Catalyzing Innovation

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THE INNOVATIVE NATIONAL RURAL LAND ADMINISTRATION INFORMATION SYSTEM OF ETHIOPIA

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Abstract

The National Rural Land Administration System (NRLAIS) of Ethiopia was developed and implemented for the country's Ministry of Agriculture to harmonize the rural land administration. The system was developed on the basis of free and open source software (FOSS) components, applies the ISO Land Administration Domain Model (LADM) standard and provides Open Geospatial Consortium compliant services. It stores all data, geometries and their associated textual information. The architecture is innovative and follows a modular "toolkit" approach. The system can easily be adapted for the different legal requirements of the Ethiopian regional states. It applies unique holding and parcel identification numbers. It represents all processes of the Ethiopian rural land administration which are carried out at the various administrative levels, from the central ministry to the district (woreda) level. The system also includes a mass registration solution for systematic land registration and a data migration tool to convert existing land records.

Key Words:

Land administration domain model, land information manager, mass land registration, open source software, rural land administration

Introduction

The Federal Democratic Republic of Ethiopia's land legislation gives significant powers to its regional states. Each of the nine regional states is responsible for the implementation of the land administration services within its region on the basis of the national laws and regional regulations. This situation has resulted in different regions implementing land administration systems in slightly different ways and some regions became more advanced than others in terms of numbers of parcels registered and the level of service being provided. Thus a harmonization of the land administration was needed to ensure transparency across all national administration levels. The Rural Land Administration and Use Directorate (RLAUD) of the Ministry of Agriculture (MOA), which is responsible for managing and administering the rural land, commissioned the development of a pilot Rural Land Administration Information System (NRLAIS) to Hansa Luftbild, Germany, in order to harmonise the rural land administration in the country. RLAUD was supported by the Responsible and Innovative Land Administration Project (REILA) during the harmonization process.

NRLAIS is a key strategic development within the land administration sector in Ethiopia and provides the required functionalities to manage the land administration datasets and administration services of the rural land. It is also the key element of the national ICT strategy for the standardisation and harmonization of the rural land administration. The contract covered the development and implementation of a pilot NRLAIS which was installed at selected sites. These sites are the Ministry of Agriculture in Addis Ababa, and in two regional states, at one zonal office in one state, and at two woredas (districts), one in each state.

The design and the development of the system is based on free and open source software (FOSS) components and applies the ISO Land Administration Domain Model (LADM) standard. With its innovative and cost-effective architecture and modular "tool-kit" approach it is independent of a fully functioning internet infrastructure and is easily adapted to cater for different legal requirements of the Ethiopian regional states.

The pilot system development also had a concurrent knowledge transfer programme running alongside it that effectively prepared the MOA and the regional staff to operate and manage the system. The knowledge transfer programme was carried out to support and develop the knowledge of the RLAUD staff at the central federal level so that the staff could take over the responsibility for the system operation, management and support after project completion. In addition, support was extended to cover the pilot sites at the regional level and woreda level especially during the operational acceptance testing.

Even though the pilot NRLAIS development was initially deployed and installed at selected sites only, the system functionalities were complete and catered to the needs of land administration according to the Rural Land Administration System (RLAS) manual of the Ministry of Agriculture. Thus, the system development

with all its phases from the requirements analysis, business process reengineering assessment, the system design and architecture to the implementation covered the entire system development process.

Hansa Luftbild engaged a local Ethiopian IT company, INTAPS Consultancy, during the system development and implementation. This ensured that the system could be sustained and maintained without the continued assistance of German system developers. The system development and implementation was completed in 2017. It is currently on trial in different regional states in Ethiopia. After the trial phase a large scale roll out of the system is planned for around 260 districts (woredas) throughout Ethiopia.

This paper describes the Rural Land Administration Information System (NRLAIS) and its components and the main phases of system development and implementation of the pilot system.

NRLAIS Description and Components

NRLAIS represents all the processes of the Ethiopian rural land administration carried out at the respective administrative levels from the Federal Ministry of Agriculture down to the districts (woredas). Accordingly, its functionality varies at each level. That is, at the central level a data aggregation system has been developed that can support the decision makers in implementing their policies by preparing and generating reports for all administered regions. Similarly, at the regional level the system performs advanced data processing and management of cadastral parcel data, as well as manages all zones/woredas within that region. At the zonal level it has the capability of viewing and carrying out administrative actions and functions. The land parcels and holdings are maintained and managed at the woreda (district) level. The system benefits the rural communities by improving their tenure security, contributing to the improvement of their livelihoods and supporting the conservation of natural resources as per the legal framework of the Ethiopian Government.

Central to the NRLAIS development is the “toolkit” approach to managing the functionalities of the system at different levels, with the ability to customise the toolkit for different regional states. For example, some regional states require administrative functions at the zonal level, others do not. In addition the system was developed and prepared in such a way that it can be adapted by any of the regional states in order to serve as their land administration system. These regional systems conform to the standards which are laid down nationally so that compatible data can be extracted at a national level by the Rural Land Administration and Use Directorate (RLAUD) and ultimately by other users through the future National Spatial Data Infrastructure.

The system was designed and developed so that over time additional zones and woredas can progressively be brought online, in addition to other regional offices, which were not covered by the pilot sites. NRLAIS

embraced all of the land administration functions that are carried out at each administrative level (the centre, the region, the zone and the woreda) as described in the technical requirements of the project. The required functionality is different at each level, and NRLAIS has effectively the following components:

- **Central level- CENLAIS** - the Central Land Administration Information System for data aggregation of all nine regional states of Ethiopia, and for supporting of the decision making and national policy development.
- **Regional level- REGLAIS** - the Regional Land Administration Information System with advanced data processing capabilities and cadastral parcel data management including the management of zones and woredas within the concerned region.
- **Zonal level- ZONLAIS** – the Zonal Land Administration Information System with capabilities to view and carry out administrative operations at the zonal level.
- **Woreda level- WORLAIS** – the Woreda Land Administration Information System located at the woreda level on which all land administration transactions are performed, ie it manages and updates holding/land rights and cadastral parcel data.
- **MASSREG** - the Mass Registration System consisting of supporting technical tools for systematic (mass) land registration (ie the Ethiopian second level land certification program) and for data migration. The latter tool allows the migration of existing land administration data which adhere to a set of defined standards.

CENLAIS, REGLAIS (ZONLAIS) and WORLAIS are internal components integrated in NRLAIS while MASSREG is an external separate component.

NRLAIS Design and Development

The development and implementation of the National Rural Land Administration Information System (NRLAIS) followed four main phases, which were design, prototyping, implementation and finalization.

Design Phase

Taking into account the requirements of the technical specification, NRLAIS was designed and developed based on inputs from the national stakeholders and the other donor funded projects in the Ethiopian land sector. This approach ensured that the architecture of the system is valid for all regional states of Ethiopia. Prior to the development of the system the Ethiopian regions had varying methods of identifying parcels and holdings. The harmonization of the land administration thus also meant harmonizing the parcel and holding identifications. Therefore, NRLAIS now makes parcel and holding identifications consistent across all regions by applying a unified identification method. This in turn will simplify the land tenure archiving at regional and federal levels.

As part of the design the requirements' analysis was conducted first. The main focus of the analysis was to clarify the requirements which directly affect the technical system. The analysis and specifications covered different topics, some of which were:

- Stakeholders
- Legal frameworks (national and regional)
- Situation verification in 4 Ethiopian regions (Tigray, Southern Nations, Nationalities and Peoples, Amhara and Oromia)
- Current business processes in relation to NRLAIS
- Existing land administration data and its migration to NRLAIS
- Land holding / parcel updating procedure related to the Ethiopian Rural Land Administration System (RLAS) manual

After carrying out the requirements analysis the domain and conceptual model were determined. For the real property and cadastre domain, the ISO standard 19152, ie the "Land Administration Domain Model (LADM)", was used to define the land administration information system conceptual model. LADM was adapted to the requirements of the rural land administration sector of Ethiopia.

The data model was structured as four main packages plus one support package. These packages were:

- Party
- Administration
- Source
- Spatial
- Auxiliary Classes

The "Auxiliary Classes" package was used to model common structures such as code lists or common attribute sets. In contrast to the standard LADM, the adminSource concept was modelled in a separate package which was titled "Source" and was not part of the administration package. Figure 1 shows an overview of the conceptual data model which was applied in NRLAIS.

The reason for this change was that the source package was defined as the conceptual link to the archive which was associated to all other main packages. The conceptual model of NRLAIS was therefore a tailored implementation of LADM, ie not all concepts of LADM were implemented. For example, the versioning of objects as defined by LADM was not implemented, as defined in the standard, because NRLAIS uses a different approach for historization as shown in Table 1.

