Pegaso Project People for Ecosystem based Governancein Assessing Sustainable development of Ocean and coast

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Report on the Mediterranean and Black Sea assessing SDI including existing viewers, their strength and limits, and the characteristics of PEGASO geoportal development

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Abstract

In the frame of the PEGASO project, a Spatial Data Infrastructure (SDI) for the Mediterranean and Black Sea Basins has been developed. This SDI consists of a central node and a set of local geonodes distributed among PEGASO partners and is one of the core products of the project. The development and common building of an SDI, Atlas and viewers is a recent common approach supported by the European Commission with directives such as INSPIRE. The overall aim of these infrastructures and tools is, among others, to contribute to the compilation, harmonisation and dissemination of environmental data to the general public. Based on this concept, the PEGASO SDI has contributed to this aim by compiling the information produced within the project, gathering relevant and official information, and in last instance by supporting the transfer of knowledge and as such enhancing the ICZM platform developed by the project. Furthermore, the PEGASO SDI has been designed to be compatible to the Global Earth Observation System of Systems (GEOSS).

Sharing the view that spatial information plays a key role in coastal management at all levels, from stakeholders to citizens; the project has focused on developing a Spatial Data Infrastructure which includes a Catalogue, a Viewer and an Atlas to facilitate the access to spatial information. Moreover, the information in the Mediterranean Sea and in the Black Sea is diverse, both in terms of thematic and in format, and thus it requires a set of common rules for harmonisation. In this sense, the development and role of local geonodes acting as local data providers has played an important function.

In the present deliverable, an overview of the importance of sharing spatial data in both basins, related to coastal issues, is highlighted. Furthermore, a critical view is provided of the strengths and limits of the infrastructure developed, in terms of relevance for coastal management and accessibility to data. Finally, the state of the art of the PEGASO SDI is analysed with special focus on the tools that it includes, the function and role of the local geonodes, and the added value that the SDI has in supporting the ICZM process in the Mediterranean Sea and the Black Sea and to the ICZM Governance Platform.

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1. Introduction

1.1. Purpose and scope of the report

The main goal of the PEGASO project is to construct an ICZM Governance Platform as a bridge between scientist and end-user communities, going far beyond a conventional bridging. The ICZM Platform is supported by the development of a Spatial Data Infrastructure (SDI) and aset of sustainability assessment tools required for making multi-scale integrated assessments in the coastal zone by supporting and creating local geonodes in order to deliver a Mediterranean and Black Sea harmonised sets of data accessible through a dedicatedweb-basedGeoportal. Implementing a Spatial Data Infrastructure, following the INSPIRE Directive, allows to use spatial data generated within the project as well as external and to make it available to the ICZM Platform. Further, the Pegaso SDI has been designed to be fully compatible with GEOSS and thus data from non-European countries could be integrated. One of the major challenges of the project is to share the results with all the stakeholders and beyond (SDI brochure English-French).

The aim of the present Deliverable 3.2A is to provide a state of the art of the Mediterranean and a Black Sea SDI's and viewers, including the PEGASO SDI and its Geoportal, to better understand their mechanisms, future trends, strengths, limits, and to delineate how these tools can support the implementation of an effective Integrated Coastal Zone Management.

In recent years the number of tools and methods to assess and implement ICZM have increased since the coastal zone is recognised as a complex system whose management needs to involve various methodologies and stages to achieve results based on sharing knowledge and expertise between scientists, authorities and stakeholders (Malvárez et al. 2013). The request for spatial data and information has grown quickly in line with the corresponding development of new technologies, such as Global Positioning Systems (GPS), remote sensing images, sensors, etc.
Despite the innumerable environmental and socio-economic data existing in the databases of the key organizations, the information is not always readily accessible neither is it in an appropriate format, making it difficult to get a broad vision of the coastal environment at local level or across different sectors and geographical areas without previously gathering and standardizing information (Wiki article: The need for data sharing).

Therefore, the capacity to organize, harmonize and use spatial data in a suitable way is becoming an increasingly important challenge, and a major defiance for the government organizations of the Mediterranean and Black Sea regions, as well as in other regional and private organizations. Many countries have developed, or are currently developing, local geonodes linked to open data catalogues to store and organise the data, geoportals and spatial data viewers to visualise and enhance access to the information. Furthermore, in a limited number of municipalities and regions this approach is also developed with the aim of, offering very valuable coastal information to stakeholders, users and managers.

In this sense, the development of Coastal SDIs (C-SDI) has become prevalent among official Institutions and government as the strategy to achieve this goal. The main reason is that due to its design and

technology SDIs allow to store spatial data information, their attributes, and their related documentation (metadata) offering a means to discover, visualize, and evaluate related coastal information. Furthermore, SDIs facilitate access to the data themselves (some information can be downloaded and visualised in other viewers), providing a valuable tool for governments, companies and citizens to easily find, understand and re-use data and information in coastal management and decision making processes.

In the following sections an assessment is carried out of the role that spatial data play in coastal management in the Mediterranean and Black Seas and more in detail the need of sharing spatial data in these regions. For that purpose, a revision of existing initiatives for data sharing in the context of SDI and viewers is made with special emphasis on the characteristics of the PEGASO SDI. Thanks to, and based on, the experience gained during the project, the present report establishes an important reference document to highlight the role that such spatial data infrastructures have in the support and implementation of ICZM initiatives.

1.2. The importance of sharing spatial data in the Mediterranean and Black Sea

The development of databases and the exchange of information are conditions for creating the basis for a sustainable development and to support the information management needs for implementing and monitoring sustainable development policies. Sharing spatial data is becoming a diffuse practice, mostly in the management and use of territory; it is evident that every day we access an enormous and continuous flow of information and much of it refers to a position or a specific place on the surface of our planet; this information is therefore, and by definition, georeferenced. In the last 30 years, the amount of georeferenced data available has grown dramatically following the evolution of the communication means and due to the rapid development of spatial data capture technologies such as GPS, remote sensing images, sensors, etc (Phillips, Williamson, &Ezigbalike, 1999).

The reasons that underpin the need fordata sharing can be summarisedin the following points below (extracted from Coastal Wiki article: The need for data sharing):

- **Identification of the important role of the data sharing by the administrations and governments**: the spatial information is important and must be part of the basic information infrastructure that need to be efficiently coordinated and managed for the interest of all citizens (Ryttersgaard, 2001); it is true that thehuge amount of geospatial data is stored in different places, by different organizations and the vast majority of the data are not being used as effectively as they should
- **Strong necessity of data availability and access to information:** The development of databases and exchange of information are the conditions for creating the basis for a sustainable development and to support the information management needs for implementing and monitoring policies and goals like the UN Millennium Development Goals (UNGIWG, 2007).
- **Expensive resource:** geospatial information is an expensive resource, it is time consuming to produce and for this reason is important to improve the access and the availability of data, and promote its reuse. Many of the decisions that different organization need to make depend on good

and consistent georeferenced data, available and readily accessible (Rajabifard and Williamson, 2001).

- **Borders of the data:** in many cases organizations and agencies need more data than they can afford and it commonly lies outside of their jurisdiction.Likewise data collected is carried out by different organizations from other countries; in this case sharing of data avoid the duplication of the efforts, increasing its efficiently.

The availability and easy access to a wide range of data and metadata on the oceans and coastal zones is one of the key aspects to support strategic decision-making regarding ICZM and maritime policies; for instance the ICZM Protocol for the Mediterranean (Barcelona Convention), the EU Integrated Maritime Policy, the EU Marine Strategy Framework Directive and the Bucharest Convention, among others.

There is a vast quantity of data available from many sources but gathering them for particular applications takes considerable effort. The establishment of appropriate coastal and marine data and information infrastructure is of highest importance for Marine and Coastal management instruments. The European efforts towards a Sustainable and Integrated Maritime Policy highlight the development of three instruments (Commission of the European Communities, 2007):

- Maritime Surveillance (critical for the safe and secure use of marine space)
- Maritime Spatial Planning
- A comprehensive and accessible source of data and information

SDI support at least the latter two instruments by integrating existing and fragmented initiatives in order to facilitate access to primary data for users, either from public, or business, or academic, government or citizens sector.

In particular, **the Protocol for Integrated Coastal Zone Management**ofthe Barcelona Convention for the Mediterranean highlights, in its article 16, *the importance of monitoring in order to promote exchange of scientific experience, data and good practices and introduces the possibility that all Mediterranean countries can create a Mediterranean coastal zone network at scientific level*;

- **(art. 16. 3)** this would facilitate the regular observation of the state and evolution of coastal zones and to set out an agreed reference format and process to collect appropriate data in national inventories; these data have to be public access and therefore could be shared between the network.
- **(art. 16. 4),** the Parties shall take all necessary means to ensure public access to the information derived from monitoring and observation mechanisms and networks.

Furthermore, in article 27 *Exchange of information and activities of common interest*, the Protocol states that parties will undertake, directly or with the assistance of the Organization or the competent international organizations, to cooperate in the exchange of information on the use of the best environmental practices. In particular, by the definition of coastal management indicators, taking into account existing ones, and cooperate in the use of such indicators (art 27.a).

Along these lines, it is in the INSPIRE Directive that the EU states the need to establish an Infrastructure for Spatial Information in Europe to unify criteria for a common application of the geographic information. Further, it aims to enhance data sharing among countries and to support the possibility to combine seamless spatial information from different sources across Europe and share it with many users and applications. Moreover, the Directive sustains the possibility to combine spatial data from different sources across the Community (by means of network services as SDI) in a consistent way and share them between several users and applications. **Implementing a SDI following the INSPIRE Directive (and GEOSS principles), implies that local geonodes must be developed, spatial data must be standardized and harmonization must take place in order to start sharing data.**

In this context of data sharing, it has been agreed that applying Geographic Information Systems (GIS) to coastal issues can support many management tasks, including the integration and analyses of larger and conceptually richer databases; an improved sharing of information between communities, sectors and stakeholders; implementing quality control over data captured; modelling and simulation of coastal processes; enhanced decision-making and an improved visualisation and communication of concepts, information and ideas (Barlett et al., 2004). This is the complex approach that characterises any ICZM initiative, which demands on the one hand the connection and integration of inter-disciplinary and inter-sectoral information, and on the otherhand the need to guarantee access to data for multiple coastal stakeholders (Malvarez et al., 2013). It is thus where SDI is recognized as the tool that best copes with large datasets and assures the public access to data due to its combination of more sophisticated infrastructures and communications technologies.

2. Initiatives in the Mediterranean and the Black Sea

2.1. Revision of existing coastal SDI

Recently, the role of spatial data and geo-information has increased significantly for the management and study of the coast with emblematic projects such as KnowSeas, EnviroGRIDS, ODINAFRICA, SPINCAM, The Caribbean Marine Atlas and PEGASO, among others, highlighting the role of Information and its management in the overall process. Given the agreement that better and more integrated management of the coastal zone is desirable, implies the need of more efficient access to interoperable spatial data relate to the land and marine environments. In this sense, National Authorities have started to develop what has been commonly called Coastal SDI (C-SDI) and Marine SDI (M-SDI) as part of their national SDI architecture. A C-SDI is understood as an infrastructure that collects, combines and integrates data from different resources and administration related to the coastal zone (marine and terrestrial environments) (Malvárez et al., 2013).

Currently, a number of Coastal SDIs have been developed and implemented to meet the challenges of ICZM at different levels of governance and with varying degrees of success. However, they are facing common issues such as the Organizational barriers and the reluctance of many institutions to share their data which affects their implementation and effectiveness (Strain et al., 2006), the complexity of physical and institutional relationships that characterize the coastal zone and the need of integration of data on land, marine and coastal areas at different scales (Longhorn, 2003; Williamson et al., 2004; Strain et al., 2006) the multi-sectorial approach needed to manage the coastal zone require that CSDI/MGDI be developed in close cooperation with the more generic SDI initiatives of countries and regions, within which CSDI will typically be an important thematic subset of the more comprehensive National SDI (NSDI) (Longhorn, 2003).

C-SDI and M-SDI have reached a certain level of maturity since its first implementation, and thus a revision or its performance in supporting coastal management and facilitating Governance and access to data for decision-making process can be assessed. For this purpose, a revision of some of them is carried out in this report:

Table 1.Revision on existing SDI for the Mediterranean and the Black Sea.

