ΕΡΕΥΝΗΤΙΚΑ ΑΠΟΤΕΛΕΣΜΑΤΑ ΓΙΑ ΠΕΡΙΟΧΕΣ ΠΕΡΙΟΡΙΣΜΕΝΗΣ ΕΚΤΑΣΗΣ: ΕΝΑΣ ΠΛΟΥΤΟΣ ΓΕΩΓΡΑΦΙΚΩΝ ΔΕΔΟΜΕΝΩΝ ΣΕ ΜΙΑ ΘΕΜΑΤΙΚΗ ΥΠΟΔΟΜΗ ΓΕΩΓΡΑΦΙΚΩΝ ΠΛΗΡΟΦΟΡΙΩΝ

Βαΐτης Μ.[1], Carrara P.[2], Guimet J.[3], Barea M.[4], Redondo M.[4]

[1]*Πανεπιστήμιο Αιγαίου, Μυτιλήνη, Ελλάδα*
[2]*IREA-CNR, Μιλάνο, Ιταλία*
[3]*ICC, Βαρκελώνη, Ισπανία*
[4]*ICA, Ανδαλουσία, Ισπανία*

Περίληψη

Στα πλαίσια των ερευνητικών δραστηριοτήτων των Πανεπιστημίων και των Ερευνητικών Κέντρων, συχνά συλλέγονται γεωγραφικά δεδομένα που αφορούν περιοχές περιορισμένης χωρικής έκτασης. Λόγω ακριβώς του μικρού εμβαδού των υπό μελέτη περιοχών, τα παραγόμενα δεδομένα καλύπτουν ένα ευρύ φάσμα επιστημονικών πεδίων, είναι μεγάλης ακρίβειας και ως εκ τούτου έχουν υψηλή επιστημονική, τεχνική αλλά και οικονομική αξία. Παρόλη τη σημασία των δεδομένων αυτών για τη δημόσια διοίκηση, τους οργανισμούς και τις επιχειρήσεις ή το ευρύ κοινό, αυτά παραμένουν γνωστά μόνο στα στενά πλαίσια της ερευνητικής κοινότητας που τα παρήγαγε. Το έργο *IDE-Univers* επιχειρεί να αντιμετωπίσει αυτή την κατάσταση μέσω της δημιουργίας μιας *θεματικής υποδομής χωρικών δεδομένων* για τα ερευνητικά ινστιτούτα της Μεσογείου. Η υποδομή αυτή δίνει τη δυνατότητα αναζήτησης, πρόσβασης, απεικόνισης και ανταλλαγής δεδομένων μέσω του Παγκόσμιου Ιστού. Συγχρόνως, το έργο συμβάλλει στην ευρεία διάχυση της φιλοσοφίας και τεχνογνωσίας που διέπει τις χωρικές υποδομές, σύμφωνα και με την πρόσφατη κοινοτική οδηγία INSPIRE. Το άρθρο παρουσιάζει εν συντομία τα τεχνολογικά ζητήματα που αφορούν το έργο IDE-Univers και συνοψίζει την αποκτηθείσα εμπειρία και τις μελλοντικές προοπτικές.

RESEARCH RESULTS FOR SMALL AREAS: A UNIVERSE OF GEO-INFORMATION IN A THEMATIC SDI

Vaitis M.[1], Carrara P.[2], Guimet J.[3], Barea M.[4], Redondo M.[4]

[1]*University of the Aegean, Mytilene, Greece*
[2]*Istituto per il Rilevamento Elettromagnetico dell' Ambiente (IREA-CNR), Milan, Italy*
[3] *Instituto de Cartografía de Catalunya (ICC), Barcelona, Spain*
[4] *Instituto de Cartografía de Andalucía (ICA), Andalusia, Spain*

Abstract

Universities and Research Centers are often in charge of research projects regarding geographic areas of limited extent. Because of their restricted spatial scope, these projects investigate their study area thoroughly, examining many different aspects, thus obtaining precious results having a high economic and technical value. Their results are mainly in digital form: geo-referenced documents or textual, graphic and multimedia documents with a well identified geographic reference. Unfortunately, these investigations and their products are seldom known outside a small academic community, in spite of their importance for a wide users' arena. In order to deal with this situation, the *IDE-Univers* project aims to create an integrated geo-information space about small territories, produced by academic institutions in Mediterranean. In the framework of the project, a thematic SDI is being established, enabling end-users to search, access, visualize and exchange provided data through a geo-portal, using only their familiar web-browser. The project also contributes in

spreading SDI philosophy and know-how, keeping up with the INSPIRE Directive. The paper presents in brief the technical aspects of the project and concludes with lessons learned and opportunities foreseen so far.

