Geo-Spatial Data Bases – Vital Tools for the Scientific Management of Territories and Communities

Professor Eng. ec. Maricica STOICA Ph. D.
Picer assistent Cristian BUSU Ph.D. student
The Bucharest Academy of Economic Studies, Romania

Abstract: *In the paper, the authors presents the current progress in creating and assimilating geospatial databases in public administrations, database utility in territory and community management, the need to build database infrastructures on three administrative levels: county, regional and national to ensure the interoperability of spatial information with the European base infrastructure, the methodology for elaborating geospatial databases at administrative-territorial level.*

Keywords: *geospatial databases, public administration, management, methodology*

1. Introduction

The complexity of the issues raised by the scientific management of an administrative or geographic territory requires analysing it in its physical, social, economic, environmental dimensions based on geospatial information organised in databases, produced by various positioning and remote sensing technologies.

Romania's accession to the EU requires that the territory of the country is managed under the same laws, which will allow (by comparison) for appreciating in real terms the performances of the managerial teams at the helm of various administrative levels. Managers who have understood that geospatial information represents strong arguments in attracting investors, along with the transport and utilities infrastructure, development facilities, bank and insurance services will become attraction poles for capital. Practically, local public administrations should offer potential investors what they have no interest in doing: complex geospatial databases, from which to extract the information they need. Geospatial database information processing allows for calculating certain indexes and indicators, based on which scientific analyses are made on the existing situation. Complex simulations of real situations can also be made, in order to take the best decisions.

Also, geospatial databases are useful in: managing risks of climatologic, geological, anthropogenic or biological origin; managing natural soil and subsoil natural resources; managing the critical natural capital: water, air, soil; managing investments (planning, design, implementation). In addition, geospatial databases represent the most efficient managerial tools in solving all complex issues that communities raise: spatial planning, cadastral evaluation; records of properties; transport, telecommunications and utilities infrastructure management; waste and pollution management; traffic management etc. The benefits brought to the communities by geospatial information apply also to certain fields of large social, cultural and educational interest such as: reducing criminality, health, education, culture, tourism etc.

2. Current Progress in Creating and Assimilating Geospatial Databases

The concerns of the local public administrations and of the deconcentrated institutions in Romania regarding the creation of geospatial databases were low, as a result of insufficient financial resources but also incomplete information on the huge benefits they bring to communities and particularly to their management. Intense concerns and notable achievements were obtained in the area of scientific research by the research programmes developed (AMTRANS, CEEX, PNII). In many research projects based on IT, GIS and GPS technologies a series of applications were elaborated-specialised computer systems and geospatial databases designed for the public administration to solve issues in various fields (health, infrastructures, planning, development, disaster management, security, infringements, environmental protection, education, culture, recreation etc.). Many public administrations entered in the possession of specialised software for managing the related databases, but benefited also from staff training to solve various specific issues scientifically and to manage and update the databases, but particularly from a scientific multidisciplinary analysis of the databases which should be the foundation of a scientific management of the territory and of the communities.

The facilities offered by geospatial databases: viewing digital georeferentiated maps and associated information under various forms (charts, tables, texts), creating and viewing various scenarios, simulating extremely complicated real situations and events, solving in short time issues which require laborious multicriterial analyses, have made them become indispensable tools in the decision-making process. Romania’s accession to the EU requires local public administrations to use databases in order to manage the territory and the communities efficiently. All European funds intended for infrastructure, agriculture, natural risk, waste and water management, require to design projects where databases are indispensable tools for both the public and the private sector. Various deconcentrated institutions are involved in the management of a county which use the same digital map (the administrative limit of the county) specific data – depending on the powers of the institution within the county and a series of common data (e.g.: those concerning the owners of fixed assets on the territory of the localities are useful to the Cadastre and Real Estate Advertising Office, to Insurance Companies, to the Local Duty and Tax Directions, to Utility Suppliers and to Sanitation Services, the data concerning natural risk areas on the territory of the localities are useful to the Inspectorate for Emergency Situations, to the deconcentrated Institutions with powers and responsibilities in risk management, to the Urban Planning and Land Use Planning Directions in the City Hall, for entering risk areas in the General Urban Plans (PUG), to Insurance Companies for assessing the level of risk for the elements subject to the insurances, the Cadastre and Real Estate Advertising Office for assessing the yield power of lands and buildings). Therefore, local public administrations and the deconcentrated institutions will have to cooperate in order to integrate the existing databases in unitary databases, on administrative levels, complete them, ensure the integrability of computer management systems for both the existing public databases and those to be created, in order to provide access to the public data existing in the spatial database for all interested people via the Internet network. The information offered in the databases should be easy to identify and analyse, easy to obtain and easy to integrate with other information in order to serve the purpose of each user.

