

# **Building an Integrated Land Information Management System Infrastructure for the Government**

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## **Abstract**

The present paper has been prepared to provide a presentation at 18th International Conference Informatics for Environmental Protection, the EnviroInfo 2004, organized by CERN, Geneva, Switzerland, October 21-23, 2004, on how an integrated and cross-sectorial Land Information Management Infra-structure System, is being designed, built, used and benefiting central and local Government Institutions, municipalities, utilities, non-profit organizations, universities, companies and donors in the Republic of Mozambique.

A brief description of the National Directorate of Geography and Cadastre mandate within the framework of the Government is given. It describes, in an introductory country background, the Mozambican geographical location and the administrative division. Briefly outline the current policies and legal framework prevailing on the land in Mozambique. It focus on the program of Government of Mozambique that influence the setting up of the land information management system as well as on the integrated and cross-sectorial aspects concerning the geo-referencing of the maps and the IT-solutions, shows how to access to the land information and maps from the system via web-services. It describes the means for reaching the objectives, i.e. designing and building the Land Information Management System Infrastructure, the conversion of the existing data from paper into digital format, the methodologies to be used, the organizational aspects of the system, etc.

Finally, it concludes with remarks of how a such system could be adopted as an example in Africa for building an integrated Land Information Management Infrastructure for the Government.

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## 1. Introduction

The National Directorate of Geography and Cadastre, abbreviated to Dinageca from the Portuguese: Direção Nacional de Geografia e Cadastro, under the aegis of the Ministry of Agriculture and Rural Development, is an executive and government institution in Mozambique, responsible for national mapping (topographic and thematic), land administration and land management (national land cadastre and archive). It is responsible for establishing, providing and maintaining the national geodetic network, national map series, national cadastral atlas, administration and management of all land rights concessions process, information and data on land use and land cover for better planning and decision making, definition of policies, standards, norms and procedures on geo-referenced data and information.

Topographic national mapping activities offer basic maps at scale of 1:50 000 which covers the country with a total of 1207 sheets and at scale of 1:250 000 with 102 Sheets. It has also maps at different scales including the administrative boundaries, touristic, city and thematic maps at various scales and at graphical and digital formats.

Land administration and land management activities are directed to promote the land use for social welfare and economic development, security of tenure and to guarantee the access on land for Mozambican people as well as national and foreign investors.

The Government Programme 2000-2004 has defined the Land as one of the indispensable resource for production of agro-cattle breeding, for forestry and faunal exploitation, for the conservation and maintenance of the biodiversity, of ecological equity and for the construction of economical, social and habitation infra-structures.

In addition, it refers that the land management policy must guaranty the use of land rights to all singular and collective entities, nationals and foreign, those have economical and social initiatives for the benefit of the Mozambican People.

One of the ascribed role for Dinageca, as the main institution responsible for the establishment, maintenance and updating of the national land cadastre in Mozambique, has driven the Government of Mozambique to strengthen the capacity of the institution to deliver its cross-sectorial mandate on administration and management of the country's most important and precious natural resources.

Thus, the ultimate mandate for Dinageca is to design and build a modern, efficient, reliable cross-sectorial and transparent Land Information Management System Infrastructure for:

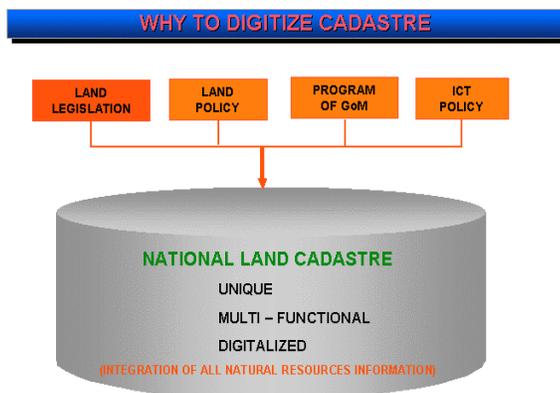
1. Internal land administration and land management responsibilities within the national directorate and its provincial offices by cross-checking and validating all land rights registration applications;
2. Inter- and intra-governmental land and other natural resources administration and management through cross-checking and validating all concessions (land, forestry and wildlife, water resources, mineral resources, etc.);

3. Inter- and intra-governmental natural resources planning and management activities;
4. Provision of a consistent database of land and other natural resources utilization for all users.

