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Addis Ababa: The Road Map to Progress through Securing Property Rights with Real Property Registration System

by

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Summary:
In September 2009 the Addis Ababa City Government called for tenders for the development of a new real property registration system and a new land information (cadastre) system. Development in the city, the redevelopment of slum areas, investment in building and infrastructure and the organisation of services was being hindered by the lack of up-to-date, accurate and reliable cadastre. The city additionally requested the implementation of a new street addressing system and the updating of existing cadastral map data. The new systems were viewed as pilots which could be ported over the entire country. Since the Addis Ababa project was to form the basis for a national solution, the transfer of knowledge and expertise to employees within Addis Ababa governmental agencies was considered vital. In addition it was considered essential that local people maintained ownership of the project throughout its development and implementation. Hansa Luftbild, a German based, geo-information and mapping company, with extensive international experience acquired the project and worked closely with the local administration to implement it. This paper gives an overview of the establishing of the new real property and cadastre system, the new addressing system, the updating of the cadastral map and the support, training and consultancy services provided by the company.

Introduction

Addis Ababa, capital of Ethiopia, has witnessed rapid urban expansion over the last 20 years. This has put pressure on the city's land resources leading to increasing areas of slum settlement. The Addis Ababa City Government (AACG) has recently instigated programs for the redevelopment of slum settlements and the development of new housing areas, both of which require reliable and consistent systems of real property rights and ownership.

Land is a major resource essential to the future development of Addis Ababa. Enhancing the optimal utilization and administration of this resource is a fundamental factor in the development and furtherance of good governance. To this end Addis Ababa City Administration (AACA) is committed to securing and clarifying land and property rights and promoting land transaction processes through registration. These aims will primarily be achieved by updating the city's cadastral map and by building a geo-database system.

In 1996 the AACA implemented a cadastral project to register all property owners so that valuation and taxes could be applied to properties. A multi-purpose cadastre was established and data collected to support urban planning, land and property transfers, issuing of building permits and title deeds, as well as implementing compensation payments. Over time insufficient integration between the various land information systems and inefficient updating mechanisms led to a significant erosion of the cadastral map's reliability. This led to widespread informal property settlements, land encroachment, inadequately secured land records and a general mistrust in official land transaction processes.

To alleviate these problems, in 2009, the AACG made a decision to develop and implement a new integrated land information system based on information communications technology (ICT). The primary purpose of the system was to establish real property registrations and a land cadastre system able to support land registration processes and municipal functions. The system's services were to be made available to both governmental and official bodies. In addition the system was intended to be part of a complete municipal information solution.

The implementation of such a system would ensure efficiency, scalability, security and integrity with the AACA's existing and future systems requirements including secured data storage, a retrieval and dissemination mechanism and connectivity in the form of an efficient interface for information access and analysis from remote locations.

On taking this decision the AACG called for tenders from international experts who could help in the process. This paper describes the processes involved in updating the AACA's existing cadastral map data, the development and implementation of a new real property registration system and a new land information system, and the establishment of a street addressing system.

Previous Situation

Up until implementation of the current project Addis Ababa operated an increasingly unreliable manual real property registration system. The cadastre map which was used was an extract of parcels and buildings from a 1996 topographic map prepared for the design of the water supply system. It did not cover the entire city and hadn't been updated since 1996. The parcels and the buildings were not identified by a consistent and unique numbering system thus the links between the registry information and the parcels were unreliable. The street addressing system was not well designed and only partially implemented throughout the city. This also adversely affected the provision of reliable municipal services. Moreover, the registration processes were carried out by a sub-section of an authority, and simultaneous update of the cadastre was not carried out.

Until recently the land and land related administration sector (LLRAS) of the city of Addis Ababa was organised into three authorities / offices. This has now been increased to four. Figure 1 shows this sector and its previous organisation.

The three-authority structure of the land and land related administration sector (LLRAS) of Addis Ababa was organized into a Permit Authority, Renewal Project Office and Information Institute, as illustrated in Figure 1. Exactly the same administrative configuration is also set up for the ten sub-cities of Addis Ababa and the 116 districts within Addis Ababa known as Woredas.

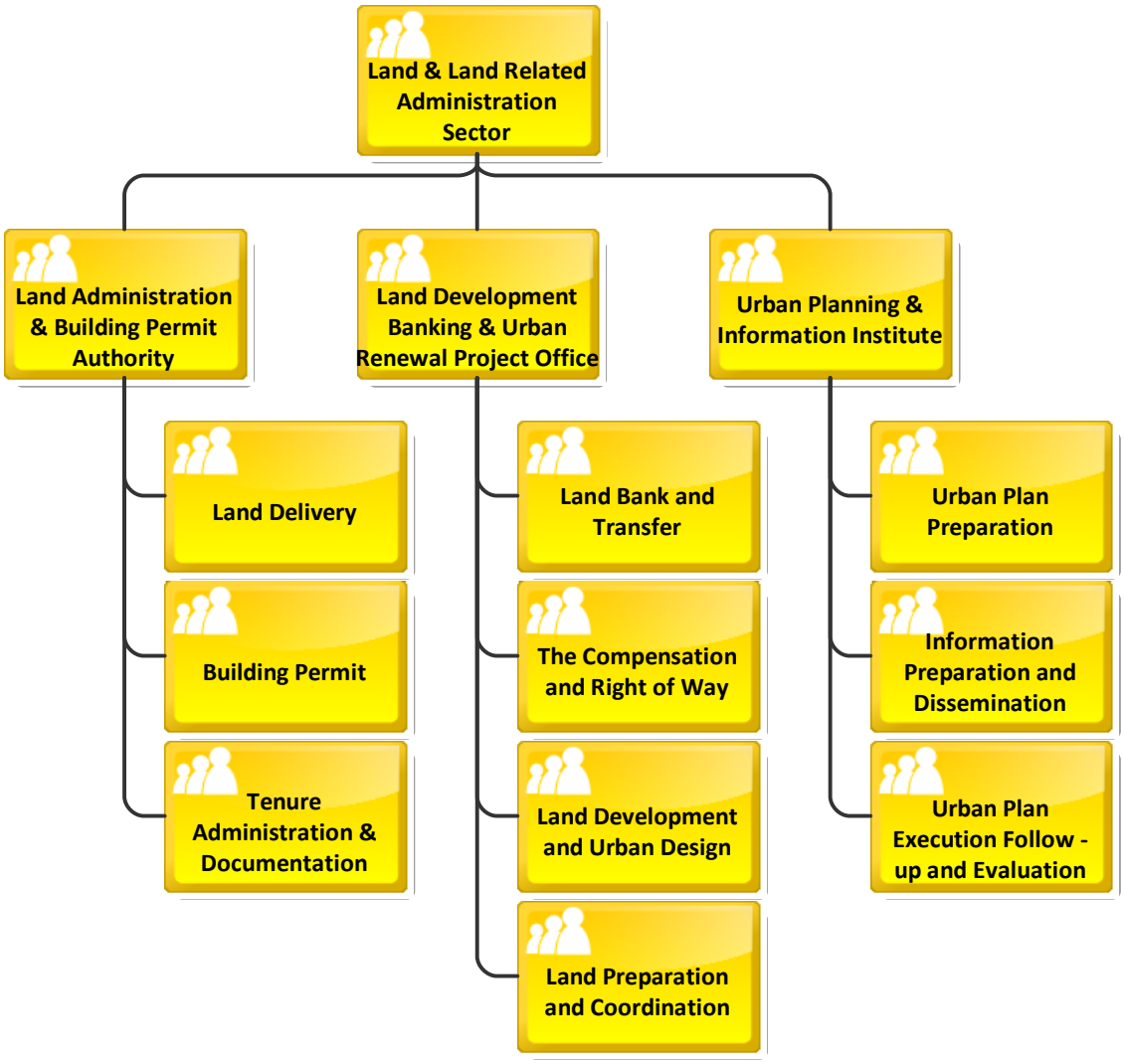
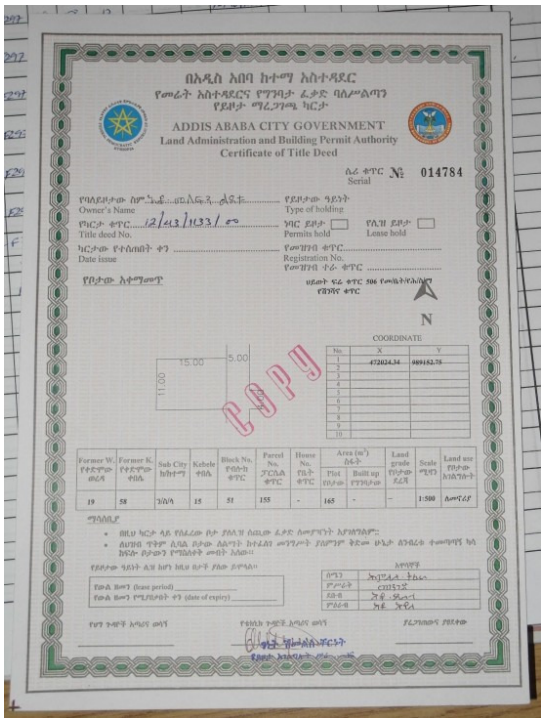


Figure 1: Previously implemented organisational structure of the LLRAS (Source: AACA and Hansa Luftbild, 2010)

The real property registration was carried out by the land administration and building permit authority (LABPA) and was based on title deeds registered in several books which provided an official record of the rights on land. Figure 2 shows a sample of an existing title deed.



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ADDIS ABABA CITY GOVERNMENT
Land Administration and Building Permit Authority
Certificate of Title Deed

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Figure 2: Sample of an existing title deed (Source: AACA, 2010)

In addition to the books there is a tenure archive containing all documents relating to a property. The archive is organized into folders. Each folder contains all documents related to a property, such as the title deed or related court injunctions. The tenure archive is indexed by sub-city, Woreda and house number. Most of the information occurs two to three times in the books. This handwritten form of registrations is prone to errors. Some intermittent, but generally unsystematic, cross checking of the written records is carried out.

For each of the sub-cities there are six (6) so called "Big Books" which are structured as follows:

- main book with the basic data (LABPA-01)
- book of title deed transactions (LABPA-02)
- book of mortgages (LABPA-03)
- book of court injunctions (LABPA-04)
- book of condominiums
- book of condominium bank loans

Figure 3 shows a photo of one of the books and Figure 4 shows a shelf containing some of the tenure archive folders.

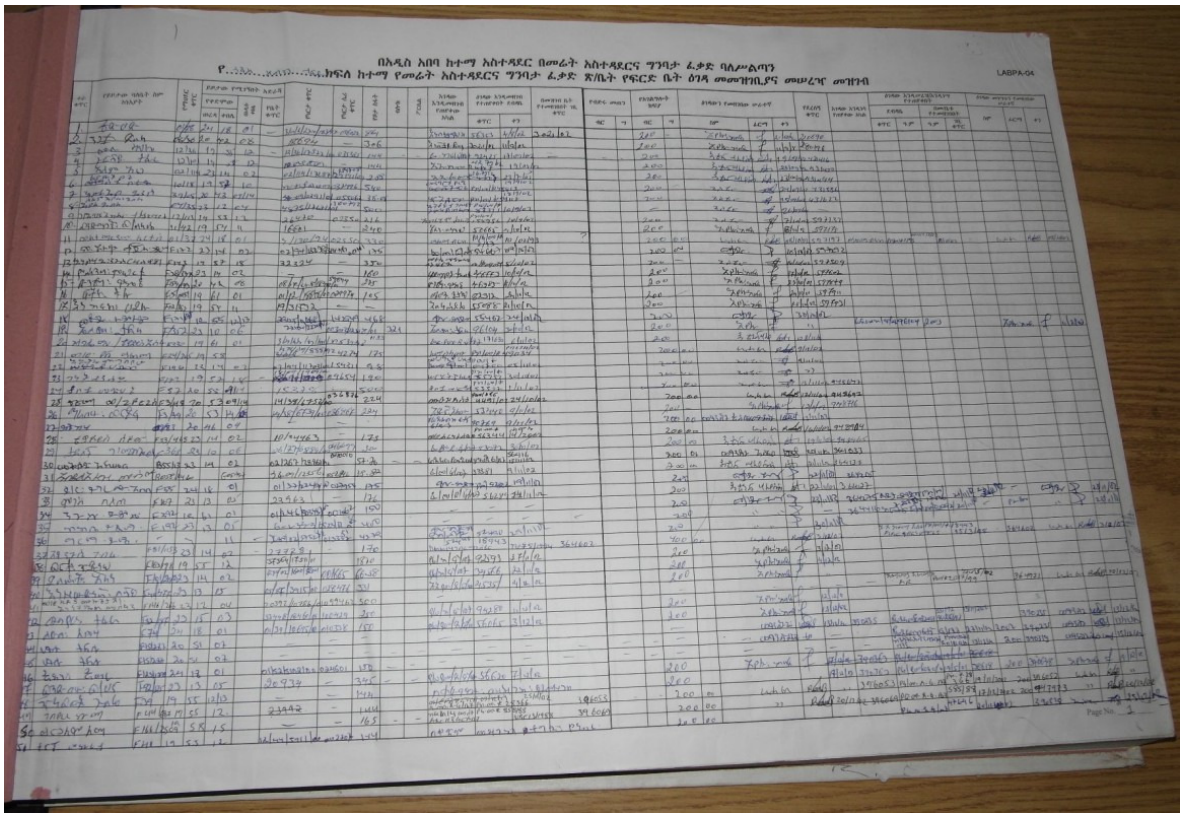

Figure 3: One of the books available for real property registration (Source: AACA, 2010)

Figure 4: Tenure archive in one of the sub-city registration offices (Source: AACA, 2010)

The inconsistencies and irregularities in the organization of the cadastre and its information were problematic. Manipulation of registration information, violation of planning and building regulations, overlapping allotment of land, missing of archive files, cumbersome technical and administrative processes were amongst some of the irregularities caused by weaknesses in the system. The system was not transparent and did not fulfill customer demand for reliable services and guarantee of land tenure. The city administration of Addis Ababa and/or the central government of Ethiopia realized that the system was hampering the development of the capital city and consequently the country at large.

In seeking to alleviate this situation the city administration identified key priorities for the facilitating of the development of new up-to-date, sustainable and reliable real property registration and land information (cadastre) systems. One of the key priorities was the setting up of an appropriate administrative framework, including the establishment of a new Immovable Property Registration and Information Agency (IPRIA) of Addis Ababa mandated to operate the registration and land information (cadastre) systems.

Project Objective and Aims

In September 2009 AACG called for tenders for the development of new real property registration and land information (cadastre) systems. The scope of work in the tender also included updating of existing cadastre map data, design and implementation of a street addressing system and support for the establishment of real property registration offices.

The objective of the project was to provide consultancy services and develop a cadastre (real property registration and land information) system for Addis Ababa City Administration (AACA) in Ethiopia. It was a two phase project with the following components:

Phase 1:

- updating cadastral map
- support for the establishment of municipal real property registration offices
- requirements analysis, design and specification of real property registration and land information (cadastre) systems
- development of addressing system

Phase 2:

- development and implementation of real property registration and land information (cadastre) systems
- support for the establishment of municipal real property registration offices

The consultancy services were to provide expert knowledge and advice for the setting up of cadastre offices as well as the update of existing cadastre maps. The development of the cadastre system included the implementation of a real property registration system as well as a land information system.

Hansa Luftbild an international geo-information and mapping company based in Germany tendered for, and won the project.

The **Integrated Land Management Information System Project Coordination Office** (ILMISPCO) at AACA had overall responsibility for implementation and management of the project. Other stakeholders or institutions involved were the Information Network Security Agency (INSA), the project supervisor, the Ethiopian Information Communication Technology Development Agency (EICTDA), the Ministry of Works and Urban Development and the Ethiopian Mapping Agency (EMA). These provided technical assistance and gave advisory support to the project office.

The respective roles and responsibilities of the ILMISPCO were the following:

- provision of office space and office equipment,
- assistance in arranging meetings/interviews with institutions/concerned bodies deemed relevant to the Hansa Luftbild's work,
- monitoring implementation of the system,
- timely feedback on implementation problems related to the whole project,
- follow-up and evaluation of the quality of the final output in collaboration with stakeholders,
- approval of payments to Hansa Luftbild as per the agreement,
- assignment of technical staff to facilitate the activities of Hansa Luftbild,
- follow-up and support as be necessary.

In detail the scope of the project included:

- update the cadastral (parcel, building, street, administrative divisions and topography) map of the city and development of cadastre database that can support municipal data needs;

- study, design, develop and implement a functional and reliable real property registration system and associated administrative organizations.

- study, design, develop and implement a functional and reliable land information (cadastre) system to support land administration and building permit issuance, land development and valuation, land use planning and taxation.

- propose, design and produce an international addressing system (including street coding and link with existing street names) to cover the city's administrative boundaries.

With its extensive experience in GIS and mapping, Hansa Luftbild fully understood the requirements of AACA and the approach needed to develop an integrated land information system. As well as utilizing in-house expertise the company drew on out-of-house expertise. Senior consultants, who had led the development of the German automated real property and cadastre system, were brought in to assist with the two phase project.

The systems developed were treated as pilot solutions which could be ported to all of Ethiopia. Such systems could also include an automated city administrative system, in essence an e-administration, and the core of a national spatial data infrastructure.

