First experiences with High Resolution Imagery Based Adjudication Approach for Social Tenure Domain Model in Ethiopia

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Key words: land administration registration, adjudication, high resolution imagery, STDM

SUMMARY

Since the start of the 21st century, great progress has been made with rural land certification in Ethiopia. This process, however, has been mainly confined to the so called first phase certificates. These certificates do identify the land holding households (with name etc. and photographs), but limit the geo-referencing to indicating the size (acreage, often only estimated) and listing the names of neighboring households. As a rule the data is also only kept as paper records at one or more levels of local government.

To be able to profit from all the benefits land administration can bring, it will also be necessary to collect graphical and/or geometrical data on the spatial units to which the land holders have their (eternal) use rights. After the adding of such spatial plans, some speak of second phase certificates, although very few of these have been actually issued till date.

In a number of places, with support from different donors (SIDA, USAID), the regional land administration authorities have piloted with using GPS and GIS to collect and process boundary surveys.

In July 2008 a team (partly overlapping with the authors), did a first simple field test with the use of high resolution imagery as base for data collection – this second phase certificate can be combined with a first phase certificate in practice. This limited data set was processed at the ITC in the Netherlands with ArcGIS software, and has been re-processed later - for test purposes - with the first prototype of the Social Tenure Domain Model (STDM). The STDM prototype will be available as a Free/Libre/Open Source Sofware and the intension is to use this software for an extensive field test in Ethiopia in 2009. This implies a digital version of the geometric data will be available – which can be related to alpha numerical data.

This paper describes the experiences during the above mentioned field test and gives some recommendations for ways forward.

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1. INTRODUCTION

Since the start of the 21st century great progress has been made with rural land certification in Ethiopia. For the rural areas several Ethiopian states have introduced land administration systems that aim at issuing land use certificates for all (sedentary) farmers in that state at an affordable cost. Unlike many of such initiatives in other countries, the implementation of this has really caught on in Ethiopia and by 2005 data had been collected on about six Million households, of which about half have actually received their 'first phase' certificates. These certificates do identify the land holders (with name etc. and photographs), but are weak on the description of the land plots, which neither include a map, nor any kind of spatial reference (save a list of neighboring landholders), and only give a roughly measured or estimated indication of the acreage.

In order to gain the benefits that land administration can bring, it is also necessary to collect graphical and/or geometrical data on the spatial units to which the land holders have their (eternal) use rights. After the adding of such spatial plans, some speak of second phase certificates, although very few of these have been actually issued till date. In practice it is possible to combine first and second phase, although very few of these have been actually issued till date.

The fact that it is covering large areas (and soon all rural landholdings in several states) makes it possible to have a real effect on the way land is administered and managed in those states. This differs from the 'advanced' cadastral and registry approaches that even after many years often only extend to certain pockets of a territory. For details on the procedures applied and the effects see e.g. Deininger et al 2006 and Deininger et al 2008.

In a number of places, with support from different donors (SIDA, USAID), the regional land administration authorities have piloted with using GPS and GIS to collect and process boundary surveys. In July 2008 a team (partly overlapping with the authors), did a first simple field test with the use of high resolution satellite imagery as base for data collection. This limited data set was later processed at the ITC in the Netherlands with ArcGIS software, and has been re-processed with the first prototype of the Social Tenure Domain Model (STDM).

The Social Tenure Domain Model (STDM) is a pro-poor land administration tool intended to cover land administration in a broad sense, including administrative and spatial components. Traditional/conventional land administration systems relate names/addresses of persons to land parcels (or spatial units) via rights. In the STDM, an alternative option for this is to relate a personal identifier such as fingerprints to a coordinate point inside the land in use by that person, via a social tenure relation. Depending on the local conditions, there can be a variety of social tenure relationship types and other rights. The STDM thus provides an *extensible* basis for an efficient and effective system of land rights recording. The STDM is to be seen as a specialization of the Land Administration Domain Model (formerly known as the Core Cadastral Domain Model) of the International Federation of Surveyors (FIG). See Augustinus et al (2006) and Lemmen et al (2007). The STDM prototype is available for testing since the beginning of 2009 and the prototype is planned to be tested in a World Bank preparatory activity in Ethiopia, in the context of rural land administration. This prototype will be available as Free/Libre/Open Source Software. Further testing of the prototype, e.g. is area's with informal settlements will be scheduled.

The field tests of July 2008 in Ethiopia, the processing of the data collected and the development of the prototype for STDM are described in the next sections. Recommendations for ways forward are also given.

2. DATA COLLECTION

2.1 Acquiring Imagery

The idea to use satellite imagery for cadastral applications is not new: Kansu and Sezgin 2006; Konstantinos 2006; Paudyal and Subedi 2005; Tuladhar 2005; Ondulo and Kalande 2006. Only of late are images available with resolutions that make them useful for standard size land parcels (spatial units). Use for large pastoral ranges, forest reserves etc. has been much longer possible. A quick scan led to the conclusion that it would be possible to acquire satellite images for a number of kebelles (lowest level of local government) in four different regions from Quickbird at 60 cm resolution which were nearly cloud free. We chose for the true color, with pansharpening.

