High Spatial Resolution Satellite Imagery for Pid Improvement in Kenya

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Key words; Cadastral mapping, PIDs, Remote sensing, High Resolution Imagery

SUMMARY

Preliminary index diagrams (PIDs) are land parcel index maps traced from unrectified aerial photographs. They were put to use in many developing countries including Kenya as a temporary measure to speed up land registration pending preparation of more accurate documents. However, half a century later, they are still actively in use. Though the PIDs have satisfied the immediate need in the provision of title to land, there is a growing concern from users about the boundary information obtainable from these maps for purposes of land administration, for instance land valuation and planning. The accuracy in acreage of land registered under Registered Land Act in Kenya is guaranteed only to within an error of 20%. Currently, high-resolution satellite imagery amongst other geo-information technologies is proving useful for cadastral surveys. This paper looks at the possibility of integrating this technology into cadastral surveying in Kenya.

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1. INTRODUCTION

Land situation in Kenya today and the manner in which it is managed can be traced back to the colonial days. The Land Law, which is intertwined with European and Arab settlement in Kenya from early historical times, is a classic example. Restructuring of land management has been central in the social and environmental change in the postcolonial era. Various land reform programs initiated have been aimed at creating individual land rights. This was intended to increase tenure security through state sponsored adjudication of rights, hence creating incentives for improved land management and increased agricultural productivity. At the same time, a number of social factors have also converged to create changes within the customary land tenure systems. In both cases, rules of access, use and transfer are reformulated to adapt to the changing context of population densities, agricultural commercialization and land scarcity.

Historically, Kenya was divided into three geographical sections in so far as land is concerned. These were the Scheduled areas, the Coastal 10 mile strip and the Trust Lands. In the scheduled areas, land was vested in the colonial government and was reserved for Europeans settlers hence the term 'The White Highlands'. The Coast was formerly leased by British government from the Sultan of Zanzibar but is now a fully integrated province of the Republic of Kenya. The trust lands were formerly referred to as Native Reserves and were then held by the British Government Land Board but are today held in trust by the respective county councils for the benefit of the people inhabiting them.

Further, land in Kenya today can be categorized into three major tenure types; government land (public tenure), trust land (communal tenure) and private land (individual tenure) and they comprise of 10%, 70% and 20% respectively of the total land in Kenya (Mwenda, 2001). Professionals within Institution of Surveyors of Kenya (ISK) have recommended that land should be classified into state (protected areas) and public (government) land as an alternative to the present classification system (I.S.K., 2000).

2. CADASTRAL MAPPING FOR LAND REGISTRATION IN KENYA

Cadastral Surveying and Mapping is the cornerstone of any Cadastral System. They usually result in the preparation of land registration documents. The process of land registration and titling is usually a large scale project and therefore requires survey techniques that are simple, quick and affordable, thus speeds up the official access to secure land tenure by many citizens. In Kenya, there are two principal methods of defining boundaries on the ground for titling; the establishment of marks to define corners and the creation or adoption of continuous physical features which become recognised as boundaries of the land parcel. To hasten the registration process, both ground and photogrammetric techniques were adopted.

Cadastral surveys prior to independence (1963) were done mainly to alienate crown lands at the white highlands and also to define boundaries of both adjudicated and unclaimed land at the coast. Accurate surveys at the white highlands were done under the provisions of the Survey Ordinance of 1923 and registered under the Registration of Titles Act (RTA) while less accurate surveys on adjudicated and unclaimed land at the coast were done under the provisions of the Land Titles Ordinance of 1908 *(Njuki,1999).* Land reforms (Land Consolidation and Adjudication) after 1963 were intended to transform customary land tenure to individual land tenure for Africans in regions currently known as Trust Lands. Cadastral surveys in these places resulted in Demarcation Maps and Registry Index Maps which were subsequently used for land registration and titling.

Surveys in areas of successful adjudication (Enclosure areas) were done to map property boundaries and to prepare the Preliminary Index Diagrams (PIDs). PIDs are maps produced by making direct tracings of parcel boundaries as depicted on an enlarged, unrectified photograph. These diagrams were to serve as interim cadastral maps in support of rapid land titling pending production of more accurate documents, surprisingly; they are still in use today. More accurate documents were to be prepared by the process of photo-restitution as proposed by *(Adams 1975)* once the funds become available. This method only worked for a short period of time and was later abandoned due to enormous cost and slow pace of title processing.

