



Science

AN OVERVIEW OF THE ENVIRONMENTAL LAND INFORMATION SYSTEM (ELIS)

M. Azharul Haque*¹, R. Karim²

*¹Dept. of Electrical & Electronic Engineering, Bangladesh University of Business & Technology, BANGLADESH

²Dept. of Electrical & Electronic Engineering, Uttara University, BANGLADESH



ABSTRACT

An overview of the application software for storage, integration and management of Land Records and Environmental Data has been presented. The title of the software is “Environmental Land Information System”, abbreviated as “ELIS”. Modern hardware technologies like Total Station, Satellite, GPS, Digitizer, scanner along with computer have been used where software technologies like GIS and RDBMS have also been used in capturing, collecting, storing, integrating, and retrieving data. Technologies like plotter has been used in generating various maps including mouza map. A Bangla interface was also integrated with the system for writing Bangla scripts on maps and other land records. Two separate types of databases have been created – one for attribute data and the other for spatial data. The application software has the capability to append new data- attribute and spatial, to the databases to update and enrich the databases. This article gives a conceptual view of the software. The main emphasis in developing the software was in the use of GIS and Bangla interface.

Keywords:

ELIS, Spatial Database, Attribute Database, Total Station, Land Use, Bangla Interface, Mouza Map.

Cite This Article: M. Azharul Haque, and R. Karim, “AN OVERVIEW OF THE ENVIRONMENTAL LAND INFORMATION SYSTEM (ELIS)” International Journal of Research – Granthaalayah, Vol. 3, No. 11(2015): 58-86.

1. INTRODUCTION

The Environmental Land Information System (ELIS) is software that has been developed under the UNDP funded Sustainable Environmental Management Program (SEMP), Component No.1.42 (BGD/96/007), executed by the Directorate of Land Records and Survey (DLRS), MOL, the GOB and implemented by Info Consult Ltd. One of the objectives of SEMP project was to design, develop and implement an "Environmental Land Information System" or abbreviated as ELIS to manage landuse and environmental information related to land. In this article, the

conceptual view of the ELIS i.e., its architecture, technologies, data structure, databases, and methods of data capturing, storing and retrieving are presented. The main concepts for developing ELIS are [34, 35]:

- i. Design and develop an environmental land information system database comprising of land records (maps & khatians) and the environment related data collected through land use survey and from different secondary sources.
- ii. Design and develop customized software interfaces for the proposed ELIS, which would be built on compatible software platform of DLRS existing system; moreover, the software interface would use the windows GUI under Bangla Font and Bangla database; and
- iii. Produce thematic maps and other analytical and technical reports, outputs with regards to land and environmental aspects by using advanced GIS analysis & techniques. Such GIS analysis and output processing will be done using ELIS database and customized software interfaces.

Modern technologies like Total Station, Satellite, GPS, GIS and DBMS have been used in capturing, collecting, storing, integrating, and retrieving data. Technologies like plotter have been used in generating various thematic maps including mouza maps. A Bangla interface was also integrated with the system for writing bangla scripts on maps and other land records. Separate databases for attribute data and spatial data have been built within the software including query system for retrieving data and reporting purposes.

The main emphasis in developing the software was the use of Geographic information system (GIS) and Bangla interface. GIS has been incorporated as it has successfully been used in scientific investigations, resource management, and development planning in different countries. For example, a GIS might allow emergency planners to easily calculate emergency response times in the event of a natural disaster, or a GIS might be used to find wetlands that need protection from pollution, the main driving force of ELIS is GIS.

2. GIS TECHNOLOGY AND MAP MAKING

A GIS is composed of a computer system capable of capturing, storing, analyzing, and displaying geographically referenced information; that is, data identified according to location including the procedures, operating personnel, and spatial data that go into it [13]. One of the most common products of a GIS is a map. Research work was carried out in order to incorporate the mapmaking processes of traditional cartographers into GIS technology for the automated production of maps [14,15].

Maps are generally easy to make using a GIS and they are often the most effective means of communicating the results of the GIS process. Therefore, the GIS is usually a prolific producer of maps. The users of a GIS must be concerned with the quality of the maps produced because the GIS normally do not regulate common cartographic principles [16]. One of these principles is the concept of generalization, which deals with the content and detail of information at various scales. The GIS user can change scale at the push of a button, but controlling content and detail is often not so easy. Mapmakers have long recognized that content and detail are needed to be changed as the scale of the map changes. For example, the Mouza Maps can be mapped at various scales, from

the small scale of 1:500,000 to the larger scale of 1:250,000 and the yet larger scale of 1:100,000 (Fig.1a), but each scale requires an appropriate level of generalization (Figs. 1b, 1c, and 1d)

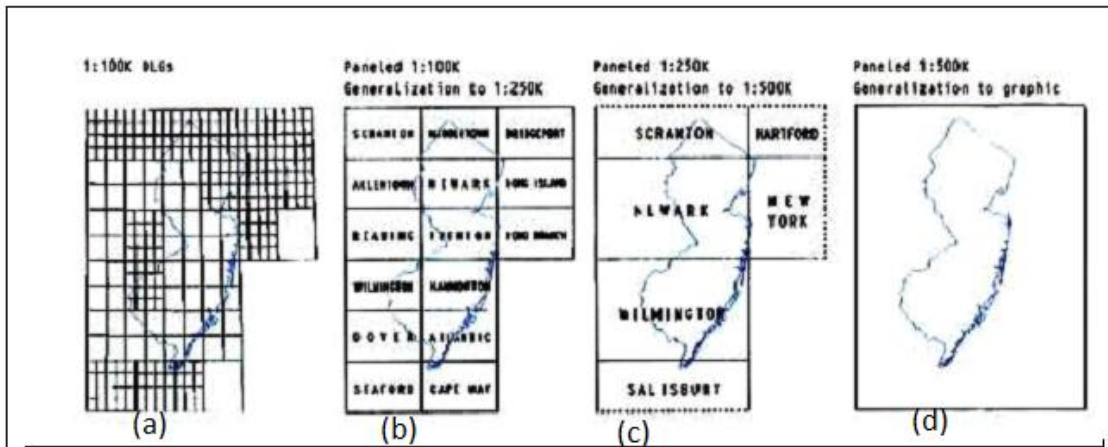


Figure 1a- 1d: Digital revision of 1:100,000-scale digital line graph data to produce a 1:500,000-scale New Jersey State base map. Paneling and generalization are shown in three stages from 1:100,000 scale to 1:250,000 scale to 1:500,000 scale [32].

The GIS is known for its ability to relate different information in a spatial context and to reach a conclusion about this relationship. Most of the information we have about land contains a location reference, placing that information at some point on the globe [10,12,17,18,19]. For example, when rainfall information is collected, it is important to know where the rainfall is located. Using a location reference system, such as longitude and latitude, and perhaps elevation, does this. Comparing the rainfall information with other information, such as the location of marshes across the landscape, may show that certain marshes receive little rainfall. This fact may indicate that these marshes are likely to dry up, and this inference can help us make the most appropriate decisions about how humans should interact with the marsh. A GIS, therefore, can reveal important new information that leads to better decision-making [6, 20, 21].

A GIS can be used to emphasize the spatial relationships among the objects being mapped. While a computer-aided mapping system may represent a road simply as a line, while GIS may also recognize that road as the boundary between mouzas and urban development between two census statistical areas [11, 12, 22, 23, 24].

Different kinds of data in map form can be entered into a GIS . For example: rainfall data, soil data, road network data, gas network data, river & cannel network data, crop data, and so on can be integrated with GIS [12,25,26]. A GIS can also convert existing digital information, which may not yet be in map form, into forms it can recognize and use. For example, digital satellite images can be analyzed to produce a map of digital information about land use and land cover [27]. Likewise, census or hydrologic tabular data can be converted to a map-like form and serve as layers of thematic information in a GIS.

To analyze the effect of the earth's terrain more realistically, one can use three-dimensional models within a GIS. A GIS can display the Earth in realistic, three-dimensional perspective views and animations that convey information more effectively and to wider audiences than traditional, two-dimensional, static maps [28, 29, 30, 31].

A GIS may not only be used to show the positions of objects on a computer screen – it can also be used to model real-world events. One of the most important examples of this is the ability to model networks. There are many networks in geographical data in a mouza, such as water body like canal or lake and street maps. A GIS can analyze the potential flow around these networks, a useful ability in flood analysis or route finding. It can only do this if the data has correct network topology – the joining of the lines at exactly the same point in the data. Lines in a GIS network are usually called links, the points which define the shape of the link are called vertices, and the points at which they join are called nodes. Figure 2 shows how a link-node topology will look like:

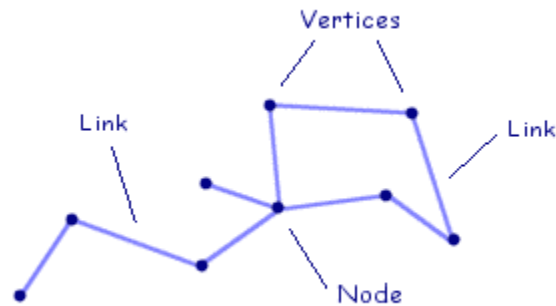


Figure 2: Link-node topology

Another important feature of GIS is Polygon topology. Area features are defined in a GIS by the linear shape of the perimeter and some kind of reference point indicating that the space enclosed by those lines relates to a geographical feature. This reference point is referred to as a centroid, a seed or a label point. Geospatial data is often captured in the form of line-work showing the extent of physical features on the ground, like fences, roads, and rivers. The area features then have to be identified by assigning seed points to each bit of space in the resulting map data. For example, a wall feature may, at one point of its length, define the perimeter of a school playground, but further along form the edge of someone's front garden. It is the seeds that store the information about which links make up the edge of an area feature and what it is. It is very important to avoid undershoots in the data, otherwise the system cannot tell whether an area is closed at a particular point. Figure 3 shows polygon topology:

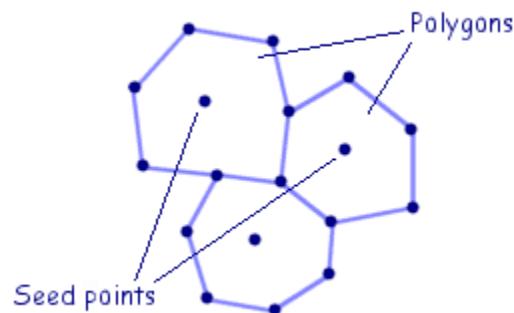


Figure 3: Polygon topology

Components of GIS are: (i) Cartographic Display System (ii) Digitizing System (iii) Database Management System, and (iv) Geographic Analysis System. All these features and capabilities of GIS was the basis of integrating GIS into ELIS.

3. CONCEPTUAL FRAMEWORK OF ELIS

Any software development undergoes different processes, which is known as Life Cycle Model of Software Development [1, 2, 3]. ELIS is not different from this. The main components of the ELIS are application software and the databases. The database for ELIS is a little bit different from the ordinary commercial database. It involves two types of data: Spatial Data and Attribute Data. So, it was needed to create two types of databases for the storage of data in ELIS - a spatial database and an Attribute database. Spatial data again needed geo-referencing. When geo-referenced, spatial data is known as geospatial data. Geospatial data stores information about the location, shape and attributes of real objects. It is the capturing of this information in digital form that makes it much easier to store and reproduce. It also enables the power of computers to be used in manipulating, updating and analyzing the information in many different ways. The creation of database again involved several processes: database design, data capture and storage according to the designed structure of the database.

