Towards the Augmented Reality of Botswana Tribal Viliages

Lopang MAPHALE, South Africa

Key words: Augmented Reality, Tribal Village, Land Ownership, Physical Planning, Utilities.

SUMMARY

This is the summary on a paper towards the augmented reality of Botswana Tribal Villages. Tribal lands of Botswana are products of British colonial native reserves and the Tribal Land Act of 1968. They are currently governed by the Land Boards which are themselves products of the Tribal Land Act of 1968. In terms of surveying, Botswana tribal areas experienced a voluntary and disjointed process based on the issuance of the tribal lease by the responsible Land Board authority. The government of Botswana through a Land Administration Procedures Capacity and Systems project is currently carrying out a land surveying exercise named National Land Registration. The LAPCAS project National Land Registration exercise is administered by the Ministry of Lands and Housing through its Department of Surveys and Mapping in collaboration with a geomatics professional body named Botswana Surveying and Mapping Association. The land surveying exercise is meant to carry out surveying of all properties found in villages across Botswana. This project came against a backdrop of several efforts which were pursued in the past but incurring their own challenges and failures. To understand how Botswana has moved to this level, the past efforts will be summarised and crystallised onto the National Land Registration project. This paper takes the position that the work involved is a break through regarding property ownership, physical planning and development in Botswana. This paper seeks to chronicle what has led to the National Land Registration exercise and how its products are going to convert Botswana settlements towards augmented reality. The augmented reality aspect can be realised through using the data as a base for making property development evaluation, carrying out of physical planning activities and reticulation of utilities such as water, electricity and telephone communications.

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1. INTRODUCTION

The tribal areas of Botswana are vested in the Tribal Land Act of 1968 which effectively divides the country into 12 tribal land administration centres. These territories have evolved from colonialization land category dubbed native reserves under the British protectorate, (Schapera 1943). Before 1970 the tribal areas of Botswana were administered largely through indigenous knowledge under the administration of the territorial chiefs, village chiefs and clan headmen, (Mathuba, 1989). During those times only tribal citizens were entitled to land allocation and it was easy to manage the land allocation based on the use of indigenous knowledge or what in geomatics can be described as mental mapping. After Botswana gained independence in 1966, two (2) years later the government realised that this way of land administration was no longer sustainable and on the basis of the existing groupings a Tribal Land Act was enacted in 1968. It was this Tribal Land Act of 1968 which led to the establishment of 12 Main Land Boards in Botswana. These Land Boards were charged with the responsibility of improving on administration of tribal land in Botswana, (Mathuba, 1989). It is the intention of this paper to review the tribal land tenure system of Botswana together with its administration through the Tribal Land Act of 1968 and the various reforms which have occurred up to date. Discussing these efforts should lead us to understand why the tribal lands of Botswana have moved from obscurity towards the centre stage of the modern technologies and real opportunities for augmented reality in its processes. The augmented reality aspect will be elaborated to indicate how it can be used together with national tribal land registration data currently being collected to support activities of land administration and development.

2. TRIBAL TENURE SYSTEM IN BOTSWANA

Tribal lands in Botswana were established through the Tribal Land Act of 1968. This act established seven (7) tribal territories in Botswana being the Bakwena, Bangwato, Bangwaketse, Balete, Batlokwa, Batawana and Bakgatla. In addition to these there are five (5) tribal areas being Ghanzi, Kgalagadi, Rolong, Tati and Chobe. These tribal areas form the basis of the 12 Tribal Land Board Authorities in Botswana created under this act. Tribal land have been reported by various authors such as Mathuba (1992) and Kalabamu (2000) to be forming around 70 percent of the Republic of Botswana. It has also been reformed through several instruments and efforts such as the tribal grazing land policy (Malope and Batisani, 2008), the 1983 Presidential Commission on Land Tenure, the 1992 white paper and 1993 amendment of the Tribal Land Act (Adams, Kalabamu and White, 2003).

2.1 Tribal land under chieftaincy system

This land prior to the 1970s was administered through a mental mapping system controlled by the chiefs and various headsman and tribesman of a given Tribal Territory or Area, (Mathuba 1992;

Kalabamu 2000; Adams et al, 2003). This land tenure system and its methods of land allocation and geospatial information are emphasised in Nkwae (2008) who indicated that it had no precise way in which land uses were categorised as there were no written rules on various processes used in its administration. This chieftaincy based land administration model or system was reformed through the Tribal Land Act of 1968 by establishing Land Board administration centres in each tribal territories and areas in 1970. The fundamental problem with these reform was continuation of the mental mapping system as a way of administering tribal land over an extended period of time from 1970 to the early 1990s.

