METHODOLOGICAL FRAMEWORK FOR ASSESSMENT AND MAPPING OF ECOSYSTEM CONDITION AND ECOSYSTEM SERVICES IN BULGARIA

PART D

Guide for monitoring of trends in ecosystem condition and ecosystem services

METHODOLOGICAL FRAMEWORK FOR ASSESSMENT AND MAPPING
OF ECOSYSTEM CONDITION AND ECOSYSTEM SERVICES IN BULGARIA

GUIDE FOR MONITORING OF TRENDS
IN ECOSYSTEM CONDITION AND ECOSYSTEM SERVICES

PART D

© Authors: Nesho Chipev, Svetla Bratanova-Doncheva, Kremena Gocheva,
Miglena Zhiyanski, Margarita Mondeshka, Yavor Yordanov, Iva Apostolova,
Desislava Sopotlieva, Nikolay Velev, Elena Rafailova, Yordan Uzunov,
Ventzislav Karamfilov, Radka Fikova, Stojan Vergiev

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1. Introduction

1.1. Objective and scope

The snapshot identification and mapping of ecosystems and their services (as outlined in parts A and B of the Methodological framework) is an important process for creating a baseline for assessing ecosystems conditions and ecosystem services provisioning. Successful ecosystem management, however, requires identifying the long term ecosystems development trends, as part of development policies, plans and projects related to people's well-being (UNEP, 2014). For the Bulgarian territory outside NATURA 2000 this baseline evaluation was created in the reference timeframe of the field seasons 2015-2016 by seven projects that performed mapping and assessment of the nine main ecosystem types within the Programme BG03 „Biodiversity and ecosystem services" funded by the EEA Financial mechanism.

However, the socio-ecological systems of Bulgaria are evolving and a snapshot assessment is not sufficient to capture trends in the development of these systems and the impacts on their biodiversity and ecosystems' functioning. Even if an ecosystem was assessed in 2015 or 2016 to be in excellent condition, with intact integrity and in a peak ecosystem services production capacity, both natural factors and human activity within a wider socio-ecological system context may change and/or adversely impact it. In some ecosystems this is a common situation – for example cropland ecosystems are heavily controlled by humans and their composition and properties may abruptly change annually upon crop rotation in a manner that is not usual for natural ecosystems; in the process of increasing urbanization, urban ecosystems tend to swallow the surrounding land with little to no regard to the integrity of the ecosystems on it and which become fragmented or completely destroyed; water ecosystems – both freshwater rivers and lakes, and also marine, are subject to increasing pollution not only from relatively regulated point sources but also from diffuse sources (such as nitrates from agriculture) or new pollutants (such as microplastics). If not continuously updated, the baseline assessment would therefore be obsolete in the short- to mid-term, becoming increasingly inadequate for the purposes of spatial planning, ecosystems sustainable management, participative decision making and other policy objectives.

Moreover, without the constant update of baselines, we would not be in the position to provide the necessary data grounds for ecosystems management and for any success we might have towards achieving the objectives of the EU Biodiversity Strategy by 2020.

The objective of ecosystem-based environmental monitoring, therefore, should be to systematically use existing data provided by other types of monitoring, collect additional data and observe trends in the development of socio-ecological systems. At present this is not entirely the case due to a number of factors – the complexity of such systems, evolution of monitoring methods underlying policy objectives and our understanding of ecosystems.

The present Monitoring guide is part of the structure of the **National Methodological Framework for the mapping and biophysical valuation of the ecosystems in Bulgaria**. It consists of:

- an Introductory part including reflections and outlined practical steps on the connection with the economic assessment, natural capital accounting and other subsequent steps -Part A,
- nine Methodologies for ecosystem and ecosystem services mapping and assessment – Part B (1-5),
- an *In situ* verification Guide – Part C,
- a Monitoring guide – Part D (this document).

The current Guide aims at justifying and outlining the practical steps for a consistent, intra-institutional monitoring of the state of the Ecosystems (ES) and the ecosystem services (ESS) provided by them, even if the institutional framework for such monitoring is not completely in place at the time of writing. The need of legal modifications is outlined in part A of the Methodological Framework and is not subject of this Guide.

The monitoring approach described in this Guide refers to the nine main ecosystem types in Bulgaria, both inside and outside the protected areas and zones. The following table shows the main types of ecosystems present in Bulgaria with reference to the related mapping and assessment methodologies and their annexes. This Guide will not detail the mapping and assessment steps but builds upon them.

Types of ecosystems in Bulgaria

ES Types	Methodology reference	Annexes to methodology
Terrestrial/ Urban	B1	***1.*** Annex № 6 to the respective ecosystem methodology: ***Indicators for valuation of the state of ecosystem;***
Terrestrial/ Cropland	B2	
Terrestrial/ Grassland	B3	
Terrestrial/ Woodland and forest	B4	
Terrestrial/ Heathland and scrub	B5	2. Annex № 7 to the respective ecosystem methodology: ***Indicators for valuation of the services provided by the ecosystem.***
Terrestrial/ Sparsely vegetated land	B6	
Terrestrial/ Wetlands	B7	
Fresh water/ River and lakes	B8	
Marine/ Marine	B9	

Taking into account the specifics of each ecosystem type, the current Guide presents a set of monitoring indicators and their parameters for each ecosystem type and derives an unified plan for calculating ecosystems' driver, pressure and state indicators from the monitoring indicators across all ecosystem types found in Bulgaria.

The document aims at aligning the ecosystems approach with monitoring performed as part of the implementation of other relevant policies resulting from international, EU level and national legal provisions, in order to create a maximal synergy between policies and build upon knowledge already collected.

The Guide's objective is also to provide guidance for a long-term collection, processing and interpretation of environmental data. In this manner, monitoring will ensure following the trends in ecosystem development, the exerted pressure and the changes in the state and quantity of the ESS provided. The document is centered on the concept of ecosystem services, therefore viewing the monitoring of trends in ecosystems' conditions as a component of the wider monitoring of trends in the increase or decline of ecosystems assets and ecosystem services flows which form the components of Bulgaria's natural capital.

1.2. Target audience

This document is for you, if you are:

1. **A performer of monitoring activities:** an official in administration that is in charge for performing, in whole or in part, the monitoring and valuation of ecosystems and ecosystem services. In this Guide, the parts most relevant for your work are marked with the sign of ;

2. **A stakeholder - user of monitoring results:** An official of a data user administration, a representative of the scientific community, of local bodies or another interested parties involved in national or local policy decision-making. In such capacity, you may find it useful to utilize the monitoring results, or based on your institutions' needs, to identify a need of improving / widening the monitoring of a particular type/subtype of an ecosystem. In this Guide, the parts most relevant for your work are marked with the sign of ;

3. **A volunteer:** A volunteer who wants to support the process of monitoring the state of the ecosystems in Bulgaria and the ecosystem services provided by them. In this Guide, the parts most relevant for your work are marked with the sign of .

Persons involved in conducting the entire range of monitoring procedures are currently expected to possess the necessary educational and qualification background, professional/specialized knowledge and experience in the field of environmental components and biodiversity conservation (detailed in the single monitoring methodologies for ecosystems components are available here: http://eea.government.bg/bg/nsmos). This monitoring however, is currently organized as **monitoring of environmental components** rather than holistic monitoring. Furthermore, due to relatively small numbers of scientists of narrow specialization, the existing capacity in Bulgaria is insufficient for handling, routinely and on the large scale, of the entire scope of indicators and measures outlined in this Guide.

Therefore, other stakeholders, and in particular the civil society, are called upon to support the monitoring effort.

Within the Programme BG03 Biodiversity and ecosystem services, the involvement of engaged volunteers was funded in the form of a separate grant scheme and their contributions from observing a number of land and water species during field seasons 2015 and 2016 are being entered into the National biodiversity monitoring information system (NBIS). The NBIS itself is undergoing significant improvements in the public user interface that will be conductive to the collection of volunteer data; free smartphone applications for the main platforms (Android, iOS, Windows mobile) are also planned to be made available to volunteers to facilitate data submission to NBIS. However, possibilities to participate are not limited to these options. Scientists, NGOs and stakeholders have already developed applications for observing single species (for example, there are several applications about bird identification by voice and appearance and tracking, including the Bulgarian bird identification and the diary SmartBirds). However, an ecosystem is more than the su m of its parts – the individual species (plants, animals, microorganisms etc.) and environmental factors. With the development of citizen science efforts across Europe however, volunteers get more elaborate tools and possibilities for measuring factors like marine pollution (using the dedicated application of the European Environment Agency – Marine Litter Watch), or even be able to participate in measuring ecosystem services, such as cultural services, by recording their actions in a simple but structured manner.



Another important addition to NBIS is the planned new module on ecosystem services. It will make available the data about ecosystems condition and biophysical valuation of ecosystem services produced by the mapping and assessment projects – both the projects conducted outside NATURA 2000 with funding from Programme BG03, and future projects to be funded by OP Environment for mapping and assessment of ecosystems and their services in NATURA 2000 areas.

The Guide contains information and guidance on:

Role of monitoring from the point of view of the relevant international models - cascade model for ecosystems provision and the European Environment Agency's Drivers-Pressures-State-Impact-Response (DPSIR) framework;

The existing institutional framework;

The process of monitoring, including:

- **Preparation steps: scope and content of cameral work,** selection of the monitoring polygons
- **Fieldwork:** Time periods of investigation, applicable methods for data collection

- **Follow-up of the fieldwork,** processing and reporting of results and obtained data to identify trends in the changing of the state of ecosystems and the quantities of ESS provided by them.

