A WATERSHED DATABASE DEVELOPMENT TO ENABLE APPLICATION AND EVALUATION OF THE ENVIRONMENTAL COMPONENT OF THE RIVER BASIN MANAGEMENT PLAN

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Introduction

The Water Framework Directive 2000/60/EC [1], which aims at maintaining and improving the aquatic environment in the Community, provides a unified competent authority to coordinate all programs of measures, following a management plan for a whole river basin district to achieve established environmental objectives.

Purpose

The present work aims at describing the development of a simple and flexible pilot database including pollution sources and their emissions, loading a river basin and affecting the quality of surface waters, groundwater and ecosystems. The database is connected to the suitable management tools of a Geographical Information System (GIS) for successful dynamic monitoring, control, prediction of the environmental quality and timely decision-making.

Methodology

Case study

The Alfeios River basin in the Peloponnese (Greece) was selected as a case study due to its significance as a natural resource and ecosystem.

Another determining factor for this choice was the fact that, in this particular region, ever-increasing human activity can unfavorably influence the natural environmental conditions. Finally, the big extent of the Alfeios basin and the abundance of different activities allow for the creation of a more abstract model that could be used in similar scenarios. Such a model could also be used for the prediction and coverage of several issues related to any river basin management.

Fig. 2: Alfeios River basin in the Peloponnese

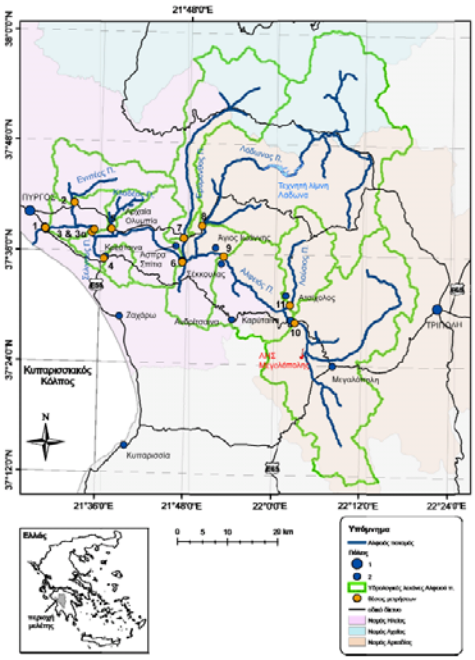

Fig. 1: Alfeios River basin [4]

Alfeios River is the largest river of the Peloponnese both in length (112 km) and flow (annual potential 2100×10 m^3) of water. [2]

It springs from the plateau of Tripolis at the foot of Mount Parnon, is situated at an altitude of 800 m and ends in Kyparissiakos Gulf (Ionian Sea). During its flow, numerous rivers and torrents are merged with it, the most important of which are: Elisson, Lousios, Ladon, Erymanthos and Kladeos [3, 4] (Fig. 1).

The hydrological basin of Alfeios River covers an area of 3.658 km^2, which is extended in the western and

central Peloponnese and is distributed in three Regions, Ilia, Achaia and Arcadia at a percentage of 26%, 17% and 57%, respectively. [2] (Fig. 2)

Data collection

Initially, all the available geographical data of the region was gathered, some of which via the responsible authorities.
Through visiting, calling and internet communication with the responsible Services of three Regions and other related Services and Institutions, I managed to collect all the necessary information such as ownership details, location, productive activity, waste treatment and disposal of the activities / pollution sources.
As a result, 11 types of pollution sources were located in the region, as shown below [4, 5]. (Table 1)

Table 1: Pollution sources in Alfeios River basin

Type of pollution source	Activity / Pollution source
Point	Dairy industries
	Slaughterhouses
	Olive oil mills
	Hog houses
	Poultry farming
	Waste water management plants
	Public Energy Corporation (Thermal and hydroelectric power plants)
Non-point	Livestock farms
	Absorbent tanks
	Fertilizers
	Land uses

Then, the spatial positioning of all potential pollution sources was carried out using Google Earth and the feedback of each activity manager.
The production, waste, waste load and waste management factors were found in the related literature.