2.2 Tribal Land Act and Land Board System

Land Boards were created across the Tribal Territories and Areas made of man and woman believed to be in possession of appropriate indigenous knowledge and mental mapping of their areas (Mathuba, 1989). What was clear about these Land Boards establishment was the desire to keep land administration connected to local communities as much as it was possible, (Mathuba, 1989). These boards continued to allocate land on the basis of tribal lineage until 1993 when the Tribal Land Act was amended to allow for Botswana citizens to be allocated land anywhere they desire in in the country, (Kalabamu, 2002; Adams et al 2003).

The Tribal Land Act of 1968 prescribes an organisational structure whereby the Land Boards are made of Board Members and the Secretariat. The Land Board Members are responsible for land allocation and earlier on they were considered to be individuals having appropriate indigenous knowledge and mental mapping of their areas. The Secretariat on the other hand has always been to support the operations of members of the Boards by recording proceedings of Land Board meetings, issue certificates following land allocation and general record keeping. This structure is considered in this paper to have had a serious technical weakness in that it failed to recognise earlier on the importance of geospatial data collection in the processes of tribal land administration. The geospatial data collection aspect would have added the appropriate technical dimension associated with land administration in a given jurisdiction.

This administration structure of the Land Boards of Botswana were to continue in this manner until 1975 when leases were first allocated for purpose of tribal grazing farms, (Adams et al, 2003; Malope and Batisani, 2008). Further to this some citizens started agitating for using their allocated land irrespective of use as collateral with the banks to access loan facilities in order to develop the same, (Nkwae, 2008). The realisation became clear that it was not possible for that to happen as the issued Land Boards certificate were not registrable. The land board came up with a leasing instrument but then it became evident that geospatial data was required to authenticate the location of the land in question. To that, Land Board sketches were instituted as part of the lease. In order to obtain title to the land the banks required that the land be registered with the Deeds Registry of Botswana. It was this move which led to the realisation of land surveying as important in the activities of the tribal land administration. The central government Department of Surveys and Mapping (DSM) which was then the only department with land surveying expertise was charged with this land surveying responsibility. As time went by it became evident that DSM was experiencing man power challenges and could not keep up with the land board requests and as a solution a move towards technical wings in land boards was pursued. The movement towards technical wings in the land boards bore real fruits in late 1980s when survey technicians were employed in the land boards for the first time to support board members with land sketches. This move was to be followed by the recruitment of Chinese Surveyors in the early 1990s through a corporation agreement with the Peoples Republic of China.

It was through the recruited Chinese land surveyors that the tribal areas of Botswana moved from the mental mapping systems into the paper based mapping systems and digital mapping systems in quick succession. It is the intention of this paper to review the process which was originated through the tribal land lease which partially led to recruitment of Chinese surveyors who started the land inventory system, (Tembo and Simela, 2004). The land inventory system had its own challenges and thereafter other efforts were pursued such as Tribal Land Management Systems (TLIMS) and The Land Administration Procedures, Capacity and Systems (LAPCAS) as articulated in Malatsi and Finnström (2008). LAPCAS has led to a massive National Land Registration project in 2016. The National Land Registration is considered in this paper to be a springboard that can be utilised to integrate augmented reality in the tribal areas of Botswana land administration processes.

2.3 Tribal Land Lease System

This system was started in 1975 as an implementation mechanism for tribal land grazing policy, (Adams et al, 2003; Malope and Batisani, 2008). It was later extended to settlement areas and in its current state there are residential leases with terms of 99 years and commercial leases with terms of 50 years, (Nkwae, 2008; Mooketsi and Leonard, 2013). The lease instruments for a long time have been the de-facto authority towards tribal land surveying and registration in Botswana. These documents are produced by the land boards and its main features are the memorandum of agreement of lease and a sketch plan depicting the locality where the property is found. The locality of the area in addition would show an estimated area of the plot that is under lease. In order to register the lease, the owner would usually engage a registered land surveyor who will then survey the land under lease according to the provisions of the Land Survey Act of Botswana and submit it to the Department of Surveys and Mapping (DSM) for examination and approval. Once the survey has been approved by the DSM, the lease holder will be given two survey diagrams which they take back to the Land Board that allocated them the lease and get two lease copies. The lessee will then compile the documents and register them at Botswana Deeds Registry. This process has for a long time remained voluntary and created gaps in that great parts of the villages of Botswana remained un-surveyed and unmapped in accordance with national land survey and mapping standards.

