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Connecting the EnviroGRIDS Black Sea Catchment Observation System to ICZM

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Abstract

The Black Sea catchment is internationally known as one of ecologically unsustainable development and inadequate resource management, which has led to severe environmental, social and economic problems. The EnviroGRIDS @ Black Sea Catchment project addresses these issues by bringing several emerging information technologies that are revolutionizing the way we are able to observe our planet. The Group on Earth Observation Systems of Systems (GEOSS) is building a data-driven view of our planet that feeds into models and scenarios to explore our past, present and future. EnviroGRIDS aims at building the capacity of scientist to assemble such a system in the Black Sea Catchment, the capacity of decision-makers to use it, and the capacity of the general public to understand the important environmental, social and economic issues at stake. EnviroGRIDS will particularly target the needs of the Black Sea Commission (BSC) and the International Commission for the Protection of the Danube River (ICPDR) in order to help bridging the gap between science and policy. This will allow the project to benefit from an existing large network of potential end-users and national authorities. In return these commissions will be able to use the results of the EnviroGRIDS project to accomplish their mission. EnviroGRIDS objectives, in particular, match perfectly those of the Black Sea Commission, enabling it to become a central piece of information system in the region. EnviroGRIDS will also build a strong collaboration with the new PEGASO project on integrated coastal zone management in the Mediterranean and Black Sea. Indeed, understanding the relationships between the expected changes in the catchment area and the ongoing development of coastal zones is of crucial importance for the future of the Black Sea region.

Introduction to EnviroGRIDS @ Black Sea Catchment

EnviroGRIDS (acronym and publicity name for EU funded FP7 project entitled Building Capacity for a Black Sea Catchment Observation and Assessment System supporting Sustainable Development) is designed to bring emerging new information technologies to significantly upgrade the way we can observe the Black Sea Catchment, which is the internationally known example of ecologically unsustainable development and inadequate resource management (WWF, 2008). At the same time the Black Sea Catchment (Fig. 1) represents a very interesting case study to test the capacity of integrating large data sets to observe and assess vulnerability and sustainability issues related to freshwater resources and land cover changes with spatially at various scales. EnviroGRIDS is funded by the European Union under Framework Programme 7 for duration of four years (start: April 1st 2009).

EnviroGRIDS is essentially concentrating on the terrestrial part of the catchment and its scientific aim is to assemble an observation system for the Black Sea Catchment that would address several GEO Societal Benefit Areas within a changing climate framework and capable of developing and implementing system of spatially explicit indicators to observe the state of vulnerability. It will contain an early warning system able to inform in advance decision-makers and the public about risks to human health, biodiversity and ecosystems integrity, agriculture production or energy supply caused by climatic, demographic and land cover changes on a 50-year time horizon.

