GPS in Cadastres: A Case Study of Kenya

George ONER OGALO, Kenya

Key words:

ABSTRACT

A cadastre is a parcel based up to date register of interest in land. It usually includes a geometric description of land parcels linked to other records describing the nature of interests and ownership of control.
Kenya practices a legal cadastre, which is a state register containing information about land parcels. This is supported by a detailed description of the parcel either in the form of Registry Index Maps (RIM) under RLA[1] or Deed Plans under RTA[2]. The index maps or deed plans are the end products of cadastral surveys.

There are two classes of Cadastral surveys, which support the two boundary systems in Kenya that is the fixed and general boundaries. The fixed boundary surveys are precise and are carried out under the provisions of the Survey Act Cap 299 of the Laws of Kenya, which details how and by who are such surveys carried out and approved. This is especially important as the Government of Kenya guarantees titles to land. The general boundaries are carried out in accordance with four other Acts i.e. The RLA, The Land Consolidation Act, The Land Adjudication Act and The Land (Group Representatives) Act.
The process of carrying out the fixed boundary surveys is expensive in terms of time and procedure besides the different confusing coordinate systems on which they are based. The general boundary surveys are inaccurate and lead to misleading information to property owners and financial institutions, which usually accept such property as collateral in loan agreements.

The Navigation Satellite Timing and Ranging Global Positioning System (NAVSTAR – GPS) is a worldwide, all weather navigation and timing system, developed by the United States Department of Defense. It allows suitably equipped users to determine their position on WGS 84 Reference Ellipsoid GPS surveys have improved in accuracy as more accurate modes of GPS observations are discovered and has gained the capacity to improve the accuracy of General Boundary surveys and fasten the Fixed Boundary surveys thus reducing the cost of surveying and enhancing access to land and value and security of tenure

This paper looks at the administrative, technical, and legislative framework required to fully integrate GPS technology into cadastral surveying in Kenya.

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[1] An Act of parliament enacted in 1963 that extended the provisions for the registration of title to land.

[2] An Act of parliament that introduced a form of title registration based on the Torrens system and conveyancing by statutory form.

CONTACT

George Oner Ogalo,
Graduate Surveyor,
Geometer Surveys Ltd.
Box 53387
Nairobi
KENYA
Tel. + 254 02 253370/500903
E-mail: geometer@bidii.com or ogalooner@yahoo.com

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1 INTRODUCTION

1.1 Land in Kenya

The Republic of Kenya has an area of 582,646 sq. Km and a population of over 28 million (1999 Census). 75% of the population occupies approximately 20% of the country considered high or medium potential and the rural community constitutes 80% of the country's population. Land in Kenya is categorized into government (10%), trust (70%) and private (20%) lands *(Mwenda, 2001).*

The ***Government land*** consists of all that land vested the crown by the Crown Lands Ordinance (CLO) of 1902, enacted by the British government, less any land granted into private ownership by that ordinance or the Government Lands Act (GLA) Cap 280 of 1915. Currently, GLA regulates the leasing and disposition of this land. GLA was enacted to replace the alienation aspects of the CLO and the registration aspects of the Registration of Documents Act (RDA) of 1902 *(Macoco, 1999)*. This is the act that introduced into Kenya the advanced registration of deeds and provided for an accurate survey as well as the 99 and 999-year leases.

Due to the high level of landlessness and desperate squatter situation that prevailed as a result of the CLO and the GLA towards 1930, the East African Royal Commission (1925) and the Carter Commission (1933) recommended the creation of ***Trust Lands*** exclusively for the use of Africans as far as ownership was concerned, but the authority of use was still vested in the local authorities or county councils *(Wayumba 1987)*. Thus, the trust lands comprise all that land held in trust by local councils for the communities ordinarily resident in those regions as defined by the Trust Lands Act, Cap 288 of the Laws of Kenya *(Baya, 2000)*.