The project's successful implementation, the transfer of knowledge to local staff, the use of technological solutions tailored to the local situation, and the subsequent recognition of the utility of such a system will accelerate the demand for the porting of the system nationwide. A nationwide system is of critical importance to the future development of local and foreign investment in Ethiopia.

The two phases were carried out with complete and thorough ongoing consultations with the client. This was to ensure maximum contractor compliance with client specifications and to ensure complete client commitment to, and ownership of all phases of the project.

Project Approach and Methodology

Hansa Luftbild's methodology and approach followed international standards.

In order to develop and implement the new system, it was necessary to establish special working groups (WG). AACA gave Hansa Luftbild a list of local professionals. The list outlined the professionals' qualifications and fields of expertise and on this basis they were assigned to working groups. The working groups provided input to and support for Hansa Luftbild throughout the project duration. In addition Hansa Luftbild was able to transfer know-how to the local professionals within the working groups

The working groups were involved in the entire development and implementation process in order to guarantee continued sustainable use of the implemented systems following the completion of the contracted work.

Six working groups were established; one for each of the following:

1. updating of cadastral map data,
2. business processes of all cadastral duties,
3. development and implementation of addressing system,
4. real property registration,
5. land information system, and
6. definition of the objects catalogue required for the data model.

The following is a description of the role of each of the six working groups:

WG 1: Updating of Cadastral Map Data

- Role: support Hansa Luftbild mapping professionals during the production of the cadastre map with local knowledge during different aspects of the production process eg data content, data modeling, map layout, updating process.

- Composition: experts in the fields of cadastre, geodetic reference system, data modeling, and mapping

WG 2: Business Processes of all Cadastral Duties

- Role: support Hansa Luftbild cadastre consultants in elaborating the processes needed for collecting, storing, distributing, and using cadastre content.

- Composition: experts in the fields of cadastre management, modelling of cadastral data, cadastral measurement processes, distribution processes, and usage of cadastral information.

WG 3: Development and Implementation of Addressing System

- Role: co-operate with Hansa Luftbild consultants in the process of defining and determining the identification system; accompany the implementation of the addressing system.

- Composition: experts in the fields of addressing, data modeling, street mapping, installing the street signs.

WG 4: Real Property Registration

- Role: support Hansa Luftbild consultants in establishing the real property registration system and offices, in elaborating system / office functions, processes and links to other information systems, in specifying system / office data management, and in checking and developing the necessary legal framework.

- Composition: experts in the fields of public Ethiopian law, real property data modeling, management of real property in Addis Ababa, and use of real property information.

WG 5: Land Information System

- Role: support Hansa Luftbild consultants in re-organizing the cadastre offices, in specifying office data management, in elaborating office links to other information systems, and in checking and developing the necessary legal framework.

- Composition: experts in the fields of public Ethiopian law, land and property management, and usage of real property information.

WG 6: Object Catalogue

- Role: support Hansa Luftbild consultants in defining all real property, cadastre, and addressing objects to be integrated into a common object catalogue in accordance with international standards.

- Composition: experts in the fields of real property registration, cadastre, data modeling, and addressing.

The working groups were supervised by Hansa Luftbild.

Hansa Luftbild recommended assigning professionals to the working groups who would later fill analogous positions of responsibility at city or sub-city level.

The following paragraphs give detailed descriptions of the methodologies used for various components of the project.

Requirements Analysis and Specification and Design of Real Property Registration and Land Information (Cadastre) Systems

The objective of the requirements analysis for the real property registration and land information (cadastre) systems was to model real property registration processes, and the derivation of products and services from the database. The products and services were tailored according to the requirements of the public and private sectors.

Key input for the analysis was gained during visits to selected sub-cities and during thorough and ongoing discussions with the project working groups. Analysis was carried out within the framework of a business process model.

The Ethiopian constitution and law accords its citizens certain property rights. These rights were taken into account during the requirements analysis. The rights state:

- The right to own rural and urban land as well as natural resources belongs only to the state and the people. Land is an inalienable common property of the nation, nationalities and peoples of Ethiopia.
- The right of Ethiopian peasants to the free allotment of land and not to be evicted therefrom is guaranteed. Particulars for its implementation shall be determined by law.
- Without prejudice to the right of ownership of land by the nation, nationalities and peoples of Ethiopia, the state shall guarantee the right of private investors to the use of land upon payment of money, the amount of which is to be determined by law. Particulars shall be determined by law.
- Every Ethiopian shall have the full right to the immovable property he builds on the land and to the improvements he brings about on the land by his labour or capital. This right shall include the right to alienate, and where right of use expires, to remove his property, transfer his title, or claim compensation for it. Particulars shall be determined by law.
- Without prejudice to the right to private property, the state may expropriate private property for public use with the prior payment of adequate compensation.

The dynamic aspects of the real property registration system were described with use cases which detailed the business processes of the real property registration sector. In total 19 business' use cases were identified and detailed. These were:

- Building Mutation
- Cancellation Court Injunction
- Cancellation of Mortgage
- Capture of Newly Created Building
- Damaged Title Deed Replacement
- Insert Court Injunction
- Insert Mortgage
- Inserting Re-parcelled Renewal Area
- Lost Title Deed Replacement
- Maintaining Cornerstone
- Maintaining the Real Property Register
- Make a Cadastre and RPR Extract
- New Ownership Registration
- Parcel Border Mutation
- Parcel Merging
- Parcel Splitting
- Private Property Transfer
- Resolving of Border Dispute
- Voiding of a Building

The proposed systems were called Addis Ababa Cadastre Information System (AA-CADIS) and Addis Ababa Land Information System (AA-LIS).

The domain model of AA-CADIS described static aspects of the system, i.e. the data model of the system. It was developed with reference to international standards such as ISO/TC 211 standard No. 19152 the "Land Administration Domain Model (LADM)". The ISO conceptual model was used to develop a concrete feature catalogue for Addis Ababa. The data model for Addis Ababa consists of two parts, a real property registration database and a real estate cadastre database. The real property registration database is non spatial while the real estate cadastre database contains spatial data. These form the common cadastral database (CCDB) which constitutes the platform of AA-CADIS. Figure 5 shows the structure of AA_CADIS and AA-LIS.

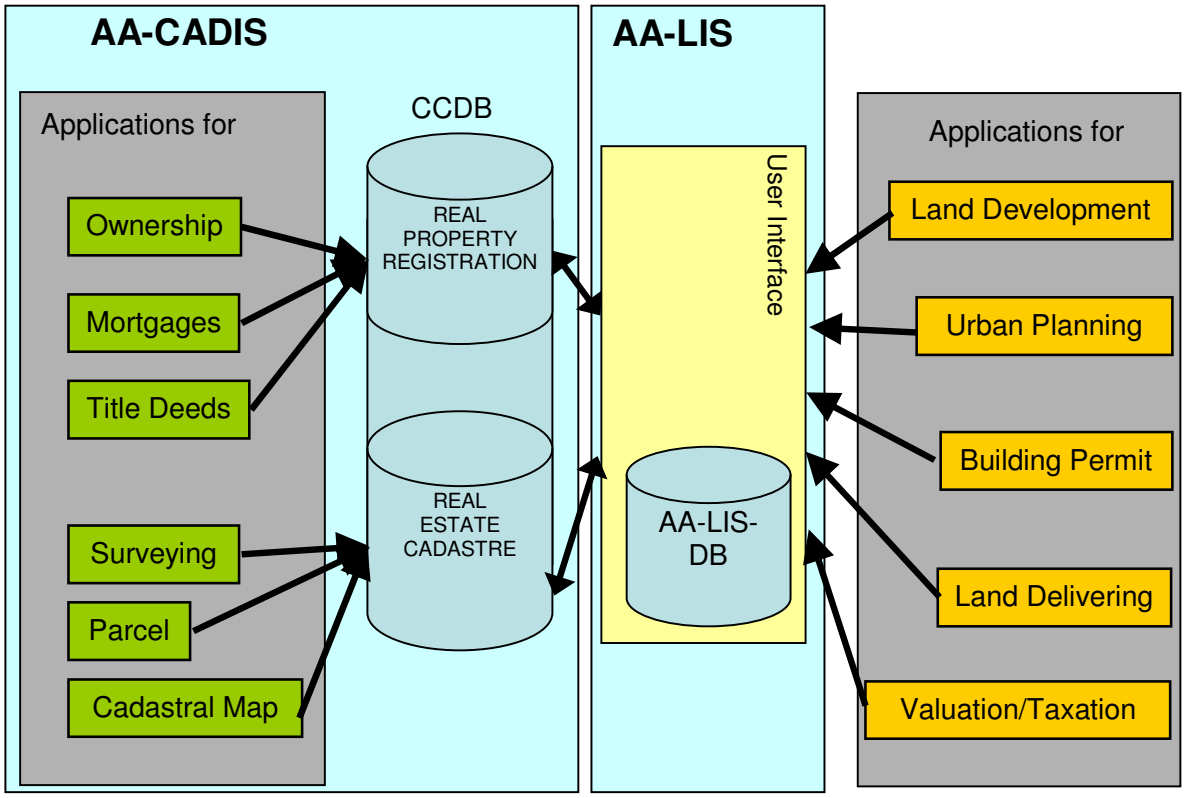

Figure 5: Structure of Addis Ababa cadastre information and land information systems (Source: Hansa Luftbild, 2010)

AA-CADIS covers the cadastre and real property processes. It serves for the administration and maintenance of real property and cadastral data and consists of two sub-systems:

- the real property registration system - RPRS, and
- the real estate cadastre system - RECS.

Both sub-systems are closely connected and operate on a common database to carry out the cadastre and real property business processes.

AA-CADIS consists of two database-based client-server applications for the RPRS and the RECS. The two applications fulfil distinct duties and functionalities in line with the fundamental software engineering principle of "separation of concerns".

Real property data, the core non-spatial data of AA-LIS, is maintained within the real property registration system. The system also has a paper based tenure archive. The archive, will for the present, stay in its current form, but may be transferred to digital format at a future date.

The real estate cadastre system will maintain and administer the cadastre map data and its descriptive information and is linked to the real property registration database. The system is the base of the spatial reference system of AA-LIS.

Figure 6 shows the organisation of AA-CADIS and its relationship to other land sectors of AACA.

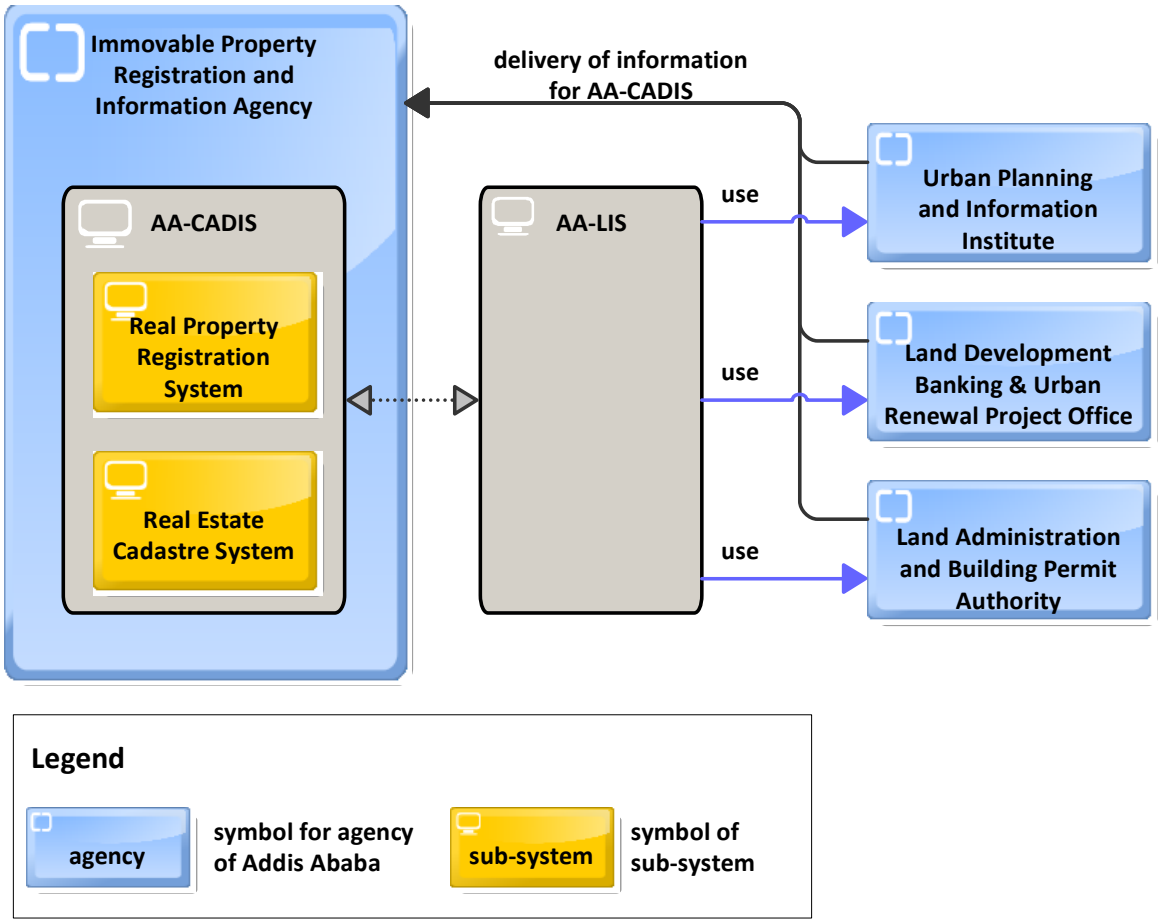

Figure 6: Organization of AA-CADIS (Source: Hansa Luftbild, 2011)

The system AA-LIS was developed to support and provide an interface to services used by public authorities and the private sector. AA-LIS is the responsibility of the real property registration agency (IPRIA) since the real property and cadastral related data from IPRIA form the core data of the AA-LIS DB.

The AA-CADIS CCDB is the production database and the AA-LIS DB is the publication database. The latter is a read only database and holds a replica of the AA-CADIS CCDB data. In addition digital orthophotos and land development plans are stored in AA-LIS.

Figure 7 shows the AA_LIS environment and user access paths.

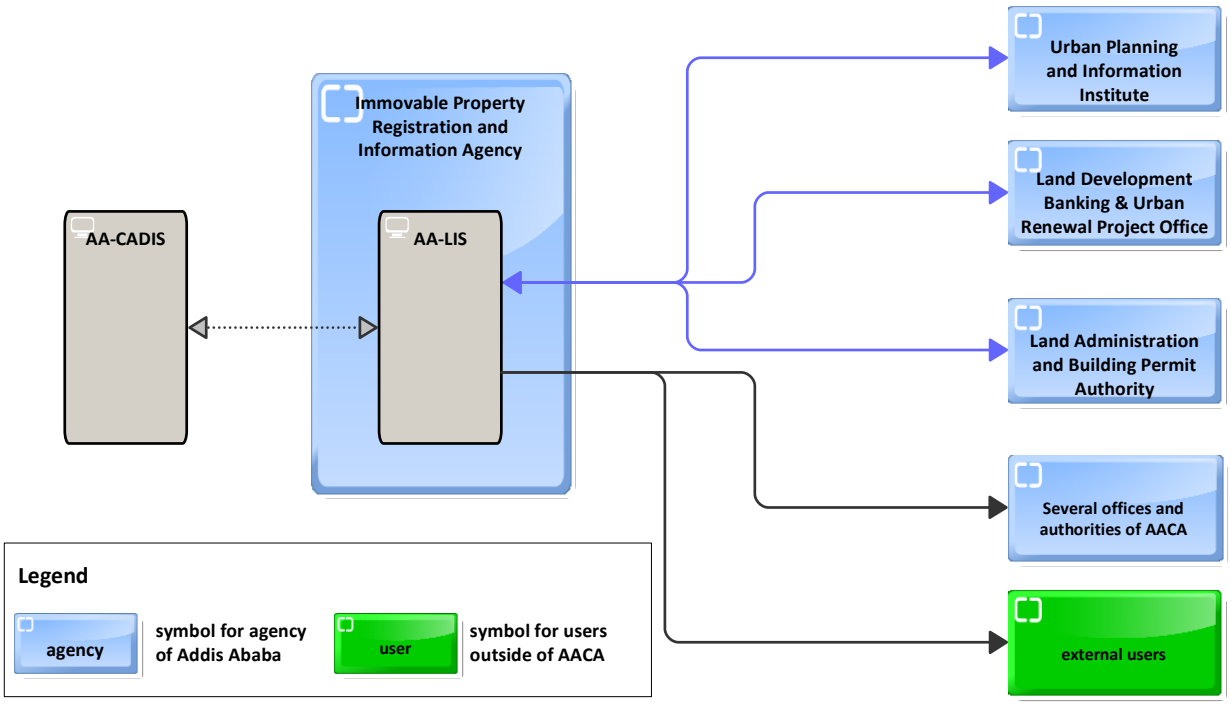

Figure 7 : Environment of AA-LIS (Source: Hansa Luftbild, 2011)

AA-LIS is implemented on the basis of Open Geospatial Consortium (OGC) web services standards, for example Web Map Service (WMS) and Web Feature Service (WFS). In addition other agencies or authorities can create their own web services or applications to extract or access AA-LIS data in support of their processes. AA-LIS also includes a Web Map Client which can be run in a web browser.

Figure 8 shows the overview of the AA-LIS infrastructure based on the OGC standards.