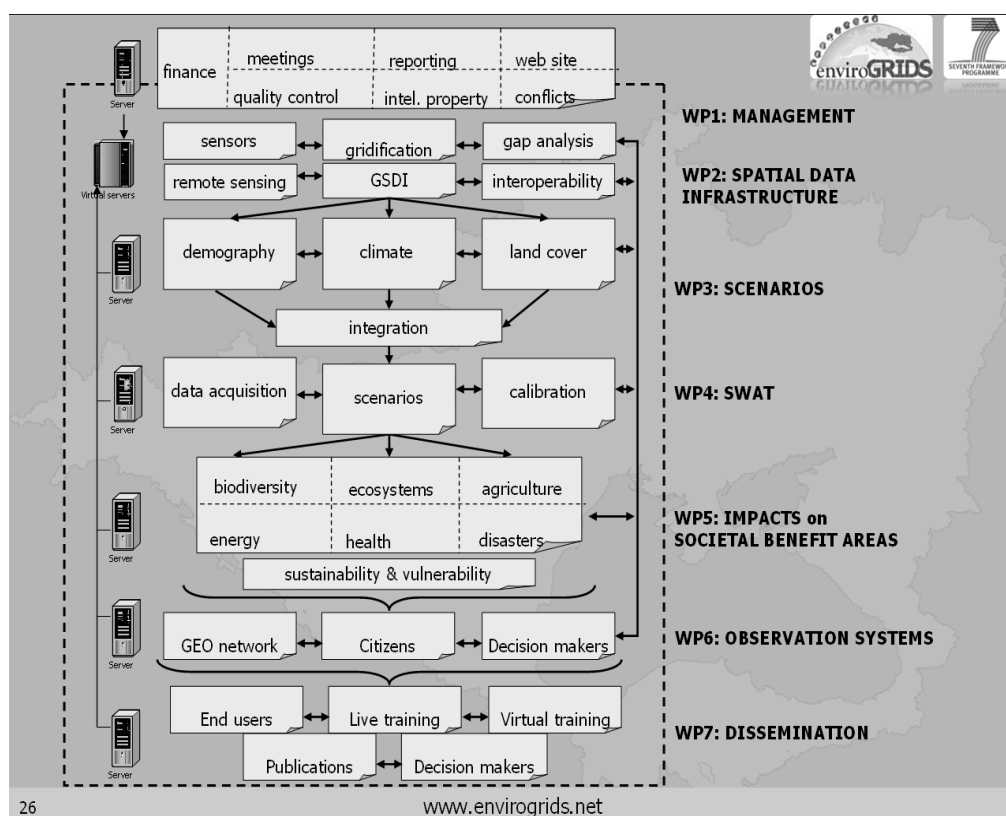


Fig. 2: EnviroGRIDS work flow and organisation

Spatial Data Infrastructure

EnviroGRIDS aims to create a Grid enabled Spatial Data Infrastructure (GSDI) so that the data necessary for the assessment of GEO Societal Benefit Areas, as well as the data produced within the project can be gathered and stored in an organized form on the Grid infrastructure and distributed across the Grid in order to provide a high performance and reliable access through standardized interfaces. Using the standardized technologies of the Grid EnviroGRIDS can provide a Single Information Space for environmental data in the Black Sea Catchment.

First a gap analysis will be made by all project partners to analyse the state of development of SDI in the different countries within the Black Sea Catchment under the supervision of BSC PS and ICPDR partners. The recommendations derived from the gap analysis should aim at complementing the existing geographical information systems of the ICPDR and BSC, and EnviroGRIDS SDI will therefore be replicated within the BSC and/or ICPDR architecture. It will serve also to bring new partners from the Black Sea countries into the project in order to fill some thematic or technical gaps. In addition to Grid-enabling the SDI, the integration of remote sensing data from airplane and satellite into the Grid architecture will be organized in collections of freely available scenes that will be accessible through the different partners.

EnviroGRIDS GSDI will allow distributing intensive calculations such as those needed for hydrological modelling and calibrations on the largest grid computing infrastructure in the world, developed through the EGEE project at CERN. This system will be fully compatible with development made on interoperability standards such as INSPIRE, GEOSS, UNSDI, OGC, SensorML or TML. Grid services can be used to replicate and distribute the data from source sites to other data centres to improve data availability and increase computational performance.

Scenarios of Change

The project is going to implement a set of models and tools for the production of demographic, climatic and land cover change scenarios at the Black Sea Catchment scale. These individual scenarios will be integrated with a descriptive storyline in concordance with global scenarios such as those proposed in the UNEP Global Environment Outlook or the IPCC reports.

The objectives here are:

- To create spatially explicit scenarios on demographic changes
- To create spatially explicit scenarios on climate change
- To create spatially explicit scenarios on land cover changes
- To integrate the outputs of the three scenarios

On the basis of widely accepted demographic scenarios, the system will allow the simulation of future populations at regional (2000-2030), national and subnational levels (2000-2050) with estimation of confidence intervals (i.e. high, low and medium variants as proposed in UN and Eurostat scenarios).

The interaction between land use and climate variability and change is poorly understood and will require the development of new models linking the geophysics of climate with the socioeconomic drivers of land use. Providing a scientific understanding of the process of land use change, the impacts of different land use decisions and the ways that decisions are affected by a changing climate and increasing climate variability are priority areas for research.

Catchment Hydrological Models

New advances in computing technology plus data availability from the Internet have made high resolution modelling of distributed hydrologic processes possible. Using the program Soil Water Assessment Tool (SWAT) (Arnold *et al.*, 1998) (<http://www.brc.tamus.edu/swat/>), EnviroGRIDS project will apply a high-resolution (sub-catchment spatial and daily temporal resolution) water balance model to the entire Black Sea Catchment (BSC). The BSC model will be calibrated and validated using river discharge data, river water quality data, and crop yield data. Calibration and validation based on evapotranspiration and runoff ensure a correct aquifer recharge and soil water storage component. As part of the modelling work, uncertainty analysis will also be performed to gauge the confidence on all model outputs. As SWAT is an

integrated model containing a large agricultural management component, the spatial variation in the quality of water balance components will provide a good indication of critical regions across the BSC. Subsequent analyses of land use change, agricultural management change, and/or climate change can then predict the consequence of various scenarios.

