

Assessment of aquatic ecosystems state based on their main services

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Abstract

European legislative framework like WFD, HD, BD, INSPIRE demonstrates a unified approach to characterize the state of the environment. Extensive spatial datasets to quantify mechanisms and processes at regional level can be used by processing data such as those provided by CCM21 (rivers and catchments database) closely related to the CLC 2012 dataset, allowing a quantitative assessment of ecosystem services such as surface water resources and ground water resources. The approach of ecological systems and mass flow at catchment level are important steps in the functional use of structural models to quantify the nonlinear dynamics of ecosystems. Quantification of reference values for ecosystem services at a regional level by a deterministic mathematical model is the goal to estimate the degree of transformation from a reference state. Comparative analysis of habitats and species distributions (article 17 report from HD) with the state of aquatic ecosystems will reflect the correspondence between these two assessments.

Keywords: MAES process, WFD, HD, CCM21 and COPERNICUS.

1 Introduction

Since the evaluation of Millennium Ecosystem Assessment (MEA) scenarios of socio-ecological systems, sustainable development was generally perceived only to be possible after identifying and characterizing the diversity of structural and functional ecological systems [1], which means quantification of ecosystem services for accurate dimensioning the level of their use by human societies. In line with current initiatives, we intend to quantify countrywide specific ecosystem services on implementing the Mapping and Assessment of Ecosystems and their Services (MAES) [5] [6] process. The activities will focus on specific aquatic ecosystems, using the proposed methodology of MAES [7] and ARIES [2], based on data structures developed under European programs, like COPERNICUS and CORINE Land Cover, but also on other high quality products provided by JRC (CCM21) [3][4]. Comparative analysis of our results with Habitat directive report and Water Framework directive report [11] will show us the level of interdependence of those assessments [10].

2 Material and methods

The activities are in compliance with the methodology of assessing water balance at the catchment level [8] as presented in the guidance document on the application of water balances for supporting the implementation of WFD [11] [4] to quantify on a regional scale the Common International Classification of Ecosystem Services (CICES) for freshwater ecosystems, from provisioning of water supplies to maintain and support the hydrological cycle and water flow maintenance.

We have adapted the input value, related to CCM21 catchments distribution, based on zonal statistics of each catchment on MODIS evapotranspiration (ET) and CLC2012 land cover classes, to model water availability at the catchment level. For the water infiltration model we used the estimated average percentage from 0.001% to 20% based on slope and soil type aggregation [12]. For evapotranspiration we used the MODIS assessment MOD16 program. This assessment is based on annual average values to predict water availability for each catchment related to water use model like proposed by Villa et al [9], but implemented in a simple way ARCGIS add-in.

2.1 CICES

Common International Classification of Ecosystem Services (CICES) was selected for Romanian assessment of the MAES process. In this respect, the assessment of aquatic ecosystems services was focused on surface and subsurface water availability extracted from general water balance equation to characterize the provisioning services of freshwater ecosystems.

In case of regulation and maintenance services we focus on freshwater ecosystems on flow regulation based on results of the ratio of available water and water used.

2.2 CCM21

CCM21 represent the main derived tool for hydrological structure assessment and is based on topology of rivers, lakes and catchments [3]. The derived data from geomorphological structure at the regional level is an important source for

mathematical modelling and for regional assessment of complex hydrological structures. We have used this structural model at the Danube catchment level to extract the sub-catchments covering all national territories. We have selected 30860 catchments grouped in 25 basins from Danube tributaries. We have used the data attributes of each catchment, like average precipitation, average slope and average altitude in relation with soil type distribution for water infiltration or land cover/land use classes for water use

Figure 1: CCM21 extraction to cover Romania.

