

# **Enterprise GIS Implementation for the National Authority for Remote Sensing and Space sciences in Egypt: A case study**

**Belal M. El-Leithy and Ayman H. Nasr**

National Authority for Remote Sensing and Space Sciences, 23 Joseph Broz Tito st.,  
El-Nozha El-Gedida, P.O. Box: 1564 Alf-Mascan, Cairo, Egypt  
belal@narss.sci.eg, aymanasr@hotmail.com

## **ABSTRACT**

National Authority for Remote Sensing and Space sciences (NARSS) is one of the Egyptian government pioneer agencies in the use and utilization of information technologies in general and spatial information in particular. More than thirty years of experience and activities have resulted in the accumulation of huge volume of valuable data and information. This includes stored satellite images, aerial photos, digital elevation models (DEM), digital thematic maps, topographic maps, field measurements data, scientific research reports and many other spatial data related to the Egyptian territory. In this regard, NARSS has established an enterprise Geographic Information System (GIS) to host and facilitate the use of this enormous volume of geographical data and information. It involves an enterprise spatial database, web components and tools to provide both map and geo-processing services for NARSS different departments. The system hardware structure is based on clustered servers for improving system availability in addition to SAN storage. The software development is based on ESRI ArcGIS server product for publishing both map and geo-processing services and ORACLE as a database management system. Since the metadata is important, from a data management perspective, for maintaining an organization's investment in spatial data, the ISO/TC211 metadata standards has been adopted. The system provides the necessary user-friendly tools to perform the geo-data/geo-information related functions; such as archiving, retrieval, updating and analysis. This system will not only protect the data and information wealth, but also play a very positive role in directing the activities of the organization and exchanging geo-data/geo-information. Therefore, the main objective of constructing this system is to improve the overall performance of NARSS in handling and managing data and information related to the previous, on-going and future activities of the organization and serve as a pilot for a nation-wide system. This paper is describing the system structure from hardware, software and data points of view, in addition to its operation and utilization.

Keywords: NARSS, Enterprise GIS, Geo-data/Geo-information, ESRI ArcGIS, ORACLE

## **INTRODUCTION**

NARSS is the pioneering Egyptian scientific authority in the field of remote sensing and GIS. It was established in 1994 as an organization under the State Ministry of Scientific Research to promote the use of state-of-the-art in space technologies to serve development projects in the country and to introduce High Tech. capabilities in national and regional planning among other applications. NARSS is organized to include eight scientific divisions as follows:

- Geological Applications and Mineral Resources
- Engineering Applications and Water Resources
- Space Sciences and Strategic Studies
- Aerial Photography, Aviation and Surveying
- Data Reception, Analysis and Receiving Station Affairs
- Agriculture Applications, Soils and Marine
- Environmental Studies and Land Use
- Scientific Training and Continuous Studies

NARSS has accomplished many projects and researches. It has the equivalent of more than 500 gigabytes of spatial data in various formats. These data was stored in directories and project folders scattered all around the Authority and replicated on many drives. Due to the storage mechanism and lack of organization standards, it is very difficult to identify, locate and differentiate between the original and current (project generated) spatial data to be stored in the database. There were no organization-wide spatial data quality control procedures, standards, or metadata. Also, data replication, duplication and reproduction may be made due to the existing lack of organization and structure for GIS and spatial data. Therefore, a Geographical Information System (GIS) program to implement an Enterprise GIS has been established. The Enterprise GIS database will store the spatial data at a centralized database for various uses and users. The system will form the spatial data framework for evaluation, assessment and selection of the projects throughout NARSS. It will also provide cost and time savings by facilitating decision making for its projects and their implementation. In the following paragraphs of this paper the Enterprise GIS system structure from hardware, software and data points of view, in addition to the progress in its implementation will be summarized.