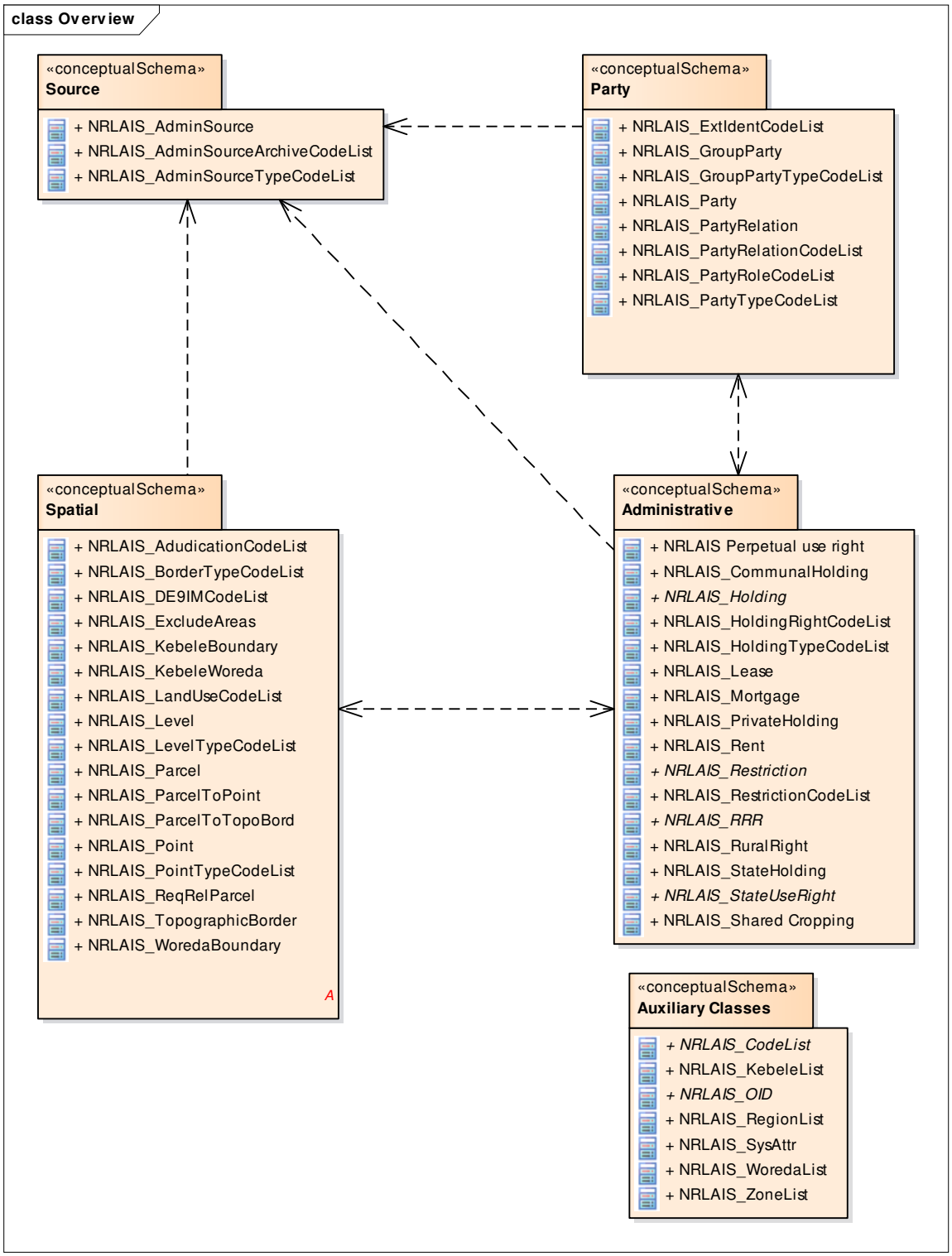

Figure 1: Overview of the conceptual data model applied in NRLAIS (source: Hansa Luftbild AG, 2019)

Name	Description
NRLAIS_Inventory	The area which contains the actual valid states in NRLAIS with legally valid information.
NRLAIS_History	This area contains previously valid states of NRLAIS ie information in this area was legally valid in the past
NRLAIS_Transaction	This area contains the states, which become valid after a transaction is completed and approved. These states are available temporarily during a transaction only. Information in this area can become legally valid after committing a transaction.

Table 1: Areas of the NRLAIS data model (source: Hansa Luftbild AG, 2019)

The three areas shown in Table 1 each contains the same domain specific information; and therefore, the class model on the level of the conceptual model is identical.

System Use Cases

Twenty one system use cases were defined on the basis of the findings of the requirements analysis and the Rural Land Administration System (RLAS) manual. This manual, which constituted an important input in the development of NRLAIS, was compiled using the experience gained during the systematic second level land certification (SLLC) process in Ethiopia. It covers the continuous updating process and describes in a structured and transparent way the processes (procedures, data, and actors) for various land transactions. Furthermore, the RLAS manual delivers (standard) forms for the land holder to apply for a land transaction.

The Rural Land Administration System (RLAS) manual defines the roles which are responsible for the execution of a land transaction. These roles are the land expert at the sub-district (kebele), the land expert at the district (woreda), and the land registrar at the district. However, during the requirements specifications it was decided to define the role of the land expert at the sub-district level to that of a land officer. Thus, the land officer registers the case application, the land expert processes the transaction on the case, and the land registrar (supervisor) approves and commits the changes created by the transaction.

Figure 2 and Figure 3 show two sample diagrams of two of the system use cases, which were defined and implemented in the NRLAIS.

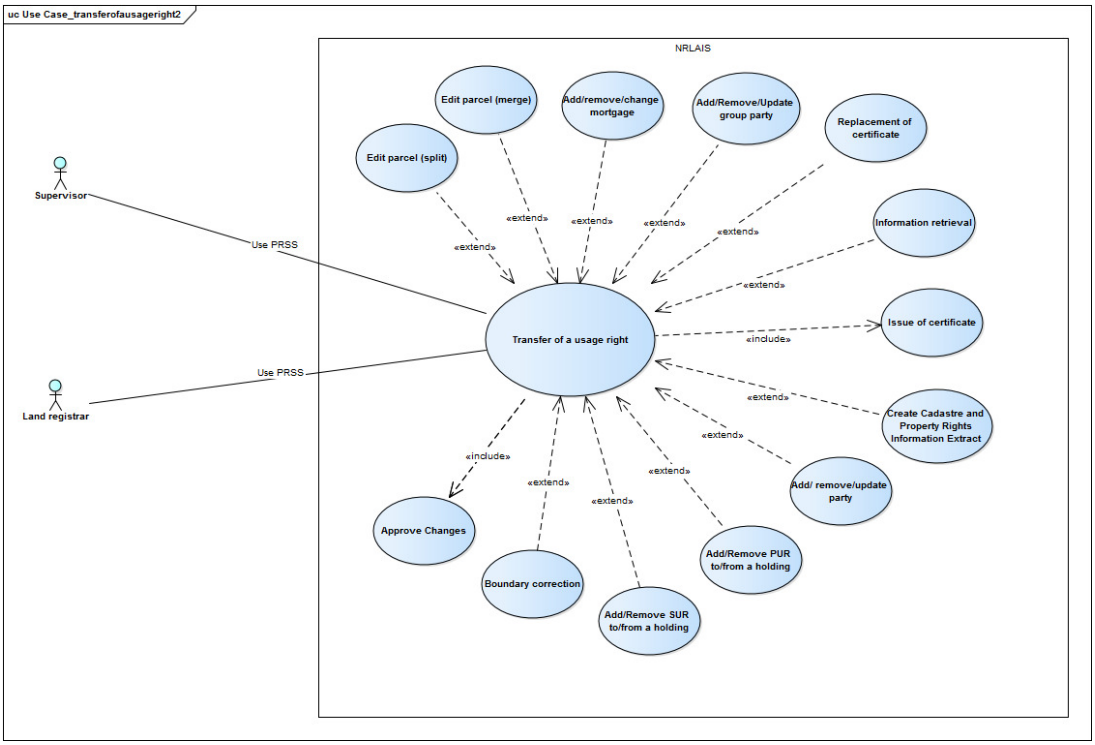

Figure 2: Use case diagram of the “Transfer Usage Right” case (source: Hansa Luftbild AG, 2019)

