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MAIN FRAMEWORK AND INDICATORS USED IN MAPPING AND ASSESSMENT OF ECOSYSTEM SERVICES FOR THE EU BIODIVERSITY STRATEGY UP TO 2020

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Abstract

Pollution, over exploitations, urban development and climate changes cause huge losses on our natural capital. The human race depends on healthy ecosystems to deliver essential services such as food, water, clean air and recreation. The need of quantifying the levels and values of these ecosystems services and incorporate them into resource management is increasing each and every day. According to EU biodiversity strategy up to 2020 (EC 2011), target 2, by 2020 ecosystems and their services must be maintained and enhanced by restoring at least 15% of degraded ecosystems. In order to measure the progress towards this target, is essential to map ecosystems and their condition. At EU and national level is proposed a general and analytical framework based on the DPSIR framework (Drivers, Pressures, State, Impact and Response) in order to integrate economic values into accounting and reporting system, but also to provide cross references with ecosystem services categories that are being used in assessments. The big challenge that European Commission is facing consists in using the large amount of geospatial data and other information that are available for building a feasible methodology and suitable data sets. The framework to be used is developed by CICES and it was evaluated among 4 pilot studies of MAES working group, same working group that came along with the proposal of indicators for mapping and assessing urban ecosystems and their services applicable to EU and most of its Member States. MAES outcome of the working group showed that when using data that already exist and combine it in a coherent and integrated ecosystem assessment yields a starting database consistency.

Key words*: biodiversity, ecosystem services, framework, indicators, MAES*

INTRODUCTION

In 2011 was adopted, by the European Commission and Council, the EU Biodiversity Strategy for 2020. The main goal up to 2020 is, on the one hand, to stop the loss of biodiversity and the degradation of ecosystem services and, on the other hand, to restore them as far as feasible in the EU and its Member States.

The EU Biodiversity Strategy includes among its components 6 interdependent targets and 20 supporting actions. Inside of Target 2, there is an action that calls for restoration of ecosystems and their services called Action 5. Within it, Member States, with the help of the Commission, are called to map and asses the state of ecosystems and the value of their services promoting the integration of those values into accounting and reporting systems at EU and national scale. The implementation of Action 5 is supervised by the working group on Mapping and Assessment of Ecosystem and their Services (MAES).

The MAES structure facilitates the collaboration between EU bodies, EC's experts, member states, stakeholder's representatives and NGOs and takes part into supporting actions such as Commission's research and reports.

The prior objectives of the MAES project are:

1. Protect and enhance natural capital (biodiversity, land and soil, water and marine, forests, nutrient cycle);
2. Facilitate the transition to resource efficient, low-carbon economy (climate mitigation, eco innovation, industrial emission, water stress;
3. Safeguard health & well-being (air quality, chemicals, climate adaptation, drinking and bathing water quality, noise).