Private land constitutes any land successfully claimed and for which a certificate of title was issued under the Land Titles Act (LTA) Cap 282 of 1910 in the Coast Province, any formerly Government land alienated within the provisions of the Government Lands Act cap 280 or any land converted to private ownership from the trust lands via setting apart by local councils or under the provisions of Land Consolidation Act (LCA), Land Adjudication Act (LAA) or the Land (Group Representatives) Act. The land holding in this category is currently registered under two main legislations i.e. the Registered Lands Act (RLA) Cap 300 of 1968 and the Registration of Titles Act (RTA) Cap 281 of 1919. Exceptions are those registered under the LTA Cap 282 and the RDA Cap 285 of the Laws of Kenya *(Macoco, 1999).*

In the recent past, there have been calls from professionals that recommend a review of this classification of land. The Institution of Surveyors of Kenya (ISK) recommends that the government land be reclassified into **State** and **Public** land. The state land should thus cover all protected areas that are gazetted e.g. for government installations and property (military and civilian), national forests and reserves, parks, water catchment areas etc. The public land should cover all unalienated government land and land within local authorities, road reserves and public utility land *(I.S.K., 2000)*

1.2 Cadastral Surveying in Kenya

Cadastral surveys are the surveys carried out to support registration of interest in land. They usually result in the preparation of the land registration documents and they conform to different requirements depending on the registration legislation in place.

Cadastral surveying in Kenya may be traced to the establishment of a survey section and the appointment of a chief surveyor in 1903 to superintend the demarcation and survey of plots that had been alienated in Nairobi *(Njuki, 2001)*. Major landmarks in the cadastral survey reforms in Kenya are associated with the different land reform programs initiated over the years.

Prior to the Second World War, the major land reform programs were the Land adjudication at the coast and the European settlement on the white highlands. Cadastral surveys concerned with alienating crown lands to the white community were done under the provisions of the Survey Ordinance of 1923 and registered under the RTA. These surveys were of very high standards, described land unambiguously and resulted in very few boundary disputes *(Njuki, 1999)*. The other form of surveys was done under the provisions of the Land Titles Ordinance of 1908 to demarcate and define the boundaries of both adjudicated and unclaimed land at the coast. These surveys were done by compass and chain with connections to very few control points and were slow, expensive and of low accuracy. Certificate of titles were issued for all adjudicated lands and all unclaimed lands reverted to the crown.

The period after the Second World War to shortly after Independence (1963) saw land reforms focus on loosening control to land ownership for the Africans. A series of recommendations, factors and events led to the Land Consolidation and Adjudication programmes which were intended to transform from customary to individual (Statutory Freehold) land tenure for Africans in regions categorized similarly in this period as Trust Lands. The Land Consolidation programme which involved adjudication and fragment gathering of small plot sizes, worked for some time and the areas in which it was implemented are referred to as Consolidation areas. The land adjudication programme replaced the land consolidation programme and abandoned the fragment gathering approach. This programme is still on going and the areas in which it has worked are referred to as Enclosure areas *(Wayumba, 1999)*. Similarly, there were areas referred to as Rangelands commonly inhabited by nomadic pastoral communities in which group ownership of land was preferred to individual. Group ranches were then registered in the name of group representatives on behalf of the rest of the group members under the provisions of the Land (Group Representatives) Act Cap 287 of 1968.

Cadastral surveys in this period were thus concerned with this endeavor. In consolidation areas, surveys were done to ascertain the sizes of individual fragments and the general size of the adjudication section, to demarcate the replanned plots and to produce the Demarcation

Maps and the Registry Index Maps. The surveys were done under the supervision of the Director of Surveys. In the enclosure areas, surveys were carried out to map the property boundaries in the adjudication section and to prepare the Preliminary Index Diagrams (PIDs). These surveys involved identification of boundaries on unrectified aerial photographs. In Rangeland areas, surveys involved identification of group ranch boundaries on 1:50,000 topographic sheets and simple ground surveys to map the missing boundaries *(Njuki, 2001)*. They resulted in the preparation of Registry Index Maps –Range (provisional).

In the period after independence, the major land reform policy has been the conversion of communal land tenure in trust lands into individual ownership through land adjudication, the transfer of land from the white settlers to the native Africans through Land Settlement Programs[1] and cooperative societies and the transfer of land from group or company ownership to individual land tenure. Cadastral surveys in the enclosure areas are as described above while surveys to subdivide group ranches and cooperative/company farms are increasingly being undertaken as per the provisions of the Survey Act Cap 299 of the laws of Kenya. In all the settlement schemes, apart from the One Million Acre Scheme, surveys involved demarcation and survey of plots by ground survey methods. In the One Million Acre Settlement scheme, surveys were done by the Survey Department and involved the preparation of topographical base maps at a scale of 1/2500, demarcation of plots and preparation of the Registry Index Map by Photogrammetric Methods *(Njuki, 2001)*.