2.4 The Review and amendment of the Tribal Land Act

The Tribal Land Act was reviewed in the early 1990 leading to an amendment in 1993 to specifically remove from it the clause that was giving exclusive rights of land ownership to tribesman and open for any Botswana citizen to apply and be allocated a plot anywhere they want to stay in Botswana (Adams et al, 2003, Nkwae, 2008). Though good for Botswana citizenry as a whole, by the time this statute was enacted there were already prevalent problems of land squatting. The areas of greater Gaborone in particular the village called Mogoditshane were much affected by these problems as reported in the Kgabo Commission, (GRB, 1992). This commission unearthed a lot of malpractices in land dealings in Gaborone peri-urban villages and also revealed that lack of geospatial data for land administration was a cause of concern for the republic's tribal territories and areas. It was during these times that the government of Botswana went out and sort technical collaborations with the republic of China in the area of land surveying. A collaboration was reached which saw the Chinese government releasing a number of experts which were deployed across the various Land Boards. On their assumption of duty these experts immediately pursued the process of developing of land inventories in their respective Land Boards, (Tembo and Simela, 2004). This process can be viewed as the first real effort towards large scale mapping in the villages of Botswana.

3. TRIBAL LAND AND MODERN MAPPING SYSTEMS

The coming of the Chinese surveyors saw the emergence of land surveying and mapping in tribal villages of Botswana. This period can be summarised as the concurrent emergence of paper based and digital mapping in tribal villages. The period was also captured by geospatial technologies such as GPS and GIS making serious inroads into the arena of geospatial information collection and processing in Botswana. Therefore, the handling of geospatial data and processes progressed along these technologies and over a short period of time maps and digitised data started appearing in the Land Boards.

3.1 The Land Inventory for Tribal Areas of Botswana

The arrival of Chinese land surveyors brought with it the surveying of a number of tribal plots, especially in the main tribal villages of Botswana such as Molepolole, Serowe, Mochudi, Kanye, Mogoditshane, Tlokweng, Ramotswa just to mention a few. The process of surveying often includes surveying design layouts before allocation and this process led to the emergent of Land Inventory System for tribal areas of Botswana dubbed LINSYS. This initiative did not bear the desired end results as reported in Tembo and Simela (2004). Following the Chinese surveyor's land inventory effort, a new concept gearing towards surveying plots in tribal villages named Tribal Land Information Management System was devised, (UN-Habitat, 2010).

3.2 Tribal Land Information Management System (TLIMS)

TLIMS was instituted in mid-2000 aimed at digitizing land records in tribal areas of Botswana. This project deployed two main approaches being geospatial data collection and use of information technology. Geospatial data was collected as pilot survey projects based on global positioning systems (GPS) in the village of Serowe and Palapye in Ngwato Land Board and Mogoditshane in Kweneng Land Board. The data was to be interfaced with the geodatabase model that was developed. The geodatabase model was developed to handle land records of various kinds in the land boards in excel, access and shapefile formats. This project as reported in IRMT (2008) and later Maphale and Phalaagae (2012) did not really achieve its intended purpose. Mooketsi and Leonard (2013) carried out a study based around Mogoditshane village regarding this system and manged to unearth a number of challenges associated with it such as its failure to meet its intended requirements, its complexity, failure to link with other governmental information systems and lack of maintenance. The system challenges have led to its abandonment and a new approach named

Land Administration Procedures, Capacity and Systems (LAPCAS) started, (Malatsi B. and Finnström Å, 2008**)**.

3.3 The Land Administration Procedures, Capacity and Systems (LAPCAS)

LAPCAS was started as partner driven project between Botswana Ministry of Lands and Housing (MLH) and Swedish Lantmäteriet. It is made out of seven components which are listed in Malatsi B. and Finnström Å (2008) as the following;

1. National systems for unique referencing of land parcels and location addresses
2. Improvement of land administration processes,
3. Deeds Register computerisation,
4. Systematic adjudication on tribal land,
5. Development of IT procedures and organization,
6. Exchange and dissemination of land administration data, and
7. Training and study trips.