SWAT will be gridified to run on the EGEE infrastructure and to store the results of the different scenarios. These results will be queries from web services built in the BSC OS. The gridified code of SWAT will become a geoprocessing service that can be called from various clients such as SWAT users or web clients.

Impacts on Selected Societal Benefit Areas

EnviroGRIDS involves the analysis of the impacts of the climate, land use and demographic scenarios on river catchment processes, primarily water quality and quantity. Based on this analysis the impacts of all these changes will be assessed on selected Societal Benefit Areas in the present and the future. The emphasis will be on impacts on ecosystems, biodiversity, agriculture, health and energy sectors.

Methodologies employed will be grounded in integrated environmental assessment and the analysis of impacts in the context of the Driving force-Pressure-State-Impact-Response framework, as applied in UNEP's GEO-4 report (UNEP, 2007) at the global scale and as subsequently translated into sub-global applications. In order to ensure the analysis reflects policy priorities and stakeholder perspectives, participatory methods in the form of stakeholder dialogues will be embedded throughout the process, from the identification of major impact areas to the mapping of impact pathways. Analysis of projected vulnerability will be synthesized based on the relevant results of the demographic, climatic and land cover change scenarios and the hydrological catchment model runs. This synthesis will allow building a solid analytic foundation for the identification of adaptation options, which will firmly connect the project to actual users of the information and impact them in positive ways.

In addition to above listed societal benefit areas and impact calculations, specific emphasis will be put on tackling flood risks. A spatially wide distributed system like the Black Sea Catchment is subjected to severe flood impacts like the extreme flood events in the years 2002, 2005, 2006. The purpose of one of the sub-tasks will be to develop and test Early Warning Systems as non-structural flood mitigation measures.

Black Sea Catchment Observation System

The project will organise all its activities to developing a Black Sea Catchment Observation System (BSC-OS) in a harmonised way (Fig. 3). The overall aim is to enhance the use of EnviroGRIDS SDI with an Observation System centred on two specific goals: to raise awareness of Societal Benefit Issues of the general public and to build regional capacities on GEO and INSPIRE new standards and approaches.

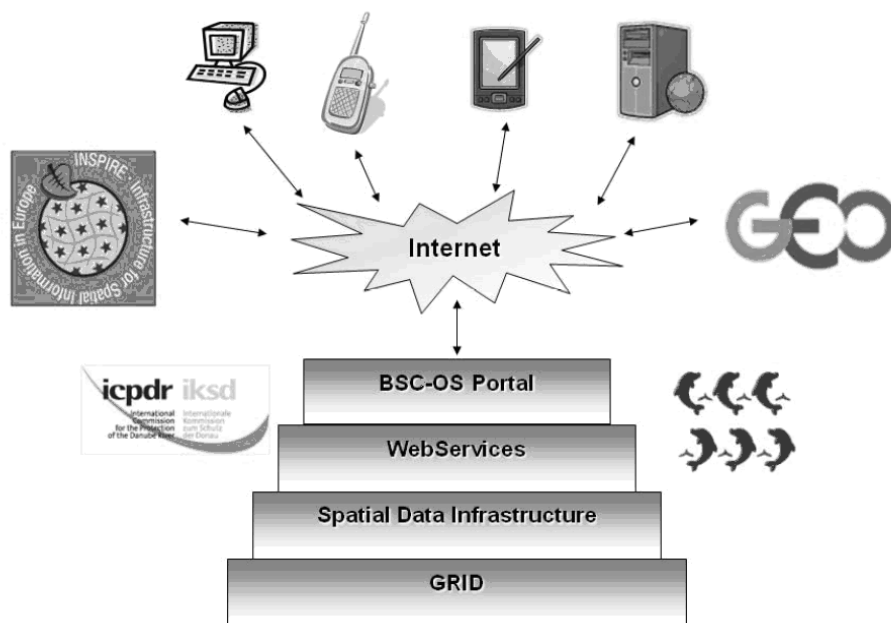


Fig. 3: Black Sea Catchment Observation System complete with a portal for the EnviroGRIDS Spatial Data Infrastructure

In the first place, the outputs of the EnviroGRIDS project will be brought to the general public through a Graphical User Interface and other visualisation tools, and in providing guidance and help functions for the entire computer based knowledge sharing through a Web Portal and platform. In a second place, the BSC-OS will be used and tested with decision-makers and the public.