Taken the size of the data set (as well as the costs), it was important to acquire only the area needed. Digital contours of the kebbelles (villages) were obtained from the Central Statistic Agency of Ethiopia (CSA) and could be used to select and order the required areas at Digital Globe. This still amounted to 5,8 Gb of data. The base price was obtained at 17 USD per sqkm, and the original choice led us to acquire 26+32+39+61 sqkm.

Overview plots of each region were made and used to define the exact test area, making sure a mix of terrain and land use modalities were incorporated. For a part of the kebelles large scale plots (1:2000) were made, covering 1 by 1 km (and some adjacent area).

2.2 Informing local communities

The local communities were informed in advance about the data collection exercise, and individual right holders as well as community representatives were available on site. The approach on collecting boundary data using enlarged high resolution satellite images can therefore be seen as participative.

2.3 Field work

Fieldwork was carried out in June 21 to July 5. On-site were performed on the potential to use satellite imagery to establish parcel index maps in selected villages using Quickbird images.

Extracts representing a size of 1 x 1 km in the field were plotted on a 1:2000 scale - on quality paper as a basis for field data collection. The 1 x 1 km square was drawn on the paper plot, the real represented area on the paper plot was bigger – to allow drawing of boundaries of parcels (spatial units of lands in use by persons).

Figure 1: Quickbird Image - fragment

Local woreda (2nd level of local government) staff accompanied the team members to different locations (Hanigodu, Megelta and Alengu) to aid with data collection. Land users in the field were invited to identify the boundaries of the land in use in the field and on the paper plots. Land owners, neighbors and village representatives participated in boundary identification.

The boundaries of spatial units were drawn on the plots by pen. Additional information collected included the name of the user of the parcel (or spatial unit), the certificate id, the area and the names of land users (neighbours) to the north, east, south and west. This additional information was to be used as administrative data, and were written on (non standardised) papers. Different methods were used for the identification of spatial units and for linking between the identified spatial units on the plot

- by writing the name of the name land user; this name was used as a link to the administrative data,
- by plot id ad give on the certificate, and:

- by co-ordinate id - combined with co-ordinate list. Co-ordinate id concern GPS co-ordinates collected with hand held GPS devices.

Local woreda staff took over the fieldwork activities in one of the teams after about an hour. It was very evident that most people/participants very quickly understood the images. They recognized where they were and even noticed changes between the present field situation and those at the time the images were made. A clear example was when looking for a small, irrigated plot in Tigray, that trees were counted, and people started to laugh when one had been chopped in the mean time. Similarly a number of water storage facilities which was black (full) on the image, were now empty.

Although people had been asked to be present with their certificates during the informing of the local communities, many of them did not show a certificate to us. Some said they did not have one, or that it was in an office for updating. Others mentioned that the family member who holds it was presently not living on the land, etc.

Figure 2: "General Boundaries" Easy to identify on the enlarged Satellite Image

In some area's the boundaries were easy to recognise on the enlarged plots – this type of boundaries appeared as paths – and looked like ”general boundaries”. In other area's the boundaries were more difficult to identify – it looked as if some boundaries ”moved” compared to the situation on the image – creative ways to plough may be the reason here.

Figure 3: "Moving Boundaries....."

2.4 Combining with GPS

The images have not been related to Ground Control Points. This implies that the absolute accuracy is (according to the provider of the images, Digital Globe) up to 14 meters horizontal accuracy (root mean squared error) and 23 meters vertical. Ortho-rectification will improve this, but for "absolute pixel accuracy" the Ground Control Points are needed. A small sample ortho-rectified afterwards, showed differences of -20 meter on mountain and +40m in valley. The NASA Shuttle Radar Topographic Mission (SRTM) was used for as a Digital Elevation Model for this (90 m). See: http://srtm.csi.cgiar.org/

3. DATA PROCESSING

Processing of the data involved, scanning; geo-referencing; digitizing; and feeding the fieldwork attribute data to the digitized parcels.

3.1 Scanning

The resultant 6 analogue images, each containing the identified boundaries and parcel-identifiers were scanned using cougar 36 scanner with 300dpi resolution, as a first step in transforming the field information in to a digital environment. Scanning resulted in 6 raster data sets in .JPEG format. Necessary corrections such as rotations were carried out in order to ease the following processes. Figure 6 is one of the six raster data (.JPEG files) obtained after scanning the field images.