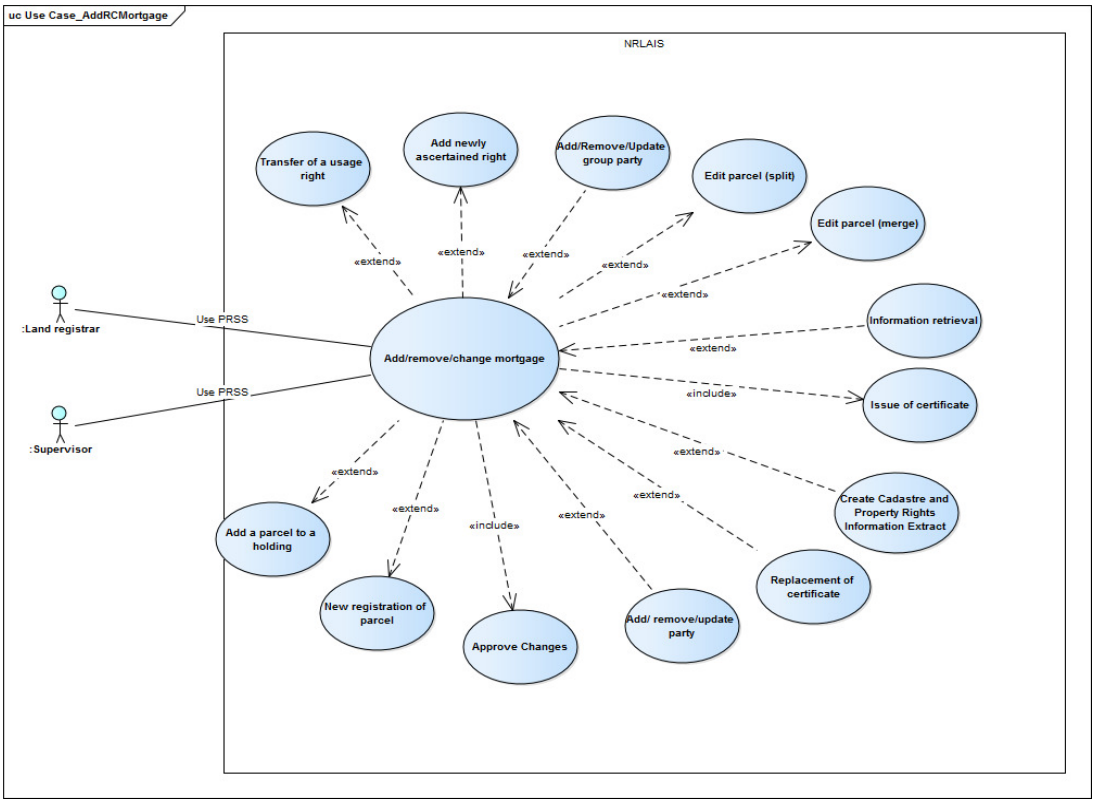

Figure 3: Use case diagram of the 'Add/remove/change mortgage' case (source: Hansa Luftbild AG, 2019)

NRLAIS Architecture

The National Rural Land Administration Information System (NRLAIS), as a national system, is required to provide functionalities for different administrative levels, ie from district to central. The system requirements were associated to the specified system components of NRLAIS, which are the Woreda Land Administration Information System (WORLAIS), the Zonal Land Administration Information System (ZONLAIS), the Regional Land Administration Information System (REGLAIS) and the Central Land Administration Information System (CENLAIS).

Though the Mass Registration System (MASSREG) is a component of NRLAIS it is not integrated in the architecture of the system and was implemented as an external separate component of the system. The basis of MASSREG is iMASSRE,G, a development which is used by the Land Investment for Transformation Programme (LIFT) during the second level land certification (SLLC) process.

NRLAIS was designed and developed on the basis of different components and sub-systems to ensure the adherence to the toolkit approach. These sub-systems are:

- Web information provision sub-system (WIPSS) - developed as a read only service, which accesses the land register and the cadastre database.
- Property registration sub-system (PRSS) - implemented as a web application and is responsible for the maintenance of the land register (read and write access).
- Cadastre maintenance sub-system (CMSS) - implemented as a customized application inside QGIS.
- Process sub-system (PSS) - a web application responsible for the process management at the server level. It handles data processes and security issues during the transactions. The data of the processes are stored in the main database.
- Database (DB) - separated into three different types of databases: inventory database, transaction database and history database.
- Document management sub-system (DMSS) - an archive system implemented as an interface for web-based indexing and document retrieval services.
- Service level - provides web services for accessing the data in the land register and the cadastre. The spatial data services are OGC compliant and cover the WFS (Web Feature Service) and the WMS (Web Map Service).

Figure 4 shows the system overview of NRLAIS at the different organisational levels, ie CENLAIS, REGLAIS, (ZONLAIS) and WORLAIS, in relation to the afore-mentioned sub-systems. Figure 5 shows the overview of the different sub-systems and services vis-à-vis NRLAIS.

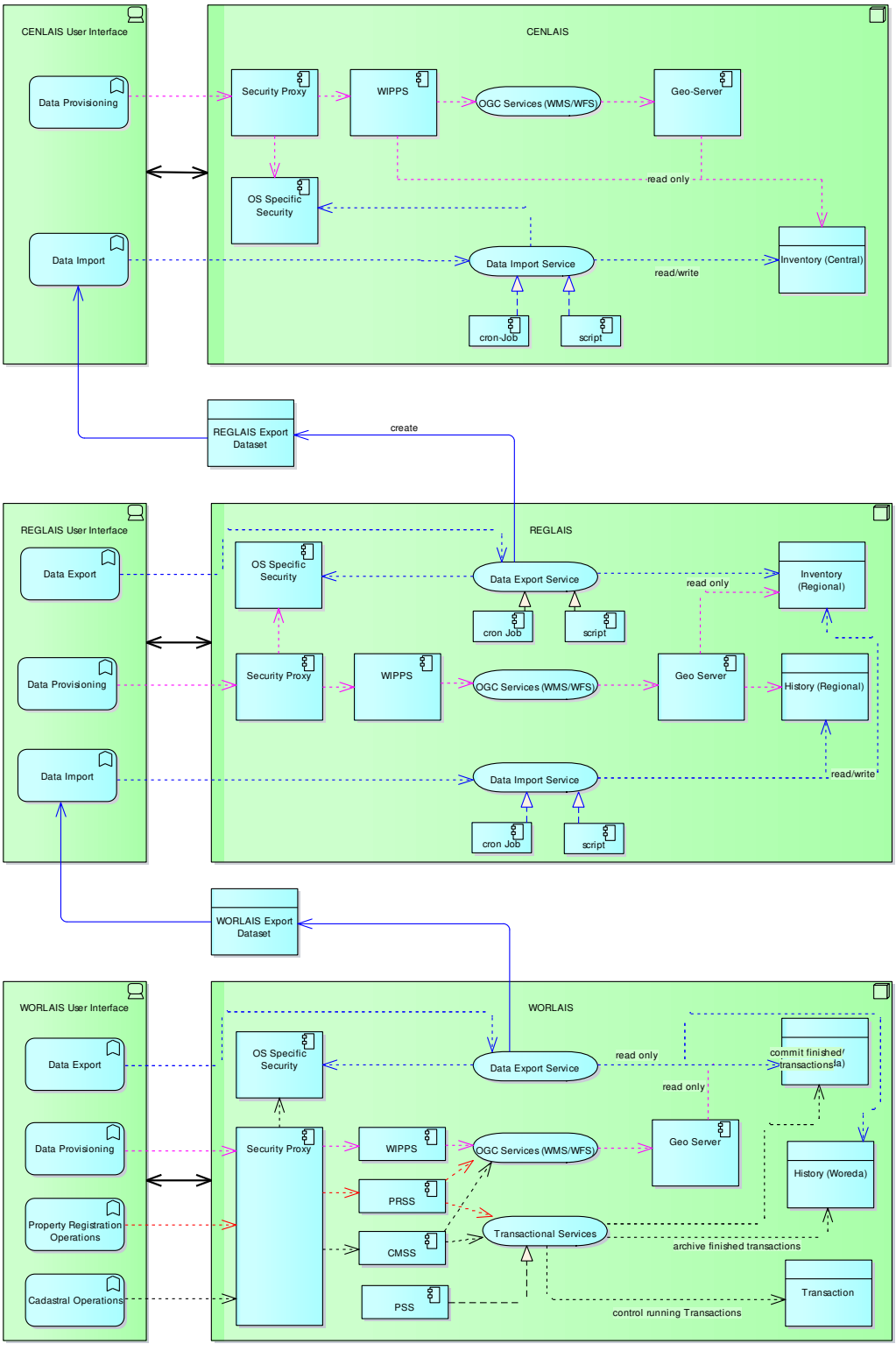

Figure 4: System overview of NRLAIS with the CENLAIS, REGLAIS, (ZONLAIS) and WORLAIS components (source: Hansa Luftbild AG, 2019)