3. The Need to Achieve Spatial Information Interoperability

Geospatial information organisation and management started all around the world at the end of the 20th century within the so-called National Spatial Data Infrastructures. Their main purpose was to reduce the duplication of efforts for various institutions or agencies in the process of collecting and producing geospatial data, to improve the quality of geospatial data and to significantly reduce costs in obtaining them. At global level, Spatial Data Infrastructures were regulated, developed and implemented such as: GSDI (The Global Spatial Data Infrastructure), GEO's GEOSS (The Global Earth Observation System of Systems initiated by Group on Earth Observation), GMES (Global Monitoring for Environment and Security) and at the European Union level, the regulation materialised following the approval and the adoption of European Directive 2007/2/CE INSPIRE (European Spatial Information Infrastructure). According to this directive „... it is necessary to establish a particular coordination between the users and the suppliers of information, so that the information and the knowledge in different sectors can be combined." Thus, all European Union member countries are bound to build and implement National Spatial Data Infrastructures by 2013, the interfacing between the system and the users being made by means of a portal which will allow for navigating, publishing and enquiring metadata catalogues. INSPIRE aims at developing a legal framework which should support the creation of a European SDI starting from the environmental field, but also ensure a complementarity of spatial information at European and national/regional level.

The purpose for building a Spatial Data Infrastructure, at whatever level, (county, region, national, European, global) consists in:

- developing and maintaining spatial data and metadata;
- accessing and distributing spatial data and metadata;
- viewing and analysing them.

Building or consolidating spatial data infrastructures relies on data and services which are based on technological developments where the standards specific to the field of geographic information are applied.

In many countries around the world people are working to create spatial data infrastructures; many countries already have presentation catalogues and main data sources on Web pages. In Romania, there are concerns within the scientific community to consolidate the National Spatial Data Infrastructure, the final purpose being the creation of a portal which should allow for access to geospatial data and services in Romania (figure 1).