## **OBJECTIVES**

Development of standard operating procedures, quality assurance/quality control procedures and timely updates are determined as a necessary and integral part for well-organized, efficient GIS database development (Cesur, 2005). These procedures provide feedback on database users' abilities and ensure the quality, currency and accuracy of GIS data. NARSS GIS system was established to develop and implement a regional GIS database and associated

components for the most up-to-date data. This system is responsible for promoting and developing strategies for organizational spatial data standardization, automation and integration, and for ensuring consistency between the different departments. The system would not only protect NARSS valuable data and information wealth, but would also play a vital role in directing its activities and exchanging geo-data/geo-information.

The objective of constructing this system is to improve the overall performance of NARSS in handling and managing the huge data and information related to previous, on-going and future activities of the organization. It will help in:

- NARSS data gathering and documenting.
- Data integration and standardization assurance.
- Easiness of data retrieval.
- Availability of analytical data for Decision makers support.
- Supporting data security in more reliable way.
- Preventing data and effort duplication within different departments.
- Supporting the ongoing projects conducted by NARSS.
- Accomplishing a follow-up mechanism for the ongoing projects
- Data and information availability for accomplishing tech. proposals.
- Easiness of marketing NARSS's data.
- Capability to have a link with other information agencies.

## **METHODOLOGY**

The implementation sequence of the Enterprise GIS database system has been developed according to the procedure demonstrated in Figure (1). A major portion of the feature and attribute data entry will be carried out by departmental personnel. NARSS already gathered and standardized some of the data layers that would be used as a starting point for departmental GIS database formation. The GIS database includes many data types that are used by all departments of the organization, as shown in figure (2). The system provides mechanisms to have inter-departmental, organization-wide communications, feedback, and collaboration. Figure (3) depicts system hardware configuration and availability. Existing personnel includes a system manager, administration and several technicians.

