Remote sensing and GIS for water district management: The Caia network case study

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ABSTRACT: The development of irrigation technologies related with the different areas covered by irrigated crops in Portugal as well as in the Southern countries of the EU taking into account the relative importance of Agriculture, in what concerns the integration, Water Framework directive and the Eco-compatibility principles requires the capability for the management of big amount of spatial data, a detailed knowledge of their structure and links, the improvement and development of GIS skills at Local, Regional or National scale, integrating remote sensing data on different systems, allowing a better water use, allowing a better knowledge of spatial and temporal distribution of land Use, Soil Types, Crop Water requirements, water distribution network and a more rational management of the available water resource. The application of the GIS to the areas covered by the different Water Districts Management Boards, spread all over the country, gives the possibility for a better use of water for agriculture, on the frame of programs like the EU INTERREG II C Program.

1 INTRODUCTION

As in the Southern European Countries, rainfall distribution is not homogeneous, and does not follow vegetation growing cycles. Irrigation is strongly dependent on water and soil (L.S. Pereira 1986), with a very strong demand for an eco-compatibility use of these resources, assuming a sustainable water use by the maintenance and control of their quantity and quality.

Considering that Agriculture is the main water user/consumer there is a strong need for a deep knowledge on crop water requirements, along cropping calendar in accordance with the irrigation distribution schedule, based on different land cover data availability and water availability and quality for irrigation.(A. Perdigão 2001).

Assuming that the Water Frame Directive takes in account different types of water users, theirs priorities and the main guide lines policy for the use of this natural resource and the fact that different related sectors, supply a big amount of spatial data with geographical representation as well as spatial attributes. The detailed knowledge of their structure and related interconnection must be assumed as a key tool, for development and set-up of the GIS at different scales (Rocha, 1996).

GIS software systems offer actually different technical skills in what concerns data development, updating and maintenance, integrating Remote Sensing and different sources of data acquisition, on the frame of what the Project for the setting-up of the Geographical Information System for Management and Conservation of the Caia Irrigation District has (SIGHAC).

The need for the promotion of a better water use for irrigation, leads the Caia Water Board District to combine strategies to set up a Geographical Information System (SIGAHC), on the

frame of the INTERREG IIC Program, aiming at an improvement of data availability for better support in water management at District level. This work integrates the different strategies defined on the frame of the National Water Institute (INAG) and of the National Irrigation Sustainable Plan.

2 MAIN AIMS OF THE SIGAHC

The development of new farming technologies and the implementation of methods for evaluation of water delivering for each crop, as well the increasing of the available area for irrigation result of the height demand of high productivity crops for supplying the international markets. As it happens in the European Union, the Portuguese Agriculture is depending of the Common Agriculture Police and the live stocks market necessities, reason why the Portuguese irrigation areas increased and new crops have been implemented.

Taking in account that different sectors related with farming, supply a big amount of spatial data, the detailed knowledge of their structure and their related inter-connection, must be assumed as of great importance, for the setting-up of Geographical Information Systems at local, regional or national level, on the way to allow an integrated set-up, management and follow-up of the different users.

In what concerns water for irrigation purposes, water represents a very important role taking into account the availability of surface and ground-water water resources, requiring a better management a and/of ? control procedures, for this resource.

On the frame of the INTERREG IIC Program (Land Use planning and Drought Fight)-measure 2-Reinforcement and optimization of water use for Agriculture, the Project for the setting-up of the Geographical Information System for Management and Conservation of the Caia Irrigation District (SIGHAC) has been developed, integrating the ideas and strategies defined on the frame of the Water National Institute (INAG) and of the National Irrigation Sustainable Plan.

The main goals of the SIGAHC are the analysis, storage, setting-up, management of the Geographical Information and raw databases, integrating data concerning land owners, farmers, crops, land use, irrigation skill, farming technology and useful information for the Water District Management (P. Oliveira 2000), to support their decisions based on real time consumption data, allowing a better knowledge of the crop spatial distribution inside the District, soil types and water consumption associated with the related crops (Fig. 1).