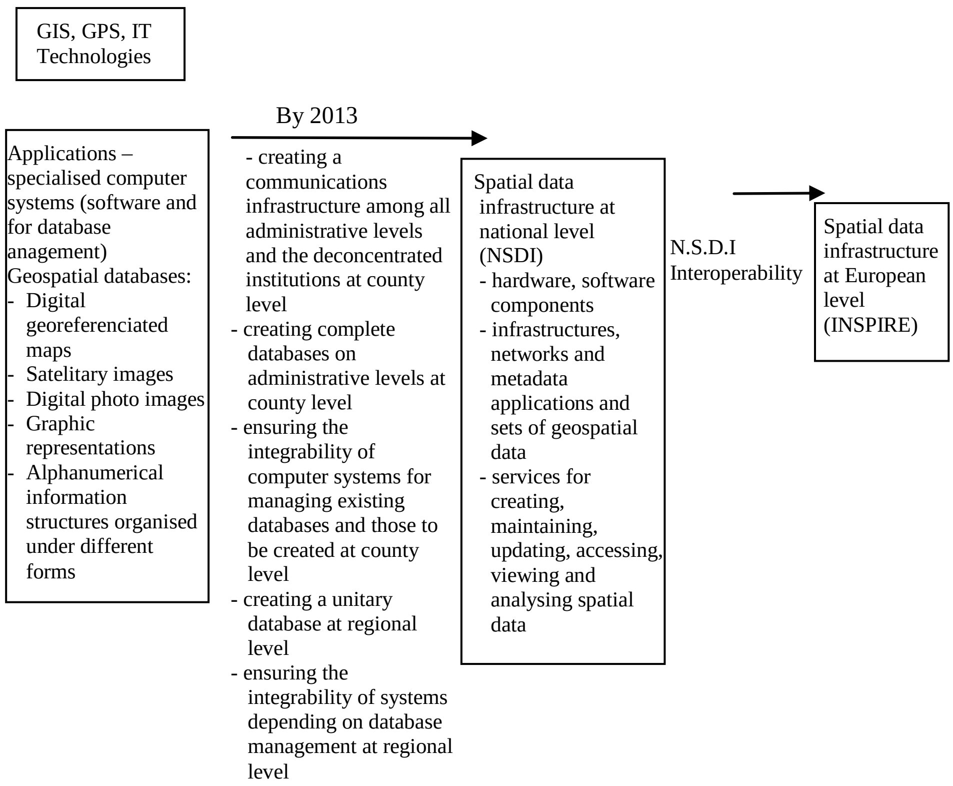
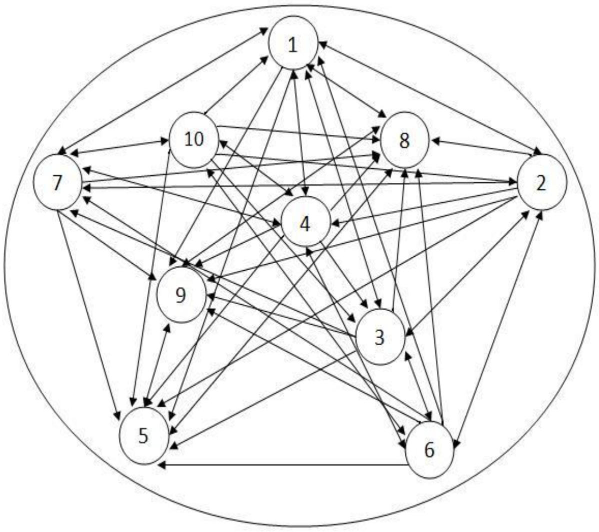


Figure 1. Current structure and evolution of geospatial databases in Romania according to EU requirements (European Directive 2007/2/CE/INSPIRE)

The portal will make available to users a set of tools which ensure the publication of metadata by geospatial data suppliers, the function for searching in the metadata catalogue and for connecting data and services, in order to be able to display them together, as well as the tools which will offer differentiated GPS (DGPS) correction services for professional GPS equipment. From the technical point of view, the implementation of a Spatial Data Infrastructure involves the hardware, software component, the network infrastructure, and that of applications which will ensure a medium necessary to create and maintain spatial data and metadata, access and distribute them, view and analyse them. Therefore, one of the key challenges in technical terms for implementing a National Spatial Data Infrastructure involves the corroboration of information and the integrability of computer systems for managing spatial databases/communes/towns/deconcentrated institutions/county/regions considering the European standards. The integrability of computer systems is also the essential condition for using spatial data from the most diverse computer systems. Considering the specific nature of the local public administration, the integrability of GIS solutions with the other applications can substantially contribute to the fluidisation of information flows. Regional development is also emphasised at EU level, therefore the issues occurring at the level of the local public administrations and at the level of the deconcentrated institutions should be solved, involving the following: creating a communications infrastructure among them, creating complete databases at commune/town/municipality/county level, ensuring the integrability of computer systems for managing existing databases and those to be created, integrating all databases created in various applications, in one database, at regional level, able to make available various information to all users whatever their location.