A lot of geospatial data has been created for ELIS using existing mouza maps as a template. Also some geospatial data have been captured by taking measurements direct from physical surveys. The two most important methods of geo-spatial data capture are scanning and digitizing. For scanning maps, scanners were used. The scanner takes any printed image and takes a picture of it. By capturing the image in digital form it was stored on the computer. Scanning a map is a straightforward process and generally fast, but it does not provide for the capture of attribute information for features, such as the address of a building.

Data capturing involved vectorization of scanned data. Some very specialized computer systems are able to convert raster data to vector data by recognizing patterns in the image. For instance, it can guess that sequences of colored pixels which seem to form a line across the image are showing a linear feature of some kind. If the system knows the extent of the real position of the image, it can convert these shapes into vector information. This vectorization from raster data can be a fast method of capture because it can be automated, but is usually less accurate than manual digitizing.

For storing geo-spatial data, it was necessary to use some coordinate system, because points and features on, above and below the earth's surface have position. To express that position, we needed to choose an appropriate coordinate system so that positions can be defined within it. For such a system obviously each point was given a different coordinate.

Geospatial data inherit topology from the source material. It describes the precise physical location and shape of geographical objects. Hence, when digitizing a map, the topology, which is implicit in the visual interpretation of the map, has been built into the data. However, the term topology is more concerned with the logical relationships between the positions of the geographical objects.

3.1. CONCEPTUAL VIEW OF ELIS

Figure 4 shows how the ELIS has been conceptualized:

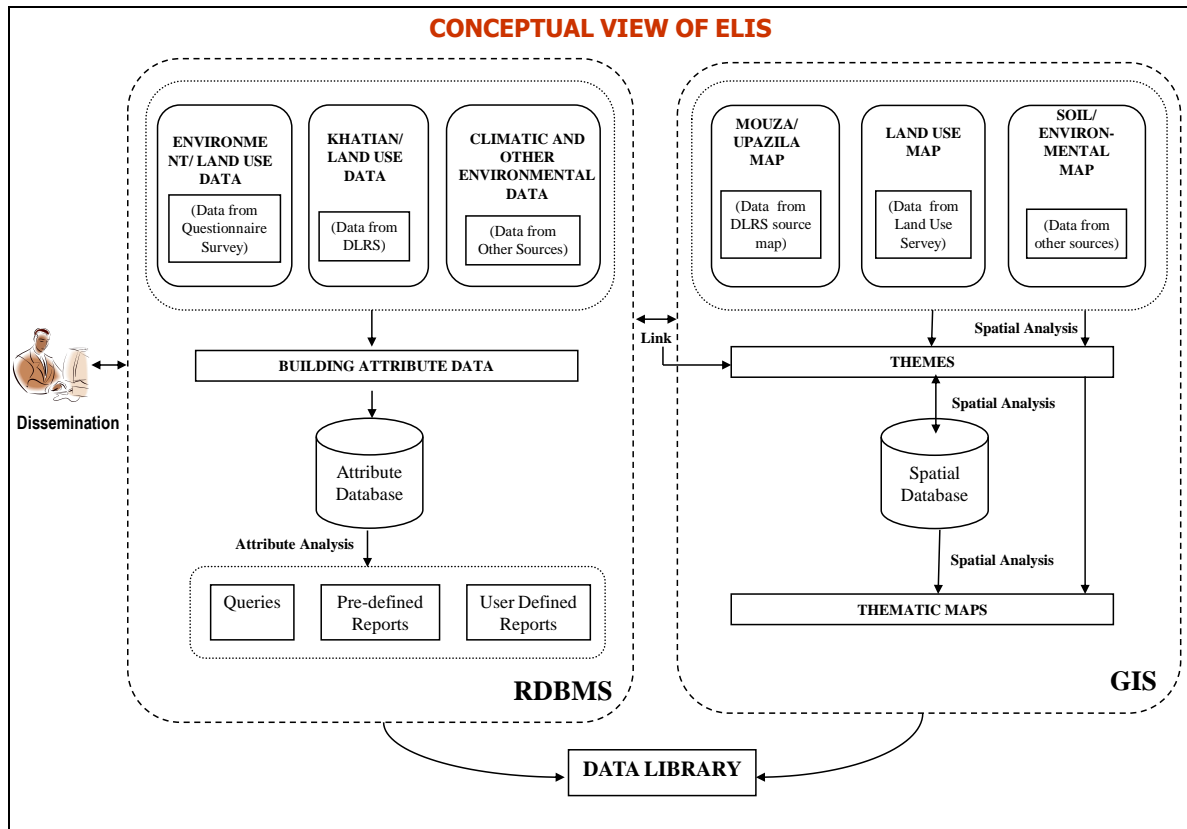


Figure 4: Conceptual Overview of ELIS

From this diagram, we can see that two databases – one of attribute and the other of spatial data is created by the system. In creating the attribute database popular ORACLE RDBMS has been used and in creating spatial database, popular GIS software ARC/Info has been used. The attribute database consists of: Environmental Data, Khatian Data; and Climatic and other environmental Data.

The spatial database consists of: Mouza Map, Land Use Map, Soil/Environmental Map (from secondary and tertiary sources). The figure-4 also shows how the data from these two databases are linked together to create the environmental maps.

3.2.FEATURES OF ELIS

The following capabilities have been built in ELIS:

- A data ware house containing Spatial & Attribute Databases
- Means of Data Entry, Updating, Backup, Archival & Retrieving data through user friendly interfaces
- Generation of Thematic Maps using spatial analysis and query
- Displaying, composing and plotting of maps at different scales
- Facilities to disseminate data to stakeholders like Planners, Researchers and other interest groups in different formats
- Generating thematic maps on Land use pattern and land use changes at plot level

- Generating and printing reports and thematic maps on land uses, resources, and environmental aspects based on Queries at Mouza and Upazila level
- Performing statistical and GIS analysis
- Integrating with Land Khatian Data at DLRS developed under a pilot scheme for Land resource management
- Provision of importing and exporting spatial data in various formats such as ArcView Shape file, ArcInfo coverage, DXF for other vector-based programs
- Provision of importing and exporting attribute data in various formats such as .mdb file, .dbf file, .xls file, .doc file
- Most of all, ELIS has a user friendly Bangla interface for writing map features in Bengali script on to the map.

3.3.DATABASE IN ELIS

Any application software is incomplete without the database that is to be used for generating information for the users, especially for the decision makers in the form of reports, graphs, maps, etc. So, data capture or data acquisition & storage plays a greater role in the software development.

In ELIS, creating two separate categories of databases was necessary. These are (i) Spatial Database: data describing features of a space or location; and (ii) Attribute Database: data related various aspects of the spatial data.

Data are available as raw geographic data: (i) in analog form - mouza maps, aerial photographs, satellite, image or tables; and (ii) in digital form - from secondary sources or through digitization

A map is a geographic depiction of all or a part of a geographic realm in which real world features have been replaced by symbols in this correct spatial location at a reduced scale serving as a method of visually interpreting the data representing real world features. The spatial data on map form an important source of spatial data, but it cannot be utilized for various types of analysis. For GIS analysis of spatial data on map, it is needed to be digitized

In ELIS, data capture—putting the information into the system—involves identifying the objects on the map, their absolute location on the Earth's surface, and their spatial relationships. Software tools that automatically extract features from satellite images or aerial photographs or Total Station are gradually replacing what has traditionally been a time-consuming capture process. Objects are identified in a series of attribute tables—the "information" part of a ELIS. Spatial relationships, such as whether features intersect or whether they are adjacent, are the key to all GIS-based analysis in ELIS.

There are three (not mutually exclusive) ways to create geographic database:

- Acquiring spatial data in digital form from secondary sources
- Digitization of the existing analog data such as map
- Carrying out direct digital capturing such as cadastral survey using total station and geodetic survey using Geographic Positioning Systems

However, in all these three cases, the data must be registered or recorded geometrically according to a generally accepted and properly defined coordinate system.

Another important point for geographic database is that whether data is in analog or digital form, it has to be converted to the internal format of the GIS being used to store the data. Once this is done, the data may be assigned to different layers and the entire map can be reconstituted by combining these layers.

The data represented in the map may be manually incorporated to ELIS in the following 4 main stages:

i) Entering the spatial data; ii) Entering the attribute data; iii) Spatial and attribute data verification and editing; and iv) Linking attribute data to spatial data, where necessary.

In ELIS, the questions to resolve were “How to capture the data from the maps?” and “How to organize the data to be used as the information on a map?” The data to be used by the computer is not available in digital form i.e., in a form the computer can recognize. Various techniques may be used to capture the data from the maps. These are: (i) digitizing hard copy maps by hand tracing with a computer mouse on the screen or by moving a digitizing tablet on the mouza map to collect the coordinates of features; and (ii) by using electronic scanners to convert maps to digits. Coordinates from Global Positioning System (GPS) receivers and Total Station for Cadastral Survey can also be uploaded into an ELIS.

3.3.1. ENTERING THE SPATIAL DATA

Spatial data may be entered in 3 different methods:

- a. Inputting from key board: Simplest way of inputting spatial data is by typing the coordinates into a file or input program of a GIS by a Keyboard. But this is time consuming and laborious.
- b. By digitizing the map: The laborious method of typing in geographic data can be avoided by using a piece of Hardware device called digitizer & GIS. Must GIS offer digitization programmer as part of the Software, which allows semi-automating the digitization process through a series of dialog box driven routines. The main purpose of digitization is to merle the map coordinates (y-coordinates). The result is the vector form of maps.
- c. By Scanning: In this method, the map is scanned using a high-resolution scanner. The result is a map in bitmap form, which may be converted to vector form by Software program modules offered by GIS.

3.3.2. ENTERING ATTRIBUTE DATA

Attribute data (also called feature codes) are the descriptive information about the geographic features used to describe characteristics, measurements, and other facts and observations about geographic features. Attribute data may be input into ELIS in either of the following two ways:

Manually or importing the data from the secondary sources using standard transfer format, like TXT or ASCII.

3.3.3. DATA VALIDATION IN ELIS

Once the data has been entered into the database, it is important to check them for errors, inaccuracies, omission, and other problems. Data errors in ELIS are checked in the following manner:

Spatial data: by printing the data and comparing the data with the printed data;

Attribute data: Checked manually, or by running a computer program to check gross errors & printing an exception report & cross checking it with actual data.

