WHY MAPPING ECOSYSTEMS SERVICES IS A MUST IN EU BIODIVERSITY STRATEGY FOR 2020?

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Abstract

Technological and industrial evolution generated an increased demand for natural resources as well as destruction of the global biodiversity at unprecedented rates. Worldwide projections evaluate an extinction ratio of species up to 10 times higher than the current rate. Up to 2020 EU has established targets for mapping and assessment of the ecosystem services including all the main stakeholders, covering forests, agro-ecosystems, freshwater and marine ecosystems, urban, arid zones and wetlands. The general mapping approaches for the EU member states involved in the process consist in using GIS instruments and work flows on land cover/land use data through ESRI’s ARCGIS Platform. About 80% of the EU member states have started the MAES process (Mapping and Assessment of Ecosystem Services) at national, regional or case-study level. The essence of the MAES process is to maximize the use of scientific knowledge and technology available in order to make a significant contribution for the ecosystem services and policy decisions to improve and protect biodiversity and life quality, as well as getting an accurate evaluation of the associated costs. The paper integrates scientific data over the MAES targets using Geographic Information Systems by the evaluation of multiple ecosystems types and services, on different temporal stages and synergies in different layers of information. Ecosystems services provide to the human kind nutrition, clean air, water, safety and healthy environment. This is why, mapping and assessing these services would allow determining the direct connections and dependency on biodiversity and its functions.

Key words: biodiversity, ecosystem services, MAES, GIS, UE Environmental policy, 2020 strategy.

INTRODUCTION

The European Commission and Council had adopted in 2011 the EU Biodiversity Strategy for 2020 which aims to stop the loss of biodiversity and the degradation of ecosystem services, but also to restore them as far as feasible in the EU up to 2020. For European Conservation, the EU Biodiversity Strategy is a landmark and its commits the European Parliament, the European Commission and the EU Member States into taking action for preventing biodiversity loss. The Biodiversity Strategy has 6 inter dependent targets and 20 supporting actions. The one that calls for restoration of ecosystems and their services, but also for a better protection is Target 2. Within it, by 2020, Action 5 calls all Member States to map and assess the status of ecosystems and their services, the economic values of ES and to promote their integration into reporting and accounting systems at EU and national level. This will constitute the knowledge base for the Green Infrastructure Strategy and the establishment of ecosystem capital accounting. Other targets of the EU Biodiversity Strategy depends on Target 2 and it highlights the importance of an integrate view in the process of making decisions. The key to approach synergies and trade-offs in regard to policy impacts on ecosystems and ecosystem services, is a robust knowledge base. The Biodiversity Strategy involves two timelines for their targets. By 2020, mapping and assessing the ecosystems and their services must ensure guidance for the Member States in order to determine the strategy for Europe’s green infrastructure, the restorations of 15% of degraded ecosystems and ecosystems services initiatives. The long term target for 2050 consist in protecting, evaluating and appropriately restoring for biodiversity intrinsic values and for their essential contribution to human life and wellbeing and also to economic prosperity of the natural capital, the biodiversity and the ecosystem services it provides.
A working group was established to take steps into the concept and methodologies for Action 5 of Target 2. The collaboration of European Commission, Joint Research Centre of the European Commission, European Environment Agency and Member States is the MAES initiative.

The MAES project was initiated under the perspectives and necessity to maintain the interdependent link between biophysical assessment and monetary accounts, such as “Carbon, Land and Water and ecosystems condition accounts” (as MAES categorization), and to develop, improve and share data about the ecosystem services across the EU’s Member States to achieve improvements in biodiversity quality.

For the MAES project, 3 priority objectives have been established, namely:

1. Protect & enhance natural capital - accounting the biodiversity, water and marine ecosystems, land and soil, forests and nutrient cycle;
2. Transition to resource efficient, low-carbon economy - refferring to climate mitigation, SCP, waste, eco - innovation, industrial emissions, water stress;

The first step of MAES consists in agreeing a framework. In order to ensure that the EU and its Member States adopt a harmonized approach, the Commission in guidance with experts and stakeholders, had published a coherent analytical framework. It consists in identifying the ecosystem types that combine land cover classes and habitat classification systems. When discussing the first version of the conceptual frame (as MAES analytical framework discussion paper of 4 June 2012) it appeared the need to include various institutions, stakeholders and user group in the framework.