Design and creation of the database

The next step was the design and creation of the database, in which all interesting information can be stored.
After extensive research into the possible alternatives, Microsoft Access 2007 was chosen, as it combines:

- User friendliness
- Ability to work with many other databases
- Supported by ArcGIS

At the initial planning of the database layout, the first step was to make clear what this database would be used for and design it accordingly.
Thus, it was created for the purpose of registering organisations and storing all environmental data of river basins. In this way, via its connection to compatible databases of authorised Services and the GIS, it would create a complete data processing and management system, allowing for the sustainable management of the region.
The next step was to determine the users and the way that each of them will use the application.
It was considered that the individuals using the database will be employees of the appropriate authorities, and potentially the employees of all the other authorised Services. The latter will be able to connect to the database via the internet.
The entities/elements of the database were determined afterwards, as it appears below:
Elements of the:

- Regions

- Municipalities
- Municipal districts
- Pollution sources
- Productive activities
- Waste production
- Waste treatment and disposal

The next step was to determine data update interval. Monthly updates were considered to be the optimal choice, as it allows for easier monitoring of both the modifications in the region and the data of the responsible Services.
The last step of the database design was the determination of the registered entities relationships.
At the build phase of the database, the tables in which the data will be stored were created. The nature of the data to be stored required the creation of 9 tables, each one of which includes the fields of each type of entity, as it appears in the next table (Table 2).

Table 2: Database's tables

Table	**Description**
Regions	It includes the Regions which are found in the geographical area under investigation.
Municipalities	It includes the Municipalities which are found in the study area and the corresponding data.
Municipal districts	It includes the Municipal districts which are found in the study area and the corresponding data.
Pollution source type	It includes the pollution source types which are found in the study area and the corresponding data.
Raw materials	It includes raw materials of each activity that is located in the study area. The design of the current table allows the registration of more than one raw material for each activity, and their easy modification.
Products	It includes the products that are produced by each raw material and the production, waste and waste load factors. The records of the table refer to specific month of the year. The design of the table allows the registration of more than one product for each raw material and their easy modification.
Pollution sources	It includes the specific pollution sources / plants that are located in the study area. The content of this table is related to the ownership, the exact place, the type and the operation of the pollution sources.
Waste treatment	It includes the treatment system that each plant uses and its data, as well as the waste disposal data. The design of this table allows the change of the characteristics of the applied treatment system, which serves in cases of system upgrade, problematic operation etc.
Production of pollution sources	It includes raw material, production, waste and waste loads data. The records of the table refer to specific pollution source, month and year.

Finally, the actual collected data were added in the database.

Creation of the user interface

The creation of an easy and clear interactive environment followed.
The application includes a number of forms, via which data insertion, retrieval, export, display and processing can be performed.
The objective was to creation a user interface that even someone with little or no previous experience would find easy to use.

Firstly, the potential user types of the application were created, giving each the appropriate allowances and access rights. Therefore, it was decided that there will be two types of users:

- The **administrator** of the system, who will be one of the employees of the designated authority and will have full rights over the database. This means that he will be able to intervene in all the tables, importing new data, updating or even deleting the existing ones. He will also be able to alter the database structure, create users or/and add them in user groups and give or remove rights from the existing users.
- All the other **users**, consisting of employee of all the responsible authorities, Services and Institutions for the activities that are included in the database, and will participate in the database update procedures.

In order to enforce the above access policy, the users will be required to enter a username and a password before being allowed to enter the application.

The final step of this procedure was the creation of the code of the user interface's forms, as well as the code of all the necessary operations between the tables and the tables' fields. This was performed with a combination of the programming languages Php, Html, JavaScript and SQL.

In the next figures the first form of the administrator's (Fig. 3) and simple user's environment (Fig. 4) is presented. As it is observed, the simple user's capabilities are distinctly limited.

Connection of the database to the G.I.S.