4. The Methodology for Elaborating Geospatial Databases

The elaboration of a geospatial database at administrative-territorial level is a complex multidisciplinary research activity which involves a tremendous volume of work and which can be carried out only by collaboration within interdisciplinary teams made up of specialists in IT, computer systems and spatial databases, mathematicians, geographers, geologists, hydrologists, pedologists, biologists, climatologists, town planners, economists etc. The structure of the team is given by the field subject to analysis and the detailing level of the data. The design and the analysis of the geospatial database at administrative-territorial level require knowledge on systems theory. In simplified terms, these relations are shown in figure 2, for an administrative territory where all types of ecosystems and human habitats are identified (designed and built systems)



1 - economic infrastructure
2 - social capital
3 - cultural capital
4 - human resource
5 - (agricultural, aquatic, forest) ecosystems
6 - political system
7 - pollution
8 - critical capital (water, air, soil)
9 - climate
10 - external (economic, social, environmental) factors at regional, global level

Figure 2. **The interdependence relations among the component subsystems of the designed and built ecosystems and systems identified at county level**
(project 1136/2004.CNCSIS Research on the ecosystemic approach of sustainable development at administrative-territorial level)

The conception of geospatial databases and of Spatial Database Management Systems (SDMS) is made concomitantly due to the fact that users' requirements are increasingly complex, and on the other hand, S.D.M.S. should ensure the conversion, the import and the export of data in/from other types of geospatial bases using various computer systems. The elaboration of the spatial database has a systemic nature, in the sense that it requires the identification of all types of entities, phenomena, of the types of relations among them, the identification and the association of the attributes of each entity, phenomenon, or of the relations among them, so as to create all the conditions for a global and pragmatic approach and analysis of all geographic, hydrological pedological, biological, economic, social and ecologic aspects of an area, ecosystem or community. The decisions in the scientific administration of a territory should be always the result of certain analyses and multicriterial evaluations of a volume of sufficient and multidisciplinary data, modelling and simulations. Suggestively, this scientific method can be presented as a pyramid (figure 3).

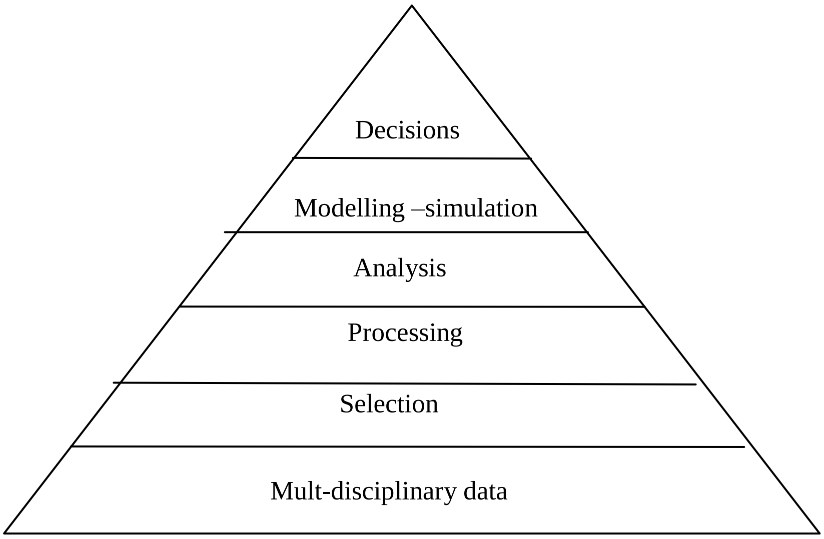


Figure 3. The stages in the elaboration of decisions in the scientific administration of a territory

The base of the pyramid is created from the multitude of data collected in the field with various techniques (or from other existing databases) and stored under various forms, followed by a data selection and successively, by processing and analyses, the data become more concentrated (as indicators, charts, tables, maps, schemes, diagrams) and describe the situations in the field better and better, until reaching, following modelling and simulations, decisions – the top of a pyramid – which rely on complex scientific analyses.