Λέξεις κλειδιά: Υποδομές Γεωγραφικών Πληροφοριών, διαδικτυακή χαρτογραφία.

Key words: Spatial Data Infrastructures (SDI), thematic SDI, web mapping.

1. Introduction

Universities and Research Centers are often in charge of research projects regarding geographic areas of limited extent. Because of their restricted spatial scope, these projects investigate their study area thoroughly, examining many different aspects, thus obtaining precious results having a high economic and technical value. Their results are mainly in digital form: geo-referenced documents (such as maps and images), or textual, graphic and multimedia documents with a well identified geographic reference (i.e., reports, theses, books, presentations, etc.). Unfortunately, these investigations and their products are seldom known outside a small academic community, in spite of their importance for a wide users' arena.

The promotion of the significant amount of geo-referenced information generated by University Departments and Research Centers is a fundamental step towards collaboration among researchers and external users, such as public administrations or the private sector.

IDE-Univers (http://www.ideunivers.eu) is a project funded within the Measure 3.4 (Communication and information technologies for land development) of the Programme Interreg IIIB MEDOCC (http://www.interreg-medocc.org), started last September, 2006. The mission of the project is to create a geo-information space on the Internet, aiming at integrating knowledge about small territories, produced by academic institutions in the Mediterranean. It capitalizes on contemporary technological advances in the field of Spatial Data Infrastructures (SDI) (i.e., geographic metadata standards, catalogue and geographic services), in order to support the discovery and exchange of spatial information derived from research activities. More specifically, the objectives of the project are:

- To enroll geographic information for small areas, produced by research institutions of the Mediterranean basin.
- To generate metadata for the geographic information and publish them on the Internet using catalogue services.
- To build a network of interoperable platforms, enabling searching and viewing of published geographic information.
- To promote participation of different institutions to the project, reinforcing collaboration and culture sharing between academic institutions at a European level.

The geographic information may be related to different fields, while the focus is on three main domains: environment, land management and socio-economics. By its ending date (March 2008), 5.000 metadata records and more than 30 newly developed Web Map Servers (WMSs) located at University Departments and Research Centers, distributed at Spain, Italy and Greece, will be available to at about 300 end-users, through a *thematic* SDI. End-users will be able to search, access, visualize and exchange provided data through a geo-portal, using only their familiar web-browser. It is the first example of SDI connecting academic organizations in the involved countries.

The project will also contribute in spreading SDI philosophy and know-how in the

scientific practice of the partners involved, their collaborators and within the academic community in general. Moreover, the project is keeping up with the INSPIRE Directive (INSPIRE, 2007), furnishing not only new and detailed environmental geo-information, but also testing flexibility, robustness and efficiency of standards and solutions in the SDI framework (since geographic data are extremely heterogeneous in many different dimensions, including formats, quality, reference systems, resolution, semantics, etc.).

The paper is organized as follows. Section 2 gives a brief description of the role of SDIs and their hierarchical or thematic organization. Section 3 briefly presents the architecture of the systems and services of the SDI. Sections 4 and 5 present the software applications supporting all the data management activities: metadata generation, and data storing, searching and viewing. Section 6 points out the consortium of the project, while section 7 concludes the paper and presents future work.