The LAPCAS concept has allowed for a real possibility of all tribal village plots in Botswana to be surveyed and given unique reference numbers through component 1. Partnership with the private sector has been a cornerstone to the geospatial data collection whereby the Ministry of Lands and Housing through its Department of Surveys and Mapping went into a collaboration with Botswana Surveying and Mapping Association to utilise their private land surveyors. This collaboration which started in January 2016 has yielded some fundamental milestones in a period of a year whereby tribal plots running into some hundreds of thousands were surveyed according to the standards of the Botswana Land Survey Act. This process has now yielded a result similar to figure 1 for most villages where both photogrammetric and land survey data can be superimposed to validate property boundaries, development and offer guidance to land administration in Botswana tribal areas.

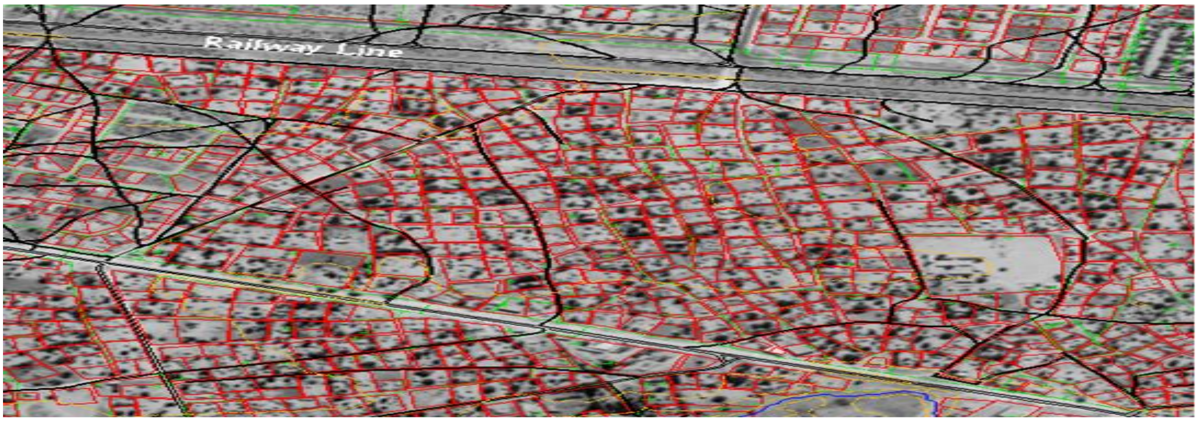

Figure 1: Botswana tribal land going digital; An Orthophoto superimposed with survey data in one of Botswana Tribal villages. Source (Courtesy of Botswana Department of Surveying and Mapping)

The result portrayed in figure 1 signifies a real movement into the geospatial data digital realm for Botswana tribal villages which offer real milestones in processes of development, monitoring and better decision-making. Going forward new and emerging technologies have to be considered and harnessed for utilisation in Botswana to further geospatial data collection interest and move towards development of geospatial data infrastructures. Augmented reality is the technology which the author has in mind. If this technology is considered research should be done to allow for the use of augmented reality methodology in surveying of various installations and infrastructures such as property development status, power, water, telephone and roads.

4. AUGMENTED REALITY

The computer technology has revolutionised several activities of man and made it possible to venture into specialised handling of information and environment. One such technology that supports this is called augmented reality which by the words of Chi, Kang and Wang (2013) it can be defined as "environment where computer generated information is superimposed onto the user's view of a real world scene". Augmented reality systems should allow the user to interact with the real environment. In this case the user should be able to work in both the virtual and real environment in a three-dimensional format, (Azuma 1997; Azuma et al 2001, Roberts et al, 2002). These authors emphasize that a functional augmented system should have the following components; scene generator, tracking system and display. This is important because today many technological platforms can be utilised in an integrated format. Video based AR systems are being developed and directly linked to the virtual environment with the help of the information communication technologies such as the internet. Augmented reality which is believed to originate from the work of Sunderland in the 1960s was in the 1990s given research impetus by the work of Azuma and research has since been galvanised in the area, (Azuma et al., 2001).