1.3. Background

Place of the Monitoring Guide in the National Methodological Framework. Scope and development needs

Monitoring, in the context of the National Methodological Framework, is an ongoing activity following the baseline mapping and assessment and providing information for next steps in the national natural capital accounting process, as presented in Figure 1:

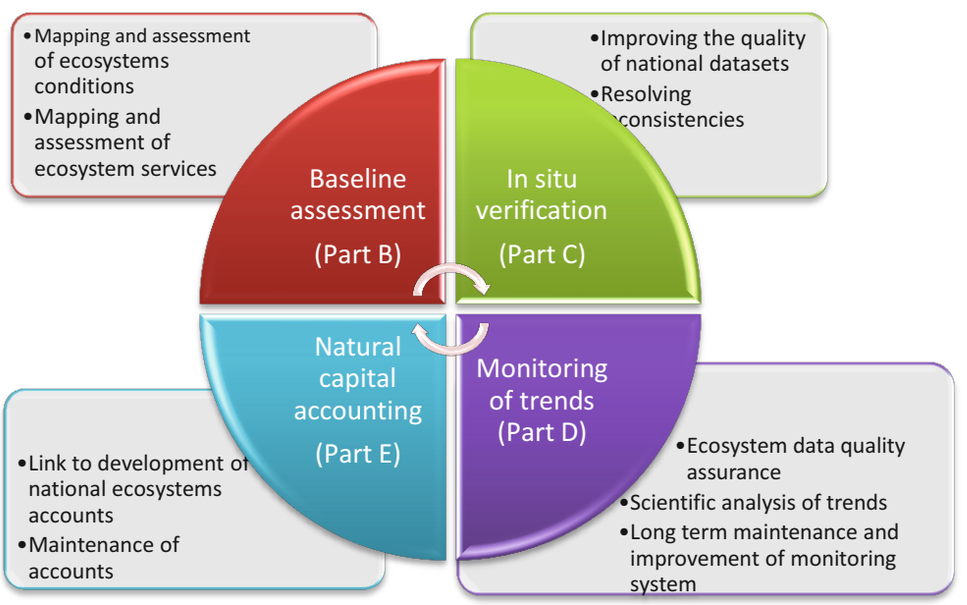


Figure 1. Place of the monitoring within the National Methodological Framework

Monitoring is a continuous activity to be performed by multiple actors, combining off-site and on-site activities aiming at:

- Continuous collection of data about the ecosystems by using **monitoring indicators**
- Identification of changes in ecosystems' condition and the corresponding change in the provision of ecosystem services
- Processing and interpretation, using expert knowledge and models, of the difference in ecosystems' state between the baseline and the new observed state – **DPSIR indicators** that highlight the **drivers** of ecosystems **change**, **pressures** which led to the new **state**, **impacts** of human activities and the effect of **responses** set in place by existing policies

- Formulating and communicating to stakeholders qualitative data and scientifically sound basis for policy decisions and corrective measures – legislative, institutional and practical
- Providing a well-founded practical basis for creating and maintaining national environmental accounts
- Supporting Bulgaria's reporting to the EU and international organizations to meet international obligations and support negotiation for resource allocation

These purposes, with reference to the respective parts of the Guide, are presented in Figure 2:

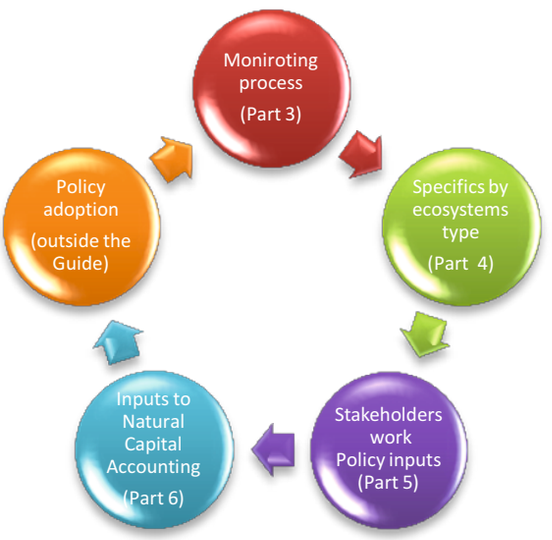


Figure 2. Structure of the Monitoring Guide and relations between the activities in it

The Monitoring Guide is a living document. In its current form, it is focused on monitoring the trends in ecosystems condition change and inferring the trends in capacity of ecosystems to produce ecosystem services (biophysical assessment). The monetary valuation of ecosystem services may be subject to monitoring at a later stage, depending on the available data, precision of models set up for predicting their supply and demand, and other factors. Therefore, the policy response, although outside the scope of the National Methodological framework, is an important consideration for the further development of the ecosystems monitoring and corresponding modifications of the Monitoring Guide.

Difference and complementarities between monitoring and on-the-spot verification

The National Methodological Framework also contains a document called ***In situ* verification guide (Part C).** If you look at that Guide, you will see similarity between its approach and the approach outlined in this document. However, there are significant differ ences in the purpose, scope and intended target audience of the outcomes from the *In situ* verification guide and the Monitoring guide; therefore, they also rely on different methods "under the hood" (Figure 3).

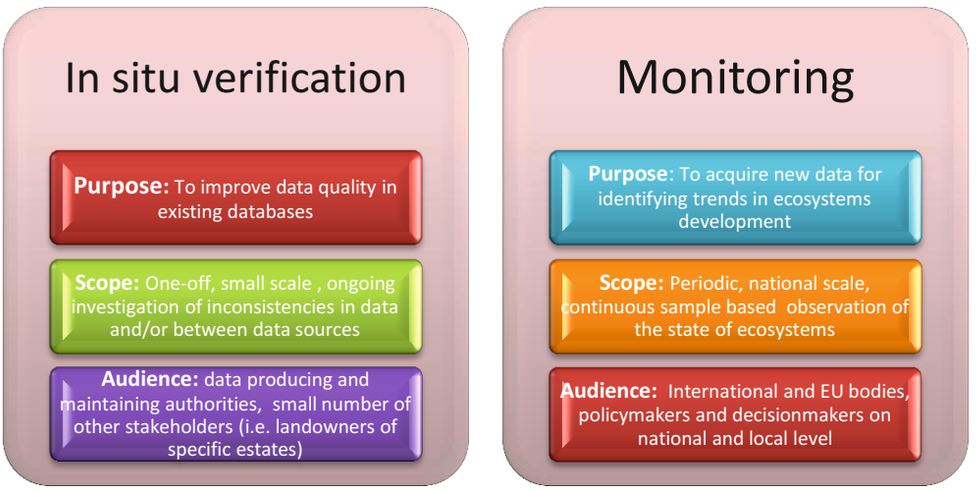


Figure 3. Comparison between the approaches of *In situ* verification and Monitoring

Further, applying the Monitoring guide shall, periodically, perform *in situ* validation in order to assess whether a given monitoring spot is suitable to be included in the monitoring programme, or has, on the contrary, to be excluded or used for monitoring of another ecosystem type due to change in land use or the ecosystems' type (i.e. succession).

2. The Bulgarian ecosystems monitoring in context – international developments and national specifics

2.1. The ecosystem services approach

Ecosystems, in more scientific terms, are communities of interacting organisms and the physical and chemical non-living components of their environment, e.g. water, minerals, soil and climate. These biotic and abiotic components are linked together through food-webs, nutrient cycles and energy flows (Odum, 1971).

Ecosystems are defined in the Convention on Biological Diversity (CBD) as 'a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit' (UN, 1992). Ecosystems are multi-functional. Each system provides a series of services for human well-being either directly, e.g. as food, fibers or timber, or more indirectly by e.g. providing clean air and water.

Ecosystem assessment is an instrument for structured and targeted analysis of environmental change and its impact on human well-being. The structural and functional entities of ecosystems are key entry points for our understanding of how species interact with each other and their abiotic environments, and how these interactions are affected by human activities.

An ecosystem services (ESS) approach is one that integrates the ecological, social and economic dimensions of natural resource management (Cork et al., 2007) who have described an ESS approach as follows:

> An ESS approach helps to identify and classify the benefits that people derive from ecosystems. It also includes market and non-market, use and non-use, tangible and non-tangible benefits.
>
> It also explains consumers and producers of ESS for maintenance and improvement of ecosystems for human well-being.
>
> The approach helps to describe and communicate benefits derived from natural and modified ecosystems to a wide range of stakeholders.