2. The role of SDI

The term "Spatial Data Infrastructure" (SDI) is often used to denote the relevant base collection of technologies, policies and institutional arrangements that facilitate the availability of and access to spatial data. The SDI provides a basis for spatial data discovery, evaluation, and application for users and providers within all levels of government, the commercial sector, the non-profit sector, academia and by citizens in general (Nebert, 2004). As geographic information is getting a fundamental component in the decision-making process in many fields (if not all!) of human/social life (e.g., environmental management and protection, security and logistics, social and health development, service improvement), the development and maintenance of SDIs constitutes a funding priority for many countries or unions of countries. For example, the INSPIRE initiative of European Commission (INSPIRE, 2007) is a legislative instrument laying down a general framework for a SDI for the purposes of Community environmental policies, and policies or activities which may have an impact on the environment.

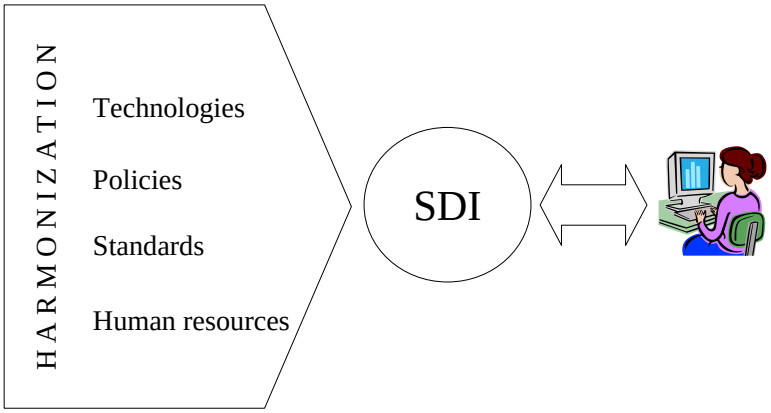

Figure 1. The role of an SDI

The components of an SDI are: (a) an institutional framework; (b) a set of technical standards; (c) a number of fundamental datasets; (d) supporting access networks; and (e) human resources (Rajabifard *et al.*, 2003). As geographical data are usually heterogeneous in terms of projection systems, file formats, storage systems, semantics, access rights or billing procedures, the role of an SDI is to harmonize all these issues and provide a single interface to support users' searching and exploring tasks (figure 1). In this way, both the management of spatial data and their utilization are improved. The data producers/providers

keep working with their preferred procedures for data acquisition and processing, while they have to engage predefined rules for data documentation (metadata) and storing (for sharing). Users have a single point of access, while all the heterogeneity of spatial data is transparent to them.

An SDI is usually based on a three-tier architecture (figure 2). The bottom level constitutes of the various spatial data repositories, distributed on various servers hosted on various organizations. At the middle level a number of catalogs manage the metadata for all the data stored at the repositories, while a number of services support the discovery, searching, processing, and visualization or downloading of data. At the upper level the end-user utilizes the services of the middleware, either using a specific application or the preferable web-browser.

