A Systems-Based Generic Suite of Tools to Support Knowledge Sharing and Scenario Planning

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Abstract

The Combined Water Information System is a Web information and knowledge sharing platform that is meant to support the activities of collaborative groups, such as Learning Alliances, involved in a planning process.
The backbone of CWIS is its system-based database. The system elements, their related information and their interactions, can be viewed and navigated on a text/image web-like basis (dynamic reporting tool hosting data and reports), on a spatial basis (GIS viewer) and according to the systems logics (system viewer).
Among others these tools provide support for scenario-planning by hosting the data related to a base case as well as to alternative options, eventually linking to simulation models and handling simulation results, in order to provide a basis for decision making.
The potential of CWIS is illustrated through a case-study in Alexandria.

Keywords: data model, database, environmental data, data integration, integrated resources management, systems approach, systems thinking

1 Introduction

While working in multidisciplinary contexts, systems approaches are of great interest to deal with complexity and to bring the various fields of science together (Midgley, 1992; Mulej et al., 2004). This is particularly true in the frame of Integrated Urban Water Management (IUWM), where modeling[1] of the ecological system as well as the social, technical, political and economic systems are key issues towards sustainable planning (Bellamy et al., 2001; Rammel et al., 2007). In that sense, IUWM requires tools that cope with interdisciplinarity, multiple scales (e.g. spatial, temporal or organizational) and knowledge from various

[1] The term 'modeling' refers to the descriptive representation of objects or phenomena, and therefore differs from the term 'mathematical modeling' which implies the use of mathematical equations to simulate the response of the system being modeled.

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sources. CWIS aims to address these issues by providing a generic database whose design is based on a "systemic structure" and the use of ontologies to ensure the semantic integration of the data.

2. The system-based organization of the data

2.1 Table vs. object-oriented data design

In relational databases, the classical approach is to consider one table per type of object, the columns of the table being dedicated to store the attributes of the objects. While developing an information system (IS) to be used in the field of IUWM by non IT specialist, this approach has two main drawbacks: (1) It requires special skills to work with the database management system (DBMS). (2) The adaptability of the system is low, as any change in the types of objects and their attributes may have significant repercussion on the structure of the database, as well as on the software design of the IS.

In order to address these issues, an innovative data model (Schenk, 2010) has been developed, which gets rid of the profusion of tables by providing a fixed and generic data structure that handles (almost) any kind of objects and information.

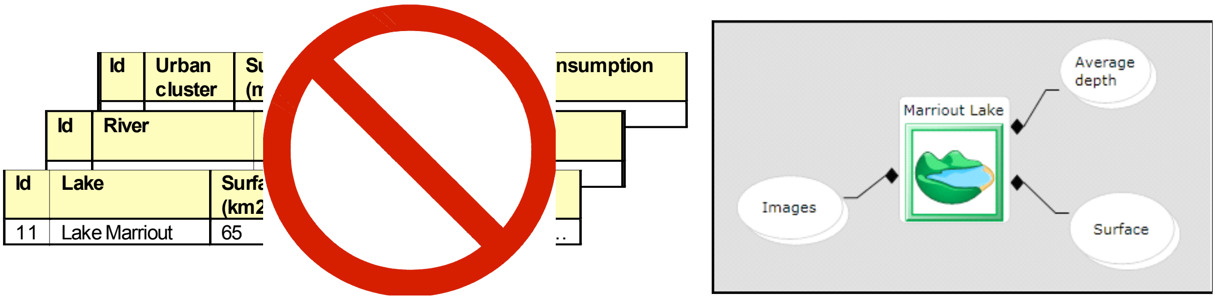

Figure 1 Characteristics of the objects defined through properties

As shown in Figure 1 with the example of a lake having three attributes (surface, average depth and images), the characteristics of an object are defined through properties, which can be attached "on demand" to the object. Adding new properties do not involve any modification of the database structure; it only requires adding a new element "property" in the schematic view provided by the CWIS interface.

2.2 System-based data structure

The objects represented in CWIS are considered as systems. It means that each object can be characterized by some "inputs" and "outputs" that define the interaction of the object with its environment and some "parts" which describe the subsystems of the object, as illustrated in

Figure 2.

