Building Harmonized Private and State Land Data and Information Systems in Ethiopia

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Introduction

Different government institutions in Ethiopia are working on land related issues to tackle and manage data and information independently from each other, even though their activities and mandates are often related or even overlap. Those institutions do not have a shared modern information management system to properly compile and store data in such a way that users from other relevant institutions can access and share such data and resources for better planning and informed decision making. The lack of a common shared system has led to the transfer of land to investors which were formerly used by small-scale farmers or areas within national protected zones. This challenge has been addressed via a joint initiative involving the Ethiopian Ministry of Agriculture and the former Ethiopian Horticulture and Agricultural Investment Authority with support by the Finish Government (REILA Project) and an EU/German co-financed project, Support to Responsible Agricultural Investment implemented by GIZ.

The development and implementation of the National Rural Land Administration Information System (NRLAIS), a cadaster system dealing with individual land user rights in rural areas, is one of these initiatives. NRLAIS is an information system which provides a foundational core architecture according to which others can build their systems. NRLAIS is the key strategy in the development of an integrated land administration sector in Ethiopia. It provides the required functionalities to manage land administration datasets and administrative services. On the other hand, EHAIA initiated the development of an IT system that handles state land areas transferred to investors for commercial agricultural purpose. In order to allow smooth data exchange between both systems, the Commercial Agriculture Management Information System (CAMIS) is based on similar open source technologies as NRLAIS.

This paper provides main arguments for linking efforts between different governmental institutions - mandated for the management of different land types – via the use of linking information systems built on common software development architecture to facilitate enhanced coordination and data exchange between institutions and to improve their overall efficiency.

Land Information sharing among institutions in Ethiopia

Until recently, a systematically organized IT based land information system, which enables land data and information sharing among various users, was non-existent. The main challenges in land administration at all levels, from federal to woreda (nearly equivalent to district) administrative hierarchy, are that records on land holdings and use rights are not properly organized. So far, these records have been stored manually and were not easy to access. Different governmental institutions which are directly related to land or use of land most often act independently, with

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insufficient communication of their activities. Any data or information generated by these institutions are not well coordinated and shared.

Recognizing the challenges in the land record system, the Amhara regional state developed its first Information System for Land Administration (ISLA) with the support from the Swedish International Development Agency (SIDA). ISLA supports first level land registration, which can register and maintain land holdings, holders and descriptive information about land parcels. However, it does not support physical and spatial registration of parcels. In an attempt to address the prevailing problems related to land information system and enable the use of common data model for data and information sharing among the regional states, the Ministry of Agriculture with the support from the Government of Finland, is developing the National Rural Land Administration Information system (NRLAI). NRLAIS will be a standard legal cadaster system that will be implemented in all the regional states of Ethiopia and provides a consistent and common land information sharing platform for the users at different administrative levels. NRLAIS is already developed and implemented at five pilot sites (Ministry head office, two regional head office, two woredas in two regional states (Tigray and Southern Nation, Nationalities and Peoples Region). Currently, NRLAIS is on the roll out to different woredas of different regional states.

NRLAIS development framework

NRLAIS is a system for handling both systematic land registration (mass registration) and sporadic registration. It is also maintaining the land records through transactions and provides land administration datasets throughout Ethiopia. The system was designed to be in accordance with rural land administration structure and levels of Ethiopia. For each administration level, NRLAIS has different functional features which are:

- **Federal level**: features for data aggregation and analysis supporting decision making and national policy development, monitoring of land administration and land use and acting as a portal for supplying rural cadaster and land registration data to the Ethiopian National Spatial Data Infrastructure.
- **Region level**: features with advanced data processing capabilities and management of cadastral parcel data, management of all zones and woredas in the region, providing security to woreda level data-stores, analysis of land use and holdings, providing the basis for regional level policymaking with a regional spatial data infrastructure and supporting woredas in carrying out their mandated duties.
- **Zone level**: features for viewing and carrying out administrative actions through a web-portal.
- **Woreda level**: features for registering land and maintaining the land records through all types of transactions and being the only level, which has, write access to the database.
- **Kebele level**: currently receiving applications on a paper basis and forwarding these to the woreda office for processing the applications.

The NRLAIS allowable transactions were designed based on the Rural Land Administration System Manual (RLAS), harmonization documents and technical requirements. These documents include the process of establishing and maintaining the land register which contains the data from systematic registration. It also includes the updating procedures for land records which are carried out through land transactions. Figure 1 shows an overview of NRLAIS.