2.2. Links between ecosystems, ecosystem services and their socioeconomic use: Cascade model of ecosystems provision and the place of monitoring

In order to scope monitoring, it is necessary to understand the socio-ecological system in which both humans and the ecosystems are placed within the ecosystem services framework. From the ecological point of view, humans are a species inhabiting most ecosystems. However, unlike other species, we have developed tools and mechanisms for production, transportation and other activities on a planetary scale, therefore modifying the living space of other species often to the extent of annihilating them and their living space. The use of ecosystem services in this socio-ecological system is represented in the Cascade model developed by (Haines-Young & Potschin, 2010), pictured below as adapted by (European Environment Agency, 2016) in the Common International Classification of Ecosystem Services (CICES):

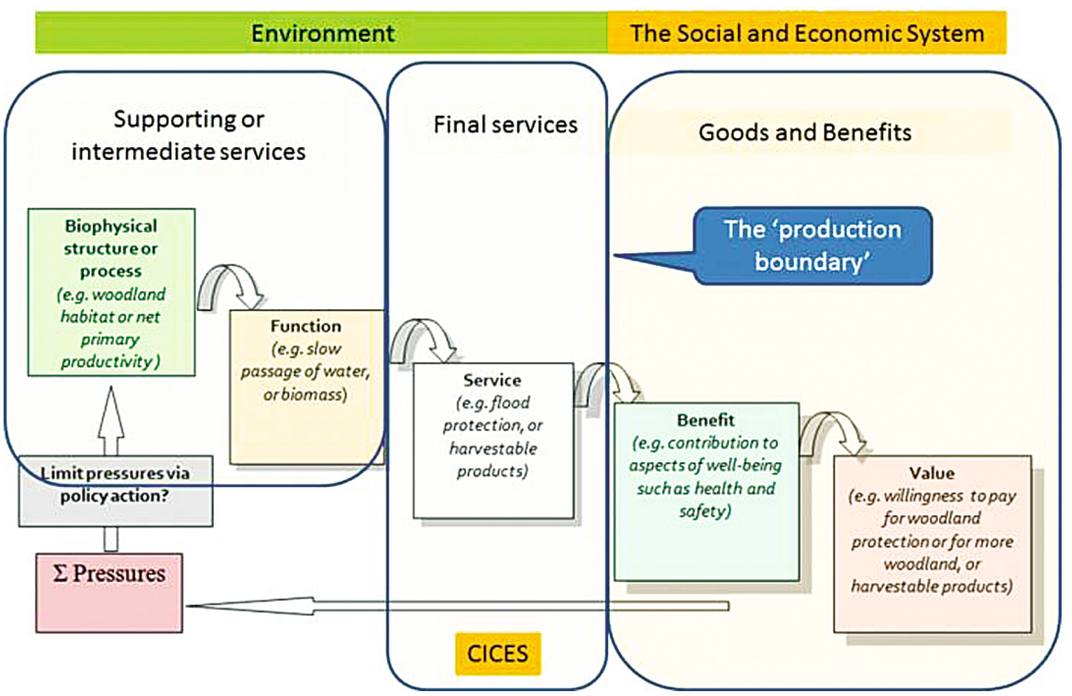


Figure 4. The Cascade framework for ecosystem services assessment according to CICES

As can be seen, some of the services provided by ecosystems (final services) are directly used by humans depending on their type – for example provisioning ecosystem services provide inputs to the production of industrial goods and services, regulating services often serve as a positive externality to cut costs, whereas both provisioning and cultural services also play a role in the life of households outside the formal economy or otherwise for sustaining the human well-being. The consumption of these services removes matter and energy from ecosystems. On the other hand, residues and waste from human habitation and production (i.e. of energy, goods and services impacting the environment, i.e. transport) result in pressures that adversely affect and in some cases destroy the ecosystems.

This cascade model forms the background for the current Guide. Significant work has been done over the years on monitoring various components of the environment (such as air, water, soil, biodiversity, some ecosystems, notably forest, emissions, specific pollutants, etc.), and monitoring systems for these elements were set up and produce time series of data for the monitoring locations, albeit not for the entire territory of Bulgaria. Even though these data do not cover the entire spectrum of data needed for ecosystem monitoring, it is expected that the monitoring performed so far on single ecosystems components, together with other data collected from other sources (such as spatial planning, agriculture, statistics, trade etc.) and produced as needed by modeling, will contribute to understanding the anthropogenic pressures on the ecosystems. Monitoring can also contribute to quantifying the production of ecosystem services in non-monetary terms, therefore facilitating our understanding of causal relationships between pressures and their results, and providing a robust foundation for decision making and implementation of specific management tools.

2.3. The DPISR framework - connections to ecosystems monitoring





The mapping and assessment of ecosystems, their conditions and services they provide, is a tool intended to acquire a "snapshot" of the state of nature as of the mapping period.

The Driver-Pressure-State-Impact-Response (DPSIR) framework adopts a holistic prospective on the ecosystems' evolution and the ways human activity impacts it. These interactions are depicted in the graphic (Figure 5) produced by the European Environmental Agency:

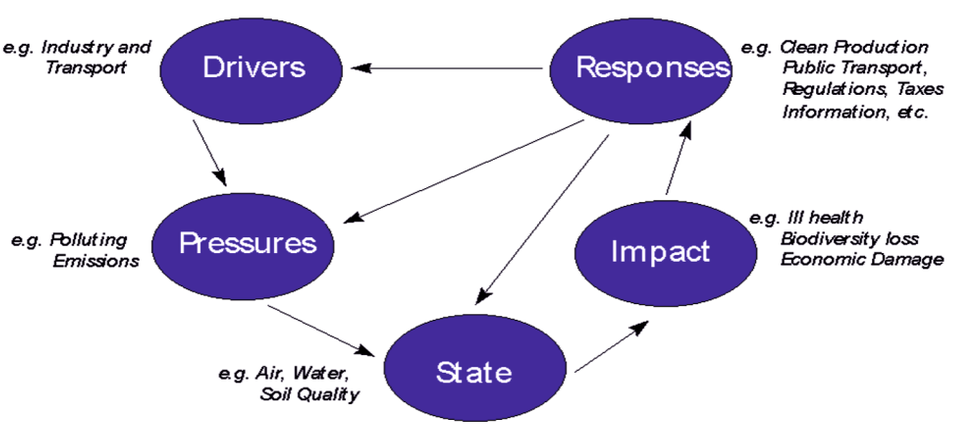


Figure 5. The DPSIR analytical framework

As can be seen from Figure 5, the DPSIR framework is not purely ecological; rather, it is a causal framework to gauge human impact on the environment and its response to management measures. DPSIR was not coined specifically for ecosystems or ecosystem services studies; however, since ecosystems are a key element of our environment, and their integrity determines the provision of services vital to humans, the adaptation of DPSIR to ecosystems monitoring is an important part of the holistic approach adopted in the National Methodological Framework.

The present Guide also contributes to implementing the DPSIR framework. In particular, for each ecosystem type, suitable **monitoring indicators** were selected and classified. Using these indicators, the Guide aims at deriving **DPSIR indicators** identifying the changes in ecosystem state as impacts and attributing them to specific drivers and pressures (in case of worsening state) or responses (in case of improvement following policy measures). It is to be noted that **the monitoring indicators are not identical with DPSIR indicators**; rather, DPSIR indicators are to be calculated from the measurement of monitoring indicators, as described in this Guide.

2.4. The existing national environmental monitoring framework and other relevant data sources



The set-up and functioning of the National Environment Monitoring System is regulated in the Environment Protection Law and its sub legislation. Some of the monitoring elements are also contained in special laws, i.e. the Water law. This legal framework defines the system as a set of national monitoring networks that collect and process information on all elements of environment, except for urban noise. Its elements include monitoring systems for air; rain and surface water; groundwater; marine water; geologic environment; soils; forests and protected areas; biodiversity; radiology; landfills and old pollutants.

Monitoring is organized by the Minister of environment and water and performed mostly by the Executive Environment Agency (ExEA), the Regional Inspectorates for Environment and Water and Basin Directorates. ExEA is in charge for the methodological leadership and resource provision for monitoring, as well as a wide range of specific monitoring activities: data collection, processing, storage, visualization, maintenance of maps and registries, as well as forecasting of the state of environment and environmental risks, providing information for policymakers and the society as a whole, and reporting to the EU Monitoring system.

Other institutions involved in collecting data and/or performing some parts of the environmental monitoring include the National Statistics Institute (FDES statistics), Ministry of Agriculture and food and its Agriculture Fund, Ministry of Health, the Executive Forestry Agency, the Executive Agency for Exploration and Maintenance of the Danube River, and institutes of the Bulgarian Academy of Sciences – National Institute of Meteorology and Hydrology, and Institute of Oceanology. Furthermore, a number of institutions not directly related to environmental monitoring collect information relevant to ecosystems monitoring.

Such authorities include, for example, the Ministry of Agriculture and Food, the Ministry of Regional Development and Public Works, the National Statistics Institute, the Cadastre, municipal authorities etc.

Last but not least, data is being gathered in the framework of different projects both by scientific organizations to perform monitoring (such as the Institute of Biodiversity and Ecosystems Research, the Forestry Institute at the Bulgarian Academy of Sciences, universities and high schools), and a number of non-governmental organizations who systematically collect and organize time series of species data – birds, bats, turtles, dolphins, some plants, etc. This data could form a valuable complementary information source to augment the legally mandated monitoring.

3. Organization and implementation of the ecosystems based monitoring

3.1. Data sources

The initial data forming the basis of the monitoring comprises the data available and collected during the 2015/2016 mapping and biophysical valuation of the nine ecosystem types in Bulgaria and the ecosystem services provided by it. This dataset represents a "snapshot" of the state of each ecosystem and the range of ecosystem services provided by it. This dataset being not the only one in the country, the data sources for each ecosystem type's monitoring are to be augmented by available data produced by authorities competent in a given area or other interested parties, such as volunteers, companies, etc.

Depending on the ecosystems type and its management, the initial information used for ecosystems monitoring will vary. A comprehensive list of data sources for each ecosystem type can be found in part B – Mapping methodology for the respective ecosystem.

3.2. Preparatory work

The ecosystems monitoring has to take into account the optimal observation periods for ecosystems by ecosystem type, such as vegetation periods, phenology observation times, breeding or migration seasons, etc., as well as the identified periodic monitoring needs and available resources at the exact time during the year. Therefore, in line with legal and institutional procedures, its preparation must start long before the actual monitoring takes place, and be organized on a regular basis. A possible sequence of activities involves set-up activities and periodic monitoring activities according to schedule, and is presented in Figure 6 and

Figure 7 below. Long term and midterm activities are presented in Figure 6. These arrangements will of course not be made overnight and in their absence, organizational and practical steps towards the ecosystems monitoring will perforce be more limited in scope and resources. Since these institutional changes are not likely to be implemented within the duration of the project **MetEcoSMap**, such activities are also outside the scope of the present Guide.