![Figure 1. Importance of Action 5 in relation to other supporting actions under Target 2 and to other targets of the EU Biodiversity Strategy (Source: MAES, 2013)](Image)

![Figure 2. MAES’ role across the environment (Source: MAES, 2013)](Image)

**THE ROLE OF BIODIVERSITY IN SUPPORTING ECOSYSTEM FUNCTIONS AND SERVICES**

What is an ecosystem and an ecosystem service?

An *ecosystem* is a community of organisms interacting with each other and with their environment such that energy is exchanged and system-level processes, such as the cycling of elements, emerges.

*‘Biodiversity’*, meaning the variety of all life on earth, plays the most important role in the structural set-up of ecosystems which is crucial in maintaining basic ecosystem processes.

*‘Ecosystem function’* is the technical to define the biological, geochemical and physical processes and components that take place within an ecosystem. Sometimes, ecosystem functions are called ecological processes. Maintaining ecosystem function is important to maintaining the capacity of the region to supply ecosystem services.

*‘Ecosystem services’* are the many different benefits that ecosystems provide to people (MA, 2005). Ecosystem services result from ecosystem functions and represent the benefits provided by ecosystems that contribute at making human life possible and worth living. Examples of ecosystem services include
products such as food and water and non-material benefits such as recreational and spiritual benefits in natural areas. The term ‘services’ is usually used to encompass the tangible and intangible benefits that humans obtain from ecosystems, which are sometimes separated into ‘goods’ and ‘services’. This is why, policies concerning natural resource management aim to affect drivers of change to achieve a desired future state of ecosystems.

The concept of ecosystem services was brought into discussion by the Millennium Ecosystem Assessment (MA) which is a global initiative set up back in the 1999 used to assess how ecosystem change would affect human well-being (MA, 2005). The MA divided the ecosystem services into 4 categories:

1. Supporting services - the services needed for the production of all other services. Ex: nutrient cycling and soil formation;
2. Provisioning services - represented by the products obtained from ecosystems. Ex: food and timber;
3. Regulating services - consists in the benefits obtained from the regulation of ecosystems. Ex: purification of water, flood control, regulation of climate within the carbon sequestration;
4. Cultural services - these are the benefits that people obtain from ecosystems through spiritual enrichment, reflection, recreation, aesthetic experiences and cognitive development.

MAES uses the Common International Classification of Ecosystem Services (CICES) system for classifying ecosystem services (Maes et al., 2013a; Haines-Young&Potschin, 2013). CICES is more comprehensive than the MA and TEEB, and enables users to diverge between them. The hierarchical structure of CICES also allows assessments to accommodate to specific needs while being able to make comparisons with others. CICES divides the ecosystem services into 3 categories:

1. Provisioning services;
2. Regulating and maintenance services;
3. Cultural services.

This system is created to deliver “final services”, the ones that directly affect human well-being. This in why the “supporting” services of the MA are not included. Also, the MAES initiative says that the ecosystem services represent “the realized flow of services for which there is demand” (MAES, 2013). Sometimes the “flow” is hard to quantify, but the basic concept is still the same: an ecosystem service is only an ecosystem service when it is providing a realized benefit to people.

The overall scope of MAES is to assess the most important services of ecosystems affected by antropic actions, such as:

- Marine, costal and inland water;
- Forest and woodland;
- Cultivated/Agricultural land;
- Grassland and mountain;
- Dry land and urban;
- Heathland and shrub;
- Sparsely vegetated land;
- Rivers and lakes.

How does biodiversity affect ecosystem functioning?