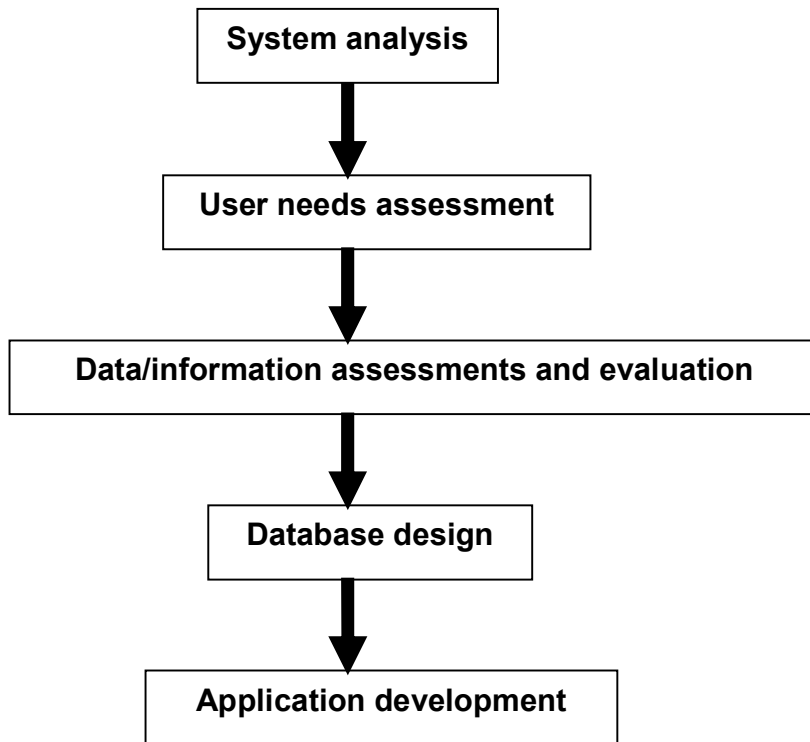


Figure (1) The implementation sequence of the system

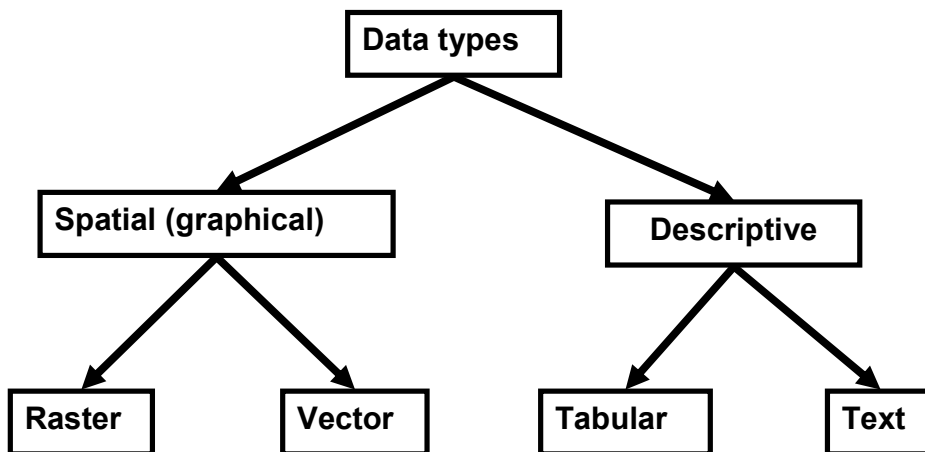
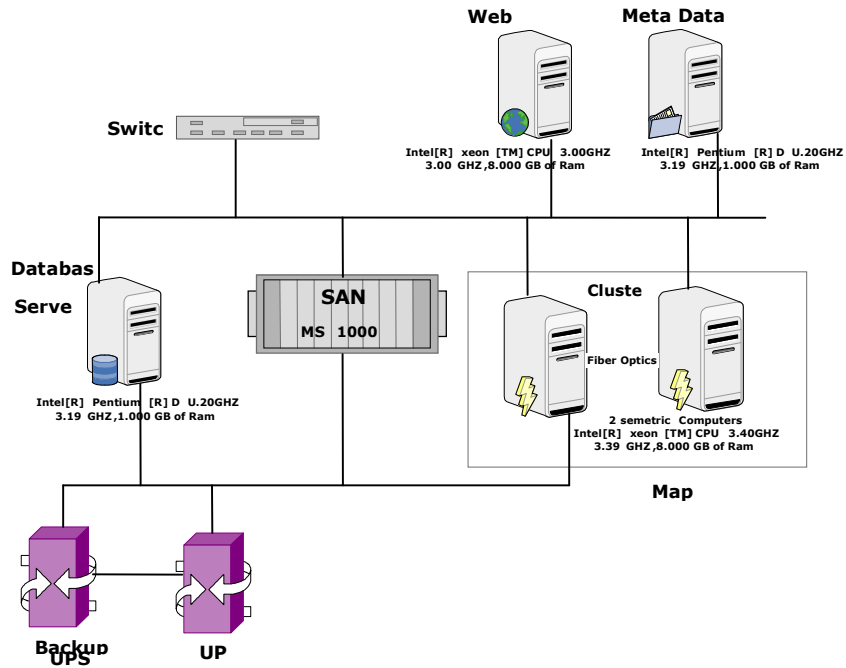


