying Zambian company that is in charge of quality control of the field surveys executed by the surveyors of the Ministry, under the Surveyor General. The goal of this JV is to create a National Spatial Data Infrastructure that will serve the Ministry, to maximize the usage of accurate geographical data for the benefit of the public serving both the Ministry and other E-GOVERNMENT initiatives.

Mapping is an essential element in the development of a country. Land Registration at high accuracy (Cadastral Scale) can serve as the hub for the nation development such as the development of roads, water resources, town planning, land uses, tourism, forestry, addressing etc. For Cadastral usages (land ownerships), an accurate map is the basic component for the management of a proper land allocation. It enables the surveyors and the land officers to properly identify the land parcel boundaries and its surroundings such as nearby roads, land uses and other affecting elements.

The objective of the NSDI is to store the mapping data at a central location and share it with different stakeholders (ministries & governmental agencies) and with the public through digital means. The NSDI leverages the usability of the data and reduces costs by preventing double acquisition of the same data. Using a National Spatial Data Infrastructure – NSDI – aligns with the government's e-government initiative and serving this objective.

The Mapping stage has begun with creating Ground Control Points on the ground that can be identified in aerial photographs. The GCPs, as they are called, are cast in concrete in the ground all over the country by the Ministry's officers, sometimes by the aid of local workers.

The next step is aerial photography and acquisition of Satellite imagery. The raster dataset comprises orthophotos covering I ,800 square kms. of the 15 main cities of Zambia at a resolution of 10 cm per pixel, 36,500 square kms. of state land at 20 cm per pixel, 2,225 square kms. of Pleiades satellite imagery for 88 townships at 50 cm per pixel, and about 712,000 square kms. of Spot 6/7 imagery at 250 cm. per pixel for the whole country. All orthophotos are accompanied by DTMs at proper scales.

The accuracy of the background raster data allows for participatory parcellation at a smaller accuracy than required by the Zambian Land Act for final registration but parcel data that can be delineated from the orthophotos with additional conflict resolution on the ground is better than no data at all.

The system will be installed at 3 interconnected sites: The Ministry, The National Data Centre (NDC) which serves as a hub for e-government and at the National Remote Sensing Centre.

The NDC is the connection between the NSDI and the public. It hosts the NSDI Portal which is a toolset intended to serve the entire population of the Country, for those who do not have GISs to work with. For specialists, which have their own systems, 2 types of Web Map Services are available: an ESRI based service and a service adhering to OGS Standards.
Two specific web services connect the NSDI and ZILMIS (the land management system). The NDSI displays a geographical subset of ZILMIS's dataset, namely the Cadastre Layer, with data that can be publicly exposed without compromising citizen's privacy and in the opposite direction – ZILMIS uses the background raster data from the NSDI.
A very important aspect of the project is the Capacity Building of the Ministry's officers. The Ministry has insisted on specific measures that will ensure that its officers will be in full command of the data and the advanced processing procedures.
This is the main challenge of the Project as the Ministry has failed over and over again to find the funds to complete its part of the project, namely to fund the allowances for the field crews, petrol for the cars and allocating the proper equipment for executing the field surveys.
The data collected by this project is a national asset and is going to be managed and secured as such.

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1. BACKGROUND AND VISION

One of Zambia's important challenges is to recognize the title of property owners on their land. Land statutory rights (tenures) are vested and managed by the Zambian government through the Ministry of Lands and Natural resources and Environment Protection (MLNREP), now renamed as the Ministry of Land and Natural Resources (MLNR).
To begin a LAND AUDIT and to be efficient in charging the revenues, the Ministry has installed ZILMIS – the Zambia Integrated Land Management Information System (Sivan 2016). The MLNR has contracted Sivan Design D.S Ltd to design and implement the system which is up and running since 2014.
One of the Lessons Learned from the implementation and operation ZILMIS is that the absence of a good quality and up-to-date national map is an obstruction in the path of reaching a comprehensive Land Audit. To that end, under the Surveyor General of Zambia – the head of the Survey department of MLNR, a contracted Joint Venture was formed to solve this deficiency. The JV is led by Sivan Design, together with another Israeli company – Ofek Aerial Photography. The Survey department insisted that the Ground Control Points will be measured by the Department's own surveyors and Ground Force Land & Engineering Services, a surveying Zambian company was contracted to be in charge of quality control of the field. The goal of this effort is defined as the creation of a National Spatial Data Infrastructure that will serve to maximize the usage of accurate geographical data for the benefit of the public, serving both the Ministry and other E-GOVERNMENT initiatives.