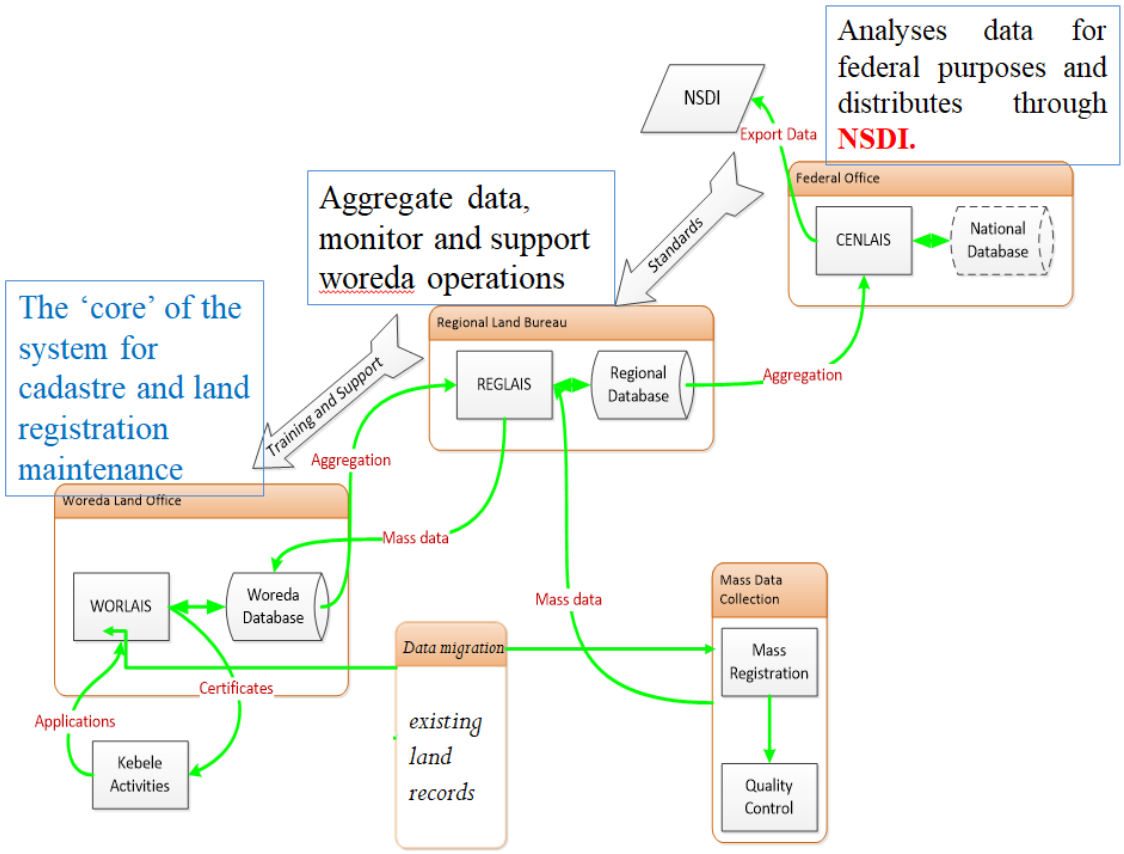

Figure 1: Overview of NRLAIS system

NRLAIS Development: The development of NRLAIS is entirely based on open source software tools (see table 1).

Name	Usage
PostgreSQL	Database management system. PostgreSQL was used on all levels of the 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 the NRLAIS for high-end editing, visualization and analysis of geospatial data.
GDAL/OGR	Converting different GIS formats
Geoserver	Geoserver used on all levels of the NRLAIS for OGC compliant services such as WMS or WFS
MapProxy	MapProxy used as proxy to encapsulate WMS requests for performance and security reasons
ExperMaps	Basis for web based geospatial clients in the NRLAIS
node.js	Application environment
Python	Customization of QGIS

Table 1: List of open source software used in the development of NRLAIS (Hansa Luftbild, 2016)

The main system components and subsystems of NRLAIS were developed based on system requirements and the system design. They are physically independent but logically dependent on each other and are connected to each other at database level. They were implemented according to their specific purpose. The following paragraphs describe the development of the

subsystems, where each subsystem has its own specialized graphical user interface to handle different types of data and to fulfill the corresponding tasks.

Database: The NRLAIS database architecture was separated into three different types of databases:

1. The main database contains current processed data and is the source for information requests,
2. The transaction database deals with the transaction data from the initialization of a new transaction until it reaches its finished status as an accepted or rejected transaction process, and
3. The archive database files regularly conducted transaction processes and the content of the main database

WIPSS: The Web Information Provision Subsystem (WIPSS) was developed as a read only service, which accesses the land register and the cadaster database. The subsystem was implemented on top of ExperMaps, a webGIS developed with open source software.

PRSS: The Property Registration Subsystem (PRSS) was implemented as a web application, which is responsible for the maintenance of the land register. It was implemented as an extension of ExperMaps with node.js server as a backend. For the user interface, additional implementation in JavaScript was carried out to support Asynchronous JavaScript and XML (AJAX) capabilities. This eliminated the need for installation or configuration on the client side of the PRSS. Future changes will be able to perform at low maintenance and administration costs. PRSS includes ExperMaps for displaying the geometry (spatial data). The communication with the NRLAIS server components and service level were implemented with web-service techniques. PRSS is capable of performing transactions on the land register, reading directly from the main database. All transactions will be handled by a transaction manager, a tool which manages the transaction process. PRSS selects and locks the data need for a transaction. During the transaction, the data remains unchanged in the main database and identified as a transaction. Changes made by the PRSS during a transaction are stored in a separate area of the database, i.e. in the transaction database. When changes to the data are completed then these changes are passed on via the transaction manager to the main database for application to the land register. This procedure ensures the integrity of the database at any time by committing the changes by one instance rather than many instances. The transaction handling is here carried out in the same way as a transaction on the land register. A transaction can therefore combine changes in the land register as well as in the cadaster.

CMSS: The Cadaster Maintenance Subsystem (CMSS) client was implemented as a customized application inside QGIS. This application, which was implemented in Python as a plugin in QGIS, allows the management of cadaster functionalities. QGIS was configured at the user interface level in order to provide those functionalities and elements only, which are necessary for the CMSS.

DMSS: The Document Management Subsystem (DMSS), an archive system, was implemented as an interface for web-based indexing and document retrieval services. The documents can be stored either in the document management server or in the file system while the index is stored in the central database. The DMSS was implemented with open source software and is located at the district (woreda) level.