3.4. DATA INTEGRATION IN ELIS

For creating reports, there is need for integrating data from different database files. In ELIS, there is need for integration of data from spatial and attribute databases. Spatial data from different layers of spatial databases. In ELIS, GIS has been used to link, or integrate information that would have been otherwise difficult to associate through any other means. Thus, ELIS can use combinations of mapped variables to build and analyze new variables

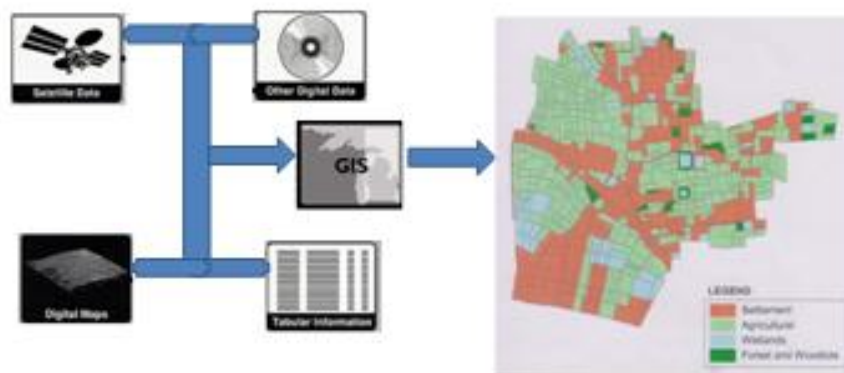


Figure 5: Data integration by interfacing information in diverse forms through a GIS.

Thus using GIS technology, ELIS can combine agricultural records with hydrographic data to determine which streams will carry certain levels of fertilizer runoff. Agricultural records can indicate how much pesticide has been applied to a parcel of land. Locating these parcels and intersecting them with streams, ELIS can be used to predict the amount of nutrient runoff in each stream.

3.5. PROJECTION AND REGISTRATION OF DATA IN ELIS

Projection is a fundamental component of mapmaking. A projection is a mathematical means of transferring information from the Earth's three-dimensional, curved surface to a two-dimensional medium—paper or a computer screen. Different projections are used for different types of maps because each projection is particularly appropriate for certain uses.

A property ownership map might be at a different scale than a soil map. Map information in the ELIS must be manipulated so that it registers, or fits, with information gathered from other maps.

Before the digital data can be analyzed, they may have to undergo other manipulations—projection conversions, for example—that integrate them into an ELIS. Since much of the information in ELIS comes from existing maps and GIS uses the processing power of the computer, capabilities in ELIS has been built to transform digital information gathered from sources with different projections to a common projection.

3.6.DATA STRUCTURES FOR DATABASE IN ELIS

As ELIS is basically a Land Information System (LRS) [4,5], it deals with two main types of data - spatial and attribute. Again, ELIS captures data from existing mouza maps through digitization and/or scanning, which are in vector form and raster form respectively. Raster data files consist of rows of uniform cells coded according to data values. An example is land cover classification given in figure 6 [32]. The computer can manipulate raster files quickly, but they are often less detailed and may be less visually appealing than vector data files, which can approximate the appearance of more traditional hand-drafted maps. Vector digital data are captured as points, lines (a series of point coordinates), or areas (shapes bounded by lines). An example of data typically held in a vector file would be the property boundaries for a particular mouza as shown in figure 7 [32].

1	1	1	1	1	1	1	3	3	3
1	1	1	1	1	1	1	3	3	3
1	1	1	1	1	1	3	3	3	3
1	1	1	2	2	2	2	3	3	3
1	1	1	2	2	2	2	3	3	3
1	1	1	2	2	2	2	3	3	3
1	1	1	1	2	2	2	3	3	3
1	1	1	1	1	1	3	3	3	3
1	1	1	1	1	1	1	3	3	3
1	1	1	1	1	1	1	1	3	3

Figure 6: Example of structure of a raster file.

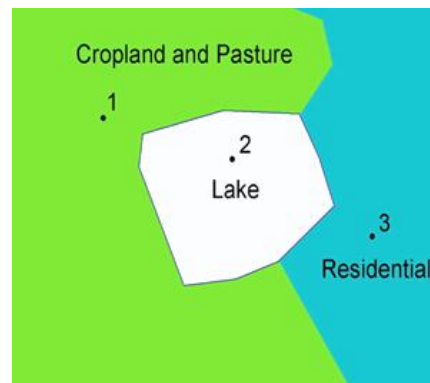
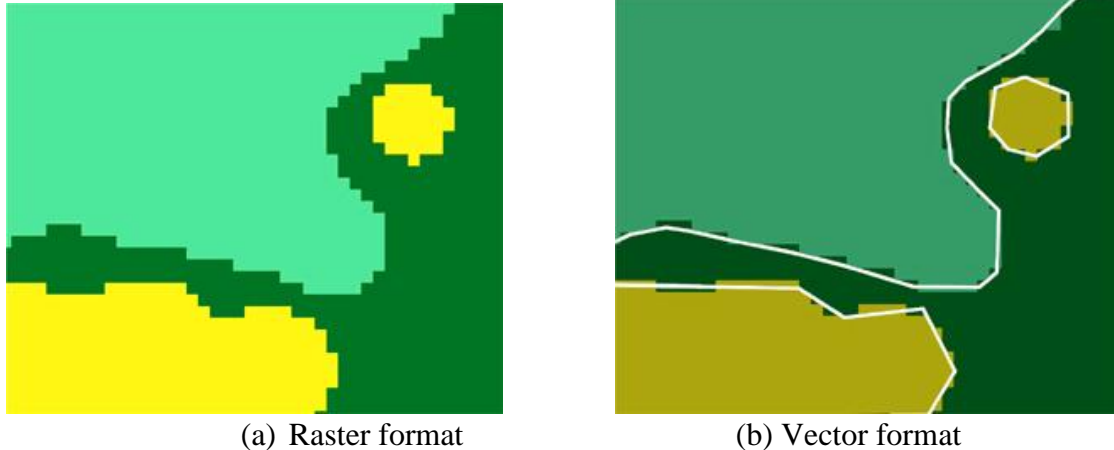


Figure 7: Example of structure of a vector data file.

As data in ELIS may come from different sources e.g., Map Digitization, Land Data collected by using Total Station, Data from secondary sources or Data from Satellite Images, these data of diverse sources are collected and stored in different ways so that any two data sources may not be entirely compatible. Therefore, the power of GIS to convert data from one structure to another has been utilized in ELIS. For instances, satellite image data that have been interpreted by a computer to produce a land use map may be "read into" the ELIS in raster format.

GIS has been used in ELIS to convert a satellite image map to a vector structure by generating lines around all cells with the same classification, while determining the spatial relationships of the cell, such as adjacency or inclusion. Figure 8 [32] shows how it has been done in ELIS by using GIS features.



(a) Raster format

(b) Vector format

Figure 8: Magnified view the same GIS data file

3.7.DATA MODELING IN ELIS

It is not possible to collect data over every square meter of the earth's surface in the mouza. Therefore, samples are collected at discrete locations. A GIS can be used to depict two- and three-dimensional characteristics of the earth's surface, subsurface, and atmosphere from points where samples have been collected. Many sophisticated methods can estimate the characteristics of surfaces from a limited number of point measurements. For example: two- and three-dimensional contour maps created from the surface modeling of sample points from field measurements covering the area can be analyzed together with any other map in a GIS. This feature of GIS has been incorporated in ELIS.

3.8.INFORMATION RETRIEVAL IN ELIS

The specialty about the ELIS is that the maps and other data are stored or filed as GIS layers that make it possible to perform complex analyses on the data stored in the database. With the help of GIS in ELIS, we can "point" at a location, object, or area on the screen and retrieve recorded information about it from off screen files. Using scanned aerial photographs as a visual guide, one can use ELIS to query the database about the water body or vegetation of the area or even about how close a river is to the edge of a street. This type of analysis allows the users to draw conclusions about the environmental sensitivity of the mouza.

3.9.KEY APPLICATIONS OF ELIS

Few of the many key applications of ELIS are Topological Modeling, Networking, and Overlaying Information Presentation.

3.9.1. TOPOLOGICAL MODELING IN ELIS

GIS can recognize and analyze the spatial relationships among mapped phenomena. It can be seen in figure 9 [32]. Based on this capability of GIS, features have been built into ELIS to test for

conditions of adjacency (what is next to what), containment (what is enclosed by what), and proximity (how close something is to something else) can be determined using ELIS

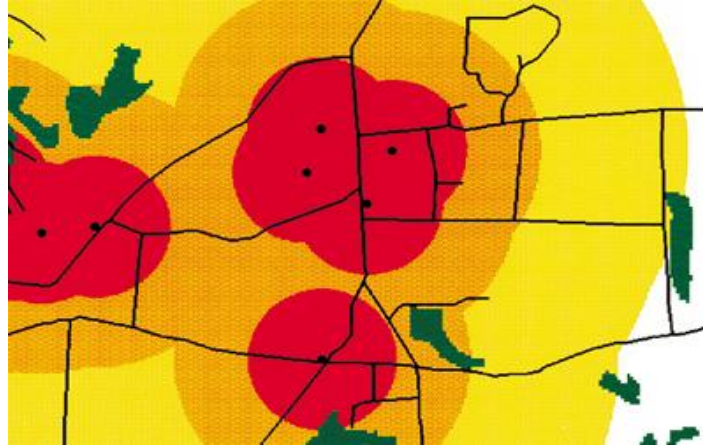


Figure 9: Sources of pollution are represented as points. The colored circles show distance from pollution sources and the wetlands are in dark green.

3.9.2. NETWORKS IN ELIS

When wastes from an industry are running off into streams, or into a plot, it is important to know in which direction the streams flow and which streams empty into other streams. ELIS does this using a linear network of GIS. It allows the computer, to determine how the wastes are transported downstream. Additional information on water volume and speed throughout the spatial network can help the ELIS to determine how long it will take the wastes to travel downstream.

3.9.3. OVERLAY IN ELIS

Using maps of water bodies, streams, land use, and roads, the ELIS might produce a new map layer or overlay that ranks the mouzas according to their relative sensitivity to environmental damage from industrial wastes run off figure 10 shows a landuse map of the study area produced by using ELIS to combine various landuse features.

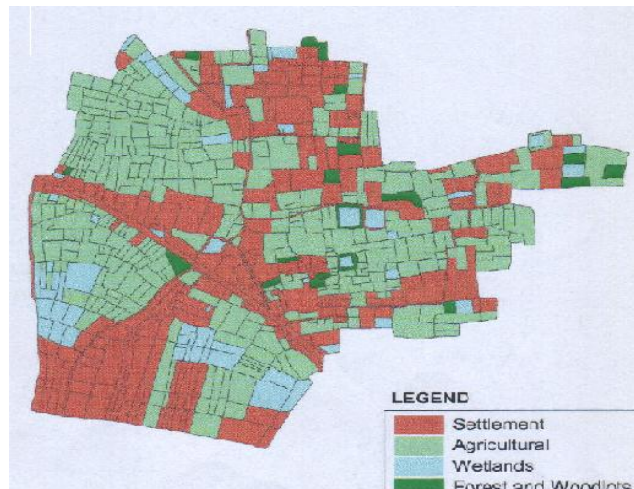


Figure 10: Map indicating various land uses in the study area.

3.9.4. INFORMATION PRESENTATION

A critical component of ELIS is its ability to produce graphics on the screen or on paper to convey the results of analyses to the people who make decisions about resources. Mouza maps, Union maps, Upazila maps, interactive maps and other graphics can be generated, allowing the decision-makers to visualize and thereby understand the results of analyses or simulations of potential events (figure 11).

