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Experiences in Cadastral Surveying for Land Registration in Africa: An Overview

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1. Introduction

Cadastral surveying and mapping efforts are taking place across Africa and developing countries worldwide. They have experienced varying degrees of success. This paper explores the range of technologies (appropriate and otherwise) that have been or might be applied to such efforts. It will also present a few select examples of such implementations in Ethiopia and throughout Africa and discuss the issues involved. It addresses how spatial data created from the cadastral mapping effort can both contribute to and benefit from the development of land management systems and Spatial Data Infrastructure (SDI). Finally, the paper uses extensive use of quotations from known field practitioners in order to reinforce the ideas being presented.

For the sake of clarity in the following, a cadastral system, cadastral surveying, and cadastral mapping are defined below:

Cadastre:
Dale and McLaughlin (1988) define cadastre as:

> a technical term for a set of records showing the extent, value and ownership of land… In practice the cadastre serves two other equally important purposes. It provides a ready means of precise description and identification of particular pieces of land and it acts as a continuous record of rights in land… The modern cadastre normally consists of a series of large-scale maps or plans, and corresponding registers. Both the plans and registers may be stored in computers.

In 1995 the International Federation of Surveyors (Féderation Internationale des Géometrés - FIG) adopted a statement that cadastre

> … is first of all a land information system to provide information about rights, use or values on land. It is usually (but need not always be) parcel-based. This meant that the important information carrier in the system is a piece of land, which it, for some reason, is meaningful to keep separated from other pieces of land…. The purpose for which cadastre has been established has first of all been for land administration by government…. The second most important purpose has been to provide security of tenure for the land owner/user. The growing need of a cadastre is to provide land information for sustainable management of the land resources in a perspective of environmental concerns, both from government and land owners….

In addition, the FIG emphasizes that the cadastre is not only an information system, but also a process (Osterberg 2001).

According to FIG, a cadastre should address the following issues:

- Land tenure
- Systematic and sporadic land registration
- Definition, demarcation and delineation of boundaries
- Technical methods for surveying and mapping
- Computer technology
- Organization, co-ordination and management of the cadastre
- The role of cadastral systems in formulation, implementing and monitoring land policy
- Access to reliable data
- Financing and policy strategies.
  (Osterberg 2001 citing FIG Statement on Cadastre)

Cadastral survey:

"The goal of cadastral information system implementers operating in a territory where land registration is taking place for the first time is to establish what parcels exist, by whom they are owned, what their approximate size and value is, and thereby, to support the certification or titling procedures" (Onsrud Hodson and Gartrell 1998).

Dale and McLaughlin (1988) define four steps in the process:

- Adjudication
- Demarcation, or the marking out on the ground of the boundaries
- Survey, or the recording of the position of the boundaries, and other elements associated with each parcel
- Documentation or the compilation of all the evidence into a set of registers.

Cadastral mapping:

A cadastral survey generally results in two different kinds of map outputs;

- *Cadastral index map* – showing all parcels in a particular jurisdiction. This map should reflect the unique parcel identifiers which act as an index to various cadastral and land registration attributes data. The cadastral map or overlay also represents the property layer in a multipurpose LIS/GIS.
- *Parcel map* – showing details of the dimensions (distances, azimuths) of the parcel boundaries (example in Photo 1), the coordinates of the parcel corners, and a short description of the monumentation of and other standard map data. This map serves as a legal description for all registered parcels. (Dale and McLaughlin 1988)

Photo. 1. Example of a rural parcel boundary.

Key components of these maps include:

- Survey of administrative boundary (e.g., kebele or sub-kebele in the Ethiopian context)
- Separation of "villages" (lowest administrative unit)
- Delineation of communal areas
- Parcels, with parcel identification numbers
- (Optional) infrastructure or natural features (e.g., roads, churches/mosque, rivers, forest, wildlife resources, etc.).

Cadastral index and parcel maps can be produced in a variety of ways and all are acceptable. In order of difficulty to produce, they would range from hand sketched maps to one mechanically plotted by a surveyor using hand tools to computerized production using surveying or GIS or other mapping software (example in Fig. 1).