PSS: The Process Subsystem (PSS) is a web application responsible for 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. This subsystem was implemented on the node.js/ExperMaps platform. For the user interface, additional implementation in JavaScript was carried out in order to support AJAX capabilities. The PSS is the initial interface of the NRLAIS. Its purpose is to create and maintain the processes. A process combines several tasks on the land register and the cadaster. Examples of such processes are sporadic land registration or transfer of usage rights. Single tasks are carried out in the PRSS and the CMSS. In the context of the NRLAIS a process is defined as a transaction.
Service level: The service level provides web services for accessing the data in the land register and the cadaster. For the spatial data the services are OGC compliant, these are the WFS (Web Feature Service) and the WMS (Web Map Service) services. These services were implemented using the Geoserver open source platform. Other services were implemented on the node.js platform and are accessible via REST (Representational State Transfer) web services. The technical specification of NRLAIS includes a mass land registration software component, named MASSREG. The basis of MASSREG was the software iMASSREG or interim MASSREG which had been developed by DFID funded Land Investment for Transformation (LIFT) program in Ethiopia using open source software (QGIS, PostgreSQL and Glassfish Java application server) and is currently being used as an interim solution while waiting for the completion of NRLAIS. As stated, MASSREG will be used for the initial systematic or mass registration of rural land. After mass registration, the legal and the spatial data will be migrated to the NRLAIS core system (WORLAIS).

Conceptual design framework of NRLAIS: The ISO standard 19152, "Land Administration Domain Model (LADM)" was used as the basis for the specification of the NRLAIS conceptual data model. It was adapted to the requirements of the rural land administration sector of Ethiopia. Figure 10 shows an overview of the applied conceptual data model of NRLAIS. The NRLAIS LADM packages were structured into four main packages plus one support package. The structure of the conceptual model follows the general structure of the LADM. The NRLAIS LADM adopted 4 main packages and one auxiliary class package. The five packages are:

1. **Party:** containing all the classes necessary for modelling all aspects of natural and non-natural persons with direct or indirect interest in land.
2. **Administration:** containing all elements of the conceptual model with a relation to legal aspects. The core of the package is the implementation of the Right, Restriction and Responsibility (RRR) concept of LADM.
3. **Source:** containing all the elements of the conceptual model that are related to documents. A source (document) is the evidence for a fact in NRLAIS.
4. **Spatial**: containing all the classes necessary for the modeling of the spatial aspects of NRLAIS and represents the cadaster.
5. **Auxiliary classes:** models common structures such as code lists or common attribute sets.

NRLAIS applies three database schemas namely:

1. ***NRLAIS_Inventory* database:** schema which contains actually valid state of NRLAIS and legally valid present information
2. ***NRLAIS_History* database:** schema that contains previously valid states of NRLAIS and legally valid past information

3. ***NRLAIS_Transaction* database:** schema that contains information about the state of valid a transaction. This state is only temporarily available during a transaction and contains legally valid information in the present.

The above schema contains the same domain specific information; and therefore, the class model on the level of the conceptual model is identical. The history of a parcel starts with a transaction. All data involved in a transaction is first transferred to the beginning of the transaction from NRLAIS Inventory to NRLAIS_History. The changes are then applied to NRLAIS Transaction. After the transaction is completed and confirmed, the new state of the data is transferred from NRLAIS Transaction to NRLAIS Inventory thus becoming the new valid legal state. If a transaction is not confirmed, then the temporary state in NRLAIS Transaction and the saved state in NRLAIS_History will be removed and NRLAIS returns to the state it was in before the transaction was initiated. During requirements specification twenty-one system use cases were identified and documented, as listed below in table 2:

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

Table 2: System use cases identified during the requirements specification of NRLAIS (Hansa Luftbild, 2016)

Core architecture of NRLAIS: NRLAIS as a national system is required to provide functionalities for different administrative levels, i.e. from district to central. The system requirements were associated to the three specified system levels of NRLAIS, which are WORLAIS, ZONLAIS, REGLAIS and CENLAIS. Therefore, the NRLAIS was designed on the basis of different components and subsystems which adhere to the toolkit approach as designed in the System Design Description (HansaLuftbild, 2016c). These subsystems are:

- Web information provision subsystem (WIPSS)

- Property registration subsystem (PRSS)
- Cadastre maintenance subsystem (CMSS)
- Process subsystem (PSS)
- Database (DB)
- Document management subsystem (DMSS)
- Service level

Figure 2 shows the system overview of the NRLAIS at the different organizational levels, i.e. CENLAIS, REGLAIS, (ZONLAIS) and WORLAIS, in relation to the afore-mentioned subsystems. The different transaction types which can be carried out on NRLAIS are conducted with the PRSS and the CMSS by the end user. WORLAIS is an integrated land administration system and the core 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 by the WIPSS, CMSS, PRSS and PSS subsystems. At the backend, the inventory, transaction and history databases allow the transaction data management and archiving, which is controlled by the PSS system. WORLAIS data can be exported and aggregated to match the requirements of the REGLAIS.

Standards: International 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
- Web standards such as HTML, HTTP, XML, SOAP
- UML
- LADM

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 WIPSS and PSS. In addition, data can be archived at the regional level. The data exchange to national / central applications at the CENLAIS level is conducted by import and export functionalities in WORLAIS and REGLAIS. 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 functionality of each of the six subsystems is gradually reduced from the woreda level to the central / national level, as e-governance of cadaster (Hull & Whittal, 2013). The system use cases, which were identified during the requirements specification, were mapped to the subsystems of the NRLAIS as is shown in table 3.