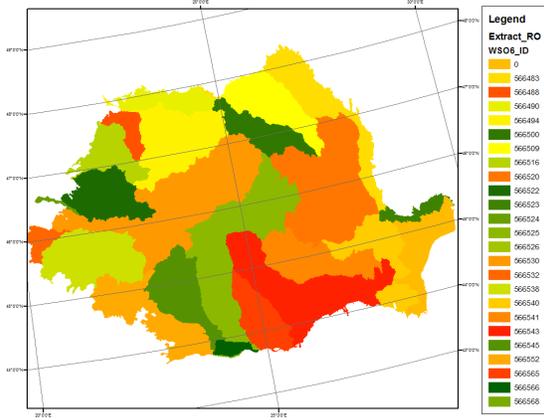
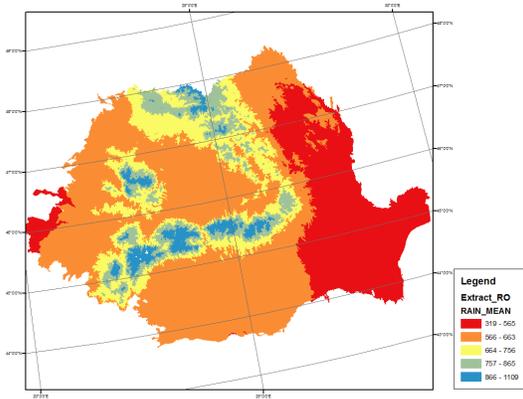


Figure 2: CCM21 average precipitation.



2.3 CLC2012

The project activities have benefited from the use of the pan-European CORINE Land Cover 2012 products. The repartition of land cover/land use classes allows us to have a general picture on the spatial dimension of land distribution for different types of management (agricultural, forestry, industrial or residential). It is clear that these types of management have impact in water use based on quantity of water abstractions for production or functioning processes. Also, at regional level, these different types of LC/LU classes also have influence on water percolation and water runoff process. Considering the

annual water balance, this influence can be considered negligible.

2.4 MODIS – MOD16

The MOD16 dataset is based on the Penman-Monteith equation and developed on estimation used by improved algorithm of ET by Mu et al [13]. The ET from MOD16 distribution at 1 km resolution was extracted for each catchment based on zonal statistics and reflected by ET mean from 2000 to 2013.

Figure 3: CCM21 – MOD16 annual average ET

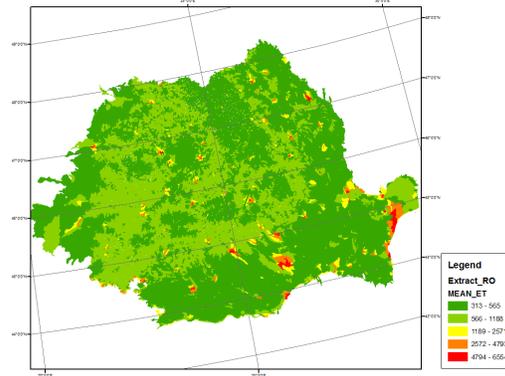
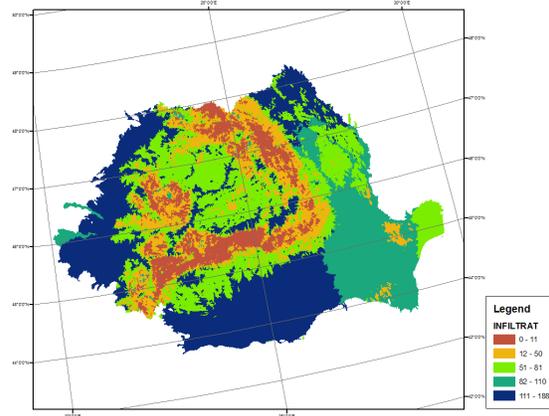