The scale of cadastral maps is of great importance. Since the object of the map is to provide a precise description and identification of the land, the scale must be large enough for every separate plot of land which may be the subject of separate possession to appear as a recognizable unit on the map. When map data are stored in a computer, they may be drawn at almost any scale. Despite providing greater flexibility, there is a danger that this can give an impression of greater accuracy than the quality of the survey data may warrant (Dale and McLaughlin 1988).

The scale of most cadastral maps depend on size of parcels, but tend to be at scales of between 1:500 and 1:2500 although in densely developed areas a larger scale may be needed while in open countryside much smaller scales are acceptable. In Thailand, for example, the preferred scale is 1:4000.

How these mapping and surveying activities are carried out vary greatly between developed and developing countries, but in most cases come down to access to resources and the basic infrastructure within which they are being undertaken. Developing countries have less of each, and because of this, several important questions need to be answered:

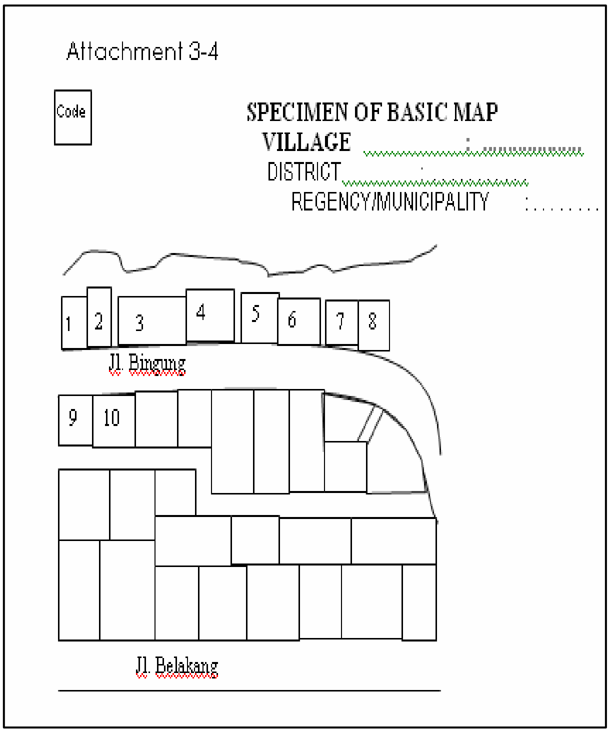

Fig. 1. Index map in an Indonesian cadastral survey.

- What does a specific cadastral mapping project need to accomplish, that which is defined in classic western or developed country cadastral mapping and surveying, or something that is specific to a given developing country?

- What is the "appropriate technology"? Is a traditional measurement and resulting area estimation sufficient, or does the activity truly require the use of electronic surveying equipment? How close is close enough?

These and numerous other issues face any country undertaking land registration. Several African countries have already attempted to implement these systems, while others find themselves in situations similar to Ethiopia's, defining a new or recently initiated effort.

2. Approaches to cadastral surveying and mapping

Onsrud, Hodson and Gartrell (1998) describe the general boundary approach of boundary delineation:

> The concept of general boundaries has its origins in colonial English land tenure arrangements, where the emphasis lay on the recording of deeds, and where the recognized physical demarcation of boundaries on the ground proved the primary evidence of the location of title rights. As opposed to other methods of boundary definitions which rely on extensive boundary surveys to determine the location of property interests, the historic English system required adjacent landholders to demarcate mutual boundaries in an easily recognizable manner and to a degree of precision that allows each to proceed with their intended uses for their land. ….The drawback of the general boundary methods as often applied is that boundaries between parcels must somehow be physically marked along the lines and maintained by adjoining landholders. In many developing regions lines of cooperation are not well established to the extent that they are readily apparent and imposing a burden to make lines physically visible would be onerous.