Figure (2) Different Data Types of the system

**NARSS Data Warehouse Hardware Diagram**



**NARSS Data Warehouse Software Diagram**

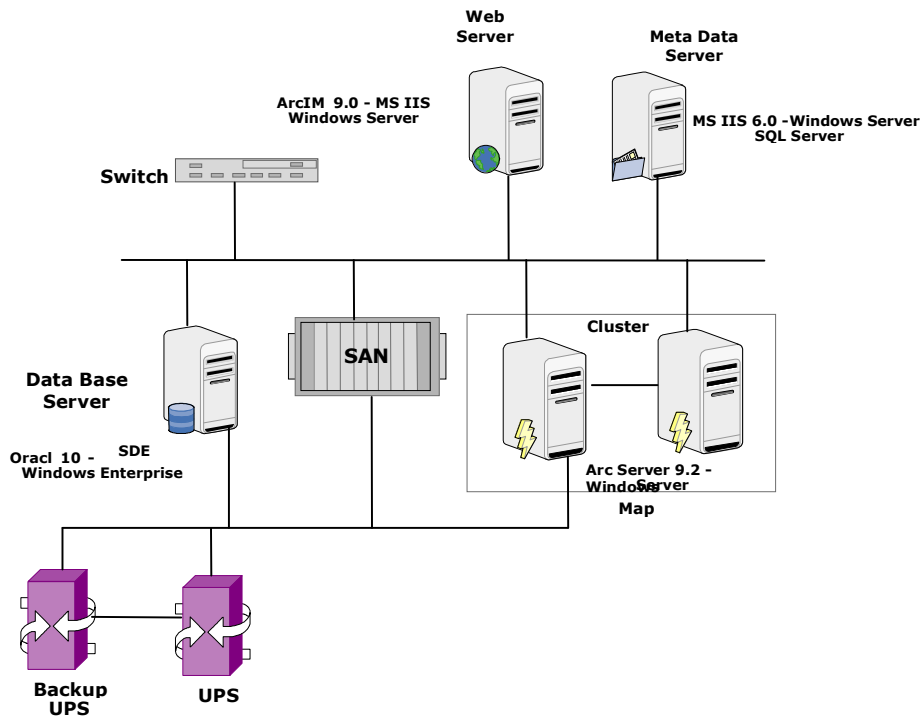


Figure (3) System configuration and availability.

### **Current System Architecture:**

The system developed as a web base application, using ArcGIS server as spatial data management, administrative and geo services publishing development tool. (ESRI,2007).

### **Hardware:**

Current Hardware Configuration includes:

2 Dell Poweredge Servers with dual processor 3.0 Gbyte, Ram 8 Gbyte  
1 IBM Msan Server with 2 terabyte HDD and 8 Gbyte Ram.

### **Software:**

ArcGIS version 9.0

Oracle 10 G

ArcGIS Server version9.0.

### **System Modules**

The system has four main modules which are being used in sequence to allow the different departments to benefit from the numerous organization spatial information and tasks, as presented in figure (4). The four main modules are:

- Authoring Module: This allows the departments to prepare the spatial data and tasks that will be shared, and how they will be presented.
- Publishing Module: This allows the departments to avail their authored GIS resources to be consumed by others.
- Administration Module: This allows the system administrators to defined participated departments and users, and allows departments administrators to control the privileges on their published resources.
- Using Module: This allows departments users to consume the published GIS resources.

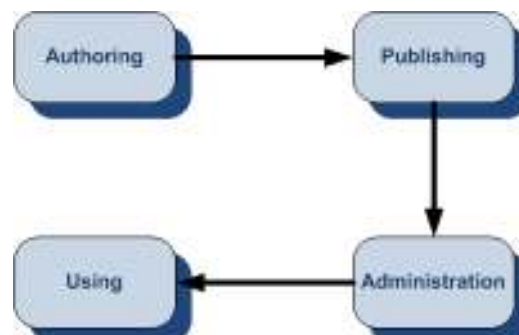


Figure (4) System Modules

## Authoring Module

The authoring module is the main module for organizations to author their spatial data infrastructure which is not limited to geographic information but it also includes geographic tasks to be automated on the available geographic information.

## Geographic Information

Map documents are authored using ArcGIS Desktop to convey the geographic information into thematic representations, figure (5), through:

- Discrete features such as collections of points, lines, and polygons.
- Map symbols, colors, and labels that help to describe the objects in the map.
- Aerial photography or satellite imagery that covers the map extent.
- Continuous surfaces such as elevation which can be represented in a number of ways—for example, as a collection of contour lines and elevation points or as shaded relief.

