CERIS : Civil Engineering Research and Innovation for Sustainability

MARS – Managing Aquatic ecosystems and water Resources under multiple Stress

Summary

MARS was a research project whose purpose to supports European policies, such as the Water Framework Directive, and the Blueprint to Safeguard Europe's Water Resources. There were two target groups: "water managers" assessing and restoring rivers and lakes; and policy makers drafting and implementing policies related to water.

The main objectives were:

- To understand the effects of multiple stressors on surface water and groundwater, their biota, and the services they provide to humans.
- To understand how ecological status and ecosystem services are related – if at all.
- To advise river basin management how to restore multiply stressed rivers and lakes.
- To advise the revision of the Water Framework Directive on new indicators for ecological status and ecosystem services.
- To develop methods and software for the Programs of Measures.

The specific objectives at the three different scales were:

- At the water body scale, to enhance the mechanistic understanding of how stressors interact and impact upon water resources, status and ecosystem services, and identify threshold responses to optimize stress reductions. We will address stressor combinations and response variables characteristic for major European regions. A focus will be on the effect of extreme climate events such as heavy rainfall, heatwaves as well as water scarcity and the effects of environmental flows.
- At the river basin scale, to characterize relationships between multiple stressors and ecological responses, functions, services and water resources, and assess the effects of future land use and mitigation scenarios. Work in 16 river basins in Europe, chosen to represent a wide range of multiple stress conditions, will focus on water scarcity and flow alterations (Southern Europe); hydrology, morphology and nutrient alterations (Central Europe); and hydrology and temperature alterations (Northern Europe).
- At the European scale, to identify the relationships among stress intensity, status and service provision, with a special focus on large transboundary rivers, lakes and fish as sentinels of multiple stressor impacts on biodiversity and direct providers of ecosystem services.

Eventually, MARS intended to generate information at the different scales with existing knowledge in the form of information systems and diagnostic and predictive tools, applicable at the three spatial scales.

According to a recent EEA report (EEA 2018), about 40% of Europe's water bodies are impacted by two or more pressures. Ignoring this fact may lead to wrong decisions within River Basin Management (RBM), and further to ineffective measures and stranded investments. MARS has analyzed data from various spatial scales, i.e. local water body, single river basin and European scale, in order to better understand and disentangle complex interactions between pressures, resulting stressors and their effects on aquatic biota. Several stressors from one or more pressure categories often occur in combination (multiple stressors) and can have a variety of outcomes: Additive effects equal the sum of single stressor effects, while synergistic effects are larger Directive (WFD) and who have to make recommendations or take decisions based on existing monitoring data. MARS mainly addressed pressures regarding hydromorphology, nutrients and climate change, while the focus of this document is on the most common and typical stressor combinations of European waters. The FP 7 "sister projects" SOLUTIONS SHARE-SQUARE and GLOBAQUA SHARE-SQUARE specifically addressed multi-stressor issues related to toxic contamination and water scarcity. For convenience and better readability, this document uses hyperlinks to relevant MARS results SHARE-SQUARE, models SHARE-SQUARE and tools SHARE-SQUARE to enable readers to directly access the respective websites. In regards to terminology and definitions, the Freshwater Information Platform SHARE-SQUARE contains a collection of terms from previous EU projects in the Freshwater Glossary SHARE-SQUARE, which should be used for further information. than the sum of single stressor effects and antagonistic effects are smaller than the sum of single stressor effects. When various stressors are active in a water body, their combined effects pose various challenges to River Basin Managers. Multi-stressor situations thus require knowledge on the relative importance of different stressors (stressor hierarchy, including dominating stressors) and their impacts in order to find the best combination of mitigation or restoration measures. MARS has generated a general framework supported by MARS tools for tackling multi-stressor conditions in River Basin

Project Reference

Grant agreement ID: 603378

Leading Institution

UDE – University of Duisburg-Essen (Germany)

Partners

AU – Aarhus University (Denmark), AZTI – AZTI-Tecnalia (Spain), BOKU – University of Natural Resources and Life Sciences (Austria), CHMI – Czech Hydrometeorological Institute (Czech Republic), CU – Cardiff University (United Kingdom), DDNI – Danube Delta National Institute for Research and Development (Romania), DELTARES – Stichting DELTARES (Netherlands), EMU – Estonian University of Life Sciences (Estonia), FVB-IGB – Leibniz-Institute of Freshwater Ecology and Inland Fisheries (Germany), IRSTEA – National Research Institute of science & Technology for Environment & Agriculture (France), JRC – European Commission Joint Research Centre (EU), METU – Middle East Technical University (Turkey), NERC – Natural Environment Research Council (United Kingdom), NIVA – Norwegian Institute for Water Research (Norway), NTUA – National Technical University of Athens (Greece), SYKE – Finnish Environment Institute (Finland), UL – University of Ljubljana (Slovenia), ISA – Instituto Superior de Agronomia (Portugal), IST – Instituto Superior Técnico (Portugal), APA – Portuguese Environment Agency (Portugal), BMLFUW – Federal Ministry of Agriculture, Forestry, Environment & Water Management (Austria), EA – Environment Agency of England and Wales (United Kingdom), ICPDR – International Commission for the Protection of the Danube River, NARW – National Administration Romanian Waters (Romania)