While the general boundary approach has been attempted in several African countries, there remain numerous countries that require some level of surveying of existing boundaries for their proposed cadastre. There is a wide range of surveying techniques that can and have been applied to cadastral mapping. Initially, there must be definition of requirements, be it through legislation or other governmental mechanisms, which must answer the question of what is the purpose of the cadastral map, and therefore, what techniques are required to produce a product capable of providing that level of information?

At its simplest, surveying might result in demarcating a given parcel through description of its neighbors and a rough estimation of area, either by measuring the boundaries and making simple calculations, or by the best estimate of its owner or the tending technician. To improve upon that, an appropriate method might be geo-referencing, i.e., attaching geographic coordinates to various positions on the parcel such as at the corners, parcel centers, or even a full and complete geo-referenced boundary. Each of these results can be achieved via one or more recognized surveying techniques.

One can think of two general sources of data for developing cadastral maps – data collected on the ground and those data collected from the air. Ground data are effectively those resulting from field work using the full range of field survey techniques. Locations can be determined by traversing which, simply put, proceeds by measuring the angle and linear distance to the next point on the traverse. An alternative approach, use of a global positioning system (GPS) can be used to determine the required locations without typically using the above described approach of traversing. This method still requires a field effort to verify boundaries with rural landholders.

Aerial based data on the other hand are photographic in nature, typically in the form of aerial photographs or satellite imagery. Boundaries that are recognizable on the image are demarcated and maps generated, with or without geo-referencing. The general process of transferring these data collected by air based systems to a usable map base is known as photogrammetry.

The following descriptions, though not exhaustive, will touch on the range of approaches that can be undertaken by the cadastral surveying team.

Field-based Data Collection

The methods of field based survey commonly include the following:

- Traditional methods, e.g., ropes
- Tapes/compass
- Theodolite, electronic distance measurement (EDM)
- Total station
- GPS (handheld GPS, DGPS, RTKS GPS).

Photo 2. Traditional rope surveying method.

Traditional methods vary both between and within countries. They typically consist of a relatively simple method for measuring parcel boundaries and another for area estimation. One common example would be the rope method, which utilizes a rope of known length (e.g., 50m, 100m) to measure boundaries of parcels (example in Photo 2). Areas are determined using simple mathematical methods (areas of rectangles and triangles) with assumptions on parcel shape.

Tape and compass or theodolite and EDM are well accepted survey methods for determining position and area based on the concept of measurement using distances and angles. The total station combines angular qualities of a traditional theodolite with electronic distance measurement and automatic data recording. These methods are more accurate than traditional methods, but require more resources in order to implement them (Dale 1999).

There are several variations of GPS equipment that can be applied to cadastral and other types of surveying, each different in their initial cost, skill required to use them, and the resulting positional accuracy of their readings. “Handheld” units can be the relatively inexpensive recreational or navigational models with positional accuracy typically ranging from 5 to 10 meters, or units that function in differential GPS (DGPS) or real time kinetic systems (RTKS) that can yield sub-meter accuracy. DGPS requires the handheld measurements to be post-processed with data collected from a base station GPS sitting over a benchmark of known high accuracy. RTKS actually corrects the position inaccuracies of these handheld units in real time, but requires a fairly sophisticated national geodetic infrastructure.

“While GPS may be regarded as a hi-tech approach… it also simplifies certain procedures. The field operation or collection of GPS data, for example, is far less complicated than procedures involving theodolites, tapes, and EDM equipment. GPS planning and post-processing requires advanced training and skills, but this is offset by the fact that one planning/processing person can support many field crews.” (Barnes, Eckl and Chaplin 1996)

> The benefits and usefulness of using rough GPS surveys as an alternative means for initially representing land parcel limits is that inexpensive equipment and simple procedures may be used, yet the rough cadastre may serve as a base upon which more extensive, higher-accuracy cadastres may be developed over time as actual demands require and resources allow…The initial lower-precision GPS observations continue to be retained in the cadastral database but would carry less weight than later more precise observations … In some instances the methods described for locating parcel boundaries may simply replace precise surveying methods if more precise boundary locations are never desired by current or future parcel owners (Onsrud, Hodson and Gartrell 1996).