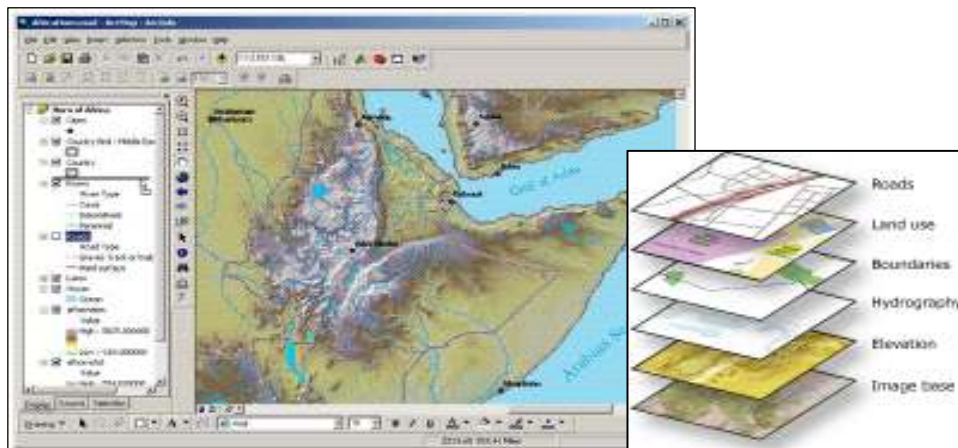


Figure (5) Thematic representations of the geographic information

## Geographic Tasks

Geoprocessing toolboxes are authored using ArcGIS Desktop ESRI product to convey the geographic tasks by chaining a sequence of operations where each one is performed on an ArcGIS Dataset to produce a new dataset as a result of the operation, see figure (6). The kinds of tasks to be automated can be mundane—for example, to wrangle herds of data from one format to another. Or the tasks can be quite creative, using a sequence of operations to model and analyze complex spatial relationships—for example, calculating optimum paths

through a transportation network, predicting the path of wildfire, analyzing and finding patterns in crime locations, predicting which areas are prone to landslides, or predicting flooding effects of a storm event.

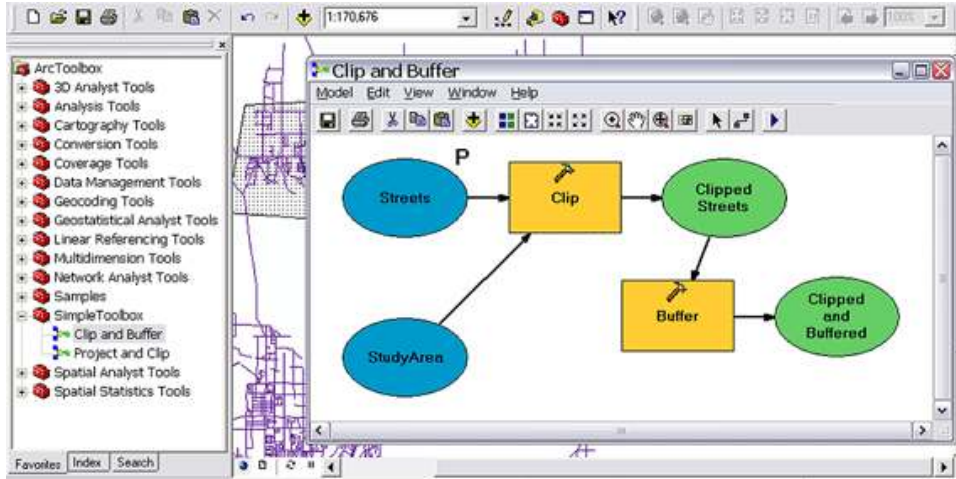


Figure (6) The Geoprocessing toolbox

## Publishing Module

Once the organization authored its GIS resources, including map documents and geoprocessing toolboxes, they publish those resources as services using either the ArcGIS Server Manager, figure (7) web application or the ArcGIS Desktop. Published map services provide access to the contents of authored map documents with the needed mapping functionalities including map rendering, identifying, finding, selecting, querying and other tools. Also, published geoprocessing services provide access to the authored geoprocessing toolboxes to execute its tools as geoprocessing tasks.