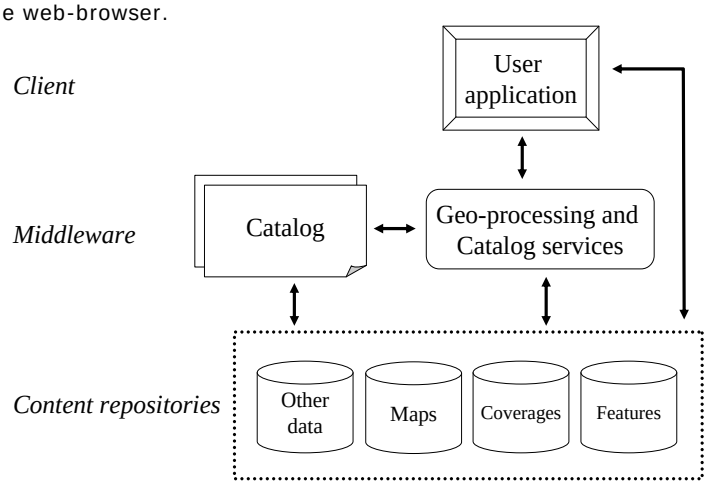

Figure 2. SDI architecture

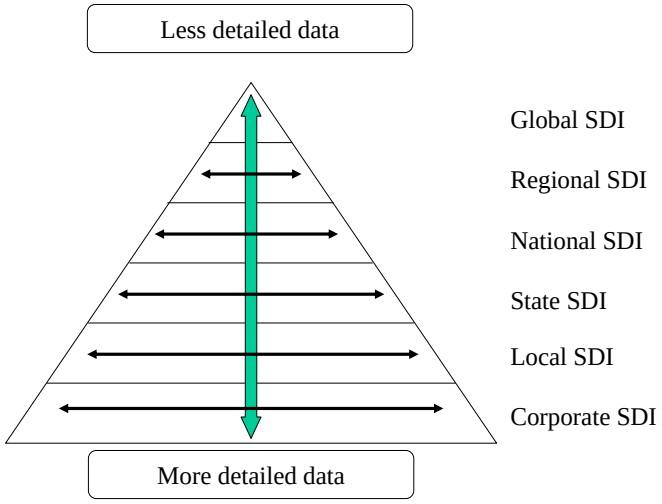

Figure 3.SDI hierarchy and relationships among levels [Based on (Rajabifard et al., 2003)]

Usually, SDIs are organized in a *hierarchy* of levels, from the corporate level up the global – universal – one, where more detailed data are managed by infrastructures at the lowerst levels. Each level serves the planning process at a particular degree of authority (figure 3). The arrows, both vertical and horizontal, represent the complex relationships that exist between different levels, as well as the intra-jurisdictional ones (Rajabifard *et al.*, 2003).

Besides this organization, an SDI may be focused on a particular subject (e.g., forestry or coast management), gathering information from different authoritative levels, thus forming a *thematic* infrastructure. Thematic SDIs have a number of significant benefits, like: (a) the enhancement of related organizations engagement in their activities; (b) user needs are defined more accurately, due to the common interest on a particular domain; (c) the importance of spatial data sharing is made apparent to organizations, public authorities, private companies and groups of people working on the same subject; and (d) they constitute a first step in the development of ontologies in specific areas (Guimet, 2004). Thematic SDIs may contribute in the construction of state, national or regional (multi-national) SDIs.

3. The IDE-Univers architecture

The IDE-UNIVERS is a multi-level thematic SDI. It is composed of four participating SDIs, one for each technical partner of the project. Every component SDI follows the three-tier architecture, as depicted at figure 4.

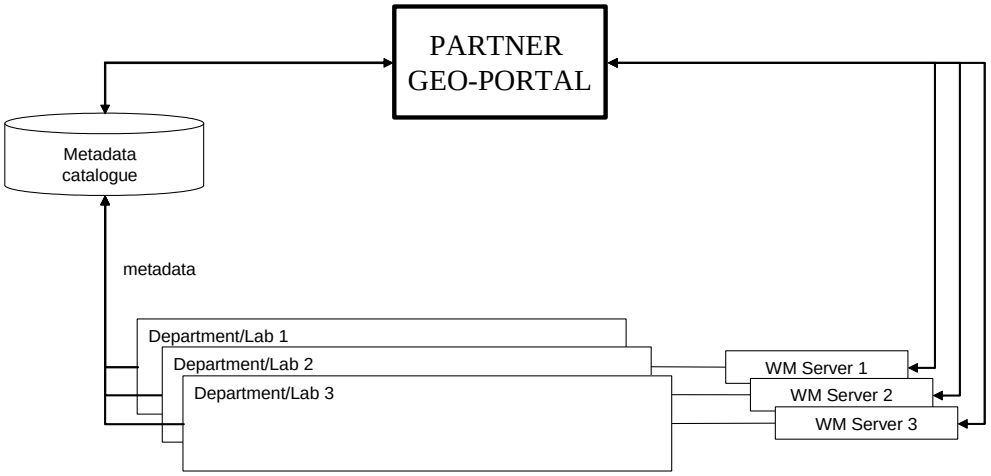

Figure 4. Component SDI

Each partner's geo-portal supports searching and visualization services. A catalog manages all metadata for the spatial and non-spatial data stored at the University Departments' and Research Centers' Laboratories that are in the jurisdiction of the partner. Each laboratory hosts a Web Map Server (supporting at least the OGC-ISO/TC 211 Web Map Service Interface) for the rendering and distribution of spatial data. Different laboratories utilize different WMS software and operating systems for their WM Servers, including University of Minnesota (UMN) MapServer and ESRI ArcIMS, or Microsoft Windows and Linux. All partners' geo-portals are interconnected to a global geo-portal, providing services at a higher level (figure 5). This constitute an open architecture, enabling more component SDIs to participate (given they serve the same thematic domain and agree to follow the metadata and web mapping standards).

