Open source tools to support Integrated Coastal Management and Maritime Spatial Planning

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ABSTRACT

This paper describes an open source suite of libraries and tools to support research activities on marine and coastal environment. The suite was initially implemented for the ADRIPLAN portal, an integrated web platform aimed at supporting Maritime Spatial Planning (MSP) activities and other activities concerning the managing of marine environment for the Adriatic-Ionian region. The main elements of the implemented solutions are: i) a GeoNode implementation for sharing geospatial datasets and maps; ii) a new python library (RectifiedGrid) that facilitates the work with geographical grid data; iii) a new python library (MSPTools) to perform spatial analysis and assessment of human uses, pressures and the potential impact of maritime and coastal activities on the environment; iv) a new GeoNode plugin (called GeoNode-MSPTools) that provides interactive widgets to set up the analyses and to visualize and explore the results.

The MSP Tools and the developed software have been released as FOSS under the GPL3 license and are currently under further development.

Keywords: maritime spatial planning, open source, spatial analysis, geographic information systems, python

INTRODUCTION

Management and planning of coastal and marine areas are complex processes that are more and more required to effectively support a coordinated development of socio-economic activities while preserving the environment using ecosystem-based approaches (European Union, 2014; Center for Ocean Solutions, 2011; Douvere, 2008). Practical tools to support the implementation of the various steps of Maritime Spatial Planning (MSP) have been developed in various contexts and also analysed to evaluate their usability for different purposes (Stelzenmüller et al., 2013).

A series of tools to support Ecosystem Based Management have been recollected and classified by the "EBM tools network" (`https://ebmtoolsdatabase.org/`), with respect to type, costs, skills, data and technological requirements. Considering as a central point of MSP the management of conflicts between marine uses, the project COEXIST (Stelzenmüller et al., 2013) developed a tool to analyse the level of coexistence among uses, depicting areas where different sectors more likely overlap in space and time.

Various authors proposed methodologies to create cumulative impact maps to reconnect the effects of human uses of the sea on environmental components, starting from the methodology firstly introduced by Halpern et al. (2008) at global scale, then implemented in several Marine Regions (Mediterranean by Micheli et al. (2013), Baltic Sea by (Korpinen et al., 2013), and North Sea (Andersen et al., 2013)). In particular, Stock (2016) developed an open source software for mapping human impacts on marine ecosystems.

This paper presents a set of open source tools developed to support the implementation of Maritime Spatial Planning in the Adriatic and Ionian Region, with a specific focus on the analysis of conflicts between marine uses and the analysis of cumulative impacts (CI) of human activities on marine environments.

The suite of tools composes an integrated system where data are managed over the entire workflow, from the collaborative upload in a web portal, the creation of metadata, portrayal styles, aggregated maps, the set up of uses cases and the elaboration through specific modules producing final maps and descriptive reports.

IMPLEMENTATION AND ARCHITECTURE

In the view of integration of available software and development of new tools, the architecture described in Figure 1 has been developed.

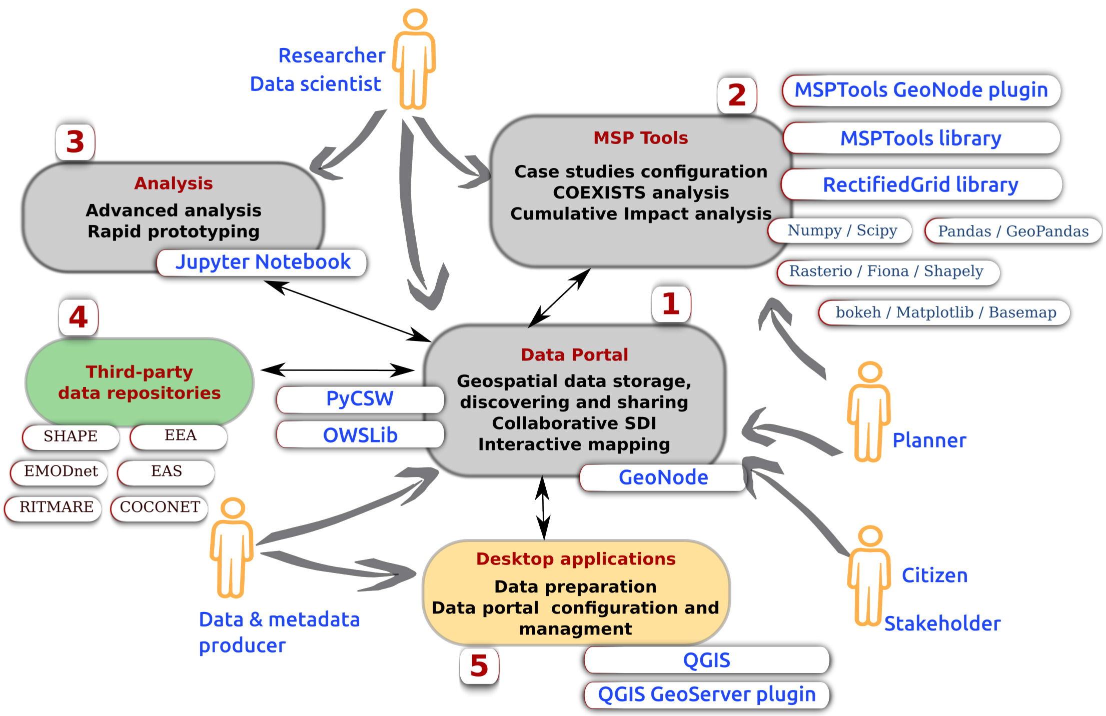

Figure 1. Simplified architecture of the ADRIPLAN portal for data management and analysis.