One of the main focuses of the project will be to develop adaptive components for custom-based content delivery to various actors in Integrated River Basin Management (IRBM) and concerned citizens. It will also cover a description of the decision making context in a given river basin so that the main actors and their inter-relationships will be considered together with the descriptions of the physical system and the problem at hand. This approach will enable the informed citizens' involvement through the process of learning about the social and physical aspects of a given river basin.

Dissemination and Training; Involvement of Decision- and Policy-Makers

The objectives of this part of EnviroGRIDS can be summarized as follows:

- To involve decision- and policy-makers in the Black Sea Catchment and disseminate project results through ICPDR and BSC (Fig. 4).
- To build capacity of end-users in the Black Sea catchment for the domains of EnviroGRIDS; thereby contributing to the Global Earth Observation System of Systems (GEO) by means of workshops, conferences and virtual platforms.
- To promote the sustainability of partnerships and enhance local ownership of the data and outcomes.

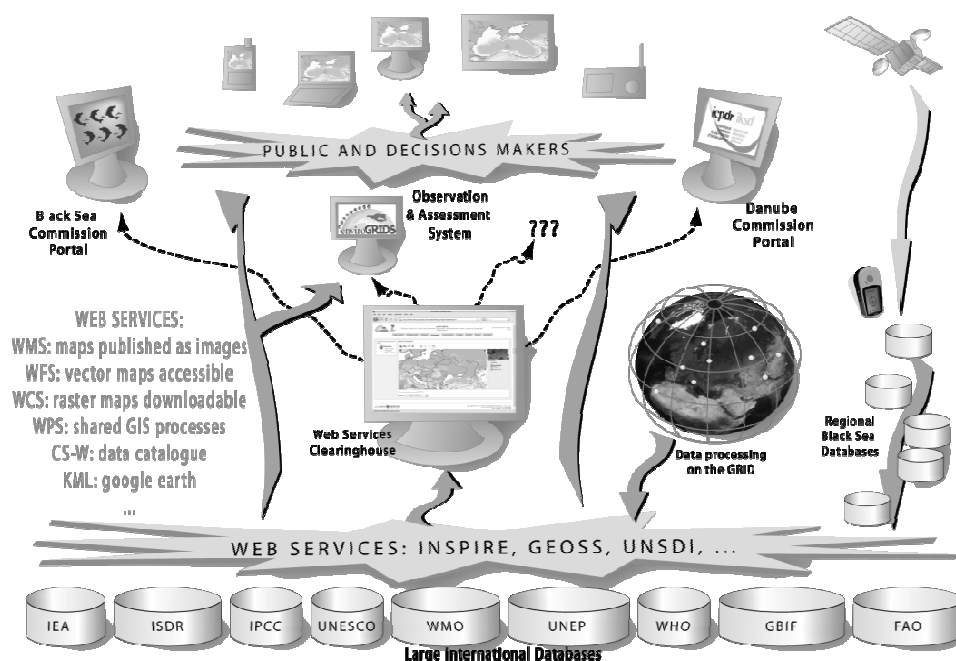


Fig. 4: EnviroGRIDS data flow through web services

The communication activities will be targeted to higher level policy processes and international platforms able to influence the development and implementation of policy in the Black Sea Catchment. To achieve this, the partners will develop a strategy early in the project in which they will identify the most important policy and implementation process targets and the key institutions and fora to engage during the project. It will include a strong engagement of the ICPDR and BSC and will contribute to the Global Earth Observation System of Systems (GEOSS).

To ensure a sustained engagement of the end-users, a post implementation plan will be setup. This plan will essentially concentrate on the needs of the BSC and ICPDR by making sure that they can continue to use the spatial data infrastructure built during the project, as well as the Observation System.