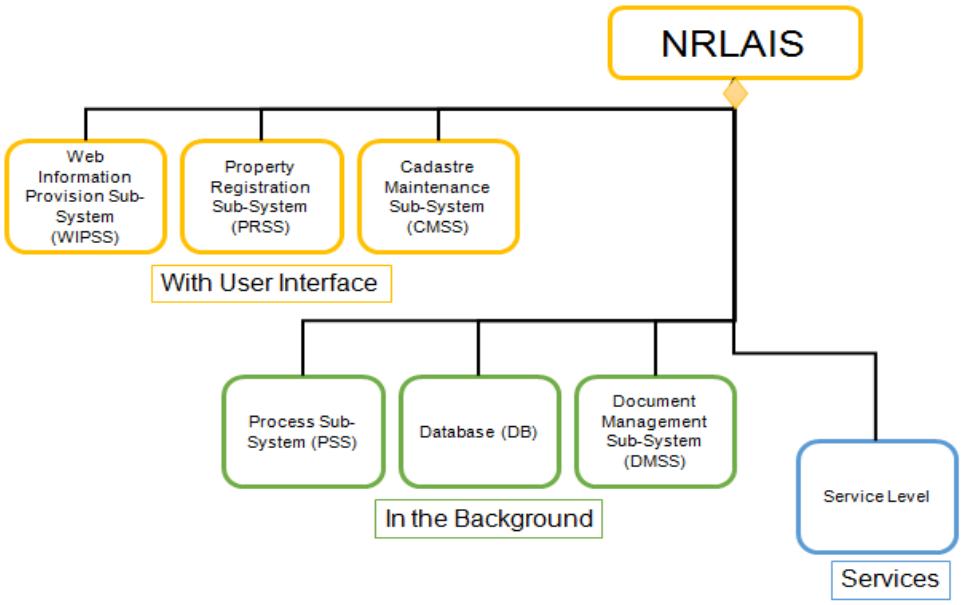

Figure 5: Overview of the different sub-systems of NRLAIS (source: Hansa Luftbild AG, 2019)

The Woreda Land Administration Information System (WORLAIS) is an integrated land administration system and constitute the productive system of NRLAIS. It allows the management and the maintenance of property rights and cadastral information. All transaction relevant processes such as the management of property rights and cadastral data are carried out with the property registration sub-system (PRSS) and the cadastre maintenance sub-system (CMSS). At the back end, the inventory, transaction and history databases allow the transaction data management and archiving, which is controlled by the process sub-system (PSS). WORLAIS data can be exported (replicated) and aggregated to match the requirements of the the Regional Land Administration Information System (REGLAIS).

Data from the districts (woredas) serve as an information source within REGLAIS, no transactions are conducted above the woreda level. The information service is provided by the web information provision sub-system (WIPSS) and the process sub-system (PSS). In addition, data can be archived at the regional level. The data exchange from WORLAIS to REGLAIS and from REGLAIS to the Central Land Administration Information System (CENLAIS) is conducted by import and export functionalities in WORLAIS and REGLAIS, respectively. CENLAIS serves as an information system only and has no data archiving functionality implemented in it. On the basis of the NRLAIS requirements the extent of functionalities of each of the six sub-systems was gradually reduced from the woreda level to the central level. That is, while all sub-systems encompass WORLAIS two sub-systems encompass REGLAIS and CENLAIS. The twenty one system use cases, which were identified during the requirements specification, are mapped to the sub-systems of NRLAIS as is shown in Table 2.

Use Case No.	Use Case Name	Covered in System / Sub-System
1.	Transfer of a usage right	WORLAIS - PRSS
2.	Add rent/shared cropping right	WORLAIS - PRSS
3.	Add/remove/update party	WORLAIS - PRSS
4.	Change party role	WORLAIS - PRSS
5.	Add/ remove relationships between parties	WORLAIS - PRSS
6.	Add/remove/update group party	WORLAIS - PRSS
7.	Add newly ascertained right	WORLAIS – PRSS
8.	Add/remove/change mortgage	WORLAIS – PRSS
9.	Edit parcel (split)	WORLAIS – PRSS; WORLAIS - CMSS
10.	Edit parcel (merge)	WORLAIS – PRSS; WORLAIS - CMSS
11.	New registration of parcel	WORLAIS – PRSS; WORLAIS - CMSS
12.	Boundary correction	WORLAIS – PRSS; WORLAIS - CMSS
13.	Add/remove perpetual usage right (PUR) to/from a holding	WORLAIS – PRSS
14.	Add/remove state usage right (SUR) to/from a holding	WORLAIS – PRSS
15.	Change holding type	WORLAIS – PRSS
16.	Add a parcel to a holding	WORLAIS – PRSS; WORLAIS - CMSS
17.	Information retrieval	CENLAIS-, REGLAIS-, ZONLAIS-, WORLAIS-WIPSS
18.	Create cadastre and property rights information extract	WORLAIS – PRSS
19.	Issue of certificate	WORLAIS – CMSS
20.	Replacement of certificate	WORLAIS – CMSS
21.	Approve changes	CENLAIS-, REGLAIS-, ZONLAIS-, WORLAIS-PSS

Table 2: System use cases identified during the requirements specification mapped to the sub-systems of NRLAIS (source: Hansa Luftbild AG, 2019)

As mentioned previously the other NRLAIS component is the mass land registration system MASSREG. This software tool is used for mass land registration in the second level land certification (SLLC) process. MASSREG provides the following broad functions that facilitate the SLLC work:

- Data entry
- SLLC workflow management
- Certificate preparation
- Transferring certified parcel records to the Woreda Land Administration Information System (WORLAIS)

MASSREG was developed to include different applications such as the web application being the main interface, a mobile Android mapping application for collecting spatial adjudication data in the field, and a data migration tool. After mass registration the legal data and the spatial data are migrated to NRLAIS. In addition, MASSREG incorporates the migration tool which allows data migration from old land administration systems to NRLAIS.

International IT standards and a best practices approach were applied in the design and the development of the NRLAIS. These standards were:

- Standard web architecture
- Standard programming languages such as JavaScript (ECMAScript 5) or Python
- SQL standard
- Web standards such as HTML, HTTP, XML, SOAP
- UML standard
- LADM standard
- OGC standard

Prototype Phase

NRLAIS was developed as an evolutionary prototype. The evolutionary prototyping main goal is “to build a very robust prototype in a structured manner and constantly refine it. The reason for this approach is that the evolutionary prototype, when built, forms the heart of the new system, and the improvements and further requirements will then be built”

When developing a system using evolutionary prototyping, the system is continually refined and rebuilt. This technique allows the development team to add features, or make changes that couldn't be conceived of during the requirements specification and design phase.

Hansa Luftbild developed the NRLAIS system with open source software. The advantages of open source are manifold for the client. These are:

- The system can be installed on as many nodes as needed, without license costs.
- Reduced costs for base software. The system can operate on Linux. For example, if all 800 woreda sites run two servers each, then the cost of the server operating system will be significantly more if proprietary software was used.
- Due to the availability of the source code, changes to the user interface to accommodate local languages is possible.
- Stable and community driven development processes; PostgreSQL, for example, has been under continuous development without interruption since 1997.

Table 3 lists the standard open source software components, which were used in the development and implementation of NRLAIS.

Component Name	**Usage**
PostgreSQL	Database management system. PostgreSQL was used in all components of NRLAIS for storage of structured and semi-structured data
PostGIS	Extension for PostgreSQL was used to handle spatial data.
QGIS	Desktop GIS was used in NRLAIS for high-end editing, visualisation and analysis of geospatial data.
GDAL/OGR	Converting different GIS formats
Geoserver	Geoserver used in all components of NRLAIS for OGC compliant services such as WMS or WFS
MapProxy	MapProxy used as proxy to encapsulate WMS requests for performance and security reasons
node.js	Application environment
Python	Customisation of QGIS

Table 3: List of standard open source software used in the development of NRLAIS (source: Hansa Luftbild AG, 2019)

Also a major software platform which was used to develop NRLAIS was ExperMaps. This is a WebGIS which was developed by Hansa Luftbild based on open source software. ExperMaps was used as the basis for the web-based geospatial client in NRLAIS.