The last step was the connection of the database to the GIS. Thus, a Personal Geodatabase was created, in which the tables of the database and all the available geographical data of the region were imported. The layers of the application were created next. (Fig. 5)

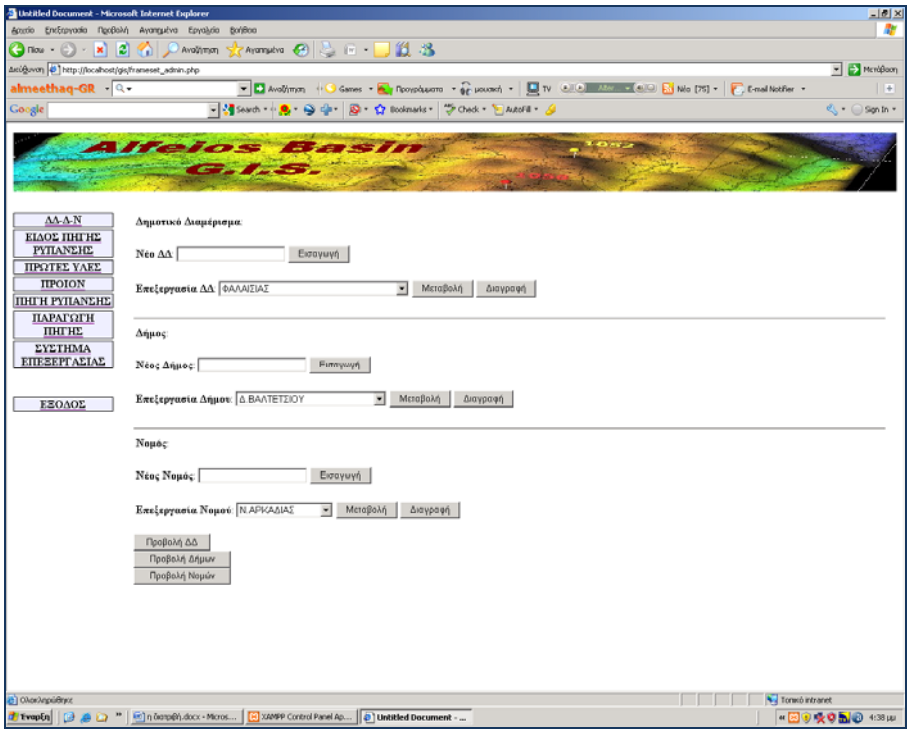

Fig. 3: The first form of the administrator's environment

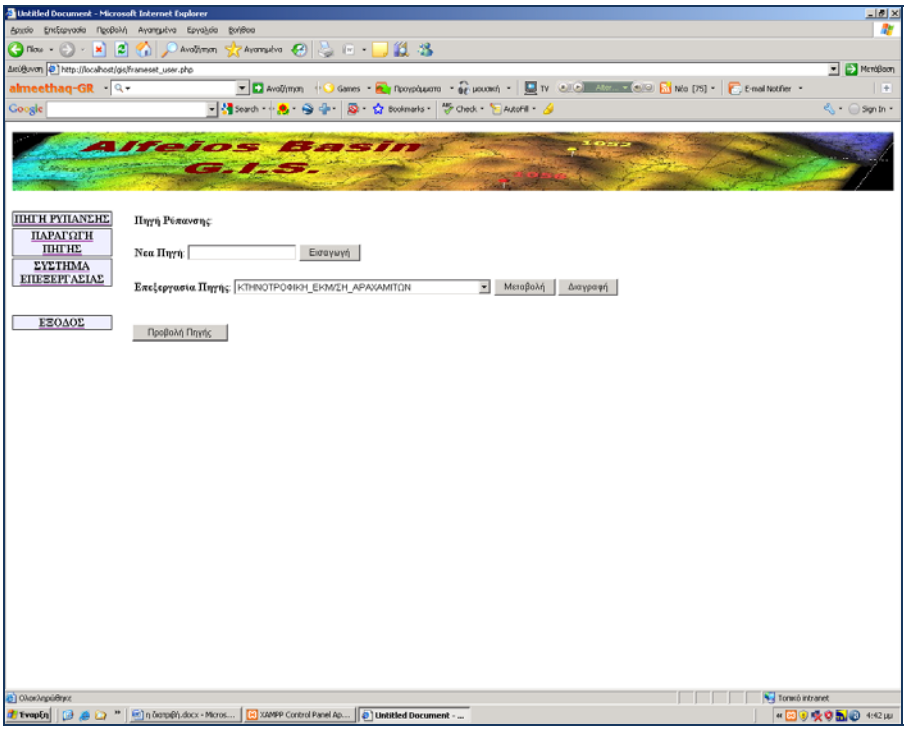