Figure 6. Institutional set-up of ecosystems based monitoring

However, in as much only organizational and not legal or budgetary measures are concerned, there's no specific obstacle to immediately applying the principles outlined in this Guide to the extent feasible. This may, for example, be the case when a given area is being visited in the frame of a different type of monitoring (such as species monitoring) and the experts use the opportunity to collect data on one or more indicators from the preset Guide.

To do so, a set of monitoring polygons should be established, based on the following considerations:

MSV

1. The polygons are established as monitoring spots for other types of monitoring (i.e. species, habitats) or as part of a project / volunteer campaign;
2. The polygons correspond to the requirements set out in this Guide and are of monitoring interest for one or more ecosystem types;
3. The planned monitoring allows for extension by including easy-to-perform in situ activities, such as counting of animal species, applying of transect methods for identifying plant species, collecting soil, water or species' tissue probes for later processing. In case of volunteer campaigns, the activities should also be easy to perform by volunteers of lower skills, and be easy to verify and process by experts (i.e. photographs of species, GPS track, etc.);

4. The planned monitoring will be performed in a time of year that is conductive to the additional monitoring activities (i.e. during phenologically interesting time spans, vegetation or breading seasons for species of interest, etc.).

Necessary resources for implementation periodical monitoring involve: experts by type of expertise (for example phytocoenology, mycology, fauna, GIS, statistics); equipment for spatial data collection and processing (including computer equipment for data storage and sharing and modelling computer equipment), equipment for biomass collection and measurement (precision 0.1g), GPS, camera, Unified Field Protocol.

Necessary finances for implementation periodical monitoring of ecosystems include: daily subsistence and accommodation for field trips, travel costs, payments for data acquisition, staff remuneration, hire or purchase of equipment (i.e. ships and/or boats for investigating freshwater and saltwater bodies, autonomous vehicles, diving or protective suits, and other specialized equipment).

So far, no resource estimates were made on permanent ecosystems level monitoring (which is currently not legally mandated and organized). With the advance of space observation and modeling technologies, it is very likely that permanent monitoring may be feasible and relatively cost efficient on a national scale.

These resources and financing must be considered for pre- and post-processing of data for the entire monitoring territory, as well as for ensuring field trips to all monitoring areas planned to be visited during the particular year. Sufficient reserve should also be planned for follow-up visits if these are to be verified *in situ*, or further observations are needed for another reason (for example, an invasive species was found and experts of other domains of expertise must be included). In estimating both the resource needs, and the amount of contingency to be planned, the actual costs incurred for mapping and assessment of the relevant ecosystem type can be used as reference.

Regardless of the extent of the particular monitoring campaign in a given year, a number of practical steps are to be performed to prepare, conduct and follow-up the monitoring, as presented below:

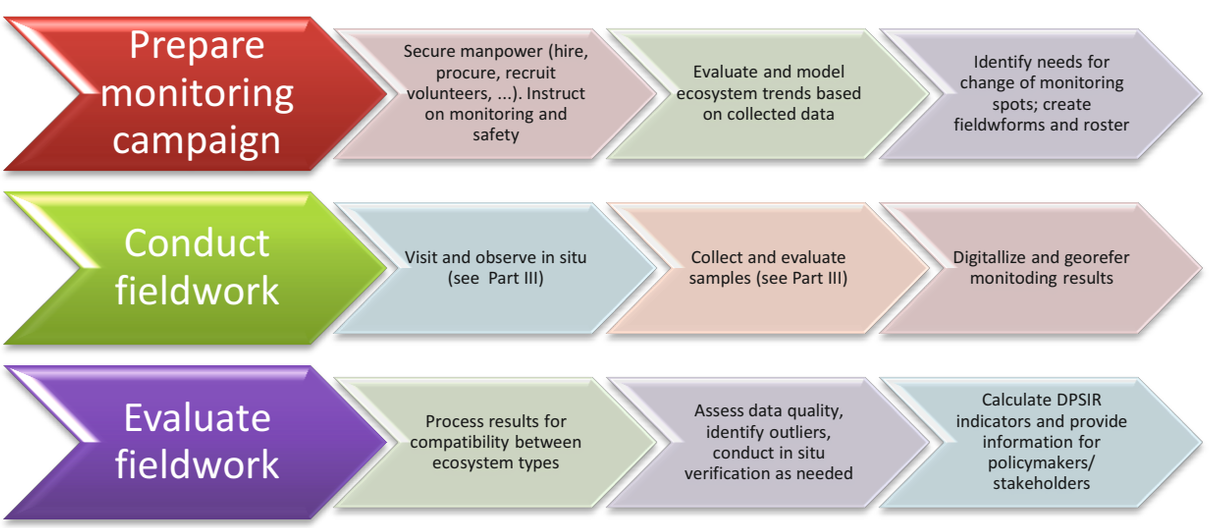


Figure 7. Organization of ecosystems based monitoring campaigns

3.3. The monitoring campaign: preparation, implementation, evaluation



Monitoring campaign preparation includes a number of practical steps that are organization-dependent and will necessarily vary from one organization to other. Such steps involve the recruitment, training and instruction of monitoring personnel, and preparing of monitoring rosters within the organization. However, to ensure a uniform approach in monitoring, the evaluation and modeling of ecosystems must follow the same procedures. In particular, they must contribute to the same nationally harmonized database that is defined in Part B of the National Methodological framework. Where modeling is used, it has to contribute to a common set of objectives, as follows:

1. Demarcation of ecosystem types and subtypes, including pattern recognition, where appropriately augmented by multifactor modeling
2. Identifying ecosystems development trends, including visual recognition (such as following of transitions from grassland to heathland and shrubs to forest within the same polygon, or change of land use and recognition of the new ecosystem type on a given polygon), as well as recognition in ecosystems' conditions (such as fragmentation, changes in phenological cycles, species composition and invasive alien species invasions, ecosystems boundaries)
3. Modeling of ecosystem services production functions for validation during the monitoring or in-situ verification
4. Transfer modeling, for example retroactive extension of (incomplete) time series, extrapolation of ecosystem conditions between similar types of ecosystems in different locations, including inside and outside NATURA 2000 (in particular if they are geographically close).

Due to the fact that ecosystems monitoring will most likely be introduced in stages, the consistency between models used by different participants should also be secured, i.e. through inter-calibration. Consistency must at least involve:

1. obtaining similar results from different models: when running them with the same datasets, the models should yield statistically insignificant differences;
2. achieving continuity across polygon and ecosystems borders: the models should yield the same values on borderlines between areas where they are deployed, for example between forest and grassland, or within different forest areas modeled using two different models.

It is to be noted that in practice both base years and monitoring cycles are likely to vary between different locations due to a number of considerations, such as:

- The division of the country in areas for monitoring in different months or even years;
- Different baselines between areas outside and within NATURA 2000;
- Different monitoring cycles for ecosystem subtypes;

- Different base years for obtained huge amounts of information for the purposes of other policies (for example via agricultural, ortho photometry or via inventories in forest ecosystems which will be performed regionally);
- Different years of adoption of management plans which include thorough studies and are likely to require monitoring of the condition for the respective plan's timeframe.

Therefore, it is strongly recommended that interinstitutional exchange is performed continuously and information obtained is processed without delay in the receiving organizations to inform their own monitoring preparation.

The **field forms** used in ecosystems monitoring cannot be prescribed in great detail due to the differences between ecosystems types and subtypes, and the variety of methods used according to different pre-existing legislation. However, the following minimal requirements should be ensured for compatibility (unless impossible due to legal restrictions):

A. **Information compatibility:** Information must be compatible with the respective methodology from Section B for the respective ecosystem type to be monitored. This involves using the same methods, the same measurement units and other monitoring parameters so that results from the assessment and monitoring could be easily compared with each other.
B. **Minimal information content:**

1 Polygon ID
2 Polygon coordinates
3 Expected ecosystem type and subtype(s) – names and codes, with checkboxes for these being found or not found during the fieldwork
4 Monitoring indicators – type (condition or state)
5 Monitoring indicators – code and name
6 Monitored parameters for each indicator – code and name
7 Table of findings containing the codes of all indicators and parameters to be measured and observed
8 Monitoring results – text fields for comments, structured by indicators, parameter
9 Notes and observations – text field for comments related to the polygon as a whole, i.e. fragmentation, succession, state, etc.
10 Urgent action needed, institution to be informed: a field that contains any findings requiring immediate response

C. **Usability**: Field forms must contain instructions on the methods used. While simplicity will be conductive to improving usability, the level of detail of such instructions must correspond to the experience and knowledge of the experts who will be performing the monitoring. Sufficient detail should be provided at all times instead of references, having in mind that the monitoring expert may not have the necessary hardware and con-

nectivity to view instructions contained, for example, in relevant ordinances or other online documents.

D. **Error minimization**: Where feasible, field forms should be tabular for easy post-processing. As far as possible, the data entry should be made electronically, in the following order of preference:

1 Entry to databases via online interface and web services
2 Entry to database(s) via smartphone applications
3 Entry to suitable tabular forms with appropriate data validation, for example CSV, for subsequent database import
4 Entry to other types of files
5 Entry to paper forms.