## 2. The National Land Cadastre

Dinageca build, maintain and distribute national geo-referenced data and information to support multi-disciplinary applications that address increasing demands on management of natural resources to provide goods and services to the increasing population.

Many other government departments responsible for the inventory and management of natural resources use the basic products from Dinageca as the basis for the inventory of soil types, geology, water, and so on. These users have been adopting the levels of spatial resolution that is determined directly by the scales of the maps that are produced by Dinageca even though often their levels of resolution and other forms of topographic coverage requirements are not met by the standard topographic map series. In many situations, these departments assume that maps they require exist containing the required information and accuracy. The relationship that was being established between Dinageca and them was one way direction without return, i.e. each department acquired maps, design and build its own database and systems without an coordination with Dinageca and/or other Government institutions. The immediate consequence is the proliferation of database and systems being most of which are not compatible. In addition, duplication of effort and waste of resources have often occurred for a country with scarce funds.



The Land Law, at its article 5 starts that:

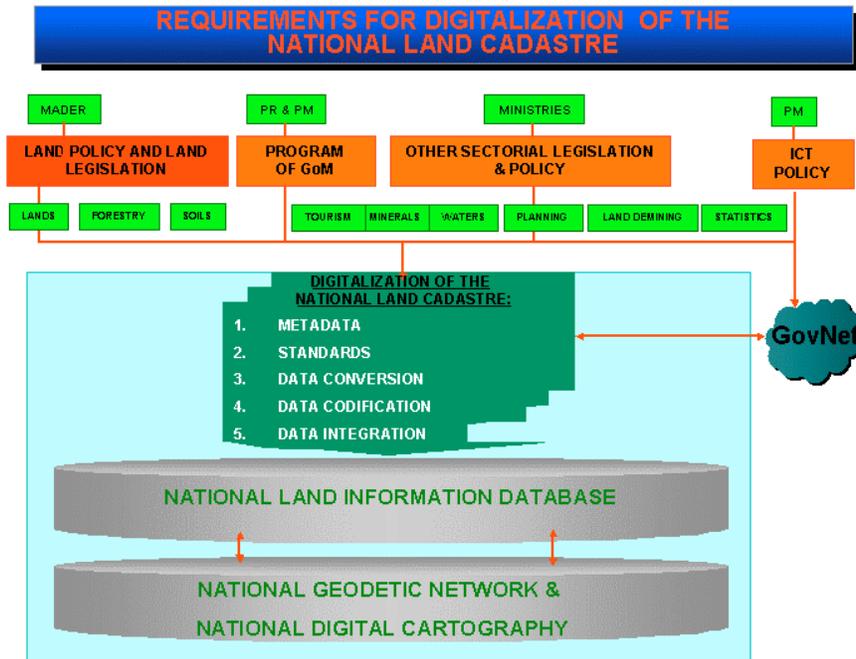
- 1) The National Land Cadastre shall consist of all necessary details namely to:
  - Know the economic-judicial situation of the land.
  - Know the type of occupation, use and benefit as well as the evaluation of soil fertility, forestry areas, water, fauna and flora reserves, mining exploration areas and areas for tourism.
  - Organise effectively

land utilisation, its protection and conservation.

- Determine the appropriate regions for specialised production.
- 2) The National Land Cadastre shall carry out the economic qualification of the details defined in the previous number, in a manner, which will permit the confirmation of the planning and distribution of the country's resources.

In the addition, the Land Law Regulation, re-emphasis on its article 3 that:

- The National Land Cadastre operates at the Cadastral Services.
- The Cadastral Services will arrange in each Province a local section of the National Land Cadastre.



- The entities which have supervise over the areas of soil, forestry, wild life, water, mining, tourism and others within the public domain shall forward the necessary details for the organization and updating of the National Land Cadastre in accordance with the norms defined by the Cadastral Services.

Thus, Dinageca has its mission as being to deliver high quality national georeferenced data and land information for better planning and decision making to the government authorities and general public in the most cost-effective manner possible using modern, efficient and advanced technologies.

### **3. The National Land Information Management System Infrastructure**

The initial steps toward rational use of natural resources requires an inventory which is accomplished with the aid of land information taking into account that much of Mozambique's resources have not been adequately inventoried because the capacities are beyond the budgets of many governmental institutions involved.