Table 1 compares several of the more common field surveying techniques using the criteria of accuracy, complexity, and cost. Note that GPS is rated as variable in all categories, due to the different GPS technologies available, but would generally be medium to high.

Table 1. Comparison of surveying methods*

Dimension	*Surveying technique*	*Accuracy*	*Complexity*	*Cost*
Angles	Compass	Low	Low	Low
	Theodolite	High	Medium	Medium
Distances	Rope/Tape	Low/Med	Low	Low
	EDM	High	High	Medium
Both	Total Station	High	High	High
	GPS	Variable	Variable	Variable

*Adapted from Dale and McLaughlin, 1988.

Photogrammetry

In this section, we discuss the use of photogrammetric methods for producing a map base from either aerial photography or imagery collected from satellites. The former is a long-used data source collected from an airplane with analog or digital cameras at a scale determined by the needs of the given project. Satellite imagery, on the other hand, is available at set scales or resolution, and the particular satellite source is chosen based on resolution needs. Commercial satellite data is presently available at resolutions sufficient for cadastral mapping (.5 – 1 m. panchromatic, 2.4 - 4 m. multispectral). These satellites include two that are most popular in Africa, the IKONOS satellite from SpaceImaging/GeoEye and the Quickbird satellite from Digital Globe. The most serious drawback of using these high resolution satellite data is their expense, with data costing from $20 to $30 per sq. km.

Broadly speaking, aerial photographs have been used in cadastral mapping in many different ways. In the simplest case, contact scale or enlarged photographs may be used as a base on which to outline the parcels (example in Photo 3). In some countries it is sufficient to produce a plan that points back to the parcels, the boundaries of which can be determined by inspection on the ground. Then there is no need to record the accurate dimensions of any land parcel as long as its boundaries are clearly visible on the photographs. This method is useful where large numbers of parcels needed to be recorded over a short time. Where time and money allow, it can be resurveyed to higher accuracy at a later time (Dale 1999). The same can be said for the use of satellite imagery.

Photo 3. Delineating parcels on high resolution satellite data.

Dale and McLaughlin (1988) summarize the use of these data with the following observations on a photogrammetric approach:

a) Where air surveys are part of the ordinary survey practice of a country, they may also prove suitable for large cadastral jobs, provided that the amount of supplementary ground work required is not so large as to make it more economical to use ground staff alone. In such cases it may be economical to use photography of sufficiently large scale to meet the needs of cadastral surveying even though this exceeds the requirements of other mapping projects. To carry out a dual or multiple purpose survey through one set of photographs may make economic sense. Often, however, the needs of different applications of the photography are incompatible and multiple sets of photography may be required.

b) Where a new cadastral survey of a large area is required to be carried out quickly, air survey is often the best practical method, unless a great deal of supplementary ground work proves necessary.

c) Cadastral surveys of small areas, extensions to existing surveys, and revision work will usually best be done by the ground staff of the national cadastral survey organization, according to a continuous program.

d) Air survey will not supersede ground survey for cadastral purposes, but it should complement it. Where there is no great hurry to cover a large area, and especially where local ground surveyors are available or can be made available in sufficient numbers, it may be better to rely entirely on ground survey for cadastral maps.

Many other uses exist for air photos and high resolution satellite data which can begin to justify the relatively high initial cost (e.g., monitoring land use and land cover change, forest inventories, erosion control, etc.). These make the idea of cost sharing by land management ministries a viable approach for government acquisition.

Simpler methods of surveying and mapping exist, building on more common field or aerial based data collection. One is the idea of the community based map. Onsrud, Hodson and Gartrell (1998) describe this method: “These community–based maps often lack geometrical correctness, but this is compensated for by their accurate topological correctness, which helps assure for instance the correctness of parcel addresses and relationships of parcels to each other”.