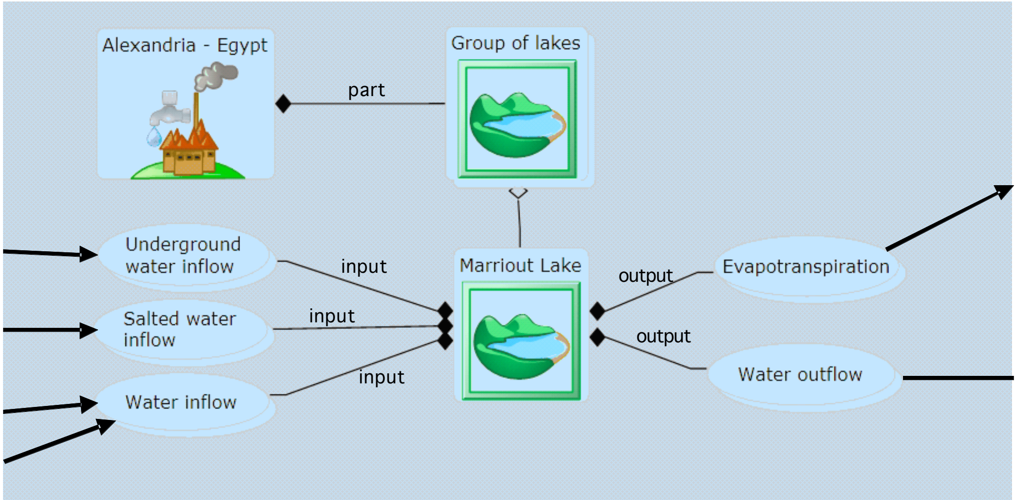

Figure 2 Adoption of a systems perspective through the classification of the properties as system parts, inputs or outputs

2.3 Classes and ontologies

The database structure enables the definition of some classes. A class is a template for objects (or information) sharing one or more identical properties. One can consider the class as a blueprint for the creation of instances, i.e. some objects (or information items) that belong to the class (Figure 3).

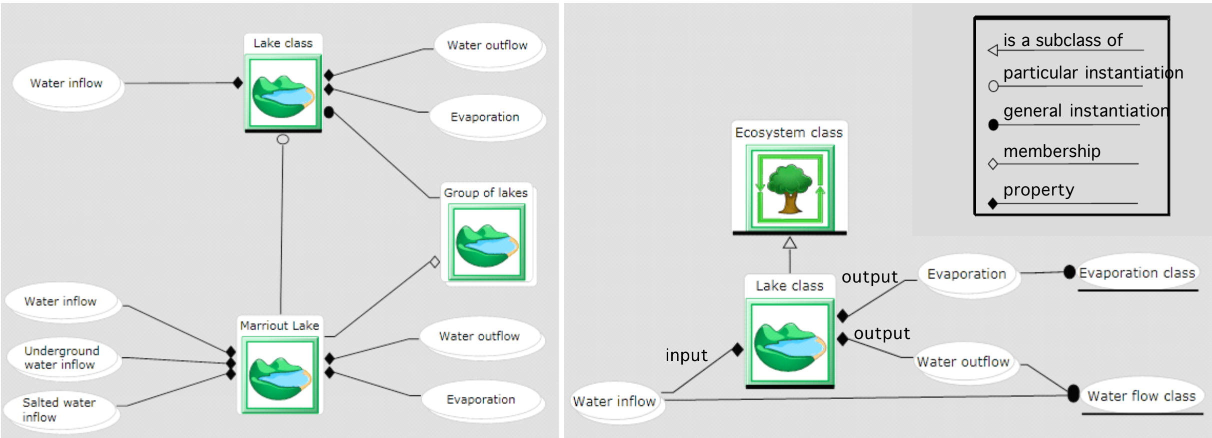

Figure 3 Derivation of classes to create properties and instances of object and information

Together all the classes defined in the CWIS form what is called an ontology, i.e. a formalization of the elements that characterize a knowledge domain. An ontology allows sharing unambiguous meaning about the concept used in models. This is particularly important in the context of IUWM, where models may be the results of participative processes that involve many stakeholders with a variety of knowledge background.

