SPATIAL DATABASE CONSTRACTION FOR NATURAL RESOURCES AND WATERSHED MANAGEMENT AT THE PROVINCIAL LEVEL IN IRAN: A CASE STUDY IN ARDABIL PROVINCE

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KEY WORDS: Spatial data; Database construction; Ardabil province; GIS; Natural resources management

ABSTRACT: In order to provide a provincial spatial database of the bureau of natural resources and watershed management in Ardabil Provence, this paper presents a scheme for spatial database construction to meet the needs of Iran for affective natural resources and watershed management. The objective and overall technical route of spatial database construction are described. The logical and physical database models are designed. Key issues such as integration of multi-scale heterogeneous spatial databases, spatial data version management based on metadata and integrative management of map cartography and spatial database are addressed.

1. INTRODUCTION

Currently, the fundamental geographic information data for the study and implementation of different projects in Natural Resources And Watershed Management (NRAWM) sections in Iran are in 1:250000; 1:50000 and 1:25000 scales, and all data and information layers are produced, analyzed, managed and distributed by involved organizations and consulting engineering(s) including Ardabil province (Figure 1). So far there are a few attempts to construct geospatial database at the watershed or paddock level (Husseini-Asl et al., 2008), however less attention in the provincial and integrated level, and mostly data produced and distributed as single layers or in the best situation presented in the classified folders. Although there are a few evidence of surveying and mapping and construction of geospatial database in the main watershed level such as Karkheh Watershed, which is in 1:250000 scale, the main management strategy are based on provincial and political boundaries such as Ardabil province. This paper puts forward a scheme and a preliminary step which describes the process of NRAWM provincial spatial database construction, including the objective and overall technical routes, the logical and physical geodatabase models and key issues. This scheme can meet the requirements of Iranian province fundamental geographic information database construction.

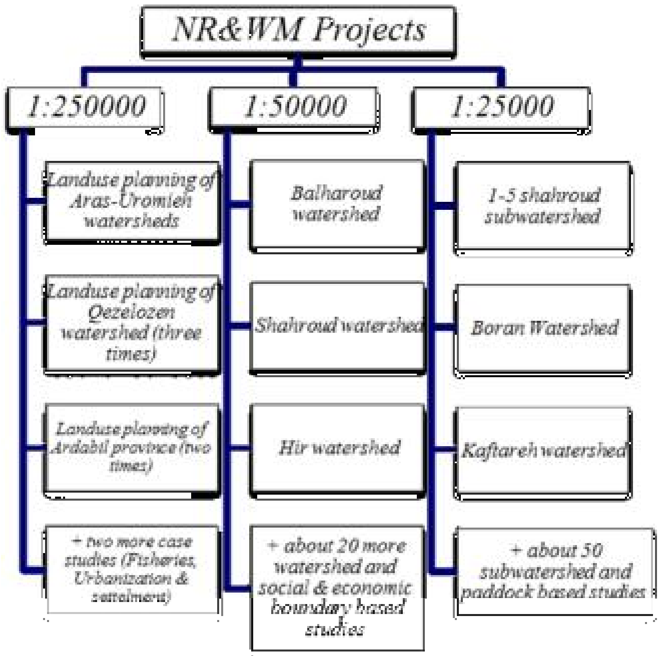

Figure 1: Conducted studies in Ardabil province in 1:250000, 1:50000 and 1:25000 scales in NRAWM sections (more than 60% of the produced data and information are pre era GIS and in the hardcopy format, some of them is not possible to access/ Aradabil province is covered by Qezelozan and Aras watersheds)

2. SPATIAL DATA CONSTRACTION FOR NRAWM

Geographic Information Systems (GIS) application in NRAWM in Iran is almost new (about two decades), however it is growing very fast and almost all of the studies are currently using GIS in these fields. However, the main problematic issues, which causes to create inappropriate and insufficient achievement from the use of GIS technology in NRAWM is the lack of attention to the spatial geodatabase for main watersheds such as Ars, Ghezel-Ozan and Karkheh or in the provincial level. As different sections of the NRAWM are producing maps for different purposes, one of the main issues is inaccurate boundaries, which in some cases errors are very high and the accuracy and precision of the produced maps are not acceptable (Figure 2) (Ghorbani et al. 2009). Moreover, some other issues, mainly inaccurate data generation and analysis i.e. the lack of topology, coordinate systems, and etc. which causes inaccuracy and wrong data and information, which by implementing this inaccurate information, we should not expect a sustainable NRAWM practices. In Iran, the spatial data (non GIS format) in 1:250000 scale were produced for most of the areas of country (Reclamation and Development of Agriculture and Natural Resource in 1960s & 1970s) and in 1:50000 scales were also produced (mostly in non-GIS format) for considerable parts of Iran as the feasibility studies of NRAWM. In some cases there is evidence that, for a specific area with the same procedure, studies have been conducted more than once because of no access to the previous studied documents. Overall, classification and distribution of these data are subject to various restrictions. Therefore, the provincial spatial database level can be considered to solve and manage these kinds of problems in the NRAWM sectors.