Fig. 4: The first form of the simple user's environment

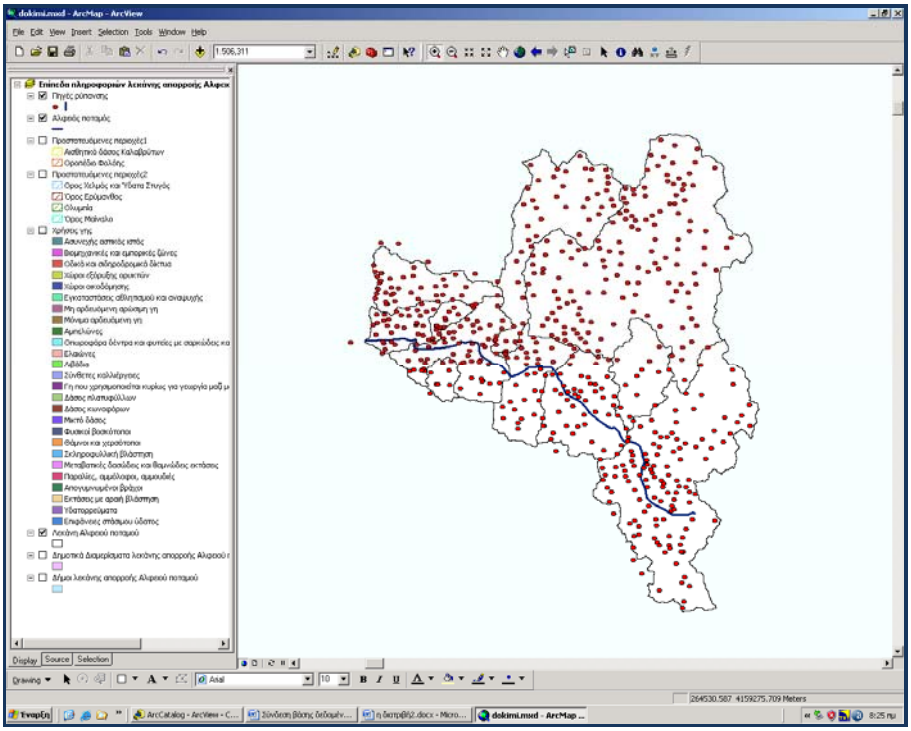

Fig. 5: The application's layers

Then, all the necessary procedures were carried out in ArcMap and ArcCatalog, so that the review of individual characteristics of the region's activities would be made possible, either in the pattern of analytic data (Fig. 6), or with the form of a column diagram (Fig. 7)