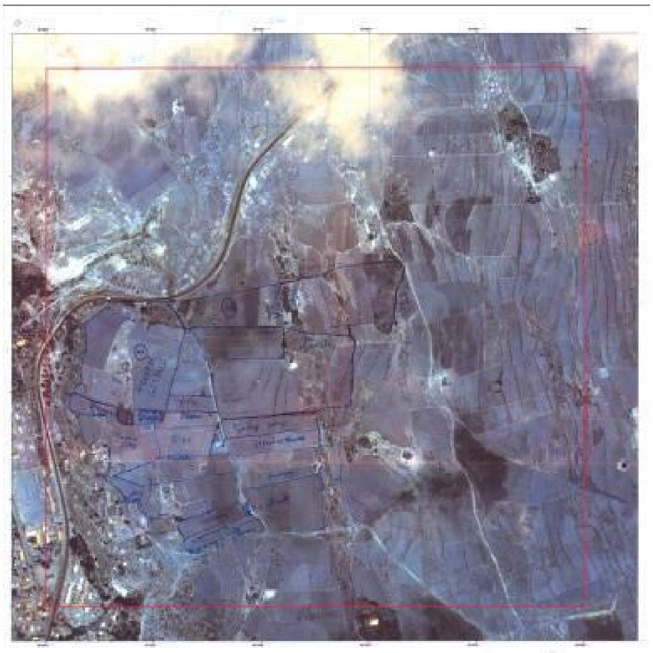

Figure 4: Raster data of Hanigodu-Megelta with parcel boundaries, identifiers and names of parcel owners

3.2 Georeferencing

The 6 raster data sets contain undefined spatial reference. Spatial reference was defined by importing the coordinate system and projection of the original image. After defining the reference system, geo-referencing was then performed through identification and matching the coordinates of the new images (these were marked at the edges of each scanned image) within original image. Control points such as road intersections, and other identifiable features were also used. Figures 7 and 8 show an overlay of the scanned and geo-referenced photo-images against the original image.

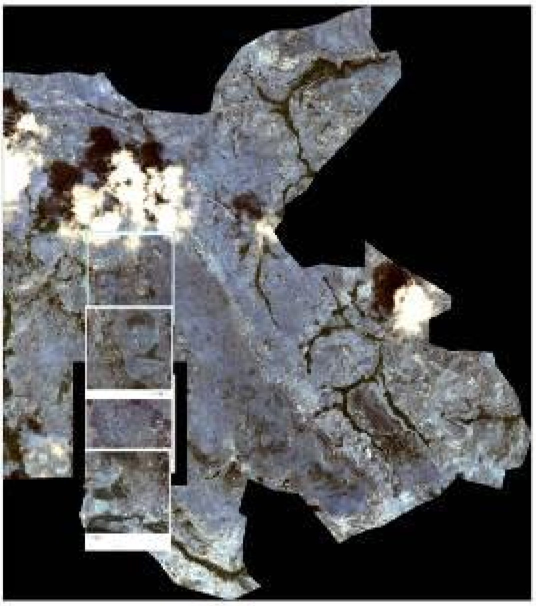

Figure 5: Georeferenced images from Hanigodu-Megelta overlaid on original aerial photo

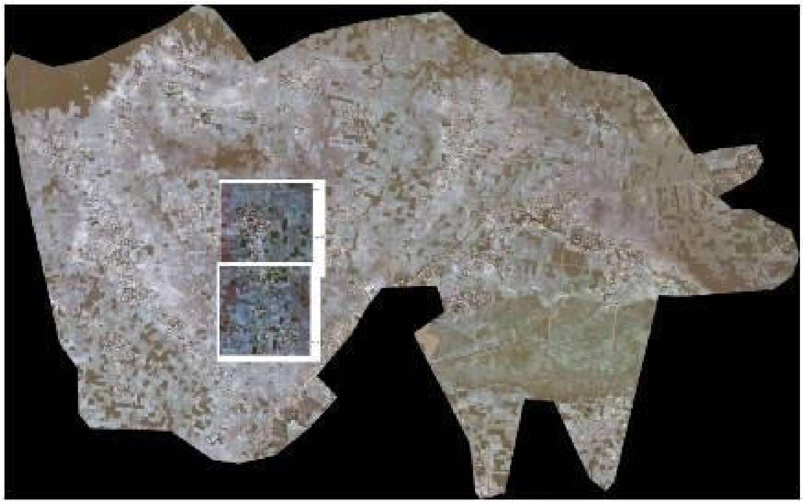

Figure 6: Georeferenced images from Alengu overlaid on original aerial photo

3.3 Digitising

Once the images were geo-referenced, on-screen digitizing was performed in ArcGIS. Parcel boundaries were extracted by pointing and tracing the cursor along parcel boundaries. Each parcel was created as a closed polygon. The polygons do not share boundaries with neighboring parcels, therefore independently identifiable. The digitizing process tried as accurately as possible to avoid overlaps between boundaries, especially where parcels boarder each other. See Figures 9 and 10. Resultant features were parcel boundaries in shape file format. Two shape files were created: from Hanigodu-Migelta, and other from Alengu.

Figure 7: Digitized parcels shown in red lines in ArcGIS

3.4 Linking field (administrative) data to spatial units in ArcGIS

A database containing administrative data about attributes of the parcels was created in Microsoft Excels and was exported and joined with the attribute table of the parcels shape files.