Research has revealed the augmented reality concept as very intriguing and capable of deployment in several domains. For instance, the work of Wagner and Schmalsteig (2003) has focussed in development of handheld augmented reality systems relying on already existing infrastructures such as mobile networks. This kind of innovation has largely initiated the use of augmented reality in the area of geospatial information by integration with technologies such as Global Positioning Systems (GPS), Remote Sensing (RS) imagery, Geographical Information Systems (GIS) and Information Communication Technologies (ICT). Geospatial information has a lot of field service activities which are existing gaps that can be filled through the exploitation of the augmented reality concept. Similar work was conducted by other researchers such as Roberts et al (2002). The examples stated here shows that augmented reality can be superimposed on technologies which are primarily used in processes of land administration.

5. AUGMENTED REALITY AND GEOSPATIAL INFORMATION

For augmented reality technology to be utilised profitably in operations we require accurate geodatabases of the areas of interest, (Roberts et al, 2002). This is consistent with geomatics.

Robetrs et al (2002) started an integrative work of geospatial technologies with augmented reality through development of a system they called "Tracker Technology". The development of this tracker technology was conceptualised in figure 2 whereby the land surveyor with a GPS back pack can be able to replicate the measurements of all features in a given site within the frameworks of virtual environment and augmented reality. Acknowledging ingenuity of this work Nartz et al (2006) pursued research along the use of mobile units in a car. This signifies research intensification of integrating geospatial technologies with augmented reality.

Figure 2: Conceptual land survey augmented reality. Source (Roberts et al, 2002).

These earlier efforts have aided the work of Talmaki, Dong and Kamat (2010) who have developed a framework for the processes of working with underground utility infrastructure as shown on figure 3 below involving underground utility infrastructures.

Figure 3: The architecture of the visual excavator - utility collision avoidance framework. Source (Tamaki, Dong and Kamat, 2010)

Figure 3 above reveals an integration of various technologies such geodatabases, video, global positioning Systems (GPS) and excavation equipment all utilised in a pipeline excavation process. This picture shows how these technologies are integrated in a real site situation to now create an augmented visualisation shown in figure 4. The system is now integrated with the information communication technologies through google earth to create a real augmentation of the reality.

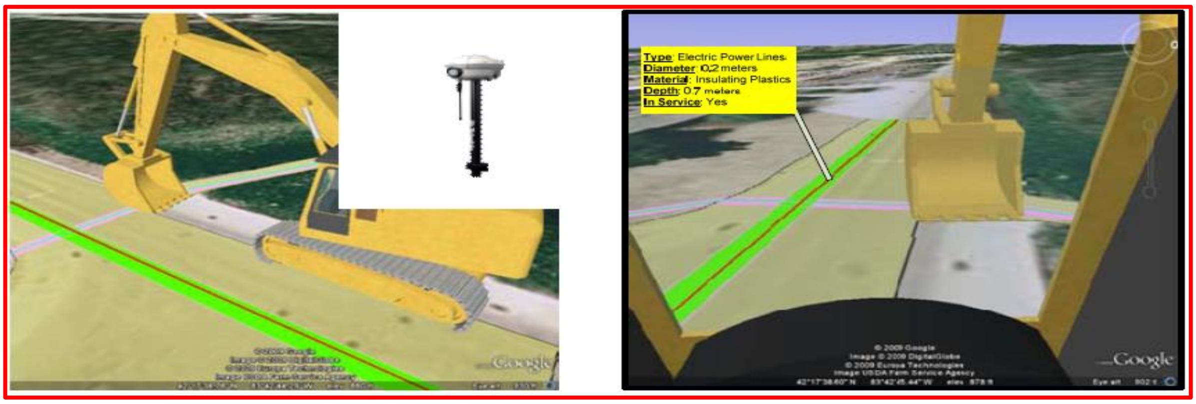

Figure 4: Interface of collision avoidance augmented reality system. Source (Tamaki, Dong and Kamat, 2010)

The above example demonstrates how geospatial technologies together with augmented reality approaches are being integrated into a powerful set of solutions. But for these solutions to be effective geospatial base data set have to be acquired first and it has to be accurate to within cadastral and engineering standards which can go as high as sub-centimetre. This is well stated by Roberts et al (2002) when they say "Thus the position information and the survey data must agree else the system can never work effectively". The current work in Botswana carried out under the LAPCAS project is based on high levels of accuracy as all plot corners are measured horizontally to within errors of 3 cm. This effort will establish a good base upon which geospatial technologies enabled with augmented reality can be used to support data collection, development and land management in Botswana tribal villages.