Testing

Different types of testing were carried ou during the system development. The first tests were performed at the development sites in Germany and Ethiopia. These were unit, integration, system, functional, performance and acceptance tests.

Prior to the delivery of the evolutionary prototype (ie the base system) comprehensive use case tests (ie functional tests) were conducted. These tests covered 21 use cases. Figure 6 shows the use cases which were implemented as transactions in the Woreda Land Administration Information System (WORLAIS) of NRLAIS.

The initial NRLAIS prototype was delivered to the Ministry of Agriculture (MOA) with the test scripts prepared by the system developer. After the delivery of the NRLAIS evolutionary prototype the MOA conducted it tests on the base system using its own test scripts as well as Hansa Luftbild's test scripts. The results of the MOA tests were documented as remarks for changes and for bug fixes. The remarks were classified as general remarks as well as specific remarks related to the woreda, the regional and the central land administration information systems (WORLAIS, REGLAIS [ZONLAIS] and CENLAIS).

Figure 6: Transactions implemented in WORLAIS of NRLAIS (source: Hansa Luftbild AG, 2019)

The results of the base system testing were analysed by the system developer and issues were solved / bugs were fixed in the system. A few system upgrades / software patches were delivered to the Ministry of Agriculture (MOA) by the time the prototyping was completed and the operational acceptance testing (OAT) commenced.

Implementation Phase

This phase included two main sub-phases, which were:

- preparation of the pilot test plan and execution of the integrated operational acceptance testing, and
- training and knowledge transfer

Pilot Plan and Pilot Execution

An operational acceptance testing (OAT) plan was prepared which covered the acceptance of the project including the pilot system. Table 4 and Table 5 show the test types planned and conducted on the NRLAIS project.

Test Type	Requirements (Requirement source)
Review of in-house test	Review of technical documentation
Project document review	Review of technical documentation
Code review	Review of the source code and/or data structure to ensure their fidelity to the accepted technical documents
Pilot User Acceptance Test (UAT)	The system does not crash (does not stop responding while in operation)
	The responsiveness tests of the system
Performance Test	Testing the roll-back procedures
	The system is bullet-proof, meaning that it is resistant to various user-mistakes (e.g. pressing wrong keys, entering wrong data, etc.)
	The system can re-boot itself in the event of system failure (except in cases of hardware failure)
	The responsiveness tests of the system

Table 4: Test types for overall project acceptance (source: Hansa Luftbild AG, 2019)

The OAT of the pilot system was carried out applying a number of test scenarios for each NRLAIS component. Table 6 shows the number of test scenarios conducted on each system component.

Test Type	Requirements (Requirement source)
Pilot User Acceptance Test (UAT)	Requirement: completeness
	Requirement: Fulfilled technical requirements
	Requirement: successful operational acceptance testing of the pilot system
	Requirement: system requirements completed, ie does the complete and integrated system cover the system requirements
	Requirement: functional requirements
	Requirement: non-functional requirements
Performance Test	Requirement: system requirements completed
	Requirement: non-functional requirements, ie are all non-functional requirements of NRLAIS satisfied
	Requirement: requirements corresponding to the parameters defined by the contract, ie does the whole integrated system work within the parameters defined by the contract as agreed to between MOA and Hansa Luftbild

Table 5: Test types for operational acceptance testing of the pilot system (source: Hansa Luftbild AG, 2019)

System Component	WORLAIS	MASSREG	ZONLAIS	REGLAIS	CENLAIS
No. Test Scenarios	33	6	8	9	9

Table 6: Number of test scenarios carried out on each system component (source: Hansa Luftbild AG, 2019)

For each test carried out on the different components issue / bug reports were filed and provided to the system developer to review and rectify the issues / bugs. Table 7 shows the number of issues / bugs, which were reported during the operational acceptance testing (OAT) for each system component.

System level	WORLAIS	MASSREG	ZONLAIS / REGLAIS	CENLAIS
No. Issue / Bug Report	72	10	10	8

Table 7: Number of issues / bugs reported during the operational acceptance testing at each system component (source: Hansa Luftbild AG, 2019)

A few system upgrades and patches were delivered and installed during the implementation phase in which issues were solved or bugs were fixed.

During the prototyping and implementation phases as well as during the system warranty period an issue tracking system was used to manage the issues and bugs that were reported by the Ministry of Agriculture (MOA) testers during the base system testing and the operational acceptance testing (OAT). This helped the MOA testers track the issue solving and bug fixing process.

The total number of issues and bugs which were identified and reported, fixed and solved during the base system testing and the pilot implementation was 347. These were categorized and numbered according to the system components as shown in Table 8.

Issue / Bug Category	Number
WORLAIS	223
REGLAIS (/ZONLAIS)	19
CENLAIS	14
MASSREG	58
All system components	33

Table 8: Reported issues and bugs in NRLAIS (source: Hansa Luftbild AG, 2019)

During the operational acceptance testing (OAT) the source code and the data structure of NRLAIS were also reviewed and assessed according the following criteria:

1. Maintainability
2. Coding structure
3. Data structure
4. Testing and code analysis
5. Security aspects
6. Access to source code, build/maintain the system

The NRLAIS performance tests were also carried out in Germany and Ethiopia during the OAT. These tests were conducted on a set of test scenarios which were assessed according to predefined pass / fail criteria. Table 9 shows the scenarios applied for performance testing of the Woreda Land Administration Information System (WORLAIS) at the pilot woredas and the Regional Land Administration Information System (REGLAIS) at the pilot regional sites while Table 10 shows the pass / fail criteria which were applied.

No.	Name of Test Scenario	Description of Test Scenario
1	perf_load_textual queries	queries responding with text should be no more than 20.0 seconds
2.	perf_load_parcel_map	display a parcel map --- less than 10 seconds

No.	Name of Test Scenario	Description of Test Scenario
3.	perf_load_kebele_map	a complete kebele base map shall be shown within 15 seconds
4.	perf_availability_system	restart of the system

Table 9: Test scenarios of performance testing (source: Hansa Luftbild AG, 2019)

No.	Risk/Event	Consequence	Impact	Counter measures
1	queries responding with text should be no more than 20.0 seconds	Performance does not comply with criteria	Insufficient performance	Discover bottlenecks in the system and avoid them if possible
2	to display a parcel map --- less than 10 seconds	Performance does not comply with criteria	Insufficient performance	Discover bottlenecks in the system and avoid them if possible
3	A complete kebele base map shall be shown within 15 seconds	Performance does not comply with criteria	Insufficient performance	Discover bottlenecks in the system and avoid them if possible

Table 10: Pass / fail criteria applied for performance testing of NRLAIS (source: Hansa Luftbild AG, 2019)

The NRLAIS passed all the performance tests.

A review of all technical documents delivered by the project, which covered the design documents and the system manuals, was carried out. The documents were reviewed according to 7 criteria:

1. Terminology
2. Accuracy of the content and completeness
3. Structure and clarity
4. Internal consistency
5. Ease of understanding
6. Support for training
7. Supporting the next phase

The following figures show samples of WORLAIS and MASSREG user interfaces.

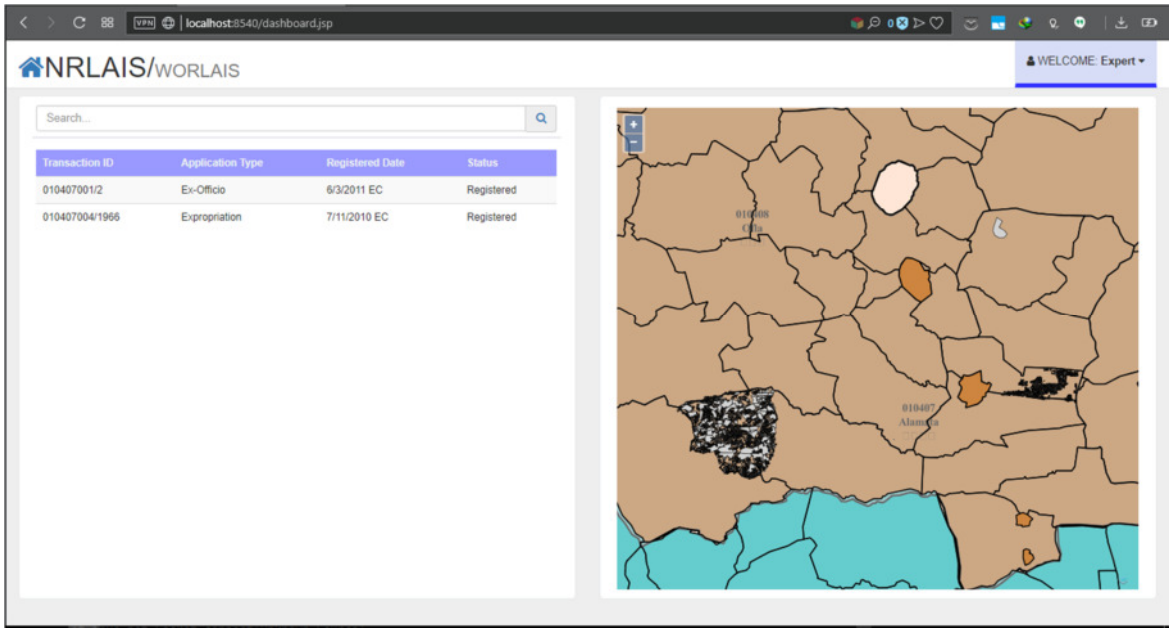

Figure 7: Land expert dashboard in the Woreda Land Administration Information System - WORLAIS (source: Hansa Luftbild AG, 2019)