The assumption approached in the EU policy that ecosystem services protection will relate to biodiversity protection is central to the inclusion of ecosystem services. This approach forms a part of the strategy to avoid biodiversity loss until 2020, as a key part of Target 2. But first, there is a need to understand what is meant by the term “biodiversity”. It’s well known that it means the variety of all life on earth, plays the most important role in the structural set-up of ecosystems which is crucial in maintaining basic ecosystem processes, but in reality is much more complex. The definition that is used by Convention on Biological Diversity, which is also used within the EU MAES framework, is this: “The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems” (Maes et al., 2014, http://www.cbd.int/convention/articles/default.shtml?a=cbd-02).

Cardinale at al. (2012) said that: “There is now unequivocal evidence that biodiversity loss reduces the efficiency by which ecological communities capture biologically essential resources, produce biomass, decompose and recycle biologically essential nutrients.”
In figure 3 are related different roles of biodiversity in supporting ecosystem functions and services. It is presented as a butterfly that has six dimensions of biodiversity which connect to ecosystem services and functions within three dimensions on each wing.

Figure 3. Adapted from EEA (2015), illustrating the different components of our natural capital, encompassing both ecosystem stocks and service flows (Source: MAES, 2016)

On the left wing are presented the three dimensions of biodiversity that enrich to ecosystem functioning:

1. Biodiversity magnify the efficiency of ecological processes which are key determinants of ecosystem function.

2. The second most important determinant of ecosystem functioning consists in functional diversity which represents the variation of the expression of multiple functional traits (define species in terms of their ecological roles- the way they interact with the environment and other species).

3. An important role in structuring habitats, ecosystems and landscapes, has the plant species diversity (MAES, 2013). On the other hand, the right wing is represented by the three dimensions of biodiversity that contribute to ecosystem functioning, but which also directly deliver ecosystem services.

1. Genetic diversity is the diversity of the gene pool of single species. (MAES, 2013)

2. Another indicator frequently used for biodiversity is the species richness and taxonomic diversity.

3. The diversity of specific biotic interactions in species networks. Placing ecosystem services in the EU policies that concentrate on the conservation of terrestrial, freshwater or marine ecosystems concludes that there is a connection between the state of the ecosystem and the services they deliver.

Figure 4. The multi-faceted role of biodiversity to support the delivery of ecosystem services and to assess the status of ecosystems. Biodiversity has multiple roles in relation to the delivery of ecosystem services (Source: MAES, 2013)
The connection between biodiversity, ecosystem state and particular ecosystem functions and ecosystem services involves multiple combinations of the dimensions of biodiversity and the usage of those for mapping and assessment.

**WHY DO WE NEED TO MAP AND ASSESS ECOSYSTEMS?**

Maps were produced since the beginning of time and have had various purposes and serving from navigation, military strategies, land survey and road maps to nowadays web mapping tools with multiple thematic applications. A map should be a model representing the earth and it should follow scientific methods, characteristics of reproducibility, validation and unpredictability assessment. Short form, a map can be defined as “a graphic model of the spatial features of reality” (Kraak and Ormeling, 1996), in such a way that allows communication and additional analysis in GIS post-processing and modeling. Through the scope of MAES, mapping ecosystem services is useful in several purposes:

- Spatially explicit representation of synergies and trade-offs within different ecosystem services, and between ecosystem services and biodiversity;
- Initiating discussion with main stakeholders through communication tools;
- Looking for the precise location where valuable ecosystem services are being produced or used;
- Planning and management of biodiversity protection areas and involving their ecosystem services at sub-national, national and EU level;
- Supporting the decision makers to properly identify priority areas and relevant policy measures in real time.

Mapping ecosystem services may represent different biophysical dimensions of the services: as example ecosystem services flow, potential, stock and demand. Each and every dimension uses a certain approach and data type and in consequence mapping each dimension produces different output. An option extremely used is mapping ecosystem services values, additional to mapping the biophysical output of ecosystem services. It is appropriate to map ecosystem services values just after having mapped ecosystem services. *In this case the monetary value of the service is represented spatially showing how values vary across space* (Schägger et al., 2013).