Currently, majority of the cadastral surveys in Kenya, done for purposes of first registration, change of lease, conveyance or any other may be classified under two broad categories i.e. the fixed boundary surveys and the general boundary surveys. These two survey categories seek registration under two main registration legislations i.e. The RLA and the RTA.

1.3 The Registration Documents

As has been outlined above, the different forms of cadastral surveys resulted in the preparation of certain registration documents. These documents may be divided into three broad categories namely: The Interim Registry Index Maps, The Registry Index Maps (RIM) and the Deed Plans.

The Registry Index Maps obtained by the "refly" program is sufficient, as the technical process used was supervised by the Director of Surveys, though, the boundaries are not mathematically described resulting in many boundary disputes.

The Deed Plans result from very accurate surveys and provide the highest security of tenure. Any boundary disputes are effectively resolved by a mathematical reestablishment of the original boundary. It is an exact document though expensive and currently only applicable in urban areas on 99-year leaseholds *(Wayumba 1987)*.

The Interim Registry Index Maps, though initially intended to be just a stopgap measure to speed up land registration pending preparation of more accurate documents, are still in place

[1] See Mwenda 2001 or Njuki 2001 for more details

in Kenya. They include Registry Index Maps (Provisional), Preliminary Index Diagrams and the Registry Index Maps- Range (Provisional). These interim RIMs are produced by Junior Survey Assistants from the Department of Land Adjudication and Settlement, who have limited knowledge of and training in mapping, resulting in very inaccurate documents. Due to this, *Mwenda (2001)*, recognizes the following concerns:

I. The Interim RIMs do not allow for adequate accurate spatial integration with other thematic land cover types
II. Proprietors of the various parcels do not realize maximum possible benefits from them. It is noted that financial institutions generally advance only 40% of the value against titles registered based on these Interim maps, as compared to 90% in the case of titles registered on the basis of more accurate maps.
III. *Mulaku and McLaughlin 1996* note that discrepancies exceeding 50% in parcel areas as obtained from some of these Interim RIMs have been detected when compared to those from more accurate survey methods. This problem becomes significant now following the amendment of Section 32 of the RLA in 1987 to allow for the inclusion of the parcel area in title deeds, which had hitherto been known as land certificates.

1.4 The Problem Areas of Cadastral Surveying in Kenya

As described above, there are problems associated with the general boundaries, as they never offer a secure and valuable land tenure. The fixed boundary surveys are far so expensive that they inhibit access to land for so many especially in the urban areas. The changes in registration requirements over time have not been reflective on the technical requirements in the preparation of the relevant registration documents. In summary, the actionable problem tasks of cadastral surveying in Kenya may be broadly identified as:

a. Fixation of general boundaries
b. Provision of Survey Controls
c. Fixation of Group Ranches
d. Fixation of Adjudication Surveys
e. Adjudication of land in the Arid and Semi-Arid Lands (ASALs) of Kenya

1.5 The Global Positioning System

The Navigation Satellite Timing and Ranging Global Positioning System (NAVSTAR – GPS) was developed by the United States Department of Defense as a world wide, all weather navigation and timing system. GPS allows suitably equipped users anywhere in the world to determine, instantaneously, their position and velocity.

The GPS programme (worth about 10 Billion Dollars) is a joint service programme managed by the U.S. Airforce with representation from the Navy, Army, Marine Corps, Defense Mapping Agency (DMA), Department of Transportation, NATO and Australia. The National Ocean and Atmospheric Administration (NOAA), the National Aeronautics and Space Administration (NASA) and the United States Geological Survey (USGS) have an interest in either the development or in the application of GPS for geophysical and geodetic purposes *(Bossler, 1985)*.