Developing Sustainability and Vulnerability Indicators through EnviroGRIDS

The development of integrated indicator systems was energized around the world by the introduction of sustainable development as a societal goal in the early nineties. Since then a large and still growing number of countries, municipalities, communities and other entities have started developing indicator systems reflecting their key policy priorities and helping to communicate progress to a wide range of policy audiences and the public (Pintér *et al.*, 2005). While indicator development and use has progressed, the field continues to face critical challenges some of which EnviroGRIDS will directly address. While the development of indicators on multiple scales is by itself a sign of success, it also led to a large and growing diversity of often incompatible indicator approaches. This of course not only constrains comparability of indicators developed in different contexts, but also limits the effectiveness of policy

coordination, particularly with regard to policies that cut across multiple jurisdictions, such as EU policies. While core indicator sets have been developed also by many organizations, making these accepted in various local jurisdictions that always face some unique issues is not straightforward.

Another key area of weakness associated with indicator systems is the availability and quality of suitable data. Regardless of jurisdiction, data sets in support of indicators almost without exception have serious data gaps both in the temporal and spatial sense and in terms of data quality. Also, in many cases indicators are still just plain statistical measures without spatial texture. This is helpful when it is enough to communicate trends through simple charts, but it also hides spatial realities that are often critical for understanding the nature of vulnerability and sustainability problems or to identify solutions and policy responses. Although it is a growing area, geospatial information is still rarely used to support indicators. EnviroGRIDS will enable to add, on a systematic basis, the spatial dimension to indicators, therefore providing far more accurate information on watershed and associated processes. In addition, the system would also provide geospatial information in time series which is critical for understanding the dynamics of most landscape processes. Thirdly, related to the last point, in present practice indicators are typically presented in a retrospective context that is based on historical data. This is helpful when trying to evaluate changes in the past and understanding policy effects and effectiveness in the ex post sense, but does not make use of the potential of indicators to help plan and evaluate policies ex ante. By explicitly connecting historic trends with business as usual and alternative projections using the same indicators, EnviroGRIDS will not only help learning from the past, but also serve as a directly useful tool when developing and evaluating policy options for the future.

Connecting EnviroGRIDS to Integrated Management of River Basins & Coastal Zones

EnviroGRIDS approach

To demonstrate the applicability of novel approaches and sets of EnviroGRIDS driven sustainability and vulnerability indicators, harmonizing their application across the river basins and coastal zones, two pilot case areas will be identified from two regions in the Black Sea catchment, one adjoining the sea coast and another in the upstream catchments. For these two pilot case studies, the main actors involved in river basin and coastal zone management activities will be identified, together with their respective responsibilities. Data, model results and predictions for future scenarios will be associated with these actors and their responsibilities. The aim will be to present to the citizens of the regions an integral view which will cover both the physical / environmental aspects of the issues at hand and the social / institutional actors involved. Spatially explicit sets of indicators will be exploited for the analysis of watershed processes in both of these upstream and shoreline catchments.

Cooperation with PEGASO

PEGASO (2009) is the forthcoming large-scale integrated collaborative project under the European Commission's 7th Framework Programme (FP7), coordinated by the

Universitat Autònoma de Barcelona (UAB), with participation of the Permanent Secretariat of the Black Sea Commission among twenty-five project participants in the capacity of both the full partner and as the project beneficiary.

The aim of PEGASO is to build on existing capacities and develop common novel approaches to support integrated policies for the coastal, marine and maritime realms of the Mediterranean and Black Sea Basins in ways that are consistent with and relevant to the implementation of the ICZM Protocol for the Mediterranean. One of the objectives of PEGASO is to refine and further develop efficient and easy to use tools, including progress indicators, for making sustainability assessments in the coastal zone.

To that end, PEGASO will streamline efforts to create a set of relevant, well supported and operational spatially explicit indicators that will facilitate comparisons across the region in a standardised and transparent way. The work will follow the guidelines of DEDUCE (2007) which argued that it is easier to integrate different dimensions within a spatial framework because conflicts on land and sea are placed in a geographical context. The Driving force-Pressure-State-Impact-Response framework will be used to explore linkages and cause-effect relationships among different indicator elements. PEGASO will identify combinations of different indicators together to give the best possible integrated vision of sustainability issues in the coastal zone, and suites of regional vulnerability indicators that can be used to inform coastal authorities in the implementation of effective planning and management processes.