The organization of monitoring campaigns is bound to be different in each monitoring year due to at least following factors:

1. Not all ecosystem indicators need to be monitored annually. Therefore, some monitoring activities will skip one or more years between being again included in the monitoring roster
2. In case of shortage in funding, the in situ works may be reduced by excluding some of the polygons. The exclusion may be decided based on the following considerations:
   a. There is good remote sensing and modeling coverage allowing the conclusion that no significant changes happened in the polygon since the last monitoring visit
   b. The polygon was visually changed to a different ecosystem type and that ecosystem type has sufficient monitoring spots already; no immediate replacement can be made for the polygon with another one of the same ecosystem type
   c. The resource is insufficient and the polygon does not contain priority monitoring objects (i.e. rare species, identified pressures, need for impact measurements, etc.)



When excluding polygons from the roster for any given year, care should be taken that the remaining polygons still contain sufficient diversity of ecosystem types and subtypes so as to allow conclusive monitoring results.

A monitoring calendar derived from the identified monitoring needs of all ecosystems, is presented below. This calendar covers the fieldwork part of monitoring (see **Figure 7**) which are more specifically bound to rigid timings as determined by the ecosystem populations' lifecycles. To keep the table simple, details on the specifics of ecosystem monitoring by ecosystem type are omitted in this table; however, when planning the monitoring campaign, the instructions for specific monitoring timing by ecosystem type and in some cases also by subtype (see chapter **4. Monitoring specifics by ecosystem type: monitoring sites, time periods, indicators, methods, DPSIR considerations and** risk assessment), should be consulted. This chapter also contains references to legally prescribed methods for monitoring, where applicable.

Table 1. Calendar of monitoring activities for 2017-2027 years

Indicator	Monitor in:								
	Urban	Cropland	Grassland	Woodland and forest	Heathland and shrub	Sparsely vegetated land	Wetlands	River and lakes	Marine
Reclaimed waste deposit areas, including reclaimed areas from mining returned for agricultural use	Annually	Annually	N/A	Annually	N/A	N/A	Annually	N/A	N/A
Biotic diversity	2020, 2023, 2026	Annually	2020 2023 2026	Every 10 years, in a schedule involving 10% of territory each year	2020, 2023, 2026	2020, 2023, 2026	2020, 2023, 2026	Annually	Annually (plant diversity only)
Abiotic heterogeneity, incl. water column/ bottom	2020, 2023, 2026	2020, 2023, 2026	2021	Every 10 years, in a schedule involving 10% of territory each year	2020, 2023, 2026	2022, 2027	2022, 2027 (except soil quality – N/A)	Specific according Flood Protection Plan	Annually
Matter budget/ storage	2020, 2023, 2026	2020, 2023, 2026	2020, 2023, 2026	Every 10 years, in a schedule involving 10% of territory each year	2020, 2023, 2026	2020, 2023, 2026	2020, 2023, 2026	Annually	Annually
Water budget	2020, 2023, 2026	N/A	N/A	N/A	N/A	N/A	2020, 2023, 2026	Annually	Annually
Energy budget	N/A	N/A	N/A	N/A	N/A	2020, 2023, 2026	N/A	Annually	Annually
Nutrition	N/A	2020, 2023, 2026	2020, 2023, 2026	Every 10 years, in a schedule involving 10% of territory each year	2020, 2023, 2026	2020, 2023, 2026	2020, 2023, 2026	Annually	Annually
Materials	N/A	2020, 2023, 2026	2020, 2023, 2026	Every 10 years, in a schedule involving 10% of territory each year	2020, 2023, 2026	2020, 2023, 2026	2020, 2023, 2026	Annually	Annually
Lifecycle maintenance, habitat and gene pool protection	2020, 2023, 2026	2020, 2023, 2026	2020, 2023, 2026	Every 10 years, in a schedule involving 10% of territory each year	2022, 2027	2020, 2023, 2026	2022, 2027	Annually	Annually
Regulating services other than lifecycle maintenance and pollination	2020, 2023, 2026	2020, 2023, 2026	2020, 2023, 2026	Every 10 years, in a schedule involving 10% of territory each year	2022, 2027	2020, 2023, 2026	2022, 2027	Annually	Annually
Pollination	N/A	2020, 2023, 2026	2020, 2023, 2026	Every 10 years, in a schedule involving 10% of territory each year	2020, 2023, 2026	2020, 2023, 2026	2022, 2027	N/A	N/A
Cultural services other than aesthetic landscapes and monasteries, churches, places	2020, 2023, 2026	2020, 2023, 2026	2020, 2023, 2026	Every 10 years, in a schedule involving 10% of territory each year	2022, 2027	2022, 2027	2020, 2022, 2027	Every 6 years	Every 6 years
Aestetic lanscapes	2020, 2023, 2026	N/A	2020, 2023, 2026	Every 10 years, in a schedule involving 10% of territory each year	2020, 2023, 2026	2022, 2027	2020, 2022, 2027	Every 6 years	Every 6 years
Monasteries, churches, places	N/A	N/A	2020, 2023, 2026	Every 10 years, in a schedule involving 10% of territory each year	2027	2022, 2027	2020, 2022, 2027	Every 6 years	N/A

Based on the monitoring objectives and extent, as well as this calendar, an annual roster of field-visit polygons and the precise times for visiting them is to be elaborated by the organizations involved in monitoring in the particular year. The polygons are to be selected and information for them processed considering the specifics of ecosystem types listed in the next section.

The calendar (Table 2) is set up assuming that 2016 is Initial Year (Year 0) and all of the indicators below were measured in that year; for areas in NATURA 2000, the calendar will have to be extended once the mapping and assessment is done according to parts B of the National Methodological Framework and the baseline year is known. Until then, information collected for NATURA 2000 ecosystems ought to be extrapolated or modeled based on available information.

Note: *The specific timing of ecosystems monitoring even for the same monitoring indicator varies from one to other ecosystem type and in some cases even between ecosystem subtypes. Please refer to the specifics of ecosystems monitoring as described in the chapter Monitoring specifics by ecosystem type: Monitoring places and times, indicators, methods, DPSIR considerations.*

Note that his calendar by itself is indicative. The monitoring roster has to consider both the information from this calendar (broken down by month and where necessary by week, as per the resource allocation schedule) and the allocation of polygons to be visited each year.

Evaluation of fieldwork is the set of activities immediately following the field campaign for the respective year. Except for cases of urgency (for example, impending destruction of a valuable ecosystem, habitat or species, or identified high risks requiring immediate reaction – such as fire or flood risk), it is to be limited to obtaining and systematizing data (i.e. processing laboratory samples) and entering the new information into the database. The further use of data is discussed in detail in chapters **Use of monitoring information by policymakers and stakeholders** and **the creation of such infrastructure is already underway due to the increasingly interlinked EU policies and the reporting needs they create. It is in Bulgarias best interest to not merely "comply with EU legislation" but to make this process its own in order to receive the benefits described above.**

Inputs to the Natural Capital Accounting. In general, it aims at responding to the question "What happened on the ground since the last known information about this area?" No attempts should be made at this stage to interpret the results in terms of DPSIR since the correct interpretation may involve the contribution of additional information from stakeholders.

Even within this scope, evaluation remains a challenging task. It may identify areas of previous incorrect identification of polygons, or involve additional expert work to resolve borderline cases. If the information suggests earlier errors, *in situ* verification may need to be performed. If outliers are detected, an analysis using multiple data sources should be used to determine whether there is an error, or a recent new development that needs to be reflected in the DPSIR analysis.

In some cases the ground truth will be different from the prognoses due to similar visual characteristics of the available remote observation data (for example, orthophoto images of harvested cropland and harvested grassland can easily be mistaken). To improve the forecasting, this new monitoring data together with other available data (such as land use registries data, or phenological information at lower resolutions) could be used to re-calibrate any models used and improve future pattern recognition for the same borderline case in this and other areas.

This step is finished when:

- new data gained at all of the participating institutions is aligned with existing data;
- possible inconsistencies are resolved, if necessary by in situ verification or obtaining additional information and/or performing *in situ* verification;
- any non-structured data (such as earlier publications or other public documents, such as is old public records related to the polygon in question), is digitalized and georeferenced to the extent possible;
- all data is entered into the ecosystems module database at the Executive Environment Agency and/or other databases as prescribed by law.

3.4. Deriving DPSIR indicators

As mentioned above, the "static" ecosystems conditions and services indicators do not automatically translate into ecosystem dynamics parameters that can be evaluated within the DPSIR framework. The relations between these are rather manifold and differ at the levels of ecosystems conditions and ecosystem services. In general, the adoption of ecosystem integrity approach requires the monitoring framework to consider the processes within the ecosystems. In this spirit, the attempt is made to derive DPSIR indicators by processing "raw" monitoring data. This is, however, a work in progress since the conceptual base – both on the scientific and the policy levels – is still under development.