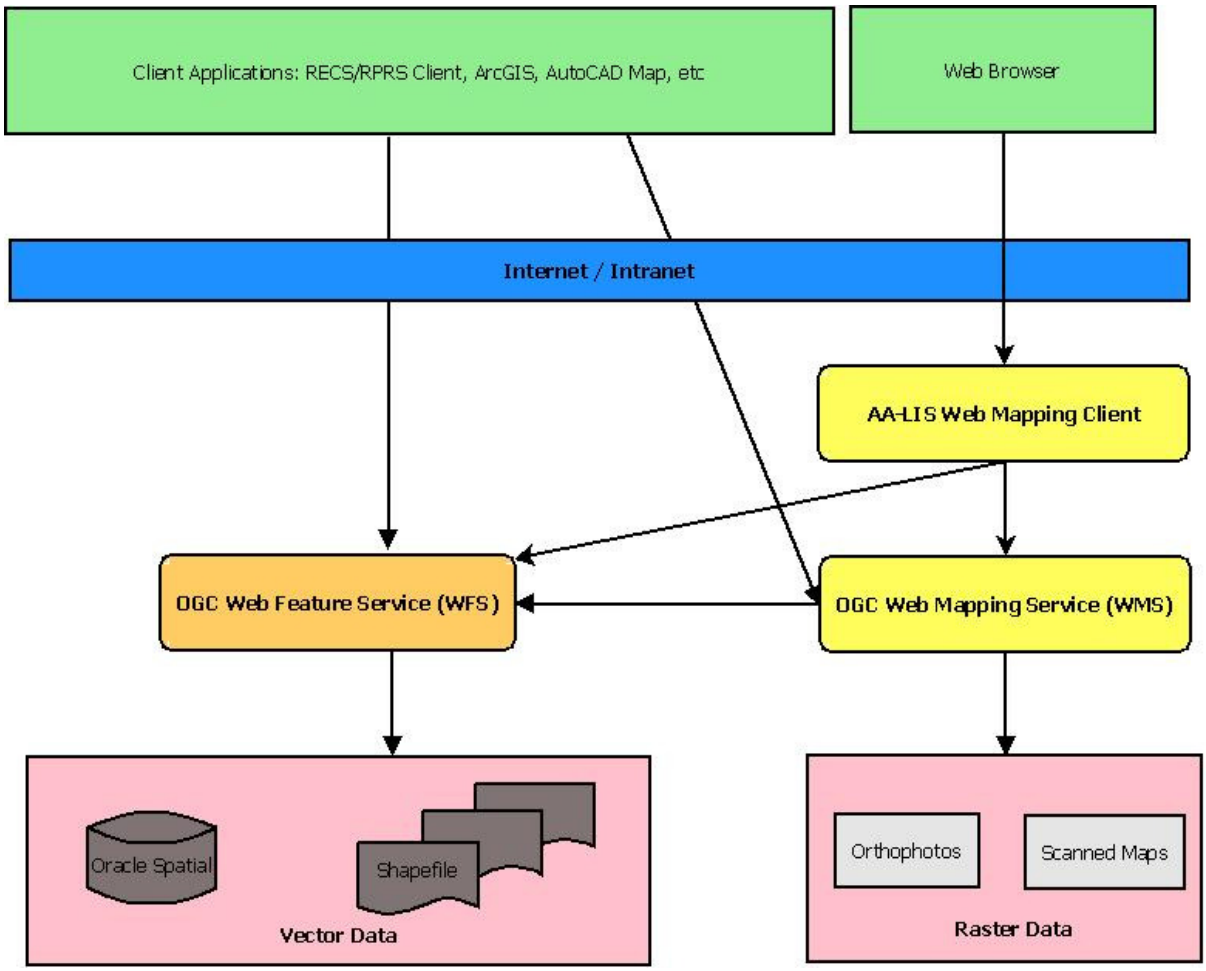

Figure 8: Overview of AA-LIS Infrastructure based on OGC standards (Source: Hansa Luftbild, 2011)

The architecture of AA-CADIS and AA-LIS consists of six major technical components as shown in Figure 9.

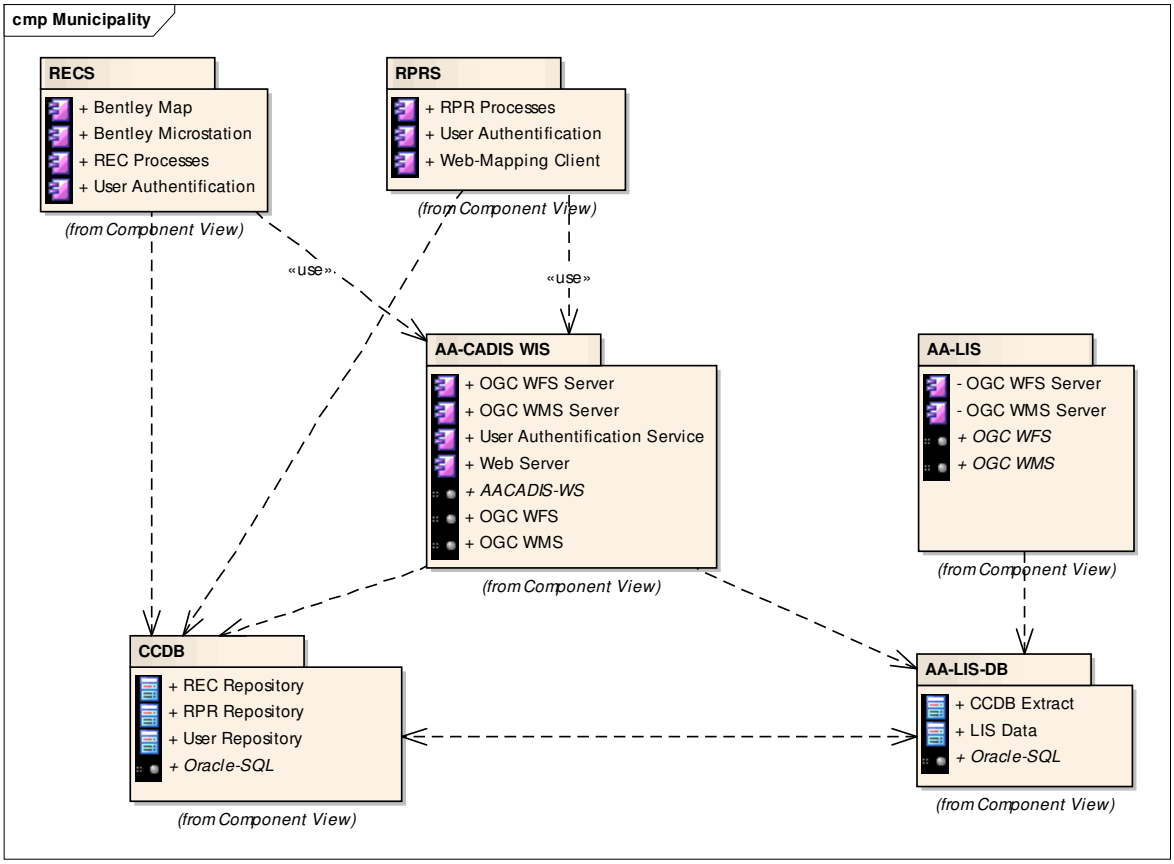

Figure 9: Overview of the AA-CADIS and AA-LIS architectures (Source: Hansa Luftbild, 2011)

Updating Cadastral Map Data

The updating of the cadastral maps was divided into 3 tasks, as shown in **Chart 1.**

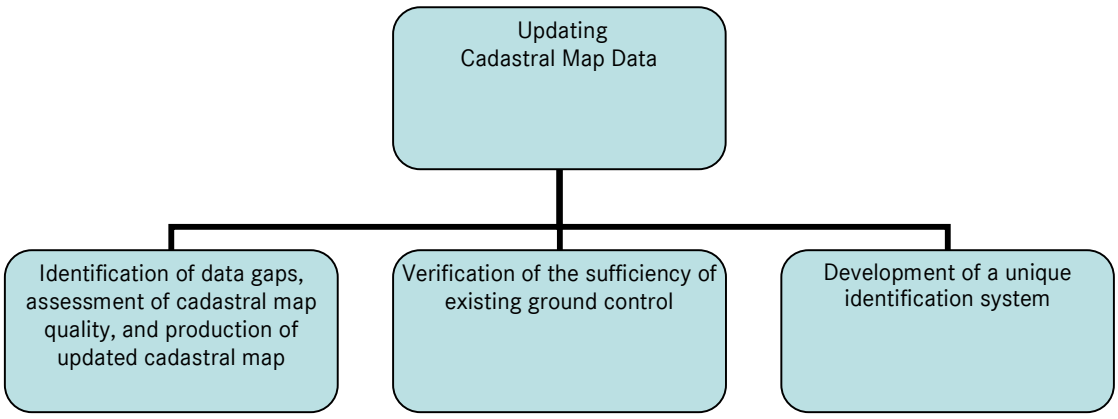

Chart 1 : The tasks of updating the cadastral map data (Source: AACG, 2009)

The three update tasks as shown in the chart above are described in the following.

Identification of Data Gaps, Assessment of Cadastral Map Quality and Production of Updated Cadastral Map

This task was split into three sub-tasks.

Identification of Data Gaps

Before updating the maps the quality of the existing data and gaps in it were assessed. To identify gaps in the cadastral map data, the existing cadastre data and the ortho-images (tiles), which were produced in 2005 / 2006, were compared. Figure 10 shows in black the existing cadastre map data cover in Addis Ababa prior to the update.

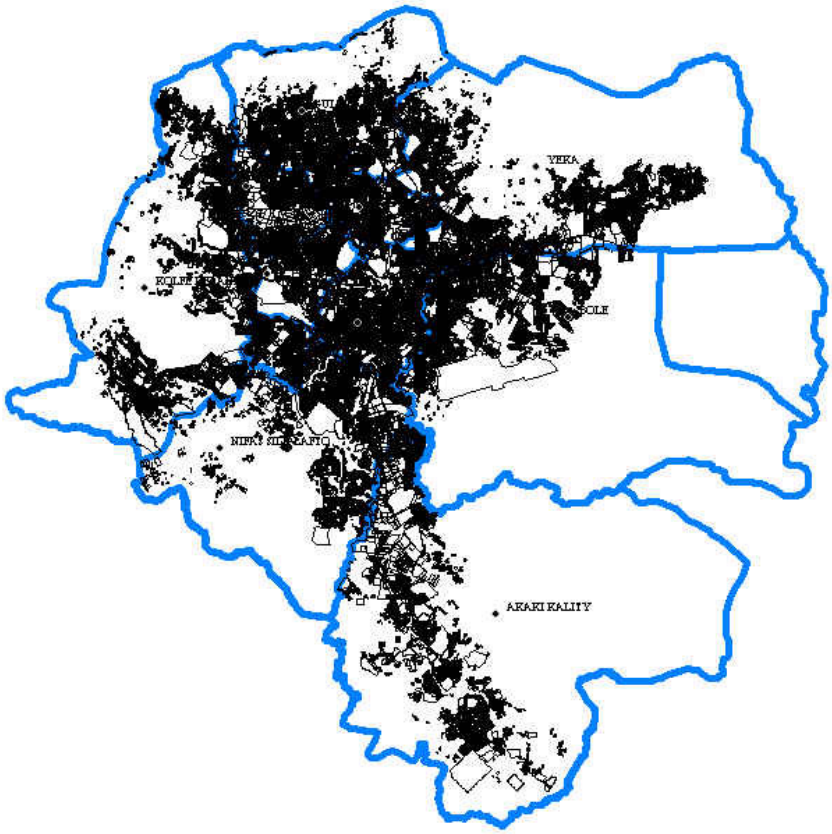

Figure 10: Existing cadastre map data coverage of the ten sub-cities of Addis Ababa (Source: Hansa Luftbild, 2010)

The existing data was analyzed in accordance with the following method:

Ortho-images of Addis Ababa from 2005 / 2006 were overlaid with digital vector data. The entire image area was divided up into old and new areas and further subdivided into 6 categories according to the following schema:

The categories of the "old" areas are:

- Old densely built up areas OB

- Old loosely built up areas OLB
- Old rural areas with few scattered buildings OIR

The categories of the "new" areas are:

- New densely built up areas NB
- New loosely built up areas NLB
- New rural areas with few scattered buildings NR

The size of the areas covered by existing cadastral data was then determined. The results can be seen in Table 1 which also shows the percentages of update and new capture.

Class	Area in sqkm	Percentage of update	Percentage of new capture
OB	114,03		
OLB	86,38		
OIR	101,20		
NB	8,92		
NLB	29,74		
NR	178,25		
Sum	**518,54**	41,8%	58,2%

Table 1: Total areas of six categories with total percentages of update and new capture (Source Hansa Luftbild, 2010)

The results of the analysis can be summarized as follows:

- cadastre data exists for about 60% of the whole city of Addis Ababa;
  in square kilometres 301.62 of a total area of 518.54 sq km;
- the existing data for each sub-city varies significantly with regard to coverage:
  - five sub-cities were covered completely by data. These are
    Addis Ketema, Arada, Gulele, Kirkos and Lideta;
  - the following sub-cities were partially covered:
    Akaki Kality, Bole, Kolfe Keraniyo, Nifas Silk Lafto and Yeka;
  - the largest area requiring new capture was situated in Bole where about 75.3% of the sub-city area needed new mapping

Thus new data capture was necessary for 58.2% of the city while 41.8% of the city needed a data update.

Assessment of Cadastral Map Quality

The scope of the project works specified in the Terms of Reference (TOR) included the updating of the cadastral parcel data, estimated to total around 300,000 parcels. This figure was specified in the TOR as 196,000 parcels already in digital format and 100,000 parcels needed to be digitised. The TOR also specified that an assessment of the quality of existing parcel data and building data, i.e. the cadastral map data, be carried out.

To evaluate the quality of the cadastral map data, orthophotos produced in 2005 / 2006 were compared with existing cadastral map data. It was assumed that any differences identified would also be present when orthophotos produced from aerial imagery acquired in November 2010 were compared. The next step was to identify further differences by a comparison with the most recent orthophotos, those of 2010.

The comparisons were made over the entire project area by superimposing cadastral map data (vector) over the orthophotos. Changes were identified. To report on the changes and quality of the cadastral data 10 representative areas were chosen in each sub-city, in total 100 areas.

Figure 11 shows the locations of the 100 representative / sample areas distributed over the ten sub-cities of Addis Ababa.

The sample areas also clearly show those parts of the city in which no data exists. This is especially evident in the eastern parts of Bole and Akaki Kality as well as in the northern part of Yeka.

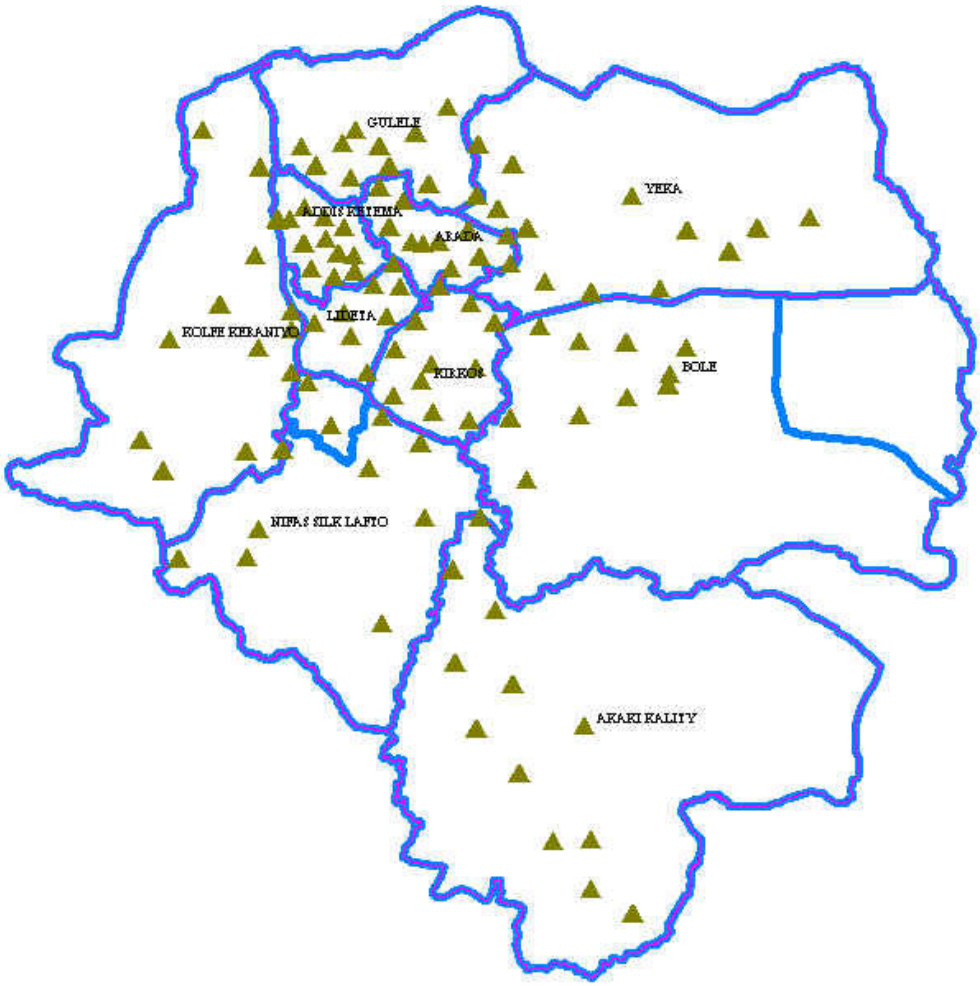

Figure 11: Location of the 100 sample areas distributed over 10 sub-cities (Source: Hansa Luftbild, 2011)

Figure 12 shows a representative area in the sub-city of Addis Ketema. The cadastral map data is superimposed over the existing orthophoto tile.