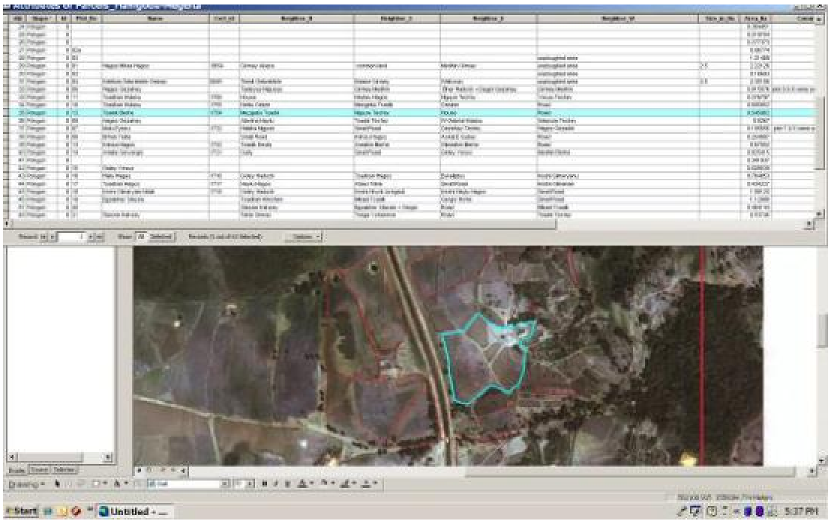

Figure 8: Attributes of the parcels are linked to parcels

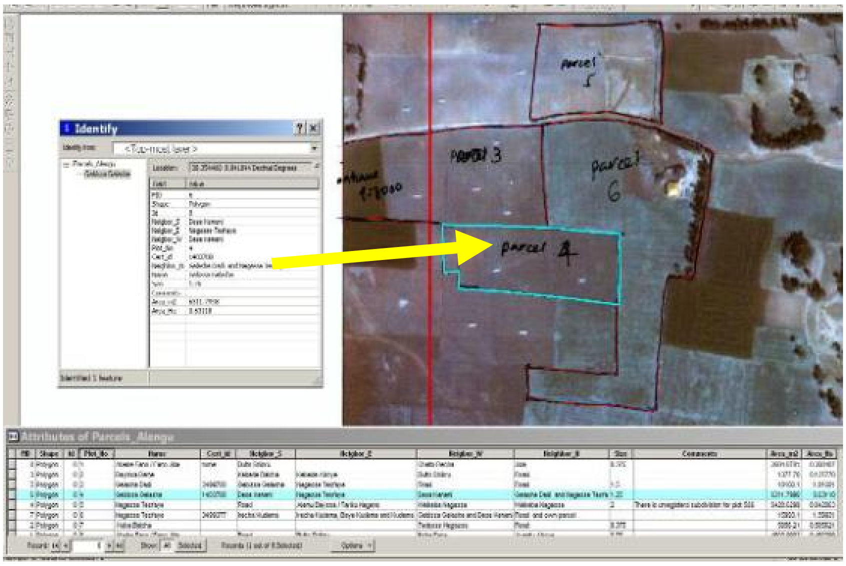

Figure 9: Parcels and attributes identified using 'identify' icon in ArcGIS

The results were that parcels (geometric data) now also contained administrative records, i.e. the names of user of the parcels, their certificate id's, the area and the names of land users (neighbours) to the north, east, south and west. This information has successfully been linked to STDM for the purpose of testing, and the first version of the prototype already available for testing in the field.

3.5 Using GPS positions to ground truth parcel information

GPS points consisting of survey points from edges of various parcels from the field were uploaded and superimposed on the shape files. They were examined for mismatches between the GPS positions and corresponding parcels (see figure 12 and 13)