6. THE AUGMENTED REALITY AND BOTSWANA TRIBAL VILLAGES

In all tribal villages of Botswana, developments had preceded collection of any useful geospatial data that can be used to aid planning and development. A lot of developments got carried out without much reference to geospatial data and the current LAPCAS project geospatial data collection will work towards correcting this status quo. In addition, topography and the rest of existing developments such as roads, telephone lines, water pipelines, powerlines and associated installations have to be surveyed and integrated with the property boundaries data. The figure 5 below reveals a geodatabase attribute table that has been developed and standardised to support surveyed and processed property data of the villages in the LAPCAS project.

Table

Sesungall

FID	Shape	STAND_NAME	STAND_AREA	LegalAreaU	SR_Numb	DSM_NUMBER	TYPE	LOT_NUMBER	LO_BAND	LAND_USE
0	Polygon	31	20189.7682*	Square Meter	0	0	Village Lot	31	LO25	
1	Polygon	32	932.388062*	Square Meter	0	0	Village Lot	32	LO25	
2	Polygon	33	920.601053*	Square Meter	0	0	Village Lot	33	LO25	
3	Polygon	34	911.304736*	Square Meter	0	0	Village Lot	34	LO25	
4	Polygon	35	911.930045*	Square Meter	0	0	Village Lot	35	LO25	
5	Polygon	37	1361.49591*	Square Meter	0	0	Village Lot	37	LO25	
6	Polygon	38	922.883633*	Square Meter	0	0	Village Lot	38	LO25	
7	Polygon	39	898.417191*	Square Meter	0	0	Village Lot	39	LO25	

Figure 5: The geodatabase attribute table extract

The attribute table was connected to the shape files shown in figure 6 in an ArcGIS environment. This geodatabase major emphasis have been on establishing the polygons and linking them with their areas as computed from the coordinates of the plot surveyed. From the geodatabase it can be depicted that some columns remain empty such as that of land use. This geodatabase can be further developed by attaching more attributes to the surveyed plots and creating a comprehensive virtual environment about the plots. A number of things can be performed with this data such as establishing the quality of existing data. For instance, figure 6 shows two plans side by side resulting from geospatial data collected by two different organisation on the same place. The two data sets were overlaid and some discrepancies observed as shown in figure 7. The yellow data represent the recent survey of the LAPCAS project while the red information represent what was existing as data for the plots.

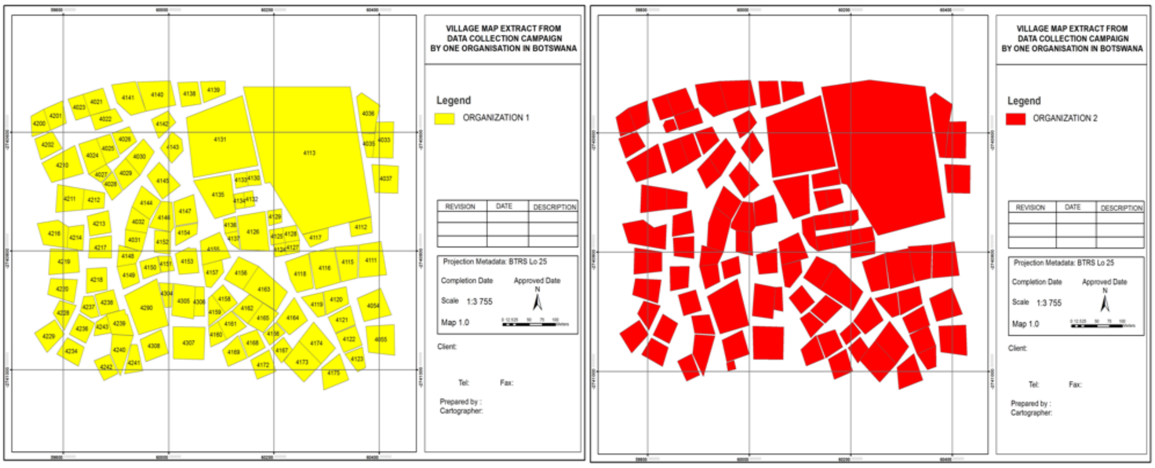

Figure 6: Typical Botswana tribal village plans extract collected by two different organisations

Figure 6 and 7 shows very simple representations and comparisons of collected geospatial data for supporting land administration. Though this represents a simple operation in a GIS environment, it also exposes the power of the information in hand. It offers opportunities for testing this data in the real environment in order to improve on data quality and control.