3. CWIS

CWIS consists in a modular software application (using Microsoft Silverlight application framework[2]) associated to the system-based database (implemented with Microsoft SQL server 2008[3]). Each module of the software provides a different way to represent data, for instance through system diagrams, geographic views or reports. The interface of the software is shown in Figure 4.

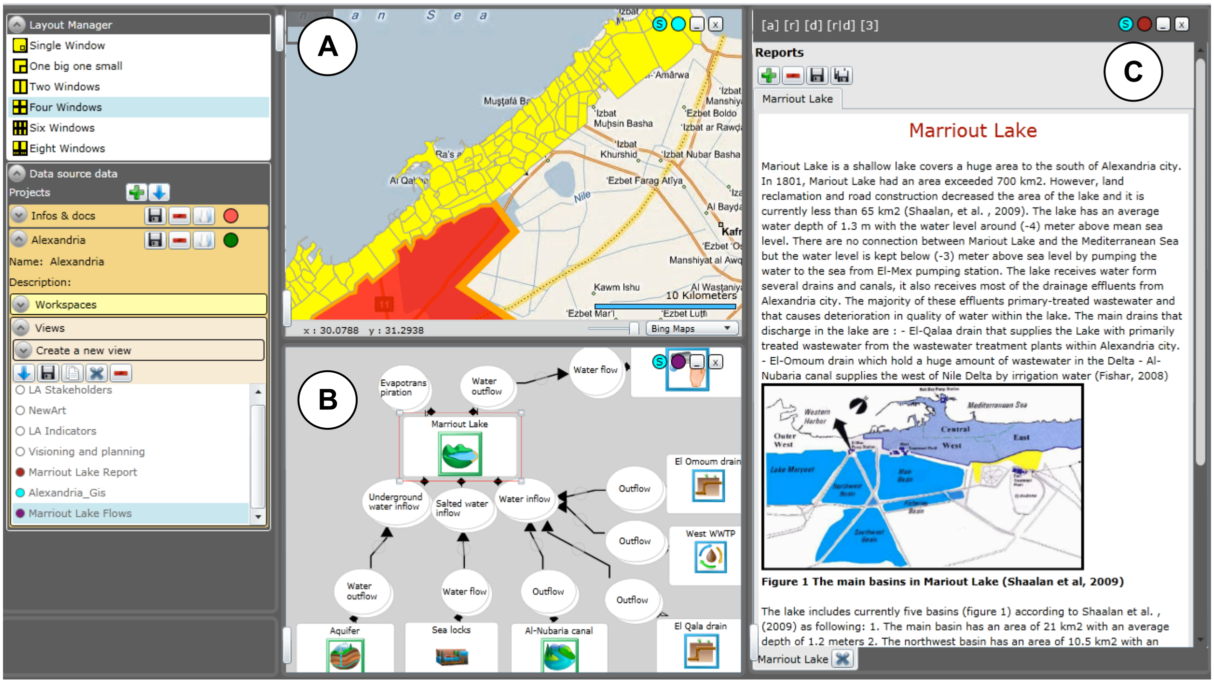

Figure 4 The main modules of CWIS: (A) geo viewer, (B) system viewer and (C) reporting tool

The three main modules of the application are:

(A) Geographic module

The geographic module allows visualizing and managing the spatial properties of system elements, i.e. their geographic locations and spatial shape. The module can display multiple layers of objects and edit their appearances, including their color, transparency or line thickness. It also enables the creation of thematic maps, where the appearance of the spatial elements corresponds with some indicator values.

(B) System module

The system module enables the management of ontologies and the modeling of systems, according to the system-based design of the database. The “systemic view” allows editing objects and their properties (such as parts, inputs or outputs) and their interactions (flows or influences). Beyond the representation of systems, the module enables the creation of thematic views such as problem trees, views of flows, causal loops diagrams, etc.