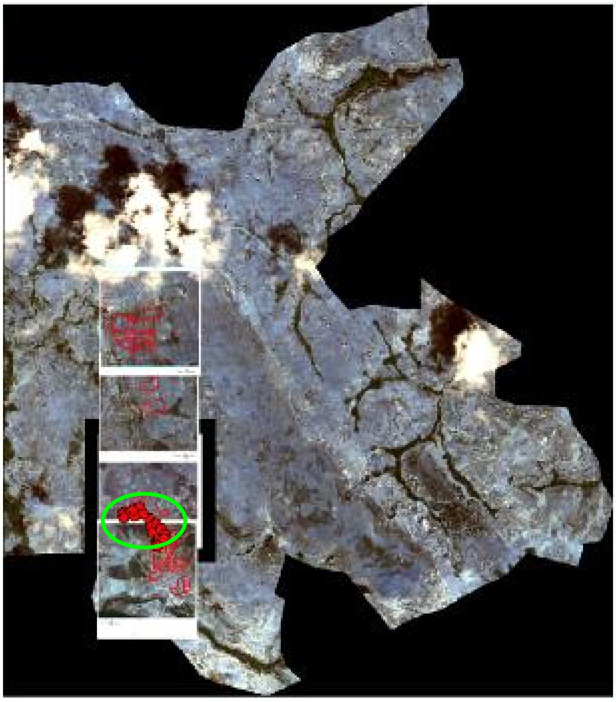

Figure 10: GPS positions overlaid to image

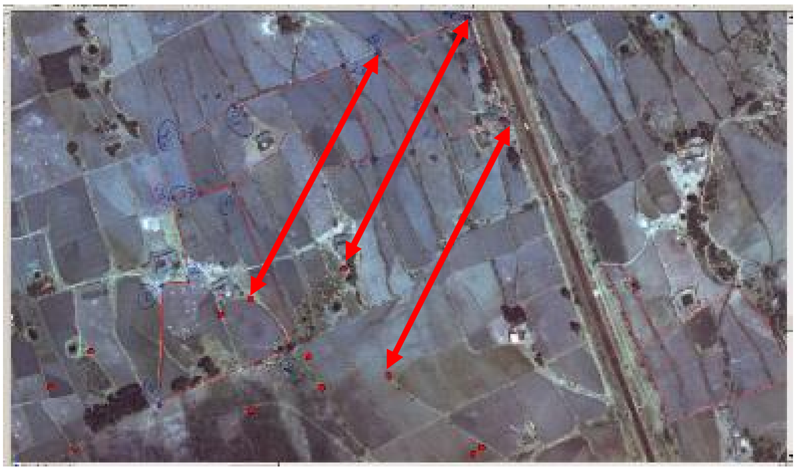

Figure 11: Offset of GPS positions from parcel about 200m

It was observed that the:

- GPS positions displayed with both vertical and horizontal offset,
- vertical offsets were greater than the horizontal offsets, and:
- parallel diagonal offset is of about 200m.

These offsets are likely caused by the fact that the images were not ortho-rectified and by errors introduced during scanning and geo-referencing processes (see figures 5, 6 and 12), or relief distortion resulting from the differences in elevation of the aerial images and the GPS observations (see also paragraph 2.4).

Figure 12: Scanned and original image

4. THE SOCIAL TENURE DOMAIN MODEL

The Social Tenure Domain Model (STDM) is a multi-partner software development initiative to support pro-poor land administration. The initiative is based on open source software development principles. The STDM, as it stands, has the capacity to broaden the scope of land administration by providing a land information management framework that would integrate formal, informal, and customary land systems and integrating administrative and spatial components. The STDM makes this possible through tools that facilitate recording all forms of land rights, all types of rights holders and all kinds land and property objects / spatial units regardless of the level of formality.

Not only with regard to formality does the thinking behind the STDM depart in terms of going beyond some established conventions. Traditional or conventional land administration systems, for example, relate names or addresses of persons to land parcels via rights. An alternative option being provided by STDM, on the other hand, relates personal identifiers such as fingerprints to a coordinate point inside a plot of land through a social tenure relation such as tenancy. The STDM thus provides an ***extensible*** basis for efficient and effective system of land rights recording. The STDM is a specialization of the Land Administration Domain Model (LADM), previously known as Core Cadastral Domain Model, which is a similar effort initiated by the International Federation of Surveyors (FIG).

4.1 People – Land Relationship

The Social Tenure Domain Model (STDM) describes relationships between people and land in unconventional manner in that it tackles land administration needs in hitherto neglected communities such as people in informal settlements and customary areas. It supports development and maintenance of records in areas where regular or formal registration of land rights is not the rule. It focuses on land and property rights, which are neither registered nor registerable, as well as overlapping claims, that may have to be adjudicated both in terms of the 'who', the 'where' and the 'what right'. In other words, the emphasis is on social tenure relationships as embedded in the continuum of land rights concept promoted by GLTN and UN-HABITAT. This means informal rights such as occupancy, adverse possession, tenancy, use rights (this can be formal as well), etc or customary rights, indigenous tenure, etc as well as the formal ones are recognized and supported (with regard to information management) in STDM enabled land administration system. Likewise, the STDM accommodates a range of spatial units ('where', e.g. a piece of land which can be represented as one point – inside a polygon, a set of lines, as a polygon with low/high accuracy coordinates, as a 3D volume, etc.). Similarly, the STDM records all types of right holders ('who', e.g., individuals, couples, groups with defined and non-defined membership, group of groups, company, municipality, government department, etc.).

In regard to evidence, STDM handles the impreciseness and possible ambiguities that may arise in the description of land rights. In a nutshell, the STDM addresses information related components of land administration in an innovative way.

4.2 Data Acquisition

In STDM enabled land administration, data coming from diversified sources is supported based on local needs and capabilities. This pertains to both spatial and administrative (non-spatial) data. For example, it may be, in informal settlements, sufficient as a start to relate people-land relationships to a single point. Then attributes such as photographs and fingerprints can be attached to the records. In a central business district (CBD) of a city, a traditional cadastral map/register may be required while in a residential area, land administration needs may entail using a map derived from satellite images and combined with formal descriptions of rights and right holders. The STDM encourages and caters for all these variations.

High resolution satellite image is one of the emerging and a very promising source of spatial data for land administration. A large-scale plot of such images can be used to identify land over which certain rights are exercised by the people themselves, i.e., in a participatory manner.