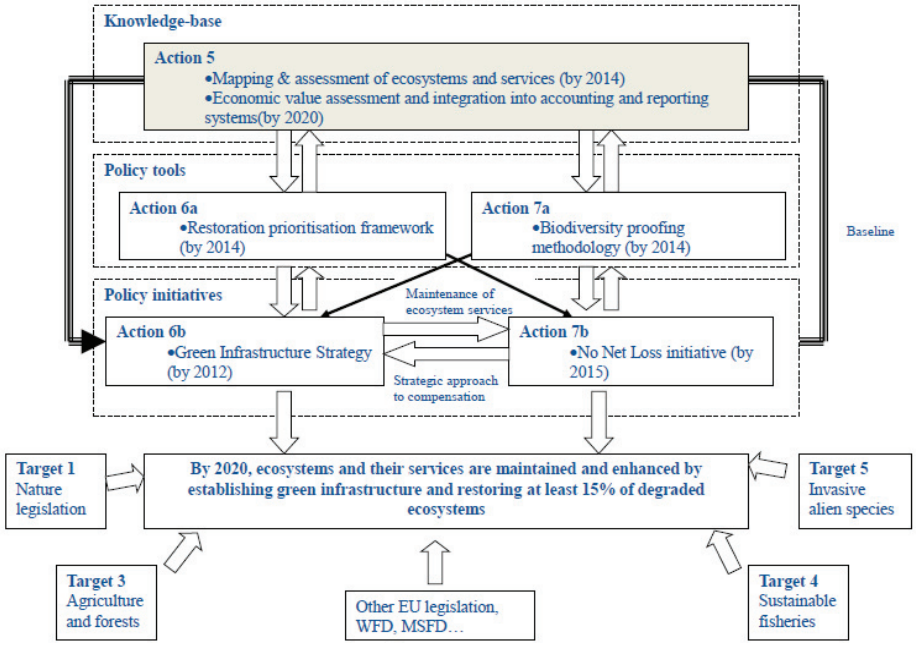

Figure 1. Importance of Action 5 in relation to other supporting actions under Target 2 and to other targets of the EU Biodiversity Strategy (Source: MAES Report, 2013)

The first action taken by the MAES working group was supporting the development of an analytical framework to be applied at EU and national levels in order to assure that national priorities are properly identified and the proposed common typology of ecosystems is used correctly for consistent aggregation across scales and comparison of results

MATERIALS AND METHODS

CONCEPTUAL FRAMEWORK FOR ECOSYSTEM ASSESSMENT

An ecosystem contains various living organisms and microorganisms have adapted to life in a particular environment which has physicochemical characteristics. Anything that interferes and causes changes to these characteristics, has the potential to change the entirely ecosystem and to affect its habitats and biodiversity.

Data base and information available for assessing the environmental conditions, changes, impacts and policy responses to cope with negative impacts may "be structured using the well-established Drivers, Pressures, State, Impact and Response (DPSIR) framework (EEA, 1999; Niemeijer and de Groot, 2008).

This theoretical framework is used to classify the information needed for analyzing the environmental issues and to identify the measures to solve them (Turner et al., 2010).

DPSIR is not dependent from spatial and temporal scales and it can be adapted and applicable to any ecosystem type at any kind of level. It helps to identify relevant data needed in order to perform assessment in suitable temporal and special resolutions.

In order to find consensus between the different policies of the Member States of EU, the initial framework had to suffer some modifications. Some Member States plead for focusing on the proper functioning of ecosystems and the biodiversity role, while other states chose a deeper emphasis on the demand site of ES with much more focus on unrevealing the benefits that arise from ecosystem services (J. Maes et al./Ecosystem Services 17, 2016).

After consulting several biodiversity researches and taking into consideration all the point of views received from the Member States, the

MAES working group adopted a final framework which links socio-economics system with the flow of ecosystem services through the drivers of change.
In the context of MAES, a specific framework was provided based on the concept of ecosystem services (Luck et al., 2009).