The functional relations between monitoring and DPSIR indicators and the possible way for them to translate to Natural Capital Accounting (NCA) are presented in the following figure:

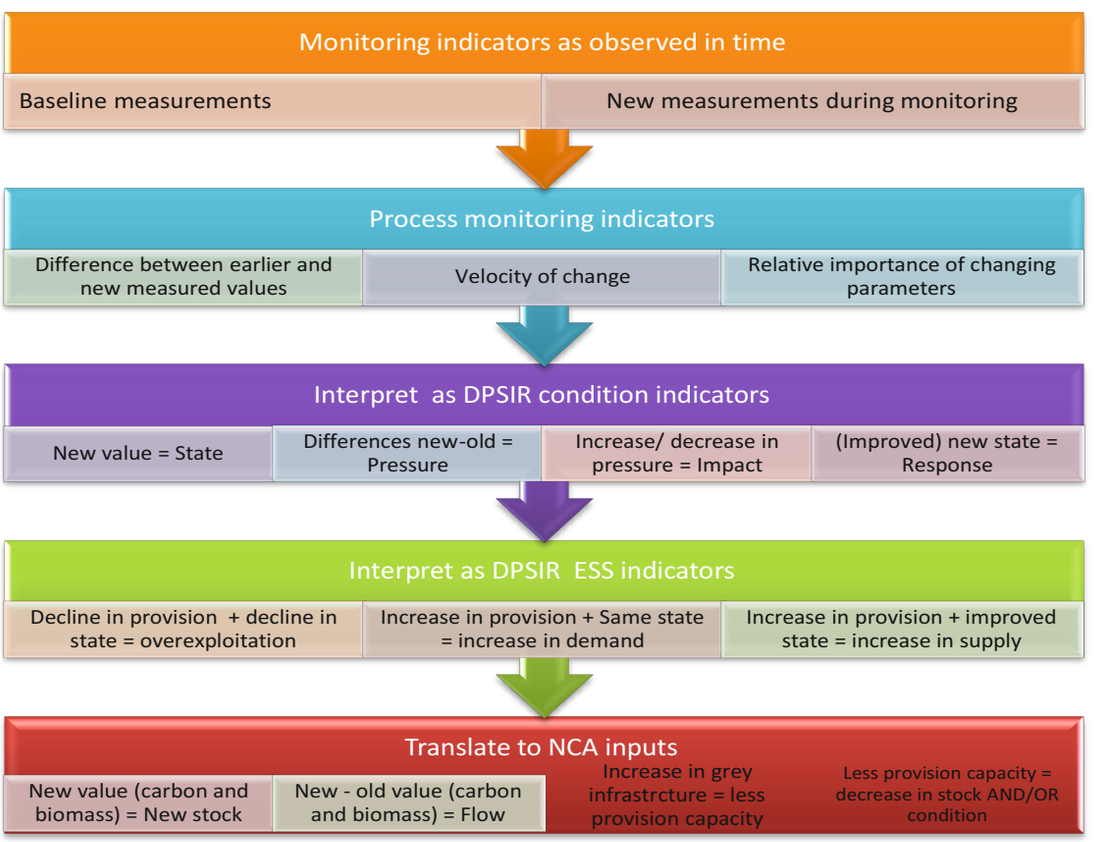


Figure 8. Relations between monitoring and DPSIR indicators with examples of possible relations to National capital accounting (NCA)

In general, even with the best monitoring imaginable, all we have is the – more or less complete – information on past ecosystems developments. Some of the relations between these changes in values old and new are relatively straightforward to interpret in a qualitative way. If we represent each conceptual group in different font colors corresponding to the colors in **Error! Reference source not found.**, we are able, in some cases, to give a consistent qualitative assessment (see Box 1).

Box 1. Example of qualitative description of relationships between ecosystems state, trends, DPSIR and NCA

*For example **harvesting 90%** of the **timber** with a **market value of X EUR/m^3** in a forest ecosystem represent a huge **anthropogenic pressure** which is likely to lead to a significant **decline in the ecosystems condition** (new state with a smaller area and/or trees population), which in turn translates in a **decline of timber stock** and a **flow of timber provisioning services** across the **production boundary**. This situation obviously would call for a **managerial response** (planting trees), and possibly also **policy response** (legal restrictions on timber harvesting beyond the ecosystem resilience limit). Hopefully after this response, a positive **impact** (recovery of state and biomass) will be observed in future monitoring sessions, and the **value** of the forest's **natural capital** will increase again.*

Even such a simplistic representation, however, illustrates some of the problems inherent in the translation between static/one-off observations of multiple monitoring indicators, their interpretation using the DPSIR framework and the final results to be achieved in terms of an objective assessment and valuation of natural capital. Notably, the following issues can be found with the interpretation:

1. Ecosystems may have multiple stable states and sometimes reaching and passing a tipping point between these can lead to irreparable changes. In our example, if trees require a minimal density of 40% coverage in order to survive, the overuse of the system may lead to the irreversible loss of species even if re-forestation may prevent the full deforestation. The relations between intervention and reaction of the system is most likely non-linear, dependent on many factors and the significant change in one condition parameter (tree cover density) may adversely influence the production functions of many, if not all ecosystem services.
2. Ecosystems are inertial systems and the consequences of drivers and impacts can be observed with a time lag (lag effect). Since this lag will depend on the ecosystems' properties (condition, vulnerability, adaptive potential, resilience, etc.) and the nature of driver/impact, it is to be expected that different impacts or responses caused by the drivers/impacts will occur at different moments in the future.
3. Not all elements of DPSIR can be monitored in the ecosystems context unless the humans are also included as one of the species in the ecosystem. In our example, the driving force for removing 90% of the trees may be increased demand for timber; there is, however, no way to establishing this correlation without involving additional data (such as statistics figures on timber pricing, trade volumes and/or export). Even further from

the traditional ecosystems approach is the economic reasoning behind the rise in timber prices (which may be due, for example, to two very different processes – fluctuation in commodity prices for timber, or the overall reduction of timber stocks as results of over-harvesting. Therefore, finding the correct response also highly depends on data outside the monitoring exercise.

4. Progress in new technologies and our knowledge about ecosystems both demand an improvement of data collected about the ecosystems. In case of technologies, new and increasingly affordable ways are being opened to collect data, examples including remote sensing technology improvements such as LIDAR (airborne and drone-mounted), a range of autonomous equipment (i.e. portable NDVI sensors) and carriers to bear it to the monitoring spots (i.e. drones, autonomous underwater vehicles), as well as an unprecedented quality of satellite imagery with the new sensors being brought to space (i.e. Sentinel 2 mission with an improved resolution and a number of ecologically useful sensors). In case of policy change, the last decades have seen a shift in scientific thinking from local to holistic (species to habitat to ecosystem to ecosystem service) that have translated into policy changes (the Aichi targets and the EU Biodiversity strategy to 2020). Both developments although very positive in themselves, place the scientific and monitoring communities in the situation to answer a number of increasingly focused questions without consistent and sufficiently long time-series of data.

At the current stage, establishing the correct production functions of the ecosystems services as dependent on the ecosystems state are insufficiently studied, with a very few exceptions, mostly involving provisioning ecosystem services; at the same time, responses are needed with an urgency dictated by the accelerated loss of biodiversity. This necessitates an incremental approach of many mixed tools, which in our view ought to include:

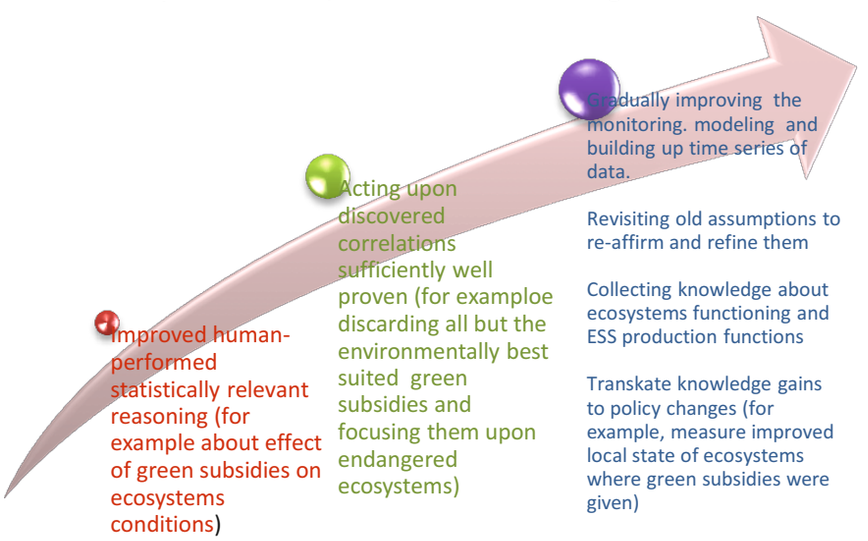


Figure 9. Integrative processes of refining the monitoring and its influence on policymaking

This process is, of course, limited by the existing institutional and legal framework, and where possible, coherence must be created. In water ecosystems, for example (freshwater and lakes, and marine ecosystems), the processing of results from monitoring activities should be done in accordance with the respective legislation or sub-legislation that regulates the methodological guidelines for each of the used parameters, as described in the methodological guidelines for the WFD monitoring and the MSFD Art. 11. Monitoring program.

4. Monitoring specifics by ecosystem type: monitoring sites, time periods, indicators, methods, DPSIR considerations and risk assessment

4.1. Urban ecosystems

4.1.1. Scope and application

Monitoring design of urban ecosystems has the objective to ensure consistency between the aims of the MAES process and the activities carried out to achieve them.

The objectives of the Methodology for mapping and assessment of ecosystem services in urban ecosystems provide some guidance for design, and ask for differentiation in geographical and urbanization aspects. The monitoring of urban ecosystems is therefore defined by the number of investigations carried out on and for the monitoring area and by the number of monitored sites covered by the investigations/observations. In designing the monitoring of urban ecosystems condition and ecosystem services the following criteria were considered:

• Network design: Monitoring of urban ecosystems requires data to be formally representative for all subtypes of urban ecosystems at national level. Considering the geographic aspect a probabilistic selection is required in order to allow design-based inference. Considering the level of urbanization aspect the monitoring site can be allocated according to different criteria (purposive observation/sampling).

• Variables to be observed/measured: Monitoring of urban ecosystems concerned with the condition, and the attributes (indicators, parameters etc.) to be observed/measured are typically those able to describe urban ecosystems condition. Assessment of these variables is also the basis for large-scale assessments of urban ecosystems condition and ecosystem services. Having into consideration that the Monitoring Guide aims also at understanding of trends and tendencies through involving the DPSIR analyses and the relationships between the condition of urban ecosystems and their capacity to supply ES, it requires observations/measurements to cover a range of indicators. In short, Monitoring of urban ecosystems envisages a large number of observations/measurements on a limited number of sites and regions.