GPS is made up of three components namely:

- The Ground Control Stations, from which the satellite's almanac is predicted, computed and up linked to the satellite for transmission to the receiver. Also called the Operating Control System (OCS), it maintains and supports the rest of the system. It consists in a single Master Control Station at Colorado Springs (USA), Five Monitor Stations (Hawaii, Ascencion, Diego Garcia, Kwajalein and Colorado Springs) and Three Ground antennas at the monitor stations excluding Hawaii and Colorado Springs.
- The space infrastructure comprising of a constellation of 21 operational and 3 stand by satellites arranged in six near circular polar orbits crossing the equator at 55^0 inclination. It provides global coverage with four to eight simultaneously observable satellites above 15^0 elevation.
- The User Segment, consisting of unlimited number of receivers, which receive the satellite signals and calculate the position and other navigation information *(Aduol 1999)*.

Since reaching its full operating capacity (FOC) in July 1995, GPS has grown into complete relevance in quite a range of sectors. Applications associated with the primary use of GPS technology i.e. navigation and positioning, have seen a steady growth and have engulfed areas that had hitherto remained out of the domain of Geoinformatics. The GPS method of position determination has undergone improvement in accuracy brought about by improved instrumentation, field methodology of the static and kinematic techniques and modeling of GPS observations. This has made GPS the mainstay tool and the future of point positioning *(Lwangasi 1998)*. With the removal of Selective Availability in May 2000 by the then US President William Jefferson Clinton, the accuracy of GPS point positioning is bound to surpass any earlier predictions.

GPS obtains positions on the surface of the earth primarily on the World Geodetic System – 1984 (WGS-84) reference ellipsoid. The development of WGS84 may be traced to the National Imagery and Mapping Agency (NIMA) formerly DMA of the United States of America (USA). It was obtained by modifying the Naval Surface Center by; lowering the origin of NSWC9Z-2 by 4.5m, rotating the NSWC9Z-2 reference meridian westwards by 0.814 seconds of arc to zero meridian as defined by Bureau International de l'Houre (BIH), and changing scale by $-0.6x10^{-6}$ *(ICAO, 1996)*.

The WGS84 reference ellipsoid was adopted by the International Geodetic community at the International Union of Geodesy and Geophysics (IUGG) 17th quadrennial meeting, held in Canberra, Australia, in 1979, as best representing the size and shape of the earth *(Langley 1992)*.

GPS belongs to a family of a range of Satellite or Space based point-positioning systems, which include among others the Satellite Lunar Ranging (SLR) and The Very Long Baseline Interferometry (VLBI).

GPS as opposed to most of the other similar systems has the advantage that it is available all round the clock and the required observation time is short. This increases its relevance in various applications for which the other systems may not be suited such as navigation and real time monitoring of moving objects.

The widespread civilian use of GPS has its roots in the downing of the Korean Flight 007 in 1983 within the USSR airspace- a tragedy that might have been prevented if better navigational tools were in place- and may be attributed to the then US President Ronald Reagan, who issued a directive that guaranteed availability of GPS signals at no charge to the world *(Wayumba 1999)*.

2 GPS IN CADASTRAL SURVEYING

Njuki A. (1998), in his address as the Director of Surveys (Kenya) to Licensed Surveyors, says, "*The days when a cadastral surveyor used to have six chainmen are gone. With the advent of Total Stations and GPS- the black boxes that almost anyone can operate- the surveyor will have to change his approach to surveying. There will be little need for manual skills and more emphasis will be laid on management skills*".

Yego J. K. (1998) notes, "*GPS has been designed to facilitate roaming through the so called Real Time Kinematic Systems (RTK). This has made possible rapid point layout using these systems. GPS accuracies are now in the region of 5 – 20 cm well within our cadastral standards*".

"GPS technology has been used in cadastral surveys in countries such as El Salvador, Indonesia, Morocco, Botswana, Namibia, Jordan and in a number of countries in Eastern Europe. Tests for use of GPS in RTK surveys in Belize and Albania have demonstrated that the use of GPS in cadastral surveys has considerable cost savings" *(Mwenda, 2001)*.

There is no doubt therefore about the potential of GPS in cadastral surveying in Kenya. At the moment though, there is not much GPS activity in the area of cadastral surveying. However, in light of the actionable problem tasks listed above, GPS comes across as the most efficient method of solving the problems. The rest of this paper looks at these solutions task by task.

2.1 Fixation of General Boundaries

General boundaries as has been introduced, define most of land property in Kenya. They are found in all consolidation, enclosure and rangeland areas. The registration in these areas is supported by either the Registry Index Maps (RIM) or the Interim RIMs.

One major problem of general boundaries is that whenever the boundary is lost or a dispute arises over it, the method of reestablishment leaves so many loopholes for abuse.