Unfortunately, land and other natural resources information have become progressively more expensive for the Government of Mozambique who can hardly fund small-scale mapping and land information management systems programmes. With the advent of modern and efficient technologies and systems a great opportunity to the Government of Mozambique has arisen to obtain adequate funding and technical assistance to design and build a National Land Information Management System Infrastructure for natural resources inventory, administration and management. In the light of these circumstances, Dinageca has decided to design and build a national land information management system

Dinageca early understood that designing and building a modern, efficient, cross-sectorial and transparent Land Information Management System Infrastructure needed better and sought extensive partnerships with all institutions within the Ministry and across government wherever land and other natural resources administration and management are factors in the identification and delivery of economically and environmentally sustainable and socially acceptable development.

#### **3.1 The management system infrastructure objective**

We have seen that the Government of Mozambique has recognized that land, as a key source of wealth, lies at the heart of good governance and effective public administration. In adopting its agricultural development program, the Government has assigned a priority to land registration and improving the capacity for land information management. The various institutional, technical and process changes and developments that have taken place to date constitute concrete steps in this direction.

The importance of a digital land registry system is further underscored in the National Information and Communications Technology Policy Implementation Strategy where Mozambique requested a high priority assistance from the e-government for development program of the Government of Italy and the Development Gateway Foundation to fund the building of a modern, efficient, reliable cross-sectorial and transparent land information management system infrastructure for the Government.

It was recognised that land information management system is a means which should be used to produce a good land use and development, a system of land holding through registration which provide an administrative aid for the new generation

of users who are more concerned with the problems of establishing a comprehensive land information management systems with a wide range of benefits rather than keeping a fragmentary or limited system that has fewer benefits to offer.

The current advancement in technology combined with limitations in the amount of usable land and increasing demand for more information related to land, have refined land management to an extent where systematic land information system of the country appear to be an ideal as well as a practical solution to land and other natural resources management problems.

A modern, efficient and reliable cross-sectorial land information management system infra-structure offers so many advantages and opens so many more possibilities that it is generally preferable in the long run, however it will be possible with the funding and if when there is co-operation of a large number of diverse institutions and experts.

The overall mission of national land information management system infra-structure is to satisfy the national interest and customer need for accurate, up-to-date and readily available land information data of the whole country. All data have to be represented in the basis of a national geodetic reference framework under which virtually all other data collected by government is referenced.

The ultimate objective for the program is to design and build a modern, efficient, reliable cross-sectorial and transparent Land Information Management System Infra-structure in order to:

- ❖ Facilitate land rights application handling within the cadastral services, the National Directorate and its Provincial Services (offices) and the Municipal Directorate of Construction and Urbanisation by cross-checking and validating all legal requirements for land rights registration, land administration and land management responsibilities.
- ❖ Facilitate the administration and management of land and other natural resources within the Government institutions, i.e. lands, forestry and wildlife, waters, mining, tourism, physical planning, statistics, etc., through cross-checking and validating all legal requirements and restrictions and planning.
- ❖ Facilitate input, consultation, verification, updating and use of land and other natural resources information.
- ❖ Facilitate the exercise of inter- and intra-governmental activities of planning, distribution and management of natural resources within the Government institutions.
- ❖ Facilitate the provision of a consistent database on utilization of lands and other natural resources.

## **3.2 Designing and building the management system infrastructure**

Increasingly, nowadays, there is a major concern about access to and security of land as mankind's primary asset from which people are fed, clothed and housed, and which is used to generate their wealth and recreation specially in the case of Mozambique where 71% of the total population live in rural areas and depend on land, i.e. agricultural activities for their subsistence. Many policy-makers and scientists have emphasised that decisions concerning the allocation and use of land even shaped by political, economic and social values, depend on the quality, accuracy and appropriateness of the land information, data available to the participants for effective and efficient decision-making.

Systematic information of land has great importance for natural resource management, i.e. public administration, land planning and development, and private transactions in land. The management of land and other natural resources is set by the land rights vested in landowners and/or land managers who administrate the land rights units. Thus, the first stage of managing natural resources is the identification of the units as the areas of decision-making through identification of boundaries on the ground.