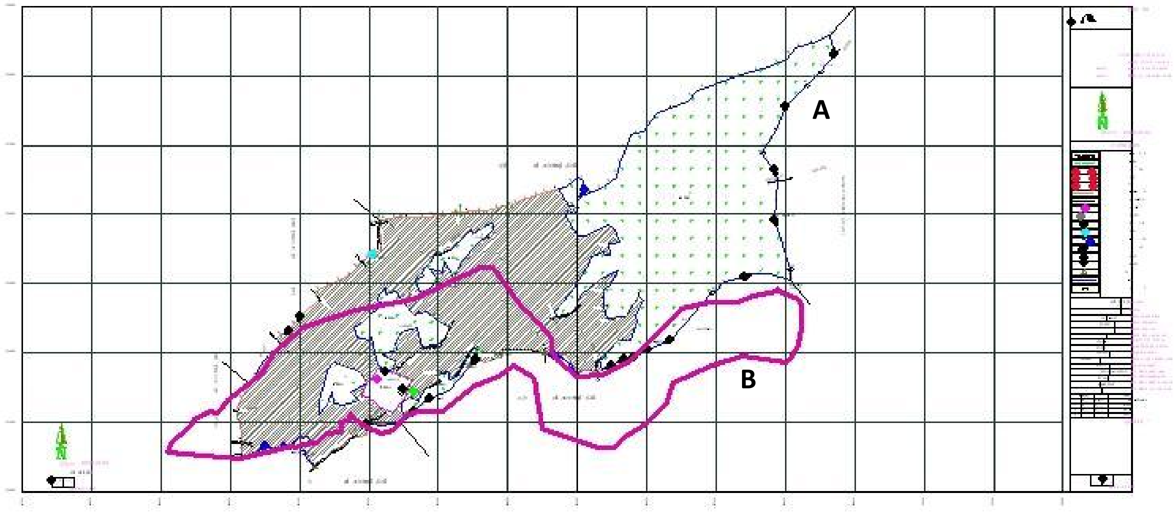

Figure 2: Example of boundary mismatching A) boundary of rangeland paddock, which controlled with GPS, and B) boundary of paddock which were mapped by consulting engineering in Soha watershed in Ardabil province

3. OBJECTIVES

By considering literature (Yildirim et al., 2001; Sonmiz & Sari, 2006; Husseini-Asl et al., 2008; Wang & Gong 2009; Ghorbani et al., 2009; Ghorbani & Kake-Mami 2012) and local requirements, the specific objectives for construction spatial geodatabase in the provincial level can be considered as:

a. Build spatial database management systems and achieve integration of spatial data from different sources.

b. Build a sharing mechanism and a distribution service system of fundamental geographic information data.

c. Build a good system of data service; shorten the traditional way of “data retrieve- order-process- offer”, and enable users to “find-see-take” the data; and some specific objectives such as:

- Explore readily available and distributed data for use in the provincial level and further applications for different studies;
- Promote and inform landowners, farmers, extension agents and etc. about the subject of NRAWM perspectives and land use potentials;
- Offer a decision support system for NRAWM planning, species selection, etc.
- Using criteria such as site characteristics, management objectives and management practices;
- Provide a user-friendly map interface for site selection which is linked to spatial data, eliminating the need for extensive knowledge on regional soils and climate characteristics of an biological site selection for reclamation;
- Provide a user-friendly, comprehensive menu of different management objectives, benefits and practices associated with NRAWM for the appropriate management;
- Incorporate ecological, economic and management criteria for the management of NRAWM, and

- Develop an application which can easily be expanded for other province in Iran by modifying the NRAWM database and incorporating the appropriate soils, climate and other spatial data.

4. GENERAL FRAMEWORK

We take the database construction of Ardabil province as an example. ArcGIS10 from ESRI is selected as the GIS and Geodatabase platforms for this preliminary study.

4-1. GEODATABASE CONSTRACTION AND MANAGEMENT

As highlighted by Wang and Gong (2009) and Ghorbani and Kakeh-Mami (2012) a fundamental geographic information geodatabase is that provides an accurate data, monitor produced data by consulting engineers and the fundamental geographic information services to users by which the fundamental geographic information enters the watershed, regional and national information data network. Figure 3 is the framework flow chart of geospatial database construction, management and distribution in the provincial level. Internal user (NRAWM Bureau) can query required information from the produced geodatabase and runs on the Bureau's systems. External users can query the information they need from the metadata-database released on the Internet and then send the trade request. When a trade request is received, a data distribution clerk retrieves the corresponding data in the fundamental geographic information database, confirms the required data and then submits the request to a data manager for the data requisition. According to the request, the data manager sends the corresponding data to the data distribution clerk. Finally, the data distribution clerk sends the data to the user after he/she verifies the data and transacts procedures with the user.