The use of PIDs resulted in the successful titling in most of Kenya's high potential agricultural land and they comprise majority of registry index map sheets used in Kenya. From an earlier survey of Kenyan land records, it was estimated that over 1 million parcels covering over 3 million hectares, had been registered on the basis of PIDs and their usage increased at a rate of 25 000 per year excluding further subdivision (Mulaku, 1995). Majority of cadastral surveys in Kenya today for first registration, change of lease, conveyance or any other comprise of fixed boundary surveys and the general boundary surveys and are registered under Registered Lands Act (RLA) and RTA. These different forms of cadastral surveys resulted in the preparation of certain registration documents such as the Interim Registry Index Maps under which PIDs fall. The others are the Registry Index Maps (RIM) and the Deed Plans.

Mulaku (1995) and Mwenda (2001) have discussed some of the characteristics of a good boundary map; assist in parcel identification, parcel indexing, area determination of parcels, boundary relocation, parcel subdivision, land management, equitable valuation and property assessment, land planning and facilities management. The PIDs adequately fulfils the first two purposes but suffer from gross positional inaccuracies due to various geometric and radiometric errors induced during the flight acquisition and data transfer from photos to the tracings. The boundary information provided cannot therefore be relied upon for other purposes such as valuation. Discrepancies in areas up to and exceeding 50%, minimal financial benefits against the titles are some of the concerns that have been noted by Mulaku and McLaughlin (1996). Based on these concerns Mwenda (2001) recommends the use of high-resolution satellite imagery for upgrading PIDs.

3. SATELLITE IMAGERY AND CADASTRAL SURVEYING

Presently, diverse needs of land information and technological advancements have necessitated changes in land administration systems, which is placing great pressure on the way the organizations do their business. The digital analysis of remotely sensed data has become an important component of a wide range of land studies. In addition, the compatibility of this data for digital image processing and analysis offer much advantages. However, due to the low resolution of the former generation of satellite imagery, the use of satellite data in the surveying field has been limited. This has gradually changed with the introduction of high-resolution satellite imagery amongst other geo-information technologies.

High resolution imagery is proving useful for cadastral surveys. Consequently, traditional cadastre and land registration systems have been undergoing major changes worldwide (UN-FIG, 1999). Investigative work and production projects have shown that a spatial resolution of 2m or better would be required to support most cadastral applications (Helen *et al*, 1997). This threshold of spatial resolution has now been realized with the launch of systems offering the potential of up to <1m panchromatic and <4m multi-spectral spatial resolutions.

Few cadastral projects have used satellite imagery to delimit parcel boundaries. Argentina and Nicaragua have experimented SPOT 4 on fiscal and physical cadastral plans but could not achieve accurate boundary maps because of the poor resolution of the image, (Axes, 2004). The launch of SPOT 5 improved the geometric performance of its previous models and has brought a significant support to cartography.

In Guatemala, SPOT 5 imagery has been evaluated with data from total stations – GPS measurements and orthoimage identification for different types of parcels. Good results were obtained for large and medium extensions; although it presented its limits for identify accurately small parcels, peri-urban and urban estates. The accuracy of identification depended directly to the size and shape of the property, the topography of the area, the type of fences and vegetation coverage present on the study area as well as the scale of the orthoimage used in the identification process (Corlazzoli, 2004). The Guatemalan research recommended the use of SPOT 5 orthoimage as an input that can be considered in countries regarding cadastre with less strict precision.

Mamoru *et al* (2002) considered the possibility of IKONOS imagery for making topo-cadastral maps. The results suggested that IKONOS imagery has advantageous characteristics of interpretation for making and updating middle scale topographical maps such as 1:25000,

compared with analogue aerial photo. The horizontal accuracy of IKONOS ortho-imagery varies between 1.0-1.2m in flat areas and is worse in mountain areas.
QuickBird satellite imagery has the highest resolution, among the satellite imaging systems that are commercially available. This will definitely be the possible immediate option in resolving Kenya's PID problem.

