A Geospatial Decision Support System for climate change risk assessment and management

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ABSTRACT

DESYCO (DEcision support SYstem for COastal climate change impact assessment) is a GIS based Decision Support System which has the main aim of assessing the impacts related to climate change in coastal areas and related groundwater systems (e.g. sea level rise, storm surge floodings, changes in water quality, decrease of groundwater level and salt water intrusion in the aquifer). The system integrates different components: i) a geodatabase for the management of all available data useful for the application and their metadata, ii) automated customized tool for the application of the methodology, iii) Graphical User Interfaces (GUI) that simplify the interaction of the final user with the system and simplify results understanding.

The RRA methodology integrates the outputs of climatic, hydrodynamic and biogeochemical models for the construction of hazard scenarios at the regional scale, uses MultiCriteria Decision Analysis (MCDA) methods and vulnerability indexes and indicators to compare and prioritize impacts, targets and areas potentially at risk in the area of interest. All the outputs generated by DESYCO are raster maps based on a grid with a variable dimension that can change according to user requirements and available data.

The DSS structure, the main functionalities and the preliminary results obtained from the application to the case study areas of the North Adriatic Sea will be presented and discussed.

THE DSS DESYCO

The DSS DESYCO was developed with the main aim to identify and prioritize potential impacts, targets and areas at risk from climate change on coastal areas and related groundwater systems at the regional scale. The core of the application is a Regional Risk Assessment (RRA) methodology that allow to estimate the relative risks in the considered region, compare different impacts and stressors, rank targets and exposure units at risk from climate change, in order to support decision-makers in the design of adaptation strategies.

The Regional Risk Assessment methodology

The proposed RRA methodology for the estimation of climate change impacts on coastal systems is intended to be an aid for national and regional authorities in examining the possible consequences associated with uncertain future climate and prioritize adaptation measures. RRA aims at providing a quantitative and systematic way to estimate and compare the impacts of environmental problems that affect large geographic areas (Hunsaker et al., 1990) and is defined as a risk assessment procedure which considers the presence of multiple habitats, sources, stressors and endpoints (Landis, 2005). Accordingly, the RRA approach concerns the use of MultiCriteria Decision Analysis (MCDA) in order to estimate the relative risks in the considered region, compare different impacts and stressors, rank targets and exposure units at risk, and select those risks that need to be investigated more thoroughly.

According to Torresan et al. (2007), the RRA methodology is part of a more comprehensive framework that integrates tools and methodologies for the identification of potential climate change impacts and the assessment of bio-physical and socio-economic coastal vulnerability, in order to rank relative risks in the considered region. The framework structure is composed of 3 main phases: i) the Scenarios construction phase which is aimed at the definition of future climate scenarios for the examined case study area at the regional scale, ii) the integrated impact and risk assessment phase which is aimed at the prioritization of impacts, targets and affected areas at the regional scale, iii) the risk and impact management phase which is devoted to support adaptation strategies for the reduction of the climate change risks and impacts in the coastal zone, according to ICZM principles. RRA output maps include exposure maps representing the exposure to climatic changes against which a system operates (e.g., inundation level), vulnerability maps representing the spatial distribution of environmental and socio-economic vulnerability factors, and risk maps that allow the identification of areas and targets at higher risk in the considered territory. These maps allow the visualization and prioritization of impacted areas and vulnerable coastal receptors, the identification of more sensitive areas in the coastal territory, and the location of more suitable areas for human settlements, infrastructures and economic activities.

The software architecture and the geodatabase

DESYCO is a multi-tier application based on the use of open source libraries implemented defining three different tiers.

The Data Tier is based on a geodatabase in the ESRI Personal Geodatabase format (i.e. the Microsoft Access format) containing all necessary metadata and maps, stored in apposite defined folders as raster maps.

The Logic Tier is represented by a library of functions written in Python, which uses the opens source libraries GRASS GIS, GDAL and OGR in order to implement the basic functions useful for the application of the RRA methodology (e.g. the equations supporting the implemented Multi Criteria Decision Analysis). These functions are then used in more advanced formulas of the methodology through C# commands (e.g for the vulnerability matrix calculation).