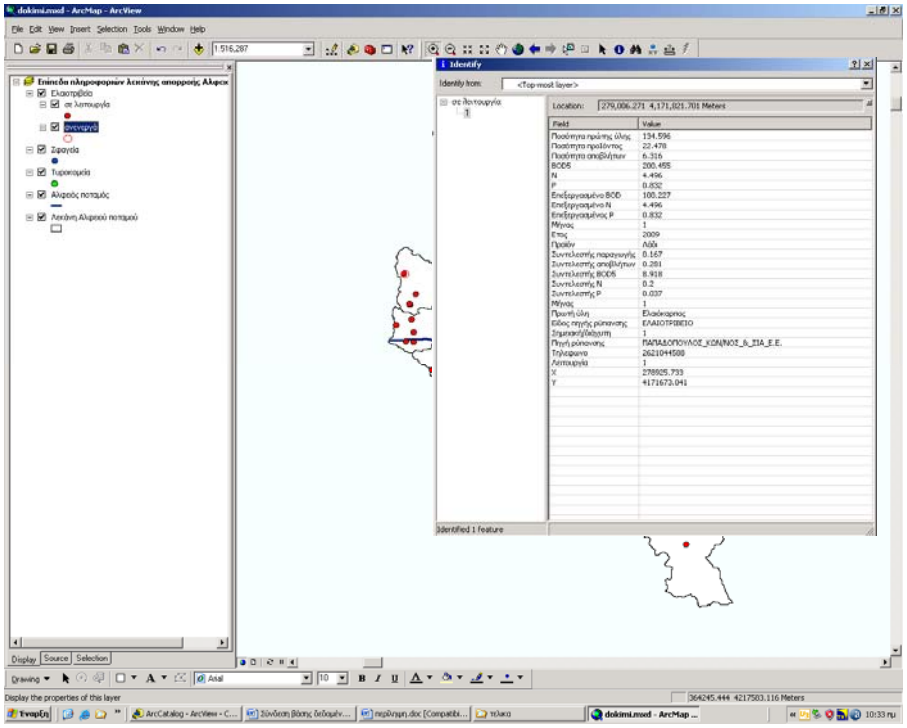

Fig. 6: Review of the activities' characteristics in the pattern of analytic data

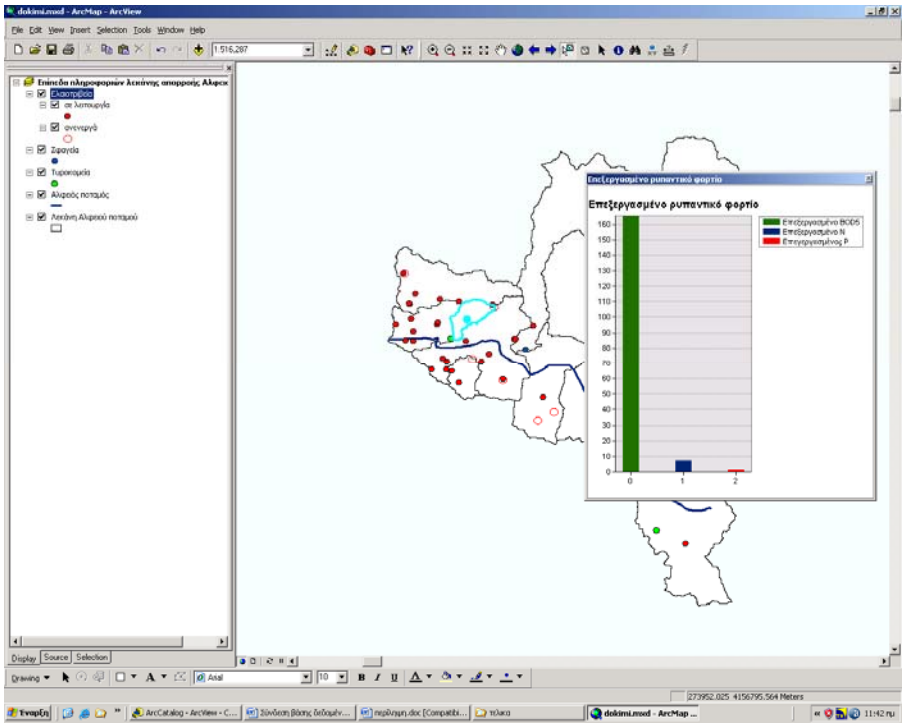

Fig. 7: Review of the activities' characteristics with the form of a column diagram

Conclusions

A modern and effective tool was created, which allows the longitudinal monitoring, protection and management of the water quality of any river basin in complete adherence to the Directive 2000/60/EC.