SUB REGIONAL INITIATIVES of SPATIAL DATA INFRASTRUCTURE		
Name	**Website**	**Description**
ENVIROGRIDS	http://www.envirogrids.cz/view	The SDI of Envirogrids Black Sea Catchment project deals with environmental and socio-economic problems. It is supported by the Global Earth Observation System of System (GEOSS).
CAMPLA	http://laboratorioredia m.cica.es/VisorCAMP/	The Coastal Area Management Plan Levante de Almeria is an ICZM pilot Project involving the administrations and territorial stakeholders in coastal management promoted from UNEP MAP, the Spanish Ministry for the Environment and the Regional Ministry for the Environment of Andalusia. With the main objective of implement the Protocol on Integrated Coastal Zone Management in the Mediterranean at local scale, the Levante coast of Almeria (Spain) demonstration project is based in shared knowledge, capacity building and tools such as an SDI for sharing results.
SEXTANT	http://www.ifremer.fr/sextant/	Sextantaims tocollectand make availablea catalogue ofgeo-referenceddataonthe marine realm. Itis in supportof issuessuch as biodiversity, renewable energy at sea,integratedcoastal zone management, fisheries, coastal anddeep-sea environment, exploration andexploitation of the seabed. Accessiblevia the Internet,ingeneral publicaccessor, for certain data, restricted, itincludesvector andgridded dataproducedby Ifremerand its partners
EUROPEAN AND REGIONAL INITIATIVES (SDI)		
Name	**Website**	**Description**
DISMAR/DISPRO	http://dispro.ucc.ie/apps/dismar/index.xml	Data Integration System for Marine Pollution and Water Quality has the objective of improving the management of pollution crises in coastal and ocean regions of Europe through the use of an advanced web-based information system. The focus of the project, for demonstration purposes, is on oil spill and harmful algal bloom events.
KNOWSEAS	www.knowseas.com	The Knowledge-based Sustainable Management for Europe's Seas project counts with the participation of 32 institutions and the supporting of Marine Strategy Framework Directive (MSFD). The aims of the SDI is to build scientific knowledge for the application of the Ecosystem Approach to the sustainable development of Europe's regional seas based on the practical choices faced by decision makers in marine issues, using existing data and missing filling data gaps using new approaches.
SEADATANET	http://www.seadatanet.org/	Pan-European infrastructure for Ocean & Marine Data Management is an Integrated Research Infrastructure Initiative which aims to develop an efficient distributed Pan-European Marine Data Management Infrastructure for managing these large and diverse data sets. The objective is to create a network based on the existing professional data centres of 35 countries, active in data collection, and provide integrated databases of standardized quality on-line.
EMODnet	http://www.emodnet.eu	The European Marine Observation and Data Network (EMODnet) is a consortium of organisations within Europe that assembles marine data, data products and metadata from diverse sources in a uniform way. The main purpose of EMODnet is to unlock fragmented and hidden marine data

	resources and to make these available to individuals and organisations (public and private), and to facilitate investment in sustainable coastal and offshore activities through improved access to quality-assured, standardised and harmonised marine data. EMODnet is an initiative from the European Commission Directorate-General for Maritime Affairs and Fisheries (DG MARE) as part of its Marine Knowledge 2020 strategy.

DATA BASES AND GIS-APPLICATIONS

Other relevant initiatives (projects, networks, websites) that cannot fully be considered SDIs, but sources of sectorial geo-referencing spatial data or statistic are summarised below.

Name	Website	Description
GISCO	http://epp.eurostat.ec.europa.eu/portal/page/portal/gisco/introduction	Geographic Information System of the European Commission originally conceived as a prototype GIS cell that would serve a wide spectrum of users and uses, the GISCO project has developed a service-oriented dimension, namely in geographical database development, thematic mapping, desktop mapping and dissemination of data. Providing these types of services is directly related to key parts of the GISCO mandate.
OneGeology-Europe	http://www.onegeology-europe.org/	Aims to create dynamic digital geological map data for Europe. It makes a significant contribution to the progress of INSPIRE - i.e. develop systems and protocols to better enable the discovery, viewing, downloading and sharing of core European spatial geological data. OneGeology-Europe addresses licensing and multilingual aspects of sharing geological knowledge and demonstrates best practice examples of the delivery and application of geological spatial data in the public and private sectors.
SEA AROUND US	http://www.seaaroundus.org/	Sea around us project offers data about the impact of fisheries on the marine ecosystem of the world and proposes mitigation solutions to a range of stakeholders. The data produced are distributed at the scale of countries, Exclusive Economic Zones, Large Marine Ecosystems, the High Seas and other spatial scales, and as global maps and summaries. The project also emphasizes catch time series, and fisheries-related information on every maritime country (e.g., government subsidies, marine protected areas, marine biodiversity).
Mediterranean Operational Oceanography Network	http://www.moon-oceanforecasting.eu/index.php	It is a Network between different scientific members and projects who share the objectives to consolidate and to expand the Mediterranean Sea concerted monitoring and forecasting systems, and to facilitate the availability and dissemination of long term high quality data required to advance the scientific understanding of the Mediterranean Sea.
Marine Regions	http://www.marineregions.org/index.php	It has the purpose to create a standard, relational list of geographic names, coupled with information and maps of the geographic location of these features. This will improve access and clarity of the different geographic, marine names such as seas, sandbanks, ridges and bays and display univocally the boundaries of marine biogeographic or managerial marine areas. Marine Regions is an integration of the VLIMAR Gazetteer and the VLIZ Maritime Boundaries Geodatabase.
EurOBIS	http://www.eurobis.org/	European Ocean Biogeographic Information System is an online marine biogeographic database compiling data on all living marine creatures. The principle aims of EurOBIS are to centralize the largely scattered biogeographic data on marine species collected by European institutions

		and to make these data freely available and easily accessible.
EuroGOOS	http://www.eurogoos.org/	The European Global Ocean Observing System is an association of national governmental agencies and research organisations committed to European-scale operational oceanography within the context of the intergovernmental Global Ocean Observing System (GOOS). EuroGOOS has 34 members, providing operational oceanographic services and carrying out marine research, from 16 European countries. EuroGOOS advocates the development of common European operational data procedures, products and services, including a common infrastructure and major systems in collaboration with public and private sector organisations and programmes.
European Atlas of the Seas - European Commission	http://ec.europa.eu/maritimeaffairs/atlas/index_en.htm	Maps usually show Europe as a group of countries surrounded by the seas. They focus on cities, roads and landscapes – the seas fall into the background. The new European Atlas of the Seas takes the opposite perspective: it puts the seas and all their different uses in the foreground. In the Atlas you can find reliable data on topics such as the European fishing fleet, motorways of the seas, the relief of the ocean floor, coastal erosion, maritime transport. It is regularly being updated as new data becomes available.
GEO-GEOSS	http://www.earthobservations.org http://www.geoportal.org/web/guest/geo_home	The Group on Earth Observations (GEO) is coordinating efforts to build a Global Earth Observation System of Systems (GEOSS). GEO was launched in response to calls for action by the 2002 World Summit on Sustainable Development and by the G8 (Group of Eight) leading industrialized countries. These high-level meetings recognized that international collaboration is essential for exploiting the growing potential of Earth observations to support decision making in an increasingly complex and environmentally stressed world.
ICAN	http://ican.science.oregonstate.edu/	ICAN is a community of practice of organizations who have been meeting over the past two years to scope and implement data interoperability approaches to coastal web atlases (CWAs). The mission/strategic aim of ICAN is to share experiences and to find common solutions to CWA development while ensuring maximum relevance and added value for the end users.
African Marine Atlas	http://www.africanmarineatlas.org/	The purpose of the African Marine Atlas (AMA) is to identify, collect and organize available geospatial datasets into an atlas of environmental themes for Africa, under the sponsorship of the ODINAFRICA Project of the Intergovernmental Oceanographic Commission's (IOC) International Oceanographic Data and Information Exchange (IODE) Programme. The African Marine Atlas will include and involve a number of other geo-spatial data projectson and around the African continent.
IUCN Atlas / United Nations Atlas of the Oceans	http://www.oceansatlas.org/index.jsp	The UN Atlas of the Oceans is an Internet portal providing information relevant to the sustainable development of the oceans. It is designed for policy-makers who need to become familiar with ocean issues and for scientists, students and resource managers who need access to databases and approaches to sustainability. The UN Atlas can also provide the ocean industry and stakeholders with pertinent information on

		ocean matters.
IFEN	http://www.statistiques.developpement-durable.gouv.fr/	The dynamic mapping tool of the Coastline Observatory provides access to a wealth of information in the 26 coastal departments of Metropolitan France. Simple in use and with limited access in time, users can view the land use and many others geographic information (rivers, roads, protected areas, etc.). Moreover, many environmental, social and economic are available.

Source: (UPO Team, 2013); (Malvárez, Guisado, Lescauwaet, Claus, & De Hauwere, 2011):

Other initiatives are the Eurosion project sets out data that quantify the status, impact and trends of coastal erosion in Europe and assess needs for action at EU, Member State and regional levels), EUROSTAT (offers the official statistical data of the European Union and permits, through the GIS portal analyses the data and comparison them between countries and regions and ECA&D (European Climate Assessment & Dataset which contains the data and the information on changes in weather and climate extremes, as well as the daily dataset needed to monitor and analyse these extremes).

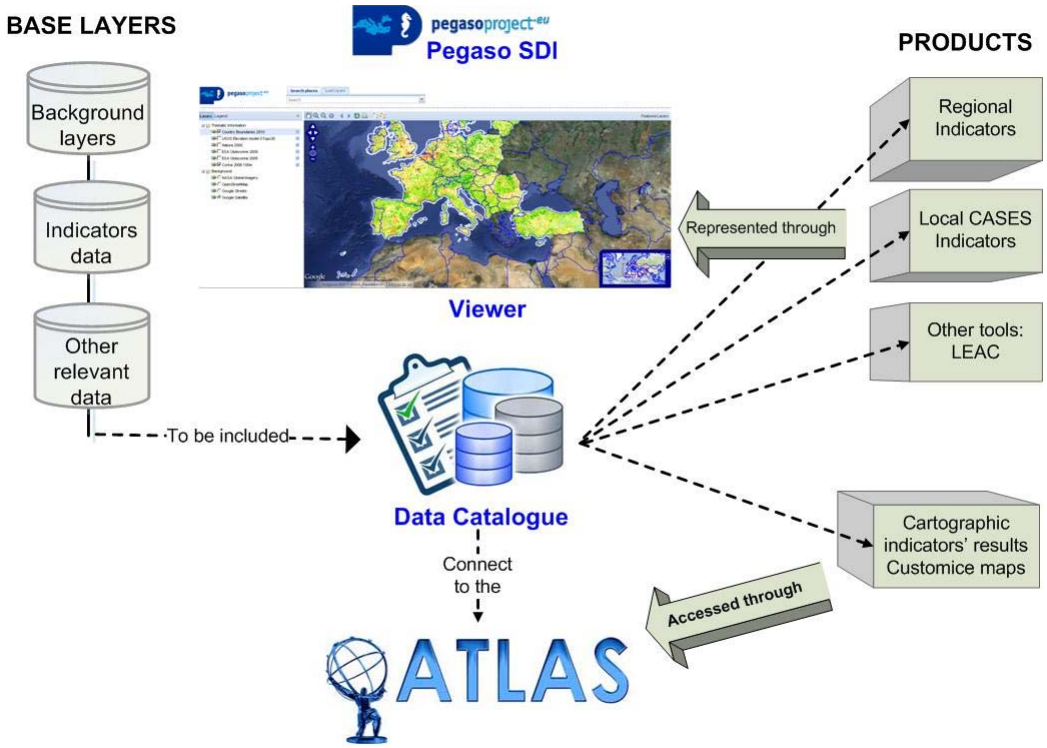
Atlases are other sometimes part of an SDI as they provide ready and easy access to coastal and marine data and maps. Interesting initiatives are for instance the UN Atlas of the Ocean, created by the United Nations that provides important information to the sustainable development of the oceans.