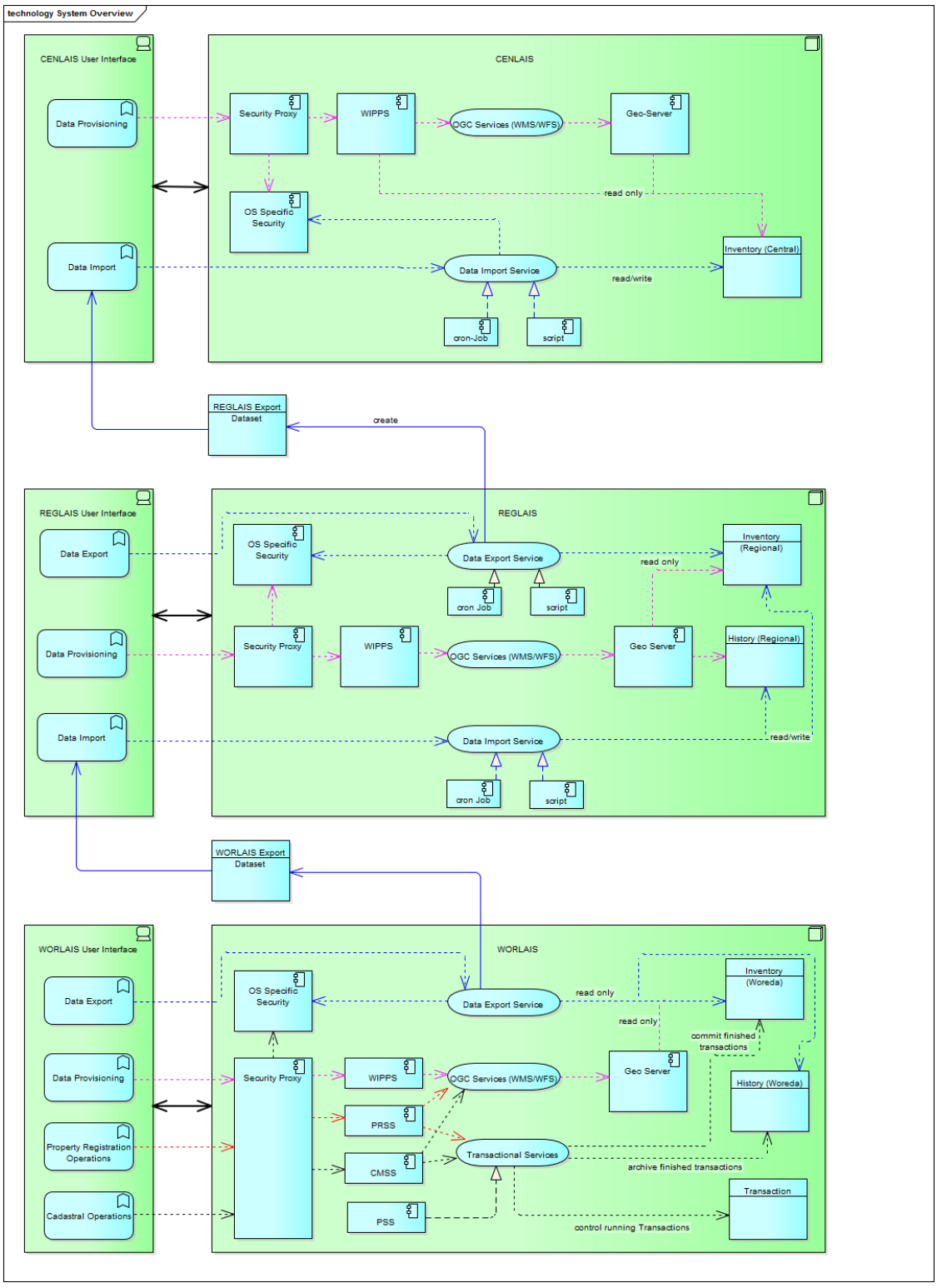

Figure 2: System overview of NRLAIS from Woreda (District) to federal level (Hansa Luftbild, 2016)

Use Case	Name	Covered in System / Subsystem
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

Use Case	Name	Covered in System / Subsystem
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 – PRSS
20.	Replacement of certificate	WORLAIS – CMSS
21.	Approve changes	CENLAIS-, REGLAIS-, ZONLAIS-, WORLAIS-PSS

Table 3: System uses cases identified during the requirements specification mapped to the subsystems of NRLAIS (Hansa Luftbild, 2016)

Figure 3 shows the overview of the different subsystems and services vis-à-vis the NRLAIS.