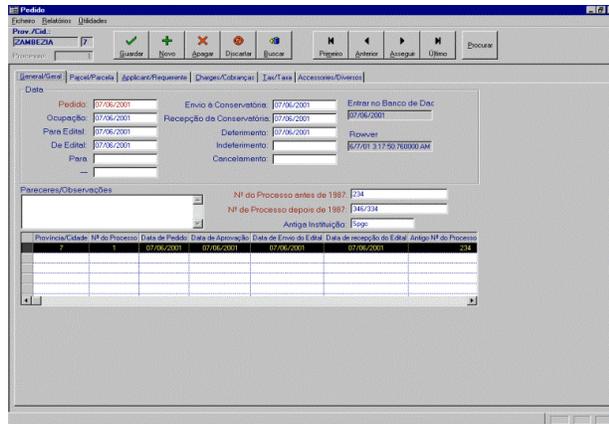
Different steps have been taken in order to accomplish the identification of the units and boundaries through detailed survey, using Differential GPS, has been finished in four District, Manica, Angónia, Gúruè and Mandimba using outsourcing of private land surveyors. In addition to that, a preparatory work is underway to certify individual land rights ownership for small and medium agricultural producers for the market using smart card technologies. All digital data resulting from these undertakings will be incorporated into LIM-SI. The Government of Mozambique has concluded that land information management system is an essential part under which proper management of natural resources are undertaken.

### **3.2.1 Designing the LIM-SI**

Since 1990, Dinageca has been attempting to establish an electronic land application handling system (LAHS). Initially, the system was in house development under the funding of Swedish International Development Agency through technical assistance and consultancy from Swede Survey AB. The major problems accounted with the system early developed were following:

1. Complete dependency on foreign designer and developer of the system;
2. Lack of local support of the system;
3. Finishing of the project that funded the development of the system;
4. Unsolved Year 2000 bugs;
5. Runs on SQL Base Server;

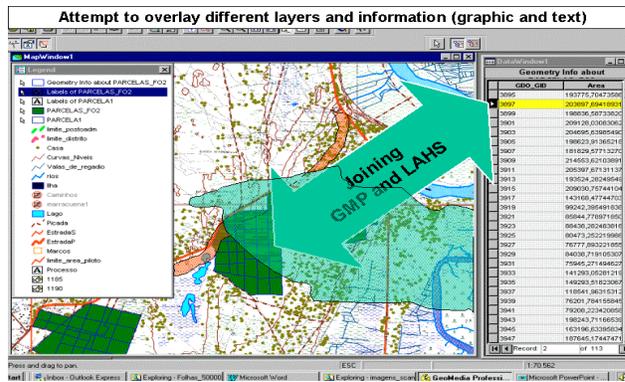
6. Database not spatially aware;
7. No tracking and management of changes taking place opening possibilities for vulnerability;
8. Duplication of information on the forms;
9. Lack of some of desired functionalities.



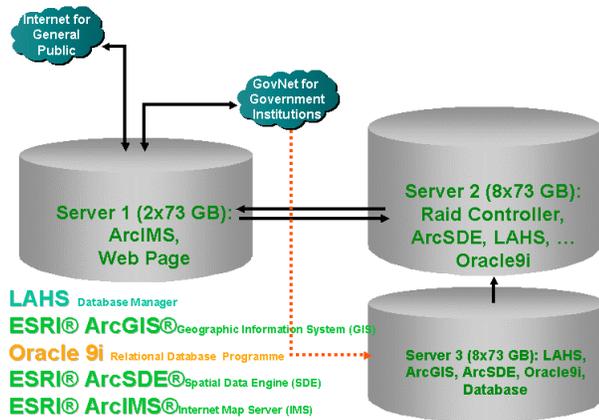
Using internal resources through the National Program for Agriculture, Proagri, Dinageca trained its personal trying to directly connect between alpha-numeric and graphic entities to manage cadastral data. Various attempt were made using different off the shelf solutions,

i.e. Access, Excel, GeoMedia Professional, etc. but none of them gave satisfactory results.

Mapping products from Dinageca have been used as tools for supporting the policy of central Government in administration, defence, security and natural resource management. Land administration and land management activities are directed to promote the land use for social welfare and economic development, security of tenure and to guarantee the access on land for Mozambican people as well as national and foreign investors.