Any geospatial database should be designed so as to meet the following requirements concomitantly:

- data collection should allow for permanent updating (or whenever required) to offer current and non-contradictory data;
- the database management system should allow for data collection being used by as wide a range of users as possible, not necessarily computer specialists;
- the possibility to offer complex information to the user in a synthetic form, easy to interpret at different decision levels, in as short a time as possible and at as low a cost price as possible;
- ensuring as good a protection of information as possible against attempts to steal and destroy accidentally or wilfully.

The methodology for elaborating spatial databases comprises a strategy and a tactics. The strategy consists in breaking up the elaboration process into phases, stages, and combining them by using well established techniques (figure 4).

The tactics consists in the arsenal of specific design methods and techniques and of work principles.

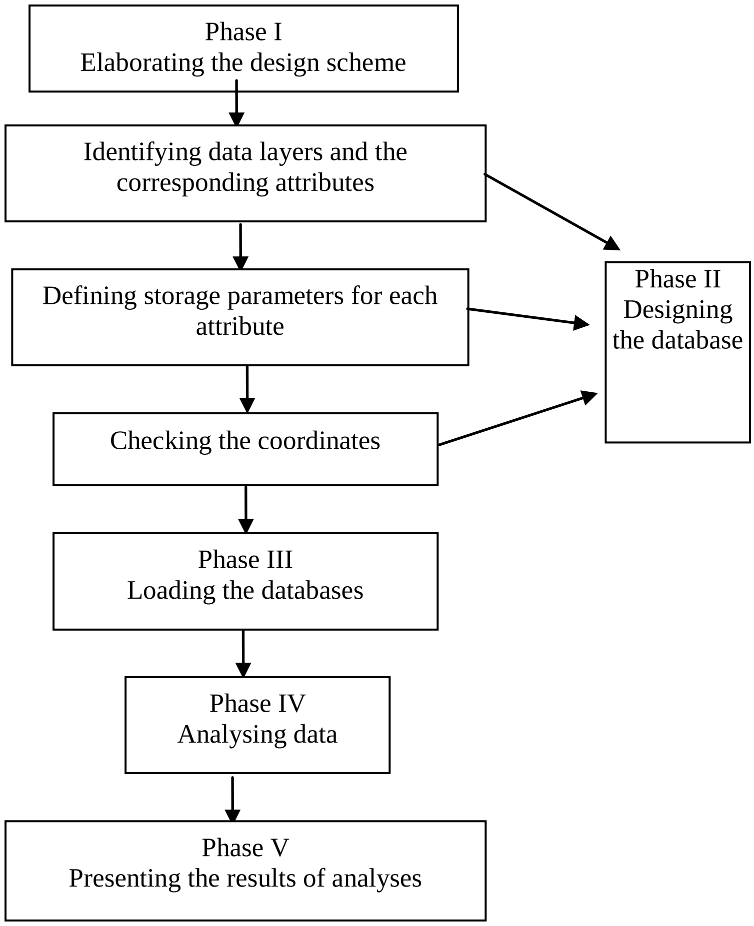


Figure 4. The phases and the stages in the elaboration of geospatial databases

Elaborating the Design Scheme

The aim of this phase is to design the structure of the database which will have to be furnished with information either already structured, taken from other databases, as well as the architecture of the ***software which will have to allow for accessing, viewing, processing and integrating data***. The following elements are mentioned in this phase: the issues to be solved, the entities to be studied, identifying the interdependence relations among them, the information which is necessary for the specific nature of the geospatial application, the research methodology, the information sources, the way the database is managed, the elements for presenting the results (reports, plans), the beneficiaries of the database, other possible users (figure 5).