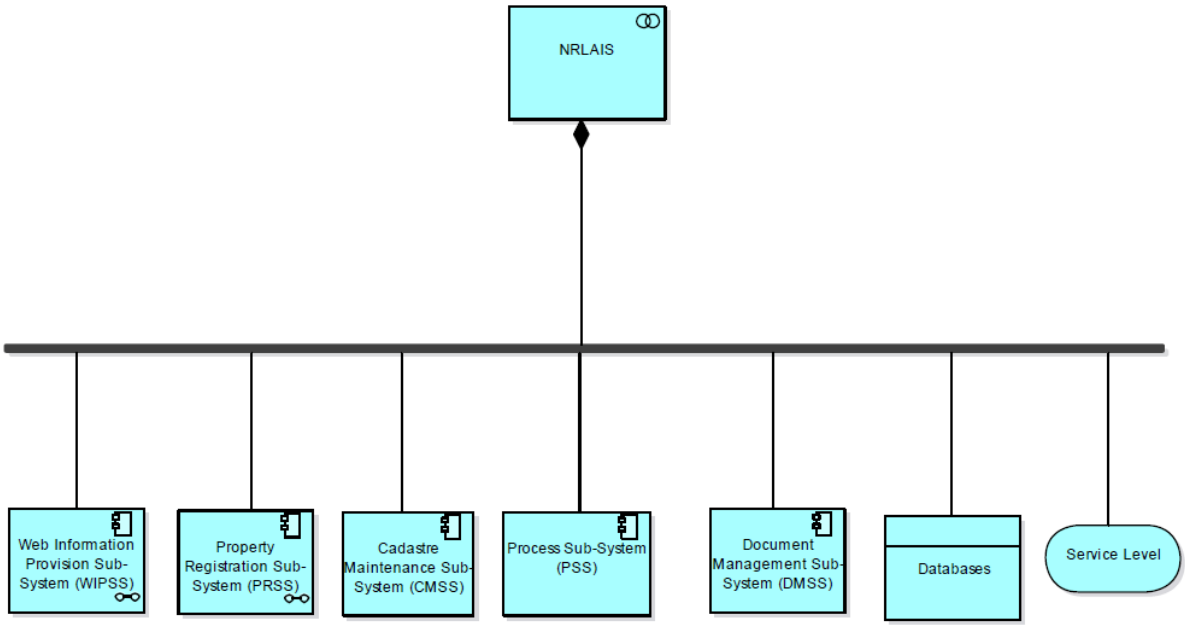

Figure 3: Overview of the different subsystems and services of NRLAIS (Hansa Luftbild, 2016)

Commercial Agriculture Management Information System

Core functional components of CAMIS: Commercial Agriculture Management Information System (CAMIS) is a distributed web application system aiming to provide functions to support the inventory of commercial agricultural investments and different contract farming models. The system in particular targets the performance monitoring and evaluation of lease-based largescale agricultural investment projects. The system also handles other investment business functions like horticulture including floriculture, livestock and fisheries as well as investments on forest and forest products.

The CAMIS system includes the following functional components: land administration, bid workflow management farm management, performance monitoring and evaluation, mobile field farm monitoring and contract farming. The land administration function keeps track of land leased to investors, and areas and locations of land suitable for future investments. For the last, it also provides basic information on parameters of soil, climatic conditions, landscape and water quality for irrigated lands. The Bid workflow management is part of the web portal that enables land promotion for investment, provides an online platform for the registration of investors for their participation in the bid process and facilitates bid analysis. Farm management and performance monitoring and evaluation components are mainly providing functions for keeping track on the records of commercial farms inventory, their periodic performance monitoring records as well as measures regarding their business plan, social and environmental impact assessment/environmental management plan. Basically, the mobile field farm monitoring component is part of the farm management module, that helps collecting field level data during the monitoring of agricultural investment projects. Contract farming component provide functions that handle inventory of different models of contract farming.

Architecture of CAMIS: The implementation of CAMIS is at the final development stage. It is being built using different open source software tools. As already stated, CAMIS is a distributed system having different regional nodes. Each node runs independently of each other and has an own localized interface language but with similar deployments and minimal differences. The central national node will be linked to each regional node via VPN (Virtual Private Network). The data from the regional node is then automatically transferred for aggregation and reporting at the federal level on real time basis or scheduled during the time when network traffic is minimal depending on the volume of data.

CAMIS nodes are implemented based on a three-tier client-server architecture that further consists of three layers: the presentation/user interface, business/application logic and data store/database layers. Each tier is built based on open source software tools. The presentation layer is designed and implemented using different web-interface development tools. The web mapping application is developed using OpenLayers; mobile application interface is developed using ReactJS; web application front end is developed based on ASP.NET Core, Angular, bootstrap, jQuery and HTML5. The presentation layer also interfaces with NRLAIS for data communication. The business logic layer implements the business rules of CAMIS using web server, Geoserver and custom-built tools developed using C#. This layer bridges the data store layer with the presentation layer. The data store layer is implemented using PostgreSQL with PostGIS extension, and it also includes flat files that include documents and raster based geographic data.

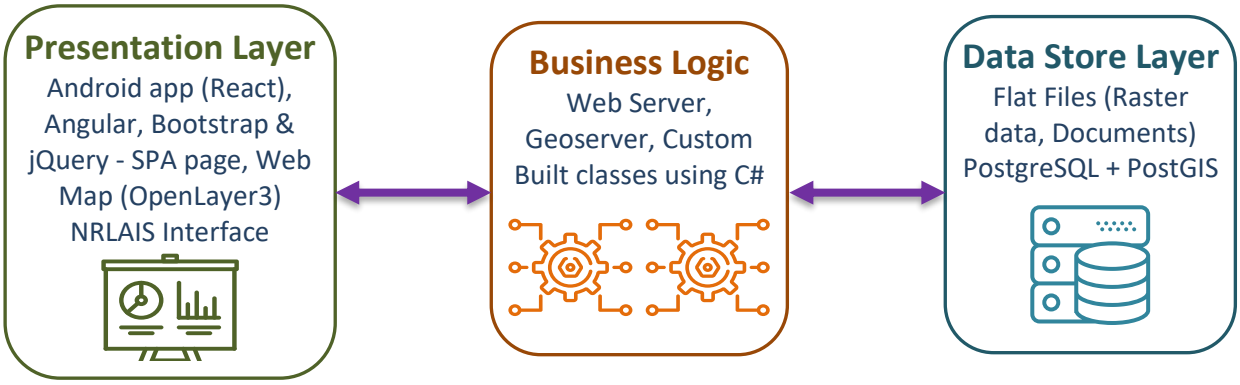

Figure 4: CAMIS Architecture (INTAPS, 2018)