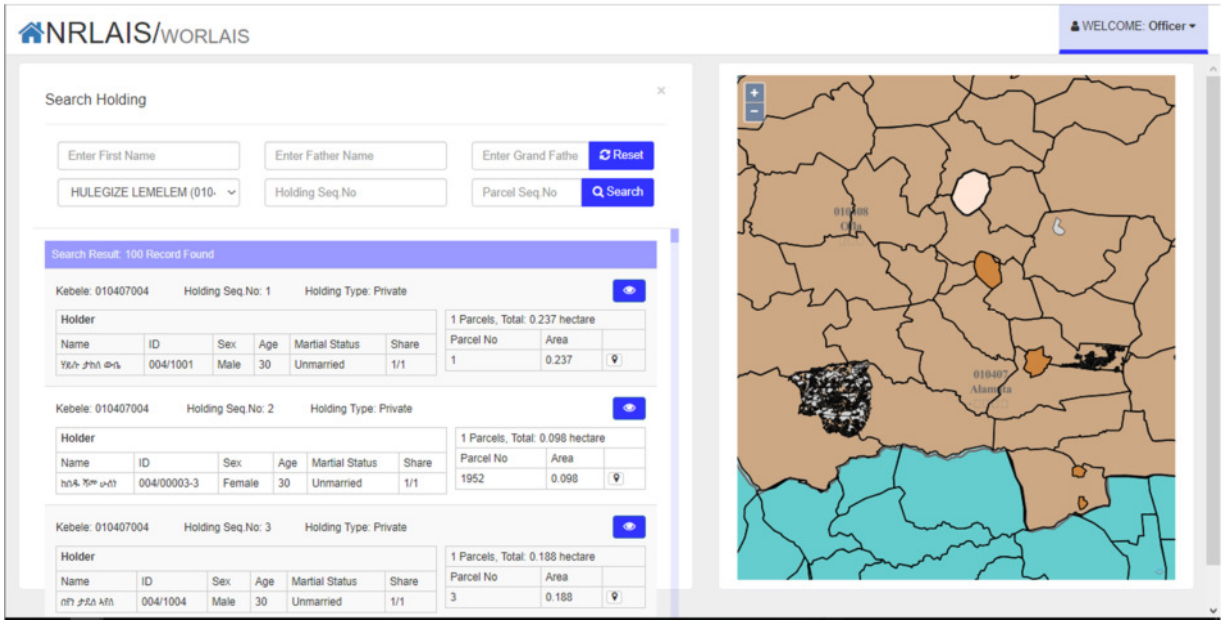

Figure 8: Woreda Land Administration Information System - WORLAIS data browser (source: Hansa Luftbild AG, 2019)

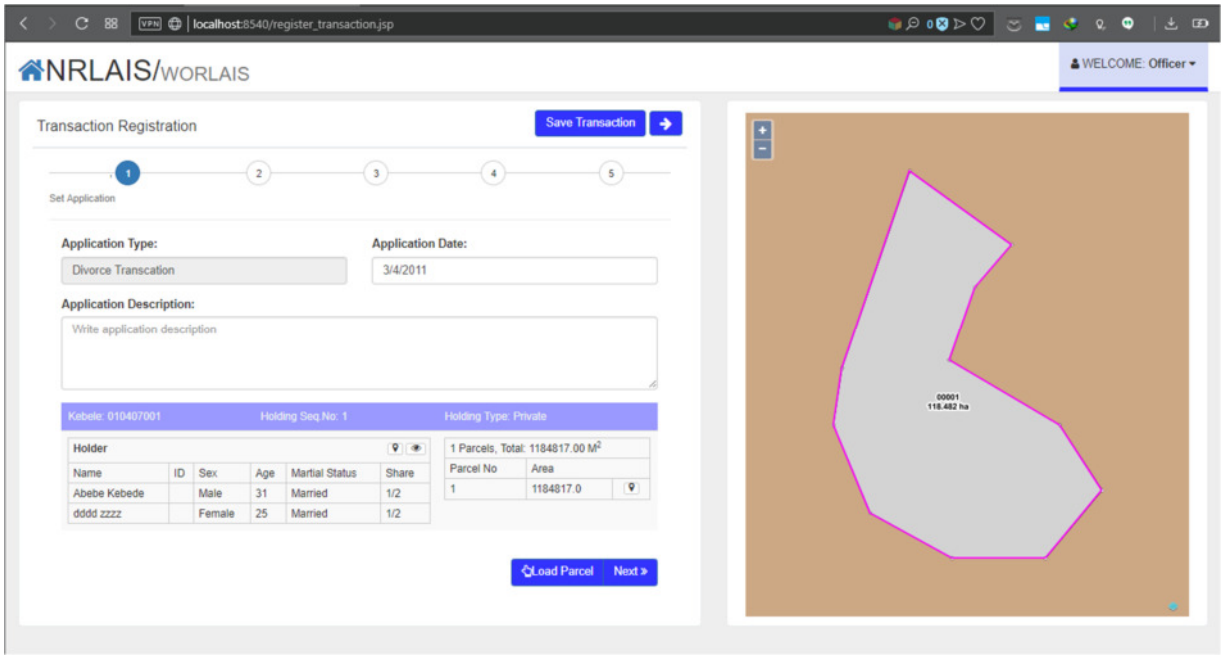

Figure 9: WORLAIS application registration of a land transaction (source: Hansa Luftbild AG, 2019)

Figure 10: WORLAIS Ex-Officio transaction details (source: Hansa Luftbild AG, 2019)

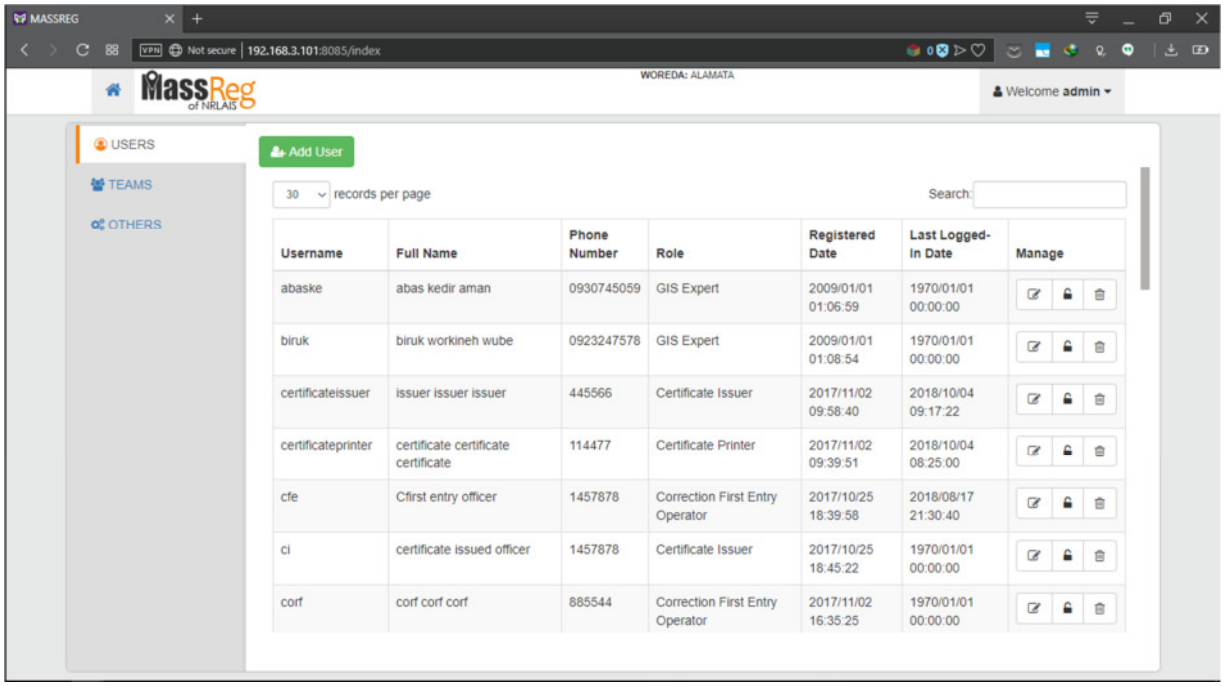

Figure 11: Managing user access in MASSREG (source: Hansa Luftbild AG, 2019)