The RLA provides that in cases of disputes, the Land Registrar after gathering all views of the people resident in the area and any other relevant information including that provided by the surveyor, decides the position of the disputed boundary and his/her decision is final. It is noted that the RIM is not an authority on boundaries and the opinion of the surveyor is just treated alongside all the other views of the elders.

Wayumba (1999) recommends, *"due to the inaccuracies associated with land adjudication programs, the areas of parcels quoted in the title deeds are at variance with the true physical area. This causes problems at the time of land subdivision for sale or transfer and* ***there is therefore an urgent need to fix general boundaries so as to upgrade them to the RTA type of surveys".***

The RLA stipulates two ways through which general boundaries may be fixed thus:

- If the Land Registrar, in light of endemic disputes, decides that the boundaries should be fixed.
- If the concerned parties make an application to the Land Registrar seeking the fixation of such boundaries.

If an approval for fixation of boundary is obtained, how and by whom such fixation may be done shifts to the Survey Act Cap 299, and considering that most general boundaries exist in the rural areas of Kenya where there is lack of survey control, GPS proves most useful in such circumstances.

2.2 Provision of Control

Survey control is the most fundamental aspect of land (Cadastral, Topographical & Engineering) Surveying. The history of land surveying in Kenya starts in earnest with the history of the Kenya – Uganda Railway late in the 19^{th} Century *(Aduol, 1998)*. This subsequently prompted the establishment of a national trig network for cadastral surveying and topographical mapping. By Independence, Kenya was probably the emerging country with the best surveying system especially within the Commonwealth.

Unfortunately, this was not to be for a long time. As the land reform programs gained gear after independence, the focus of the government shifted to title surveys, rendering the provision of national geodetic control network to utter neglect, and at present, the network covers approximately 65% of the country. About 70 – 80% of this control was destroyed as false rumor spread that the control pillars were erected on sites with red mercury underneath, prompting massive destruction of survey pillars and only 10% of the geodetic cover is available today *(Okumu, 1990, Aduol, 1998)*.

The government of Kenya is not able to provide funds for this exercise first because of the high cost of the exercise and secondly because there is no guarantee that they will not be destroyed again.

GPS has the capacity to reduce substantially the cost of establishing this network especially when a multi-faceted approach involving other projects (Implementation of the ICAO[2] Resolution, Monitoring of the movement of the Rift Valley & Location of Communication

[2] The International Civil Aviation Organization

Base Stations) is used *(Mwenda 2001)*. Further, this approach does not require pillars to be positioned on excluded mountaintops, as GPS does not require intervisibility of the stations. This can guarantee the security of these pillars.

The other areas in which GPS would be useful in provision of control in Kenya include:

- In Kenya, there exist at least four projection systems upon which coordinates are declared in different parts of the country. These are the Universal Transverse Mercator (Clarke 1880- modified), Cassini Soldner (Clarke 1858), the East African War System and Local Origin System. All the systems are used for cadastral surveys except the East African War system, which is largely used for topographical mapping *(Lwangasi, 2000)*. GPS may be used to provide control in the different areas with a view to transforming all the systems into one system on a single ellipsoid.
- As indicated earlier, the cost of fixed boundary surveys is quite high. Most of this cost is attributable to the high cost of extending survey control into the survey area. Modes of GPS observations currently deliver sub-millimeter accuracies *(Dana, 2000)*, way higher than the cadastral requirements. The cost of providing this kind of control is way below that of conventional EDM or Chain traverses as commonly done in Kenya. This has the potential of significantly reducing the cost of fixed boundary surveys in Kenya.
- *Mulaku and MacLaughlin (1996)* suggested that one method of improving the PIDs in Kenya is by a least squares transformation based on common points identifiable both on the photographs and on the ground. *Mwenda (2001)* argues that this method has the capacity to progress at a rate 12 times that of direct ground surveys and could lead to cost savings 14 times less. However, in doing this, these points upon which the transformation is to be based will have to be precisely positioned in a reference coordinate system. In light of the scanty trig control network at the moment and the numerous disadvantages of the conventional control extension methods such as intervisibility requirements, GPS offers probably the most efficient control provision method.