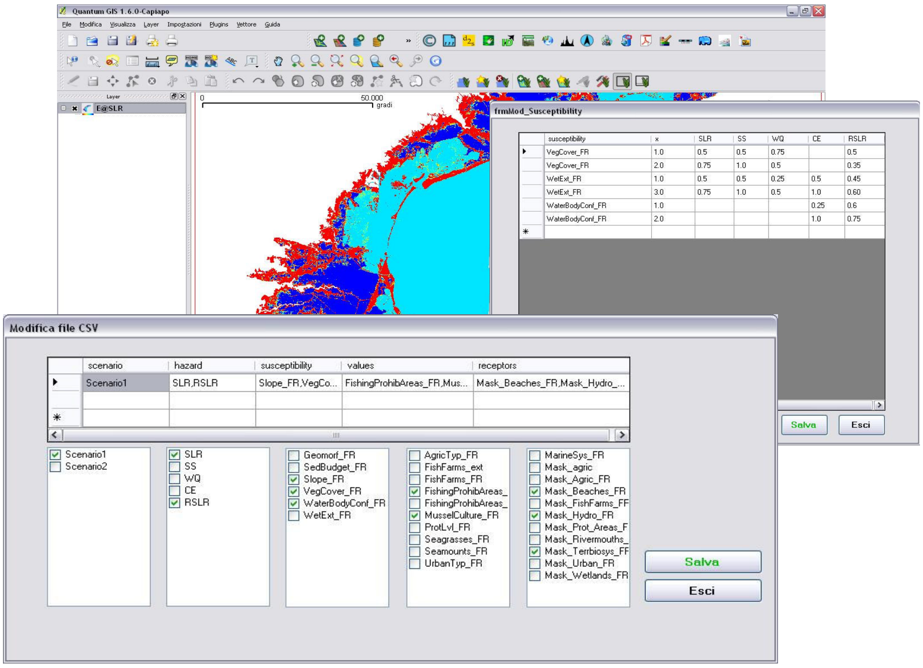

Figure 1: First prototype version of DESYCO interfaces.

Finally, the Presentation Tier is represented by the GUI (Figure 1) and manage all the interactions between the different components. The DSS can have desktop interfaces within stand alone applications or can be integrated within existing ones (e.g. as a plug-in) or web interfaces (also in this case can be a stand alone application or integration of new modules within existing ones).

CONCLUSIONS

DESYCO and the RRA approach are innovative tools to study climate change impacts on coastal zones at the regional scale and support the development of effective adaptation strategies and sustainable Integrated Coastal Zone Management (ICZM), taking into account the increasing issues related to climate change. Moreover, DESYCO can be a useful tool to investigate the impacts associated to different climate change scenarios in sensitive areas (e.g. river deltas, coastal lagoons and estuaries) and to support the development of sustainable policies, taking into account the risks associated to future climate change projections.

The application is fully customizable and can be applied in any area using data specific to the studied area, having the possibility to modify the list of the considered impacts and factors. Moreover the application can be integrated with the equations of new impacts.

The DSS has been applied to the North Adriatic area. The geodatabase for the case study area was populated with data retrieved from several different public administration and local authorities. These data were used to build risk maps related to four impacts (i.e. sea level rise, storm surges, erosion and water quality) and nine receptors (beaches, wetlands, river mouths, marine biological systems, terrestrial biological systems, hydrological systems, fisheries and aquaculture, protected areas, urban areas).

The originality of the approach consist in the application a multi-model chain which allow to downscale information provided by climate models at the global and sub-continental scale and to investigate cascading processes at the regional/local level; and in the development of a vulnerability assessment procedure that provide a ranking of relative vulnerabilities in the examined coastal territory and allow the identification of the potential for harm from a range of climate-related impacts.

Building a multi-model chain requires great initial efforts in terms of time and resources and the tool is applicable only for the study area of concern. However, once set up, a model chain can be improved with other models and used to perform other scenarios simulations.

BIBLIOGRAPHY

Hunsaker, C.T., Graham, R.L., Suter, G.W.II, O'Neill, R.V, Barnthouse, L.W., Gardner, R.H, Assessing ecological risk on a regional scale, Environmental Management 14, 325-332, 1990.

Landis, W.G., Regional scale ecological risk assessment, Using the relative risk model, Edited by Landis, W.G, CRC PRESS, 2005.

Torresan, S., Critto, A., Dalla Valle, M., Harvey, N. and Marcomini, A., A regional risk assessment framework for climate change impacts evaluation in a coastal zone management perspective. In Özhan, E. (Editor), Proceedings of the Eighth International Conference on the Mediterranean Coastal Environment, 13-17 November 2007, Alexandria, Egypt, MEDCOAST, Middle East Technical University, Ankara, Turkey, 2, 741-752, 2007.