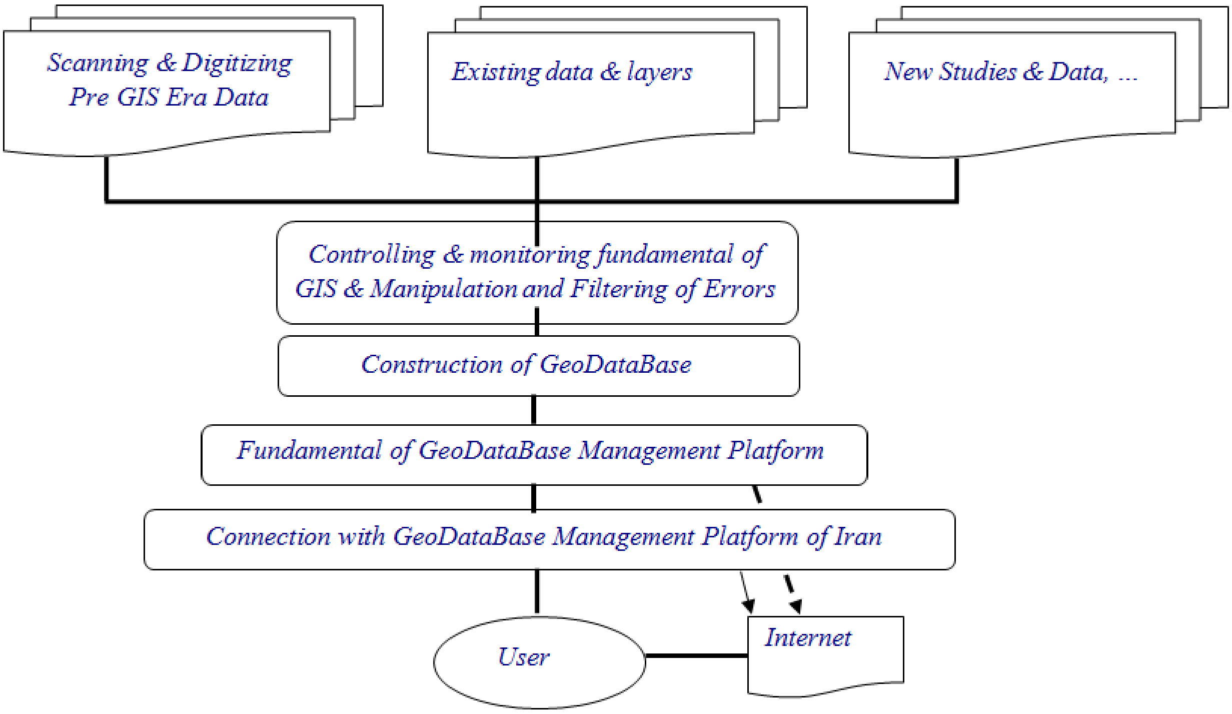

Figure 3: Geodatabase construction, management and data distribution

4-2. TECHNICAL ROUTE OF DATABASE CONSTRACTION

Overall technical route of database construction after defining the main goal of building a geodatabase, the logical and physical model of the geodatabase are designed according to the analysis of NRAWM organizational goals and user's demand of the fundamental geographic information database and the spatial data itself and by considering literature (Yildirim et al., 2001; Sonmiz & Sari, 2006; Husseini-Asl et al., 2008; Wang & Gong 2009; Ghorbani et al., 2009; Ghorbani & Kake-Mami 2012). Data storage is built according to the design scheme (Figure 4). Geospatial data are input into the geodatabase after being checked and processed. When geodatabases are integrated as one, the whole system is tested. After being checked and accepted, the construction of the database is completed. Finally, the work turns into daily running and maintenance of the database (So far the end user of the constructed database is only the Bureau of NRAWM of Ardabil province).