In addition, other important organizations that have promoted similar initiatives are the EEA(European Environmental Agency), and the JRC, which produces a great quantity of environmental spatial data and fosters its sharing use with various programmes: SEIS (European Shared Environmental Information System), EIONET (European Environment Information and Observation Network), INSPIRE (Infrastructure for Spatial Information in the European Community) and GMES (Global Monitoring for Environment and Security) or EMIS (http://emis.jrc.ec.europa.eu.), among others. The ESA (European Spatial Agency) that provides access to satellite imagery and data (ESA Earthnet Online).

In this context, the PEGASO project is an example initiative for the Mediterranean and Black Seas building a shared ICZM Governance Platform with scientists and end-users, linked with new models of governance. The PEGASO ICZM Platform is supported by the development of a Spatial Data Infrastructure (SDI) and the suite of sustainability assessment tools required for making multi-scale integrated assessments in the coastal zone.

Thus, a key objective of PEGASO is to set up a functional SDI, where all data and indicators from PEGASO participants can be shared, using the different services that are offered through its geoportal. It builds on a functional network of geonodes with all partners, the supporting of capacities in the Southern countries to co-develop and support existing geonodes and to build local/regional or national geonodes if requested by stakeholders. Data then becomes easily accessible through a web portal that also helps in managing communication and dissemination of results amongst partners and the Shared ICZM Platform components. PEGASO supports harmonization of data and metadata, which are key components to build assessment tools and to support the regional assessment in the Mediterranean and Black Sea basins. In doing so, PEGASO draws on existing SDIs from project participants (UPO Team, 2013).

Figure 1. Conceptual structure of PEGASO SDI



To address the PEGASO project strategic objectives (through a common SDI), PEGASO has conducted a survey on the levels of capacities, available data-infrastructures to implement an SDI and potential data and information sources (from the partner institutions and relevant EU projects). The results from this survey evidenced the presence of a wealth of information for the entire area covered by the project and a great capacity within the consortium, with promising opportunities to share data and expertise between the partners. However some issues like scale differences, integration and standardization needed to be addressed and above all it was necessary first to achieve a common understanding and common view on how the SDI should deliver the objectives of the ICZM policies. To this purpose, the guidance and common views and objectives as constructed within the ICZM Governance Platform is fundamental, since it is considered to be the platform where Science-Policy Interaction takes place in support of ICZM. See also D3.1 Report on the inventory of participants and main relevant EU projects, data and SDI with a quality assessment and an identification for needed actions on harmonization tasks (UPO Team, 2013); (Malvárez, Guisado, Lescauwaet, Claus, & De Hauwere, 2011) (http://www.pegasoproject.eu/images/stories/Pegaso-D3.1-VLIZ_110519-L-1.3.pdf)

2.2. Strength and limitations of existing initiatives

The SDI allows combining spatial data that resides and is managed in different sources so as to provide the user with a unified view of these disperse spatial data. The advantages of creating integrated SDIs are many:

- **Sharing of data:** single (shape)files or spatial data-layers are generally owned and managed by single users or data providers who develop one aspect of the environmental data needs, whereas the SDI can offer the one-to-shop for an overview, compilation and combination of all available data-layers. Also, the SDI is mostly managed by one supporting organization that can promote and communicate from one centralized institute or institutional effort. This may also provide 'Economy of scale': promotion and communication and management costs and resources can be pooled, so a lower cost is involved per user.
- **Control of redundancy and version contro**l: different users or data providers may have different versions of the same spatial data whereas the SDI may offer the most actualized version of the same data (version control), and offer archive and storage other versions in a structured and searchable environment.
- **Data consistency:** the SDI eliminates redundancy as the data need to be updated only once at one place, whereas in a distributed (spatial) data file system, files are distributed and data need to be updated in all of the files.
- **Improved data standards:** the database manager or managing authority of the SDI defines and/or implements standards on how to represent the data (format, conventions).
- **Improved data Integrity:** the SDI managing may define integrity constraints. e.g. question type1 cannot access information that answers question type 2.
- **Improved access to spatial data:** fragmented and 'hidden' coastal and marine data resources are unlocked and made available to users. A query language support allows any user to get or visualize data required anytime at any place, and there is no need for a programmer or intermediary service to extract the data.
- **Faster development of new applications:** a well-designed SDI is modular, so when a new application, tool or service is purposed, the SDI and underlying spatial database structure can respond.

The disadvantages are mainly related to the initial investment costs to set up geonodes and the capacity and training required in achieving this. Secondly, the resources and efforts required for maintaining the SDI both in terms of 'internal' maintenance and 'external' flow and feedback to data providers can be considerable. This often leads to the SDIs that are operational on-line, however without being updated and managed according to recent standards and guidelines.

Furthermore, the existing SDI's have to deal with a number of weaknesses, challenges or limitations. The main challenges can be summarized as:

- **Up and downscaling:** difference of scale between 'local' initiatives with a need of high-density data and high-resolution information compared to regional or basin-wide data and objectives, within the same SDI. This may represent challenges in terms of definitions, coverage, resolution and overall visualization.
- **Diversity of data:** slightly different definitions and units may apply in different regions, to measure similar trends or phenomena. This requires substantial efforts in terms of data harmonization or standardization.

- **Language issues:** words' translation into different languages can be an issue when combining data from different resources on a SDI, but also when query for information by name or categories in a data catalogue or through the metadata fields. Thus a common standardisation of language is sometimes needed and could be a significant shortcoming when building a common SDI.
- **Rights and policy:** The data policy and the proper citations, metadata and/or source indication are often missing, incomplete or insufficiently clarified, which restricts the possibility of redistribution of the data.

3. The PEGASO SDI

3.1. Development of PEGASO SDI and its components

The main objective of PEGASO WP3 is the construction of a Spatial Data Infrastructure (SDI) to support the implementation of the processes described in the ICZM Protocol for the Mediterranean Sea and the Black Sea.

PEGASO SDI has delivered a web application named PEGASOgeoportal which is publicly accessed in this URL, http://pegasosdi.uab.es/geoportal and it has been thought as a common and integrated access point to the main developed PEGASO components: Viewer, Catalog and Atlas (seeFigure 1).

Figure 2.PEGASOgeoportal web interface.

Essentially, a geoportal is a content management system that allows anonymous/registered users to easily create content and manages all difficulties encountered in the creation of data-driven dynamic web pages: templates, sessions, user profiles and so on. Among effective benefits offered by PEGASOgeoportal:

- **All components** developed in PEGASO are publicly available from a common and integrated web page
- **Provides**more visibility to SDI within PEGASO project offering new Web 2.0 capabilities like RSS feeding or multimedia content
- **Generates** accessible/restricted content in a structured and organized way
- **Establishment of** a collaborative way of working in the creation of dynamic content, for example, generation of spatial-aware articles inside Atlas section by content editors, thus combining interactive maps with other types of content (text, images, videos)
- **Dissemination** of SDI-related information and news that can be useful for anonymous users as well as users that can potentially use SDI web services like partners, researchers, stakeholders, policy makers (see 'Figure 3: Display of content related to PEGASO web services & how to connect to those services (a) and geonode status within PEGASO SDI (b).').

Regarding the access point to SDI components, there are four menus sited on topside in the web interface: Description, Catalog, Viewer and Atlas.

- **Description** gives a brief textual description of SDI and its role within PEGASO project.
- **Viewer** and **Catalogue** are links to PEGASO Viewer and PEGASO Catalogue respectively, which are designed web applications.
- **Atlas** is a collection of articles that embraces dynamic content related to regional assessment, final products like Cumulative Impact Mapping (CIM), Land and Ecosystem Accounts (LEAC), ICZM indicators and so on, namely, PEGASO Atlas.

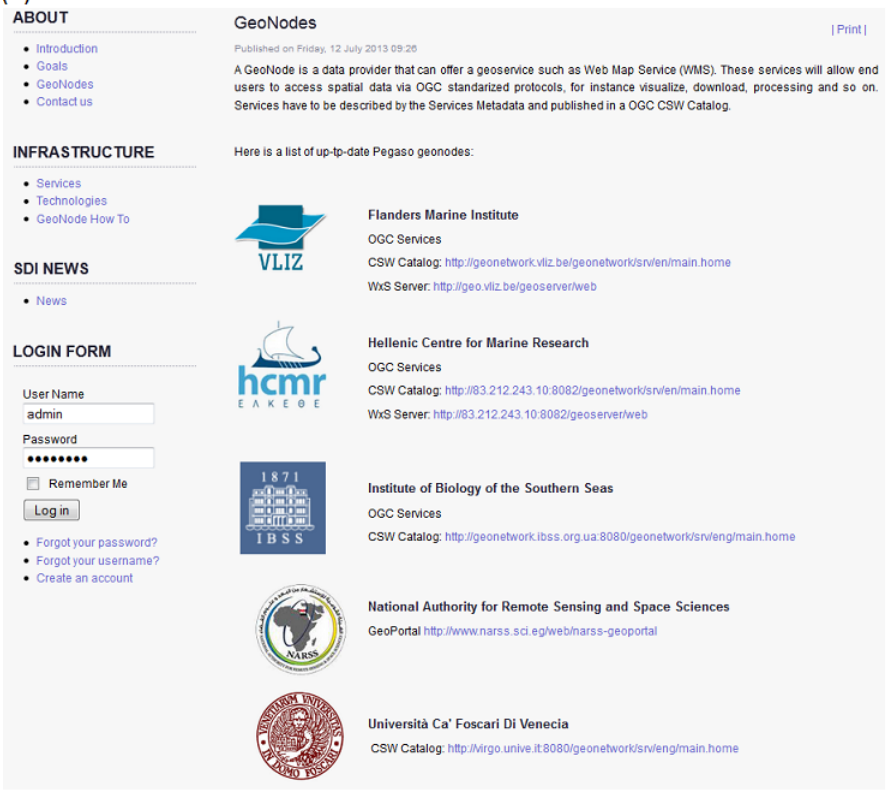
Regarding explicit content in PEGASOgeoportal, articles have been organized in three public sections as appeared on the left side of web interface: About, Infrastructure and SDI News.

- **About** section describes goals and benefits of PEGASO SDI as a support tool in the implementation of ICZM protocol for Mediterranean and Black Sea. As PEGASO SDI is a transboundary SDI with public geonodes sharing diverse information related to the project, this section contains a description of delivered local services and their current development status.
- **Infrastructure** provides technical information related to technologies employed to implement OGC standard services in PEGASO SDI as well as developed tools like web clients or desktop-like tools to connect to those services.
- **News** gives information that has been considered as relevant for PEGASO SDI. For instance, remote repository to download the source code to deploy a customized viewer as developed inside this project. Or a multimedia demonstration of PEGASO Viewer.

Figure 3. Display of content related to PEGASO web services & how to connect to those services (a) and geonode status within PEGASO SDI (b)

(a)

(b)



A. PEGASO Viewer

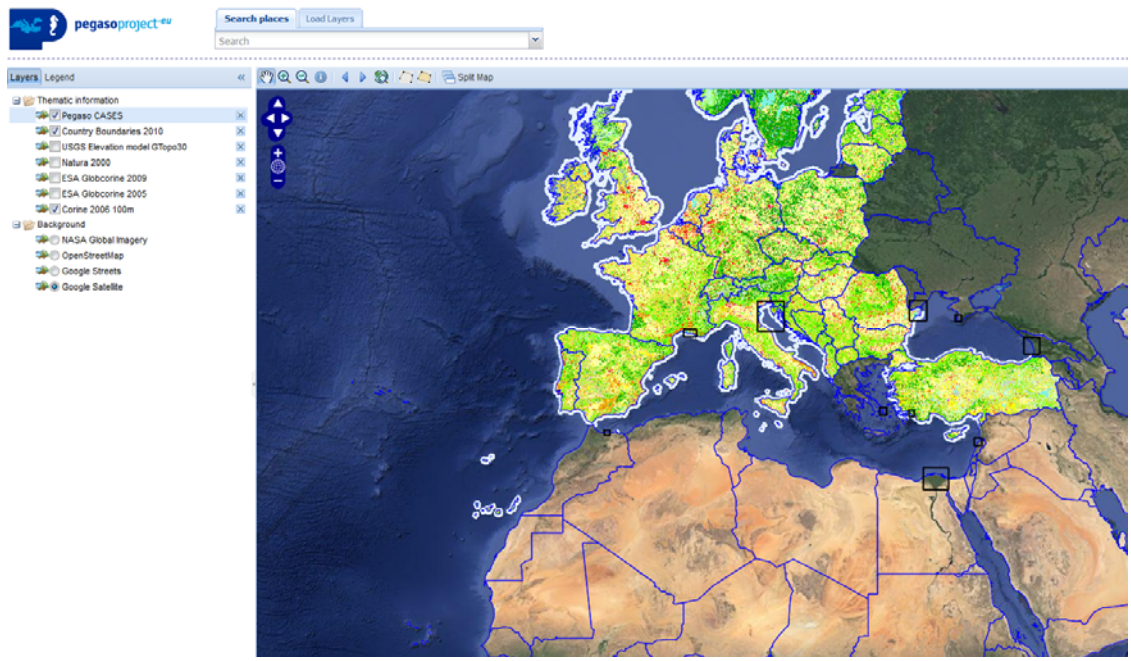
PEGASO viewer is a desktop-like online application designed to easily render and display map images and vector graphics on browser screens.