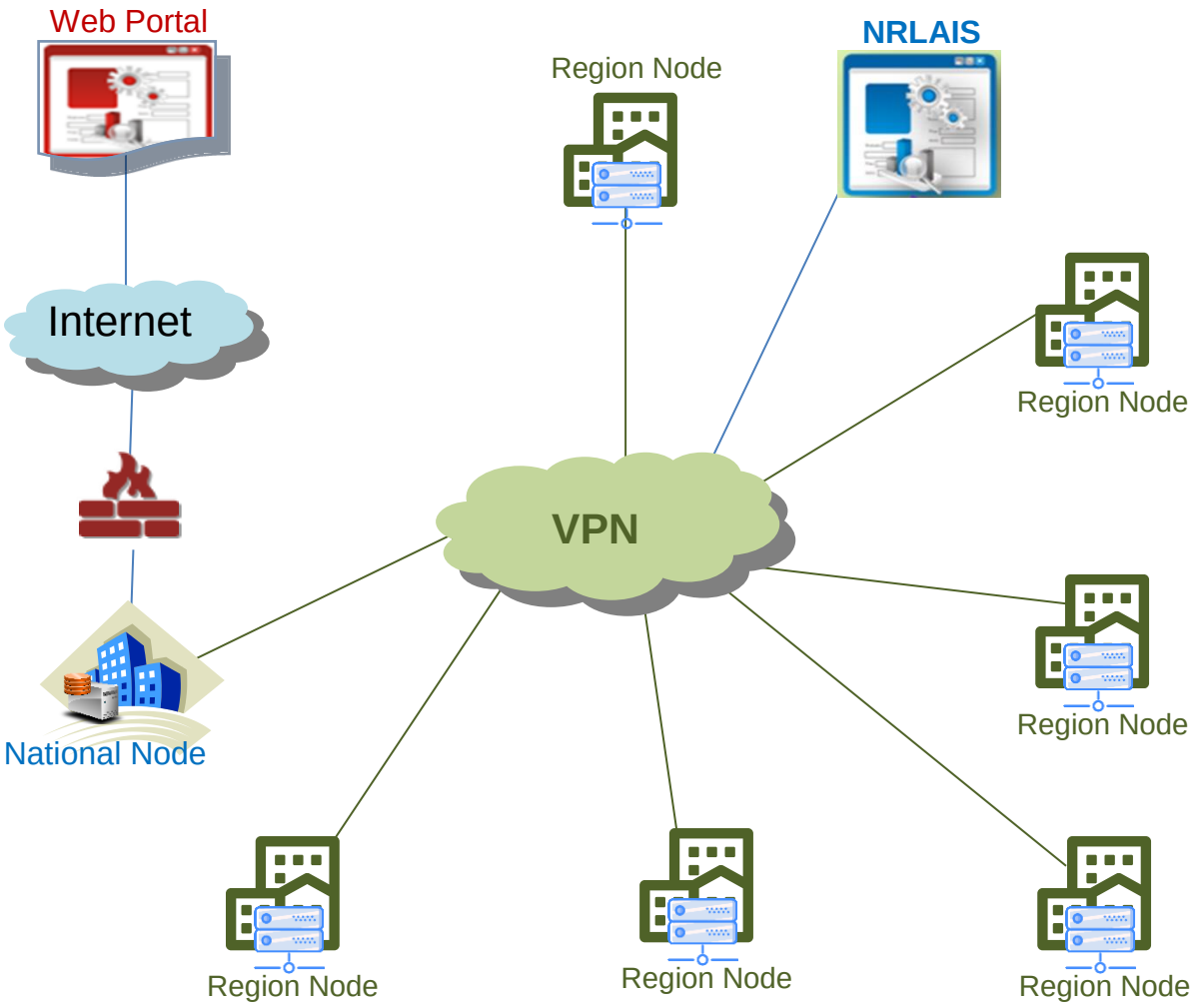

Figure 5: CAMIS Physical Deployment

Integration of NRLAIS and CAMIS

NRLAIS is completely designed and developed based on open source components and brings along reduced license and basis software costs. Central to the NRLAIS concept is a “toolkit” approach to manage the functionality at the different levels with the ability to customize the toolkit for different Regions. Furthermore, it is allowed to reuse and extent the fully accessible source code of mature open source software (OSS) projects like QGIS for efficient implementation of NRLAIS functionality. Moreover, OSS makes stable and community driven development processes possible. NRLAIS components are designed and implemented such that they can be used in different context inside and outside the project. The services defined and in use by the related modules in the system (PSS, PRSS, WIPSS) can be consumed by different application in the same manner for different purposes. The design shows that it is easy to be adopted, customized, scaled, maintained that conform to recognized architectural standards, manageable to add different end points and build other systems based on the core architecture of the system. NRLAIS architecture interacts easily to provide end points to access data from its database with other systems. NRLAIS is mainly responsible for maintaining land registration on

the basis of the provisions of national and regional legal framework and regulations for the implementation of land administration services (Hansa Luftbild, 2016). NRLAIS is implemented based on Land Administration Data Model (LADM-19152), which is a conceptual internationally accepted standard model to guide the development of land administration system (Lemmen, 2015). During the requirement analysis phase of NRLAIS development, Ethiopian legal and other terms were aligned with LADM definitions and terms. Important terms that link NRLAIS and CAMIS lie in basic spatial land units in the cadaster system, which is called parcel and use right. The following conceptual diagram shows the use right for rural land.