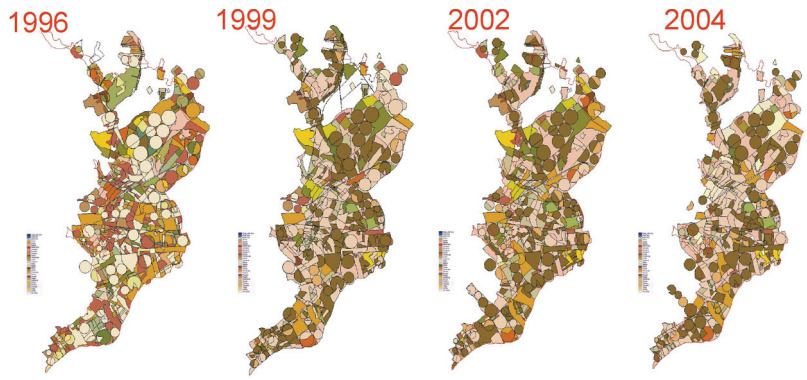

Figure 1. GIS AHCaia output / land use temporal evolution.

This tool allows the Caia Water Board Management District to use a tool for decision support, allowing a better knowledge of the crop spatial distribution inside the District, as in what concerns soil types and water consumption associated to the related crops. This tool has been developed on the basis of a dynamic model, allowing the analysis of questions related with Land use and water consumption for agriculture, on the way that a better knowledge of the agricultural reality, can lead to a much better management of the available water resources.

3 BASIC DATA

The SIGHAC has been developed using a dynamic model, allowing the analysis of Land use and water management for agriculture relationships aiming at a better management of available water resources, following a step by step strategy, related with the spatial resolution of the processing systems.

The system has been structured, using chosen software, allowing a more friendly use, reducing redundant operations and adapted to the skill of the users. The setting-up of the SIGAHC, covered the evaluation of all the cartographic historical documentation available for the Water District Board and further analysis of the related data whose digital conversion was required (A. Perdigão 2001).

Some of the tasks concerning GIS setting-up and improvement could not previously be forecasted, that is the case of ground truth operations and the ones related with the availability and quality of information, some of them using Remote Sensing and other cartographic source data. Their use proved to be very useful to identify land use units for each year's irrigation season campaign.

The set-up of the Geographical Information System was the result of evaluation and integration of the different layers of available topological vector data, image raster databases and the linkage to external attributes databases (P. Oliveira 2000).

The database is a relational model, developed with data available on the Irrigation district, integrated on the SIGAHC, shown on Fig. 2. This model type improves the storage capacity efficiency, and simplifies the method concerning the relation of external databases and the ESRI GIS software (ESRI 1997) adopted as working platform.