4.3 Standardization

FIG has submitted the Land Administration Domain Model (LADM) to the International Standardization Organization (ISO) Technical Committee 211 (geomatics group) with a view to making the model a descriptive global standard. The STDM, as a specialization of the LADM, is integrated in this standardization exercise.

4.4 STDM Prototype

The STDM development activity has thus far generated conceptual, functional and technical designs and software development, starting with a prototype and testing this through a pilot project in a country which has slums, customary tenure, overlapping claims and non-polygon spatial units, etc. The prototype is under development at the International Institute for Geo-Information Science and Earth Observation (ITC) in close co-operation with Global Land Tool Network / UN-HABITAT and the International Federation of Surveyors (FIG). The World Bank led pre-project (preparatory) activity in Ethiopia is creating opportunities to test the prototype in the context of rural land administration.

The STDM under development covers the information-related components of Land Administration. The STDM software is based on Integrated Land and Water Information System (ILWIS) and PostgreSQL. ILWIS is a PC-based GIS & Remote Sensing software, developed by ITC up to its last release (version 3.3) in 2005. Since July 1st, 2007, ILWIS software is freely available ('as-is' and free of charge) as open source software (binaries and source code) under the 52°North initiative (GPL license). This software version is called

ILWIS 3.4 Open. PostgreSQL is a very powerful, open source object-relational database system. Figure 1 presents the STDM main window.

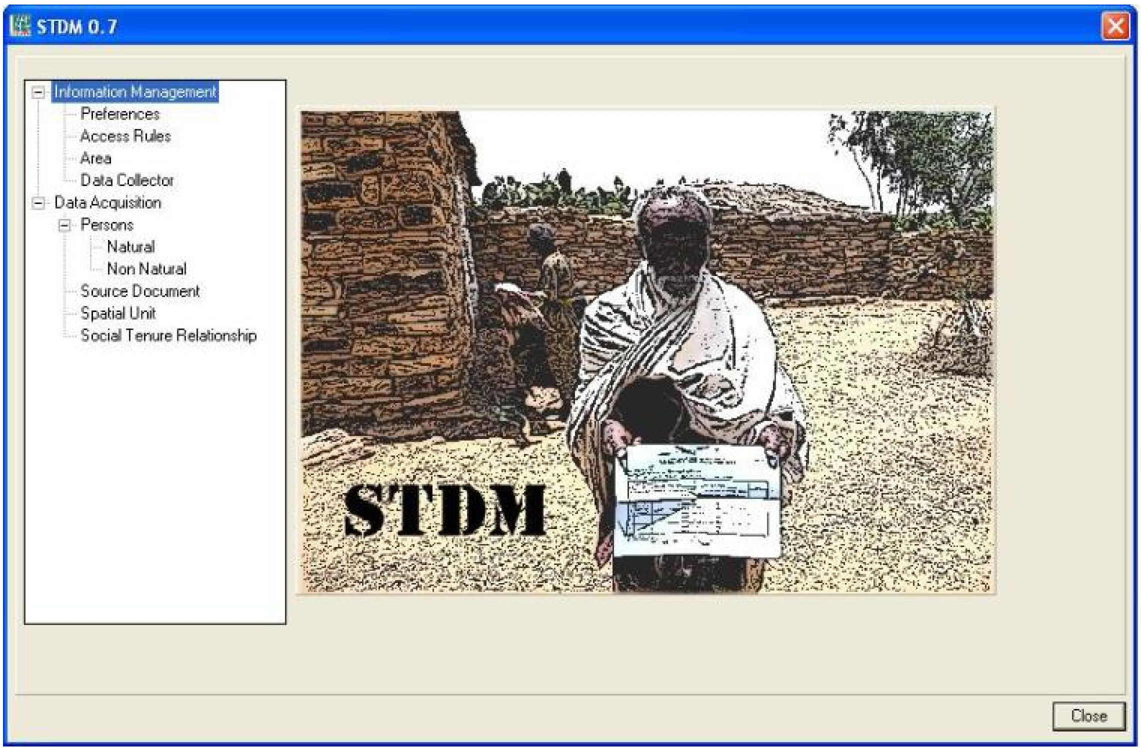

Figure 13: STDM Main Window

The data collected in July 2008 have been inserted to ArcGIS and have been re-processed in the STDM prototype in the beginning of 2009 – for internal testing. The testing will be continued as an extensive field test in the first half year of 2009 in Ethiopia. A combined collection of spatial and administrative data is possible.