They also put forth the Cadastral Measurement Management approach which upgrades survey measurements over time, with emphasis on an enhanced midpoint method. The midpoint idea uses a centrally identified point within each parcel to identify the parcel object to which a right of unmeasured extent is attached. One of the advantages associated with this method is that it doesn’t force landholders to decide upon boundaries if that is not one of their current principal concerns. Onsrud takes the midpoint method a step further, an intermediate approach between the midpoint method and the traditional cadastral system that requires precise delineation of boundaries prior to registration. This involves handheld GPS delineation of the boundaries as well as the midpoint (Onsrud, Hodson and Gartrell 1996).

3. African examples including Ethiopia

In order to speed up processes of land registration, several African countries have been innovative in the creation of new forms of land tenure. Some of the better known examples are village titles (Tanzania, Zimbabwe), certificates of occupancy or rights of occupancy (Tanzania, Nigeria), group ranches (Kenya), flexible titles (Namibia), customary rights issued by land boards (Botswana, Uganda, Namibia), co-ownership (Mozambique), and (South Africa) communal title (van der Molen 2002).

Although technically there are similarities in cadastral surveying across Africa, developing countries, and even developed countries, there still aren't many examples of successful national-scale rural land registration surveying efforts in sub-Saharan Africa. Some of the better known include those in South Africa, Kenya, Ghana, and Uganda. Others include examples from Botswana, Somaliland, Malawi, Namibia, and Zambia. Zimbabwe has been active in the past, but the present land re-distribution system may have rendered those previous efforts irrelevant.

Botswana passed the Tribal Land Act of 1968 which created two core responsibilities: land administration, and surveying and registration (Tembo, Manisa, and Maphale 2001). They used enlarged aerial photography to identify a particular parcel and parcels boundaries, respectively. Photo-maps were then suitably annotated to identify particular parcels. Between 1970 and 1980 the government developed techniques for settling disputes (visual interpretation of air photos), and in the 1990s instituted more sophisticated computerization. In 1991 they engaged a consulting firm to help set up GIS (Dale 1999). They have also been carrying out research on demarcation, community participation, and traditional concepts of boundaries for traditional lands (Nkambwe 2002).

While South Africa has probably the best land registration system in sub-Saharan Africa, most of those holding completed to date are of the former white-owned areas. The full range of sophisticated surveying techniques has been employed. Methods are still being developed for the most efficient surveying of settlements and informal areas which comprise the remaining 20 percent of land still not completed (Fourie 2001). Those methods include the use of participatory techniques, video, GPS, and GIS (Augustinus 2003).

In the 1960s and 1970s, Kenya used simple chain and air survey methods for the first registration of land. This required planted physical boundaries which could be seen in the air photos which were enlarged to a scale of 1:2500 (Wanyoike 2001; UN HABITAT 1990). Four types of mapping products came out of those efforts: the registry index map, demarcation maps, preliminary index diagrams, and registry index maps for range (Njuki 2001).

Osterberg (2001) notes that Kenya "has tried to establish European-like cadastral systems for land registration through adjudication of existing traditional rights in a very systematic and comprehensive way, through different more and more simple methods in order to keep the costs for registration as low and affordable as possible. Several million parcels have been registered in this adjudication process. Yet, there is no clear evidence that this enormous investment by the government is contributing to the economy. On the contrary, the cadastral system thus established seems in many cases to fall apart through lack of proper maintenance."

In Ghana, the Survey Department is the custodian of national geographic databases. They are digitizing and scanning the country's 1:50,000 topographic maps. In urban areas 1:25,000 cadastral plans (part of land registration) are created by licensed surveyors using GPS and total station (urban). These data are now being put into the GIS based system within the LAP (Land Admin Project). There is also a developing emphasis on SDI (Karikari 2005; Karikari, Stillwell and Carver 2006).

As with Kenya, Uganda has incurred problems because of failure to update surveying records in the cadastre. More recently, Uganda has attempted to reinvigorate its land registration efforts through the passing of the Land Law resulting from the 1995 Constitution and the Land Act of 1998. LIS/GIS are being set up to address both cadastral and non-cadastral land management.