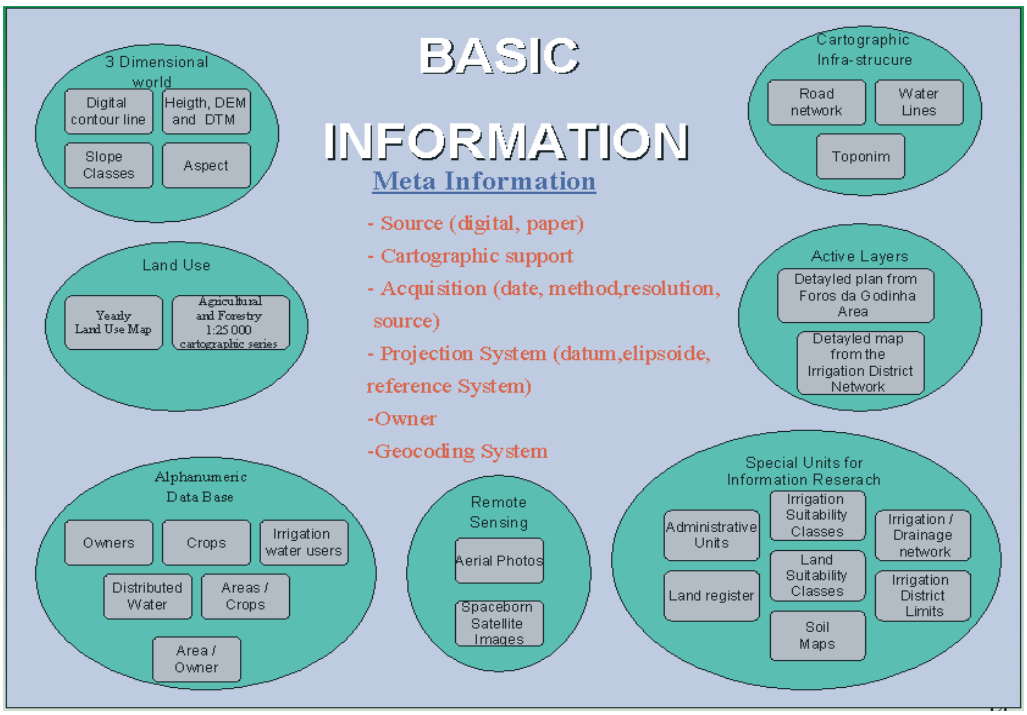

Figure 2. Data structure and basic Information.

4 SIGAHC AND DEVELOPMENTS

The SIGAHC information obtained was structured in different layers covering the following themes organised and structured in maps (P. Oliveira 2000):

1. Cadastral Map Infra-structured
2. Irrigation Network
3. Drainage Network (identifying canals and drainage nodes)
4. Road and Railway network
5. Rehabilitation infra-structure blocs
6. Environmental protection for wildlife (ZPE-Ecological Protection Area)
7. Urban and excluded areas
8. Suitability for Irrigation map
9. Land Use map

Using topological procedures of the different ZPE layers, Land Use, Soil and Capability maps, an improvement has been obtained in what regards the identification and characterisation of the areas belonging to Caia Irrigation District that can be affected by the application of regulations related with the ZPE and other ecological and environmental limitations. These kinds of restrictions are a good example of the spatial analysis of the different source of available and related data, essential to the Water Board District.

The different modules of SIGAHC were developed, aiming to provide management data to the Water District Board. Figure 3 illustrates the flux gram of the different module structure and relations between them.