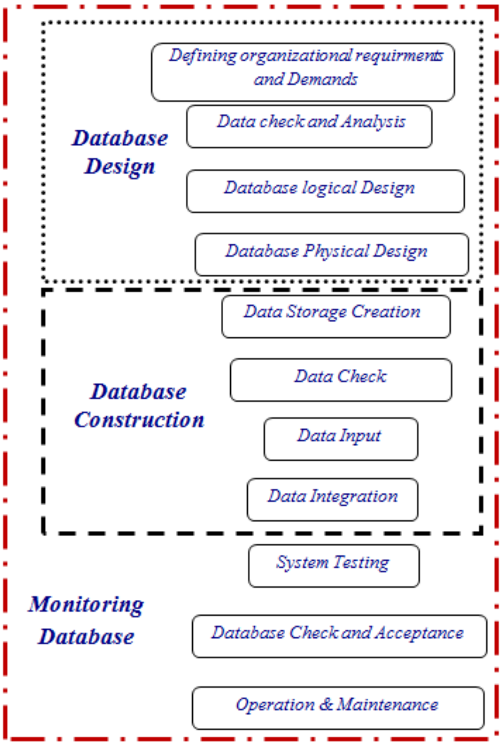

Figure 4: Flow chart of database construction and management

4-3. DATA AND DATASETS

Different data types and models were adopted according to different types of data in the construction of the NRAWM provincial geodatabase.

a. The base map datasets (vector datasets) such as topographic map sheets in 1:2500000; 1:50000; 1:25000 scales; and other scales, (mostly large scales), which are produced in the NRAWM mechanical planning stages in watershed management studies by consulting engineers. Map sheets in 1:250000 or 1:50000 scales are in hardcopy format (in some cases different bureaus and organizations scanned, geometrized, digitized these map sheets) and 1:25000 and larger scales usually in digital format. Digital data are in GIS-based, CAD-based and Microstation-based formats (Figure 5 as an example).

b. The DEM datasets are modeled as pyramid model. The vector database, DEM database is beyond the concept of the map sheet and built in a seamless pattern (Figures 5 and 6 as an example).

c. The aerial photo datasets and the DRG datasets are modeled as the relational model and catalog management. Almost in all the studies the Bureau of NRAWM in Ardabil province has been supported finically to buy and use aerial photographs, however in all cases in accessible files for conducted studies, there is no evidence of aerial photos, although usually in documents they have mentioned, the use of this tools in producing the maps.

d. The multispectral satellite imagery datasets are modeled as the relational model and catalog management. Already Landsat TM, ETM^+ and IRS LISSIII imagery in 4 series from 1987 to 2010 included in the satellite imagery dataset of Ardabil province.

e. The high spatial satellite imagery datasets are modeled as the relational model and catalog management, in the case for three watersheds including ShrvanDarasi, Onar Chay and LalGange QuickBird imagery have been taken and are using in the watershed management studies. These images were included in the NRAWM geodatabase.

f. The hyperspectral satellite imagery dataset can be modeled as the relational model and catalog management. So far not only in Ardabil province, but also in whole country, there is no evidence of using hyperspectral imagery in NRAWM studies. However by increasing the knowledge of remote sensing in the country this tool should be included in the NRAWM projects and geodatabse.

g. The thematic datasets (vector datasets) in different disciplines with different layers including: Physiography and watershed physical characteristics; Weather and climatic; Hydrology (surface and grand water); Geology and Geomorphology; Pedology; Vegetation (based on Rangeland or Forestry according to the physiognomy of Land); Social and Economic (human population, Agriculture, Animal husbandry, horticulture); River engineering; Erosion and sediment; Flood management; Water spreading projects; Land use planning and etc. are modeled as a relational or object-based models.

h. Finally a metadata datasets is modeled as a relational model, to guide the user for the process, data format, produced year, etc. of the included data in the NRAWM geodatabase.