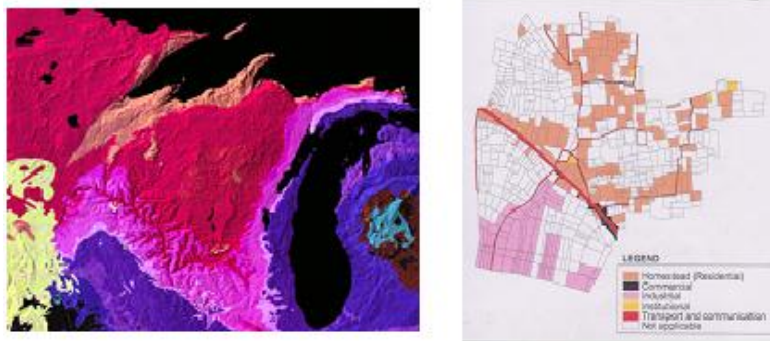


Figure 11: Examples of finished maps that can be generated using a GIS, showing landforms and geology (left) and human-built and physical features (right).

3.9.5. FRAMEWORK FOR COOPERATION IN ELIS

The ELIS has built in features that are developed using GIS that will encourage cooperation and communication among the organizations involved in environmental protection, planning, and resource management. The collection of data for a ELIS is costly. Data collection required very specialized computer equipment and technical expertise.

For the ease of exchange of digital information among users of different systems, standard data formats have been used in ELIS. This will ultimately help data sharing, and, in many cases, would give users access to data that they could not otherwise collect for economic or technical reasons. Organizations such as the Directorate of Land Records and Surveys, Survey of Bangladesh, Local Government, Bureau of Statistics, SRDS may be encouraged to standardization efforts for sharing data

3.10. BUILDING DATABASES IN ELIS

ELIS database is a combination of various database components such as Land Parcel Level (Micro Level) database (figure 12), Mouza Level (Macro Level) database, spatial database from primary sources (figure 14) and secondary sources of data, and so on.

3.10.1. BUILDING SPATIAL DATABASE FROM PRIMARY SOURCES

Figure 12 shows how the spatial database is created from the primary sources of data. The primary source of data is the Mouza Map on P-70 sheet that has been produced by DLRS in its Printing Press from the data collected through Traditional Field Survey method of Van Dyke Process, the Ownership and other attribute data, Upazila Maps and data from other secondary sources. The

figure 12 shows the Conceptual View of the Land Parcel Level (Micro Level), Database creation process and figure 13 shows the Conceptual View of Mouza Level (Macro Level) Database creation process in ELIS. Figure 15 shows how data from various primary sources are integrated in ELIS.

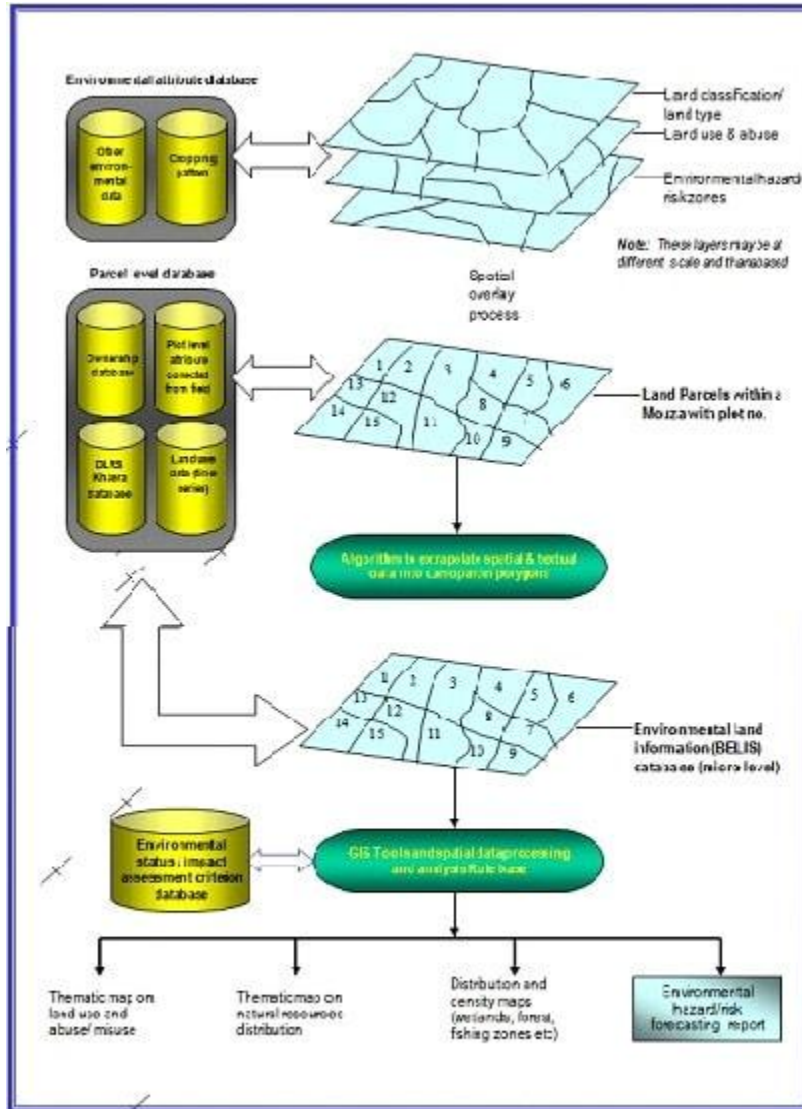


Figure 12: A Conceptual View of Land Parcel Level (Micro Level) in ELIS Database Creation

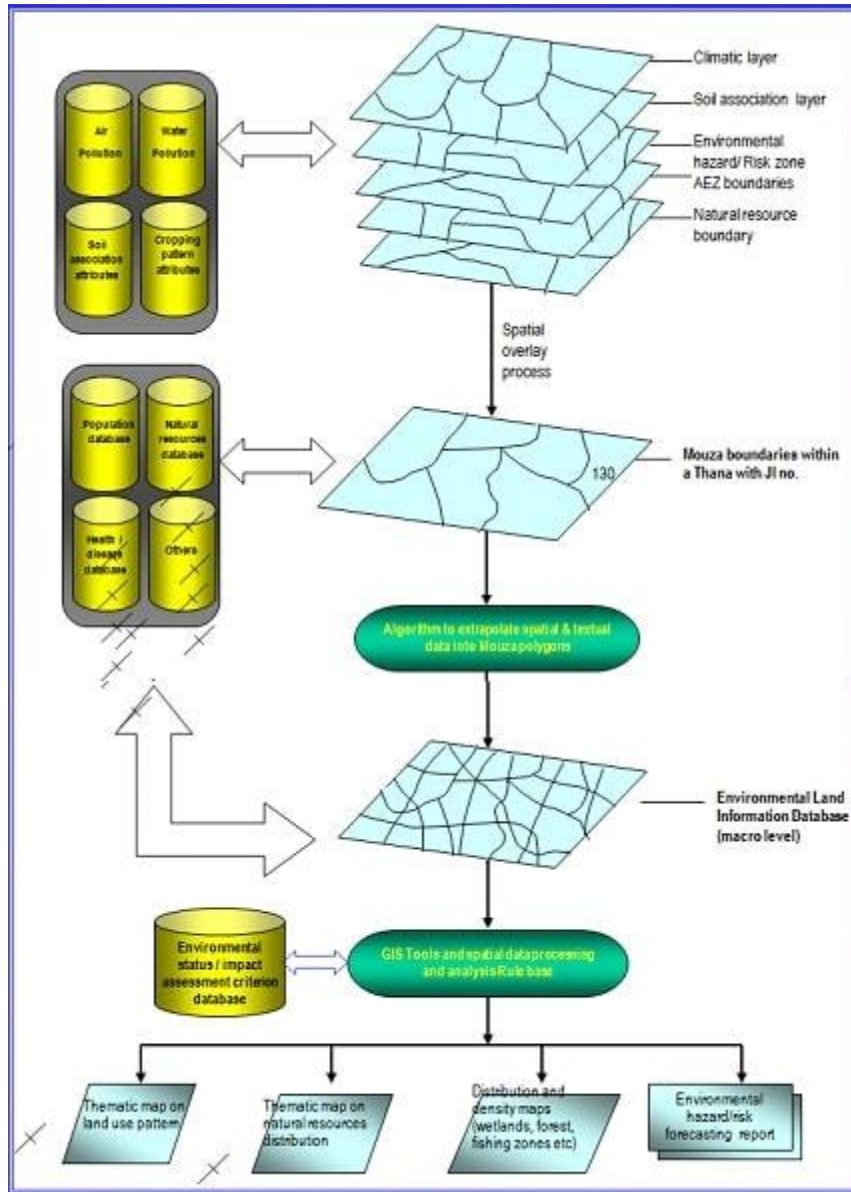


Figure 13: A Conceptual View of Mouza Level (Macro Level) in ELIS Database Creation

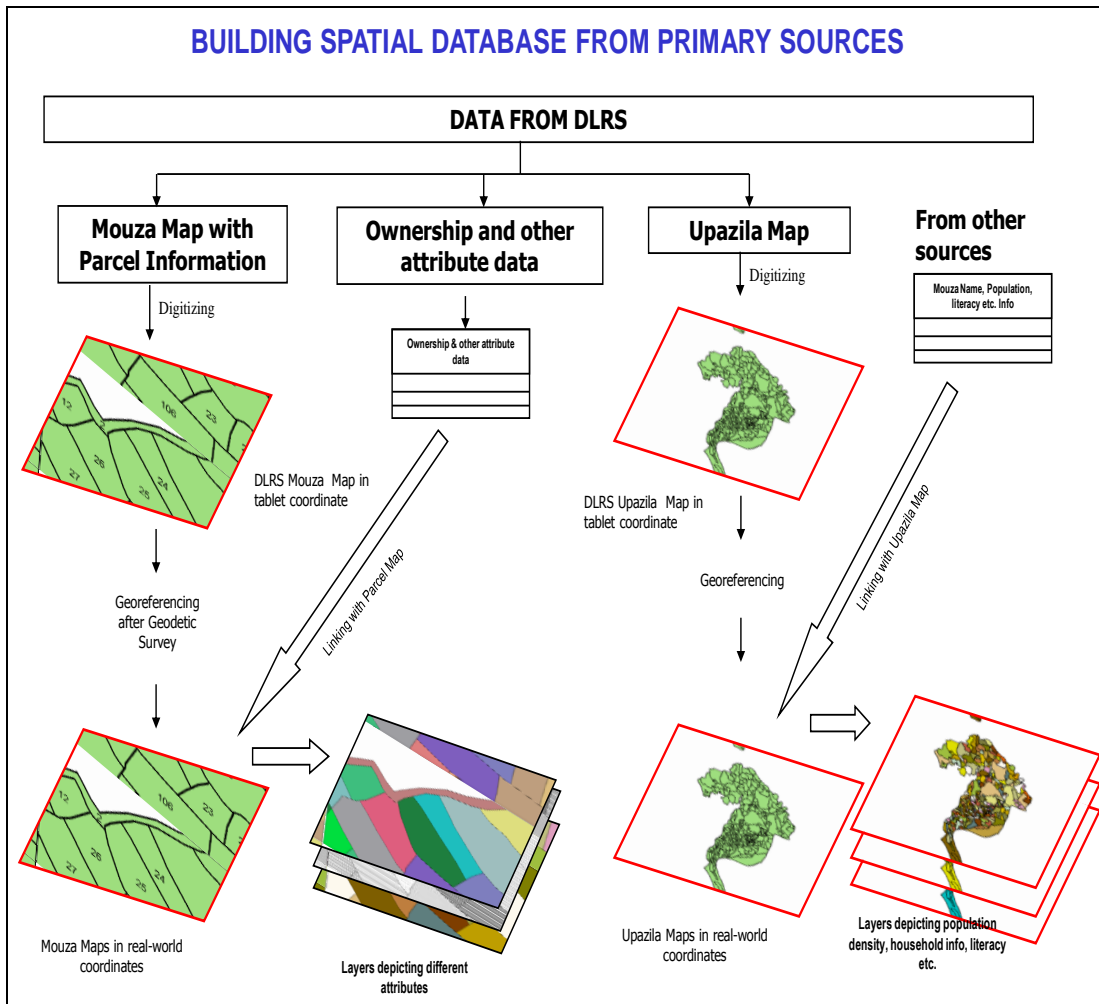


Figure 14: Different steps in building spatial database.