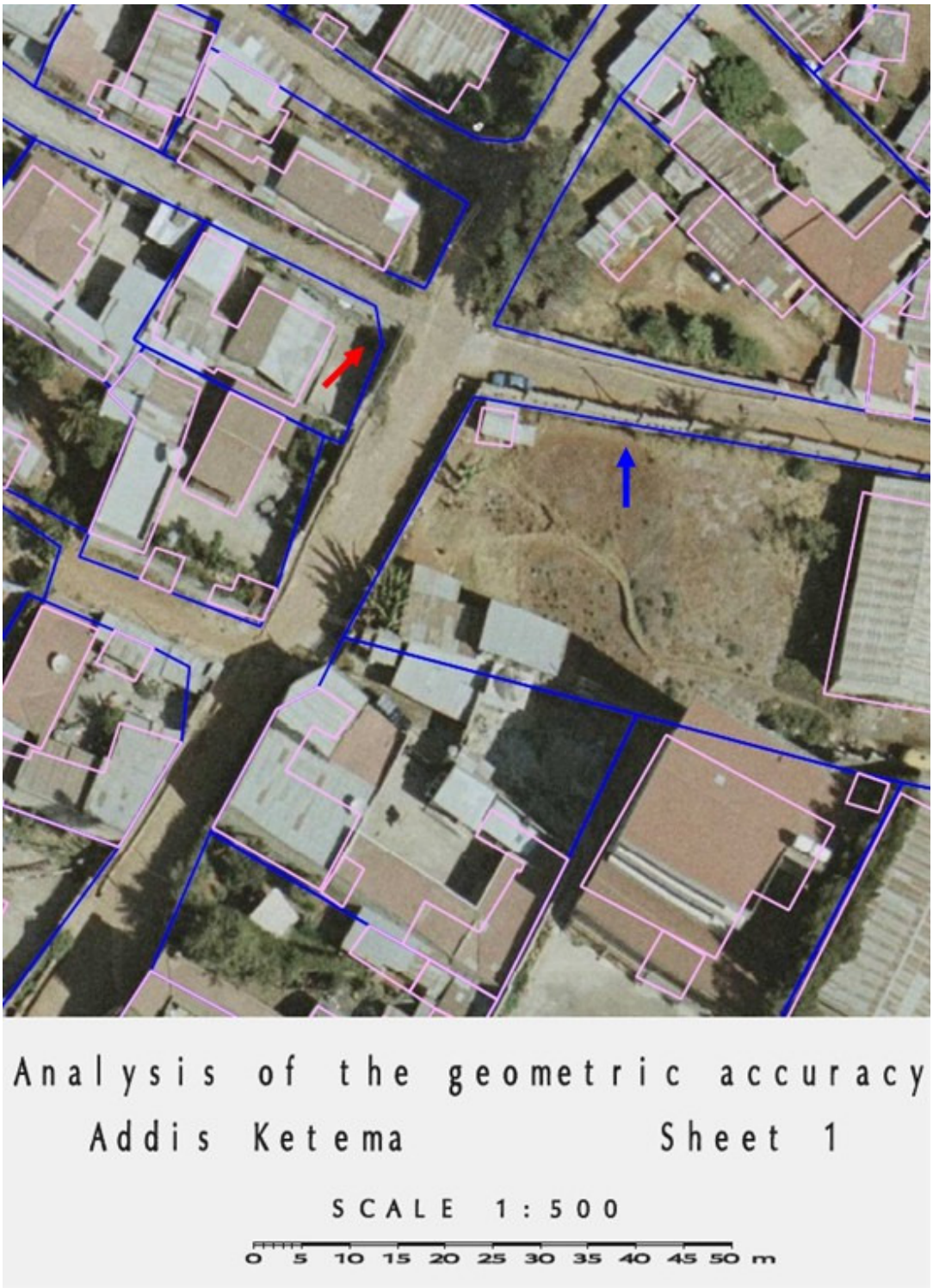

Figure 12: Cadastral map data in selected area of the sub-city Addis Ketema superimposed over 2005 / 2006 orthophoto (Source: Hansa Luftbild, 2011)

The two arrows indicate two representative situations:

- The red arrow points to a difference between the shape of the wall boundary on the ground and the cadastral boundary in the data set. During updating the cadastral map data was revised to match the real ground situation.
- The blue arrow points to a cadastral boundary which fits well with the foot print of the wall. This fit was checked and confirmed during updating using a photogrammetric stereo measurement method.

Figure 13 shows the same representative area in Addis Ketema as shown in Figure 12 but uses the orthophotos produced from the aerial imagery acquired in November 2010.

Again the matching of the vector data over the orthophoto is evident (blue arrow) as well as the difference between the visible boundaries and the mapped boundaries (red arrow).

Major parts of the project area were treated as new mapping, rather than being updated and / or having missing parcels added to the existing data set. This was due to significant changes in the urban landscape having taken place across all the sub-cities of Addis Ababa.

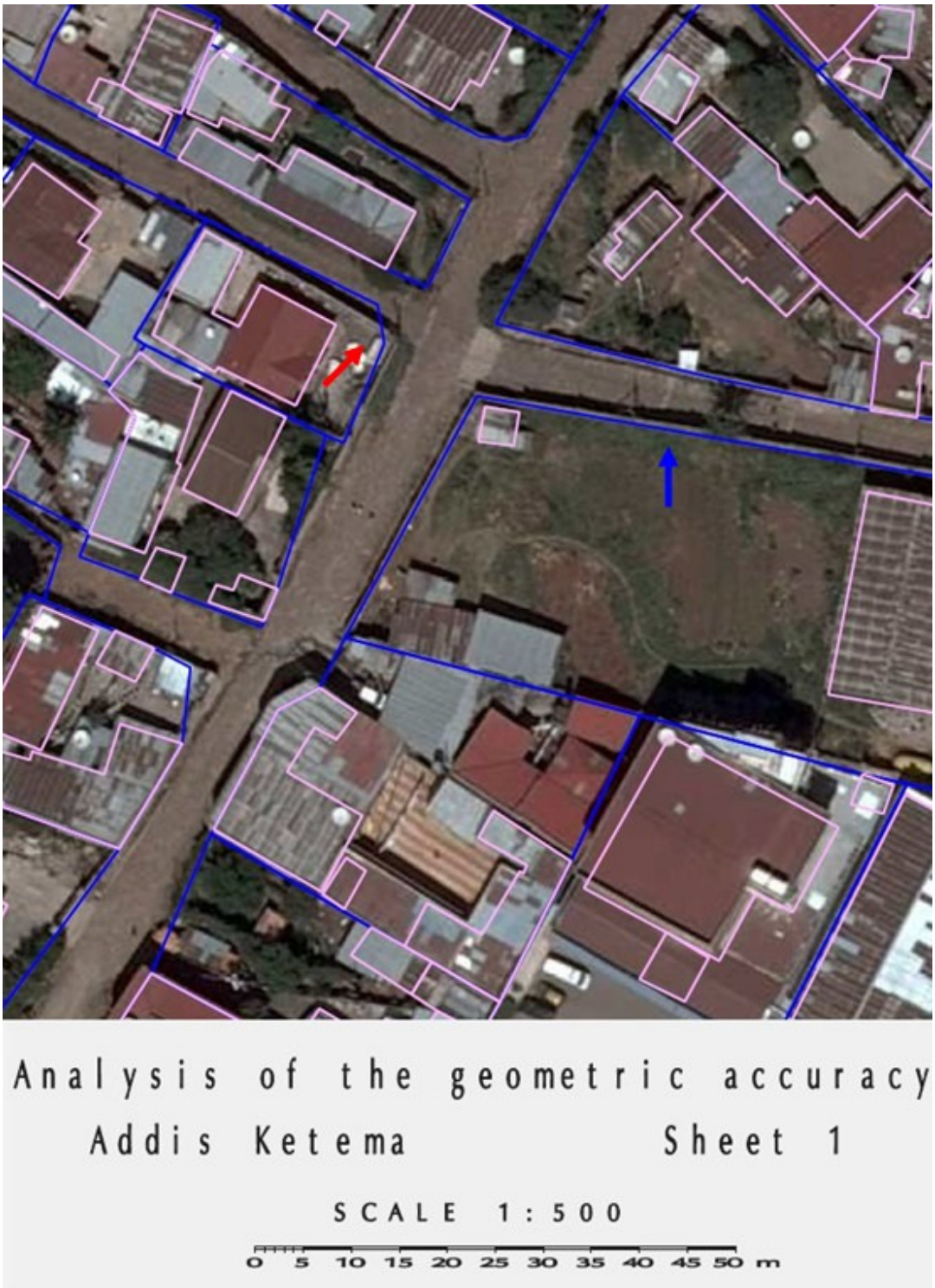

Figure 13: Cadastral map data in selected area of the sub-city of Addis Ketema superimposed over 2010 orthophoto (Source: Hansa Luftbild, 2011)

Production of Cadastral Maps

New aerial photography was acquired in order to update and complete the data coverage of Addis Ababa. The digital aerial photography was acquired at a ground resolution averaging 17cm. This resolution was suitable for mapping at scale 1:2000 as well as for producing digital orthophotos at a ground sampling distance (GSD) of 20cm which is also equivalent to a map scale of 1:2000.

Figure 14 shows the flight lines which covered the entire project area with 17cm ground resolution aerial imagery while Figure 15 shows the new parcel data coverage after the updating. Figure 16 and Figure 17 show the existing building data before and after the updating.

In addition to the parcels and buildings the street and road network was mapped and used to set up the street addressing system.

The photogrammetric data capture in a 3D – stereo environment was carried out on a Bentley MicroStation V8. After data capture the data was input in ESRI ArcGIS and processed so as to generate closed polygons, to assign unique identification numbers and to merge existing attribute data to new polygons.

In statistical terms the final results and output of the updating can be summarized as follows:

359,897 parcels were generated (the initial estimate of AACA was 296,000 parcels) of which
less than 0.1% were unchanged parcels and

- around 49% were new parcels, and
- around 51% were changed parcels

The number of building or construction features mapped was 1,145,690.

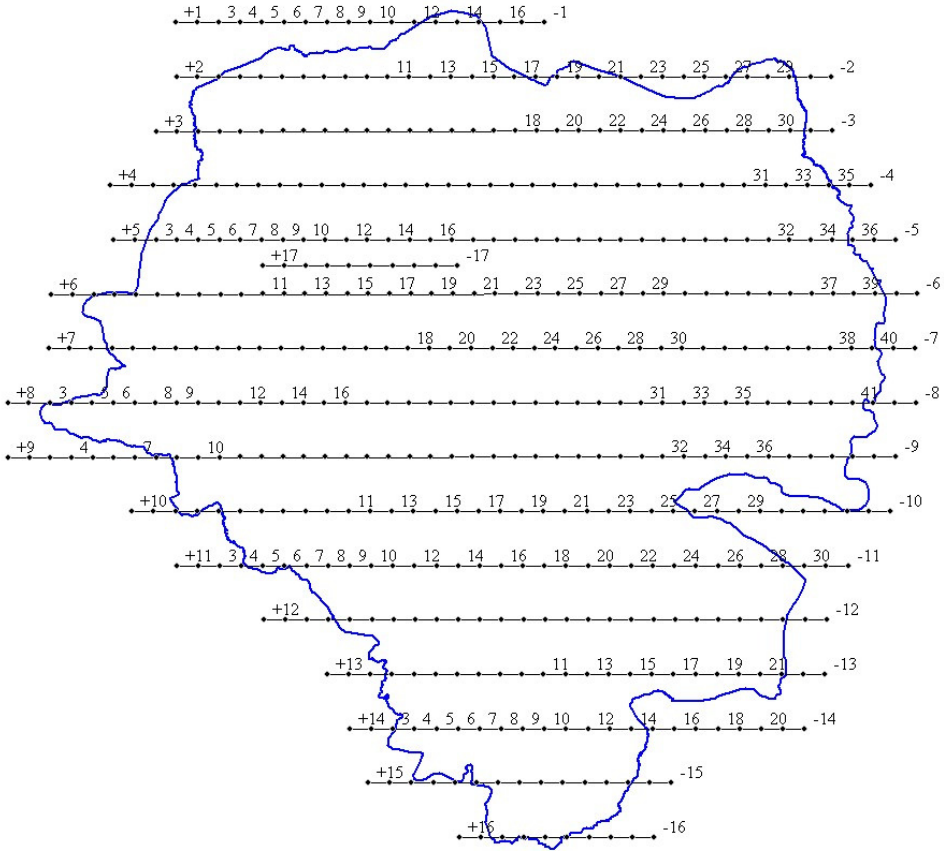

Figure 14 : Flight lines covering entire project area of Addis Ababa city (source: Hansa Luftbild, 2010)

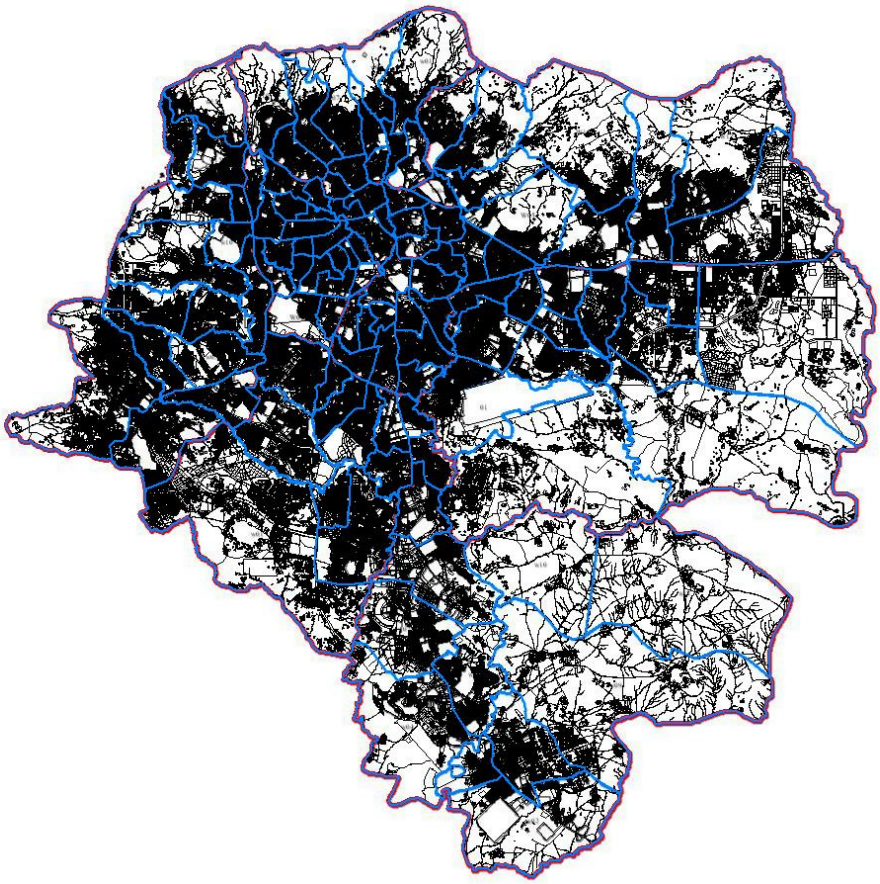

Figure 15: New parcel data coverage (in black) after updating (Source: Hansa Luftbild, 2011)

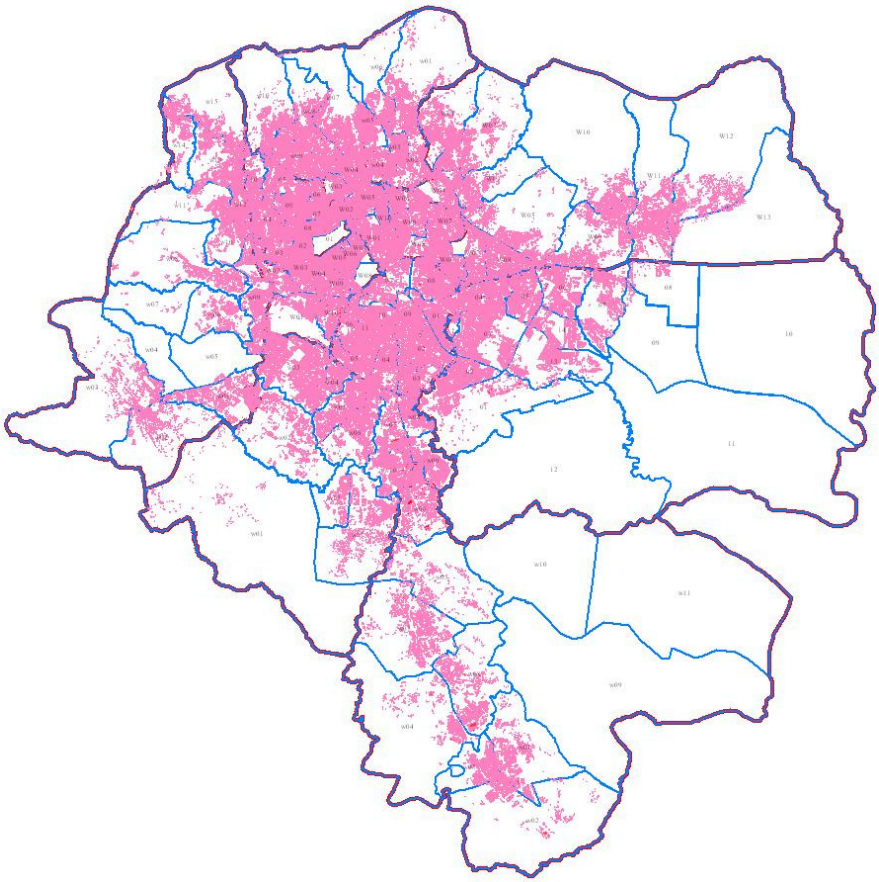

Figure 16: Existing building data coverage (in red) before updating (Source: Hansa Luftbild, 2011)