Meanwhile, Dinageca through different sources acquired some modern equipment and started digitising the existing topographic maps (scales 1:50,000 and 1:250.000) and the toponymy of Mozambique. With the technical assistance of IBIS Technologies, a South African private company, Dinageca has re-written the LAHS into new version using a front-end application in Microsoft Visual Basic with map



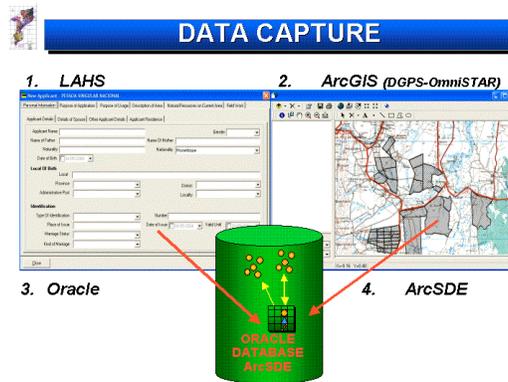
object oriented, Oracle 9i and ESRI ArcGIS and ArcSDE products for the first phase.

Other steps include the digital mapping of the territory (already scanned but not vectorized) and the development of adequate applications using advanced technologies to handle web based system services to serve other Gov-

ernment institutions (under way).

The new version of LAHS intends to work on a comprehensive Land Information Management System. Dinageca has already acquired and is using the necessary software technologies (ORACLE and ESRI) for this purpose. A working version of LAHS is fully operational at central office of Dinageca and schedules have been made to start using it nationwide as from end of August, 2004.

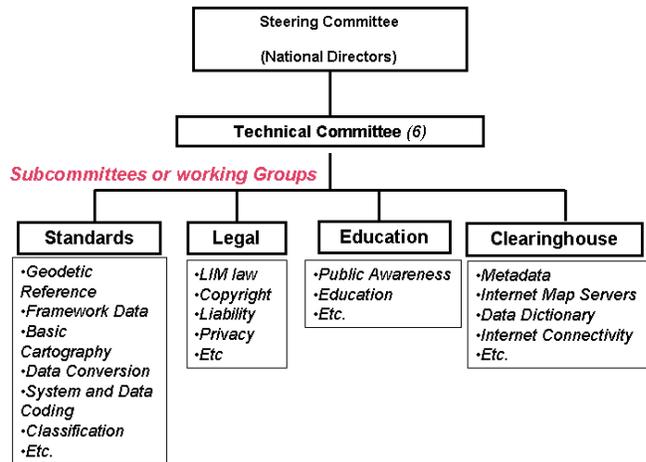
Dinageca has started the acquisition of backlog data (manual digitisation) into the system, i.e. approximately 30,000 paper folders. Each folder – related to a land parcel - contains a “summary” of 2-3 pages, blueprints, maps, deeds and other documents for a total of pages that range from 60 to 100. The mandate to Dinageca is at least to complete the digitisation of the summary data in the backlog folders by the end of 2004.



Dinageca intends to make land information (both the standard alpha numeric database and the Geographical database) accessible over the proposed Government Electronic Network and from the Internet just using a normal browser (full Internet protocol compliant implementation). It is using ESRI ArcGIS, Visual Basic as programming language and ArcSDE to be able to support images and archive information on a centralized database to be operating on an Oracle 9i platform.

Because it is now facing the daunting task of feeding the information from the various agencies involved in the production of land information into this system

through Web based platform, Dinageca is re-designing, with all Government institutions and IBIS Technology, a new application in .NET in order to run nationwide throughout the Electronic Government Network web based using ArcGIS, ArcSDE, Oracle 10g, ESRI and ArcIMS.



### 3.2.2 Implementing the LIM-SI

Simultaneously, as an important step towards the implementation of land information management system, Dinageca has started working with all Government institutions providing and/or using land and other natural resources information to resolve a number of issues:

The first crucial steps in implementing the integrated system was the creation of consensus amongs Government institutions and all users of land information. Various meetings were held with direct involvement of the Vice-Minister of Agriculture and Rural Development and the National Directors of relevant institutions. An agreement was reached appointing Dinageca as the champion of all process and two committees where set. The Steering Committee is constituted by National Directors and other personalities. It has responsibilities to provide strategic guidance and review progress of the design and implementation of the system. The Committee is chaired by the National Director of Dinageca. A Technical Committee was established composed by representatives of the main producers and users of land information to provide technical advice concerning the LIMSI as well as to conduct relevant surveys and studies.