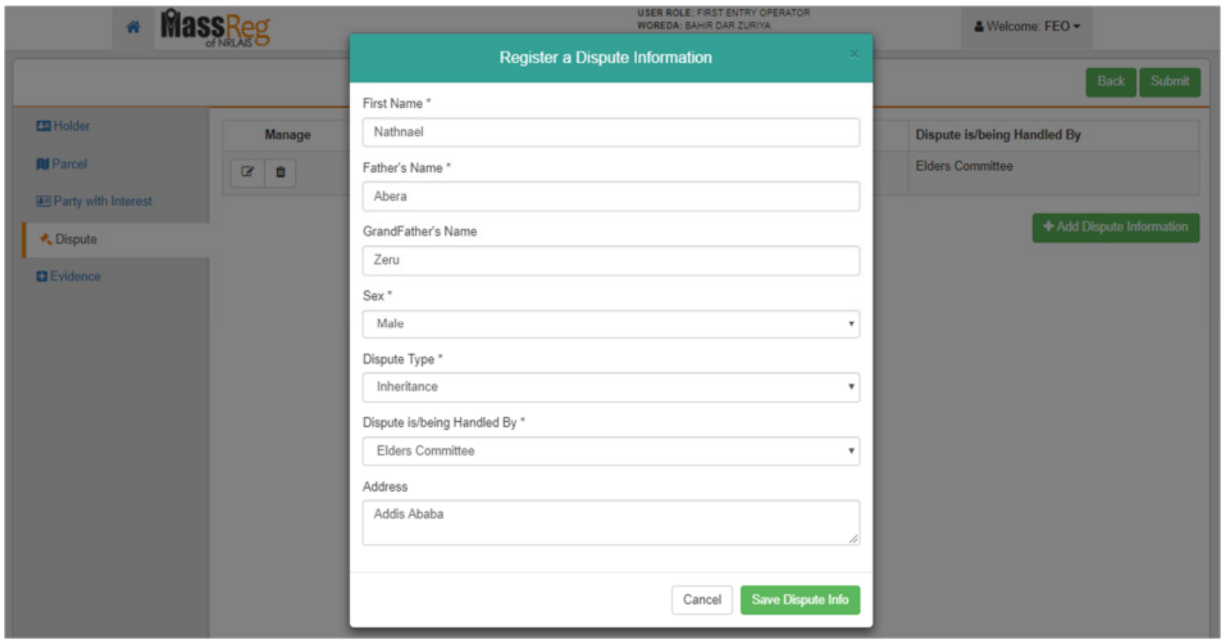

Figure 12: Registering a dispute in MASSREG (source: Hansa Luftbild AG, 2019)

NRLAIS has large built-in reporting capabilities. Reports can be generated using these built-in functions (49 standard reports are available) or by using the system relevant tools provided by PostgreSQL and QGIS. Standard report generation is available across all the NRLAIS components. A significant number of reports are related to the Woreda Land Administration Information System (WORLAIS) component only.

Reporting functions read data only and do not modify data. The standard reports are generated via the web information provision sub-system (WIPSS) or the cadastre maintenance sub-system (CMSS). The WIPSS available standard reports are categorized according to predefined themes:

- Application and Documents
- Holders and Holdings
- Parcels (Parcels – Land Use and Rights)
- Rents and Leases
- Soil Fertility / Cropping
- Expropriations, Encumbrances and Disputes
- Transactions
- Replications and Audits
- Certificates

Figure 13 shows some of the standard report types available via the WIPSS. Reports are generated as PDF or CSV files.

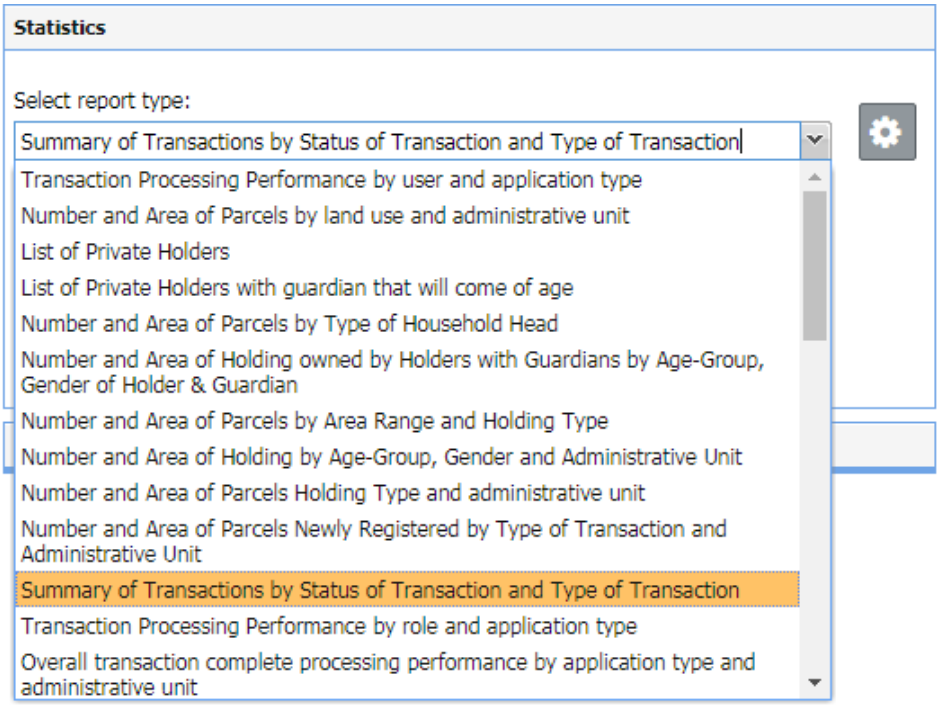

Figure 13: Standard report in NRLAIS web information provision sub-system -WIPSS (source: Hansa Luftbild AG, 2019)

Figure 14 and Figure 15 show samples of standard report generation in CENLAIS.

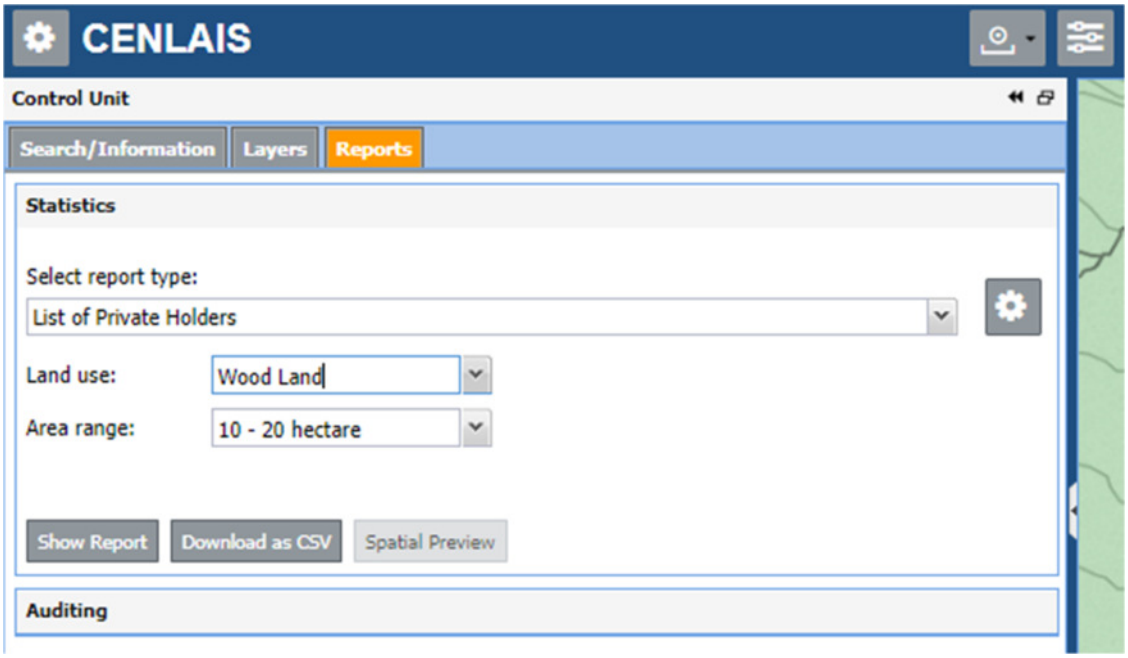

Figure 14: Standard report generation of land use and area size of private land holders in CENLAIS (source: Hansa Luftbild AG, 2019)

NRLAIS generated Report

Report generated on: 24/5/2011
By user: Expert
At: CENLAIS
About administrative unit: Ethiopia

Number and Area of Parcels by land use and administrative unit

For each land use type, there is the number of parcels and the total area in hectare.