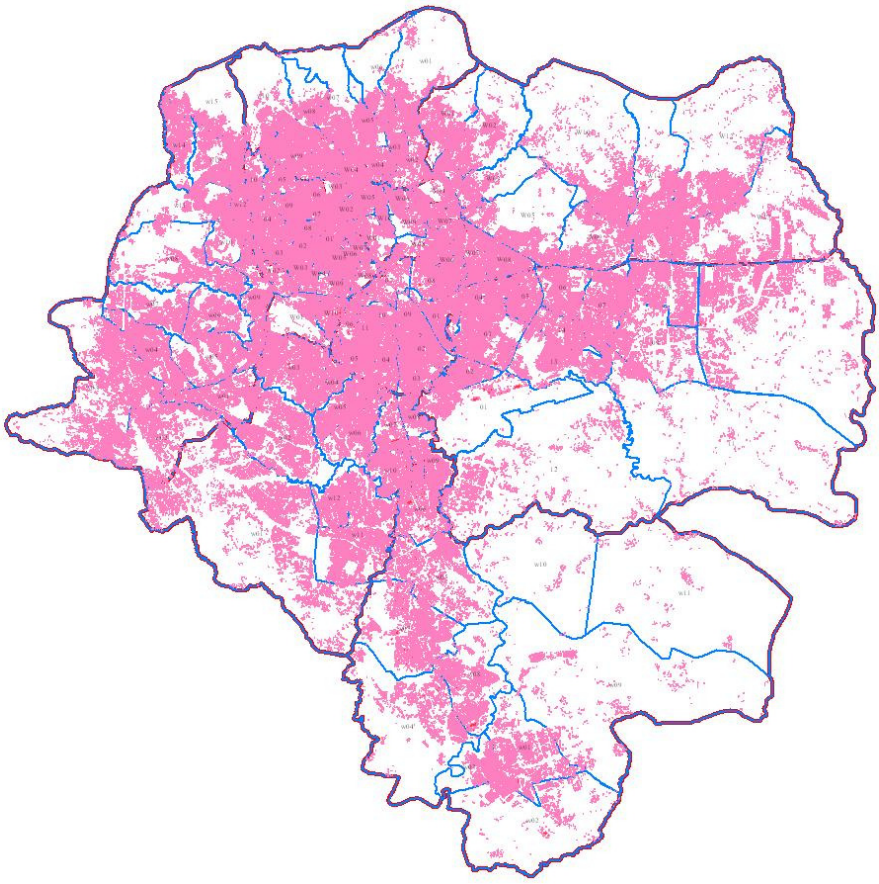

Figure 17: Building data coverage (in red) after updating (Source: Hansa Luftbild, 2011)

The update resulted in accurate parcel and building data covering the entire 520 square kilometer city area. The street and road network was also mapped and used to set up a street addressing system.

Verification of the Sufficiency of Existing Ground Control

The object of this task was to assess if the existing ground control points provided sufficient coverage for future accurate cadastral surveys, which Addis Ababa will require, since it is undergoing a period of rapid urbanization, expansion, and development.

One hundred and fifty ground control points have been established by the Ethiopian Mapping Agency (EMA) in Addis Ababa. These fall within the city boundaries and are distributed within the ten sub-cities. Figure 18 shows the distribution of ground control points inside Addis Ababa.

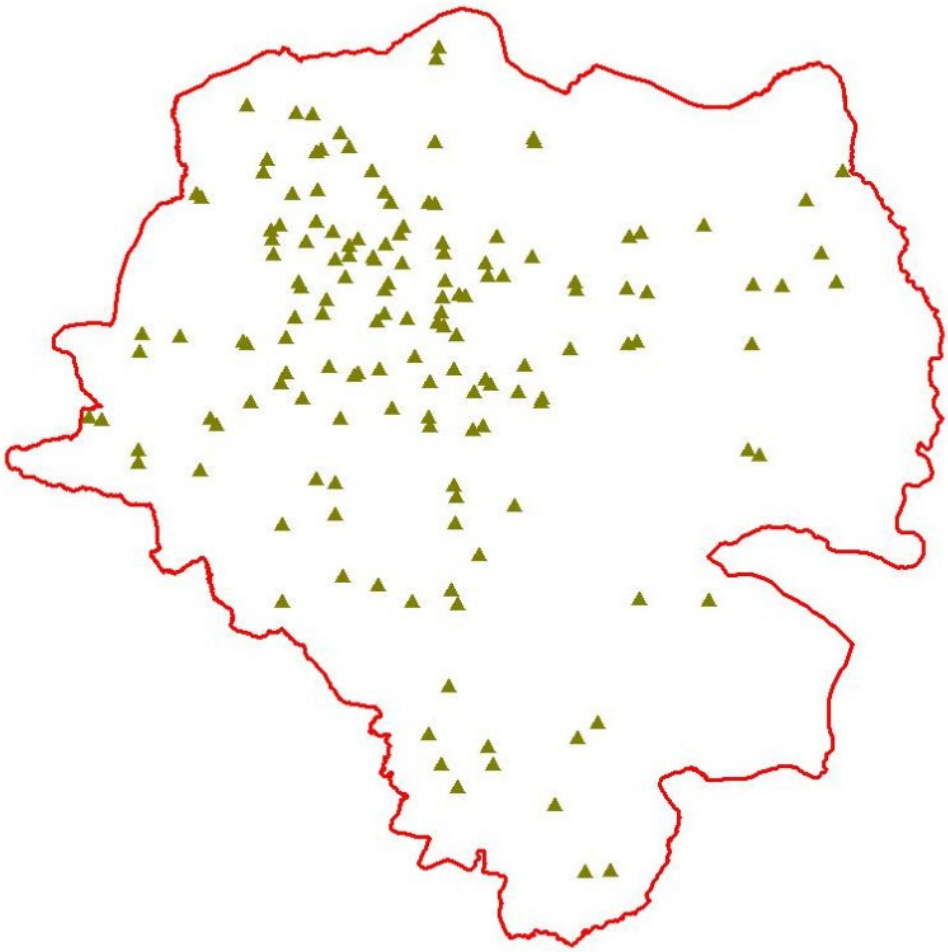

Figure 18: distribution of existing ground control over Addis Ababa

According to EMA 140 of the points were determined and surveyed with GPS technology in terms of the Ethiopian Mapping Agency (EMA) 2nd order point specification. EMA states that horizontal accuracy at 95% confidence level is 19.69cm while vertical accuracy in a closure is 0.046cm in reference to the bench mark used in the levelling. The vertical accuracy fully suffices for cadastral field surveys while the horizontal accuracy is not sufficient for cadastral field surveys. This should be 5cm and better at the 95% confidence level.

Table 2 lists the number of ground control points in each sub-city and the area in square kilometer of the respective sub-city.

Sub-city	No. of points	Area of Sub-city in sqkm
Addis Ketema	**12**	**7.39**
Akaki Kality	**18**	**124.04**

Sub-city	No. of points	Area of Sub-city in sqkm
Arada	**10**	**9.50**
Bole	**15**	**119.12**
Gulele	**12**	**31.19**
Kirkos	**21**	**14.65**
Kolfe Keraniyo	**22**	**62.93**
Lideta	**11**	**10.99**
Nifas Silk Lafto	**12**	**58.22**
Yeka	**17**	**81.49**
Total	**150**	**519.52**

Table 2: Number of ground control points in each of the ten sub-cities of Addis Ababa (Source: AACA, 2010)

During the ground points marking expedition in June 2010 surveyors checked the 150 ground control points and found that 31 points were damaged, or buried, or inaccessible.

Furthermore the distribution of the current ground control points was not suitable to adjust the photogrammetric block. Therefore 62 additional ground control points were determined and surveyed for that adjustment. Figure 19 shows the distribution of additional ground control points, which were determined and surveyed for the photogrammetric updating method.

On the basis of the foregoing it was concluded that the existing ground points provided insufficient coverage for future cadastral surveys. This would particularly be the case when a highly accurate survey is required as in determining the exact area of land parcel or subdivision of blocks of land.

Hansa Luftbild recommended that AACA implement either one of the following two approaches in order to apply cadastral field methods to adjudicate existing parcels or to survey new ones:

1. establishment of an active GPS station network, or
2. densification of the existing ground control points to 1 point per square kilometre with a horizontal and vertical accuracy of 5cm and better

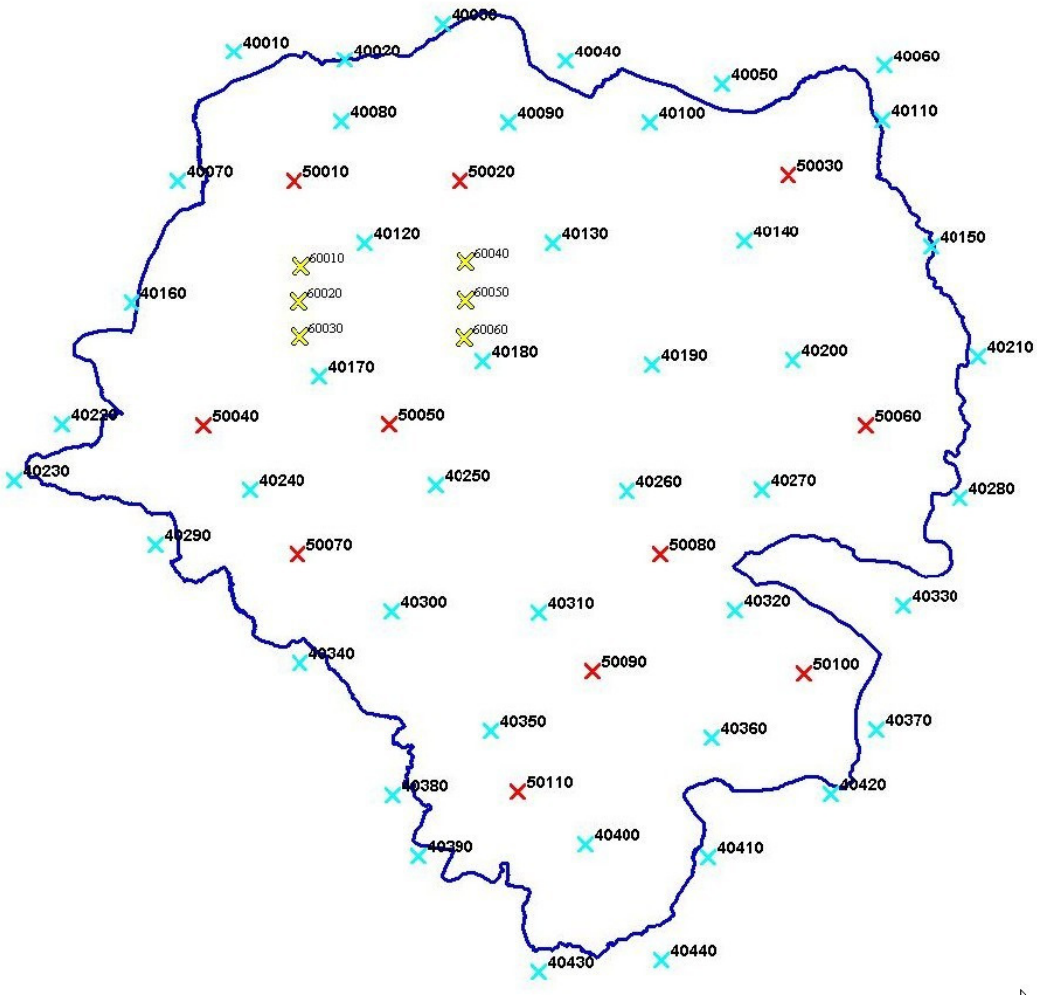

Figure 19: Distribution of additional ground control which were determined for the photogrammetric block (Source: Hansa Luftbild, 2010)

Development of a Unique Identification System

To locate a parcel in the cadastral map, it is necessary to link the parcel number with the geometry of the map, i.e. the geodetic reference system. Therefore an independent district and numbering concept for cadastral purposes with the Woreda as the smallest cadastre district was proposed by Hansa Luftbild and accepted by AACA.

This unique identification numbering system for the parcels consists of 14 digits with the following information code:

rrcccsswwppppp

rr number or code for the region (AA for Addis)

ccc number of city (000 for Addis)

ss number of sub-city (e.g.: 06 for Bole, 08 for Nifas Silk Lafto)
ww number of Woreda (e.g.: 10 at Bole)
ppppp number of parcel (00001, 00002, 00003, …)

As an example:
Parcel 235 in Woreda 10 of Bole (06):
AA000061000235

This concept uses parcel boundaries as district boundaries and includes road, railway, and river parcels. It is intended that this numbering will remain constant regardless of any future changes in administrative boundaries. Furthermore it is very similar to the German system which has continued to run reliably for more than 100 years. The advantages of this solution are:

1. it is independent of future changes in administrative structure;
2. database consistency checking is simple because a check on area coverage of the parcels within the cadastre district (Woreda) is possible;
3. a special numbering concept for roads, railways and rivers is not needed.

All buildings inside the parcels were also captured and were also assigned a unique identification number. The number consists of 15 digits defined by the following code:

rrcccsswwbbbbbb
rr number or code for the region (AA for Addis)
ccc number of city (000 for Addis)
ss number of sub-city (e.g.: 06 for Bole, 08 for Nifas Silk Lafto)
ww number of Woreda (e.g.: 10 in Bole)
bbbbbb number of building (000001, 000002, 000003, …)

As an example:
Building 439 in Woreda 10 of Bole (06):
AA0000610000439

Establishment of Addressing System

Until recently Addis Ababa lacked a fully functioning and cohesive addressing system, having only unsystematic and incomplete street addressing. Furthermore no single organisation was responsible for assigning of addresses (ie house numbers).

The lack of an addressing system meant that AACA could not provide the public and private sectors with information and services, relating to address location and street information. Locations in Addis Ababa were described by referring to commonly known landmarks, and appointments or deliveries were handled through guides or make shift maps. This hindered the development and operation of the postal, public transport, security and rescue services.

In 2003 the Addis Ababa Infrastructure and Construction Authority (now renamed to Addis Ababa Construction and Road Authority - AACRA) developed a concept and method for the implementation of a land information, addressing and street naming system for the City of Addis Ababa. The concept gave land priority over buildings when assigning addresses because this was neutral to changes in usage / construction and a more stable element in the city's development. In 2004 the Addis Ababa City Government accepted the concept.

More than 3000 streets were defined through a number code. This code formed the basis for numbering new parcels of land. The new parcels were assigned a street code and a plot number. The implementation of the concept was halted in 2005, for administrative reasons.

According to AACRA Addis Ababa currently has approximately 7,400 public road segments suitable for vehicle traffic, including paved and gravel roads.

The development of the addressing system was considered of critical importance and was foundational to the current project. Working Group 3 worked on this issue and developed key concepts / solutions for a workable addressing system. The final concept agreed to by AACA was based on data published in the World Bank's manual "Street Addressing and the Management of Cities". To implement the agreed concept a street addressing unit was established within AACA.

Using the methodology recommended in the aforementioned World Bank publication, a training manual containing 12 data sheets was prepared. These defined and canvassed the major components required in an effective street addressing system. The sheets are:

Data Sheet 1:	Preparing the cartography base
Data Sheet 2:	Identifying zones to be addressed
Data Sheet 3:	Selecting the codification system
Data Sheet 4:	Establishing the basic street addressing map
Data Sheet 5:	Developing signposting maps
Data Sheet 6:	Instituting a public awareness campaign
Data Sheet 7:	Addressing a pilot zone
Data Sheet 8:	Calling for bids and analyzing responses
Data Sheet 9:	Installing sign posts and street plaques
Data Sheet 10:	Numbering entryways and carrying out the baseline census
Data Sheet 11:	Developing an address index/database
Data Sheet 12:	Preparing and publishing the final street addressing map

Two areas were chosen for piloting the implementation of the street addressing system. Figure 20 shows the current road map of Addis Ababa. The areas outlined in blue depict the two pilot areas.

The two pilot areas were used to derive an estimated budget for the implementation. The cost estimation given by the World Bank manual starts at 0.50USD and goes up to 5.00USD. In line with these estimates the costs for Addis Ababa at today's exchange rate would be around 3.00 USD (50 Birr) per registered city inhabitant.

For Addis Ababa the following street numbering concept was applied:

1. two characters for the abbreviation of the sub-city name;
2. two digits for the Woreda number; and
3. four digits for the street number.