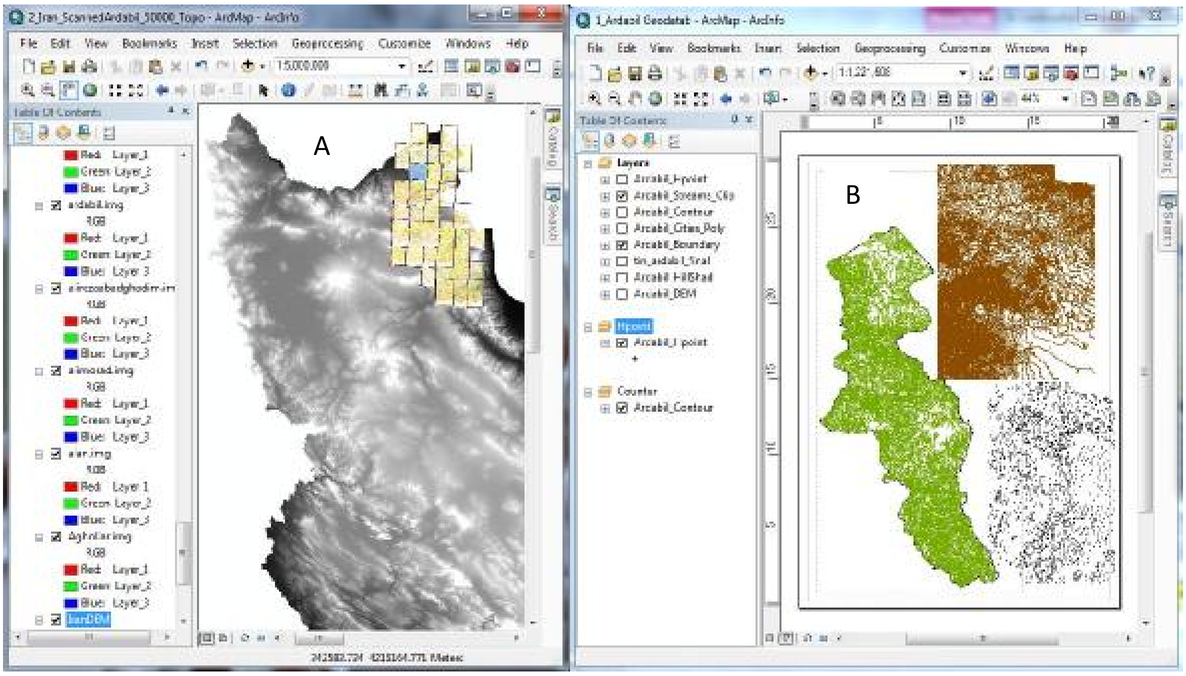

Figure 5: A) Scanned and geometrized 1:50000 topographic maps and DEM of the North-west of Iran, B) Extracted and digitized 1:50000 Layers (Stream, Contour & Height points) of Ardabil province

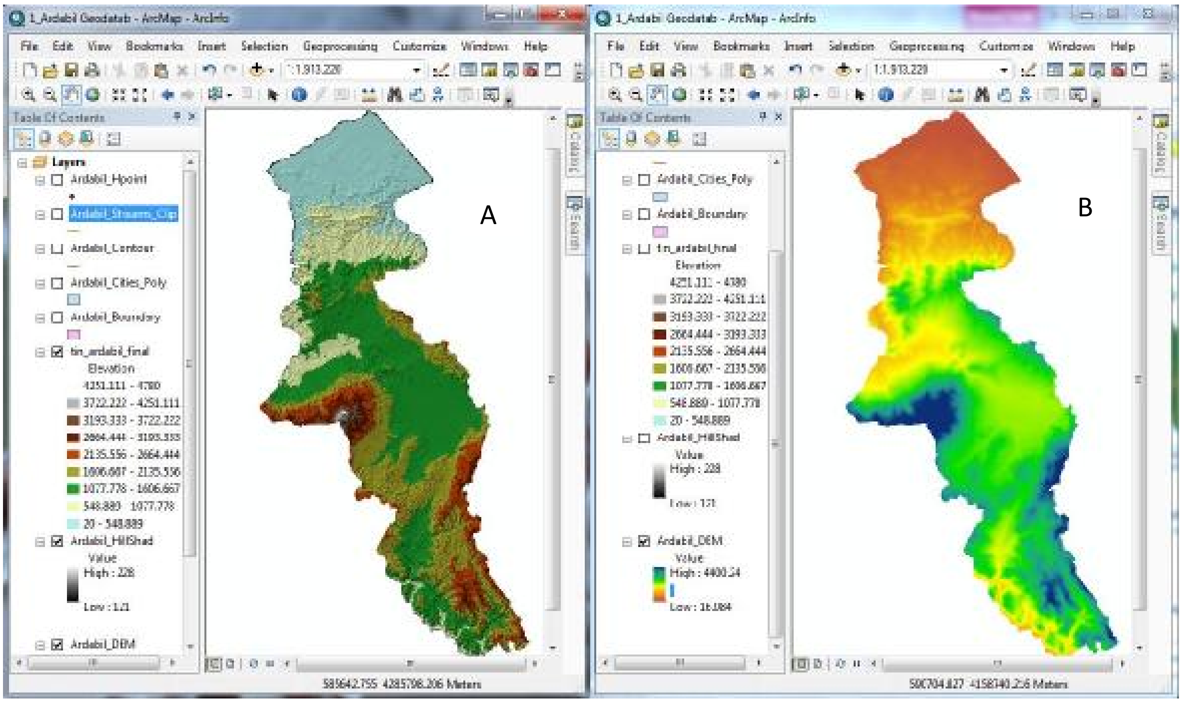

Figure 6: A) TIN model B) DEM of Ardabil province, which are included in the database

4-4. DATABASE DESIGN

The provincial NRAWM geographic information database can be considered as: seamless database, catalog database, metadata database and cartography database as illustrated in Figure 7. The details of logical design are shown in Figure 8.