#### 3.2.2.1 Common framework

It was agreed that a natural resources system integration will include the creation of a common infrastructure which identifies all ownership parcels, the assignment of

unique identifying numbers to those parcels and the creation of a centralised and readily accessible depository plants. The crucial factor in initiating an integrated LIM is providing a system which is useful and can be built upon and improved over time. Each institution, through internal sources of funding, will undertake the responsibility to start digitising the existing data under full guidance of the technical committee. In fact, the ownership of data and information will remain within the administration of the institution that has generated them. Dinageca will not be allowed to modify data that are owned by another institution.

The combination of both judicial and fiscal cadastre provides the basic tool for development of the cadastral records for all land, giving its division in units, the location and boundaries of these units and their extent. Other information may be added or taken out giving the system a dynamic reliability. Cadastral atlas based on a network of control points is integrated, thus boundaries, buildings, roads, etc. are connected with any other detailed topographic and environmental conditions.

For the purpose of an integrated LIM there is a need to make clear that the land information may serve a broad purposes of managing natural resources, e.g. hydrology, forestry, environment, town and physical planning, geology, archaeology, etc.

Hence, working together the National Statistics Institute and the National Directorate for Local Administration, Dinageca has started the assignment of unique identifying numbers for all parcels and the creation of a centralised and readily accessible depository plants.

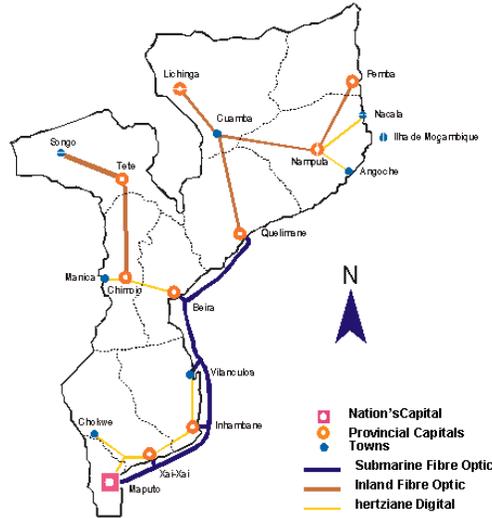
### **3.2.2.2 The Networking and Communication**

Due to the need to exchange data between Dinageca and Ministries, the future ongoing digitization of Cadastre implies a strong dependency on the availability of an efficient and reliable network.

The success of the GovNet project, jointly funded by the Development Gateway and the Government of Italy will be essential also for the Dinageca program. This clearly implies strong synergies between the two projects and the telecommunication infrastructure of the country. Mozambique has been growing in telecom services, i.e. submarine fibre optic, inland fibre optic and hertziane digital.

Setting up an efficient Government Intranet (GovNet) will provide the chance to other Institutions and Ministries of Mozambique to access cadastral data for several purposes. To face all these challenges Dinageca has therefore requested technical assistance from the e-Government Grants program.

# National Transmission Network



### 3.2.2.3 Existing data and Metadata

In the very early stage, Dinageca has identified, documented and assigned roles, responsibilities and relationships among all government institutions handling information and data on land. This is being done according to the government needs and goals that have been discussed clearly with all different stakeholders within the directorates and users.

**TECHNOLOGIES TO BE USED  
DIGITALISATION OF THE NATIONAL LAND CADASTRE**

<p><b>LAHS + DGPS</b></p>  <p style="color: green; font-weight: bold; text-align: center;">LAHS + DGPS SOFTWARE &amp; HARDWARE</p>	<p><b>LAHS</b> (Land Application Handling System) Database Entry  <b>DGPS</b> (Differential Global Positioning System) Spatial Data Acquisition in the Field  <b>ESRI® ArcGIS®</b> Geographic Information System (GIS)  <b>Oracle 9i</b> (Relational Database Programme) Database management  <b>ESRI® ArcSDE®</b> Spatial Data Engine (SDE)  <b>ESRI® ArcIMS®</b> Internet Map Server (IMS)</p>
 <p style="color: green; font-weight: bold; text-align: center;">DETAILED SURVEY OF ACCURACY, USE AND OCCUPANCY OF LAND GPS GPS GPS</p>	

A small multi-disciplinary team from different government institutions has been set up to identify and document all existing information, data and systems in Mozambique. At first stage, graphical data will be scanned and georeferenced while vectorisation is set up and gradually undertaken.