EnviroGRIDS and PEGASO share a common vision through participation of several important partners (UAB, GRID/University of Geneva, Black Sea Commission and its subsidiary bodies through Permanent Secretariat). These two projects hold substantial capacity to streamline the research in developing spatially explicit sustainability indicators and derive harmonized indicator subsets visualizing vulnerabilities across the river basins and the coastal zones of the Southern European and the Black Sea countries.

Acknowledgements

27 partners participate in the EU funded FP7 EnviroGRIDS project: UNIGE & UNEP Switzerland (lead); ARXIT Switzerland; AZBOS Ukraine; BSC Turkey; BSREC Bulgaria; CCSS Czech Republic; CERN Switzerland (Int.); CRS4 Italy; DDNI Romania; DHMO Ukraine; EAWAG Switzerland; GeoGraphic Georgia; IBSS Ukraine; ICPDR Austria; IGAR Romania; IHE The Netherlands (UN); ITU Turkey; NIHWM Romania; ONU Ukraine; SPBSU Russian Federation; TNU Ukraine; UAB Spain; USRIEP Ukraine; UTCN Romania; VITUKI Hungary; SORESMA Belgium; NIMH Bulgaria. This paper follows the contents of the EnviroGRIDS Description of Work developed by project partners through respective contributions (EnviroGRIDS, 2008).

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Appendix: Description of Important Abbreviations Used in the Manuscript

BSC PS: The Commission on the Protection of the Black Sea against Pollution (the Black Sea Commission or BSC) via its Permanent Secretariat is the intergovernmental body established in implementation of the Convention on the Protection of the Black Sea against Pollution (Bucharest Convention), its Protocols and the Strategic Action Plan for the Rehabilitation and Protection of the Black Sea.

BSC OS: Black Sea Catchment Observation System that will be built in the EnviroGRIDS project.

EGEE: Enabling Grid for E-Sciences is the largest multi-disciplinary grid infrastructure in the world, which brings together more than 140 institutions to produce a reliable and scalable computing resource available to the European and global research community. At present, it consists of approximately 300 sites in 50 countries and gives its 10,000 users access to 80,000 CPU cores around-the-clock

GEO: The Group on Earth Observations is coordinating efforts to build a Global Earth Observation System of Systems, or 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. GEO is a voluntary partnership of governments and international organizations. It provides a framework within which these partners can develop new projects and coordinate their strategies and investments. As of November 2008, GEO's Members include 76 Governments and the European Commission. In addition, 56 intergovernmental, international, and regional organizations with a mandate

in Earth observation or related issues have been recognized as Participating Organizations.

GEOSS: The Global Earth Observation System of Systems will provide decision-support tools to a wide variety of users. As with the Internet, GEOSS will be a global and flexible network of content providers allowing decision makers to access an extraordinary range of information at their desk.

ICPDR: The International Commission for the Protection of the Danube River (ICPDR) works to ensure the sustainable and equitable use of waters and freshwater resources in the Danube River Basin. The work of the ICPDR is based on the Danube River Protection Convention, the major legal instrument for cooperation and transboundary water management in the Danube River Basin.

INSPIRE: Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE) was published in the official Journal on the 25th April 2007. The INSPIRE Directive entered into force on the 15th May 2007. The initiative intends to trigger the creation of a European spatial information infrastructure that delivers to the users integrated spatial information services. These services should allow the users to identify and access spatial or geographical information from a wide range of sources, from the local level to the global level, in an inter-operable way for a variety of uses. The target users of INSPIRE include policymakers, planners and managers at European, national and local level and the citizens and their organisations. Possible services are the visualisation of information layers, overlay of information from different sources, spatial and temporal analysis, etc...

ICZM: Integrated Coastal Zone Management (ICZM) is an approach increasingly applied world-wide for achieving sustainable development along the coast. In 2002, the European Parliament and Council of Europe issued an ICZM Recommendation, which calls on the EU countries to develop ICZM Strategies and create legal and institutional structures for the implementation of ICZM. The Black Sea Commission has also been promoting ICZM at a regional level, in particular through the ICZM Advisory Group to the Black Sea Commission and a Regional ICZM Strategy and Action Plan.

OGC: The Open Geospatial Consortium, Inc.® (OGC) is a non-profit, international, voluntary consensus standards organization that is leading the development of standards for geospatial and location based services.

SDI: Spatial Data Infrastructure 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.