QuickBird has panchromatic and multispectral sensors with resolutions of 61- 72cm and 2.44-2.88m, respectively, depending upon the off-nadir viewing angle (0- 25 degrees), the geometrical resolution can be easily compared with the one resulting from an average scale aerial flight (Cay *et al.*, 2003). The sensor covers 16.5-19km in the across-track direction. In addition, the along-track and across-track capabilities provide stereo geometry and a revisit frequency of 1-3½ days. The data is available in different formats, including the raw data format (Basic Imagery), which preserves the satellite geometry and is preferred by the photogrammetry and mapping community to achieve high accuracy geometric correction and geospatial products, (DigitalGlobe, 2002)

Cay *et al.,* (2003) has enlisted the following to be some of the major strengths of QuickBird image as a source of information for cadastral survey: High geometrical resolution (for large scale projects), Multispectral capabilities, radiometric sensitivity, Good positional accuracy, Revisit capabilities and large image size.

4. HIGH RESOLUTION SATELLITE IMAGERY AND PID IMPROVEMENT IN KENYA

High spatial resolution space images are often available as geo-referenced rectified images rather than original or near to original data. The geo-reference is based on the satellite position together with the known attitudes but with additional cost, the relation between such rectified images and the ground coordinate system is available. In Kenya, several high resolution space images are available as rectified and geo-referenced products. The precise geo-referencing of these scenes can be made by a minimal number of GPS control points followed by Orthoprojection of the satellite image.

Orthoprojection of satellite images is a procedure that is used to correctly represent orthogonal projection, on a prefixed plane, of the area framed by the sensor during the acquisition. This product is obtained through the orthogonal projection of each pixel of the image of the territory onto a cartographic plane, in such a way that the original perspective representation is transformed into an equivalent metrically correct image. Depending on the region and nature of the area: topography, size of the parcel and image identification utility – the appropriate display scale is chosen, providing the clearest visual distinction of boundaries and vertices for digitizing. At this stage, it becomes possible to measure distances and angles on the resultant orthophoto and also to read the cartographic coordinates of significant points exactly like on a map which can be used to compute parcel areas.

In normal situations, the field hedges are trees, live enclosure or fences with presence of vegetation, roads or foot paths and water drainage with the presence of low altitude vegetation. This translates to about 2m width at the usual PID scale of 1:2500. Corlazzoli and Fernandez (2004), found out that for large extension in flat terrain, boundaries are easily identified in the enhanced orthoimage. Further, the variation of areas from orthoimage and ground depends on the size of the property. Medium properties between 10-20ha presented a variation of surface of 0.22%, estates of 5–10ha had a variation of 1.77% while small estates in flat areas presented a variation of 3.7%. These statistics indicate that this technology can be embraced as a solution to the current problems associated with PIDs.

5. CONCLUSION

High-resolution satellite imagery with its utility for surveying large areas in a time and cost effective manner, is considered as an interesting input for indirect land surveying methodology. Subsequently, the acquisition of Satellite Image and the computer data processing can facilitate the improvement of available documentation. Although the cost of the most common available photographs are bearable the recurrent need of enlargement, increases the costs rapidly, (Anderson, 2000). The use of satellite images is more convenient and provides a wider flexibility to manipulate the scales. This enlarged map allows an optimum recognition of the constructions and gives references for the correct delimitation of plots boundaries.

The fact that the imagery is in digital form so that it could be printed at any required scale makes it a fundamental tool, quick and cheaper as compared to the aerial photographs. On the higher resolution side, these systems will compete with the standard aerial photography market. If for some reasons high-resolution maps with worldwide high repetition rates are required, the necessary coverage asks for many cost-effective systems. Then there is a high need to install more small satellites for topographic mapping.

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BIOGRAPHICAL NOTES

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Ondulo J. D. is a Land Surveyor with the Ministry of Roads and Public Works. He holds a B Sc. (Eng.) degree from the University of Nairobi and is currently pursuing his MSc. in Surveying- Land Information Management -the University of Nairobi. He is an associate member of the Institution of Surveyors of Kenya (AISK). His research interests are in cadastre and land management in the developing countries.

Mr. Kalande William worked in Kenya and Somaliland with Ramani Communication and Somaliland Cadastral Surveys respectively as a Land Surveyor and GIS specialist. In Kenya, he was instrumental in the design and formulation and maintenance of several Land information Systems while in Somaliland he resettled refugees, IDPS and Returnees and while solving land disputes. He also lectured Post conflict Land Surveying, Land Management and Administration in The University of Hargeisa-Somaliland. He later joined the University of Nairobi where he is currently pursuing his Msc in Surveying-Land Information Management. He is also currently an employee of the Ministry of Land and Settlement. His research interests include tenure issues and evolution in developing and post conflict countries and development, implementation and maintenance of Geospatial Data Infrastructure in Developing countries.

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