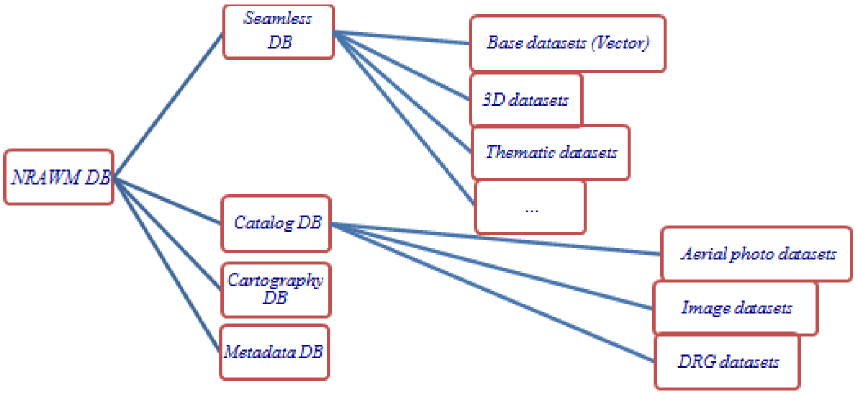

Figure 7: Logical model of fundamental geographic information geodatabase

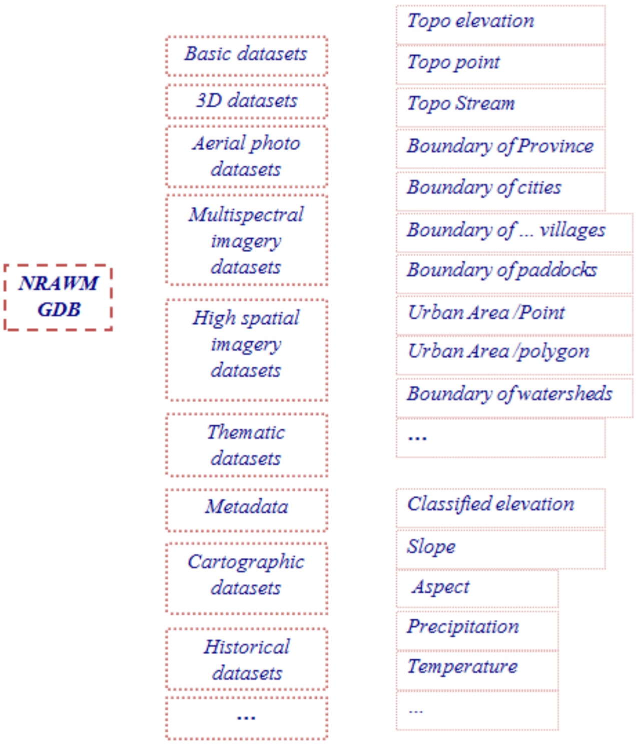

Figure 8: Logic structure of fundamental geographic information database; example layers for basic datasets and some layers from thematic layers

4-4-1. SEAMLESS GEODATABASE

Seamless geodatabase is designed by considering literature such as Wang and Gong (2009), which has explained the necessity of that based on the new extracted data and information from the base data or previously produced thematic maps such as TIN, DEM and etc. of Ardabil province. It builds for the sake of on-line and internal searching, browsing and analyzing. Many technical means can be used to process data, such as data conversion, projection transformation. A logical or physical seamless database based on the spatial database management system in GIS is built. It provides efficient search, distribution and analysis service for users. It connects various scales (1:250000 to larger than 10000 scales) and various types of spatial data (Base maps, 3D and etc. datasets together, and an integrative spatial database). According to the existence of two or more versions of spatial data in the same data unit for a specific area, the pre-version of spatial data can be considered as historical data, which is an important data source for inspecting the change of nature.

4-4-2. CATALOG GEODATABASE

By considering Wang and Gong (2009) and because of the irregularity of the data area and high overlap, and different types of data such as scanned maps, aerial photos, satellite imagery, DRG, etc. a seamless organization are not completely suitable. However, they are suitable for management by catalogs and being stored in the geodatabase in the form of single data file according to a certain geographic area or in base of watershed boundaries (most of the collected data are stored based on watersheds of Ardabil province). The aerial photo and DRG managed by catalog can do overlay with the data in the seamless database. Furthermore, they can be located and searched with the place-name database and vector database and then be distributed

4-4-3. CARTOGRAPHY GEODATABASE

In Iran mostly UTM coordinate system is used in map production and GIS datasets. Ardabil province is situated at two zones (38 and 39) of UTM. To resolve the inter-zone problem, vector database is established by geographic coordinate systems (UTM). However, the data must be symbolized and processed according to the production standards before outputting standard topographic maps. The cartography production database is established to avoid the modification of fundamental geographic information database. Data are extracted from fundamental geographic information database to production database, and the projection transformation of the data is conducted. A cartography production database is in the form of file or ACCESS database and managed by map sheet. The data are edited, symbolized, printed and outputted in the cartography production database.