Namibia has been establishing a relatively low cost approach of setting up land information system for informal settlements using combination database software, GPS and video as have been used in South Africa (de Vries 2004).

Despite the lack of international recognition as a country, the Cadastral Surveys Department in Somaliland had sent teams into the field equipped with theodolite to survey, record and map the exact locations of fixed objects such as houses or physical landmarks, and farm boundaries after adjudication by farmers. Measurements recorded and copies sent to Cadastral Surveys, quality checked and entered into a GIS. Also, the government is setting up a new Institute of Land, Soil and Water Surveying at the University of Hargeisa (Drysdale 2004).

At the project level in Mozambique they are exploring the use of Participatory GIS (PGIS) which "serves as a realistic solution to overcome the bottleneck of fast standard cadastral recording, which is a time consuming process, as such requiring non-existing technology and qualified people" (Kienberger et al. 2005). Through the use of existing map material, communities have developed their own cadastral maps.

In Ethiopia, through a series of proclamations, the Federal Government has initiated a national effort to register all rural lands. Similar proclamations are being introduced by the regional governments. In all of those there are references to data that must be collected on each holding, and therefore indirectly, beginning the discussion on appropriate surveying techniques. The following are a few key sections from the 2005 federal proclamation.

According to the "Federal Democratic Republic of Ethiopia rural Land Administration and Use Proclamation" (Proclamation No. 456/2005):

> Whereas it had become necessary to establish an information database that enables to identify the size, direction and use rights of the different types of land holdings in the country such as individual and federal and region states holding;
>
> - Part One, Section One, Item 16/ "land information system" means a system whereby rural land related information is gathered, analyzed and distributed to users;
> - Part Two, Section 6, Item 3/ any holder of rural land shall be given holding certificate … that indicates size of the land, land use type and cover, level of fertility and borders…
> - Part Two, Section 6, Item 5/ the information that describes the holder of rural lands, the holders of the bordering lands, the types of use …. shall be registered in the database and kept by the competent authority.

As with any national land registration effort, the number of rural households in Ethiopia to be registered is daunting, with the estimate ranging from 10 to 13 million made up of somewhere between 30 and 50 million parcels. Four regions have begun the effort with the assistance of projects supported by various donors and government institutions (e.g., USAID, SIDA, Ministry of Agriculture and Rural Development). Similar urban cadastre projects are underway in Addis Ababa and the other urban centers.

4. Land information systems, SDI, and tying it all together

The cadastral survey, although an important national dataset, is not in and of itself adequate to be used as the national land information system (LIS) or land information management system (LIMS). The traditional LIS is built upon all of the spatial and other data necessary to describe or manage the nation's lands. The cadastral survey often benefits from the LIS, as often does the LIS from the cadastral. But it needs to be made clear that one does not fulfill the needs of the other. Some countries are suggesting that African LIS, especially in communal or traditional lands, should move forward without any dependence on the cadastral, since so few of the countries in Africa have comprehensive cadastral mapping (Fourie and Nino-Fluck 2000; Augustinus 2003).

A way of addressing the country's spatial data needs (including LIMS, cadastral, resource management maps, census, etc.) is to establish a set of national standards for spatial data known as the National Spatial Data Infrastructure (NSDI) or simply SDI. The effort to standardize spatial data between countries is called the Global Spatial Data Infrastructure (GSDI).

Examples of African countries integrating their SDI and LIS include Kenya, Ghana, Mozambique, Tanzania, and South Africa. Other examples of African countries recently active in SDI, though not necessarily in LIS include Botswana, Burkina Faso, Cape Verde, Malawi, Mali, Nigeria, Rwanda, Senegal, Sudan and Swaziland.

During the 1999 Centre of Development Information (CODI) meeting in Addis Ababa at the UNECA, there were discussions involving countries using cadastral information for generating land information. It was generally agreed that less than 1% of the land in sub-Saharan Africa has cadastral coverage, but that the use of GIS was beginning to change that. The SDI and LIS concepts have been stressed by several organizations including CODI and emphasized in a subsequent meeting in Kenya in 2001. "It was decided that Africa would create its own agenda and not try to follow the steps taken in the developed world where the cadastre had to come first and spatial information second" (Augustinus 2003).