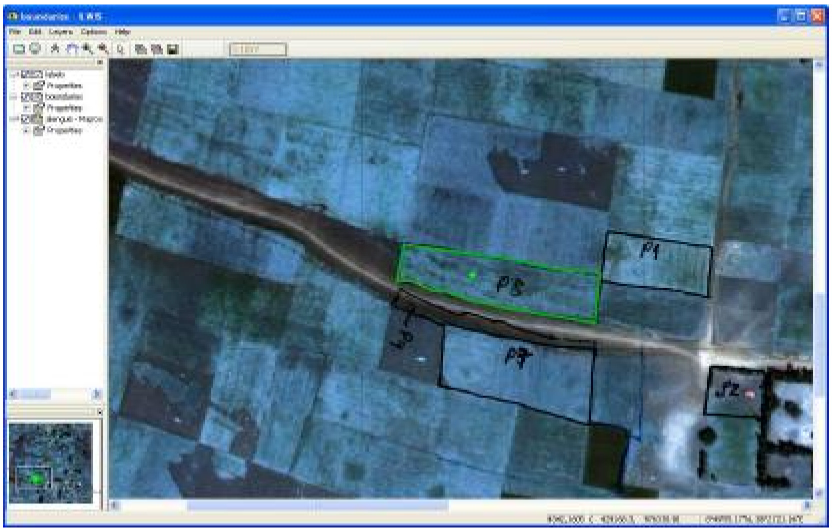

Figure 14: Presentation of parcels - shown in green lines in ILWIS /Postgres based STDM

It is intended that the STDM prototype will be available as an Free/Libre/Open Source pro-poor land tool after the testing and upgrading of the software in the first half of 2009. The prototyping is the process of quickly putting together a working model (a prototype) in order to test various aspects of a design, illustrate ideas or features, and gather early user feedback. Prototyping is often treated as an integral part of the system design process, where it is believed to reduce project risk and cost. Often one or more prototypes are made in a process of iterative and incremental development where each prototype is influenced by the performance of previous designs, in this way problems or deficiencies in design can be corrected. When the prototype is sufficiently refined and meets the functionality, robustness, manufacturability and other design goals, the product is ready for production. In the functional design in relation to the prototype development the same iterative approach will be used: the design can be made more detailed and detailed during this process.

5. LESSONS LEARNT AND FUTURE ACTION

From this exercise the following can be learned:

- People can read the images easily. Almost without exception the local people could easily recognise the area and building where they are living and using the land on the paper plot. For the data collectors it was easy to observe agreement on the location of the boundaries of land in use. In some cases when neighbours were not on site it was observed that persons tend to claim extra. An alternative approach may be to bring a Personal Digital Assistant (PDA) to the field and to present the satellite image on a screen. This implies that the screen data must be readable in case of sunshine. But costs could be saved in plotting and scanning and by directly vectorising on site. But such approach may not have the same perception of collecting evidence from the field.

- The approach is a participatory approach. The paper plots are *attractive*, people are surprised by what they see and recognise. The paper plot is something "to sit around and to work with"; for sure also for illiterate people. The same may be valid for an alternative setting where a village community is invited to identify boundaries in a room where the satellite image is projected on a wall. But this is not a real evidence from the field – where you have to walk around the land in use.
- Boundaries can be identified on the satellite images easily *in most cases;* especially when small paths are in use to access the lands – in fact a type of general boundary. Sometimes people even demarcate the boundaries. But this is not always the case; in some area's the boundaries are "flexible" and moving during the seasons. Clear differences between the boundaries observed on the images and the field situation have been observed in case of such "flexible boundaries". It has to be stated that easiness to identify boundaries on the satellite image may depend on the weather conditions during the date of observation from the satellite. Of course there should be no clouds and images made during rainy season may be not so clear for being used in this application.
- The data are available in a homogeneous reference framework – the accuracy may not be comparable to conventional systems in e.g Europe. The approach allows for reconstruction of individual points within a certain standard deviation in case of boundary disputes later in time.
- It is easy to get lost in some field environments: GPS *for orientation* may be a requirement – to be investigated.
- Checking administrative data costs relatively a lot of time. It can be stated that the collected administrative data during the field work are incomplete and contain many errors, especially where the names of persons are concerned. The same names are collected several times – data duplication and interpretation errors are there: the same names appear in different spellings.
- It has to be said that in some cases the ink disappeared from the image. A good pen is a must
- For a comprehensive test the following issues are relevant:
    - paper type (costs and volume in large scale applications)
    - paper size (e.g. A3); overlap is presented area's on paper
    - ink to draw boundaries - in relation to weather conditions
    - thickness and colour of the pen (to draw straight lines on the image using a thin pen point)
    - possible impact for archiving - scanning the images of the images and the vectorising the collected spatial data in post processing
    - symbiology in drawing (e.g. to mark a line as deleted)
    - general approach in identifying objects: use lines around the parcel, this means no individual points_ids. Name of the user directly drawn on the image? Or a temporal plot_id (related to the data collector)? I prefer the last.

- in short: a more systematic approach - but we are aware of that of course, and much can be learnt from earlier work with aerial photographs

The first version of the STDM which will be under testing in field circumstances includes the following basic functionality to support data acquisition as a result of this learning experience:

- Generate and plot satellite images for field work
- Generate forms for field work
- Allow overlapping claims and tenures
- GPS data input
- Scan images
- Vectorise
- Process overlapping claims
- Proces overlapping tenure
- Link spatial and administrative data
- Holdings – groups of Parcels
- Manage history
- Support the maintenance processes (1st trial)
- Source documents
- Identify data collectors

It can be expected that further developments are needed**:** when building the second version of the prototype: STDM 2.0**.**

The Ethiopia data acquisition experience as foreseen in the first half year of 2009 will bring requirements for further developments.