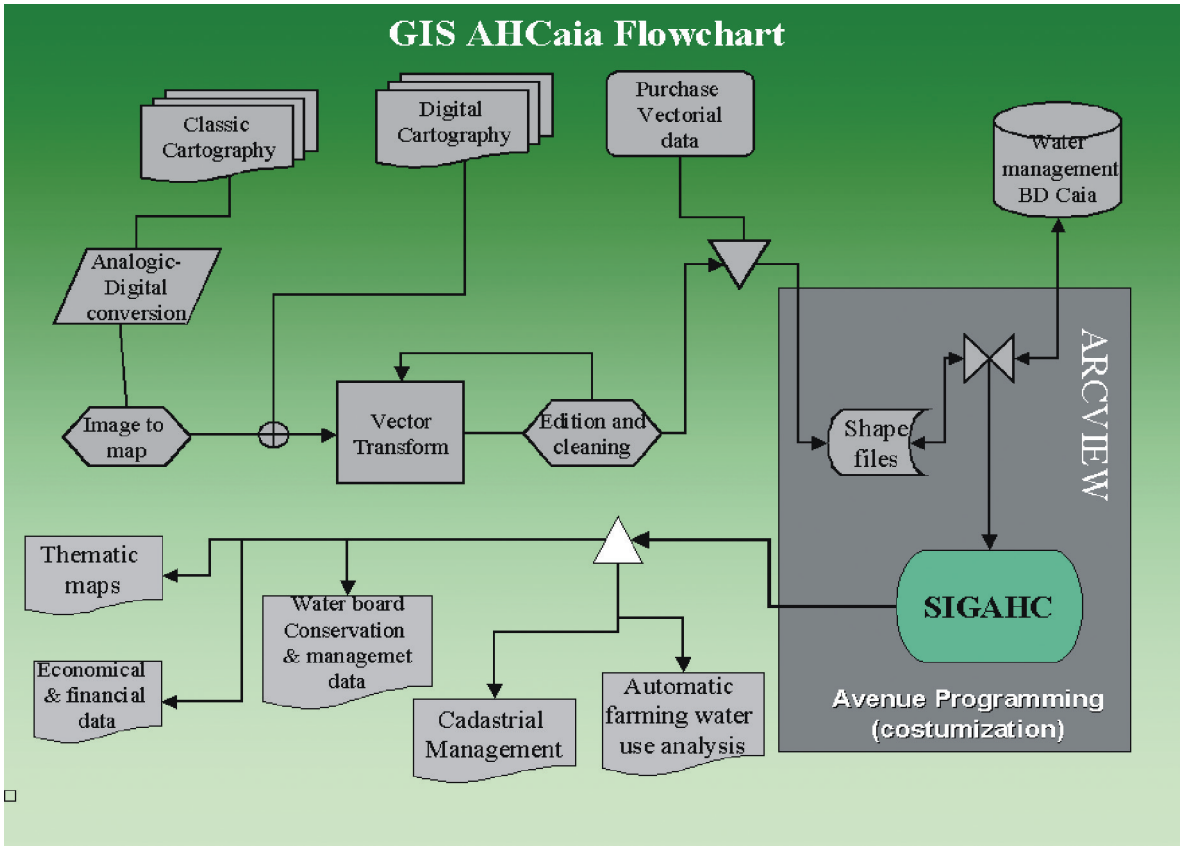

Figure 3. SIGAHC flux gram of different module.

Remote Sensing data has been adopted as basic information to update and identify irrigation plots and crop development monitoring. A good examples of the different data covered and the global project extension is shown in Fig. 4, where the integration of raw data represented by a land use map and the one obtained from space born earth observation satellites – Remote Sensing – (Landsat

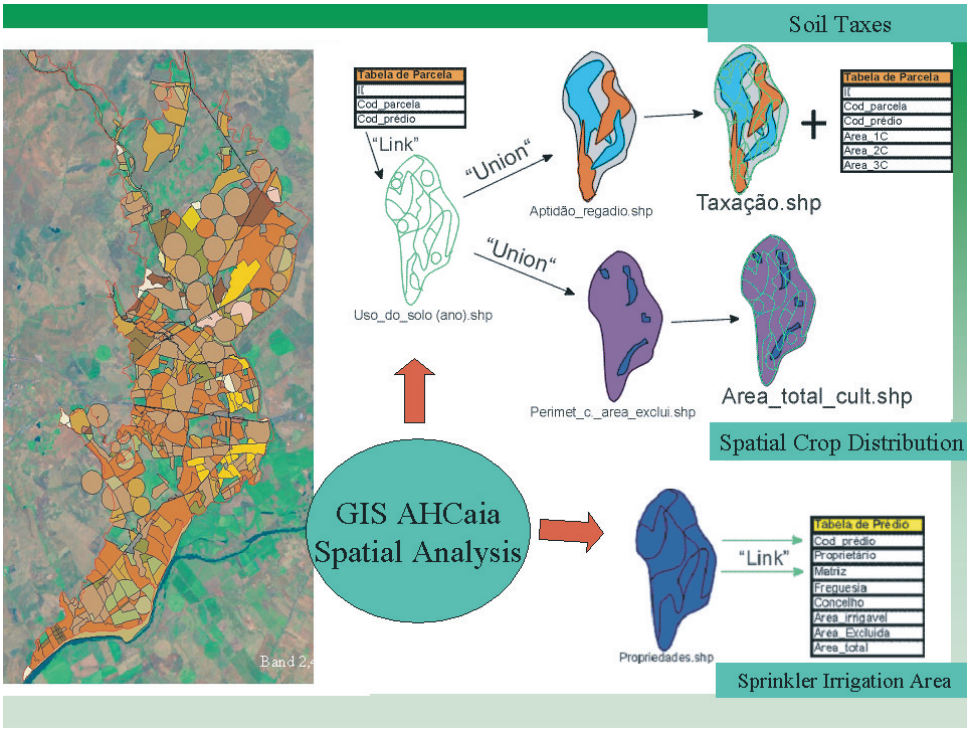

Figure 4. Land use map and irrigated crops validation.