Management and to select appropriate management strategies concerning the level and type of necessary mitigation measures. Guided by key questions, the proposed framework sup- MARS recommendations on how to best assess and mitigate impacts of multiple stressors in aquatic ecosystems 2 ports decision making by identifying dominating and interacting stressors to prioritise measures. Depending on the multi-stressor situation, most effective restoration is expected by prioritising dominating stressors in case of prevailing stressors, non-antagonistic stressors in case of antagonistic interactions and stressor combinations in case of synergistic interactions. Some general patterns on interactions between pairs of stressors have been found in MARS, e.g. waterbody type-specific synergistic and antagonistic interactions for combinations of nutrient and temperature stressors in lakes. However, the assessment of the relative importance of stressors and their impacts, as well as the concrete planning of measures requires case-specific approaches. The MARS Tools support the analytical process at various levels: The tremendous amount of EU water-related information has been integrated and synthesized within the MARS Geodatabase and the Freshwater Information System, now helping to identify important stressors, their spatial distribution and combinations as well as their effects on the ecological status of lakes and rivers. In data limited environments Conceptual Models (Figures 1 and 2) provide an overview of the cause-effect relations between pressures, stressors, status and measures. A Cookbook has been compiled for multiple stressor analysis, consisting of an analytical framework to deal with environmental and stressor data, accompanied by a procedure for statistical analysis and interpretation.

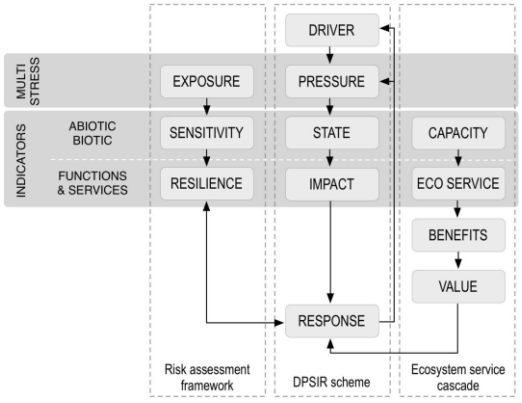

Figure 1. The MARS conceptual model for an integrated assessment framework.

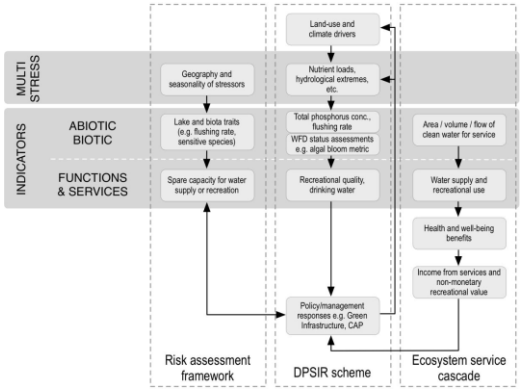

Figure 2. The MARS conceptual model exemplified for a lake affected by intense agriculture and climate change.

The Model Selection Tool provides an overview on the applicability of widely used models for River Basin Management. Heat Maps are visualisation tools to identify how two stressors interact along each of the two gradients for a certain biological quality element, leading to potential combinations of mitigation efforts needed to reach good ecological status. The Diagnostic Tool calculates the probability for causes of deterioration based on selected biological metrics. Finally, the Scenario Analysis Tool allows visualising and analysing current and future multi-stressor conditions and impacts on ecological status in European rivers and lakes. MARS tools may be supplemented by experimental settings that can serve as an effective method to tackle case specific multi-stressor situations. Within MARS a number of meso-scale lakeand river experiments provided detailed answers for case specific multi-stressor situations covering hydromorphological and water quality stressor combinations. MARS has demonstrated how the large amount of data generated in context of the WFD throughout Europe can be used to improve RMB and how science can contribute to achieve WFD objectives.

The outcomes of MARS support River Basin Managers and others faced with WFD implementation in their efforts to plan and implement effective restoration measures, by enhancing the understanding of multiple stressors, their hierarchy and interactions, as well as on the impacts they cause on the aquatic ecosystem.

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Funding

EU FP7 Framework Programme
(8 996 800.00€)

Period

2014-2018

Total

11 655 100.00€

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Funding given to IST and to ISA was managed by the Universidade Técnica de Lisboa, and afterwards managed by the Universidade de Lisboa services.

Project Website

www.mars-project.eu