This cross-browser tool has been implemented by using AJAX-based and modern web mapping technologies on the client side in such a way that user experience is fast by leveraging server loads and reducing response times[1]. Specifically, these client-side web frameworks correctly render both map images and vector geometries (features) published in OGC WMS-WFS servers.

This front-end user interface can be accessed via URL in an internet browser (e.g. Mozilla Firefox) pointing to http://pegasosdi.uab.es/viewer. Designed layout consists of three clearly different regions on the browser screen as sketched in Figure 2:

- a header region sited at the top position
- two adaptable and responsive regions:
    - A left panel with hierarchical tree referring to layers as loaded from PEGASO web map services.
    - A centred-region canvas where map and layers are drawn. An overview map on the bottom right is also displayed.

Figure 4. Loaded PEGASO viewer interface

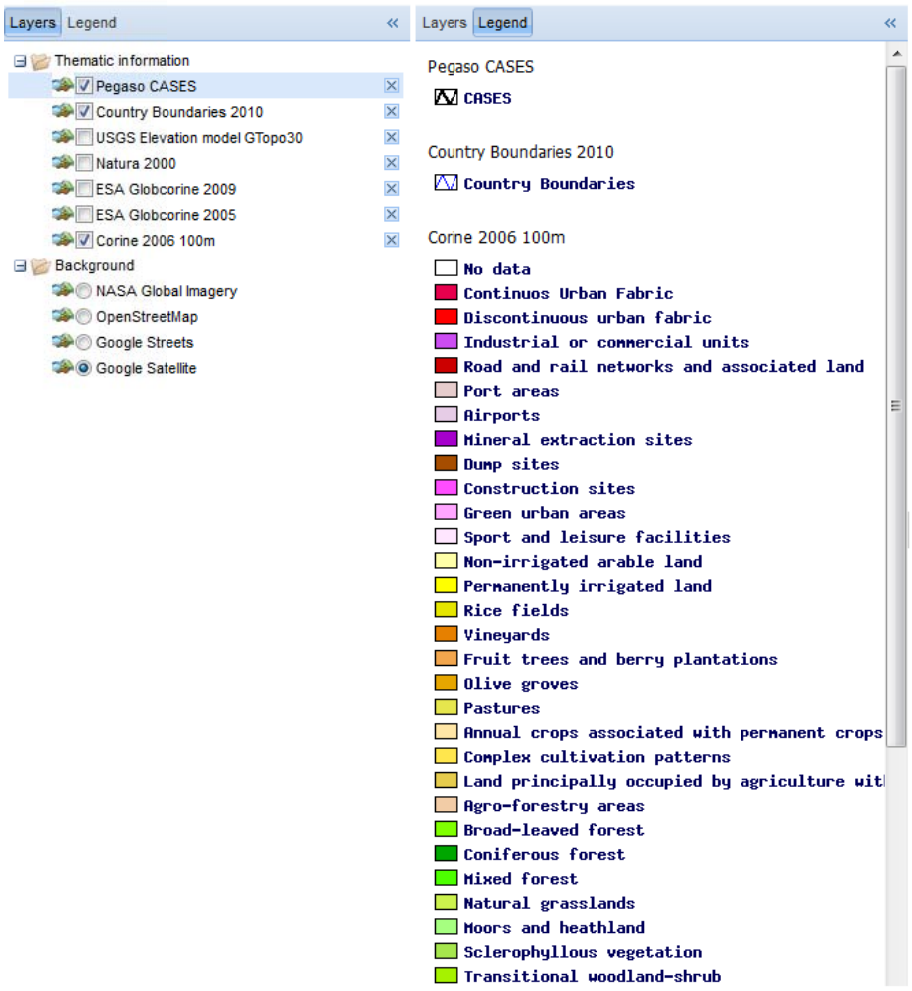


[1] Three web frameworks (OpenLayers v2.12, ExtJS v3.4 and GeoExt v1.11) have been employed during implementation phase.

Region on the left side in the layout is a tab panel that contains two related piece of information. A tree view of layers directly loaded from PEGASO web services when Layers tab is activated and legend images for active layers when Legend tab is activated (See Figure 4 for details).
This dynamic widget allows user:

- Visualize layers loaded directly from PEGASO web services.
- Change layers' visibility by clicking on the corresponding checkbox.
- Change layers' opacity by clicking on the corresponding map icon and sliding with the opacity slider (left: 0%, right: 100%).
- Remove displayed layers by clicking on the corresponding square-shape X button.
- Switch topographic & satellite layers from third-party popular services like Google, OpenStreetMap, etc.
- Print superimposed legend images.

Figure 5. Example of legenddisplayed



Note: Left - Layers tab contains a hierarchical view of layers, with two folder-icon root nodes: Thematic information, showing layer's titles and checkboxes to enable/disable layers' visibility, and Background, showing third-party topographic/reference layers acting as background ones and radio buttons to enable one at a time. Right - Legend tab contains pre-generated images for legends

As a result, a mashup in map panel is obtained that renders topographic images as reference (base) layers and thematic information overlaid on top of that as loaded from PEGASO web services. This has been possible thanks to OpenLayers mapping framework that manages WMS requests (specifically, getCapabilities and getLegendGraphic) and parse responses behind the scenes.

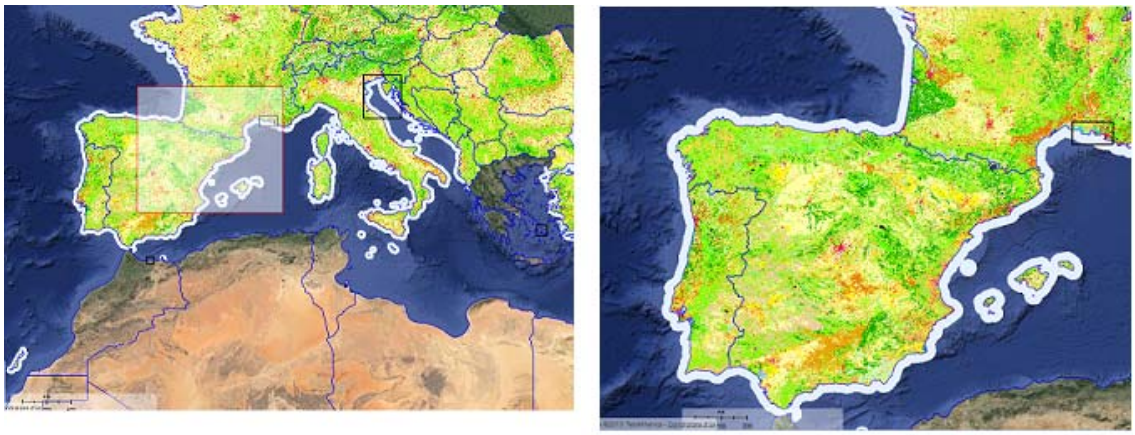
This web interface incorporates several utilities to allow final users to intuitively interact with features on the screen. Top toolbar embeds map controls to browse through/along objects rendered in the canvas. A tooltip is displayed when mouse over on corresponding buttons. A description**2** of functionality and use can be found at this table.

Table 2. Detail of analysis tools implemented in the SDI.

Map control	*Description*	*Use*
Pan	pan the map in one direction	After control activation, click on map and drag of the mouse around map.
Zoom in	increase the zoom level of the map	After control activation, draw a box on the map (click-move-drop) and map is zoomed in. See sequence in Figure 3.
Zoom out	decrease the zoom level of the map	After control activation, draw a box on the map (click-move-drop) and map is zoomed out.
Info by point	get info from displayed features	After control activation, select a layer in layer-tree panel and click on the map. A pop-up window display information for selected layers as Figure 4.
Previous	previous state in navigation history	After clicking button, map state is restored as previous state in navigation stack
Next	next state in navigation history	After clicking button, map state is restored as next state in navigation stack
Info	go to full extent	After clicking button, map state is restored to full extent
Length measure	length measurement between two points	After control activation, draw a line on the map (click-move-click) and a pop-up windows display distance between two points. See Fig. 5
Area measure	area measurement as enclosed area of a polygon vector	After control activation, draw a polygon on the map (click-move-click-move-click) and a pop-up windows display area of the polygon. See Fig. 5
Split map	split two maps	After control activation, principal map panel is divided into two map panels whose navigation that can be synchronized or not. See Figure 7.
Featured Layers	Direct layer loading	After control activation, click on corresponding image and layers is loaded on the map. See Figure 6.

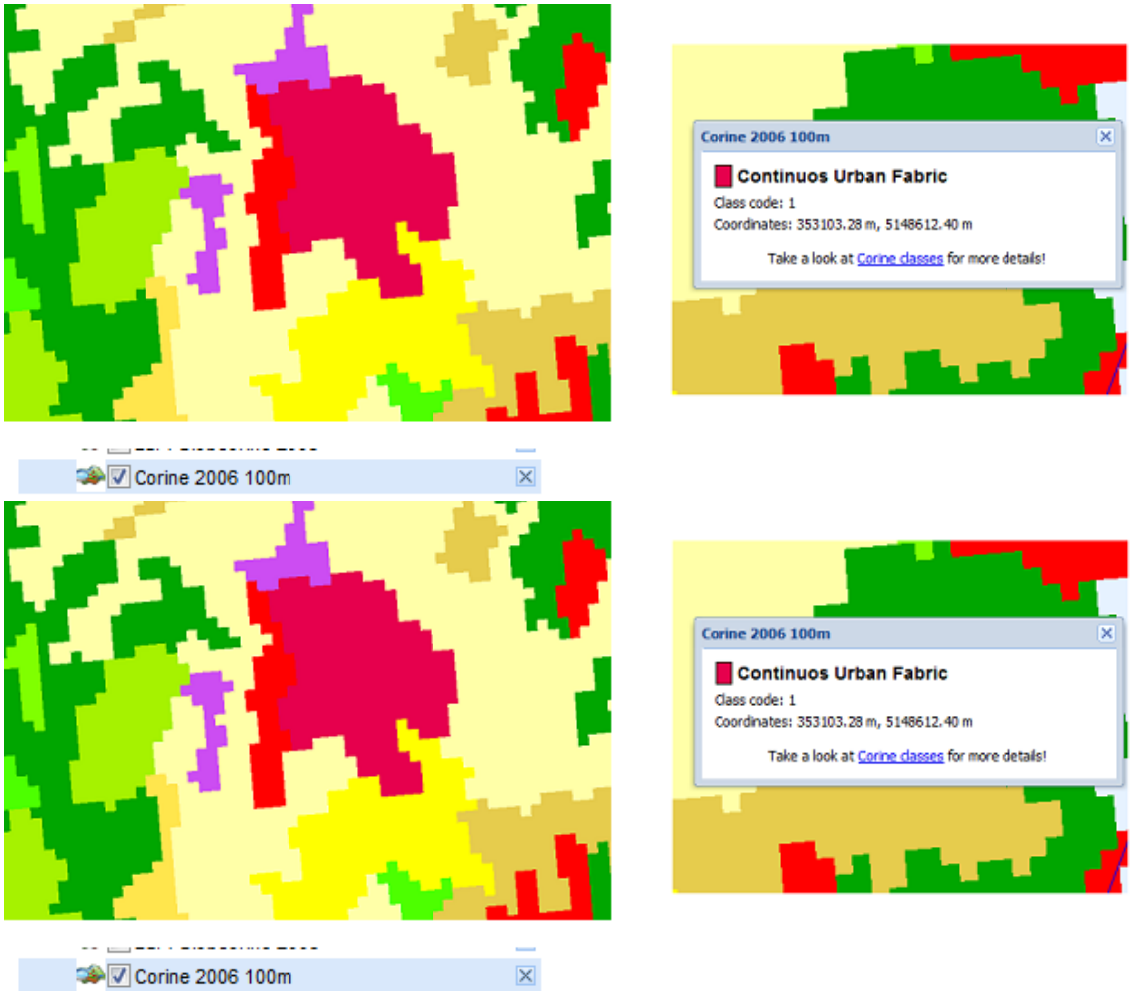
[2] In-order description of map controls from the left to the right.