TM data), supports the decision makers with information concerning farmers not belonging in legal way to the irrigation district.

The economical cost of this information is very high for the Water Board District, reason why the use of this technology did not have a great diffusion and answer as it was expected near this type of small Portuguese institutions.

Several studies concerning the crop evolution inside the Irrigation district were carried during several years on the study area, allowing a better knowledge of farmer's land use evolution trend and a better water management at farming level and whenever possible at irrigated plot level.

5 CONCLUSIONS AND FUTURE TRENDS

The development of a GIS for the Caia Irrigation Network, allowed the different users and decision makers at different levels of decision, (national, regional and local), to clarify and obtain updated and precise information, concerning the Spatial Information related with the area increasing the capability for their management. The setting-up of the system required the updating of different data under analysis, namely the one related with land and water use, Cadastral maps and databases, with the related definition of the different required entities for the purpose of their management.

Not only for this Irrigation District, but assuming an extrapolation of data for other districts, remote sensing data can be assumed as a very valuable and trustable source for crop growing evolution monitoring, and to identify and investigate farmers not belonging to the formal irrigation area defined by the Irrigation district. Moreover, it also allows the evaluation of the irrigated areas inside and outside the administrative limit of the Irrigation District.

The evaluation and setting up of systems for water use indicators inside the Irrigation District are still under development, allowing this one and other Water District Boards with tools for water use efficiency evaluation inside the District.

Future developments will be implemented on the basis of the integration of the Automatic Management system (Fig. 5).

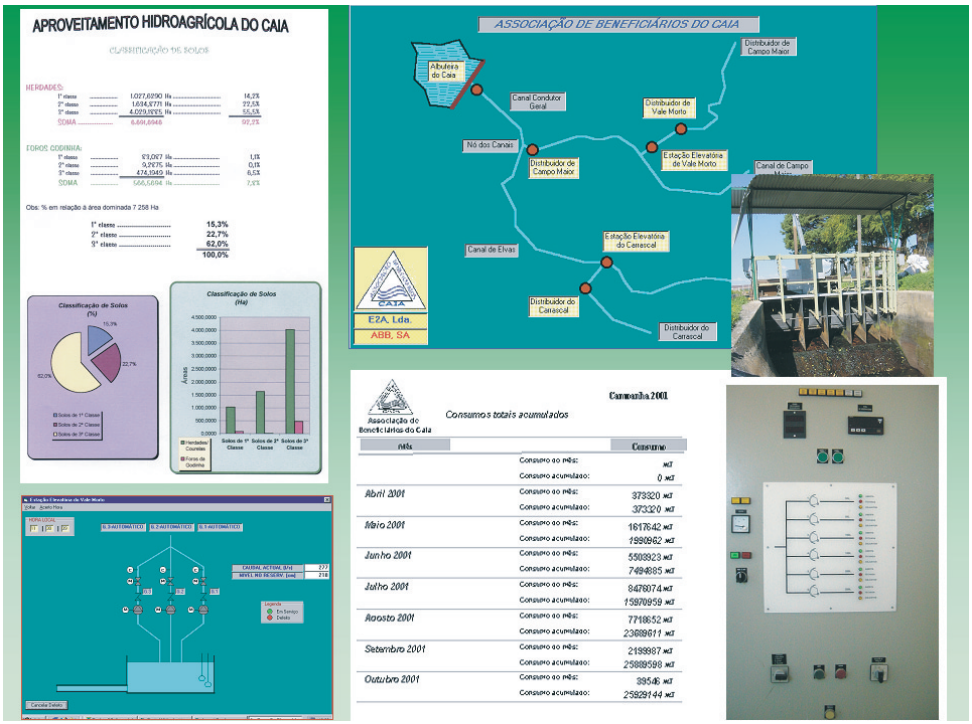

Figure 5. GIS AHCaia outputs and integration with telemetric control system.

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