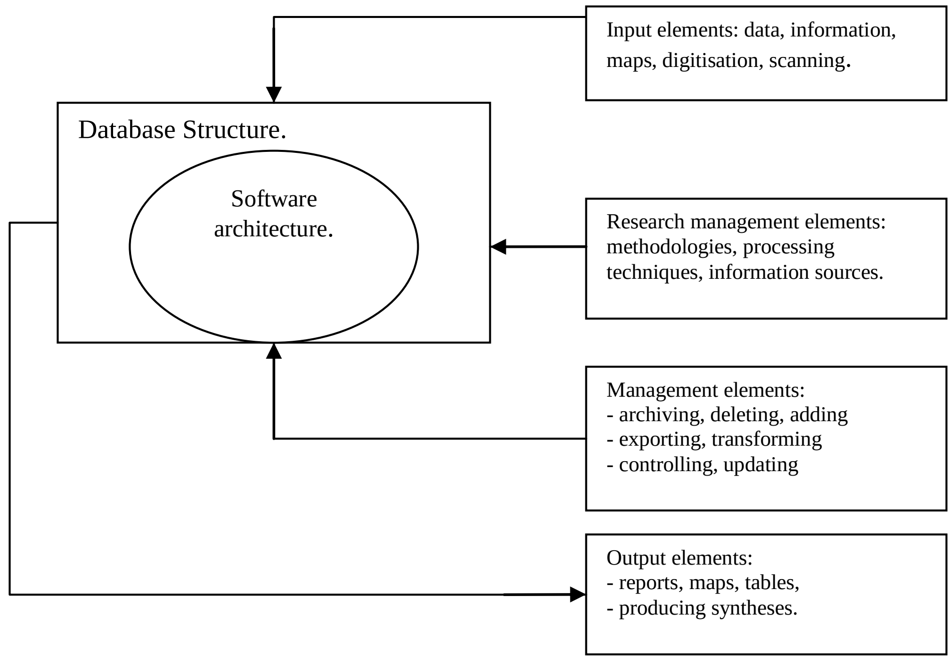


Figure 5. **Database Design Scheme**

Designing the Database

Data structure and data content are designed in this phase, which are necessary in order to solve issues, as well as the connections among them.

The stages to be run through are the following: identifying data layers and the corresponding attributes; defining storage parameters for each attribute; checking the coordinates.

Identifying data layers and the corresponding attributes, aims at determining the data to be included in the database. The following steps are run through in this stage: a) identifying the geographic entities and their attributes; b) organising the data layers; c) organising data layers into modules

a) Identifying the Geographic Entities and their Attributes

The geographic entities, the relations among them and their attributes are identified and established by investigating the area subject to research. A geographic entity may be a river, a forest, an area. The attribute, represents a feature characterising an entity. A relation among the three entities may be the following: in the area there is the river and the forest. The specific attributes characterising the three entities may be: erosion, pollution, deforestation, and as common attribute there might be pollution or erosion. The detailing degree of the attributes is determined by the analysis level of the research, for instance pollution and erosion can be detailed depending on pollution/entity types or erosion/entity type. Establishing attributes correctly and detailing them conditions the possibility to analyse all aspects that a geospatial database offers. Graphically, this information is recorded as a table, attributes being entered in the table columns, and the entities on the rows.

b) **Organising the Data Layers**

After identifying the geographic entities and the corresponding attributes, the organisation of entities in data layers follows, that is establishing the geographic elements necessary to be stored within each layer.

The data layers are organised so that the punctual, linear and areal elements are each stored in separate data layers. For instance, the water basins represented by dots can be stored in one layer, while the means of communications represented by lines are organised in another layer. The geographic entities can be also organised by subjects depending on the meaning. For instance, the „layer'' structure (figure 6) in six layers: administrative border, area, land use, vegetation, topography, hydrology, structure which allows for a complex analysis of an area, from the administrative, geographical, hydrological, biological, pedological point of view.

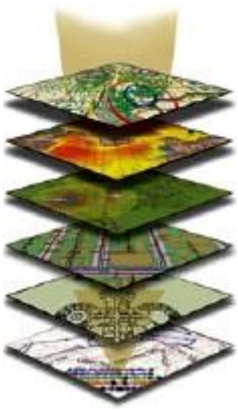


Figure 6. Layer Structure
Source: John E. Harmon and Steven J. Anderson, The Design and Implementation of GIS, John Wiley & Sons, New Jersey, Canada, 2003

c) **Organising Data Layers into Modules**

The way data layers are organised into modules will determine the content of the database-the number of files. Practically, the way the two data types, maps and tables are organised in data layers will have to be established, respectively the geographic entities along with their attributes. In practice, we sometimes meet textual attributes such as: total area, area within the built-up area, attached directly on the maps. This data grouping into modules is usually made considering the functional criteria of the entities. E.g. the modules: the road network (comprises all road categories in the researched area), urban infrastructure (comprises all utilities, sewerage and communications networks of an urban locality).