Figure 6. Zoom tool usability



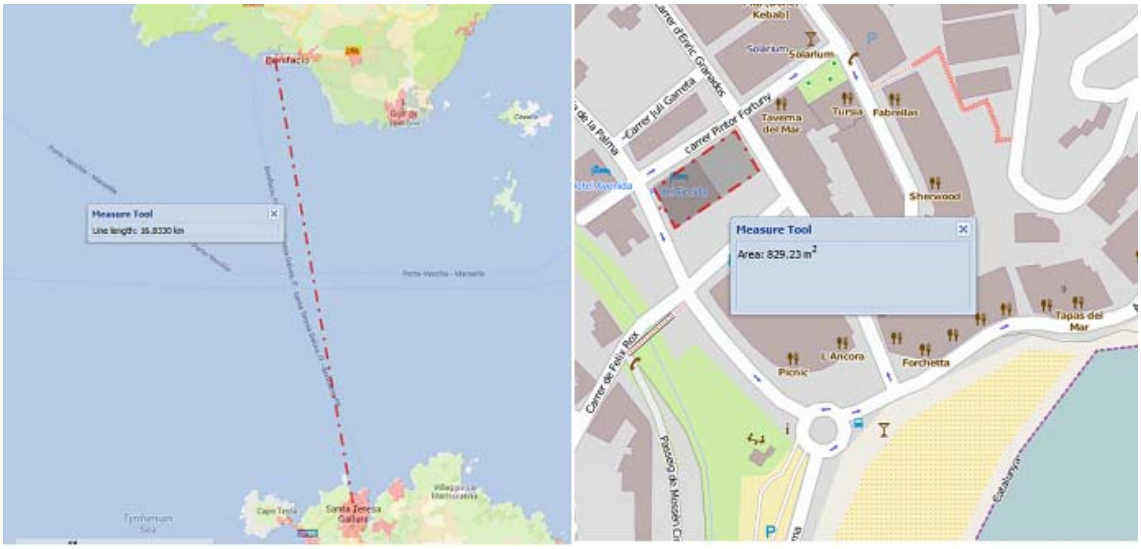
Note: Sequence of zoom in control (left) and resulting output (right). User activates this control by clicking in the corresponding icon on the toolbar; next, a red box that defines an extent is drawn by clicking on the map, moving around and dropping mouse. Consequently, map is zoomed in.

Figure 7. Info by point tool usability



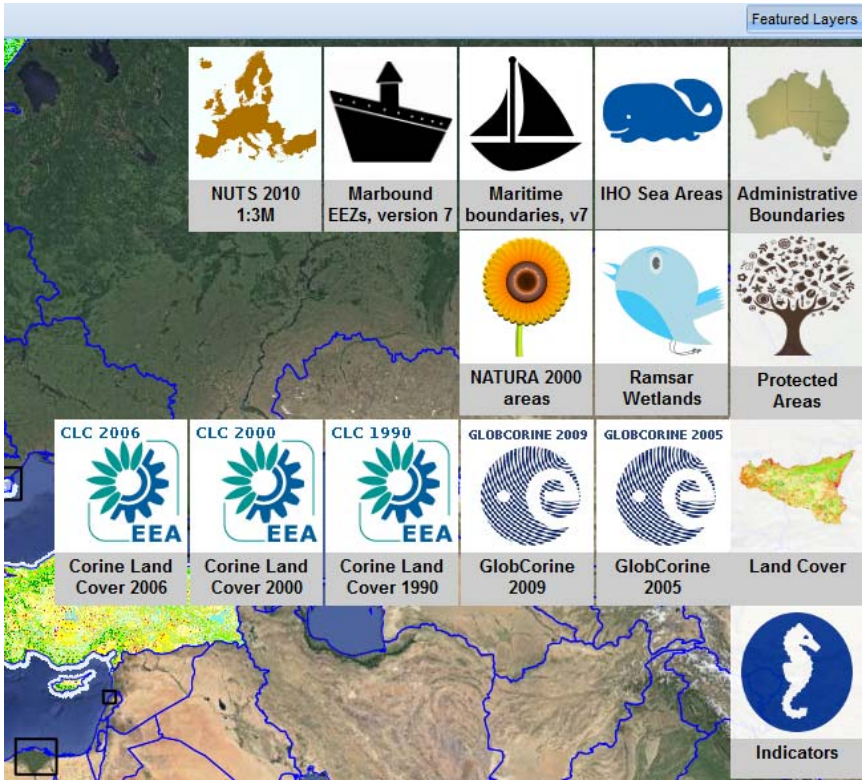
Note: Left image shows a small region-centeredCorine Land Cover raster as displayed in PEGASO viewer. If respective layer record is selected in the layer-tree panel (left bottom) and respective control icon is enabled in the toolbar, user clicks on the map (e.g, around red coloured feature) and a window prints information (e.g. associated Corine class, clicked coordinates) as fetched from PEGASO WMS servers (Right).

Figure 8. Length measure tool usability



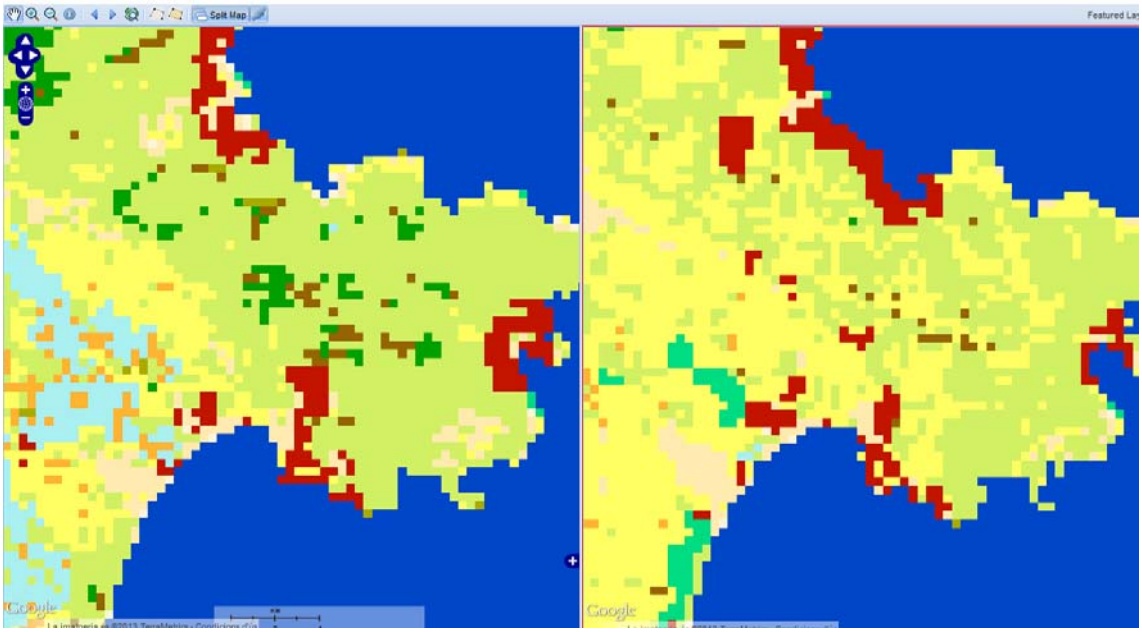
Note: Left image shows the Length Measure control in action. Dot-lined red line created with two clicks on the map and computed distance displayed in a window. Right images showing the area measurement enclosed inside a polygon drawn by user and corresponding output.

Figure 9. Feature layers control tool usability



Note: Featured Layers control showing a scrolling button with some predefined ready-to-load thematic layers falling within four categories: Administrative Boundaries, Protected Areas, Land Cover and Indicators. This component is highly customizable and icons and layers can be easily changes in source code.

Figure 10. Split map tool usability



Note: Split map control allows user to arrange two map views whose navigation (pan, zoom) can be synchronized if enabled blue synchronization button is active. However, info tool, loading layers from catalog, search location and layer tree are decoupled and available only for active layers (take a look at red squared map in right picture). This map activation can be done by clicking onto the map and it can be indistinctly switched from one to other.

On top header there are two graphical components: *search location* combo and *load layers* combo.

Search location

Search Location utility uses the *GeoNames*[3] location service allowing a great amount of place names to be available and incorporates some characteristics like auto completion, detailed output, zoom to selected location (see Figure 11a).

Load layers

Load Layers utility connects PEGASO viewer with PEGASO catalogue in a unified and simplified way. User writes text into combo, the tool makes a search by keyword in the catalogue and finally display as output results matching the search criteria. Records are pulled out from metadata database associated to PEGASO catalogue and title, abstract are shown, together with a loading button when metadata referring to a dataset is available. The window is sizeable and allows pagination to ease the output reading, especially useful for large outputs. (See Figure 11b and 11c)

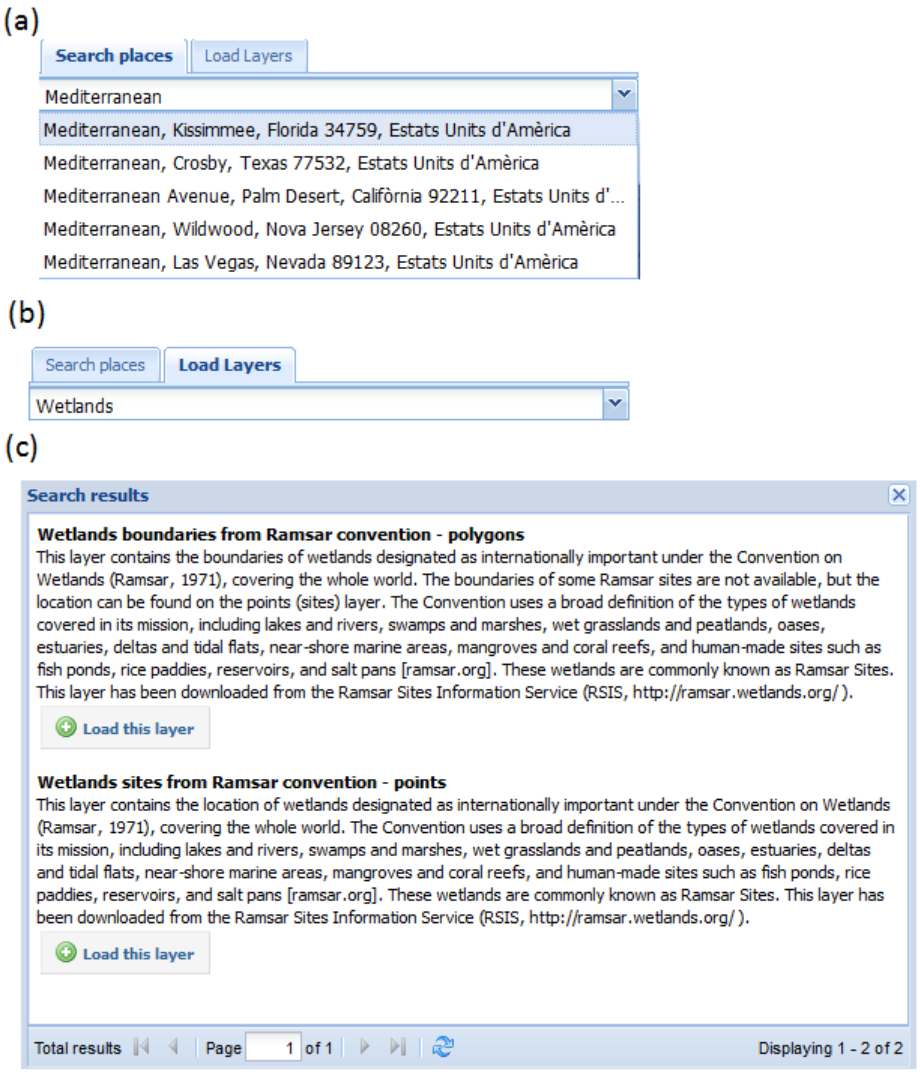
[3] http://www.geonames.org/export/ws-overview.html

Source code

All the source code of the viewer can be found and downloaded at Github repository: https://github.com/dispiste/pegaso-mapviewer.