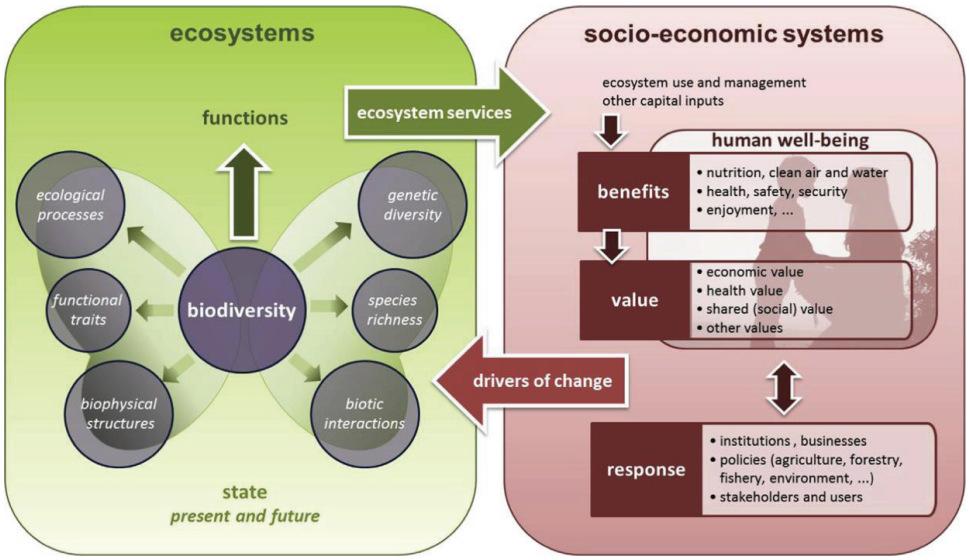

Figure 2. Conceptual framework for EU and national ecosystem assessments under Action 5 of the EU Biodiversity Strategy to 2020 (Source: Maes J. et al./Ecosystem Services, 2016).

Ecosystem functions are defined as the capacity or the potential to deliver ecosystem services (de Groot et al., 2010).
Humans take benefits from goods and services that ecosystems provide to them. This benefit consists in access to water, clean air, health, safety and enjoyment, in short terms called basic human needs. The focus on benefits implies that ecosystem services are open to economic valuation. (J. Maes et al./Ecosystem Services, 2016). All the benefits may be quantified in monetary and non-monetary values.
In order to apply the conceptual framework for the assessment of ecosystems and their services, it was necessary to define two typologies: a typology for ecosystems that would be considered in an ecosystem assessment and a typology of ecosystem services (J. Maes et al./Ecosystem Services 17, 2016).
The actual necessity of these two typologies is to integrate the information received from the Member States.
There are 3 major ecosystem types selected for the assessment:
1. Terrestrial ecosystems: urban, cropland, grassland, woodland and forest, heathland and shrub, sparsely vegetated land, wetlands;
2. Freshwater ecosystems : rivers and lakes;
3. Marine Ecosystems: marine inlets and transitional waters, coastal, shelf, open ocean.
The base for terrestrial and freshwater ecosystems consists in CORINE Land covers and EUNIS (European Nature Information System) classification.
For the ecosystem services, the MAES working group decided to work with the CICES framework because it provides the classification of ecosystem services that relies on biodiversity.

INDICATORS FOR MAPPING AND ASSESSMENT OF ECOSYSTEM SERVICES AT EU AND NATIONAL LEVEL

For Member States in order to map and quantify ecosystem services at a national scale it was necessary to have a set of possible indicators. *An ecosystem service indicator is information which communicates the characteristics and trends of ecosystem services, making it possible for policy-makers to understand the condition, trends and rate of change in ecosystem services* (Layke et al., 2012).

In order to create this set of indicators, the MAES working group organized 4 pilot cases that were made on a volunteer basis. There was participation from Member States, stakeholders and EU bodies like EC and EEA with the scope of identifying resources that could be used on measuring and monitoring the biodiversity, ecosystem condition and services both at EU and national scales.

The spatial accessibility of ecosystems and ecosystem condition is strongly connected with socio economic development and long term human wellbeing. Actually, the MAES working group conceptual model relies on that belief.

The proposed work structure for the 4 ecosystem pilots was based on a 4 step approach:

1. Mapping the concerned ecosystem;
2. Assessment of the condition of the ecosystem;
3. Quantification of the services provided by the ecosystem;
4. Compilation of these into an integrated ecosystem assessment (MAES Technical Report, 2014).

The ecosystem pilots are: agro-ecosystems; forests freshwater ecosystems and marine.

The biggest data set for mapping terrestrial and freshwater ecosystems is CORINE Land Cover. It is also allowing mapping one of the four marine ecosystems. Either way, mapping ecosystem services should not be limited at the availability of data regarding land and sea cover.

As a first step of the process, to all parties of the thematic pilots was requested to gather and compiling basic data information about all CICES ecosystem services. As a result, an *EU wide matrix was populated with indicators based on a literature review* (e.g. Egoh et al., 2012; Layke et al., 2012; Crossman et al., 2013) *and on an assessment of data and indicators available in various European data centers* (Maes et al., 2016).

In the second step, it was requested to all Member States to populate a matrix with indicators about ecosystem services available in their countries. All those matrixes were gathered and synthesized *according to reporting body, data availability, units of measurement and compiling agency* (Maes et al., 2016).