The Green Infrastructure Strategy, adopted by the Commission in 2013, makes the case that 'GI is a successfully tested tool for providing ecological, economic and social benefits through natural solutions' (EC, 2013b). It clarifies the relationship between green infrastructure and ecosystem services and makes clear the importance of ecosystem mapping in supporting the delivery of green infrastructure. Green infrastructure mapping in accordance with this approach provides a transparent and consistent knowledge base for decision-makers, helping them to prioritize measures by supporting the strategic spatial identification of habitats to

be restored. Further challenges imply the consolidation of analytical approaches for green infrastructure, including the integration of ecosystem condition into green infrastructure mapping and assessment to attribute functioning to green infrastructure elements in terms of biodiversity and capacity to provide services. Due to this the green infrastructure in urban ecosystems will be in the focus of the monitoring.

4.1.2. Approach in the selection of urban regions and sites for monitoring

4.1.2.1. Criteria for selection the monitoring sites

Following the **"Methodology for assessment and mapping of Urban ecosystems and their condition and the services that they provide in Bulgaria"- Part B1,** the Monitoring procedure of urban ecosystems should be designated according to The National Concept for Spatial Development of the Republic of Bulgaria for the period 2013-2025. This document concerns the spatial development of the territory for the past three decades, covers the entire area of the country and is being elaborated under the conditions of restored property rights on land and forests in all its modalities, increased number of actors in the process of planning and governance of the territory. The model contains a hierarchic system of core-cities extending their influence over territorial areas of different sizes. The hierarchic ranking of the core-cities has been performed through assessment of their significance and role according to a number of criteria and indicators related to the population dynamics and the degree of development of their administrative, economic, transport functions etc. The model is composed of five levels:

Level One – the capital Sofia, center of European significance for the national territory ;

Level Two – big cities, centers of national significance for the territory of the regions – Plovdiv, Varna, Burgas, Ruse, Pleven, Stara Zagora;

Level Three – medium-size cities, centers of regional significance for the area of the districts – district centers and other eminent cities – Vidin, Montana, Vratsa, Lovech, Gabrovo, Veliko Tarnovo, Targovishte, Razgrad, S humen, Silistra, Dobrich – in total 28;

Level Four – small cities of micro-regional significance for the territory – in total 90;

Level Five – very small towns and villages centers of municipal significance for the territory of the respective municipalities – in total 139 for the country.

The urban region definition and shape are the administrative borders of the city or municipality.

Criteria for selection of monitoring urban regions are:

- Different levels of urbanization should be presented – high urbanized, medium urbanized, low urbanized cities/municipalities;
- Different geographic regions of the country should be presented - continental, coastal, mountain;

- Monitoring sites should represent all subtypes of urban ecosystems according to the Methodology for mapping and assessment of ecosystem services in Bulgaria – J1, J2, J3 …J10.

4.1.2.2. Monitoring approach

In the selected monitoring urban region a network approach should be applied. This is valid for indicators of site monitoring (Table 2.2.1 and Table 2.2.2). The network in high urbanized and medium urbanized areas (Levels One, Two and Three) should be 3x3 km, while in low urbanized areas 1,5 x 1,5 km (other levels). Each cross-point identifies the monitored polygon corresponding to a certain urban ecosystem's sub-type. The site is an area of defined dimension and shape, which are the same as those of the defined polygon. For specific purposes (e.g. tree crown condition in urban parks, ground vegetation assessment) and to include all sub-types of urban ecosystems present in the urban region to be monitored, designation of one or more sub-sites may be also necessary. A sub-site is an area of defined dimension and shape according to the polygon within which the assessment and measurements are carried out. To be representative for the area, the sub-sites must be selected according to a statistically sound procedure. If not, assessments and measurements carried out on the sub-site can be considered indicative for the site if experts provide the necessary statement.

4.1.2.3. Indicators – obligatory (mandatory) and recommended (optional)

Two main sets of indicators are defined, called "obligatory" or "recommended". That formulation means that within the respective investigations the obligatory indicators must be observed/measured. On the other hand, "recommended" identifies those indicators or parameters that may or may not be measured, but their assessment is desirable and provide additional information about urban ecosystem's condition and/or relevant ecosystem service. This status must not be confused with the obligation to assess and submit data under proposed indicators and sub-types, which are basis for upgrading depending on future knowledge gained in MAES process.

Table 2. Mandatory indicators for urban ecosystem conditions

Type of monitoring	Indicator	Parameter (dimension)	Included in NEM (yes/no)	Other databases	Data availability	Method/reference link
Off-site	**Vegetation canopy cover**	%	N		Y	Maps, satellite images
Off-site	**Soil sealing**	% of the total area	Y/N		Y	Available Master Plans, Cadastre maps, Land Identification Parcel System, satellite images
Off-site	**Area of natural habitats**	%	Y	Natura 2000	Y	Maps
Off-site/In-site	**Reclaimed waste deposits areas**	**% of the total area of the waste deposit area**	Y	MoEW	Y	Maps, database, observation

Off-site	**Air quality**	SOx, NOx, O_3 (AOT40), PM10	Y	ExEA	Y	Measurements, database
Off-site	**Actual evapotranspiration**	mm $year^{-1}$	N	NIMH	Y	Database
Off-site/In-site	**Spatial structure of urban areas**	NA	N		Y	Maps, observation, satellite images
Off-site	**Trend of total CO_2 emissions**	CO_2 million tones	Y	NSI	Y	Measurements
Off-site	**Temperature sum totals (for the active growing period)**	**Σ** °C	Y	NIMH	annually	Measurements, database
Off-site	**Solar-energy potential**	kWh/m^2	Y	NIMH, MoE	annually	Maps, database
Off-site	**Urban runoff coefficient**	**Coefficient (0,1 to 0,8)***	Y	NIHM – BAS dataset; Sewerage and Water supply systems	During the periods of actualization of the urban development plans	Database
Off-site	**Natural ground water discharge**	l/sec/km2	Y	Maps, River Basin Directorates	annually	Database, maps
Off-site	**Risk to soil and atmospheric drought**	level of risk	N	Maps NIHM – BAS dataset	Every 5 years	Database, maps

NA – not applicable

Table 3. Recommended (optional) indicators for urban ecosystem conditions (new and/or not supported by data)

Type of monitoring	Indicator	Parameter (dimension)	Monitoring site	Frequency	Method/reference link
Off-site/In-site	**Type of vegetation cover**		J1, J2, J3, J4, J5	annually	Orthophotos
In-site	**Type of plant communities**		J4, J5	annually	Observations
In-site/Off-site	**Protected plant species**	number	J1, J2, J3, J4, J5	annually	Observations, maps, red list
In-site/Off-site	**Protected animal species**	number	J1, J2, J3, J4, J5	annually	Observations, maps, red list

Off-site	**Geomorphological heterogeneity (complex indicator)**	NA	All	annually	Maps, database
Off-site	**Fragmentation of GI**	%	J4, J5	Every 5 years	Maps, satellite images, observations
In-site	**Exotic species (plant, animals)**	number	J1, J2, J3, J4, J5	annually	Observations
In-site	**Invasive (plant, animals)**	number	J1, J2, J3, J4, J5	annually	Observations
In-site	**Health status**	Discoloration/defoliation/ Pest and diseases	J1, J2, J3, J4, J5	annually	Observations
In-site/Off-site	**Species diversity according "habitat saturation index"**	Number taxa/ha	J1, J2, J3, J4, J5	annually	Observations
Off-site/In-site	**Soil degradation in the green infrastructure**	Damaged area percentage (% of the soil cover)*	J2, J4, J5	annually	observation
Off-site	**Drainage density**	km/km^2	J1, J2, J3, J4, J5, J6	During the periods of actualization of the urban development plans	Maps, reports, information of MOEW, RIEW, EEA,
Off-site/In-site	**Pond area**	presence	J1, J2, J3, J4, J5, J6	annually	Maps, satellite images, observations
Off-site	**Slides**	ha / active/passive	All	annually	Maps, register of slides
Off-site	**Floods**	% territory at risk	All	annually	Maps, Basin directorates
In-site/Off-site	**Standing biomass**	tC/ha	J4, J5	annually	Measurements of tree vegetation
In-site/Off-site	**Total OM storage (TB, FF, Soil)**	tC/ha	J4, J5	annually	Sum of carbon stored in components of GI
Off-site/In-site	**OM soil**	%C	J4, J5	annually	Measurements
In-site/Off-site	**PTEs and pollutants in soil EA)**	Concentration in upper soil layer (0-20 cm)	J5	annually	Measurements/ Datasets from ExEA
Off-site	**Sediment yield**	m^3/ha/yr	All	annually	Database

**for details please look in "Methodology for assessment and mapping of Urban ecosystems and their condition and the services that they provide in Bulgaria"*

4.1.3. Type of observations/measurements

Two series of measurements are defined: off-site and in-site observations/measurements.

Off-site measurements are those that - by definition - are carried out outside the monitoring urban site. They include collection of spatial, quantitative and qualitative data for obligatory and recommended indicators.

In-site observations/measurements are all those measurements that are carried out within the defined monitoring sites (see 2.2.). They relate to the most recommended indicators: type of plant communities, protected plant and animal species, exotic species, invasive species, health condition of trees, standing biomass, organic matter in soil, total organic matter storage, potentially toxic elements and pollutants in soil.