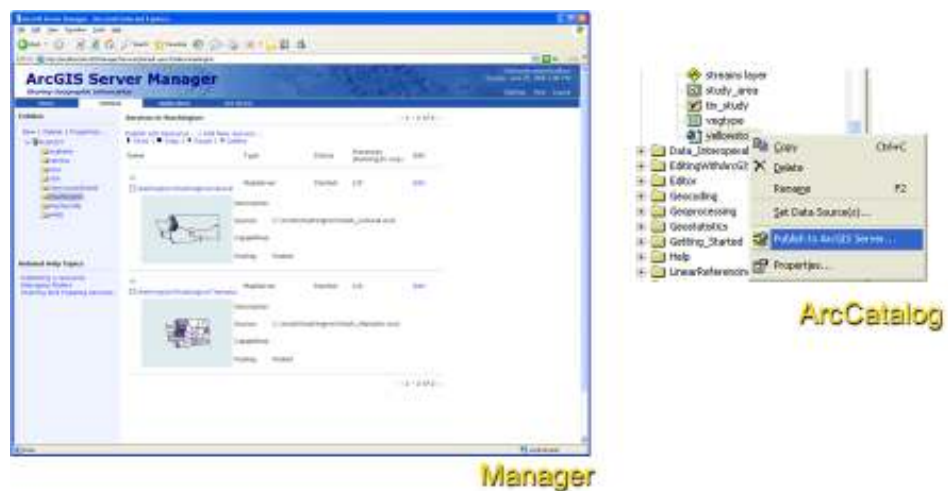


Figure (7) ArcGIS Sever Manager

## Administration Module

The administration module represents the backend for the system which allows two levels of administration. The first one is the system administration which is managed by the system administrator at the central server to define the participated departments, users and the general settings. The second one is the services administration which is managed by the departments' administrator to guarantee the spatial data ownership.

### System Administration

The system administration sub-module, figure (8), allows the system administrator to manage participated departments and users. It also provides the ability to manage the map services' categories and scales which used by departments in defining the published map services.



OrgID	Organization Name	Organization IP	User Name	Edit	Delete
13	ESA	124.0.0.55	ESA	Edit	Delete
14	MPCA	124.0.0.54	MPCA	Edit	Delete
15	Sakshat	124.0.0.57	Sakshat	Edit	Delete
17	GAEB	124.0.0.59	GAEB	Edit	Delete
18	GSDC	124.0.0.60	GSDC	Edit	Delete

Add new organization

Figure (8) System administration sub-module

### Services Administration

The services administration sub-module, figure (9), provides the departments' administrators with the ability to defined published map services and geoprocessing services in order to be used by system users. It also allows the departments administrators to control the users' privileges for both the map services and the geoprocessing services.



Figure (9) Services administration sub-module

## Using Module

The system using module is the system fronted for departments' users to get the value of published national spatial data infrastructure from the participated organizations by:

- Visualizing and interacting with maps through the maps visualization sub-module.
- Performing geoprocessing analysis.

## System Functionality

### Maps Visualization & Interaction

The maps visualization sub-module, figure (10), is Quality Standards customized web mapping application which avails the mapping functionality of published mapping services from different organizations to the users, including zooming, panning, hide/show layers. Published map services are organized by hierarchical categories, scales and organizations ownership in a way that allows users to reach smoothly the map contents they are interested in. Moreover, Users can also filter the map contents based on their needs for a subset of categories, scales and organizations.





Figure (11) Geoprocessing analysis sub-module

## Map Catalog

Under the map catalog tab, figure (12), the user can view a hierarchical form of the system maps. The maps are categorized by the business category they belong to and in each category the maps are classified according to the scale of the map to be finally classified by the departments to which they belong. Under the map name finally the user can see the layers of the published map services.

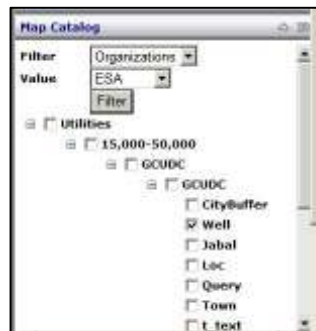


Figure (12) Map catalog

## Map Contents

The map contents, figure (13), is a more specific form of the Map categories as it displays the maps' names and under each one the layers belonging to it as well as the map legend for each layer. There is check box beside each layer that the user can use to show the layer that he/she would like to display on the map or uncheck the undesired layers to become invisible on the map.