According to MAES Technical Report – 2014 "*Mapping and Assessment of Ecosystems and their Service*", presented by MAES group, the indicators for mapping and assessment of ecosystems and their services were evaluated according to 2 criteria:

1. data availability and

2. ability to convey information to the policy making and implementation processes

- *Available indicator to measure the condition of an ecosystem or the quantity of an ecosystem service at a given CICES level for which harmonized, spatially-explicit data at European scale is available and which is easily understood by policy makers or non-technical audiences. Spatially-explicit data in this context refer to data that are at least available at the regional NUTS2 level or at a finer spatial resolution.*
- *Available indicator to measure the condition of an ecosystem, or the quantity of an ecosystem service at a given CICES level but for which either harmonized, spatially-explicit data at European scale is unavailable or which is used more than once in an ecosystem assessment, which possibly results in different interpretations by the user. This is typically the case for indicators that are used to measure ecosystem condition, which are reused to assess particular ecosystem services. This color also includes indicators that capture partially the ecosystem service assessed.*
- *Available indicator to measure the condition of an ecosystem or the quantity of an ecosystem service at a given CICES level but for which no harmonized, spatially-explicit data at European scale is available and which only provides information at aggregated level*

and requires additional clarification to non-technical audiences. This category includes indicators with limited usability for an ecosystem assessment due to either high data uncertainty or a limited conceptual understanding of how ecosystems deliver certain services or how ecosystem condition can be measured.

- *Unknown availability of reliable data and/or unknown ability to convey information to the policy making and implementation processes.*

All parties involved in the thematic pilots delivered potential ecosystem service indicators. All those indicators were scored by the MAES working group according to their data availability and they received a quality label. After classifying the indicators they received, the conclusion was that only one fifth are *widely available and supposedly ready to use for reporting under Action 5 of the EU Biodiversity Strategy* (Maes J. et al., 2016). The other indicators scored with less availability, they are actually available to usage, but they need additional expertise.

Ecosystem services	Main terrestrial and freshwater ecosystem	Indicator for terrestrial and freshwater ecosystems	Indicator for marine ecosystems
Cultivated crops	Cropland	• Area and yields of food and feed crops	• Yield
Reared animals and their outputs	Cropland	• Livestock	• Landings
	Grassland		
Wild plants, algae and their outputs	Forest	• Distribution of wild berries (modelling)	
Wild animals and their outputs	Forest	• Population sizes of species of interest	
Plants and algae from in-situ aquaculture			
Animals from in-situ aquaculture	Lakes and rivers	• Freshwater aquaculture production	
Water (Nutrition)	Lakes and rivers	• Water abstracted	
Biomass (Materials)	Cropland Forest	• Area and yield of fibre crops • Timber production and consumption statistics	• Catch per unit effort (where applicable)
Water (Materials)	Lakes and rivers Forest	• Water abstracted • Total supply of water per forest area (modelling)	
Plant-based resources	Forest	• Fuel wood statistics	
Animal-based resources			
Animal-based energy			
(Mediation of waste, toxics and other nuisances)	Forest	• Area occupied by riparian forests • Nitrogen and Sulphur removal (forests)	• Nutrient load to coast • Heavy metals and persistent organic pollutants deposition • Oxyrisk
Mass stabilisation and control of erosion rates	Forest Cropland Grassland	• Soil erosion risk or erosion protection	• Coastal protection capacity
Buffering and attenuation of mass flows			
Hydrological cycle and water flow maintenance			

Figure 3. Available indicators for assessment of ecosystem services across different ecosystems (Source: Maes J. et al., 2016)