Example: **NL.03.0004**, which means
NL for Nifas Silk Lafto
03 for the Woreda
0004 for the street

A small scale-map, of Addis Ababa, according to this numbering concept was compiled. The map shows sub-city boundaries / abbreviations, Woreda boundaries / numbers and street number ranges. Street numbering ran sequentially from one Woreda to another within discrete sub-cities. For example:

- Woreda 01 from 0001 – 0200
- Woreda 02 0201 – 0400
- Woreda 03 0401 – 0700

- .
- .
- Woreda 12 2401 – 2600

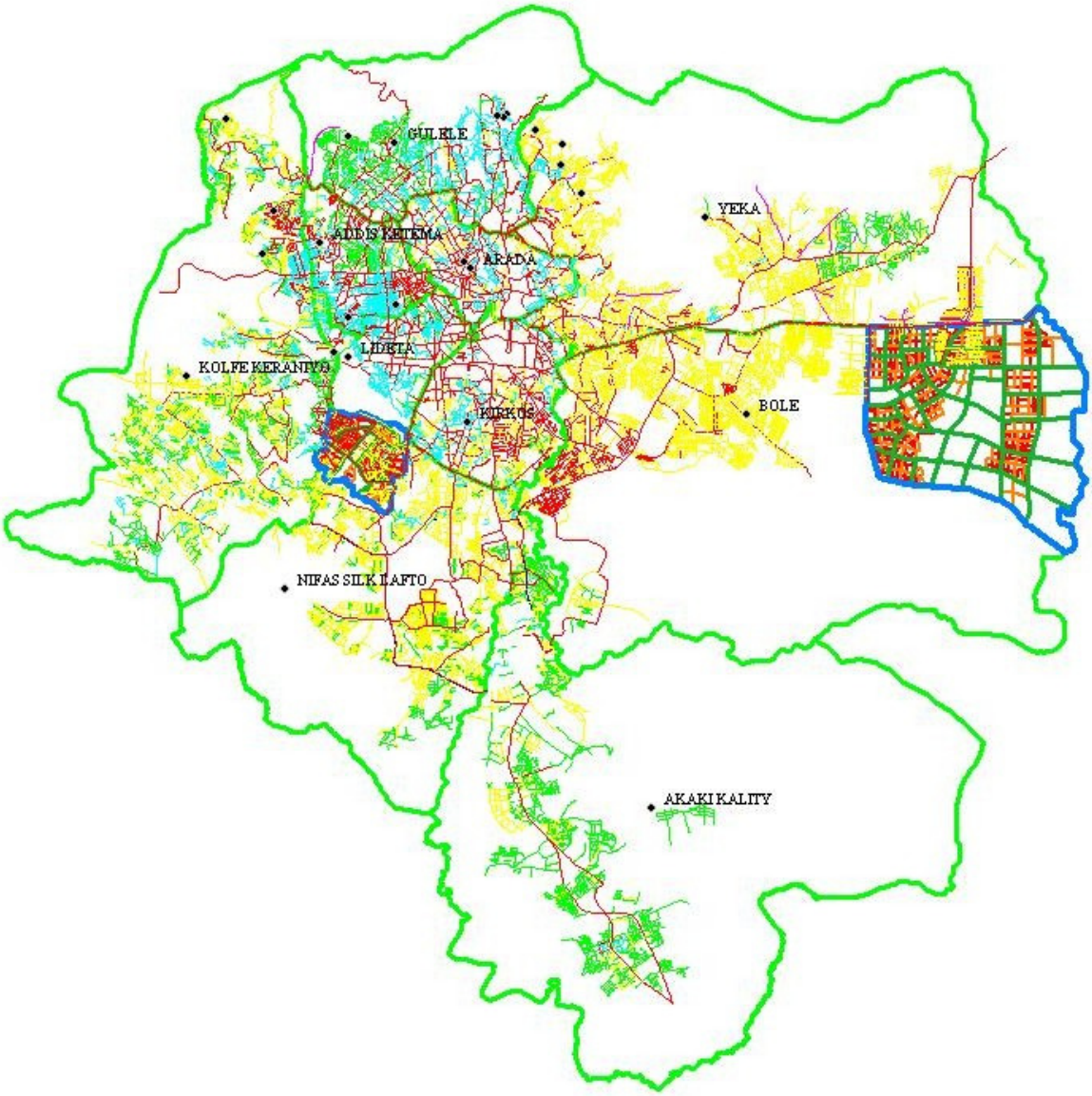

Figure 20: Roads and streets of Addis Ababa and the two pilot areas outlined in blue (Source Hansa Luftbild, 2011)

Figure 21 shows an example of this sequential, cross-Woreda, street numbering system for the sub-city Nifas Silk Lafto with its 12 Woredas.

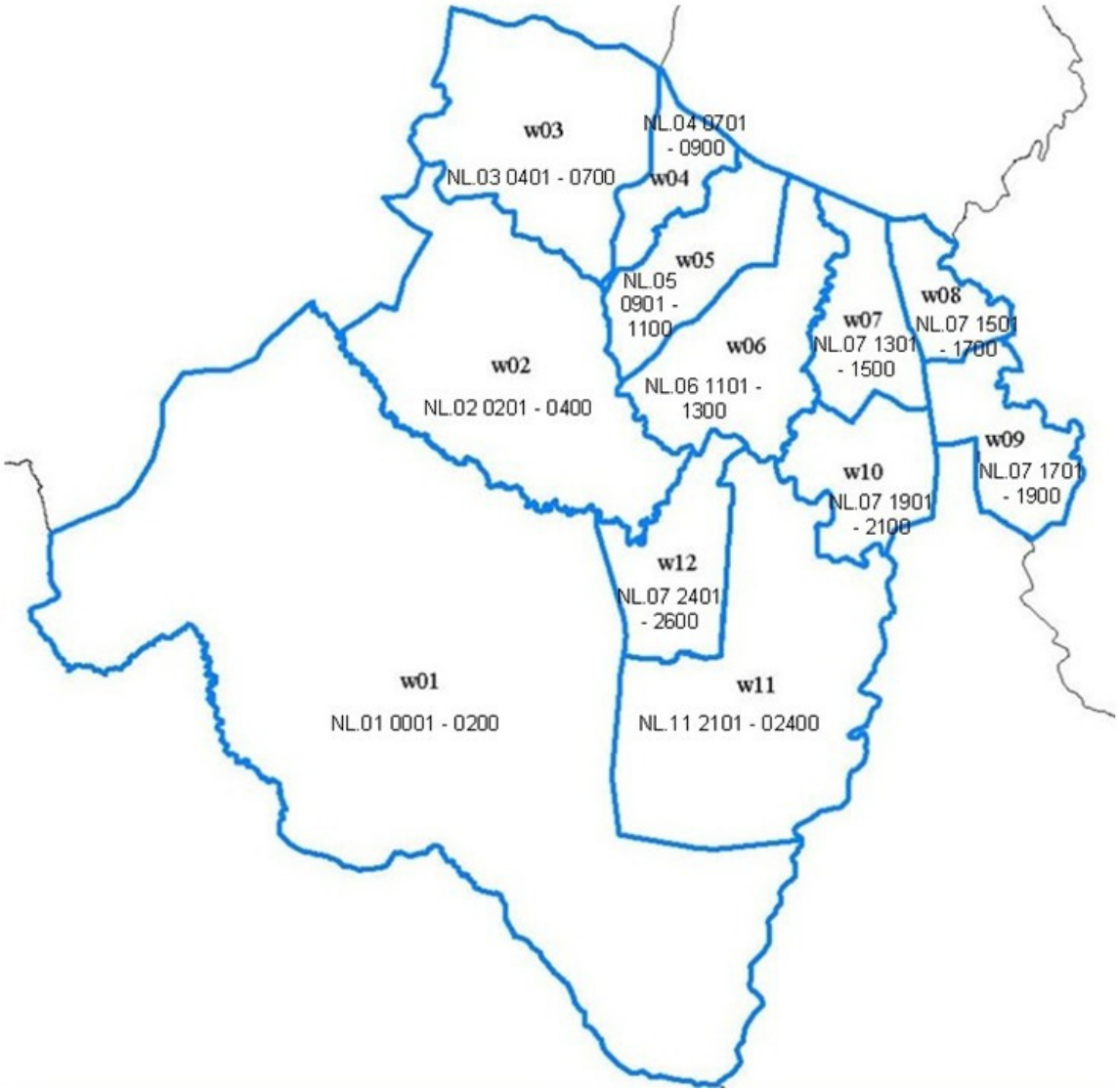

Figure 21: Sample of street numbering scheme in Nifas Silk Lafto (Source: AACA, 2011)

The orientation of the street numbers runs according to the approach recommended by the World Bank. The street numbering runs east-west and south-north. Streets running east-west are allocated even numbers while streets running south-north are allocated odd numbers. See Figure 22.

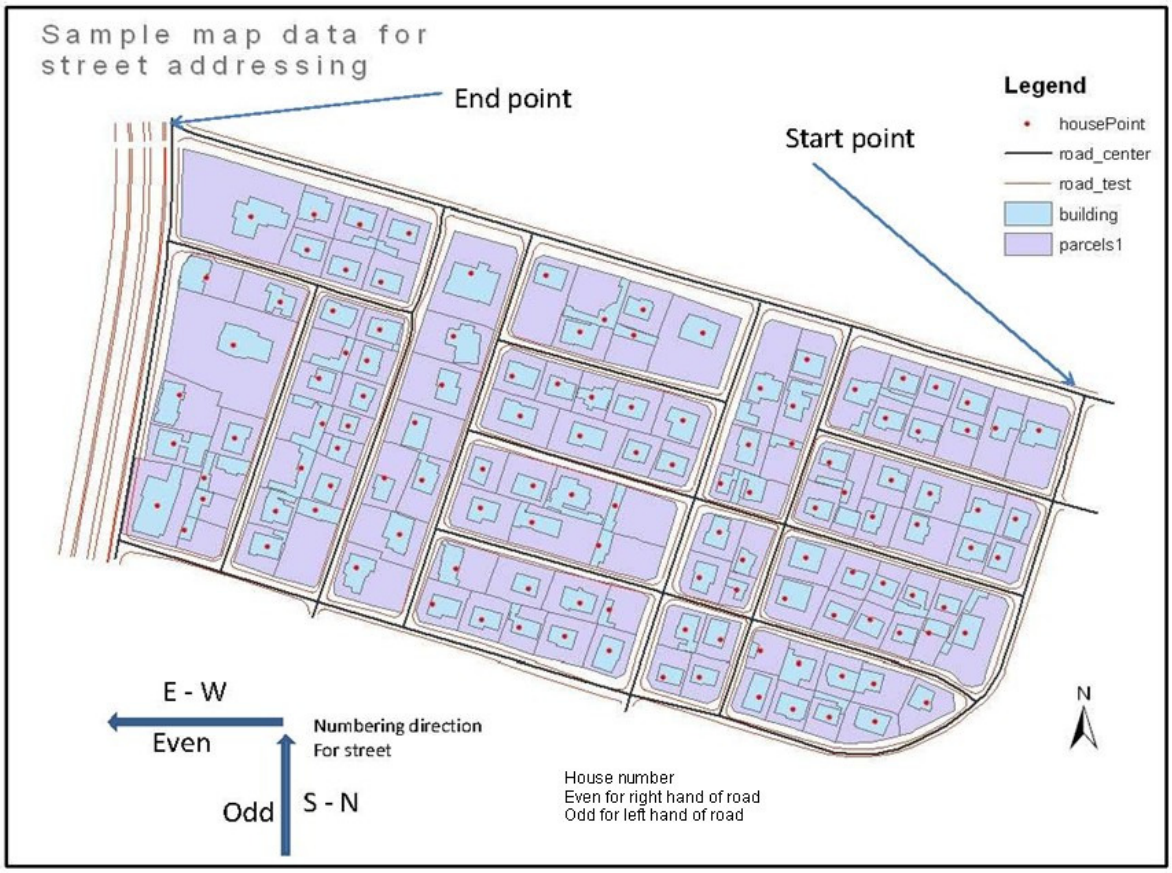

Figure 22 : Sample of numbering of the streets in Addis Ababa (Source: AACA, 2011)

Numbering of addresses was carried out under the metric system as follows:

- odd and even numbers assigned to opposite sides of the street, and
- numbers are determined by their distance from a point designated as the beginning of the street and referred to as "zero point".

Examples of the metric system are shown in Figure 23.

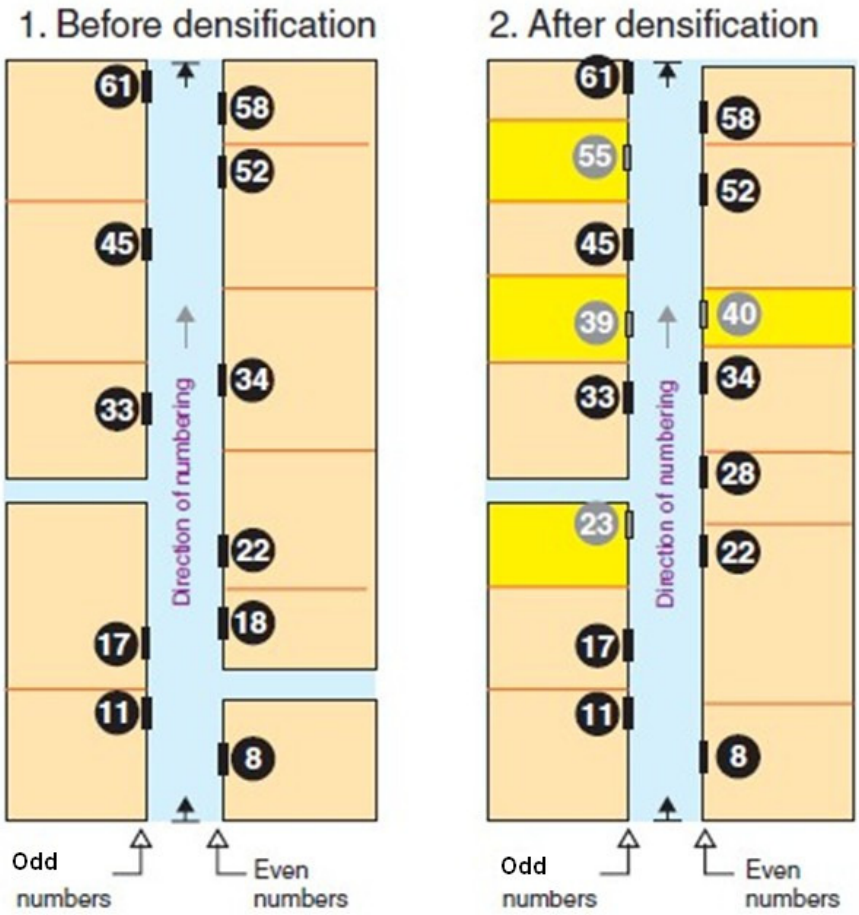

Figure 23: Metric entryway numbering (Source: World Bank "Street Addressing and the Management of Cities", 2005)

The metric system has several advantages:

- numbering is final;
- it is suitable for rapid development within neighborhoods, and for restructuring. When a new building is erected the number can be determined immediately, simply by measuring the distance from the zero point;
- address location is facilitated, for example, number 109 is always opposite number 110, and 109 meters from the beginning of the street, which expedites the tasks of administrative bodies (simplified routes for mail delivery, water meter reading, electricity meter reading, telephone services, etc.);
- it provides useful data – the linearity of roadways as well as their surface area;
- the addition or removal of entryway numbers is simplified. For addition each new building corresponds to a unique number since it is the relevant distance from the zero point. For removal a regrouping of lots may result in the outright removal of certain numbers without creating confusion.

The numbering scheme applied for the pilot areas of Addis Ababa is demonstrated in Figure 24 and Table 3.

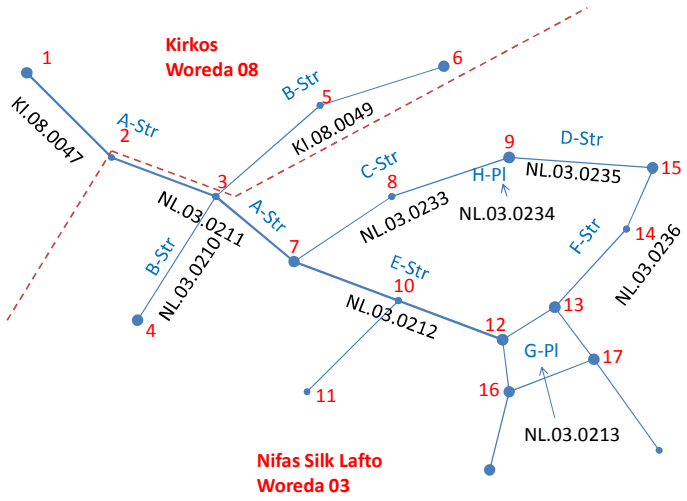

Figure 24: Numbering scheme applied in the pilot area of Addis Ababa (Source: AACA, 2011)

Str.-No.	Str-Name	Sub-City	Woreda	S-B-No	S-E-No	Traff-Dir	Length	House-No
0047	A-Str	KI	08	1	2	1	82	4,7,8,13,16
0211	A-Str	NL	03	2	3	1	86	17,22,23,28
				3	7	1	56	34,37,40,43
0210	B-Str	NL	03	3	4	2	120	5,6,15,16
0049	B-Str	KI	08	3	5	1	142	36,39,48,51
				5	6	1	158	60,63,70,71
0233	C-Str	NL	03	7	8	1	75	3,11,12,20,21
				8	9	1	87	43,46,84,89
0235	D-Str	NL	03	9	15	1	67	13,21,40
0212	E-Str	NL	03	7	10	1	89	3,13,16,25
				10	11	1	56	31-6,31-9,31-20
				10	12	1	61	37,42,50,51
0236	F-Str	NL	03	13	14	1	110	12,19,22,27
				14	15	1	90	42,45,54,59
0213	G-Pl	NL	03	12	16	2	43	2,14,24,36
				16	17	2	51	52,64,70
				17	13	2	45	94,106,120
				13	12	2	50	142,154,168
0234	H-Pl	NL	03	9				

	Traffic direction
1	Both directions
2	Direction as defined by node sequence
3	Direction opposite to node sequence

S-B-No: Intersection No at Segment Begin

S-E-No: Intersection No at Segment End

Length: Length of segment

Table 3: Numbering scheme applied within the pilot area of Addis Ababa (Source: ACCA, 2011)

Figure 25 shows the newly installed street signs with street code and house numbers.