4-4-4. META-DATABASE

The descriptive information of fundamental geographic data, including the information of data production and data management, are stored in meta-database. Meta-databases of product level, database level and map sheet level are established. The meta-databases can satisfy various query and search requirements in data production, management, and distribution.

4-5. PHYSICAL MODEL DESIGN

Produced attribute data by different consulting engineering have not uniform structure. Attribute data structure design includes identifying the names, types, fields and attribute values of the attribute items of certain features. This is one of the main problematic issues in the construction of NRAWM geodatabase at the provincial level based on the previous data and layers. A framework of building tables at GIS in NRAWM projects has already been presented by Forest, Rangeland and Watershed Organization at the national level (Meskari and Mirghasemi, 2004), however consulting engineers did not interested to use this framework. For future data, Forest, Rangeland and Watershed Organization should force the involved consulting engineers to use that framework in GIS layer and table production.

4-6. GEODATABASE CONSTRACTION

Database construction includes database building, data checking before input, data processing, data input, data checking after input, etc. The database construction process is shown in Figure 9.

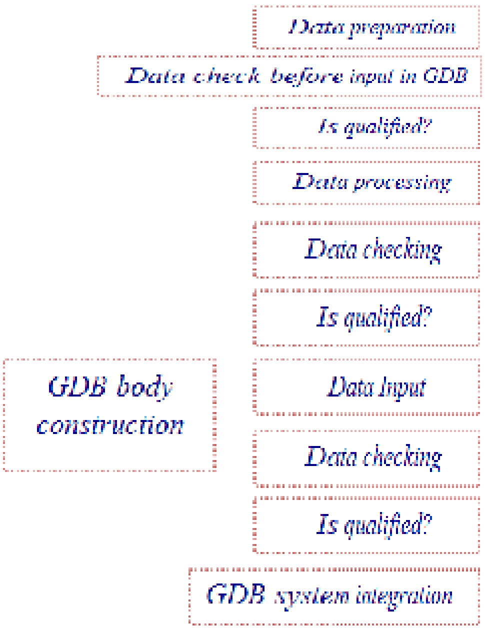

Figure 9: The flow chart of database construction

4-7. GEODATABASE STORAGE CONSTRACTION

The database storage construction includes physical space allocation, parameter setting and data table creation, etc. according to the physical design and logical design of the database. The data size of Ardabil province so far is about 100 GB. It is estimated by scanning pre era GIS data and establishing historical database, it will reached about 500 GB. Some problems such as difference in scale of data, accuracy and size, etc. are exist in spatial database construction (Ghorbani et al., 2009; Ghorbani and Kakeh-Mami 2012).

4-8. DATA CHEKING

In order to ensure data quality, before data input, spatial data checked according to production technology and quality specifications. If it cannot meet the requirements, the spatial data rectified. The data to be checked includes basic layers, 3D layers, thematic layers, and metadata. Moreover raster datasets such as aerial photos, multispectral and high spatial datasets were also checked, particularly from the geometrical aspect. The checking of metadata and place name data includes data format, data item integrality, data item naming and data content normalization.

4-9. DATA PROCESSING

There are two types of spatial data processing. The first one is the processing of the raw data or the data that does not meet the quality requirement. For example, some of the problematic issues are including: the lack of header file in imagery datasets, undefined aerial photos scales, the lack of georeferencing of aerial photos (i.e. Lighvan Chay watershed), problems with GIS layer preparations (Figure 1 as an examples). The other is the processing of the data stored in the database from which other useful information can be derived. As highlighted by Wang and Gong (2009), provincial fundamental geographic information database is responsible for spatial data management and distribution. Therefore, the data processing must satisfy the following requirements.

- **a.** The mathematical accuracy of data cannot be lowered.
- **b.** No data is lost.
- **c.** The integrity and consistency of vector data cannot decrease.
- **d.** Image data quality does not decrease.

Spatial data processing includes many contents. Among them the most important two contents are spatial data conversion and adjustment between map sheets. Spatial data conversion includes code conversion, data format conversion, coordinates conversion and projection conversion. Spatial data adjustment includes the following contents.

- **a.** Vector data adjustment between map sheets, which includes feature property and graphic adjustment.
- **b.** Image adjustment is mainly responsible for hue adjustment between map sheets.
- **c.** DEM adjustment is mainly responsible for elevation adjustment between map sheets.
- **d.** After data adjustment between map sheets, databases should be logically seamless, the correlation between the databases is true and the feature property is consistent.