Ecosystem services	Main terrestrial and freshwater ecosystem	Indicator for terrestrial and freshwater ecosystems	Indicator for marine ecosystems
Flood protection	Wetlands	• Floodplains areas (and record of annual floods) • Area of wetlands located in flood risk zones	• Coastal protection capacity
Storm protection			
Ventilation and transpiration	Cropland Grassland	• Amount of biomass	
Pollination and seed dispersal	Cropland Grassland	• Pollination potential	
Maintaining nursery populations and habitats		• Share of High Nature Value farmland • Ecological Status of water bodies	• Oxygen concentratio • Turbidity • Species distribution • Extent of marine protected areas
Pest and disease control			
Weathering processes	Cropland Grassland	• Share of organic farming • Soil organic matter content • pH of topsoil • Cation exchange capacity	
Decomposition and fixing processes	Cropland	• Area of nitrogen fixing crops	
Chemical condition of freshwaters	Lakes Rivers Wetlands	• Chemical status	
Chemical condition of salt waters	Marine systems		• Nutrient load to coast • HM and POP loading • Oxyrisk
Global climate regulation by reduction of greenhouse gas concentrations	Forest	• Carbon storage and sequestration by forests	• Carbon stock • Carbo sequestration • pH; • Blue carbon • Primary production
Micro and regional climate regulation	Forest	• Forest area	
Physical and experiential interactions	Forest Cropland Grassland Lakes	• Visitor statistics	
Intellectual and representative interactions			
Spiritual and/or emblematic			
Other cultural outputs		• Extent of protected areas	

Figure 4 . Available indicators for assessment of ecosystem services across different ecosystems (Source: Maes J. et al., 2016)

All ecosystem services are presented at the class level of CICES except ecosystem services in italic which are at CICES group level (Maes J. et al., 2016).

The analytical framework and list of indicators are essential steps for implementing Action 5 of the EU Biodiversity Strategy.

There is a need to specify that the list of indicators presented above and proposed by MAES can measure the pressure on ecosystems, the ecosystems state or a possible impact on ecosystems, but also quantify the potential and contribution of ecosystems. Within the thematic pilots, there were seized several gaps like: development and subsequent monitoring of indicators for cultural ecosystem services (Daniel et al., 2012; Paracchini et al., 2014), link between some dimensions of biodiversity, such as species diversity, and the delivery of ecosystem services, which requires

further research and evidence gathering (Harrison et al., 2014) and the low number of indicators proposed for the analysis of the demand and the valuation of ecosystem services (Maes et al., 2016).

DISCUSSIONS

The measures taken so far in order to implement Action 5 of the EU Biodiversity Strategy gave permission into establishing the analytical framework and the first set of indicators, gathering experience from different participants of the MAES working group, integrating different points of view and raise awareness at Member States and EU level. The increasing interest of the process was demonstrated by the great number of participants at the MAES working group meetings.

On the other hand, the working group faced themselves with methodological challenges and some gaps into the studies like: the indicators proposed in the study "*do not always quantify the potential or actual contributions of ecosystems for regulation and maintenance*" (J. Maes et al., 2016) or the existence of *different interpretations of data quality among the pilot studies* (J. Maes et al., 2016).

The identified gaps will remain to be debated between the stakeholders and the working group in order to align the conceptual framework and available indicators at the EU level in order to deliver the expected results of the EU Biodiversity Strategy up to 2020.

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. Mapping and assessing integrated information is essential in evaluating the environmental legislation.

The result of MAES working group 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. The pilot study initiated by MAES presents a list of indicators which may be used along with a typology and map of ecosystems in order to create an assessment of ecosystem condition and ecosystem services.

The data gaps that MAES pilot studies highlighted will be filled in further researches in order to complete a full ecosystem assessment. In fact, each concluded or ongoing project developed in Europe under the MAES methodology opens new focused visions for a better objective approach on the use of representative indicators which better describe the ecosystems. The implementation of the project entitled "Demonstrating and promoting natural values to support decision-making in Romania", implemented since March 2015 in the framework of EEA Grants, sustains the idea of using a data management system structured around three pillars: content, infrastructure and thematic cooperation between competent organizations.

The above mentioned project underlines the idea that there is real need for the policy makers of all Member States to contribute at the improvement of knowledge and evidence for EU environment policy in order to assure the continuity of Action 5 on the road towards 2020. On the other hand, EU is committed to provide tools that would facilitate the exchange of information and expertise across levels.

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