A partner can freely download this client code to deploy its own viewer in a convenience web server (Apache, nginx, Windows Server …). Source code is mainly written in *Javascript*, is documented and organized into separated files. It is intended to be reutilised to build a customized viewer for partner institutions, with another logo image and initial loaded layers.

Figure 11. Search and load layer tool.



Note: (a) Search by place name using online web services. (b) Search by keyword-title-description in the catalog by writing text in a text area and results displayed in a window (c).

B. PEGASOCatalogue

The catalogue is an inventory of all the geodata stored on PEGASOSDI. It contains an accurate description of each dataset, which is a basic step towards assessing the value of the data owned by an organization. Moreover, having this accurate and structured description of the datasets opens the door to advanced search capabilities, such as searching datasets having specific keywords, titles, spatial or temporal extents, etc.

The catalogue is useful for final users, but at the same time it is the base component on the top of which the rest of products (Viewer, Atlas) are built.

Figure 12. Metadata search

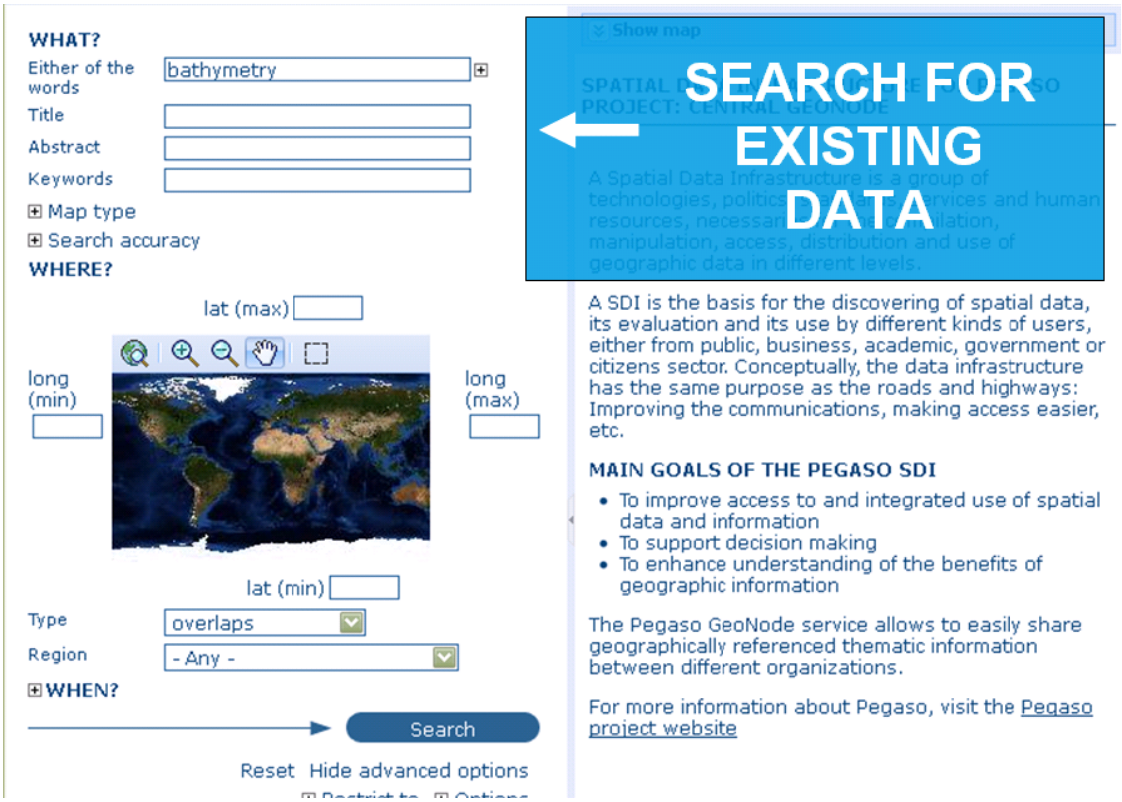
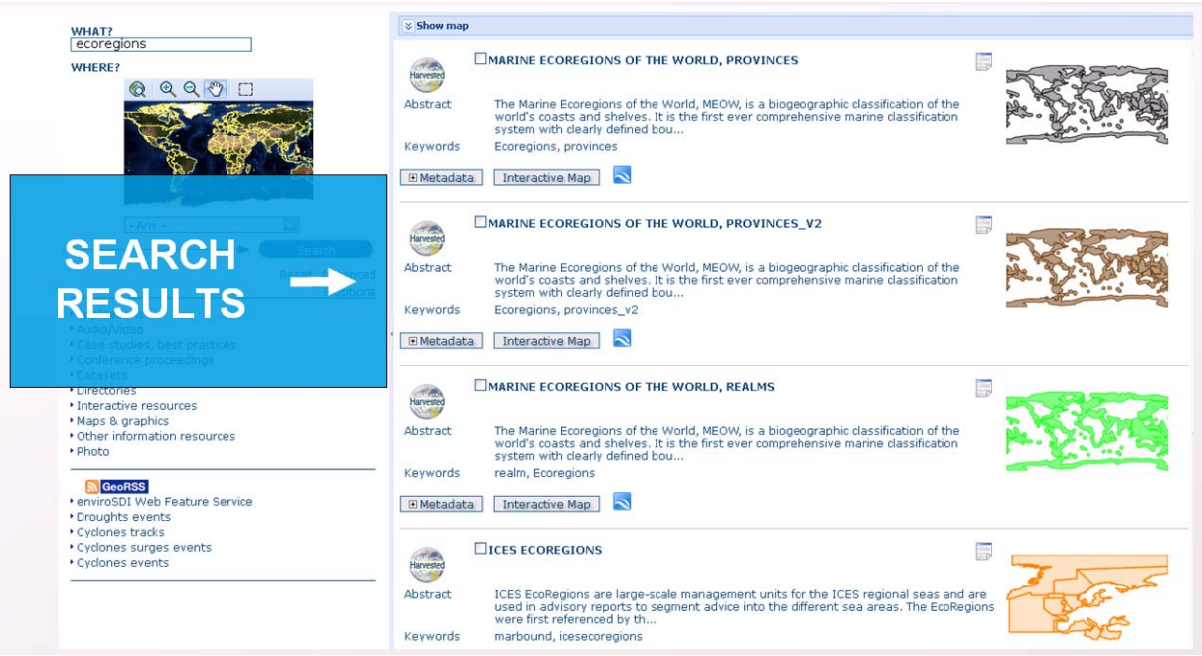


Figure 13. Metadata results on Catalogue



The description of the contents of a dataset is known as metadata. Metadata contains the description of the data (title, description, spatial and temporal coverage, distribution services, etc), which makes data more useful both for your organization and for other organizations not familiar with your datasets. In this sense, metadata clearly increases the value of your data. Metadata allows to answer questions similar to “Do we know which data we have?”, “Would we know which data we have if our senior workers retired?”, “Is this dataset suitable for our next project?”.

Figure 14. Metadata sample as seen on the Catalogue

The catalogue includes an interface to create new metadata or import existing records from different sources.

C. PEGASO Atlas

One of the results of PEGASO project is an Atlas prototype for the Mediterranean and the Black Sea. An Atlas is a systematic collection of maps that describes some aspects of the knowledge of a specific territory, and is usually complemented with text, images, tables or charts.

PEGASO Atlas is an online tool that is fully integrated in the PEGASOgeoportal and combines interactive maps with text and images, organized in different sections or topics. To create these atlas pages, an extension (*plugin*) was developed for the available geoportal[4] and allows registered users to create and

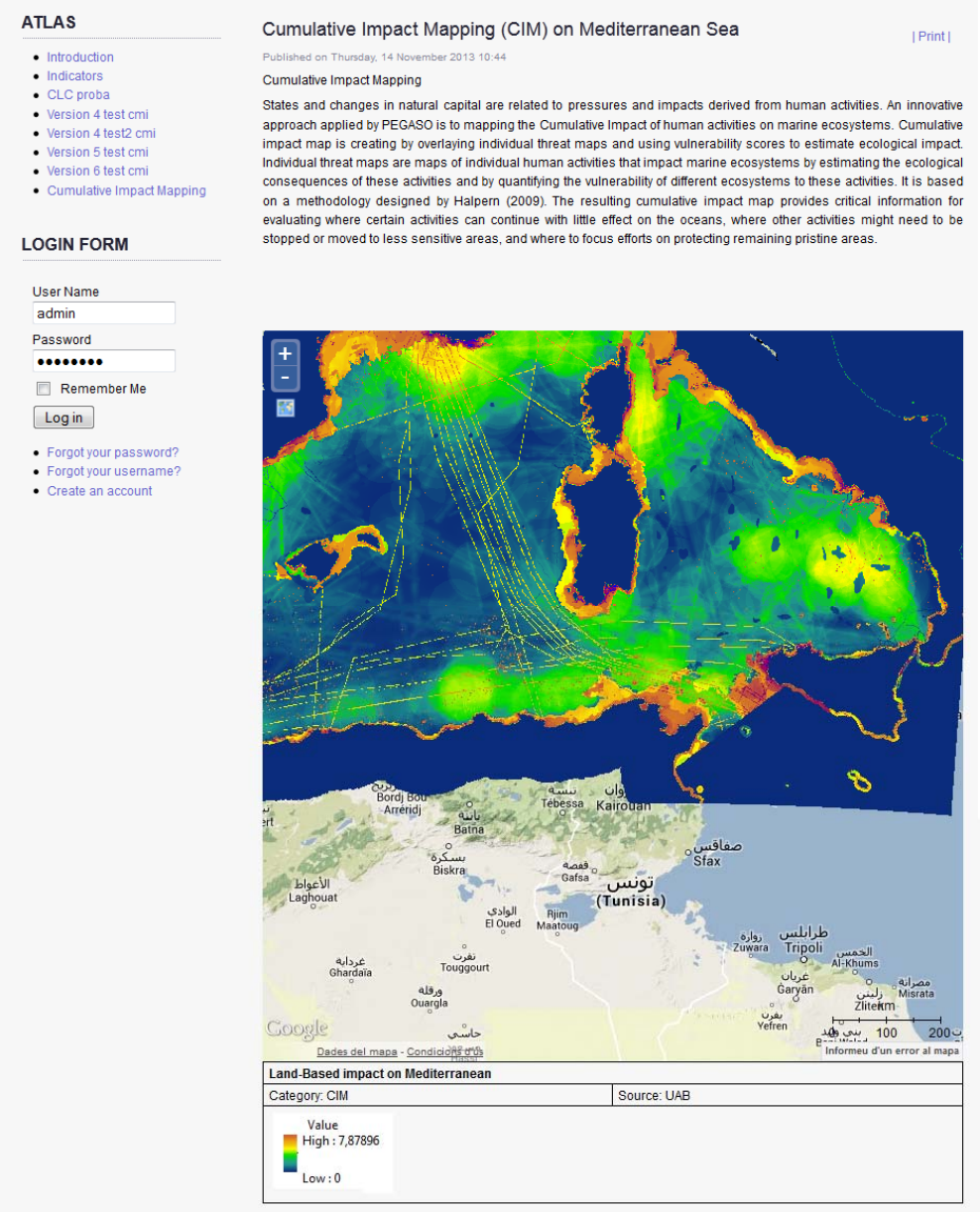
[4] *Joomla* technology (Content Management System) http://www.joomla.org/ was used to create PEGASO geoportal.

modify both sections and its content. The added value for normal articles in CMS is that those users have the possibility to insert maps on a section or a page.