[2] Microsoft Silverlight: http://www.silverlight.net/, Retrieved 28 December 2010
[3] Microsoft SQL Server 2008: http://www.microsoft.com/sqlserver/2008, Retrieved 29 December 2010

(C) ART (reporting) module

The “Active Reporting Tool” (ART) is a reporting module that enables viewing and editing non-spatial attributes linked to a system element: numeric values, texts, files (images, videos, pdfs, etc.). In addition, it allows creating reports that looks like web pages. Each report can “dynamically” incorporate data from the database to provide up-to-date information, for example by showing the last available value of an attribute, by updating data according to changes in the database, or by filtering the content of the report based on “thematic” (e.g. a scenario) and temporal conditions.

4. Scenario planning

CWIS supports the activities of collaborative groups, such as Learning Alliances, by providing a Web sharing platform to host, share and disseminate information. In the framework of scenario planning for urban water management, the data used and produced at each step of the process can be uploaded and edited in the different modules of the application (Figure 5).

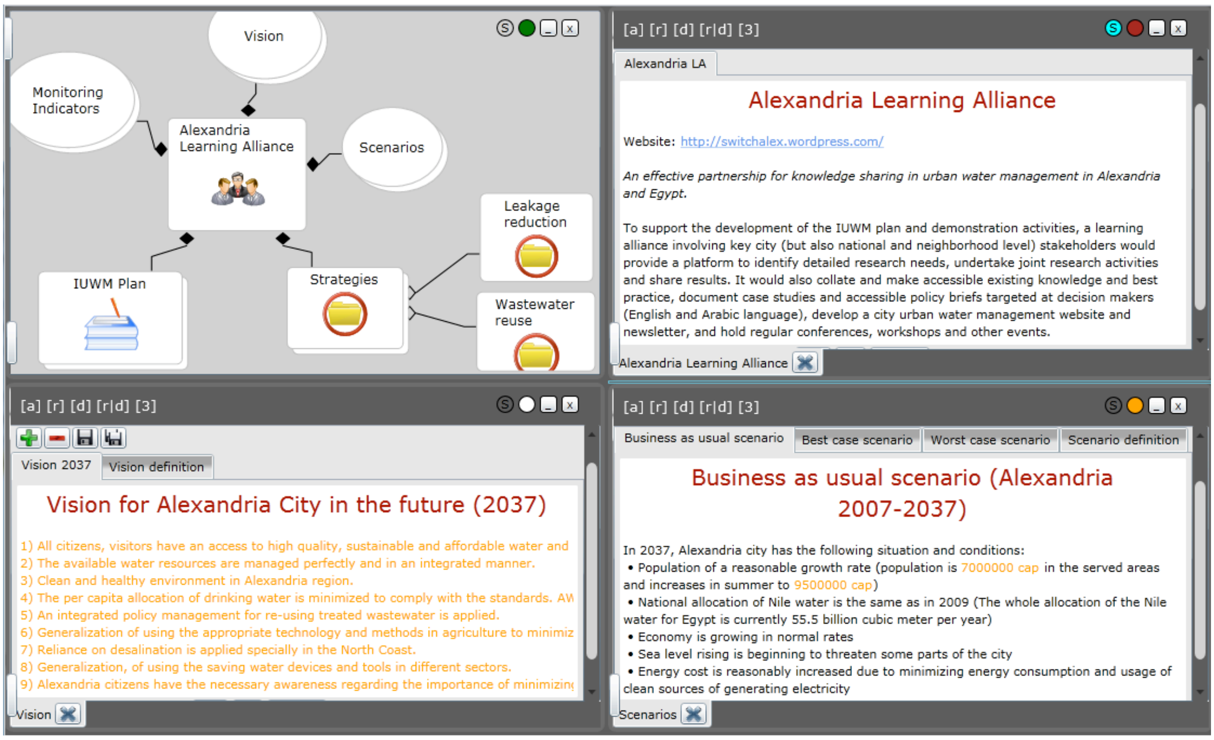

Figure 5 Using CWIS to share information about scenario planning

The vision of the water management in the future can be described with the help of reports and translated into some “target” indicators that can be monitored through the application. Several scenarios can be edited to apprehend the evolution of uncontrollable factors such as the demographic growth or the effects of climatic changes. Then, some response strategies can be designed and tested against the scenarios, possibly using some simulation models coupled with the application.

Finally, the decision makers can make use of the information and simulation results available in the views of CWIS to create a coherent plan of actions for the sustainable management of the water resources.

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