2. SCOPE AND DATA COLLECTION

The Population of Zambia is approximately 15.9M people, living in an area of about 753,000 Sq./Km., divided into 10 provinces. Land Registration at high accuracy (Cadastral Scale) can serve as the hub for the nation development such as the development of roads, water resources, town planning, land uses, tourism, forestry, addressing etc. For enterprises, such as ZESCO (Zambia's Electricity state-owned electricity provider) an accurate map is the basic component for the management of a proper land allocation. The National Spatial Data Infrastructure will allow ZESCO's engineers and surveyors to share geographical data with other entities for coordination of planning and placement of new assets. It also enables the surveyors of all relevant parties to properly identify land parcel boundaries and surroundings such as nearby roads, land uses and other affecting elements.
The objective of the NSDI is to serve as a repository for mapping data at a central location and share it with different stakeholders (ministries & governmental agencies) and with the public through digital means. The NSDI also leverages the usability of the data and reduces costs by preventing double acquisition of the same data at the National level. Using a National Spatial Data Infrastructure – NSDI – aligns with the government's e-government initiative and serving this objective.
The Mapping stage has begun with creating Main Reference Points MRP's which serve as Ground Control Points on the ground that can be identified in aerial photographs. These GCPs, as they are called, are cast in concrete in the ground all over the country by the Ministry's

officers, sometimes by the aid of local workers. Other recognizable ground points at a much larger number were identified and measured in the field and identified in the acquired imagery. This structure creates the base for Aerial Triangulation.
The next step was aerial photography and acquisition of Satellite imagery. Ofek owns specialized aerial photography airplanes which were flown twice all the way from Israel. The flight plan was impossible to complete in one run due to cloudy period restrictions.
The raster dataset comprises orthophotos covering 1,800 square kilometers. of the 15 main cities of Zambia at a resolution of 10 cm per pixel, 36,500 square kilometers. of state land at 20 cm per pixel, 2,225 square kilometers. of Pleiades satellite imagery for 88 townships at 50 cm per pixel, and about 712,000 square kilometers. of Spot 6/7 imagery at 250 cm. per pixel for the whole country. All orthophotos are accompanied by DTMs at proper scales.
The accuracy of the background raster data allows for participatory parcellation at a smaller accuracy than required by the Zambian Land Act for final registration but parcel data that can be delineated from the orthophotos with additional conflict resolution on the ground is better than no data at all. The Ministry has run a pilot on the acquired data to this effect with satisfactory results.

3. TECHNOLOGY

The system will be operable at 3 interconnected sites:

- The Ministry is the main application site. The servers on this site also run ZILMIS mentioned above.
- The National Data Centre (NDC) hosts the second site which serves as a hub for e-government. The NDC is the connection between the NSDI and the public. It hosts the NSDI Portal which is a toolset intended to serve the entire population of the Country, for those who do not have GISs to work with. For specialists, which have their own systems, 2 types of Web Map Services are available through this site: an ESRI based service and a service adhering to OGS Standards.
- The National Remote Sensing Centre has its own site mainly for Research and Development purposes.

Two specific web services connect the NSDI and ZILMIS (the Land Management System). The NDSI displays a geographical subset of ZILMIS's dataset, namely the Cadastre Layer, with data that can be publicly exposed without compromising citizen's privacy. In the opposite direction – ZILMIS uses the background raster data from the NSDI.

4. THE ROADMAP FOR FURTHER ADVANCEMENTS

A very important aspect of the project is the Capacity Building of the Ministry's officers. The Ministry has insisted on specific measures that will ensure that its officers will be in full command of the data and the advanced processing procedures. Therefore, several coursed have been tailor made to the specific requirements of the different types of users: for the Maintenance Team, for general Portal Users within the Ministry and for Web Services consumers.
The Portal User's Guide was specifically designed for laymen that may not be familiar with geographical terms to ensure that they fully understand the meaning of the results (mainly the reliability and accuracy) of whatever they have created using the system.
The data collected by this project is a national asset and is going to be managed and secured as such.
This is the second step (after the implementation of ZILMIS) that will lead to a comprehensive solution for the national land audit, in which the integrated usage of the ZILMIS augmented by the NSDI serves the infrastructure for the entire titling process.

REFERENCES

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BIOGRAPHICAL NOTES

Shlomi Sivan is an entrepreneur of vast experience in CAD, ERP based GIS turnkey solutions for land, road and infrastructure management.
Majored in Mathematics and Computer Science (BSc), with further advanced studies of Image processing and Computational geometry.
Holds personal knowledge and experience in technological and marketing initiatives, civil engineering and land survey.
Leading Sivan Design D.S. Ltd since 1999 - company specializing in comprehensive GIS solutions with ERP capabilities, 3D GIS applications, user friendly civil engineering CAD and visualization products.

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