An important aspect of this effort is the fact that the application's design and creation was done from scratch, based solely on the collected data, without reference to an existing

model. This process clearly revealed all the development particularities, problems and needs of a project like this.
It is important to note that, the collected data were the exclusive planning guide of the tool, while the whole application was generalised and was not limited to this specific case study.

The potentials that derive from the design and creation of the application can be summarised in the following:

- Application's data were defined in a way that can be easily adapted in the Services' specific data. Thereby, database updating will be a simple process, avoiding unnecessary and time-consuming procedures, or involvement of many different Institutions-sources, which could encumber the whole process. In other words, the database structure determines the import of real and available data.
- The data update interval was determined based on the equivalent of Services, in order to avoid discontinuities and / or inconsistencies.
- The database structure and, thus, the communication environment were designed in such a way as to allow an on-line contact with the corresponding databases of Services. This aims to minimize the required time for data collection.
- The user allocation and access rights and possibilities, is defined, thus data integrity is ensured.
- The cartographic display of the results in the environment of the ArcGIS is possible and so is the resolution of specific problems. This analysis can help in appropriate buffer zones being set up. Furthermore procedures as the selection or the exclusion of regions for the installation of new activities are facilitated and simplified. The management of activities in the region can, also, be facilitated, with the reorganization of the licensing system for the installation and operation of productive activities, in order to make effective use of the estimates of the legal framework for the environmental protection.
- An opportunity for monitoring the licensing and operational facilities is feasible, as, even activities that are not in operation can be registered and displayed.
- With this project the monitoring of the areas in a pollution emergency state is easier to monitor, helping in "pointing out" the most appropriate river locations that can be used for the measurements of quality parameters or even establishing the surface water monitoring network, if necessary.
- The data can be displayed on the Internet. This ensures constant monitoring of all activities that take place in a river basin and the active participation of the public. This way the reliability of daily operations of services will be upgraded, through the establishment of transparent processes and systematic briefing of the citizens. In addition, processes of installation and operational authorization of new facilities are simplified, since it will be possible to know beforehand whether the facility can be licensed or not. Thus, unnecessary and time-consuming bureaucratic processes can be minimized. Also, members of the public will be able to verify the legality of the operations taking place in their region.
- The most important advantage of this all is the creation of a functional and flexible tool that can be immediately applied in any other Mediterranean watershed. The extension capability of the application is ensured by its design mode, since, among others, it provides the functionality for the addition of new pollution source types, new and multiple raw materials per activity, new and multiple products per raw material of activity. Also, the direct monitoring and update of all factors that enter into the database has been made possible. Thus, different productive behaviours between regions and time periods, problematic behaviours in the facilities and the Waste water management plants operation can be handled effectively.

Finally, the implementation of this pilot tool, along with the Alfeios basin data registration and processing, confirmed the project effectiveness and functionality.

References

[1] Water Framework Directive. (2000), Directive 2000/60/EC, establishing a framework for Community action in the field of water policy. *Official Journal of the European Communities* L327, 22.12.2000:1-72.

[2] Manariotis I.D. and Yannopoulos P.C. (2006), "Integrated Management Plan for the Alfeios River Basin", 2nd International Conference AQUA 2006 – Water Science and Technology – Integrated Management of Water Resources, Athens, Hellas, November 23-26.

[3] http://www.minagric.gr/Greek/2.9.3.ALFEIOS.html

[4] Γιαννόπουλος Π. (2008), "Ανάπτυξη Μεθοδολογιών Χαμηλού Κόστους για Ταχεία Πρόβλεψη και Παρακολούθηση Ρύπανσης Ποταμών", Τελική Έκθεση Πυθαγόρας ΙΙ, Τμήμα Πολιτικών Μηχανικών, Πανεπιστήμιο Πατρών, Πάτρα.

[5] Manariotis, I.D. and Yannopoulos, P.C. (2004), "Adverse Effects on Alfeios River Basin and an Integrated Management Framework Based on Sustainability", *Environmental Management 34(2)*, 261-269.