High resolution imagery acquired with satellite technology has been successfully used for the trade-offs among services of water purification and agricultural food production, in order to determine the potentials and limitations of maps for decision-makers, on a regional and EU level.

There have been identified some potentials and challenges such as spatial evaluation of ecosystem services in Europe: methods, case studies and policy analysis - phase 1.

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<th>Member States (MS)</th>
<th>EU institutions</th>
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<td>• MAES started in almost all Member States.</td>
<td>• EEA: Ecosystem map, Ecosystem condition mapping and assessment, BISE</td>
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<td>• Some Member States have completed a national scale mapping</td>
<td>• JRC: Mapping ecosystem services</td>
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<td>• Many Member States have regional case studies</td>
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<td>• ESMERALDA: A dedicated coordination and support action</td>
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<td>• FP7 projects OpenNESS, OPERAs, MARS</td>
<td>• Typologies for ecosystems and ecosystem services (CICES 4.3)</td>
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<td>• Ecosystem Services Partnership, ALTER-net</td>
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Satellite data is valuable for problem identification and framing: they help identifying conflicts and synergies and designate areas where particular ecosystem services or biodiversity aspects are menaced such as the aquatic ecosystem endangered to waste its ecological status.

The satellite images resulting in maps are already used extensively, being indispensable instruments for national planning activities such as biodiversity protection areas, where the relationships among different land uses leads to the potential conflicts and alternative solutions, related to cost efficiency.
Still, the spatial and temporal scales of maps are not always identical and for seasonal evens, for example, difficult to visualize, despite the high spatial details, quite costly, which can be contested from the local level.

Figure 5. The need to map and assess ecosystems and their services (Source: MAES, 2014)

What is ecosystem mapping and assessing?

As earlier said, an ecosystem in a dynamic complex of plant, animal and microorganism communities and their non-living environment interacting as a functional unit’ (UN, 1992). An ecosystem can be of any size. MAES scope concern mapping and assessment at national and EU scales.

The process of mapping and assessment ecosystem services is a systematic process which consists in:

1. **Mapping** - This involves identifying and illustrating the spatial size of various ecosystems through a wide width of data sets and land/sea cover and environmental attribute.

2. **Assessment of ecosystem condition** - This consists in analyzing the great pressures on ecosystems and its impact in term of health of species, the condition of habitats and some other factors as soil, air and water quality.

3. **Assessment of ecosystem service delivery** - This step is related to assessing the connection between ecosystem condition, the quality of the habitat and the biodiversity and at least, the way they affect the ecosystem capacity to deliver ecosystem services in order to serve human well-being.

   “Ecosystem assessment is often constrained by scientific knowledge and data availability, but pragmatic decisions have to be made” (Maes et al., 2013).

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The satellite images resulting in maps are already used extensively, being indispensable instruments for national planning activities such as biodiversity protection areas, where the relationships among different land uses leads to the potential conflicts and alternative solutions, related to cost efficiency. Still, the spatial and temporal scales of maps are not always identical and for seasonal evens, for example, difficult to visualize, despite the high spatial details, quite costly, which can be contested from the local level.

The solution to have a general image of the ecosystems in the EU by mapping their services, in some MS for the pilot phase and extend up to the borders of the Union, is the solution to support the biodiversity strategy. Target 2 of the strategy aims to restore as much as possible the degraded ecosystems in the EU, after having mapped the ecosystems and their services, at individual service level, landscape level with metric accounting. Achieving this target would allow the decision makers to prioritize the investments in green infrastructure to develop natural or semi-natural areas and to contribute to the biodiversity conservation and increase ecosystems services.

As a method used by EU sources and its Member States in cover ecosystems and ecosystems services consists in using CICES classification and CORINE Land Cover. The main problems identified in using this method are lack of consistent approaches among all parties involved, limited resources and lack of data (MAES, 2014).

**MAES PROCESS IN ROMANIA**

In Romania the value of ecosystems and their services are not well known by policy holders and decision makers.