2.3 Fixation of the Adjudication Surveys in the ASALS

The Arid and Semi-Arid Lands (ASALS) in Kenya cover more than 80% of the country's surface and amount to a combined area of some 473,000 km^2. This large area is however occupied by 20% of the country's human population. It accounts for a vast amount of unexploited resources including 50% of the country's livestock herd *(Masakhalia, 1979, Gwynne, 1979).*

The definition of the ASALS may be made on the basis of climatic, ecological or land use characteristics. In terms of rainfall, the semi-arid areas receive average annual amounts of between 500 – 800 mm; ecologically, they lie largely within Ecological Zone (EZ) IV but extend to EZ V; and in terms of land use, they represent areas of interaction between pastoralism and cultivation encompassing the margins of rainfed cultivation and the dry season grazing areas of many pastoral groups *(Migot-Adhola and Campbell, 1981).*

Adjudication surveys in the ASALS is just a continuation of the land reform programs that were intended to transfer trust lands from communal to individual land tenure. The method of survey is provided for under the Land Adjudication Act Cap 284 and is as has been outlined in the introductory chapters. In a nutshell, the adjudication surveys involve the identification of property boundaries on unrectified enlarged aerial photographs in the field and are carried out by the Junior Survey Assistants from the Department of Land Adjudication and Settlement.

The problem with this kind of survey is that in the ASALS, there exist no prominent identifiable vegetation and the hedges even if planted cannot grow into air visible boundaries, due to the harsh weather conditions. Further more, the communities resident in these areas are nomadic pastoralists who keep on moving from place to place during different seasons and can never maintain the hedges. Even if it were possible for them to maintain the hedges, they would not favor hedges as boundaries because the hedges restrict the movement of their livestock. Finally, the best that can come out of these surveys were they to be successful, are the PIDs, which are inaccurate and guarantee only 25% of accuracy to boundaries.

From the foregoing, it is apparent that there is a serious land tenure problem in the ASALS as the current land tenure system faces the dilemma of either:

- Going into individual tenure, as is the case in the rest of the country, therefore upsetting the ecological and tourist concerns associated with these areas, or
- Preserving the ecological and tourist setting and denying the people their right to individual land titles.

No matter the land tenure finally adopted for this region, one clear way of describing the land holdings in this area is by use of GPS. This is certainly one area in which GPS has the potential to help the country come up with accurate first-class registration documents.

2.4 Fixation of Group Ranches

As was outlined earlier, during adjudication, certain areas were found to be best owned in terms of groups. Such areas are generally rangelands and the ranches are registered in the name of group representatives on behalf of the group members, as provided for under the Land (Group Representatives) Act Cap 287.

In these areas, the boundaries are adjudicated to follow natural features where possible and identified on the published Survey of Kenya 1/50 000 topographical sheets. The rectilinear boundaries are marked with permanent corner beacons and plotted by identification of details appearing on the topographical sheets or by simple survey methods with no coordinates *(Njuki, 2001)*.

However, due to political, socio-economic and management factors, the government has decided that all these large-scale farms (including Cooperative and Company farms) be subdivided to the members/shareholders.

In order to enhance the security and value of tenure in these areas, most of the groups and cooperatives are increasingly opting for the fixation of the boundaries during subdivision. The import of this cannot be overemphasized and in deed even the ranches not under subdivision should be described by fixed boundaries.

One important characteristic of these farms is that they are very large and even the resulting plots upon subdivision are equally large. It takes quite long to carry out fixed boundary surveys in these areas resulting in quite high costs of such surveys. Coupled with the scanty control in these areas, the value of GPS in these surveys goes without saying. Currently, a comparative study is being undertaken in the Namelok region of Kajiado District, by Geometer Surveys Ltd, a surveying firm in Kenya, to determine the potential benefits if any in utilizing the GPS technology in these surveys.