Browse atlas pages

When user access PEGASOgeoportal, http://pegasosdi.uab.es/geoportal, Atlas pages can be found either by clicking *Atlas* menu sited on the top menu bar or by writing down the following URL http://pegasosdi.uab.es/geoportal/index.php/atlas.

Figure 15.Example of an Atlas map output



Create new atlas pages

Users can create content by clicking *Add New Article* option from administration back-end interface and system will automatically display a parameter-based configurable form to ease the creation of articles. One embedded component inside these forms is a text editor (see Figure 9 (a)) where an additional button has been added. This button will be responsible for the spatial awareness of created articles. When pressed, a form-based window is shown as appeared in Figure 9 (b), where some identifiable sections need to be explained:

- ***CSW Server***: Name ofCatalog servers from which layers will be fetched (e.g, PEGASOcatalog), using CSW protocol form the Open Geospatial Consortium (OGC).
- ***Name***: Name of atlas page (e.g, Al Hoceima)
- ***Category***: Category in which atlas page can be fallen under (e.g, CASES)
- ***Source***: Name of data provider(s) (e.g, University Mohamed V, UAB, VLIZ).
- ***Base Layer***: Selectable layers acting as background for overlay layers (Hybrid, Terrain, Street, OpenStreetMap, None)

Advanced Options: Two-column legend, map height and legend preview.

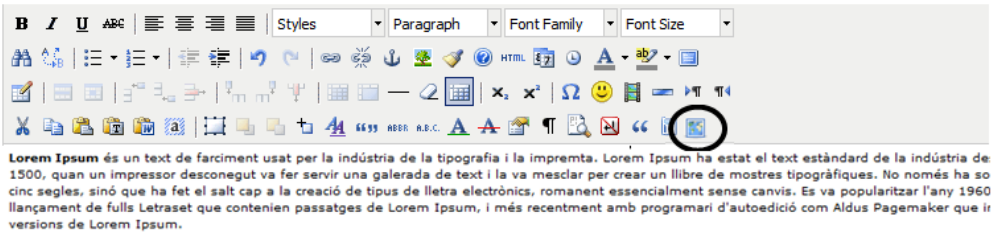
Within *Advanced options*, this creation form allows user (editor) to tailor the atlas page output. For instance, map height (700 *px*, by default) can be changed. This characteristic is very useful if several maps attached a one geoportal article are desired, not giving very long articles as result. Moreover, legend associated to each map containing layers can be displayed in one or two-columns, by grouping legend images for individual layers, being very useful for printing.

Central region contains a text area with loaded layers from selected CSW servers. Layers' title is the name of fetched layers that can be scrolled giving the abstract description. Green cross at right position adds its corresponding layer to interactive map. User can filter layer records by writing topic in the text area.

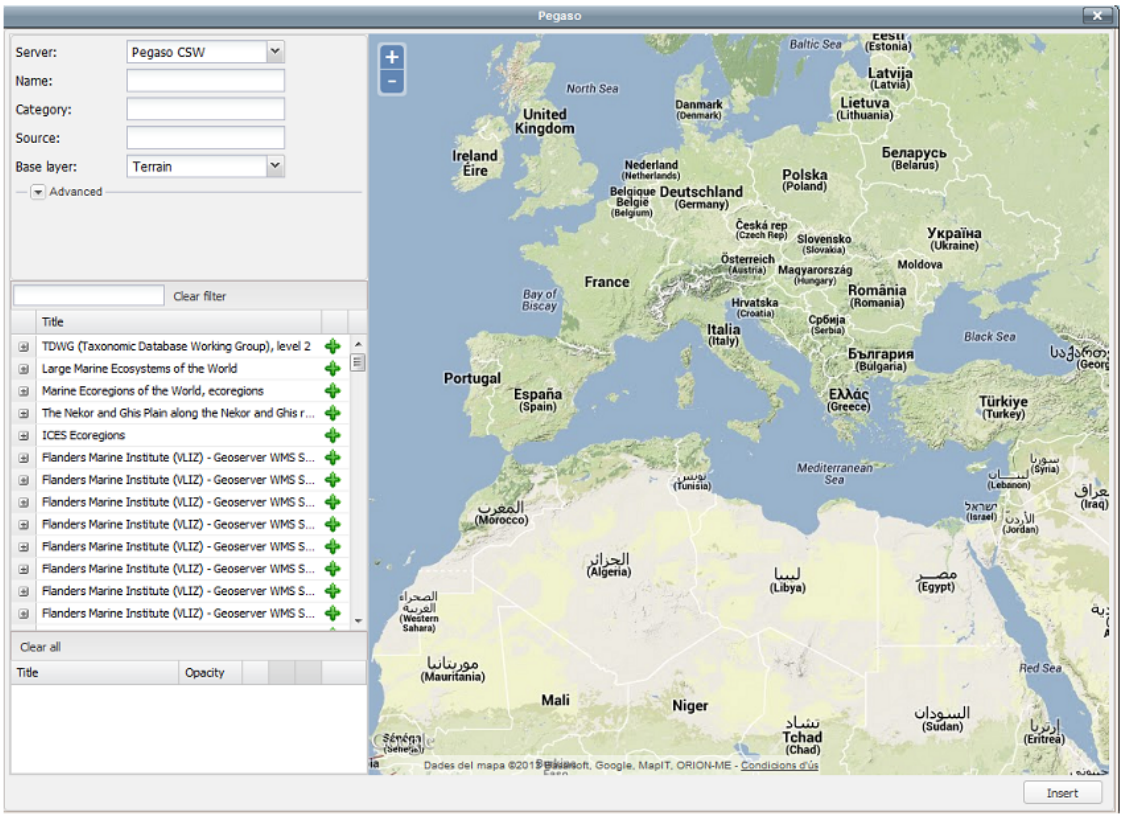
This tool will act as a client of a CSW catalog and WMS map server. However, the tool does not deal with WMS or CSW publication; it will assume the layers have been previously published on PEGASO SDI.
After pressing *Insert* button, an icon is embedded into text editor, jointly with text, tables, links, images that can help to describe the atlas pages. See Figure 16 (a). This icon can be clicked to update maps and layers as proceed in *Create new Atlas page* section. After finishing article creation session, resulting atlas pages in PEGASOgeoportal can be seen at Figure 16 (b).

Figure 16. The Atlas edition page snapshot (1)

(a)

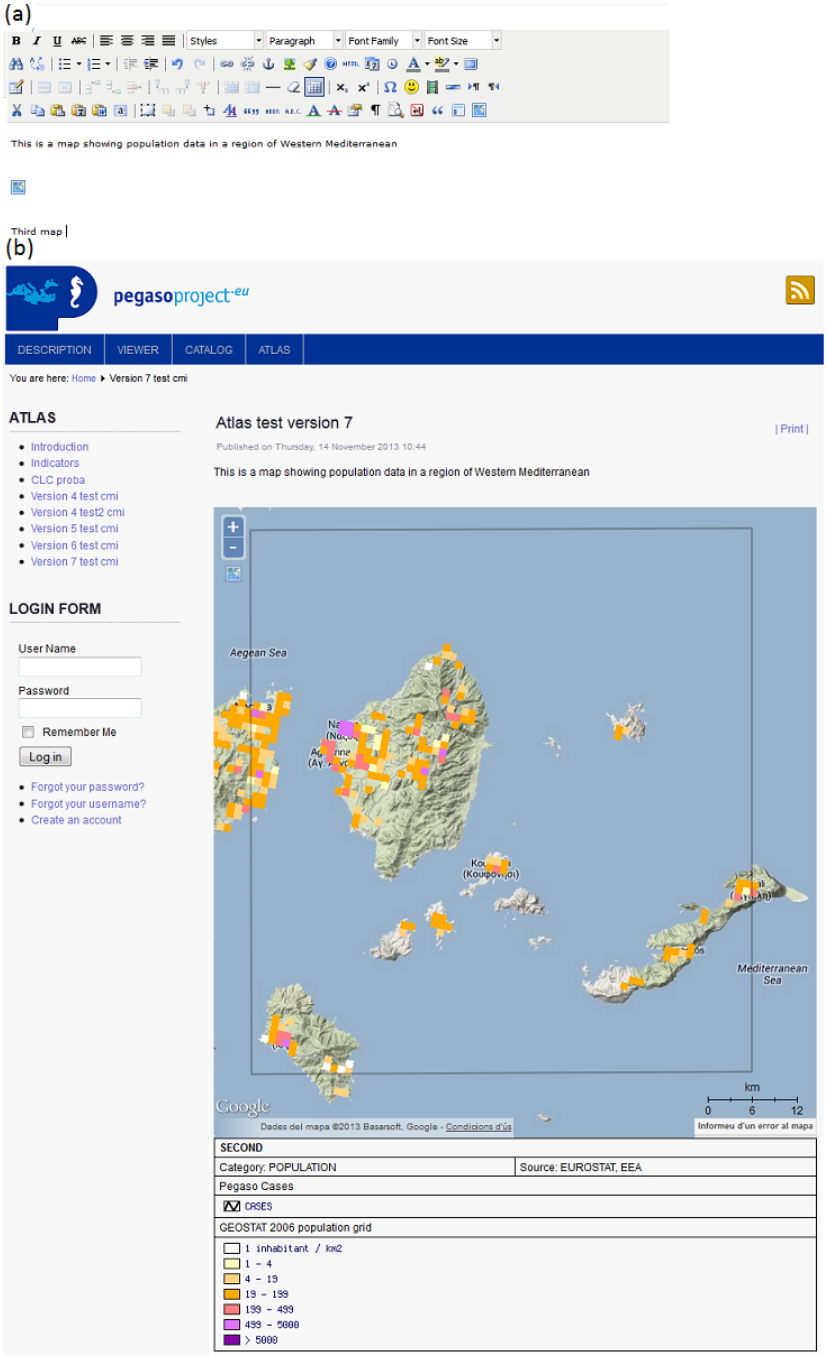


(b)



Note: (a) Figure is a TinyMCE text editor with several utilities to create rich content in CMS articles: links, images, tables... Blue button giving access to spatial functionality in articles is highlighted. (b) Configurable form to create atlas pages in PEGASOgeoportal. On the left, parameters to control CSW remote server and manage of fetched layers (map appearance, layer opacity and some categories to classify atlas pages. On the right, a simple map centered on Mediterranean Sea on which layers are overlaid, with map controls like zoom, pan to locate places. On the bottom, buttons to insert (or update) designed map in a geoportal page

Figure 17. The Atlas edition page snapshot (2)



Note: (a) Text editor in a Create new article back-end session after creating a map with layers directly with developed plugin in PEGASOgeoportal. (b) Resulting atlas page as seen in PEGASOgeoportal.

3.2. State of the art of PEGASOSDI

In its most generic sense, a SDI is a group of technologies, policies, standards, services and resources that enable the collection, handling, access, distribution and use of geographic information.

To implement and make accessible a SDI within an organization, several standards must be strictly followed so as to guarantee data access and exchange via Internet in an interoperable way. In essence, this means that independent of employed technology to deploy those web services one final user with a proper client software (e.g., browser) will be able to access geo information and resources. This is guaranteed by adopting spatial standardized protocols (OGC) for access, visualization, search and retrieve information.

Among main protocols implemented in PEGASO SDI to achieve interoperability in OGC services, the following can be cited as considered as the most common and required ones.

- WMS: Web Map Services
- WFS: Web Feature Services
- WCS: Web Coverage Services
- CSW: Catalogue Service for Web

There are versioned specifications for those protocols giving a detailed description of how request should be requested and how the response should be. For instance, WMS spec. can be found at http://www.opengeospatial.org/standards/wms.

WMS provides a simple HTTP interface for requesting geo-registered map images (png, jpeg, etc) from one or more distributed geospatial databases.
PEGASO WMS server can be accessed via URL http://pegasosdi.uab.es/ogc/wms
WFS provides a simple HTTP interface for creating, modifying and exchanging vector format (features) geographic information on the Internet. WFS responses are GML-encoding, that is a standard for geographical information exchange.