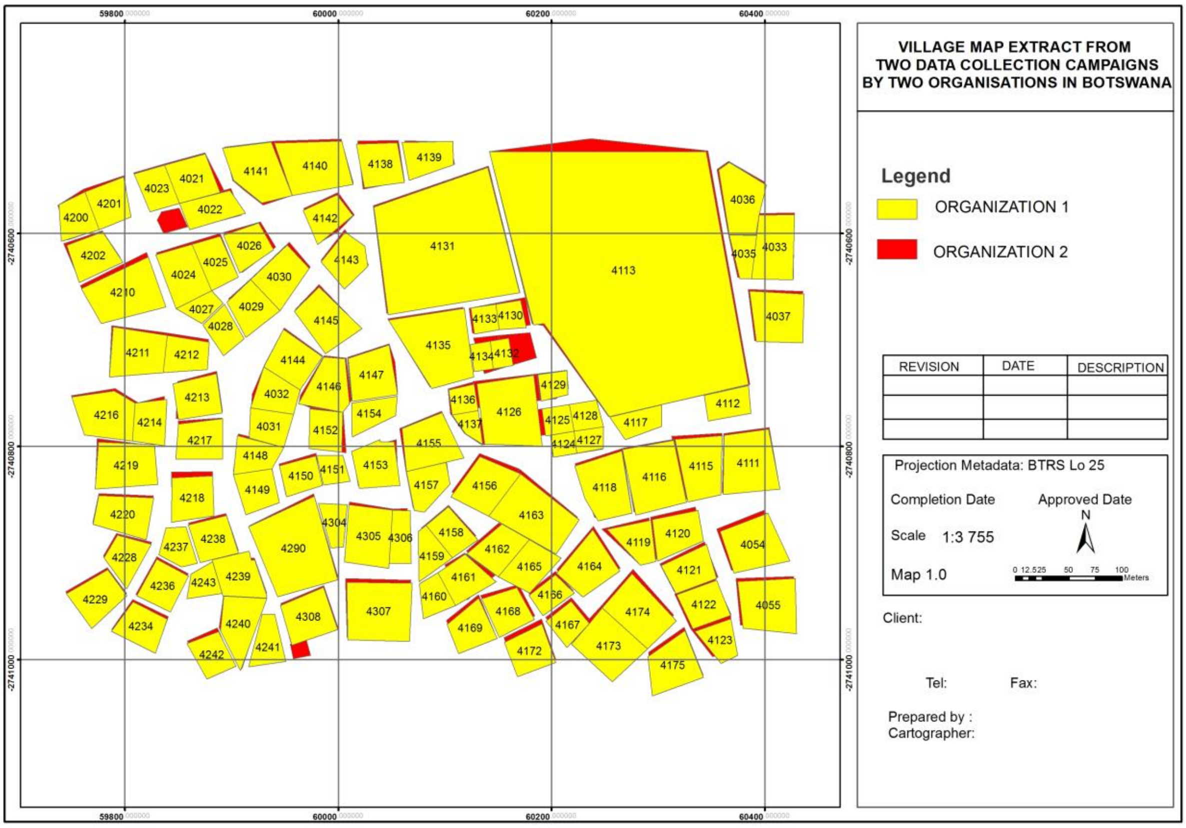

Figure 7: Overlaid plans of figure 6 revealing discrepancies

The data that have been collected should be developed into a powerful virtual geodatabase environment taking into consideration important land administration parameters. The developed virtual environment can then be utilised with systems such as those explained in Talmaki, Dong and Kamat (2010) to improve various land administration and development processes. In the view of the author the geospatial data collected through the project offers opportunities of linking land administration processes with augmented reality.