Figure 25: Newly installed street signs showing the street code number and the house numbers (Source: Hansa Luftbild, 2012)

Support for the Establishment of Real Property Registration Offices

Supporting the establishment of the municipal real property registration offices was an important service delivered by Hansa Luftbild.

The key issues addressed during the consultancy period were:

1 operational and procedural development and support;
2 public and stakeholder information, education and communication;
3 strategic management and business plan preparation; and
4 training.

Chart 2 shows the support services provided by Hansa Luftbild.

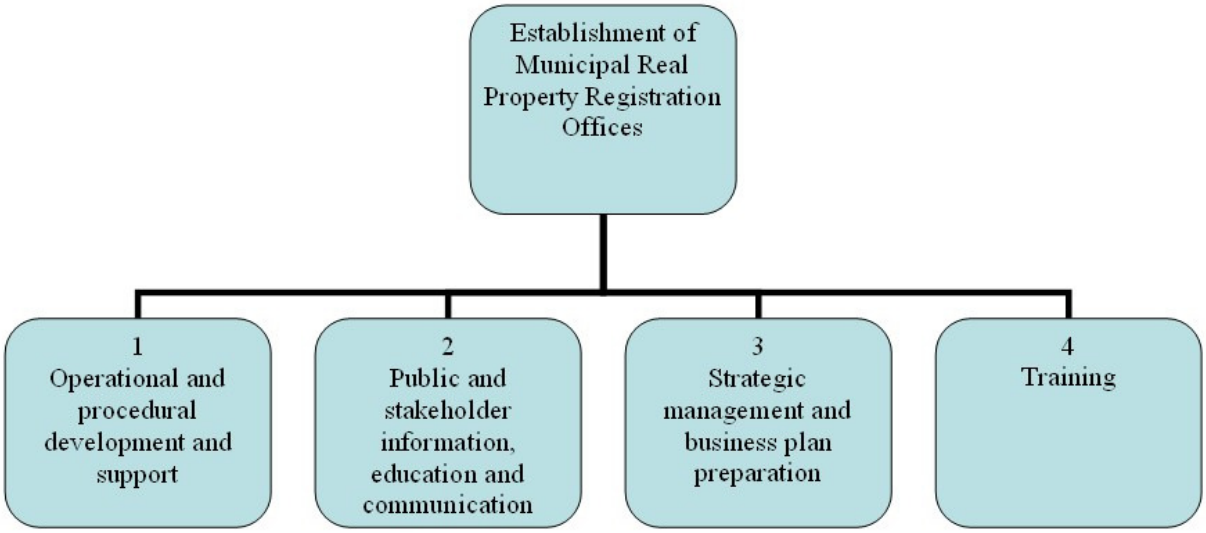

Chart 2: Services delivered to support the establishment of real property registration offices (Source: AACG, 2009)

The Addis Ababa City Government in its Proclamation No. 22 /2010 established the Immovable Property Registration and Information Agency (IPRIA). The proclamation which came into force on the 7th of June 2010 declared the IPRIA agency to be a legal entity directed by a board accountable to the city manager. In addition to IPRIA's head office the agency retains an office in each sub-city. Figure 26 shows the administrative structure of IPRIA

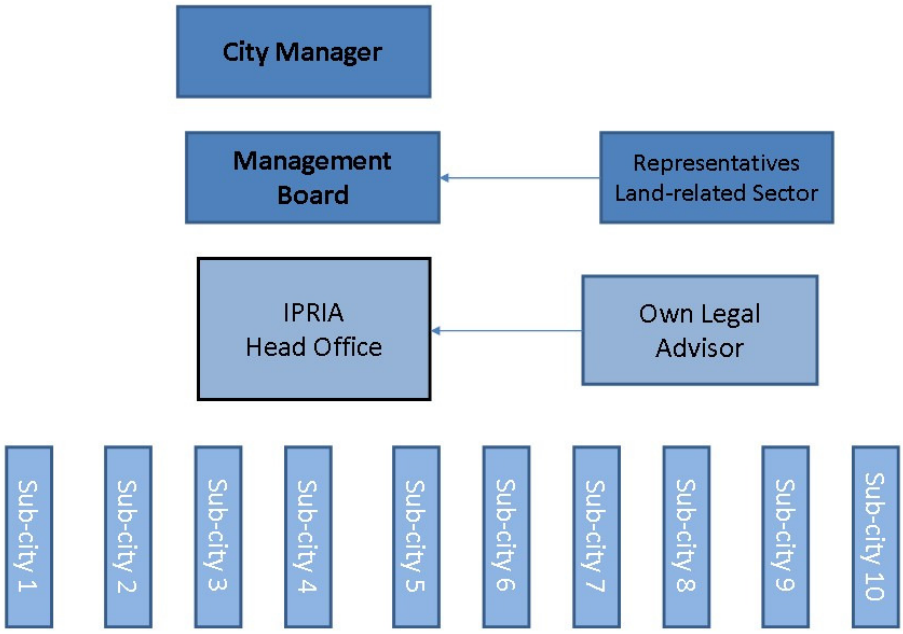

Figure 26: Structure of IPRIA (Source: AACG and Hansa Luftbild, 2011)

Figure 27 shows the functions of IPRIA in relation to the other land and land related administration sector (LLRAS).

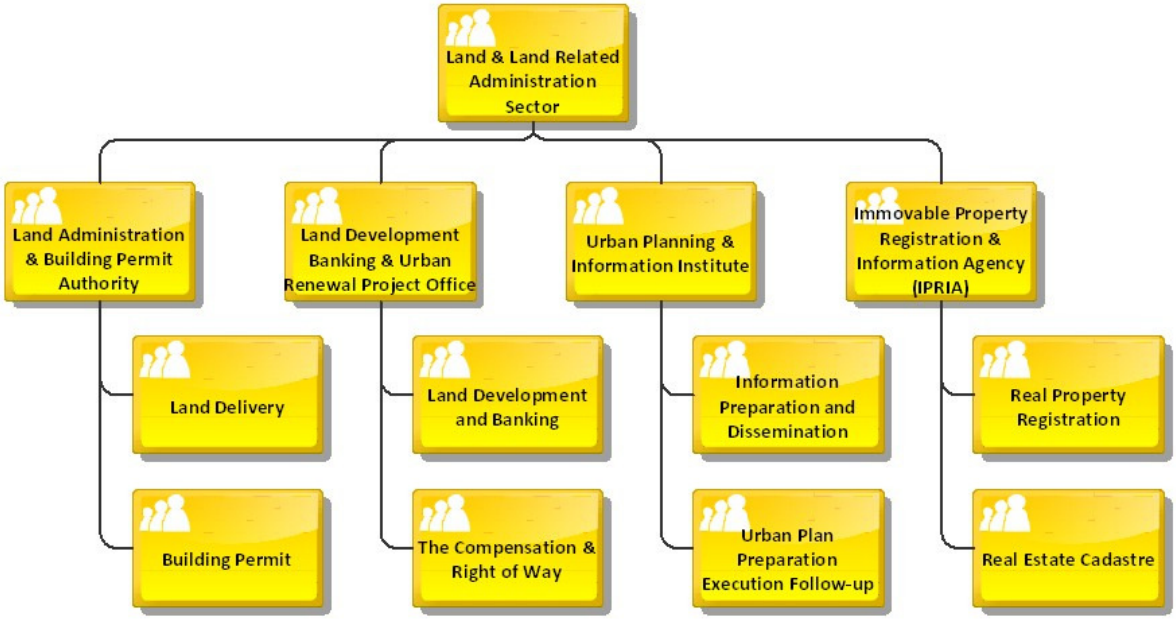

Figure 27: Functions of IPRIA within LLRAS (Source: AACA and Hansa Luftbild, 2011)

The principal tasks of IPRIA's head office are defined in Paragraph 7 of Proclamation No. 22/2010. Hansa Luftbild proposed that IPRIA's organizational structure be made congruent with the business use cases as defined in the requirement analysis. Figure 28 shows the structure of the agency at head office level.

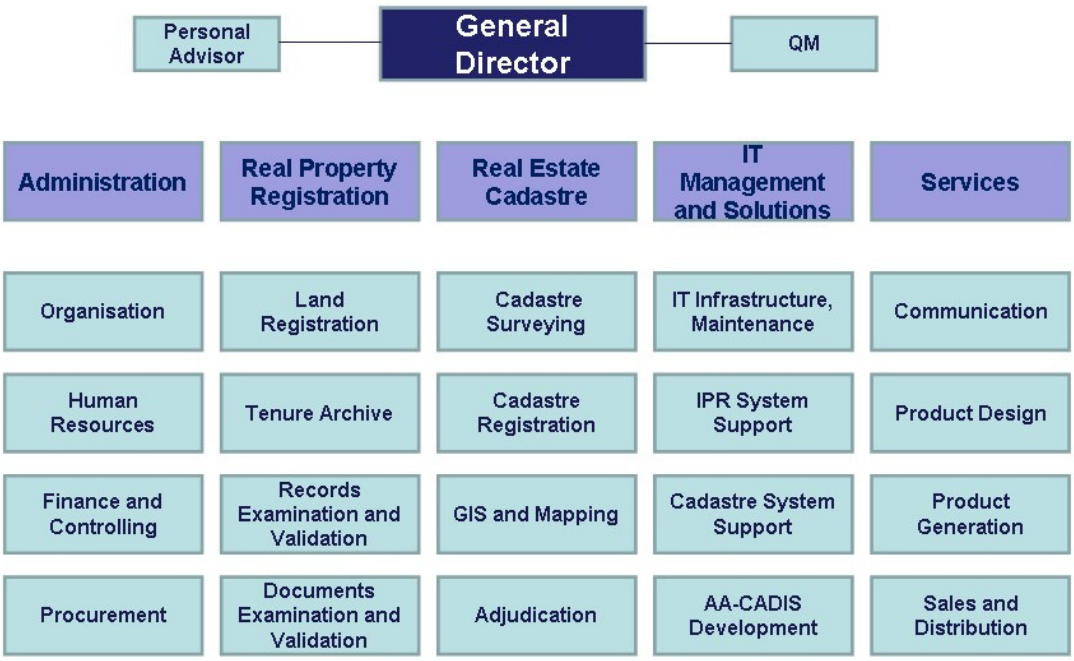

Figure 28: Organizational structure of IPRIA's head office (Source: Hansa Luftbild, 2011)

The powers and functions of the sub-city offices of IPRIA are also described in Paragraph 8 of Proclamation 22/2010. Figure 29 shows the organizational structure of IPRIA at sub-city level.

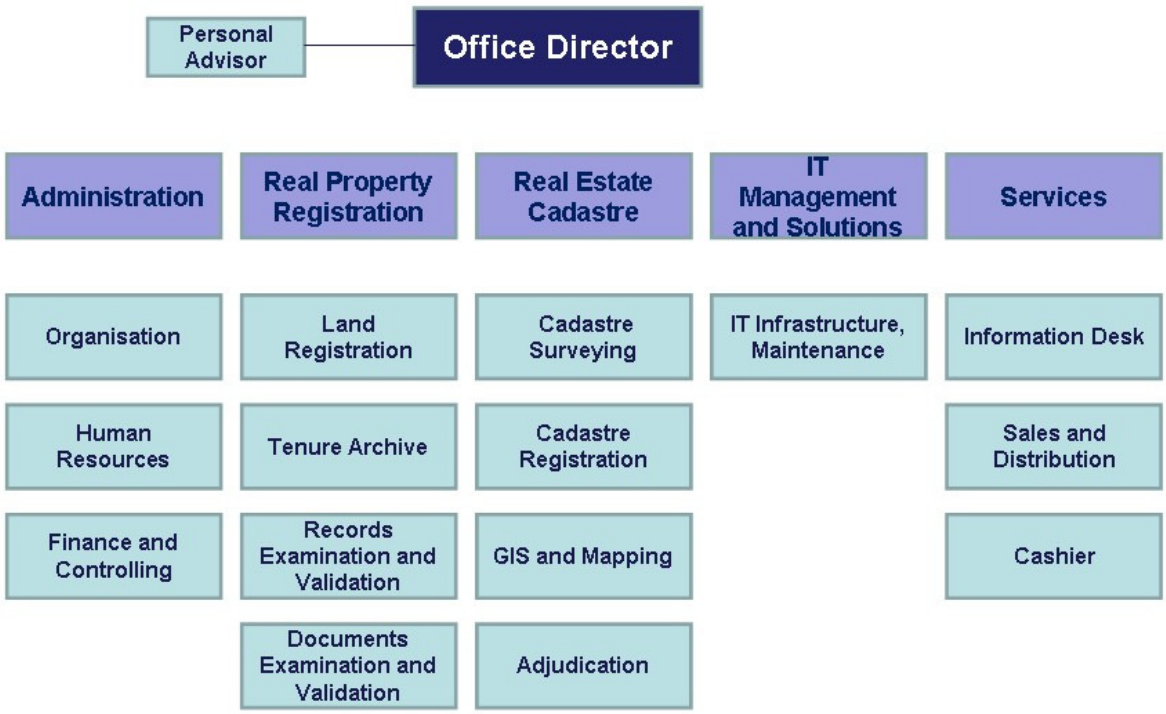

Figure 29: Organizational structure of IPRIA's sub-city offices (Source: Hansa Luftbild, 2011)

Development and Implementation of Real Property Registration and Land Information (Cadastre) Systems

The systems were designed and implemented as a three-tier architecture with a decentralised information retrieval system at head office level and sub-city level. Such a partial online solution requires less network infrastructure and since Addis Ababa currently does not possess a high capacity telecommunication infrastructure this was the best case solution.

The connection between head office and a single sub-city comprises a standard connection provided by the Ethiopian Telecommunication Company (ETC). The bandwidth is mostly used for viewing data rather than changing data. The network infrastructure within the different sites (head office and sub-cities) is however a high capacity one.

The main advantage of the client/server architecture at the sub-city level is that real time data exchanges between sub-city and head office are unnecessary thus accords with the level of telecommunication

infrastructure available. The systems can run using less expensive network infrastructure and if necessary can operate without permanent network connections between head office and the sub-cities.

Another advantage is that the dependency on vendor specific protocols and interfaces is reduced. Data maintenance of AA-CADIS is performed via an interface tailored specifically for the client. In the long-term such an interface could be used as a base for an Ethiopian national system solution.

The partial online solution allows read-only access for data viewing with OGC compliant services such as WMS and WFS at the head office and the sub-city levels. Replicas of the CCDB for viewing are held in local repository in each sub-city. These repositories are implemented under an Oracle database management system.

Updates of the AA-CADIS (ie RPRS and RECS) system are not directly implemented on the central CCDB but through data maintenance jobs which are generated in the sub-cities at set times. Such jobs contain all the information necessary for a transaction. Examples of a transaction are parcel splitting or change of ownership. The maintenance jobs are generated by the RPRS and RECS clients. The generated jobs are XMLs which are transmitted via low capacity network connections or delivered offline to head office where they are processed. This is the only way in which the entire AA-CADIS system can update the CCDB.

The RPRS client is a web application and is invoked from a local applications server in each of the 10 sub-cities and in head office. All maintenance operations are also carried out by data maintenance jobs.

In each sub-city servers were installed for the applications, the local data repository, the database and the OGC services.

OGC services are used to provide access to the data repositories of the RPRS and RECS clients.

The replication of data from head office to the sub-cities is performed using specially developed replication tools since Oracle does not provide such tools for spatial data.

The three tier architecture consists of:

- client layer, responsible for presentation and user interaction
- service layer, and
- data layer

The RPRS and RECS are implemented at the **client layer** and their applications are connected to the AA-CADIS database server. One client maintains the RPRS and the other maintains the RECS of the core business processes. RECS was implemented as a Bentley Map application and RPRS as Microsoft Windows application. The basic framework is Microsoft .Net.

The **service layer** provides the services which can be used by the applications at the client layer as well as by external applications. Two components reside on the service layer, namely AA-CADIS and AA-LIS. The AA-CADIS WIS (Web Information System) provides services such as map services, which are used by the client layer. This component also provides the centralized user management and authentication service. AA-LIS provides services which can be used by external users outside IPRIA and is the foundational infrastructure for applications which make use of the cadastral data. All services on this layer are provided as web-services, either as standard OGC services such as WMS or WFS or as AA-CADIS specific services (eg user authentication). AA-CADIS specific services are implemented in Microsoft .NET Framework.