PEGASO WFS server can be accessed via URL http://pegasosdi.uab.es/ogc/wfs
WCS provides a simple HTTP interface for requesting geospatial information representing space-varying phenomena (coverages) on the Internet.

PEGASO WCS server can be accessed via URL http://pegasosdi.uab.es/ogc/wcs
CSW provides a simple HTTP interface to expose a catalogue of geospatial records on the Internet

PEGASO CSW server can be accessed via URL http://pegasosdi.uab.es/catalog

There are several available open-source and proprietary software that implement those standards and allow institutions and companies to deploy spatial OGC services. PEGASO SDI has chosen *MapServer*[5] and *GeoNetwork*[6] as reference technologies for WMS/WFS/WCS and CSW services, respectively.

Users can connect to those services through desktop GIS clients (ArcMap, Quantum GIS, etc) or thin clients viewers (Google Earth, PEGASO viewer). To be more precise, PEGASO viewer abstracts the complexity of WMS requests and displays maps on demand (as published layers in WMS PEGASO server) with concrete characteristics like size, zoom level, centring and adds functionality to help in online map browsing like zooming, panning, measurements. Moreover, PEGASO viewer is also a CSW client as explained in PEGASO viewer functionality.

A. Geonodes

PEGASO SDI is a trans-boundary infrastructure comprised of a distributed network of geonodes that shares data and services in a standardized and interoperable way. The delivery of a geonode is an ongoing process but a current picture of geonodes in PEGASO network up to date can be sketched as Figure 20.

Figure 18.PEGASO SDI as a distributed network of geonodes.

Note: Graphical symbols represent PEGASO partner institutions.

[5]MapServer v. 6.2 http://mapserver.org/

[6]GeoNetwork 2.64 http://geonetwork-opensource.org/

By geonode term we mean a data provider with accessible technological infrastructure to share its geoinformation.
A complete geonode consists of:

- A web map server with OGC WMS/WFS/WCS services to make the data and services available in Internet
- A metadata catalogue server with OGC CSW services
- A web client to display, search, download different kind of data sets
- A web site for geoportal

In the simplest case, a geonode consists of either a map server or a catalogue server. More complex alternatives to those cases can be possible, like both map and catalogue servers but delivery of a geonode requires technological capacities, skilled professionals to manage hardware and software issues and human resources to maintain a local infrastructure with updated resources. PEGASO SDI team has given advice and support partner institutions to deploy a suitable geonode solution, providing training and technical support.

One of the most benefits for a network of geonodes is that information is stored in server belonging to providing partners and, consequently as data maintainers, these institutions will be responsible for store, share and update their public spatial resources. For those partners that a geonode technical solution is not feasible, their data release should be available via central UAB geonode by FTP uploading datasets and associated metadata & symbolization.

UAB central geonode have published data layers, which are considered relevant for the project, serving as a reference layers for subsequent calculations. Information on Ramsar wetlands, EEA biodiversity products and land-use database such as Corine Land Cover, Natura 2000, Conservation status for habitats and species (Art.17), population grid data from Eurostat, administrative units (NUTS) and coastal and marine limits and regions, etc. In case that relevant information cannot be distributed by restrictions or copyright, links to direct download points or useful remote resources (external databases, viewers and so on) have been described in metadata catalogue.

PEGASO Project has put a lot of effort on capacity building in order to provide the partners the expertise required to construct their own geonode. At the same time, the required contacts and agreements have been pushed in order to implement the geonodes. However, this is a complex process both in the technical and the organisational aspects. Therefore, the results have not been homogenous, due to the different starting context, existing infrastructure, procedures and policies, etc.

The following partners already had a geonode that has been connected to PEGASOSDI:

- Flanders Marine Institute (VLIZ)
- UniversitatAutònoma de Barcelona (UAB)
- Université de Genève (Unige) / EnviroGRIDS

The following partners have built a geonode in the context of PEGASO project and it is currently connected to PEGASOSDI:

- Hellenic Centre for Marine Research (HCMR)
- Institute of Biology of the Southern Seas /Marine Hydrophysical Institute, The National Academy of Sciences of Ukraine (IBSS / MHI – NAS)

A third group of partners have developed a geonode developed outside the scope of PEGASO project, but unfortunately it has not been possible to connect them to SDI due to technical and organisational barriers:

- InstitutFrançais de Recherchepourl'exploitation de la Mer (IFREMER)
- National Authority for Remote Sensing and Space Sciences (NARSS)
- European Commission Joint Research Center (JRC)

At some point these barriers will be overcome and these partners will be able to join PEGASOSDI.

A fourth group of partners have been working on the implementation of their geonode but it has not been possible to bring them to an operational status yet, due to different questions regarding infrastructure and sustainability:

- Università Ca' Foscari Di Venecia (UNIVE)
- University of Balamand (UOB)

A fifth group of partners were not interested on building a geonode at the moment, but have used existing geonodes within PEGASO project in order to publish their data:

- The University of Nottingham, Centre for Environmental Management (UNOT / CEM) has published their results on UAB geonode, including PEGASO Land Cover and natural capital indicators
- Université Mohammed V-Agdal (UM5a) has published their results from Al-Hoceima CASE on VLIZ geonode
- Commission for the Protection of the Black Sea Against Pollution - Permanent Secretariat (BSC), published their results from Guria Coastal Region CASE on UNIGE/EnviroGRIDSgeonode

Finally, a group of partners attended the capacity building sessions and have gained an insight about the construction process of a geonode and an SDI, even if they did not finally implemented it:

- ACRI Etudes et Conseil (ACRI-EC)
- Association de Réflexion, d'Échanges et d'actions pour l'Environnement et le Développement (AREA-ED)
- Danube Delta National Institute (DDNI)
- International Union for Conservation of Nature (IUCN)
- Plan Bleu

As a conclusion, the process of building an SDI is complex and requires time and resources. The results of PEGASO SDI can be considered as satisfactory in terms of capacity building and establishment

ofagreements and networks of institutions working together towards the goal of the integrated coastal management.

3.3. Strengths and limits of PEGASO SDI

The most remarkable **strengths** are those derived from the effort made by the partners' institutions in sharing their data and that has driven to a set of commonly agreed layers.

- Agreement on local and regional indicators (see Indicators for the Med and the Black Sea)
- Overview and comparison of information at two scales (local and regional) through the analysis of 10 CASES distributed along the Mediterranean and the Black Sea basins.
- The analysis of coastal issues and the design of indicators and tools follows ICZM Protocol principles
- Diversity of local geonodes connection from project partners and Official Institutions (i.e. EEA) which allows a wide range of spatial data information.
- Added value tools to analyse and improve decision making processes such as Viewer (with ad hoc tools for analysis) and a Coastal and Marine Atlas.
- A Infrastructure open to Med and Black Sea: shared experiences
- Its success in developing inter-sectorial networks facilitating needed bridges between the various institutions managing the coast, including research centres and universities that participate frequently in some parts of the process, though mostly as technical developers and advisors.

The **limitations** of the existing SDI are linked to the time constrain for its implementation, however could be overcome during a second phase of the ICZM platform implementation.

- Low number of connected geonodes than expected, to set a geonode requires IT services that were not available in some Institutions.
- Despite a set of Guidelines for data harmonisation has been produced and distributed, there is still a need of data harmonisation beyond borders (national administrative boundaries, diverse spatial data and sources)
- Need of stakeholders and official institutions management of the tool and capacity building to understand and use the final results and products
- Need of more regional versus local experiences through the development of regional and local indicators sets.

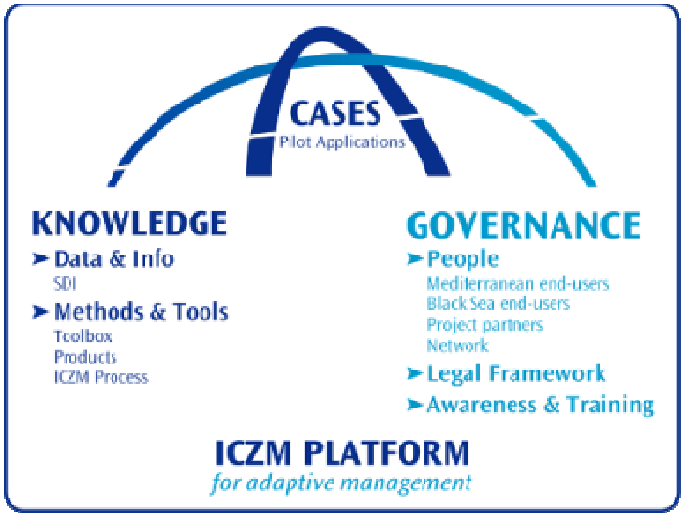
4. Conclusions

Increased knowledge of the environment including its health status, trends, impacts and resilience, ultimately leads to better decision-making, and a truly integrated and ecosystem-based management. The PEGASO SDI and its components, products and services available at the national and regional levels, contribute to the sustainable development and integrated management of marine and coastal areas in the Mediterranean and Black Sea regions.

The PEGASO SDI is developed within a legal framework (e.g. ICZM Protocol, UNEP-MAP, MSFD, etc.) and therefore enjoys a sound basis for legal and political support, and a perspective on a long-term sustainability.

It has been designed to respond in a user-friendly environment and to deliver real governance support (viewer, atlas). It has been empowered with lessons learned in previous initiatives and experiences from different regions and fields of interest. It is also unique in offering data in a regional and basin-wide perspective, in regions that have experienced a long-standing political, administrative and socio-cultural fragmentation. The PEGASO SDI is actually covering different continents in a joint vision; build by a unique ICZM governance platform that bridges science and policy, but also bridges continents. It provides specific data for ICZM within the coastal and marine Mediterranean and Black Sea regions that traditionally suffer from patchiness and fragmentation in the land-sea interface.

Figure 19.PEGASO ICZM Governance platform



The PEGASO SDI and its technical and human resources stimulate regional capacity building in areas of spatial data management, web development and data product delivery. The development of the PEGASO SDI also provides a tool to assist community building and collaboration in the region. It is in the first place a collaborative project and effort that draws on national human resources to identify issues of concern, define appropriate indicators and locate datasets that can be used in its services and shown in the atlas. In addition, data and information gaps that are needed to respond to real-world management issues and that requires additional resources, are identified.

However, in spite of the achievements, the technical progresses, and the many challenges to tackle, we must not lose sight of why PEGASO is building this SDI and investing significant Project (hence public) resources to do so. The SDI is certainly not an end in itself, but a means to improve the understanding and stewardship of the coastal and marine environment and a platform to develop our knowledge-based Governance for marine and coastal areas. In the absence of a clear view of the objective and the steps that still need to be taken to achieve these objectives, it is difficult or at least inefficient to follow the process, set priorities and address the existing challenges. It is therefore of utmost important to maintain this collaborative and joint effort and further build this joint vision for an improved and practical support to the ecosystem-based and integrated management of marine and coastal regions in the Mediterranean and Black Sea regions.

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PEGASO products

- ✓ SDI Brochure: A Shared Data Infrastructure (SDI) for integrated coastal management in the Mediterranean and Black Sea Basins

  http://www.pegasoproject.eu/images/stories/WP7/Pegaso2_En_Web.pdf

- ✓ Wiki articles based on SDI:
  1) The need for data sharing, PEGASO Wiki.
  http://www.pegasoproject.eu/wiki/The_need_for_data_sharing

- ✓ D3.1 - Report on the inventory of participant's and main relevant EU projects data and SDI, with a quality assessment and identification for needed actions on harmonisation tasks.
  http://www.pegasoproject.eu/images/stories/Pegaso-D3.1-VLIZ_110519-L-1.3.pdf

- ✓ D.3.2.B. Guidelines for an SDI construction. Geoportal and geonodes functionalities, included data harmonisation and interoperability, following INSPIRE principles, specially oriented towards capacity building with prototype.
  http://www.pegasoproject.eu/images/stories/WP3/D_3_2B__Content_20140207_final.pdf

Other relevant references

- ✓ Giuliani G., Ray N., Lehmann A. (2013) Building Regional Capacities for GEOSS and INSPIRE: a journey in the Black Sea Catchment. International Journal of Advanced Computer Science and Applications EnviroGRIDS Special Issue on "Building a Regional Observation System in the Black Sea Catchment":19-27. WWW

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