Figure 4: Infiltration estimation based on slope and soil type

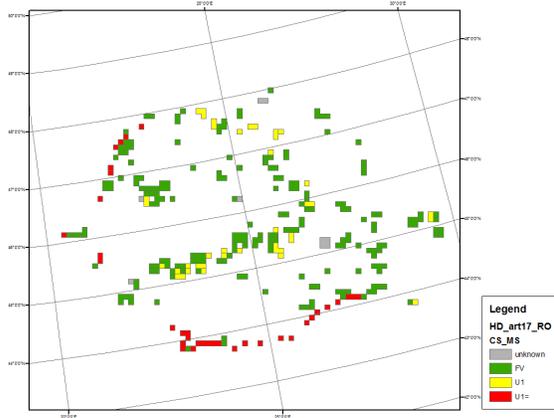


2.5 HD art 17 report

The HD report was developed based on in field monitoring of aquatic habitats and assessment of their state based on four parameters habitat distribution, species composition, structure and functioning synthesis and pressures and aggressions presence. In figure 5 we have presented the spatial distribution of aquatic habitats and their state assessed by 4 classes: 1. unknown (gray) – where we don't have enough information; 2. Favorable state (green); 3. Unfavorable state (yellow); 4. Total unfavorable state (red).

For our analysis we assessed how many reported habitats (number of cell on assessment grid) in various state are present in catchments with positive or negative ratio of water availability and water use.

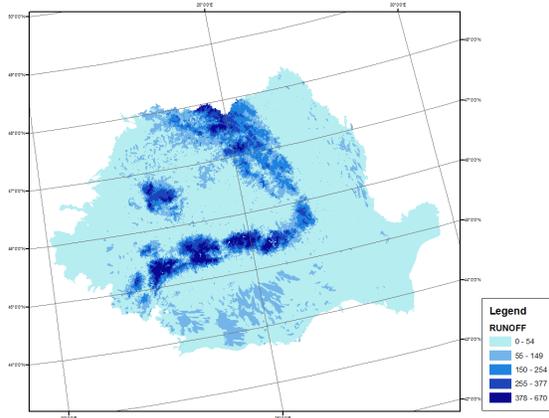
Figure 5: HD report results for aquatic habitats state conclusion



3 Results and discussions

In figure 6 we have presented the local runoff for each catchment and we have followed the topology of CCM21 structural dataset to process the input values from one catchment to another. The process was simulated based on ARCGIS add-in build to support processing inflow water from one catchment to another. The catchment WFO1_ID no 712122 was used to support the Danube inflow from outside of Romania based on assessed average inflow water as 6500 m³/s.

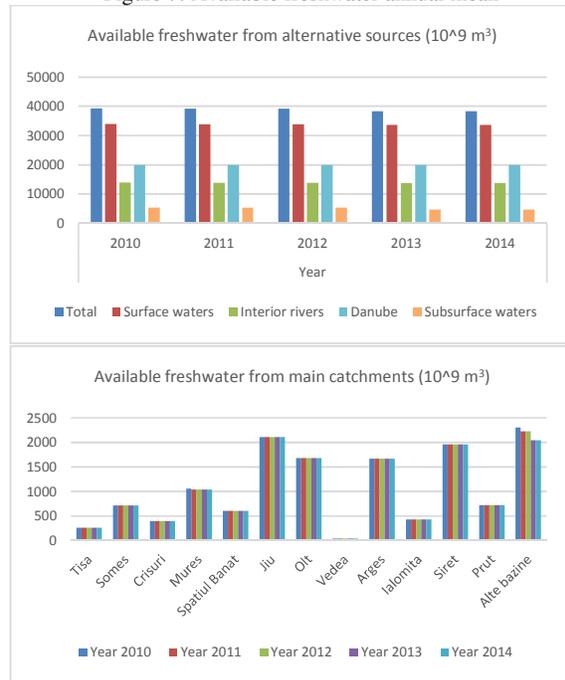
Figure 6: Water local runoff annual mean



Assessment of available fresh water has two components subsurface water and surface water. Subsurface water is estimated from infiltration proportion multiplied by the surface of the catchment. For the surface water is annual estimates for input water available for run-off based on balance equation also

multiplied by the surface of the catchment and the second components based on available inflow from other catchments. To estimate inflow components we develop and deterministic algorithms based on line of processing each time all the chain of catchments based on starting catchment to available water for runoff to next-down catchment.

Figure 7: Available freshwater annual mean



Source: National Institute of Statistics

In figure 7 we are presenting the available data at National Institute of Statistic level used for validation of our model results.