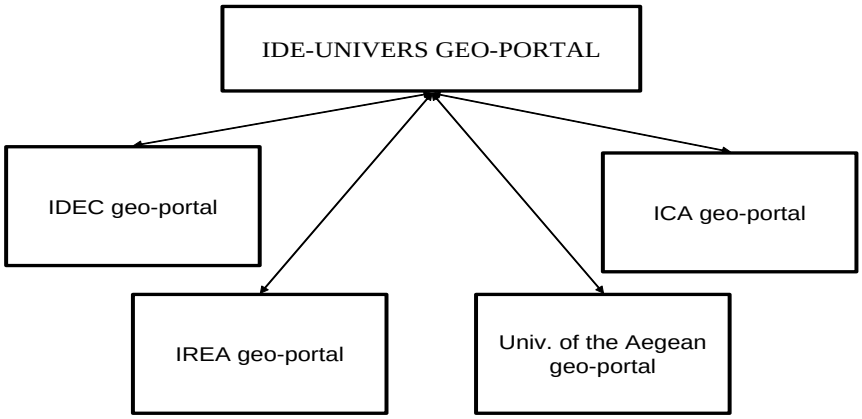

Figure 5. Integration of component SDIs

4. Production of metadata

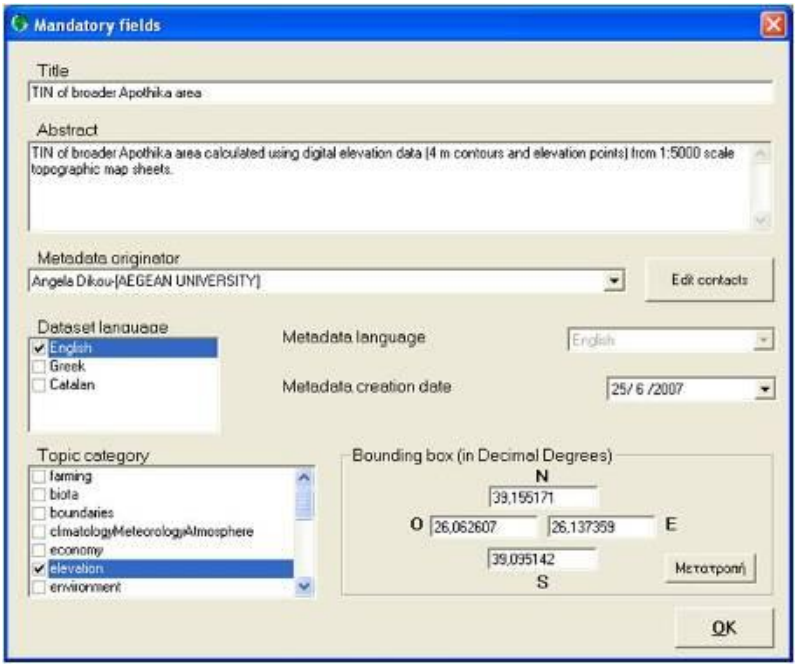

Figure 6. The mandatory metadata fields

A critical step for the development of an SDI is the documentation of the data to be shared. This is usually accomplished by the development of metadata catalogues. The ISO/TC 211 has established the 19115 and 19139 standards for geographic information metadata and their implementation specifications (Kresse et al., 2004). In the framework of the IDE-UNIVERS project, all participating data providers are using the IDEC (SDI of

Catalonia) ISO 19115–compatible metadata profile, while each country have made some modifications regarding spatial reference systems and thesauri. The MetaD software application, provided by the IDEC, is used for the management of metadata in a structured way that facilitates, besides the creation, the maintenance and the exportation of metadata in a simple and user-friendly way, while being compatible with the aforementioned standards. Figures 6 and 7 depict two representative forms of the software.