Aggregation Level: nrlais_kebeleid

Admin. Unit	Undefined		Seasonal Cropland		Perennial Cropland		Evergreen Forest		Mixed Forest		Wood Land		Afro Alpine Vegetation		Closed Shrub Land		Open Shrub Land		Grass Land / Grazing		Deciduous Forest		Consolidated		Unconsolidated		Exposed Soil		Built-up Area		Water Body		Wet Land		Other		Total	
010407004			1518	432.22	5	1.62																													1523	433.84
030703011	13	61.58	3597	965.97	3	0.43																													3613	1027.98
030703015	60	14.52	4165	1273.51	12	0.67																							1	0.01					4238	1288.70
030703001	51	13.31	5523	1731.77	62	7.83					0.77	9																	1	0.05					5646	1753.73
030703021			3129	982.38	8	0.57			0.13	1																									3138	983.08
030703010	1	0.24	3833	1125.58	1	0.02																													3835	1125.84
030703023	102	23.48	6922	2375.91	54	6.74					0.85	4																							7082	2406.95
030703002	23	73.83	3988	1292.50	7	1.40					98.36	2																							4020	1466.09
030703019	32	86.40	5199	1450.23	65	9.04																													5296	1545.67
030703014	29	5.94	1982	620.74	27	2.32					0.56	7																	4	0.44					2049	630.00
030703013	63	93.78	2366	693.62	26	3.76					0.27	2																							2456	791.43
030703008			1	78.59																															1	78.59
030703012	33	5.63	5232	2038.56	36	2.24					0.89	7																							5308	2047.32
030703003	36	37.64	4723	1431.71	12	1.38																													4771	1470.73
030703031	10	2.24	1343	383.54	7	1.86																							1	0.27					1361	387.91
030610024	5	2.09	3592	1385.23							0.66	4																							3601	1387.98
030610007			1622	664.20																									1	0.09					1623	664.29
030610005			2481	1090.26							0.36	2																							2483	1090.62

Figure 15: Generated report of number and areas by “Wood Land” land use in CENLAIS (source: Hansa Luftbild, 2019)

Training and Knowledge Transfer

The availability of well-trained and qualified staff was crucial for the success of the National Rural Land Administration Information System (NRLAIS) project. It was essential to train and qualify staff, selected

by the Ministry of Agriculture (MOA), at the operational and administrative levels to ensure successful operation and management of the system.

Workshops and training were carried out in

- use and administration of NRLAIS with all its components
- data migration
- system awareness and concepts
- knowledge transfer

The training curricula and programs were developed for two different groups - the system administrators and the end users. Trainees were selected and nominated by the Ministry of Agriculture (MOA) based on the profile requirements defined by the system developer. Both training programs for system administrators and end users covered specific training topics and user types relevant to all system components.

The system administrator training trained system administrators of the NRLAIS pilot sites. The training consisted of a mix of theoretical sessions and practical exercises consisting of 4 modules and running over a period of 16 days.

End user training trained system users of the NRLAIS pilot system. In general a mix of theoretical sessions and practical exercises were given in which the participants learned how to use and operate the system. The end user training program covered both beginners and advanced levels. This program consisted of 5 training modules running over a period of 14 days. End user training also covered legal aspects of land administration and provided background knowledge about the system.

In addition to the end user training a training in using the data migration tool implemented in the mass registration system component (MASSREG) was also given. Here an initial 5 day training was carried out training users on migrating data of different formats to NRLAIS. This initial training was followed by an advanced one day training which was conducted at the end of the end user training.

An awareness workshop and a knowledge transfer workshop were also run to introduce NRLAIS to different stakeholders and to give in depth knowledge of the NRLAIS architecture and testing.

The system awareness workshop was conducted in January 2016 and covered the following topics:

- Requirements analysis
- Cooperation with the Land Investment for Transformation Program and adopting iMASSREG to MASSREG
- Modelling land holders as LADM party

- System testing
- System architecture
- Data migration

Different stakeholders attended this workshop.

The knowledge transfer workshop, which was held in December 2016, covered the system architecture and software and usability testing. The following topics were presented and discussed during this workshop:

Architecture Design

- Introduction to software architecture, including key principles of software architecture
- Architecture of NRLAIS
- Documentation standard used for documenting NRLAIS architecture

Software Test

- Introduction to software test, including the key principles of software test
- Methodology for different types of software testing, including but not limited to:
    - Functional testing
    - Non-functional testing
    - Structural testing
    - Change related testing
- Preparation of software test plan including techniques for generating test cases
- Setting up the test environment for NRLAIS
- Test result documentation

Usability Test

- Definition
- Guide
- Tutorial
- Planning and recruiting
- Running usability test
- Analysis and reporting
- System usability scale

Finalization Phase

This phase consisted in the main of implementing three Ethiopian local languages of the user interfaces, finalizing the technical documentation and setting the plans for the support during the warranty period and for the post-pilot system operation.

The NRLAIS user interface was implemented to cover different local languages. These are the Amharic, the Tigrinya and the Afaan Oromo local languages in addition to the English language interface.

The system has been documented as manuals for the users and the administrators. Table 11 shows the manuals, which were delivered with the system.

Item No	Title
1	WORLAIS User Manual
2	MASSREG User and Administrator Manual
3.	REGLAIS (ZONLAIS) User Manual
4.	CENLAIS User Manual
5.	WORLAIS System Manual
6.	REGLAIS (ZONLAIS) System Manual
7.	CENLAIS System Manual

Table 11: System documents delivered with NRLAIS (source: Hansa Luftbild AG, 2019)

The user manuals were also provided in the Amharic, the Tigrinya and the Afaan Oromo local languages in addition to the English language manuals.

The system developer prepared also a plan for system support services which were provided during the warranty period. The scope of support covered the pilot sites and covered:

- technical support and assistance; and
- service and user support.

These were provided to the users and the system administrators.

The modes of support, which were provided, were:

- telephone contact via a hotline with the local team,
- email contact, and
- on-site visits to the user site.

The warranty period of NRLAIS was for 12 months which expired on 31 December 2018.

A post-pilot operational plan was also prepared and submitted, which defined the options which are available to the Ministry of Agriculture after the pilot system has become operational. The plan covered two aspects:

1. new sites / regions adopting NRLAIS for their land administration and information services, and
2. system maintenance and support services.

Summary

The Federal Democratic Republic of Ethiopia's land legislation gives significant powers to its regional states. Each of these states is responsible for the implementation of the land administration services within its region on the basis of the national laws and regional regulations. This situation has resulted in different regions implementing land administration systems in slightly different ways and some regions became more advanced than others in terms of numbers of parcels registered and the level of service being provided. The National Rural Land Administration System (NRLAIS) was developed and implemented for the country's Ministry of Agriculture to standardize and harmonize the rural land administration in Ethiopia. The system was developed on the basis of FOSS components, applies the ISO Land Administration Domain Model (LADM) standard and provides OGC compliant services. It stores all data, geometries and their associated textual information. The architecture is innovative and follows a modular "toolkit" approach. The system can easily be adapted for the different legal requirements of the Ethiopian regional states. It applies unique holding and parcel identification numbers. It represents all processes of the Ethiopian rural land administration which are carried out at the various administrative levels, from the central ministry to the district (woreda) level. The system also includes a mass registration solution for systematic land registration and a data migration tool to convert existing land record data. Though a pilot system was contracted the development became a fully functioning and operational land administration information system where one can claim that NRLAIS is now a "one size fits all" system.

The future vision of the Ministry of Agriculture is to prepare and implement NRLAIS as the land information management system of Ethiopia. This system will move NRLAIS towards a multipurpose cadastre system which will integrate the land administration information system with the appropriate sub-systems such as the land tenure, revenue collection and general administration systems. This will make NRLAIS the main system for the rural land administration and the rural land management in Ethiopia.

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Tables

Figures