3.10.2. BUILDING SPATIAL DATABASE FROM EXTERNAL SOURCES

The ELIS has provisions to integrate data from external sources with the Mouza Map. The following figure (figure 15) shows how the spatial database is created using data collected from various external sources:

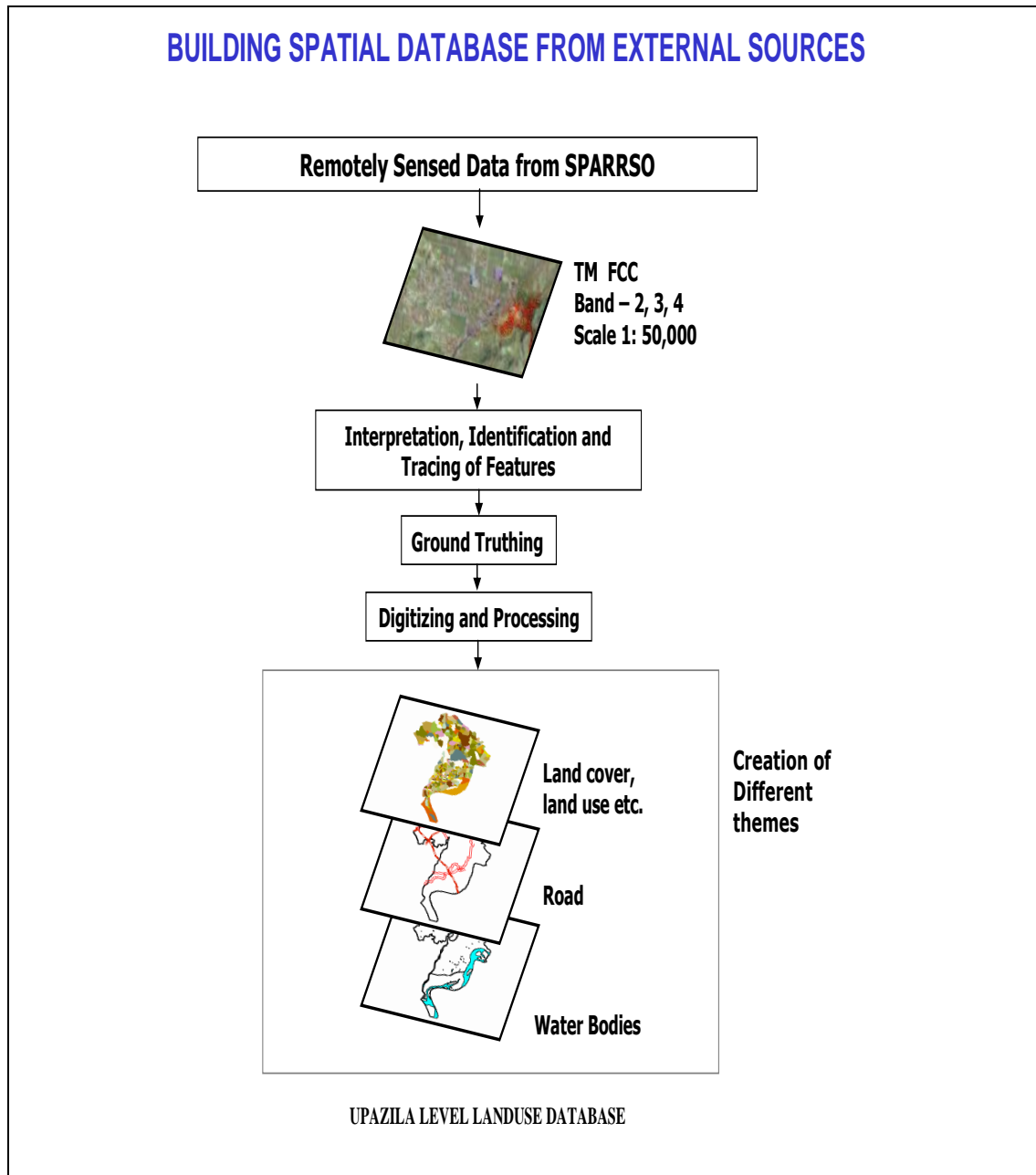


Figure 15: Spatial database from external sources

3.10.3. INTEGRATION OF SPATIAL DATABASE FROM OTHER SOURCES

The ELIS has also provision for integrating spatial data from other sources. Figure 16 shows how spatial data from other sources could be integrated in the ELIS database:

SPATIAL DATA FROM OTHER SOURCES

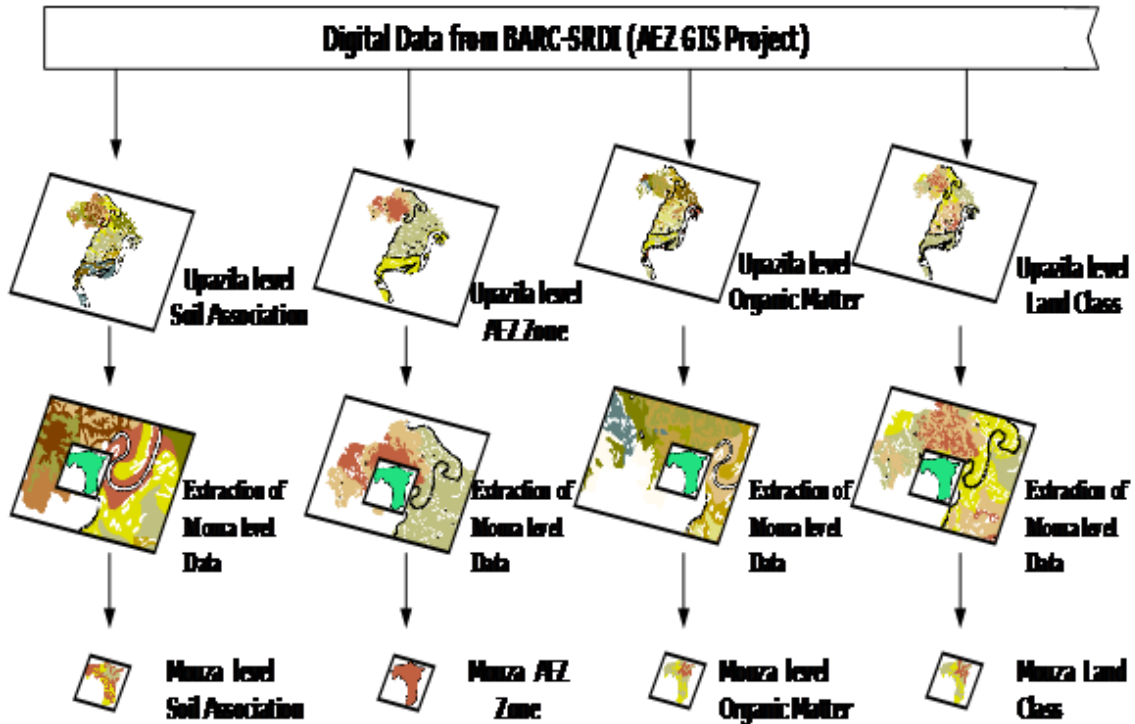


Figure 16: Spatial database from other sources

3.10.4. ENVIRONMENTAL AND LAND USE DATABASES

Figure17 shows how the environmental data and land-use data are collected during Cadastral Survey to create Environmental and Land-use database

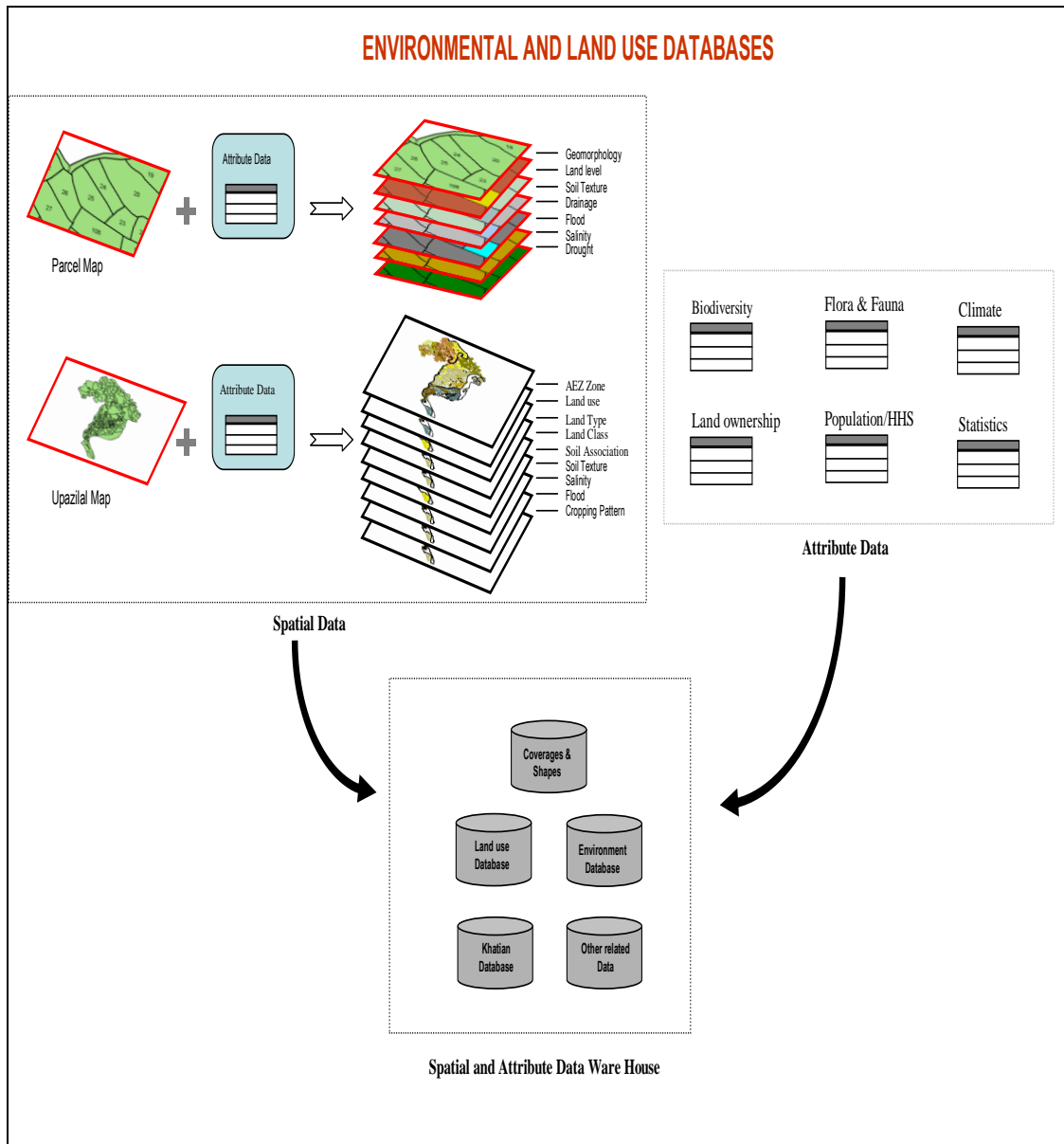


Figure 17: Environment and land use of database.