Uganda's strategic action plan requires a LIS/GIS and a LIMS for both cadastral and non-cadastral parcels as a foundation data in the same land record system, based on the 1998 Land Law. South Africa also has a fully fledged SDI, which uses cadastral data as its foundation data, but like Uganda, recognizes that it must accommodate non-cadastral spatial information in the same system (Augustinus 2003).

Ethiopia is active in SDI with an eye towards a more comprehensive national LIS. It has representation in the Centre of Development Information meetings, and both the Central Statistics Authority and the Ethiopian Mapping Agency are active in the international community's Mapping Task Force. The Ethiopian Environmental Protection Agency is developing an Ethiopia Environmental Information Node (Ethio-EIN) as part of the African-EIN and will contribute greatly in moving forward the concepts of LIS and SDI

5. Discussion

Controversies abound when discussing how best to conduct cadastral surveys in developing countries. Despite widespread use of classic surveying techniques employed in developing countries, there are a number of voices questioning these practices. Some examples include the following statements:

- **"**In the short term, some land-registration problems can be solved without land survey. Where there is good monumentation of parcels, an effective land—parcel referencing system, and a static environment, then simple adjudication to determine who owns each parcel may be sufficient to guarantee title and provide security for the landowners" (UN HABITAT 1990).

- "Existing models for defining the extents or locations of land parcels often have significant shortcomings when applied to the needs of developing countries. … The goal of this work is to provide very fast and inexpensive procedures that define parcel boundaries in a legal and highly determinative manner but leave determination of spatially precise locations of those boundaries to a later time if and when desired by the parcel owner. … Thus the precise locations of the physical corners and exact lengths of boundaries would not need to be determined during the initial registration process if it was inconvenient or uneconomical at that time to do so" (Onsrud, Hodson and Gartrell 1998).

- The result of cadastral standards from colonial past has "been the requirement of unrealistically high accuracy level, the cost of which has taken cadastral surveying out of the reach of, particularly, the poorer sectors of the population" (Barnes, Eckl and Chaplin 1996).

- "Surveying and mapping procedures typically consume a majority of project budgets, so the need for cost-efficiency is particularly acute here. …One widely recognized hindrance to surveying and mapping cost reduction is an unnecessary insistence on high precision work even in circumstances where much lower levels would satisfy titling requirements" (Onsrud, Hodson and Gartrell 1998)

- Cadastral surveying and mapping generally require a sizable portion of the budget of land-related projects. In Trinidad, it cost $250 million for 450,000 parcels. "Clearly faster and less costly alternative surveying and mapping methodologies must be developed, particularly for large numbers (hundreds of thousands) of parcels" (Barnes, Eckl and Chaplin 1996).

- "In the past, the cadastral surveying profession has based accuracy standards more on what available equipment could deliver, than on accuracy required for end use…In developing countries a high tech approach is often not the most appropriate solution to cadastral and other problems. A high tech approach often requires skills, infrastructure, and a legal framework that are inadequate or unavailable" (Barnes, Eckl and Chaplin 1996).

- "Inappropriate technology and procedures, especially the promotion that GIS technology is a panacea for all cadastral problems. This includes issues of cost, maintenance, education and training. The reality is that many of the systems appropriate to developed western countries are neither appropriate nor can they be afforded by developing countries "(Williamson 1994).

- "In the technical environment, there are two main sets of issues – data acquisition, including field survey, and data and record management. Underlying the approach to each must be an acceptance of risk. Too much time and money is currently spent on precise survey in an attempt to prevent problems in the future" (UN HABITAT 1990).

- "High standards do not necessarily require high levels of precision in survey management. ...The challenge is to encourage a realistic assessment of what is necessary and sufficient rather than what is technically the best" (UN HABITAT 1990).