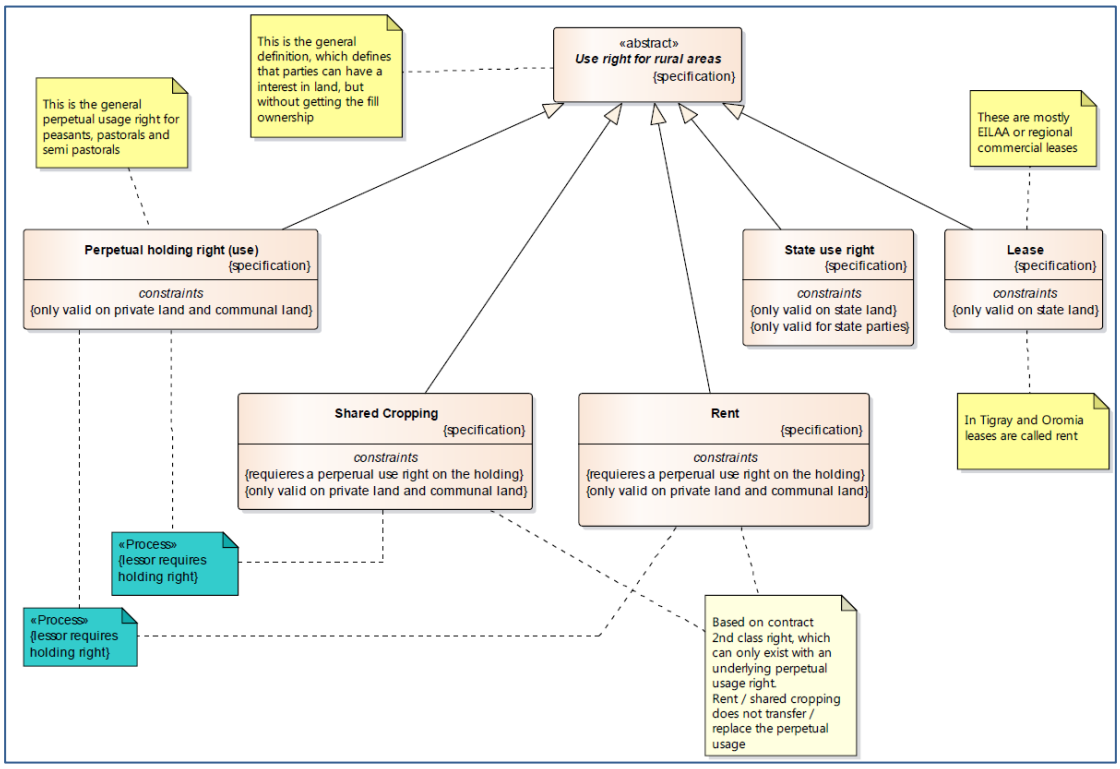

Figure 6: Conceptual view of holding right

According to the Ethiopian constitution, land belongs to the state and the peoples of Ethiopia. Other form of entities do not have ownership right but can have the right to use it. In principle, only land under the state use right can be transferred for agricultural investment purposes by lease. However, with special arrangements and compensation mechanism, land holding under private and/or communal use can also be transferred to lease holding right. Rent right is another form of commercial agriculture. Perpetual private land holders can rent the portion or whole of their holdings to commercial farmers. In addition to lease and rent, different contract farming models are practiced in the country. Contract farming agreement contracts take place between perpetual private land holders and other commercial farmers or exporters or factories, etc. for the supply of agricultural produce at agreed price or equitable sharing of profit.

CAMIS as a software system is responsible for registering and maintaining inventory of all forms of commercial agriculture practiced in the form of leased agricultural investments (large scale agricultural investment, horticulture, livestock, forestry and forest products), contract farming and rent. The registration process of these forms of commercial farms require parcel and holding right information. Even after a parcel of land is transferred to an investor through lease, several transactions can take place during the lease period:

- Lease contract can be terminated and use right can be changed due to violation/breaching of terms and conditions in the contract,
- When an investor fails to develop the whole area of land parcel within the specified duration, parts of the investment land can be split and transferred to another investor,
- Adjacent parcels can be merged as a result of expansion of farms,
- Leased land can be transferred to other party through inheritance, etc.

Any of these transactions that entails the change in use right and geometry are only carried out within the NRLAIS system. CAMIS interacts with NRLAIS during land profile registration, promotion, farm registration and during performance monitoring of investment projects. The following flow chart shows the general CAMIS workflow requests services from NRLAIS.