Defining Storage Parameters for Each Attribute

The aim of this stage is to establish for each attribute the specific parameters and the type of values to be stored. The steps to be run through are: a) codifying the attributes; b) establishing the way to store the attributes; c) building the data dictionary.

a) **Codifying the Attributes**

Attributes can be stored as numerical values and character rows. The attributes described by a character row are better represented in the computer codified. If the attribute describes a class, it can be stored more efficiently and easier as a code for a class than as a description. All entities can be always grouped into several modules-as needed, grouping which can be made based on selections depending on the codes specific to the attributes associated to the entities established initially.

b) **Establishing the Way to Store the Attributes**

The efficient use of the computer memory requires establishing the way to store each attribute, and respectively, the memory space necessary to store the name of each entity.

It should be taken into account that large data volumes will be stored. Less memory space used for an attribute will determine smaller entries, which will lead to the size of the data files being reduced.

c) **Building the Data Dictionary**

The data dictionary is a list which keeps for each entity the name of the attributes and the description of the attributive values, including a description of each code if necessary. The creation of a data dictionary is required to ensure data sharing and information transfer among different computer systems.

Checking the Coordinates

After organising the data layers into modules they should be checked in relation to their mutual position. The database will consist of a number of data layers organised into modules which represent the entities specific to the geographic area studied (figure 7).

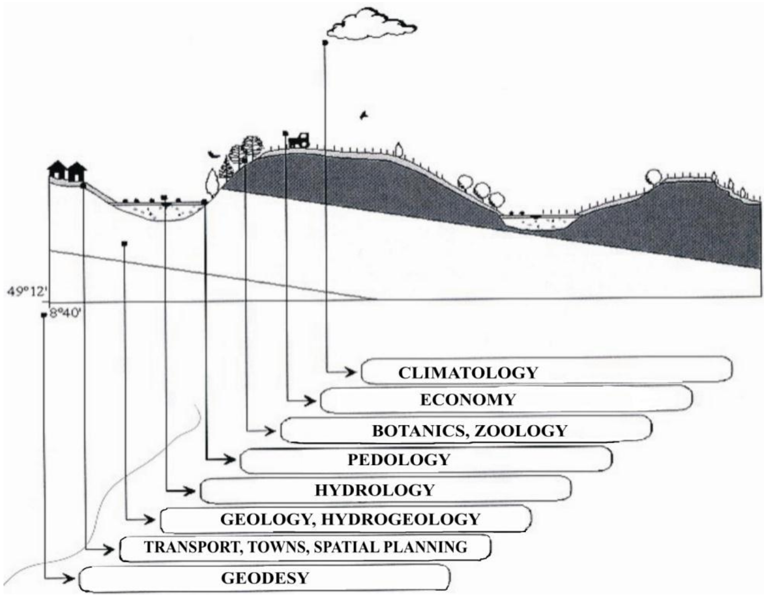


Figure 7. Checking of Data Layers (Source John E. Harmon and Steven J. Anderson, The Design and Implementation of GIS, John Wiley & Sons, New Jersey,Canada,2003

When data from a particular data layer are combined with data from another layer (e.g. when two data layers overlap to create a new one) the coinciding data should overlap exactly.

If the overlapping of the coordinates is not accurately made, we will have problems with generating maps.

Loading the Databases

Database loading consists in:

- collecting and storing data. Data can be collected directly in the field or they can be obtained by searching with different techniques, or by determinations in the laboratory. Data collection is made by means of the digitisation process or by using the conversion of data from other systems;
- checking and correcting errors;
- saving, updating, regenerating data;
- entering and storing associated attributes**.**

Analysing the Data

The analysis of the data stored is a multidisciplinary and interdisciplinary issue involving specialists, software specialised in data processing, simulations and modelling, evaluation methods, mathematical and statistical apparatus.