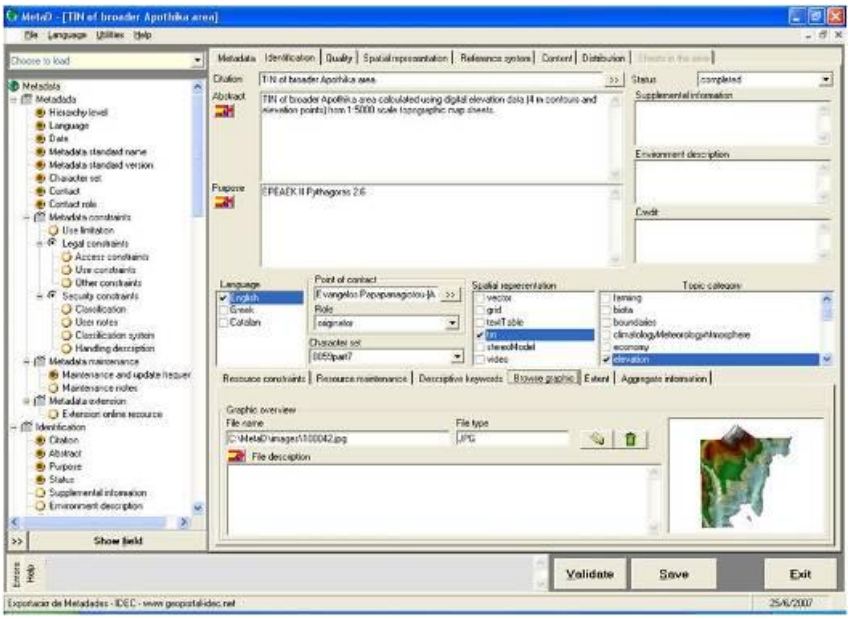

Figure 7. The main MetaD form

The first form assembles the information that is mandatory for every data item, either spatial or non-spatial, such as the title, a short description, the bounding box, or the topic category.

The second one is the main form of the application, organizing all metadata fields in tabs. List boxes, check boxes or combo boxes are used in order to assist the user filling the metadata information. At the left side of the form, a tree view designates the filled and not filled fields, either mandatory or not. All metadata are stored in a relational database. Specific operations are available for validation of the metadata, as well as their extraction in XML format for inclusion in the SDI catalogues. To support metadata catalogue services, two of the partners are customizing the Geonetwork Geographic Metadata Catalog free and open source software (http://geonetwork-opensource.org), while the other two are using the catalog software developed at IDEC.

5. Searching and viewing of spatial data

The following three figures 8, 9 and 10 depict the three main steps for searching and viewing spatial (and non-spatial) data, stored at the various WMS servers of the participating laboratories. The first step is the definition of the searching criteria at the geo-portal's first webpage. These may be alphanumeric values specified by the user for fields like title, keywords, free text, location, category, etc., or the specification of the bounding box of interest, either by entering the four coordinate values, or by zooming and rectangle selecting.