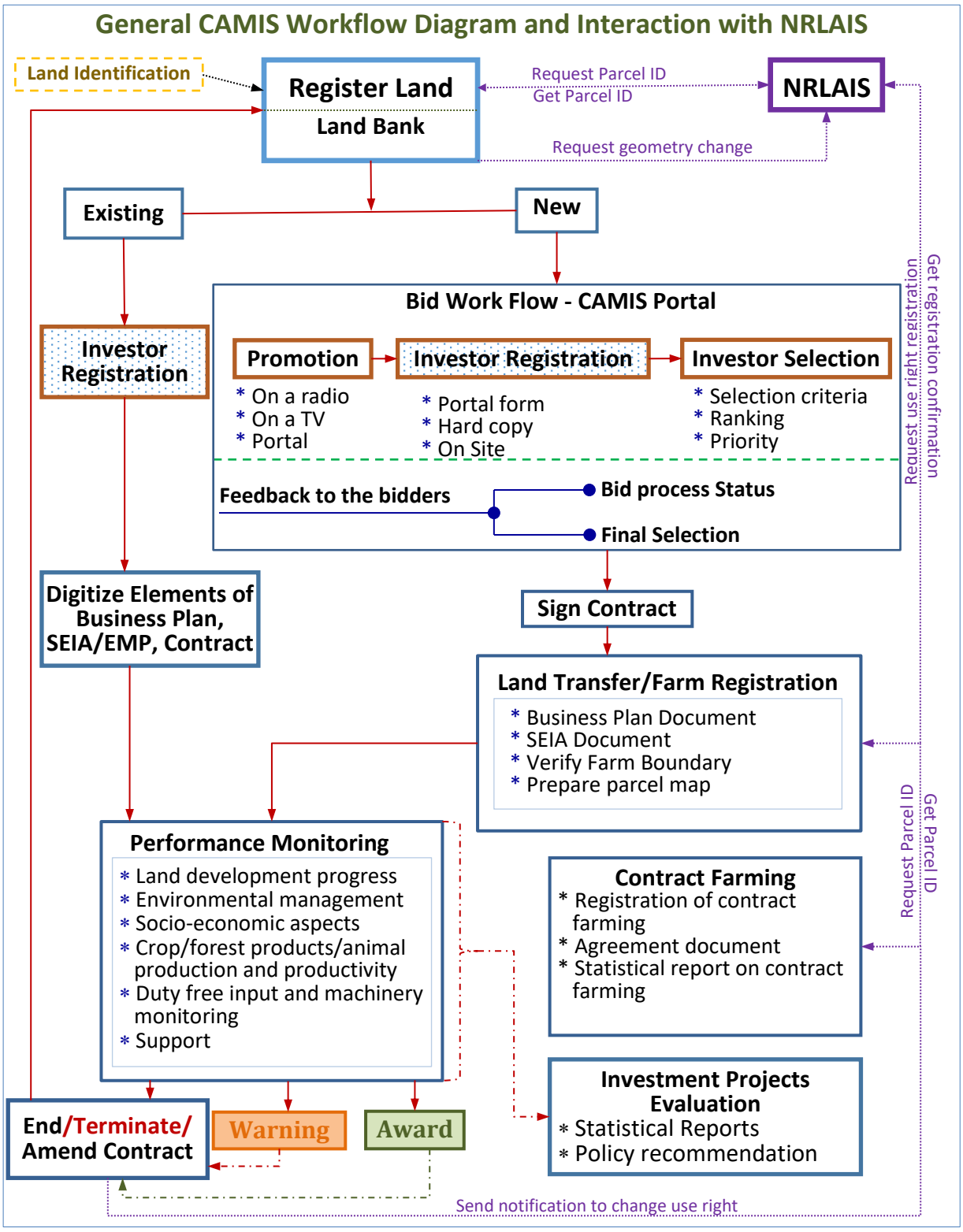

Figure 7: CAMIS general workflow and interaction with NRLAIS

As can be seen from the CAMIS work flow and interaction with NRLAIS, the main point of linkage between the two systems is that CAMIS is requesting services and NRLAIS is providing services to CAMIS. NRLAIS provides spatial data access service to CAMIS through web interface. Both systems can coexist on the same implementation platform or location or can exist on separate network and location. Both systems are not wired together, i.e. CAMIS can run independently and request services from NRLAIS when required.

Benefits of Integrating Different Systems and Land Data Exchange Among Institutions

The benefits of integrating different systems and building new based on existing system is multifold. NRLAIS created an excellent foundation for rural land management in Ethiopia. Every rural land will be registered using this system including water bodies, land under pastoral use, forests, etc. Any public or private institution involved in rural land-based development can easily capitalize on the data, information and knowledge already generated through the endeavors of realizing NRLAIS. CAMIS development is the best example, which realized the benefits of NRLAIS from the early conceptual development phase. The major benefits of integrating rural land-based systems, considering NRLAIS and CAMIS systems as best example, includes the following:

- When fully roll out at all regional states of Ethiopia, NRLAIS provides a legal cadaster system that include non-redundant, accurate and consistent parcel geometry as well as use right records. Forthcoming there is only one system and institution responsible for the registration and maintenance of rural land parcels in each regional state. CAMIS land management module is designed to access parcel and use right data maintained by NRLAIS. Any transaction which requires change in the parcel geometry of agricultural investment land is carried out by NRLAIS cadaster maintenance system. This means that time and cost related to the development for handling land management module would have been minimized.
- Both CAMIS and NRLAIS use the same database management system. Even though this does not mean a bi-directional databases access, however knowledge build in the design and implementation of the database system will increase productivity, which might lead to a roll-out of the system in other institutions.
- Another benefit of integrating NRLAIS and CAMIS is that data exchange between both systems is much easier. Import and export of data is not required. Data communication between both systems is internally handled.
- From the Ethiopian context, such kind of system integration creates a platform for better coordination of data and information at regional and federal levels on land and its use. Different sectoral institutions like agriculture, water resources, etc. most often independently function with loose coordination of activities and sometimes with overlapping mandates. With creation of integrated systems, better utilization of scarce resources can be achieved.

Conclusion

Coordinating land related issues across institutions dealing with land and developing information systems based on common software architecture facilitate easy data and information sharing at different administrative levels. In Ethiopia a modern information management system is the key to handle and share data and information that are required for informed decision making. The development of NRLAIS and the initiatives taken for an integration with CAMIS in the early conceptual design phase clearly demonstrate the benefits of system integration. Thus, future initiatives can be more effective and efficient by following similar steps.

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