### 3.3 The phases of the LIM-SI

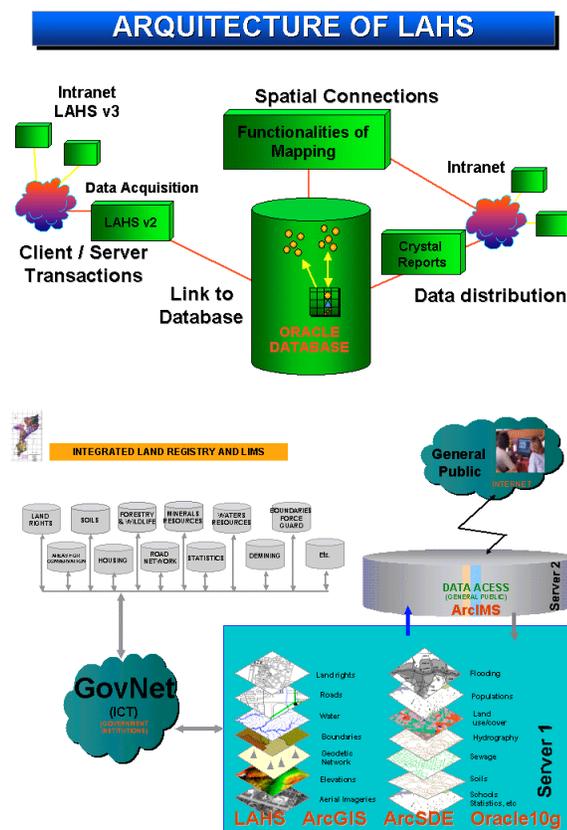
In order to build a common basic framework of Land Information Management System Infrastructure, different phases have been identified.

#### 3.3.1 Feasibility study

The feasibility study phase will have to deliver a document describing land information needs based upon the present data collection, processing and retrieval procedures and systems among the various agencies producing land information, indicating possible stumbling blocks that could hamper the transformation from any isolated and individual systems to a more efficient and transparent systems.

#### 3.3.2 System Design and Development

The design phase is regarded as the cornerstone of the total program. The system



design and development phase has to extend the existing database and LAHS at Dinageca constructing a new conceptual and logical design with its different components, which includes: analysing the functionality, data requirements, flow of the processes, validation and business rules, task sequences, graphical interfaces and the layout of the forms and data integration.

The design of the deliverables will be the design of a comprehensive national land information management system infrastructure of Mozambique, including: database structures; type of information (geo-attributes); technical requirements (workflow, da-

tabase tables and entities, data standards and terminology, user interface, spatial data requirements, hardware and software environment and maintenance procedures, etc.), protocols, basic legal and regulatory frameworks; institutional linkages; operational platforms to be used; communication procedures.

The development of the application will involve the following: form design and graphic user interface, database connectivity, security protocols, data entry validation, code modules, implementing business rules, changing and updating specifications as required, dependency checking, ongoing creation of online administrator and user help.

A conceptual and logical design will include the strategy and financial requirements for the establishment of a comprehensive national land information management system infrastructure.

### **3.3.3 System implementation**

Taking into account that a conceptual and logical design will have been constructed in the previous phase. The third phase has to produce the strategy and financial requirements for the establishment of a comprehensive national land information management system infrastructure for the Government.

Once the application has been completed, a Beta Version of the application will be installed in the internet to be tested. Any bugs are to be reported and the developer will then make the appropriate changes ready for deployment. Typical problems would include: refining the installation process, dealing with trappable errors, dealing with operating system errors, dealing with Database connections, testing application on various environments, testing possible scenarios, improving code efficiency, etc.

Once the application has been tested, Dinageca and all other Government Institutions will install a Version 1 of the system and will be asked to begin to use the application within an operational mode.

### **3.3.4 System Training**

Once the final release has been made, the team builders will do training sessions held with the officers from all institutions responsible for natural resources administration and management to facilitate the transfer of the system. The system will be developed with an on-line manual. The institutions have to specify responsible technicians for supporting the application on site.