To collect geospatial data in the tribal villages, conventional survey methods can be followed or three-dimensional (3D) survey systems enabled with augmented reality features can be used. With the cadastral base, a 3D methodology with enabled augmented reality is proposed here as a method that can be followed to help in the geospatial data collection of the following;

- **Property development status**:
  In order to ensure maximum utilisation of allocated land the land boards have a mandate to inspect the status of development of the land parcels that they allocate. Therefore, using the property base layer property development status data can be collected with the help of 3D systems which can collect data at similar accuracies as that of the base data. The data will then be processed into one quality data set of the village over a period of time. Data with the third dimension is very useful to utility corporations as they can use it to plan and install their reticulation infrastructures. This is in line with the position advanced in Jazayeri, Rajabifard, Kalantari (2014) that "*incorporating the third dimension into the land*

development cycle can potentially address such challenges by providing data that describes both the land parcel and building in 3D."

- **Utilities and roads infrastructures**:
  The roads can equally be surveyed using these technologies superimposed on the boundary layers. The good thing about augmented reality is that they will take pictures and in the process reveal the road conditions. Utility infrastructures occur aboveground and underground. All these need to be mapped using modern mapping technologies which allows for surveying in a lot of data to the existing property base layer. Visualisation of underground utilities is highly important these days when considering the rate at which their developments are being done in Botswana. Buried installations are critical and it is no surprise that research relating to integration of augmented reality with geospatial technologies have focussed on them (Talmaki, Dong and Kamat, 2010).

Three dimensional (3D) Geospatial technologies enabled with augmented reality are beginning to get trendy in the geomatics industry market for example the Lieca Pegasus. These technologies across board are sensory systems assembled with GPS receivers together with LiDAR profilers and cameras, (Toth, 2009). This systems come in normal backpack technology and GPS receivers are calibrated in the usual way either using base and rover over control reference points or connecting to available GPS network of continuing operating stations. The advantage that Botswana has is that they have a network of GPS continuous operating reference stations. In order to benefit from these technologies, an integrated approach can be adopted whereby organisations such as Land boards, Department of roads, District Councils and Utility companies come closer together and pursue a strategic objective of performing geospatial data collection through the use of augmented reality enabled land survey methods. What makes the strategic option in data collection viable is that all the organisations belong to the government of Botswana and it should be easy for them to pilot such an adventure together.

7. CONCLUSION

This paper has demonstrated and motivated why the development of Botswana tribal land administration can be further enhanced into embracing modern day technology such as augmented reality. It was the objective of this paper to show that it is possible for augmented reality solutions to be implemented to a dynamic land administration system that is responsive to changing technology and land administration methods. The real emphasis was to show a real opportunity for the development of the method of augmented reality in land administration without necessarily dwelling too much on the technical aspect of the solution. Further to this it has to be noted that research leading to integration of geospatial technologies to improve land management have been done in developed countries such as the United States of America, Europe and parts of Asia. Research is also pointing to several areas of application of augmented reality and in the USA it is being integrated into curriculum and is expected to be a growth area, (Yuen, Yaoyuneyong and Johnson, 2011). This paper has also shown augmented reality conceptual stage in geomatics (Roberts et al, 2002), its development and use in areas such as mapping underground infrastructures, (Talmaki, Dong and Kamat, 2010). In our current times every nation is driven by technology and therefore using cutting edge technology of the time will prove more rewarding for that nation in the future. The surveying of the villages of Botswana to the standards prescribed in the land survey act has opened the opportunities to utilising geospatial technologies that are enabled with augmented reality and this paper has shown that there are several areas of applications. Botswana should not wait on the use of these technologies while on the other hand it continues to develop massive civil and utility infrastructures. Botswana as demonstrated in the paper has over the years pursued several efforts towards moving its tribal land administration from obscurity to the centre stage of modern geospatial technological management and as such she can adopt geospatial information methods that are linked with augmented reality as a way forward.

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BIBLIOGRAPHICAL NOTES

Lopang Maphale is a PHD student at the University of Cape Town in South Africa. He is a Lecturer of geomatics at the University of Botswana where he is currently on study leave. He is a Registered Professional Land Surveyor and has MSc in GIS, MBA and BSc(Hons) in Surveying and Mapping Sciences. He is the former President of Botswana Surveying and Mapping Association. His research in geomatics is in spatial data infrastructures and use of modern geospatial technologies.

CONTACTS

University of Cape Town,
Faculty of Engineering and Built Environment
Department of Architecture, Planning and Geomatics Units
Geomatics Division
Private Bag X3, Rondebosch, 7701.
Cape Town, South Africa
Cellphone: +27833673526
Email: maphalegeocor@gmail.com