3.11. LINKAGE OF MOUZA MAP WITH VARIOUS DATA

3.11.1. LINKAGE OF MOUZA MAP WITH ENVIRONMENTAL DATA

Figure18 shows how various environmental data may be linked with the Mouza-map when stored in the database. The various environmental data are:

Geomorphic Features: Natural Levee, Back Slope, Beel, Flood Plain, Foot hill/Piedmont alluvial Plain

Land Level. Highest Level (Vita), Second Level (Nal – high), Third Level (Nal – low), Fourth Level (Pond, Khal).

Drainage Quality: Well Drain, Moderate Drained, Poor Drain, Water Logged

Soil Texture: Sandi, Sandi Loam, Silt, Silt Loam, Clay Loam, Clay

Flood/ Inundation: Flood Free, Low Flood (<30 cm), Moderate Low Flood (30-90 cm), Deeply Flooded (>90 cm), Permanent Water Bodies

Salinity: Low Salinity, Moderate Salinity, High Salinity

Drought: Seasonally Affected, Occasionally Affected, Rarely Affected

LINKAGE OF MOUZA MAP WITH ENVIRONMENTAL DATA

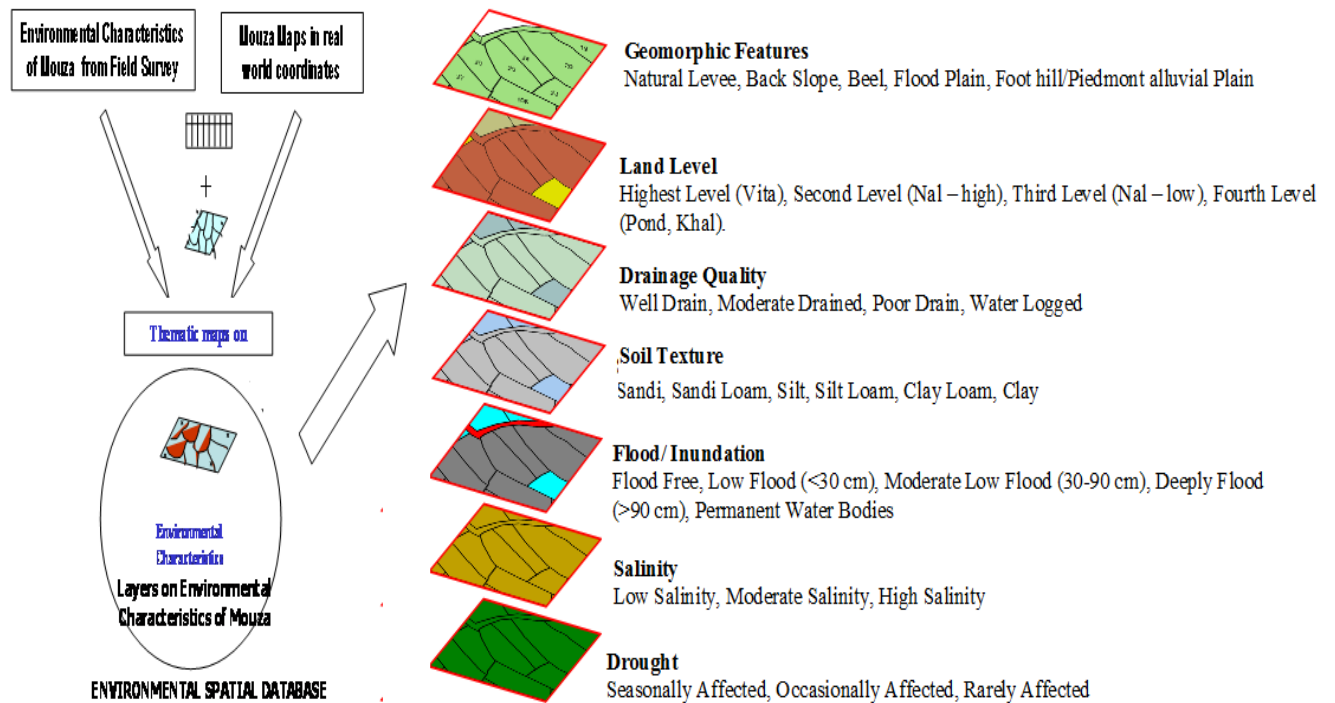


Figure 18: Showing Linkage of Mouza Map with Environmental Data

3.11.2. LINKAGE OF MOUZA MAP WITH LAND-USE DATA

Figure 19 shows how various land use data is integrated with the Mouza map in the ELIS

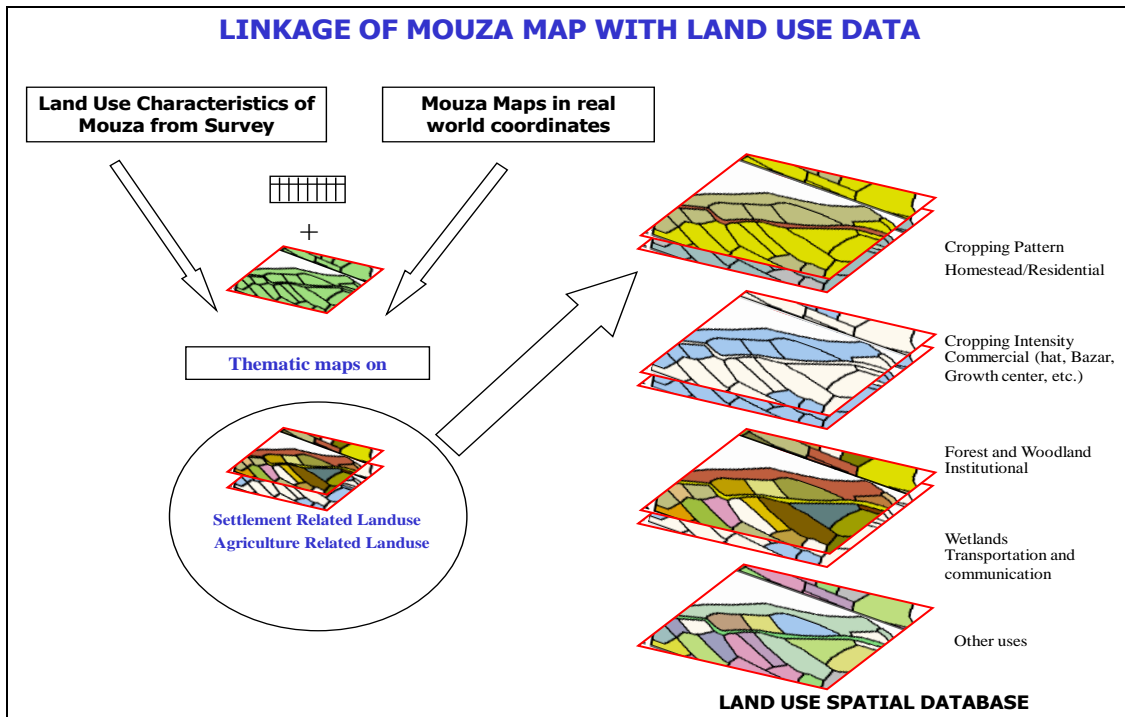


Figure 19: Linkage of Mouza map with land use data.

3.12. APPLICATION PROGRAMS IN ELIS

Figure 20 shows the structure of the ELIS application program:

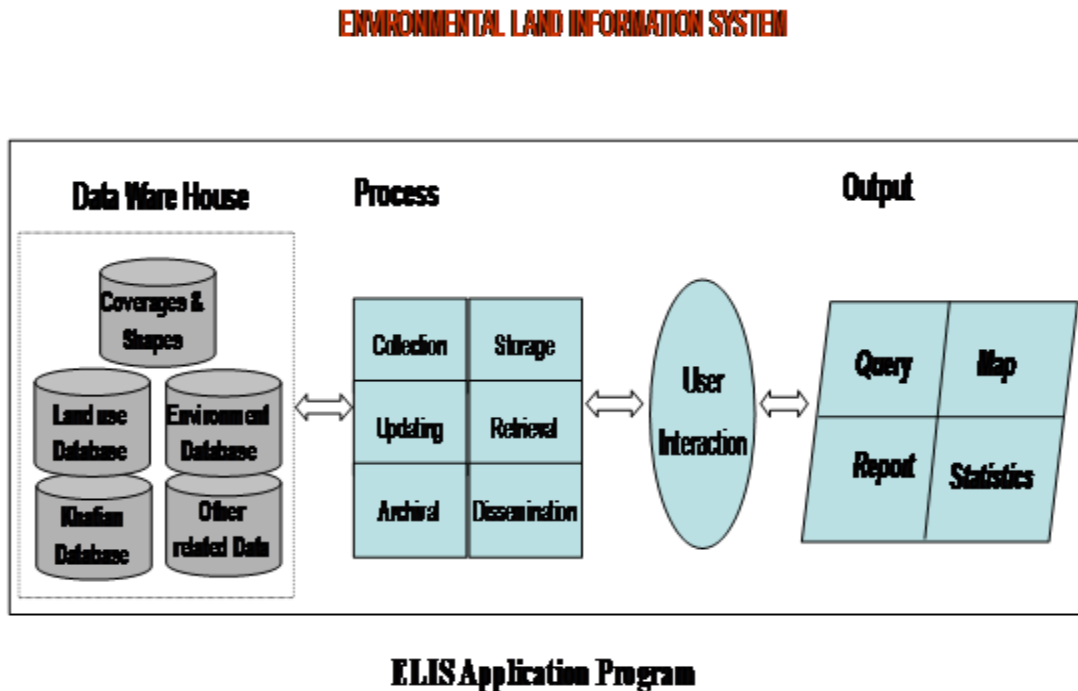


Figure 20: Environmental Land Information System (ELIS) in a short view.

3.13. LINKING SPATIAL AND ATTRIBUTE DATA

The final step of inputting data into ELIS is linking the spatial and attributes data. The linking is done through common identifiers in spatial & attribute data of geographic features. The linkage operation offers chance to verify the quality of both spatial and attribute data. It can also be used to check whether all the links have been performed properly or not. Linking of spatial & attribute data completes the creation of geographic database, which is now ready for analysis preparing maps & viewing maps.