Currently, in our country it is running a project named “Demonstrating and promoting natural values to support decision-making in Romania”
(Short title: Nature4Decision-making - N4D) whose main activities are:

- To elaborate the framework and procedures of mapping and assessment as basis to perform MAES in Romania;
- To manage data and data analysis for the MAES process;
- To map and biophysical assess the selected ecosystems.

Earth Observation data simplify the acquisition of climate and land cover information in order to create a monitoring system. An essential tool is represented by Remote Sensing which offers the possibility to produce directly (by photo interpretation of land use or land cover) or indirectly (e.g. NDVI) information for the ecosystems evaluation.

The main components of the project include biophysical mapping and assessment of key ecosystems and their services; baseline economic valuation of key ecosystem services; development of a DSS - Decision Support System for use of MAES results into policy and decision making (ESMERALDA Country Fact Sheet, 2015).

Identifying, quantifying and mapping the main ecosystem services within the project area and using that knowledge to analyze the contribution of ecosystem services to main economic sectors are the objective of the project N4D.

The project partners are National Environmental Protection Agency (NEPA), Romanian Space Agency (ROSA) and Norwegian Institute for Nature Research (NINA).

Monitoring the variability of biodiversity represents a challenge for policy holders and decisions makers (EO Satellite and In-Situ Data for Nature Conservation, Copernicus 2015).

On the other hand, a very important tool is using field in-situ data to validate the information offered by remote sensing. It will be helpful using a step by step decision making process, in order to make deliberate, thoughtful decisions by organizing relevant information and defining alternatives.

The Decision support system (RO-DSS-MAES) main goals are: monitoring structure and functions of ecosystems maintain and develop mathematical models to assess the biophysical state of ecosystems, reports on goods and services for human development and assess environmental impact (EO Satellite and In-Situ Data for Nature Conservation, Copernicus, 2015).

The Earth Observation satellite data will contribute on MAES continuous process by helping the decision support to track changes in space and time like changes in ecosystems distribution and changes in ecosystems services assessment.
CONCLUSIONS

The main target of the EU Commission with its Member States for ecosystems and their services is maintained and enriched by establishing green infrastructure and reviving at least 15% of degraded ecosystems by 2020. The utility of maps consists in spatially explicit prioritization and problem identification, exclusively in relation to synergies and trade-offs enclosed by different ecosystem services, and between ecosystem services and biodiversity.

On the other hand, maps can be used as a transmission tool to launch discussions with stakeholders, visualizing the exact locations where relevant ecosystem services are produced and used. Also, maps can contribute to the biodiversity protection through planning and management of the protected areas and by default of their ecosystem services at both national and subnational level.

The purpose of MAES will be attempted through the “combination of digital mapping with the assessment of the supply of ecosystem services related to their demand (including the spatial interactions between them)” (MAES, 2013). At the EU level, mapping will support decision makers in identifying priority areas and suitable policy measures. The present information and data on the biodiversity, ecosystems and their services and the actual status, for which, with the satellite images, there is a certain capacity to monitor the evolution, gives a perspective on the future status by 2020, if measures are not taken. Mapping and assessing integrated information is essential in evaluating the environmental legislation, at national and regional level, over the biodiversity targets established at community level, in order to develop sustainable agricultural, forestry and fishing solutions.

The evaluation of past work revealed that using data that already exists and combining it into a coherent and integrated ecosystem assessment, results in a coherent data base at starting point. Thus, the pilot studies showed that Action 5 is already completed by the current policies on agriculture, marine, forest and nature, delivering data and indicators essential for the ecosystems and their services assessment.

The EU policy and documents reveal the high potential of integrating ESS into the general policies, to be supported by satellite imagery. There is a need for capacity-building in all Member States in order to create a community of practice in Europe that will contribute to improve the knowledge and evidence for EU environment policy. Following this idea, it is essential to recognize that the biodiversity, ecosystem services and people are all part of an interconnected system (MAES, 2016).

The strength of ecosystems services concept lies in the need to consider the entire interconnected socio-economic-ecological system. Despite the challenge it takes, the benefits are awesome and the work already begun at all scales.

REFERENCES