One requirement could be the use of Personal Digital Assistants with built in GPS and camera. A wide range of devices is available. PDAs will be very supportive, e.g. in case of image based evidence finding data collection in the field. Supportive in navigation (to walk to the spot) and in orientation (to be sure that you really are at the identified vertex of a spatial unit). And in taking photographs with a GPS co-ordinate linked. Most relevant in relation to this are the knowledge and correct application of co-ordinate systems and transformations. Transmission of collected data to other data collectors in the neighborhood. As already stated above it is good to mention that in combination with the PDA method, a ***conventional paper-based procedure is done in parallel***, in order to fall back onto in case of technical problems and also for redundancy and legal purposes. Note: The camera does not necessarily have to be in one device with the GPS. The photographs can be geo-referenced in post-processing based on timestamps registered in both devices.

Then the different data acquisition methods for spatial data collection for land administration can be compared on criteria as: cost effectiveness, options for participatory approaches, level of training required, pro poor support etc. See also Palm, 2006.

ACKNOWLEDGEMENTS

The financial support of Sweden and Norway, GLTN's donors, is gratefully acknowledged as a decisive input that has made possible the development of STDM.

This work would not have been possible without the contribution and support of Dr Clarissa Augustinus, Dr Solomon Haille and Ulrik Westman from UN Habitat, Nairobi, Kenya; Gerard Reinink, Chris Paresi, Martin Schouwenburg (STDM Team) and Paul Schoonackers from the International Institute for Geo-Information Science and Earth Observation, ITC, Enschede, The Netherlands and Mrs Liliana Alvares from Kadaster International, Apeldoorn, The Netherlands (STDM Team).

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BIOGRAPHICAL NOTES

Tony Burns - as founding and Managing Director for Land Equity International, Mr Burns has over ten years involvement at management levels on multilateral financed land administration, tilting and policy projects. He is the Team Leader for the Governance in Land Administration study (Oct 2007-Nov 2008). He has over 20 years experience in land management and natural resource projects covering the full project cycle, and is an expert in project design, land policy review, evaluation of cadastral survey and mapping procedures, land titling, land administration and spatial information systems. Mr Burns also has interest and experience in management of change, performance auditing and assessment of project implementation against objectives and milestones. Mr Burns recently authored a World Bank, Agriculture and Rural Development Discussion Paper on "Land Administration Reform: Indicators of Success and Future Challenges".

Klaus Deininger -, is a Lead Economist in the rural development group of the Development Economics Group. His areas of research focus on income and asset inequality and its relationship to poverty reduction and growth; access to land, land markets and land reform and their impact on household welfare and agricultural productivity; land tenure and its impact on investment, including environmental sustainability: and capacity building (including the use of quantitative and qualitative methods) for policy analysis and evaluation, mainly in the Africa, Central America, and East Asia Regions. He is a German national with a Ph.D. in Applied Economics from the University of Minnesota, an MA in Agricultural Economics from the University of Berlin, and an MA in theology from the University of Bonn, Germany.

Christiaan Lemmen holds a degree in geodesy of the University of Delft, The Netherlands. He is an assistant professor at the International Institute of Geo-Information Science and Earth Observation ITC and an international consultant at Kadaster International, the International Department of the Netherlands Cadastre, Land Registry and Mapping Agency. He is vice chair of the Working Group on Pro Poor Land Management of FIG Commission 7, 'Cadastre and Land Mangement', contributing editor of GIM International and guest editor on Cadastral Systems for the International Journal on Computers, Environment and Urban Systems(CEUS). He is secretary of the FIG International Bureau of Land Records and CadastreOICRF.

Monica Lengoiboni is a PhD Candidate (period 2007 through 2010) at School of Land Administration Studies at the Institute of Geo-Information Science and Earth Observation (ITC), in Netherlands. Her research focuses on pastoralism as a 'migratory land use in time and space'. By studying spatio temporal land uses and interactions between pastoralist and non-pastoralist land use actors, her research assesses how pastoral land use could be supported in Land Administration systems (adjudication, survey, registration and land information management) by instituting spatio temporal land rights. She holds an MSc. degree in Geo-Information Science (Wageningen University, Netherlands), and worked at the Kadaster International (at Netherlands' Cadastre, Land Registry and Mapping Agency in the Netherlands). Prior to these, Lengoiboni worked with worked with pastoralist communities in Northern Kenya.

Jaap Zevenbergen is professor in land administration systems at the department of Urban and Region Planning and Geoinformation Management at ITC, Enschede, as well as associate professor at the section Geo information and Land Development of the OTB Research Institute for Housing, Urban and Mobility Studies of the Delft University of Technology. He holds Master degrees in geodetic engineering and law and defended his PhD on systems of land registration in 2002. He has published several articles and numerous papers about land administration and land registration. He has studied numerous systems of land registration, both as a researcher and as a consultant, the most recent being Ethiopia, Croatia, Indonesia (Aceh) and Suriname.

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