3 THE ISSUES

Surveying like any other profession, is regulated by law, ascribe to certain technical standards and operate within some institutional frameworks. In Kenya, the Survey Act Cap 299 regulates the practice of cadastral surveying and the conduct of cadastral surveying depends heavily on the office of Director of surveys. The assimilation of GPS technology into this area in the country is a change that will therefore have to necessitate certain changes in the institutional, legal and technical frameworks in place at the moment. Some of these issues are highlighted below:

3.1 Technical Issues

Some of the technical issues include:

i. **Equipments**: there are a variety of GPS receivers and accessories in the market. They support different observation modes and achieve different accuracy levels. The survey Act Cap 299 stipulates which equipment and in what condition, may be used in cadastral surveys in Kenya. The Act provides for calibration of those equipments after certain intervals of time. This is a very significant provision because it ensures the surveys conducted using these equipments are correct and consistent and generally ties with the guarantee of titles the government of Kenya offers titles to land. The issue prompted by assimilation of GPS technology is thus, which receivers may be accepted for use.

ii. **The observation modes and standards:** There are different possible observation methods e.g. the Differential GPS, Single Point Static Positioning, Inverted Differential GPS, Real Time Kinematic System etc. In order to maintain consistency in survey data and to achieve accuracy standards, certain modes must be adopted nationally and not others. This must be sorted out prior to the adoption.

iii. **Transformation Parameters**: it is generally acknowledged that there are receivers these days that are capable of giving observations in various projections on a variety of reference ellipsoids. Though there are those that cannot do this yet, the once with this capability utilize quite wide area transformation parameters that cannot support the small area situations characterizing cadastral surveys. This then requires that either the surveyors carry out the determination of these parameters for every survey they carry out or the Director of surveys publishes parameters for different regions of the country. The other option is for the necessary legislation to be amended to adopt the WGS 84 as the reference ellipsoid and an agreed projection. But even this will require more accurate geoidal determination in Kenya with reference to WGS 84 ellipsoid to aid other mapping purposes.

iv. Once a survey is done, how will the projects be submitted to the Director of Surveys? Will the data cards be submitted alongside the survey plans and computations? How will the checks especially on the GPS observations be done? How will the accuracy of the surveys be independently determined?

3.2 Institutional Issues

Some of the institutional issues include:

i. As had been indicated earlier, the adjudication surveys at the moment lie within the mandate of the Department of Adjudication and Settlement, which is not adequately equipped with trained surveyors capable of undertaking complete GPS surveys. This therefore means that either this staff is upgraded or the duties of this Department are effectively transferred back to the Director of Surveys, who has the necessary capacity to implement these surveys.

ii. At the moment, the Director of Surveys keeps all the survey data in analogue and computer activity in this department is largely administrative with little technical applications *(Yego, 1998)*. If in adopting GPS technology, it is decided that in submitting GPS surveys, the data cards are to be submitted and downloaded into the department computers for analysis and checks, then the Director of Surveys will have to do a lot of upgrading especially in the district offices. The director will have to build the capacity to store this data, check it and be able to sell it out to the surveyors who would want to use the GPS Control thus established. Refresher courses would probably be necessary to familiarize the staff with these changes.

iii. As was indicated under the technical issues, the GPS receivers will have to be calibrated. At the moment, the Survey of Kenya field headquarters has the facility to calibrate the theodolites, chains and EDMs but is not capable of calibrating the GPS Receivers. If this technology is to be included into the mainstream cadastral surveying process, this calibration unit will have to be upgraded.

3.3 Legal Issues

Some of the identifiable legal issues include:

i. **Land Policy**: this is a set of socio-economic, legal, technical and political measures that dictate the manner in which land and benefits accruing there from are allocated, distributed and utilized. Kenya at the moment does not have a clearly articulated national land policy that spells out the relationship between the People, the State and the Land *(I.S.K., 2000)*. Since a land policy aims at promoting a secure and valuable land tenure system and ensures that there is sufficient supply of land in appropriate locations at acceptable costs for different users, an absence of it reduces the underlying concerns of this paper (Security of tenure and Cost of surveys) into lacking national basis. For the Director of Surveys to raise state money for institutional capacity building in his department, a national policy must exist that ties in with the necessary expenditures.

ii. **Land registration and related legislations**: "Kenya has a plethora of enactments governing land transactions in land" *(Macoco, 1999)*. There exist 34 Acts of parliament and related legislations that deal with land in Kenya. Five of these contain provisions relating to land registration and stipulate forms of surveys capable of supporting such land registrations. For GPS to be used in cadastral surveying, all these provisions and the other related legislations must be harmonized and reviewed to support this change.

iii. **The Signal Frequencies:** in differential GPS, probably the most appropriate mode of GPS for cadastral surveying, development of technology now indicates that the use of radio communication of signal timing corrections offer improved accuracy instead of the satellite based communication *(Trimble Navigation Inc., 2000)*. Most RTK GPS surveying equipments transmit data on frequencies between 450-470 MHz. These are shared frequencies, with voice communications having priority over data communications. This has led to interferences in voice communications especially in countries where GPS activity is rampant e.g. the USA. In Kenya, the Communications Commission of Kenya (CCK) regulates the airwaves. In adopting the GPS technology, the legal issues associated with the use of the airwaves will have to be sorted out.