Currently, computer systems are being elaborated which replace analytic operations (which would be very laborious or impossible to perform by means of other methods) and which complete the specific possibilities of a GIS. There is a multitude of evaluation and analysis criteria and methods to solve the issues proposed in the first phase. Alternative scenarios can be tested and evaluated by appropriately changing the criteria and the parameters specific to the analytical study methods.

The processing and the analysis of the data in the database give indications and indicators necessary to understand the existing situation in the territory analysed, which, by simulations, modelling offer scientific assistance in taking decisions.

Presenting the Results of the Analyses

GIS offers numerous facilities for creating digital graphic maps and reports, offers spatial viewings for decision-makers to understand the spatial elements on which decisions are to be taken. The final documents should meet the requirements for which they were designed and properly represent the geographic entities as well as the relations among them. The way the results of the analyses are synthesised and represented, both graphically and in tables, will determine the quality of the decisions.

Conclusions

The problems which occur at the level of the local public administrations and at the level of the deconcentrated institutions pertain to the creation of a spatial data infrastructure/ county, by integrating all the databases created in various applications, in one database, able to make available various pieces of information to all users whatever their location. This collaboration at county/region level is required also by the fact that, the creation of a database involves time, important costs for collecting and updating certain data, but also for avoiding data redundancy, and on the other hand on the same digital map with common information structures, each institution can load to itself data specific to the field. In most cases, the sets of data exist as data banks within the local deconcentrated institutions. Often, they use a wide range of technological platforms designed for creating and managing this spatial information. It is also required to initiate institutional collaborations and arrangements at the level of the county as well as intercounty public administrations/regions, which should finally lead to the creation of unique infrastructures of databases, specialists who should manage and update these databases.

Bibliography

1. **BERCA, M.** (2006) *Planificarea de mediu şi gestiunea resurselor naturale,* Editura Ceres, Bucureşti
2. **BRIGGS, R.** (2003) *Introduction to GIS*, University of Texas at Dallas, 1996
3. Directiva 2007/2/CE a *Parlamentului* European şi a Consiliului din 14 martie 2007 de instituire a unei infrastructuri pentru informații spațiale în Comunitatea Europeană (Inspire), Jurnalul Oficial al Uniunii Europene, L108, Anul 50, 25 aprilie 2007
4. **DONISA V., DONISA, I.** (1998) *Dicţionar de teledectie şi sisteme informationale geografice*, Editura Junimea, Iaşi
5. **DIMITRIU, G.** (2004), *Sisteme informatice geografice (GIS),* Cluj-Napoca, Editura Albastră
6. **EASTMAN, J.R**. (2001) Idrisi 32 - Guide to GIS and image processing, vol 1-2, Clark Labs, Clark University, Worcester
7. Interministerial Committee for Geo Information (IMAGI) (2003) *Geo Information in the modern state*, The Federal Agency for Cartography and Geodesy (B&G), Frankfurt am Main
8. **LUNGU, I., SABĂU GH. VELICANU, M., MUNTEANU, M., POSDORIE, E** (2003) *Sisteme informatice, analiza, proiectare si implementare*, Bucureşti, Editura Economică
9. **HARMON, JOHN E.**, **ANDERSON, STEVEN J.** (2003) *The Design and Implementation of GIS*, John Wiley & Sons, New Jersey
10. **STOICA, M.** (coord.) (2004) *Capitalul natural-antropic al judeţului Bacău în perspectiva elaborării strategiei de dezvoltare durabilă*, Editura ASE, Bucureşti
11. **STOICA, M.** (coord.). (2005) R*econstrucţia durabilă-concept, model şi metodologie de dezvoltare durabilă la nivel de judeţ*, Editura Universitară, Bucureşti
12. http://inspire.jrc.it/