4-10. DATA INPUT

Spatial data input can be divided into input by region and input by feature. The former manages and stores data by region or map sheet, the latter manages and stores data by feature layer. Input by region relates to image data and DEM while input by feature relates to vector data.

4-11. GEODATABASE SYSTEM INTEGRATION

In geodatabase system integration, data integration, hardware and software integration, and function development and integration must be taken into consideration. Data integration refers to the establishment of relations between data of different types, data with the same scale, data with different scale, and metadata and corresponding data. Only by the establishment of these relations can data management and distribution be carried out smoothly. By considering Wang and Gong (2009), data integration includes the following contents.

- **a.** Integration of different types of spatial data. Vector, raster, DEM and some other kinds of data can be flexibly integrated with each other, for instance, overlay display of different types of spatial data, and spatial analysis, on the data integration platform.
- **b.** Integration of data with the same scale. That all data with the same scale are stored in the same table in the database ensures the data to be integrated seamlessly.

c. Integration of data with the different scale. For instance, raster data with different scale can be integrated flexibly by pyramid.

d. Integration of metadata and their corresponding data. Achieve a two-way query between metadata and their corresponding data by building the relationship between them.

4-12. KEY ISSUES AND INTEGRATION OF MULTI-SCALE HETEROGINUS SPAPATIAL DATABSE

The key technologies involved in database construction include integration of multi-scales heterogeneous spatial databases; inter-zone panning of raster data, spatial data version management based on metadata, integrative management of cartography and spatial database and management of catalog data. Because of different data forms among these data sources, different methods are selected for different data types to construct the database. Although spatial data are numerical and can be displayed in multi-scales by zooming in or zooming out, it is produced according to survey specifications of different scales. The data of each scale have their own data precision. The data are accepted or rejected in different scales.

4-13. SPATIAL DATA MANAGEMENT BASED ON METADATA

AS highlighted by Wang and Gong (2009), Metadata are the data about data. Metadata can help organize, manage, search and distribute spatial data rapidly. In the work of the provincial spatial database, a data version management scheme based on metadata is put forward. Each map sheet includes spatial data and their metadata in which the data contents, quality, state and other characteristics are described as text file or other format. The spatial database can be divided into three sub-databases logically: current spatial database (Figure 10), historical spatial database and metadata database. In the current database, the most updated spatial data are stored. In historic database, various version data are stored, and metadata of all versions of map sheets are stored in the metadata database. Based on metadata, the input, updating, scheduling, searching and distribution of various versions of spatial data are implemented.

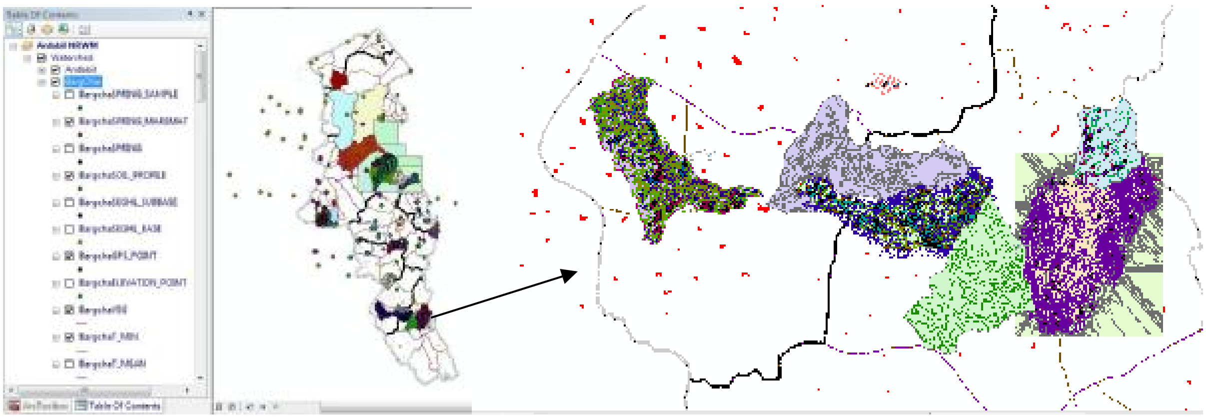

Figure 10: constructed spatial geodatabase of Ardabil province

5. CONCLUSIONS

Spatial data can assist in decision-making in many areas of NRAWM in Iran, including Ardabil province. In the vigorous developing NRAWM of Iran, the application of spatial data is at an initial stage, but the requirements are increasing intensively because of its advantage and the development of infrastructure. Owing to the characteristics (variety, multi-scale and large volume, etc.) of fundamental geographic information, a spatial data management and distribution system must be developed to meet the needs of the Bureau of NRAWM in Iran. It needs more consideration, and monitoring of preparation of data, checking data, inputting in geodatabase of NRAWM.

6. ACKNOWLEDGMENT

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