The water abstraction at this moment is assessed to cover the water use from different type on land cover classes at the catchment scale, in the following steps we will estimates the water use based on associated coefficient values. The integrated report on ratio water availability / water use will be analyzed complementary with Habitat Directive report and Water Framework report on water quantity and quality.

4 Conclusions

The current approach is representing a test process of structural model aggregation and knowledge integration to reflect actual level of available information to support decision making for quantification of aquatic ecosystems services at regional scale.

At the European level we have high quality results from projects/programs implemented and developed for member state with potential to be integrated in mathematical models.

Regional testing at the member state level permit us to cross validate results from European programs and identify the errors patterns and alternative ways to compensate them.

The standardized MAES process at European scale is a priority of all member states and the current assessment level can be improved from new achievements of JRC programs (CCM21), Environmental European Agency and European Space Agency programs (SENTINEL, COPERNICUS –CLC, high resolution products).

5 Acknowledgments

We are done the analysis with the support of the project “Demonstrating and promoting natural values to support decision-making in Romania” (Short title: Nature4Decision-making – N4D). We want to thank the financing mechanism EEA grants / Norwegian grants / Norwegian Financial Mechanisms 2009 – 2014 – Biodiversity and Ecosystems services Program.

References

- [1] Millenium Ecosystem Assessment. *Ecosystems and Human Well-Being: Synthesis*. Washington, DC: Island Press; 2005
- [2] J. Barquin et al. *Coupling virtual watersheds with ecosystem services assessment: a 21st century platform to support river research and management*, Wiley Periodicals, Inc., *WIREs Water* 2015. doi: 10.1002/wat2.1106, 2015..
- [3] J. Vogt et al. *A pan-European River and Catchment Database*, JRC reference report – Report EUR 22920 EN, 2007
- [4] G. Wriedt, F. Bouraoui. *Towards a General Water Balance Assessment of Europe*. JRC 53258, EUR 23966 EN, ISBN 978-92-79-12979-7, ISSN 1018-5593, DOI 10.2788/26925, Luxembourg: Office for Official Publications of the European Communities © European Communities, 2009
- [5] Mapping and Assessment of Ecosystems and their Services. An analytical framework for ecosystem assessments under Action 5 of the EU Biodiversity Strategy to 2020. Discussion paper – Final, April 2013
- [6] J. I. Barredo, et al. Mapping and assessment of forest ecosystems and their services – Applications and guidance for decision making in the framework of MAES. EUR 27751 EN; doi:10.2788/720519, 2015
- [7] Mapping and Assessment of Ecosystems and their Services, Mapping and assessing the condition of Europe’s ecosystems: Progress and challenges 3rd Report – Final, March 2016
- [8] S.Werth, A. Guntner. *Calibration analysis for water storage variability of the global hydrological model WGHM*. Hydrol. Earth Syst. Sci., 14, 59–78, 2010 www.hydrol-earth-syst-sci.net/14/59/2010/, 2010
- [9] F. Villa, Bagstad KJ, Voigt B, Johnson GW, Portela R, et al. *A Methodology for Adaptable and Robust Ecosystem Services Assessment*. PLoS ONE 9(3): e91001. doi:10.1371/journal.pone.0091001, 2014
- [10] R. Naidoo et al. *Global mapping of ecosystem services and conservation priorities*. PNAS, July 15, 2008, vol. 105, no. 28, 9495–9500, www.pnas.org/cgi/doi/10.1073/pnas.0707823105, 2008
- [11] G. Wriedt, F. Bouraoui. *Guidance document on the application of water balances for supporting the implementation of the WFD Final – Version 6.1 – ISBN 978-92-79-52021-1 doi: 10.2779/352735 © European Union, 2015*
- [12] D. Scradeanu. *Hidrogeologie – ISBN 978-92-79-52021-1 doi: 10.2779/352735 © European Union, 2008*
- [13] Q. Mu, et al. *Brief Introduction to MODIS Evapotranspiration Data Set (MOD16)–<http://ntsug.umd.edu>, 2011*