Hard copies of Geographic data may be produced from ELIS by using printer & plotter. The hard copies may be made on paper or transparencies or film.

3.14. USER INTERFACE IN ELIS

ELIS has the following friendly user interfaces:

Project & View Management Functionality: Opening and Saving Project, Views, Tables, Charts and Documentation. These functions are provided by Arc View GIS, without any further programming.

Position, Map Extent, and Data Selection: Function defining the area to be included in the User's view. The map extent should be determined by the geographical area defined by the user not by a range of data values.

Data Selection and Display Function: It includes providing relevant documentation about data or that the user can decide which layers should be shown, how the data will be represented or symbolized, and how legend information will appear. Also, user should be able to add their data.

Querying Tools: User interface has provided Querying Tools. Querying tools allow users to extract data from selected data layers. These tools may range from simple identify functions that will generate statistical summaries and chart to more complex Buffering and trend Analyst's Tools.

Online Help Facilities: ELIS has built in Online Help facilities.

Mapping and layout functionalities: ELIS has mapping and layout functionalities that allow users to define the area of interest for a view area by Scale (Already built into Arc View GIS), District, Upazila, Mouza, Union, Coverage (already built into Arc view GIS), and Predefined Project Areas.

4. IMPLEMENTATION AND RESULTS

In implementing the concept of the ELIS the Software Engineering and System Analysis and Design techniques have been applied in developing the structure of the system, creating the databases, developing the applications for user interfaces and queries, capturing data for the databases, etc. The system has drop-down and pop-up menus and Bengali vernacular in the menus for convenience of the ordinary users.

Land data were collected for ELIS database through primary surveys from the study areas. Various field surveys such as (i) Plot to plot landuse survey; (ii) Service economic survey; (iii) Geodetic survey [4,5,7]; (iv) Community surveys. Surveys were conducted in the study area of the project. A large volume of geospatial data - both qualitative and quantitative in nature was collected through the above surveys to populate the ELIS databases with data. These databases were created to process, analyze and produce meaningful information using applications built into ELIS. The main utility of ELIS is to provide required functionality for capturing and updating databases, processing data, and analyzing data in order to produce thematic maps by combining layers of GIS data and for producing analytical tables of data. All the thematic maps and data tables presented in the Atlas [36] have been produced by using the capabilities of ELIS.

To create Land Record System (LRS) and collection of environmental data for populating ELIS database with data, a Case Study has been carried out in Polash Upazila under Norshingdi district and Sonargaon Upazila under Narayangonj district. Databases have been implemented using Oracle RDBMS. The database has seven entity tables, three relationship tables (for many-to-many relationships) and ten queries in the implementation. One-to-one and one-to-many relationships have been implemented using the concept of foreign key. OLE data type is used to represent map of a plot as an image. Forms have been used for displaying results.

Considering the available sources of data for developing digital Topographic Database the cadastral map are most suitable in view of their rich information contents. Along with top maps, aerial photography (beyond the scope of the project) and satellite images are extra sources for collecting data.

The application software has been developed with user friendly menu options with Bangla and English version. User friendly query has also been implemented alongside the various reporting and map plotting options. Some of the sample queries implemented in the ELIS are as follows: "How many canals are existing in a particular upazila?" "Which upazila does not have any tidy canals?", etc.

GUI based expert Querying Tools have been built in ELIS that allow users to retrieve data from selected data layers. They can use these tools to get information through specially developed queries like. For example: "Show all plots in a specific mouza", "show owner(s) of a specific plot", "show all plots of a specific owner in the mouza", "show cultivator(s) of a specific plot", "show irrigation source(s) near to a specific plot", "show revenue details of a specific plot", etc.

The most important outcome of ELIS is production of a GIS Atlas on Landuse and Environment [36]. All the thematic maps and data tables included in the Atlas have been produced by using the ELIS. The Atlas included various landuse maps such as Physiography (Map #7, Page #16), Soil Texture map (Map #9, Page #19), Water Bodies (Map # 12, Page #23), Land Level Map (Map #15, Page #27), Flood/Inundation Level (Map #18, Page #31), Population Density (Map #22, Page #39), Land ownership Pattern (Map #23, Page #41). Figures 21 and 22 show the landuse maps of mouza Danga in Polash Upazila and Polash Upazila respectively produced by using ELIS software. All the raw data and processed data used in creating the Atlas are available in the ELIS databases.

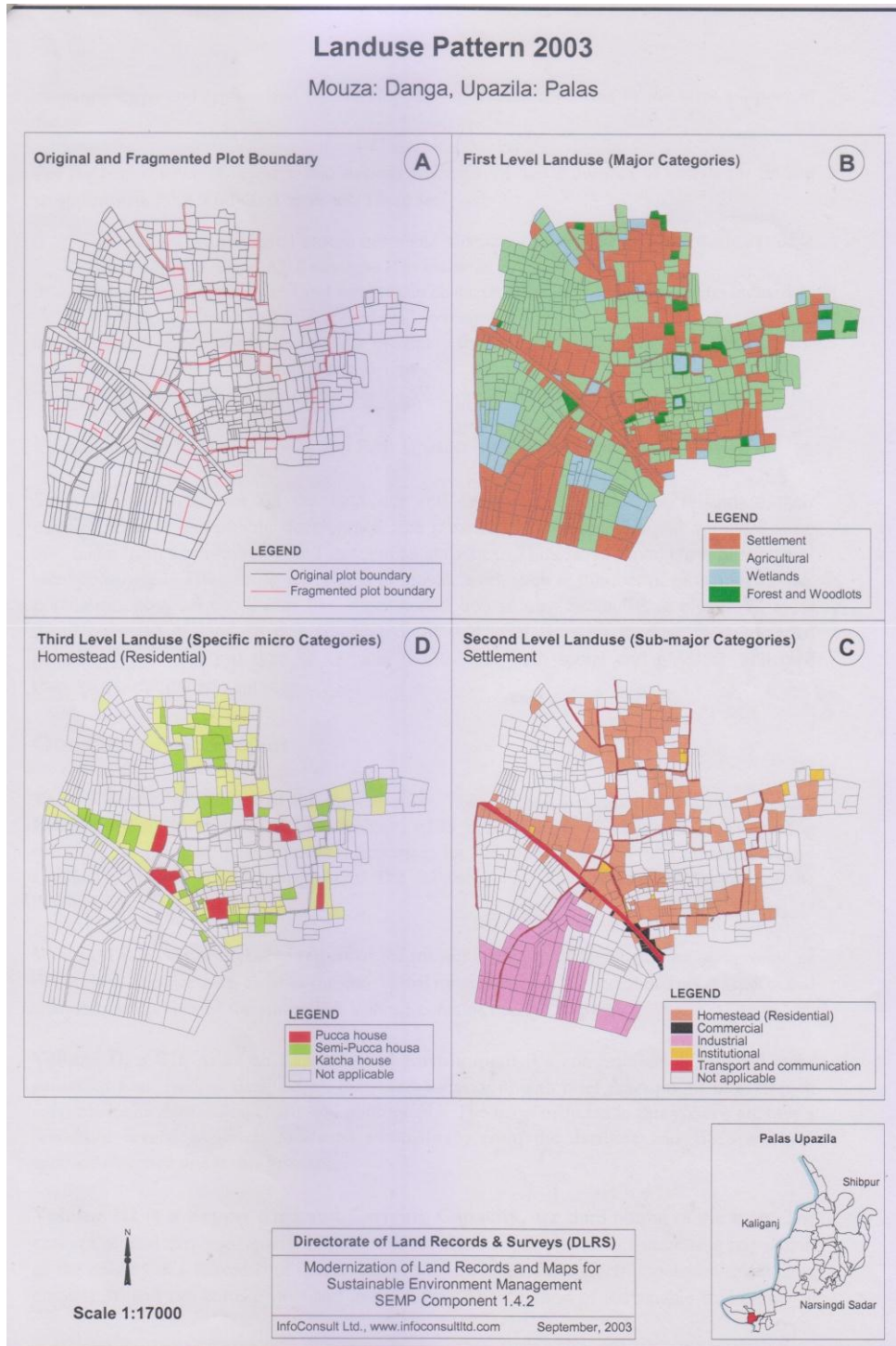


Figure 21: Landuse map of mouza Danga in Polash Upazila produced by ELIS

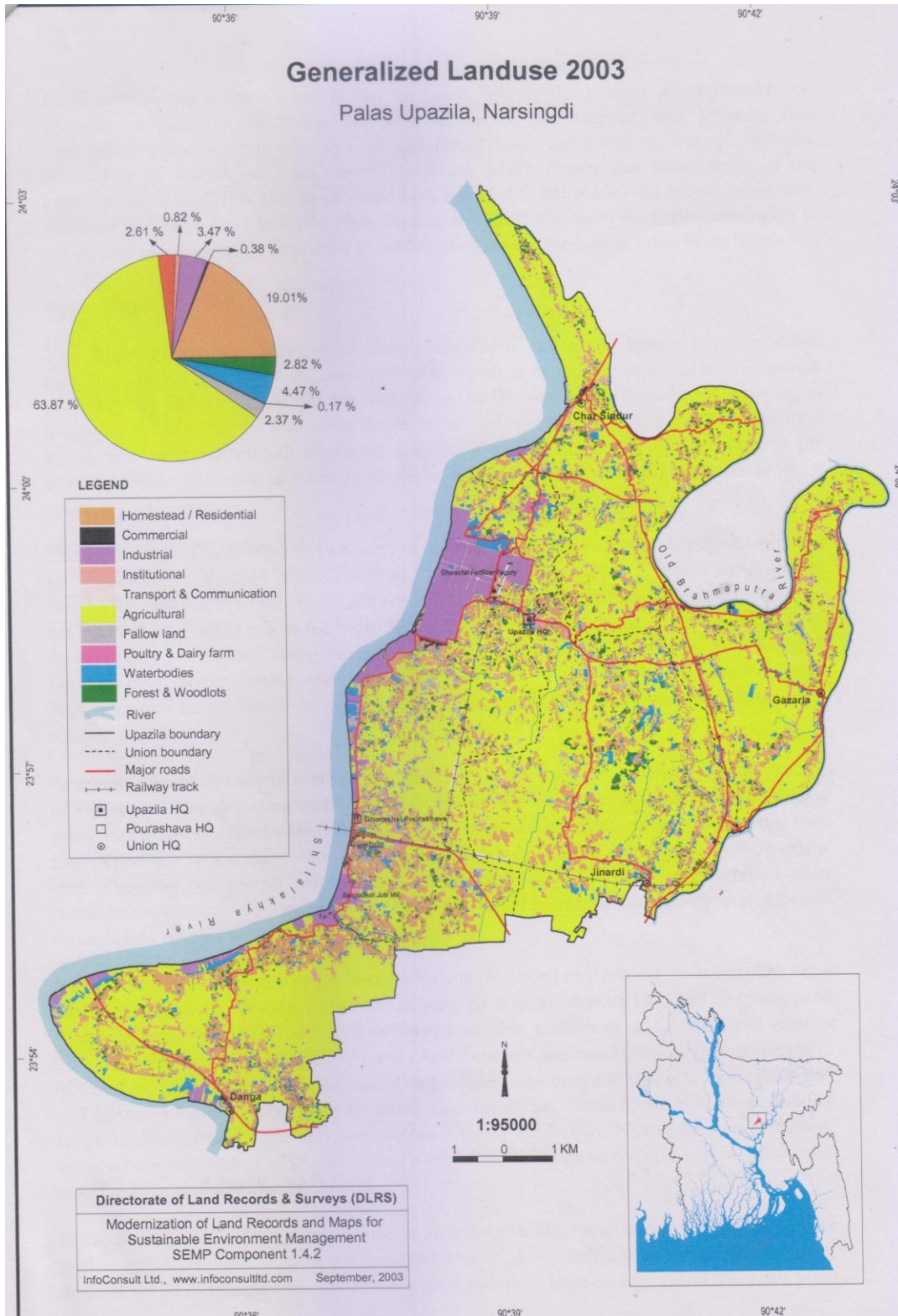


Figure 22: Landuse map of Polash Upazila produced by ELIS

5. ACCURACY ANALYSIS

The bitter truth is that all geographical data are internally inaccurate, and there inaccuracies propagate through ELIS operations in ways that are difficult to predict. Therefore, error analysis of spatial databases in ELIS is very important, with direct bearing on the accuracy of ELIS and requires a due consideration. Map accuracy is an important issue consisting of two aspects: viz. (i) Attributes and (ii) Spatial positions, whether relative or absolute.