The **data layer** holds the database consisting of two logical data sets. One set is for the real property (non-spatial) data while the other contains spatial data and its descriptive attributes. Both sets form the CCDB which is the basis of AA-CADIS. These two data sets are logically separated to reduce the complexity of the system and ensure simplicity of operation. They are stored separately and can be used independently, but are also linked to each other. The RPRS is capable of identifying or displaying the linked data of the RECS and vice versa.

The real estate cadastral data set contains three types of data; parcels, buildings and fences. Parcels cover the entire area of Addis Ababa. A parcel is classified as a plot of land with legally defined boundaries. A parcel has several attributes such as size, parcel type, etc. and can be owned by an individual or entity. The second type of spatial data is buildings and their attributes. A building must be owned by an individual or an entity. The third type of spatial data is fences. In contrast to parcels and buildings which are closed polygons, fences are polylines. They display the boundaries of parcels and are owned by the owners of adjacent parcels.

The real property registration data set consists of data of ownership and all associated attributes. Ownership relates to a parcel and/or a building.

The data layer stores the application data, which consists of two separate components, namely the CCDB and the AA-LIS database (DB). Both components are implemented in Oracle 11g R2 using the Oracle Spatial Option for storing and maintaining spatial data. Workspace Manager is also used for the versioning. All access to the CCDB and AA-LIS DB is done via SQL-Net and (Oracle) SQL.

All registration offices work with the current data while head office owns and maintains the data. The two client applications only use the necessary relevant data from both data sets and can only change the data applicable to their specific tasks. This helps ensure data security.

The following figures (Figure 29, Figure 30, Figure 31, Figure 32, Figure 33, Figure 34, Figure 35, Figure 36) step through the "new ownership" creation process as run from the real property registration system (RPRS).

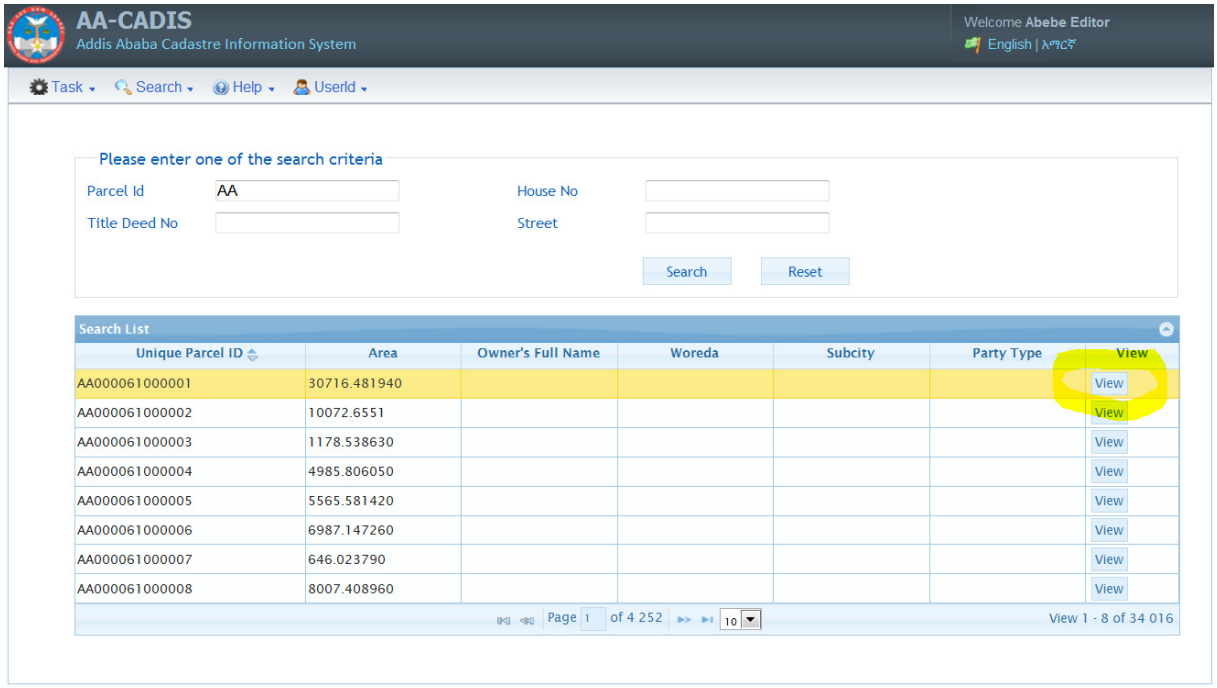

Figure 30: Locating relevant parcel in RPRS (Source: Hansa Luftbild, 2012)

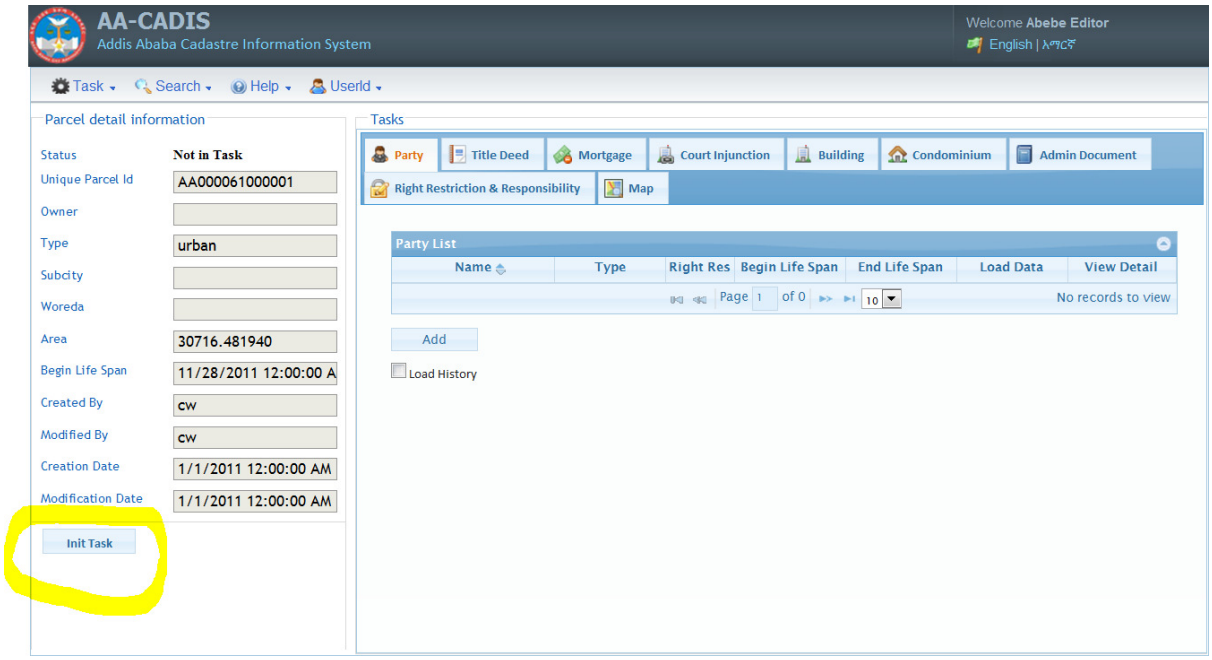

Figure 31: Parcel information form open for initiating task (Source: Hansa Luftbild, 2012)

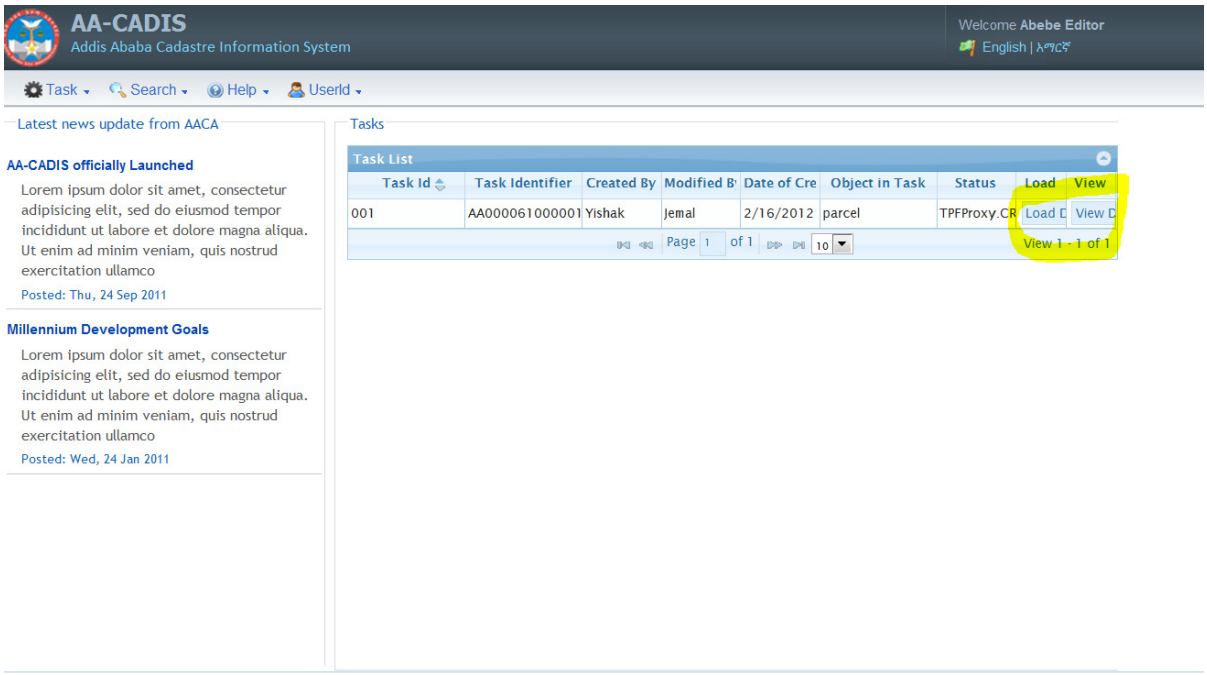

Figure 32: Parcel in task list and can be loaded for editing (Source: Hansa Luftbild, 2012)

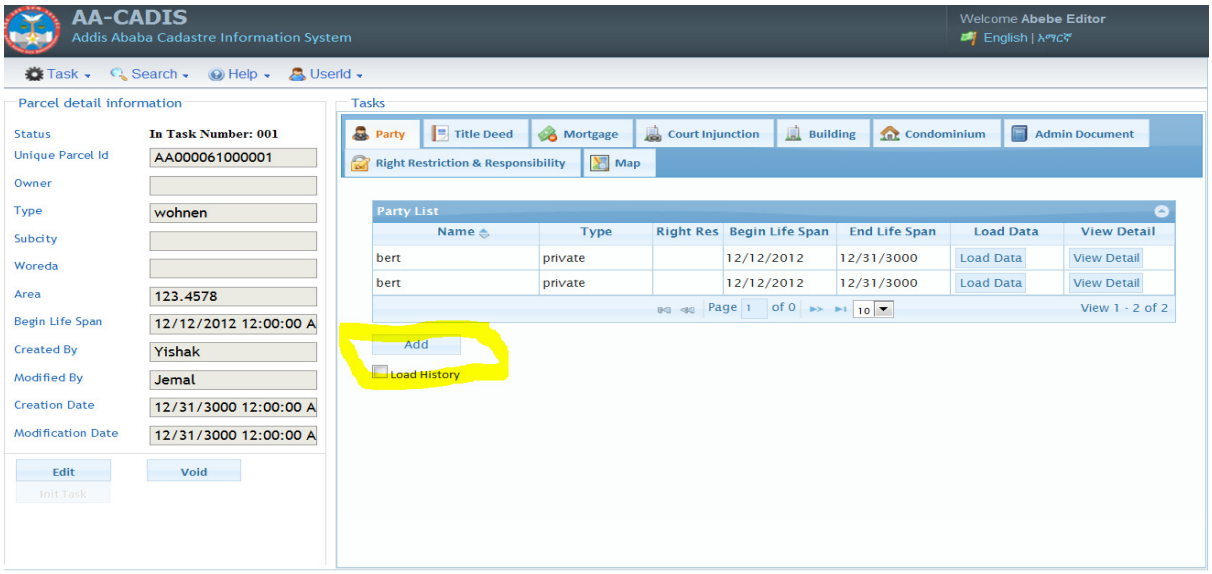

Figure 33: Editing form to add parcel owner (Source: Hansa Luftbild, 2012)

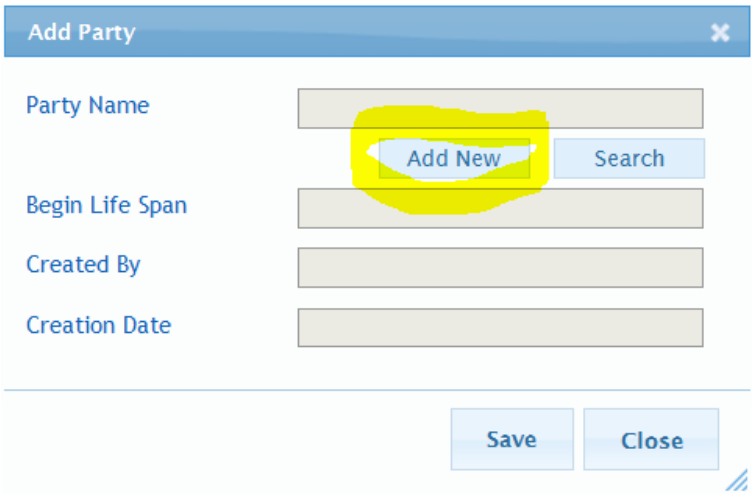

Figure 34: Adding a new parcel owner (Source: Hansa Luftbild, 2012)

Figure 35: Form to add new owner (Source: Hansa Luftbild, 2012)

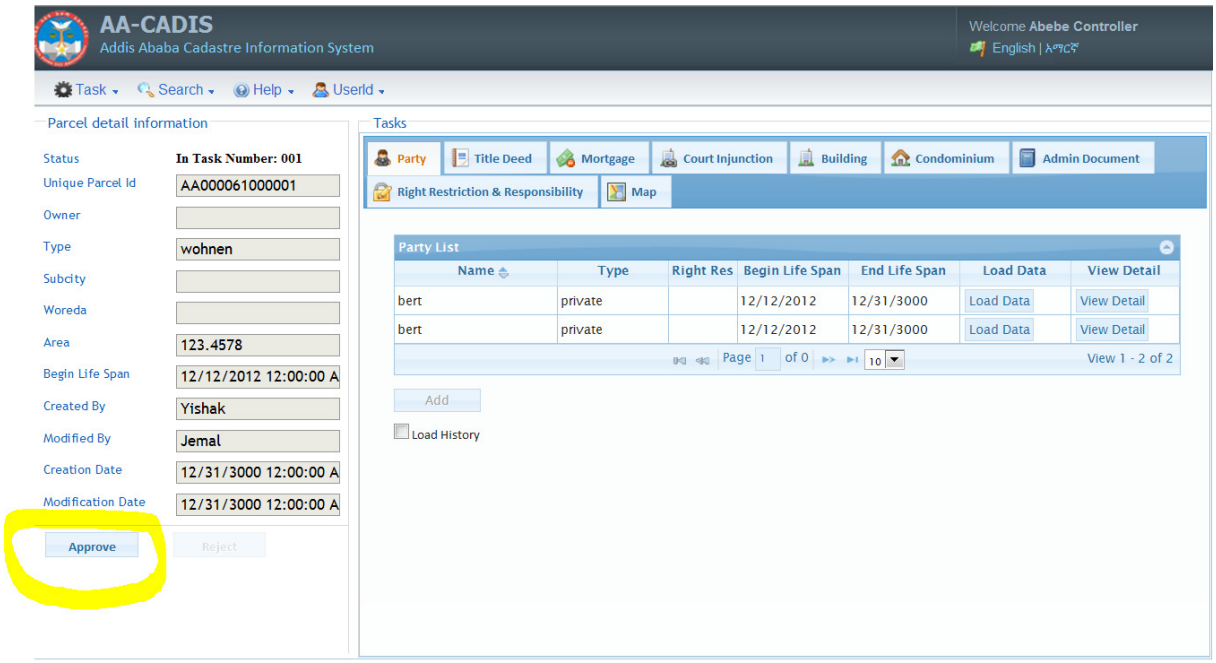

Figure 36: After inputting the details of new owner the controller logs on and checks the details prior to approval (Source: Hansa Luftbild, 2012)

Conclusion

In conclusion the Addis Ababa City Administration in close co-operation with Hansa Luftbild was able to develop a new street addressing system and two working and practical real property registration and land information (cadastre) systems within the confines of the infrastructure available. These two fully functioning systems are being used to support many services and will develop the confidence and trust of the public with regard to legal ownership of property. During the development period the local staff acquired skills and thus are able to run the systems independently. The two systems are populated with up-to-date cadastral map data produced by Hansa Luftbild and run at the newly established real property registration agency of the city. As well as being specifically tailored to AACG specifications the two systems were simultaneously developed to comply with international and Open Geospatial Consortium (OGC) standards, thus guaranteeing their transparency and interoperability locally, regionally and internationally. From this perspective the solution in Addis Ababa can be seen as a blue print for Ethiopia at a national level and as potentially utilizable throughout the African continent.

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