Figure (13) Map contents

## Geoprocessing Tasks

The Geoprocessing tasks, figure (14), allow system users to consume the published geoprocessing services from different departments based on the user privileges using two panels. The first panel is the tasks panel which displays the geoprocessing tasks available for the user to consume. By clicking on any of the tasks, a window will appear with the parameters needed to run the task. By entering the values of needed parameters and pressing the execute button, the results will appear on the second panel which is the tasks results panel, the results will also appear on the map. Through the tasks results panel the user can see the attributes information of submitted the geoprocessing task as well as download the results if the geoprocessing task supports that and the user have sufficient privileges.

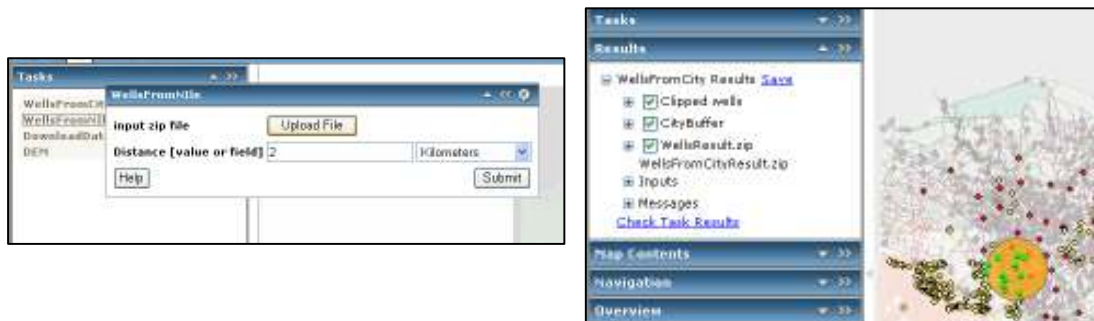


Figure (14) Geoprocessing tasks

## Metadata

Metadata "data about data" describe the origins of and track the changes to geospatial data. It is a summary document providing content, quality, type, creation, and spatial information about a data set. It can be stored in any format such as a text file, Extensible Markup Language (XML), or database record. Because of its small size compared to the data it describes, metadata is more easily shareable. By creating metadata and sharing it with others, information about existing data becomes readily available to anyone seeking it. Metadata

makes data discovery easier and reduces data duplication (ESRIa, 2002). GIS metadata has a spatial component such as the extent of the earth's surface the data covers. Metadata can describe GIS data, a GIS Web service, or an online metadata catalog. Metadata can also describe non-electronic data such as paper maps or offline electronic data such as data stored on CD or tape media (ESRIb, 2002). It maintains the value of the data and assures their continued use over a span of years. The metadata and data dictionaries have been generated/finalized for the data migrated to the enterprise GIS database, Figure (2). The project groups output are in different spatial data formats as vector data source (Shapfiles – Coverages – Cad files).we migrate all these formats to only one format ArcSDE-Oracle Geodatabase to get the benefits of enterprise RDBMS (security – backup – restore...). Currently, the loading process has been completed for some of the data sets. The departmental GIS database support projects were initiated to form department specific databases.

## **CONCLUSIONS**

This paper has provided an overview of NARSS enterprise GIS implementation. Illustrations of its architecture have been provided and demonstrated. The development of the enterprise GIS database and associated web components and implementation will ensure the spatial data quality and increase the productivity of NARSS personnel related with their daily works and will increase the organization-wide efficiency. As the development and implementation of the geo/databases continues and matures, it is expected to have more interest and extensive use of GIS database by NARSS managers and departmental staff as a spatial data management, manipulation, analysis, modeling and decision making tool on a regular basis. Therefore, it will promote cooperation by allowing department autonomy, motivate effective participation, automate performance, and support an incremental development path.

The database will support real-time, near real time and other applications. The investment in GIS will improve efficiency at NARSS by providing timely and reliable information to address regional issues, concerns and problems. NARSS GIS database and associated components will facilitate better planning, management, implementation decisions by provision of proper information, analysis and visualization capabilities. It will also provide tools to generate future opportunities and add value to NARSS services. Finally, the long time target is to reach to the Egyptian Spatial Data Infrastructure.

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