The accuracy of spatial database is a derivative of the map and results obtained are compared with accuracy of the map. The map data, raster data and vector data requires to be compared for the following three graphic primitives: Point, Line, and Area.

The scale of the map is a very important aspect since the information content depends mainly on the scale of the map. It has been found that 1:50,000 maps are most suitable for making DTDB (in Indian conditions as these maps are available readily, and information contents in much maps are sufficient to serve many purposes).

6. CONCLUSION

An conceptual view of the Environmental Land Information System has been presented along with it's Land Records Management System (LRMS) and Environmental data management system. Two essential database components - spatial database and attribute database, their creation, capturing methods of data to populate the databases with necessary spatial and attribute data, development of the applications for reporting and map production has been presented in detail. A customized software with an user friendly graphical user interface (GUI) along with Bangla interface has been developed in the ELIS.

The GUI in ELIS has provided several expert querying Tools that allow users to retrieve data from selected data layers. They can use these tools to get information through specially developed queries like: show all plots in a specific mouza, show owner(s) of a specific plot, show all plots of a specific owner, show cultivator(s) of a specific plot, show irrigation source(s) near to a specific plot, show revenue details of a specific plot, show details of a specific plot, show details of a specific estate, show owner's detail, show details of a specific cultivator.

Moreover, one can also use ELIS to find the answers to various questions like: How many primary schools are there in a particular division / district? How many are primary hospitals in a particular state? Which district has maximum per man income in a particular state? Find all plots in favor of a particular owner in a particular district? How many plots have drinking water facility in a particular division / district? How many plots have electricity connections in a particular division of a district? Display divisions having no banking facility. Display divisions having no post office. How much have state govt. earned from land revenue? How many owners have given their lands to tenants for agriculture in a mouza? Display map of a particular plot. Display rainfall level in a particular mouza. Display all reference points in a particular district. Display population of a particular mouza.

ELIS has options for saving data in different formats for data interchanges with stake holders. Further, ELIS has a plenty of highly efficient GIS aided features that support interaction among different organizations concerning environmental issues like security, arrangement, and resource regulation. It can help stakeholders of Land and Environment to evaluate the land use pattern and environmental changes affecting. Stakeholders and researchers can use ELIS to produce series of qualitative and quantitative reference maps which may lead to the formulation of more advanced and sophisticated studies. With some more additional works, ELIS could be used as a decision support tool for the implementation of land use plan and land management by the government. In view of future developments of ELIS, and to make the project outcome sustainable, areas needed to be identified and addressed, such as improve the application with additional functionality and more efficient user interface; for example, migration to new advanced software and hardware technologies.

Finally, the success of the project effort in developing ELIS is expected to the application throughout Bangladesh to make it sustainable.

7. ACKNOWLEDGEMENTS

Authors would like to acknowledge the contribution of InfoConsult Ltd. where the first author worked as the Team Leader in the SEMP project and special thanks to the DLRS & UNDP authorities to give an opportunity to work with them in the project which has enabled us to produce this research paper.

8. REFERENCES

- [1] *Application of DBMS to Land Information Systems. A Frank; Institute of Swiss Federal Institute of Technology, Zurich, Switzerland; IEEE, 1981.*
- [2] *The Design and Implementation of a Cadastral Database with a Spatiotemporal Modeling Approach in Turkey. Mustafa TURKERI and Sultan KOCAMAN 2.*
- [3] *Database Management Systems. R. G. Healey.*
- [4] *Land Record Information Management System (LRIMS) – A Conceptual Framework; Asima Mishra, Deb Jyoti Pal. Centre for Development of Advanced Computing; Pune University Campus; Map India 2000 Conference, New Delhi, April 2000.*
- [5] *Design and Implementation of LRS – A case study. S K Jain, Gulab Singh, M M Gore; Map India 2003 Municipal GIS Map.*
- [6] *St. Martin, K. 2004. “GIS in Marine Fisheries Science and Decision Making”, in Geographic Information Systems in Fisheries, W. L. Fisher and F. J. Rahel eds. (American Fisheries Society), pp. 237-258.*
- [7] *Land Records Management System in India - Technical Framework. Vinay Thakur, Ganesh Khadanga, D.S Venkatesh and Dr D.R Shukla; Map Asia 2003: Land Records Management System in India.*
- [8] *Pages 85-110 in Antenucci, J.C., Brown, K., Croswell, P.L., Kevany, M.J. 1991. Geographic Information Systems. New York and London: Chapman & Hall.*
- [9] *Antenucci, J.C., Brown, K., Croswell, P.L., Kevany, M.J. 1991. Geographic Information Systems. New York and London: Chapman & Hall.*

- [10] Burrough, P.A. 1986. *Principles of Geographical Information Systems for Land Resource Assessment*. New York: Oxford University Press.
- [11] Huxhold, W.E. 1991. *An Introduction of Urban Geographic Information Systems*. New York and Oxford: Oxford University Press.
- [12] *Geographic Information Systems as an Integrating Technology: Context, Concepts, and Definitions*. k.foote@colorado.edu.
- [13] Maguire, D. J. 1991. An overview and definition of GIS. In D. J. Maguire, M. F. Goodchild, & D. W. Rhind (editors), *Geographical Information Systems: Principles and Applications (Vol. 1)*. Harlow, UK: Longman Group. pp. 9-20.
- [14] Brassel, K.E. & Weibel, R. (1988). A Review and Framework of Automated Map Generalization. *Int. Journal of Geographical Information Systems*, 2(3): 229-244.
- [15] A study on the state-of-the-art in automated map generalisation. JE Stoter, C Duchêne, G Touya, B Baella, M Pla, P Rosenstand, N Regnauld, H Uitermark, D Burghardt, S Schmid, KH Anders, F Dávila. *11th ICA Workshop on Generalization and Multiple Representation*, 1-16.
- [16] GIS PRIMER. <http://gis.nic.in/gisprimer/mapbasics1.html>
- [17] Diaw, M.C., Aseh, T., Prabhu, R., (eds.) 2009. *In Search of Common Ground: adaptive Collaborative Management in Cameroon*
- [18] *GIS Applications in Land Use and Land Development of a City*. R. Laxmana Reddy, B. Apoorva, S. Snigdha, K. Spandana. *International Journal of Emerging Technology and Advanced Engineering*. Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume3, Issue 5, May 2013).
- [19] *The Handbook of Geoscience - Page 475*. Frank R. Spellman, Melissa L. Stoudt - 2013 <https://books.google.com/books?isbn=0810886146>
- [20] Delforce, Wayne and Rich, Bruce and Savage, Bernadette and Adkins, Barbara and Hall, Carly and Caldeweyher, Daniel (2005). *GIS as a Tool for Decision Making and Evaluation*. In Bailey, C. and Barnett, K., Eds. *Proceedings Social Change in the 21st Century*, Brisbane, Australia.
- [21] Chapter 5. *GIS and Decision-Making*. Work Site Alliance – Community Based GIS © 2000. <http://igre.emich.edu/wsatraining/TManual/Chapter5/Chap5.pdf>
- [22] *GIS - Geographic Information Systems... is what?* <http://www.baama.org/Resources/Documents/pastpresentations/gisday01/GIS-is-What.pdf>
- [23] *Environmental Informatics: Methodology and Applications of Environmental Information Processing*, edited by N.M. Avouris and B. Page, pp. 345, 1995
- [24] *Geographical Information System for Land Use Development Control Plan*. Sudin Giri, Sailesh Samanta. *International Journal of Emerging Technology and Advanced Engineering*. Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008. Certified Journal, Volume 3, Issue 9, September 2013).
- [25] Spellman, Frank R., and Melissa L. Stoudt. *The Handbook of Geoscience*. Lanham, Md.: Scarecrow Press, 2013.
- [26] Wikipedians, B.. *Geography*. Publisher: PediaPress. <https://books.google.com.bd/books?id=iZkmi7HYOvwC>
- [27] Julie Kerr Casper. *Global Warming Trends: Ecological Footprints*. Infobase Publishing, 2009. ISBN: 1438126085, 9781438126081

- [28] *Jonathan Raper. Three Dimensional Applications In GIS. CRC Press, 1989. ISBN: 0850667763, 9780850667769.*
- [29] *Smith, Dennis R., and Arthur R. Paradis. Three-dimensional GIS for the earth sciences. Three Dimensional Applications in Geographic Information Systems. Taylor and Francis, London (1989).*
- [30] *Alias Abdul-Rahman, Morakot Pilouk. Spatial Data Modelling for 3D GIS. Springer Science & Business Media, 2007. ISBN: 3540741674, 9783540741671*
- [31] *Jonathan Raper . Three Dimensional Applications In GIS. CRC Press, 1989,. ISBN:0850667763, 9780850667769.*
- [32] *Meaden, G.J.; Do Chi, J.; Geographical Information Systems: application to marine fisheries, FAO Fisheries Technical Paper No.356, Rome, FAO, 1998, 335p*
- [33] *Mikhail Kanevski, Michel Maignan. Analysis and Modelling of Spatial Environmental Data. Volume 6501 of Environmental sciences, ISSN 1431-6250. EPFL Press, 2004. ISBN: 0824759818, 9780824759810*
- [34] *M. Azharul Haque (Team leader, InfoCosult Ltd.). Project Inception Report on Modernization of Land Records and Maps for Sustainable Environment Management in Bangladesh. SEMP Component No. 1.4.2 (BGD/96/07), October 2001.*
- [35] *Nurul Islam Nazem (Land Use Expert, InfoCosult Ltd.). An Overview of the Project on Modernization of Land Records and Maps for Sustainable Environment. January 17, 2004. Dhaka, Bangladesh.*
- [36] *GIS Atlas on Landuse and Environment, Polas and Sonargaon Upazila, Directorate of Land Records & Surveys (DLRS), GOB, Dhaka, July 2004, 111p*