The ADRIPLAN portal (`http://data.adriplan.eu`) is the reference tool used to manage the data during the ADRIPLAN project (Barbanti et al., 2015) and it's based on the GeoNode software.

GeoNode (`http://geonode.org/`) is a django-based web platform for developing community-based spatial data infrastructures (SDI). GeoNode makes it easy to upload and manage geospatial data, to discover the resources and make content available via standard OGC protocols and to assemble web mapping applications.

The MSPtools are the main methodological tools developed and used in the ADRIPLAN project. The tools have been developed with the intent to carry out collaborative analyses and to improve the transparency of the whole analysis workflow.

The GeoNode-MSPTools plugin allows users to run experiments, simulations and analyses interacting directly with the data stored inside the Data Portal. The user can build several scenarios (called Case Studies) by choosing the analysis area, the data layers, the analysis grid cell and can produce and share the analysis results in terms of reports, tables, graphs and layers.

The core functionalities and analysis capabilities are implemented by the MSPTools module, a python stand-alone library able to operate independently from the GeoNode software. Currently, the MSPTools implements the COEXIST analysis and the Cumulative Impact analysis but it's designed to be extensible and to allow the integration of other modules related with the MSP process like scenario planning and

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analysis, sectoral aspects (traffic, fishery, aquaculture, energy, etc.), socio-economic aspects, participation processes.

RectifiedGrid is the lower level library which, combining into a single class several python packages (e.g. Numpy, SciPy, shapely, rasterio, fiona, geopandas, owslib, matplotlib-basemaps), simplifies geospatial grid-based analyses. Basically, it extends the numpy MaskedArray class by adding geospatial functionalities (i.e. projection awareness, bounding boxes). RectifiedGrid employs rasterio and fiona under the hood for raster and vector I/O and owslib to access data through OGC interoperable services.

The ADRIPLAN portal is completed by a Jupyter Notebook implementation which allows a more flexible and data exploration and analysis and for rapid prototyping of new analyses.

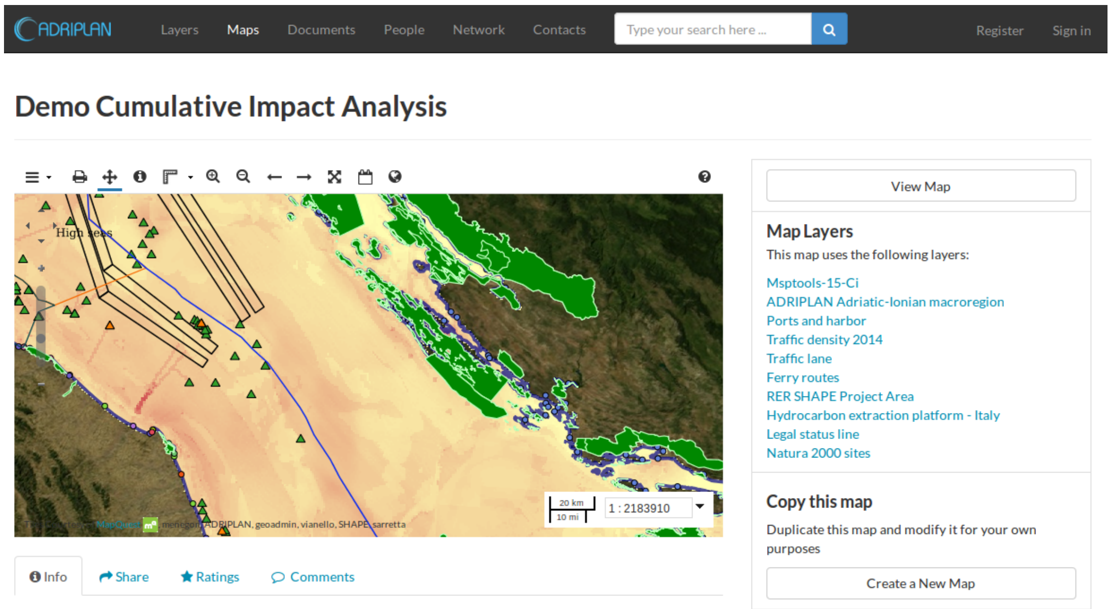

Figure 2. Example of the MSPTools output: map of the spatial distribution of the cumulative impact integrated in the ADRIPLAN portal.

Source code

The software is available at the following repositories:

RectifiedGrid

Source code `https://github.com/CNR-ISMAR/rectifiedgrid`

License GPL3

MSPTools

Source code `https://github.com/CNR-ISMAR/msptools`

License GPL3

GeoNode-MSPTools

Source code `https://github.com/CNR-ISMAR/geonode-msptools`

License GPL3

CONCLUSIONS

We developed a set of open source tools to support the implementation of Coastal Zone Management and Maritime Spatial Planning in the Adriatic and Ionian Region. Three new python modules and libraries have been integrated to manage data over the entire workflow, from the collaborative upload in a web portal, the creation of metadata, portrayal styles, aggregated maps, the set up of uses cases and the elaboration

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through specific modules producing final maps and descriptive reports. The integration of such a suite of open source tools allows a transparent, reproducible, highly interactive application of solid methodologies already applied with a specific focus on the analysis of conflicts between marine uses and cumulative impacts of human activities on marine environments. The integration of new modules will further improve the decision-support capabilities of the ADRIPLAN Portal. The products (maps, graphs, reports) are being used to support the development of maritime spatial plans within the implementation process of the MSP Directive (2014/89/CE) in various case study areas and marine waters in the Mediterranean sea. Furthermore, the release of the python tools under a GPL licence is a guarantee of possible future extensions and adaptation to other environmental domains and applications.

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