- "Better to start 'quick and dirty' and develop successfully into 'sophisticated' over the years, than to start 'sophisticated' and fail" (van der Molen 2002).

These statements emphasize the dilemma faced by developing countries. Do they undertake what is considered a classic and accepted national cadastral survey using the technologies of the day as defined by developed countries or the surveying profession from within their own boundaries? Is that level of sophistication (read accuracy) necessary, or even feasible? Can the high level of accuracy be maintained when updating the cadastre in cases of subsequent divisions? Or, should a less sophisticated, perhaps more "appropriate" methodology be used, knowing that there are the resources both financial and infrastructural to support it, and with the knowledge that they can move into more sophisticated methods as circumstances permit.

Osterberg (2001) notes that a number of cadastral efforts in several African countries have been introduced mainly through colonial administrations and served the purpose of securing tenure for settlers in and European law tradition, contrary to the African traditional law and tenure system. They have generally not been very successful. The failures have been blamed on several factors, including:

- Technical issues, for instance, too high demands on accurate cadastral surveys, which are too costly to be financed through income generated from the ongoing land use;
- Lack of well-trained staff to carry out the services;
- Lack of modern equipment like total stations, EDM, GPS for cadastral surveying and computers for land registration;
- Lack of financial resources for investments in improved and expanded systems;
- Lack of co-ordination and co-operation between different governmental departments.

There is a wide range of circumstances under which choices of surveying methodologies need to be decided. The list of possible methodologies (see section 2) should be evaluated using a set of criteria relevant to the project or the country as a whole. Those criteria might include:

Accuracy:
- How close is close enough - the purpose of the system?
- What does the farmer need? What do administrators need?

Technical Capacity:
- Existing technical pool - farmers, administrators, technicians / surveyors
- Access to skill base. Availability of skilled staff on an ongoing basis
- Access to required equipment.

Training / Education:
- Can you train non-technicians the requisite skills?
- Can training/education be in a "workshop" format rather than a degree program?
- Are sufficient short-term or degree programs available in-country?

Feasibility:

Physical -
- Terrain,
- Access (i.e., the logistics required for a mission using chosen surveying / data collection methods).

Political/Cultural:

- Lack of co-ordination and cooperation between different governmental departments,
- Customary tenure.

Cost:

Initial implementation -

- Equipment, data,
- Labor,
- Logistics.

Updating (maintenance and sustainability) -

- Transfer, division, or aggregation of parcels,
- Upgrading systems,
- Replacing equipment, training new staff.

In a yet-to-be released study conducted by the Ethiopian Mapping Agency, methodologies were compared using a slightly different set of criteria:

- *Cost*: refers to the costs incurred on technical equipment, manpower, supplies, etc., in producing the parcel map using each methodology;
- *Time/Speed*: refers to the survey time consumed by each methodology;
- *Appropriateness*: refers to whether a particular methodology is within the reach of the local (woreda level) capacity (e.g., manpower, skill, and equipment);
- *Flexibility in field operations*: refers to a methodology's simplicity in data collection and processing

6. Summary

In Africa we see there is a wide range in the technical requirements of the methodologies available for cadastral surveying. Similarly, there is a set of criteria that are relevant for determining the choice of one or more of those methodologies to meet a developing country's cadastral surveying needs. This paper does not attempt to make specific recommendations in terms of methodologies, but rather emphasizes that those choices must be made for each specific situation using those criteria. It also emphasizes several related points, including:

- Implementation of a lower-level technology does not preclude moving into more sophisticated methods as the situation demands and resources permit;
- Use of as many different approaches within an administrative area as circumstances require is more likely to provide the desired results than use of a single methodology;
- Too many attempts at land registration have failed because of the inability to maintain the cadastral system(s) over the long-term. A government should not undertake a cadastral survey methodology that cannot be supported either financially or institutionally.

Finally, the paper attempts to convey the idea that has been found in country after country which is that it is better to start with a lower-level technology and upgrade as required than to start with an overly high-tech approach and fail. The trust in government that is lost in these failures can often never be recovered.

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