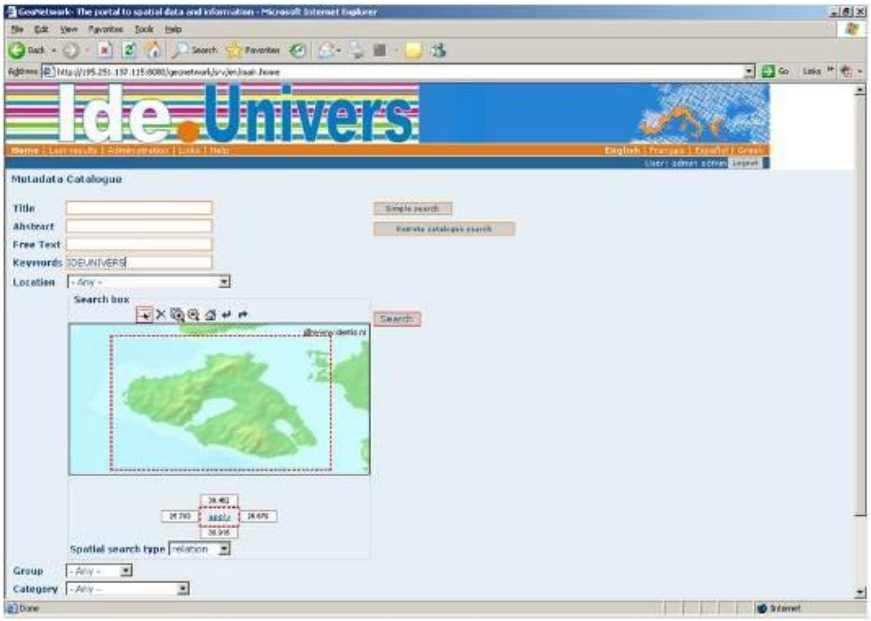

Figure 8. Setting searching criteria

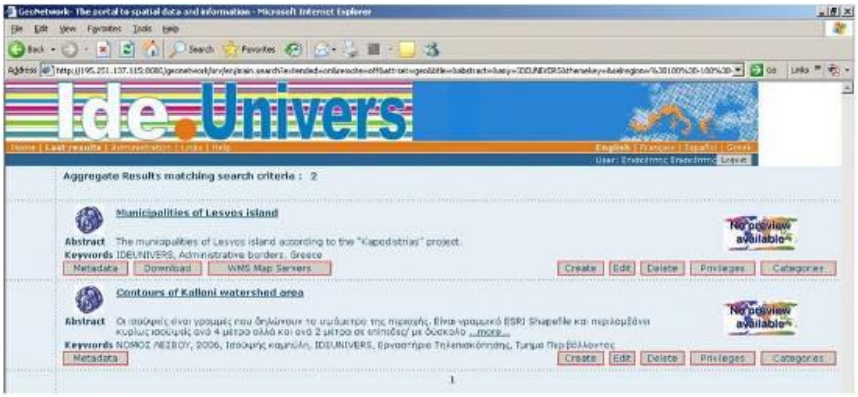

Figure 9. Displaying the results

The second step is the examination of the results returned, after the execution of the query with the searching criteria against the catalog database. For every result, the user is able to read the title, a short description, and the assigned keywords to the data item, and preview an image of it, if there is one available. For every data item, the available services are presented in the form of clickable buttons: Metadata, Download, WMS Map Servers (figure 9). The first service returns the whole set of metadata assigned to the selected data item. The second service begins a downloading process. The third service activates aWMS-client web application (IDE-Univers Map Viewer) enabling the connection to th e appropriate WMS server hosting the selected geographic data item, and the presentation of the cartographic information of that item (figure 10)

Figure 10. Displaying cartographic data

IDE-Univers Map Viewer supports the third step of the searching and viewing process. It offers a number of processing operation to the user, like zoom-in, zoom-out, etc. Moreover, it offers the possibility to the user to select any other WMS server (given its internet address is known or predefined) and explore to its available layers.

6. The consortium

The Project is coordinated by Secretaria de Telecomunicaions i Societat de la Informació, Generalitat de Catalunya (Spain), with the support of IDEC (SDI of Catalonia) and Instituto de Cartografía de Catalunya (ICC). Technical partners of the project are: IREA (Istituto per il Rilevamento Elettromagnetico dell' Ambiente) of the National Research Council (CNR) in Italy, the Department of Geography of the University of the Aegean in Greece, and the Instituto de Cartografía de Andalucía (ICA), Junta de Andalucia (Spain). Region Emilia-Romagna, in Italy, represents the public administrations interest in the project's results, in order to improve urban and environmental management.

7. Conclusions and future work

The paper has presented in brief the main technological aspects of the *IDE-Univers* project, aiming to develop a thematic SDI for geographical data produced by research activities in the Mediterranean. It is the first example of SDI connecting academic organizations in the involved countries. All software customized or developed in the framework of the project is based on international standards of ISO/TC211 and OGC, in order to enable interoperability with similar initiatives in the direction of the INSPIRE vision. Our next steps, besides the evaluation of the project results after its completion on March, 2008, include the study, development and integration of ontologies to thematic SDIs, in order to overcome semantic heterogeneity problems.

Acknowledgments

The authors want to thank Daniela Poggioli (IREA-CNR) for her initial idea for figure 1.

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