4 RECOMMENDATIONS

In light of the issues identified above, the following recommendations are made:

i. A collaborative approach be developed with the academic institutions to initiate research programs into the technical issues concerned. Some of the institutions include the University of Nairobi, Jomo Kenyatta University of Agriculture and Technology and the Kenya Institute of Surveying and Mapping.

ii. At the moment, an Information Technology Bill exists before Kenya parliament for debate. It is recommended that this bill be amended if necessary and passed to accelerate IT development within the government departments as this could build the capacity of the Survey Department to manage digital (GPS + Others) data.

iii. As *I.S.K (2000)* recommends, a national land policy should be formulated as a matter of urgency before any existing land laws are repealed and/or amended or any new enactments are made. Similarly, as *Macoco (1999)* recommends, a proactive approach by the landed profession in conjunction with the Law Society of Kenya, should be initiated to urgently address the land law situation in Kenya. It is intuitive to note that currently, there exists a sitting presidential commission charged with addressing the land situation in Kenya (Njonjo Land Commission) and similarly the Constitution of Kenya Review Commission. Representations should thus be made and fully lobbied for by these professionals to provide the country with a land policy and a substantive land law that embraces the dynamic technological world and prevents any ambiguities as the plethora of land laws currently do.

iv. As *Yego (1998)* concludes, the Kenyan Surveyor must be at the forefront in championing the changes necessary to make his profession more dynamic and profitable. It is noted that these changes have the surveyor as the potential chief benefactor and therefore must enlist the greatest support from the surveyors. The surveyors must also change and "*the good old chain must go out of the window if it is no longer serving any good purpose!*"

v. All the departments and agencies in the country utilizing the geodetic information could pool resources together to set up institutional back up systems to help in servicing technologies in this field. Some examples here include the Directorate of Civil Aviation, The CCK, The Department of Defence, The Department of Resource Surveys and

Remote Sensing (DRSRS) and The Regional Centre for Mapping of Resources for Development (RCMRD) besides the Survey of Kenya. As *Aduol (1998)* advises, the Survey of Kenya being the eventual custodian of the geodetic information should sell this information to users at prices commensurate with the information thus defraying any extra institutional costs.

5 CONCLUSION

Professor Peter Dale, while giving Hotine lecture at the Cambridge Conference for National Mapping Organizations in 1995, indicated that the role of the surveyor by the year 2020 will be among others, "that of data producer, will be involved more in data maintenance than in new topographical mapping and control surveys will depend on GPS". The *Commission 7 of the FIG* in their statement on the "Vision Cadastre 2014" among others concludes that cost/benefit analysis will be a very important aspect of cadastre reform and implementation and surveyors all over the world must be able to think in models and apply the modern technology to establish those models *(Njuki, 1998)*.

Yes, Kenya had to take drastic measures to transfer land into individual tenure even if it meant compromising the accuracy of the registration documents. In this overall endeavor, the programs have been successful (land adjudication and consolidation programs (7 Million Ha), Group Ranches (3 Million Ha), Settlement Schemes (960,000 Ha) and Cooperative Farms (2.2 Million Ha)). But then the situation now is different, the mistakes of the past must be corrected and the new documents must be produced efficiently. In any case, technology is capable of this today.

There is no doubt Kenyans deserve a valuable and secure land tenure system and there is general agreement that continuous efforts should be invested towards making cadastral surveys cheap, thereby enhancing access to land. GPS provides the opportunity to fix all forms of general boundaries thus enhancing the security and value of tenure besides reducing the cost of fixed boundary surveys.

Finally, as *Yego (1998)* puts it, technological developments are evolving rapidly in almost every area of surveying and these improvements aim at efficiency and near instantaneous achievement of results. The application of GPS technology in cadastral surveying in Kenya has similar aims except fortunately in this case the result is the land registration document.

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