Combined: In-site the verification of some indicators assessed off-site if recommended: spatial structure of urban areas, type of vegetation cover, soil degradation of green infrastructure. Off-site measurements are provided for those indicators, which require laboratory analyses for verification of the collected information: OM in soil, total OM storage, PTEs and pollutants in soil.

4.1.3.1. Observations/Measurements

The standard observations/measurements of the indicators at site level should be conducted every 5 years. The elements of green infrastructure (soil, forest floor, plant species) in monitoring sites should be conducted annually.

Measurements and reporting should include the following information: site number, urban region, site coordinates, object id of the polygon, sub-type of urban ecosystem, area of the site, installation date, altitude, slope, land use history.

4.1.3.2. Data sources specified for each indicator/parameter

The variety of indicators requires different sources of information. In data collection for indicators the overall Quality Assurance perspective should be developed and considered. In this section only the overall framework of data collection is proposed.

Off-site observations/measurements of the indicators is based on the available sources of information at national level. Spatial, quantitative and qualitative datasets can be used. Only nationally valid data from the authorized institutions/organizations owners of data are recommended. Spatial data from Cadaster, Land Identification Parcel System, Spatial Development Plans, Master plans, scientific data etc. should be used. National and European maps of qualitative parameters and indicators are also applicable. Quantitative data obtained from other systems of monitoring should be analyzed for the period between the monitoring reports (min 5 years).

In-site observations/measurements should follow the standard sampling design and standard methodologies approved at national and European level. All additional laboratory analyses should be conducted according to the standard methods.

In the monitoring reports all data sources and methods used should be described of referred.

4.1.3.3. Seasonal distribution of the monitoring activities throughout the years:

Off-site observations/measurements – out of vegetation period.

In-site observations/measurements – during the vegetation period (April – September).

4.1.4. Tracing and analysis of the changes of the areas occupied by urban ecosystems

Tracing the changes in urban ecosystem condition requires complex analyses of environmental factors. Natural factors should be analyzed based on the main parameters, available from the national database: meteorology (continuously), landscape and geology (once when initializing the site). The analytical framework for assessment is related with the DPSIR framework (Drivers, Pressures, State, Impact and Response) to identify the trends of changes. This framework allows an understanding of the causal chain of connections from human actions to impacts on the urban environment.

Analyses of the effects on the condition of urban ecosystems with focus on green infrastructure and the capacity to provide services essential for human well-being is an obligatory part of this Monitoring. Monitoring the indicators in urban ecosystems and green infrastructure of urban areas aims to analyze the pressures and their effects on the condition of ecosystems, so that policymakers can design suitable responses. Through these analyses, they will be able to answer the question "how to use available information on the relationship between pressures and biodiversity to map potential impacts of individual pressures on urban ecosystems, and exploring methods of weighting and summing multiple pressures onto a single map to assess their combined effect on biodiversity, environmental quality and ecosystem service supply". The DPSIR approach in monitoring of urban ecosystems condition can be used to identify priority areas for green infrastructure development, habitat restoration and conservation, while also making the case that enhancing and protecting green infrastructure has benefits across sectors and policies of urban and spatial planning.

4.1.5. Monitoring the capacity of urban ecosystem to supply ESS

Comprehensive and reliable information on the set of indicators for urban ecosystem condition, biodiversity in urban regions, green infrastructure and ecosystem services, and the capacity to monitor change, is essential to know whether or not policy targets have been reached, and whether or not further policy measures are needed. Monitoring the changes in the capacity of urban ecosystems to supply ES is based on the information obtained for the set of obligatory and recommended indicators describing urban ecosystems condition in the monitoring urban site. Desirably, for better assessment of the capacity of urban ecosystems to supply ES the relevant set of indicators should be included in the assessment (Table 3). Additional indicators/parameters used in the algorithms of selected ES should be enough informative, scientifically proved and supported by evidences for its relationship to the ES.

The information collected for these indicators should follow the same steps as the conditions' indicators. Complex analyses of spatial data and detailed information for green infrastructure is desirable to be conducted annually for monitoring the changes in land use, dynamics of changes, condition of green infrastructure and its role in ES supply at regional scale.

4.2. Cropland ecosystems

Cropland or Agro Ecosystems have to be realized as the main food production areas including both intensively-managed ecosystems and multifunctional areas supporting many semi-natural and natural species along with food production (lower intensity management). It includes regularly or recently cultivated agricultural, horticultural and domestic habitats and agro-ecosystems with significant coverage of natural vegetation (agricultural mosaics).

Table 4. Indicators for ecosystem services from cropland ecosystems

Type of indicator	Indicator	Parameter (dimension)	Included in NEM (yes/no)	Other databases	Data availability	Method/reference link
Recommended	Soil productivity	grades	N	Restored property map	Y/N	Database, maps
Recommended	Number of domestic animals	Number/ha	N	Ministry of agriculture	Y	Database
Recommended	Precipitation	mm	N	NIMH	Y	Database, maps
Recommended	Evapotranspiration	mm	N	NIMH	Y	Database, maps
Recommended	Exploitation index for drinking waters	%	N	River basin directorates	Y	Database
Recommended	Number of draft animals	Number/ha		Ministry of agriculture		Database
Recommended	Geology	Type of rock	N	National research database	Y	Maps
Recommended	Slope	Degree	N	National Research database	Y	Maps
Recommended	Climate	Climatic zone	N	Research database	Y	Maps
Recommended	Number of beehives	Number/ha	N	Ministry of agriculture	Y	Database
Recommended	Organic carbon in soil	t(C)/ha	N	Research database	Y	Database, maps
Etc.*						

**defined by the expert*

4.2.1. Time periods of observation

During the vegetation period (if the study included cereals - time monitoring must comply with the pre-harvesting or during the harvest periods, if there are permanent crops surveyed - the observation period must comply with the periods and phenophase of any kind).

After the harvest period for any data related to nutrition stock.

Selection the period of monitoring plan in should be planned in an earlier period, so as to ensure its conduct at the right time depending on the selected culture and selected parameter/ indicator type.

4.2.2. Selection of indicators/parameters for monitoring:

It is very important from the whole set of indicators to be extracted those that can be observed in the field /in-situ/and those who have received out of the field /ex-situ/ (statistical reference books, research papers, from literature data, etc.).
At the time of the parameters separation - field monitoring parameters and parameters based on data inventory, there are possible the following two scenarios for data inventory parameters:

Scenario 1.

If it is found that any of the sources no longer exists or does not provide data in the same extent, scale and detail and there is no other relevant data - the assessment is not subject to monitoring.

Scenario 2.

If established a new source of relevant data and this data to be reported as a potential source of data for future assessment. In this case this data to be applied in present monitoring by manner and judgment of experts conducting monitoring. Availability of new compatible data and their methods of use are described in detail by experts conducting monitoring.

Any changes of data (changes in characteristics of the data - scale administrative division, change in body which administers the data, etc.) used for assessment should be marked by experts conducting monitoring.

Depending on the time resistance, of the parameters to be monitored are divided into:

Permanent - parameters related to local environmental conditions (soil characteristics, climate conditions, etc.) - mostly covered the Abiotic heterogeneity such as: - Soil quality; Soil moisture capacity; Water bodies presence; Slope and Exposition; Fires and wind storm signs; Soil Erosion traces, etc.

Variables - related mainly to the crops and characteristics of agricultural fields - (presence or absence of terraces or field margins, presence or absence of irrigation, differences in field size, etc.) - - mostly covered the Biotic heterogeneity such as: - Crop richness; Soil cover by vegetation, Area and presence of wild plants and natural habitats; Farmed animals; Land use change, etc.

4.2.3. Selection of the monitoring polygons from all EUNIS types

Each of selected monitoring areas has to be in the range defined in methodology - representative Agro ecosystem subtypes. Due to the diverse growing conditions for different crops in the country, monitoring sites must comply with local orographic, climatic and topographical features presented. Usually, depending on growing conditions, subtypes of Agro ecosystems are unevenly distributed throughout the country territory (fruit farms occupy hills and foothill territory, cereals - mostly flat, livestock farms can be alpine and plain, etc.).

Therefore to be able to monitor by the most accurate and effective way, it is very important to select such Agro ecosystems which will be representative for both specified subtype Agro ecosystem and the local environment conditions.

Last but not least, the different surveyed ecosystems should be selected so as to ensure the highest possible number and variety of Agro ecosystem subtypes of relatively small area, so the logistics between them to be the maximum boost.

It is advisable that selected for subsequent monitoring ecosystems will be selected, near the village where field experts could receive additional updated information about monitored areas.

4.2.4. The preparation of an analysis of Drivers-Pressures-State-Impact-Response (DPSIR)

4.2.4.1. Pressures (Agro Ecosystems)

Drivers induce pressures that affect the health of Agro ecosystems, their biodiversity status and, consequently, the ecosystem services they provide for human well-being at different spatial and temporal scales. This makes both their assessment and their management complex. Climate change may operate on a global or a large regional spatial scale; political change may operate at the scale of a nation or a municipal district. Socio-cultural changes, inducing pressure change, typically occurs slowly on a time scale of decades — although abrupt changes can sometimes occur, i.e. in the case of wars or political regime changes, while economic changes tend to occur more rapidly.

Table 5. For example:

Ecosystem type	**Major pressures of ecosystem change**				
	Habitat changes	Climate change	Invasive alien species	Land/sea use or exploitation	Pollution and nutrient enrichment
Cropland-Agro Ecosystems	Land-take, landscape fragmentation, agricultural intensification (structural changes)	Changes in monthly temperature and precipitation, extreme events, fires	Expansion of invasive alien species	Agriculture intensification, loss in cropland productivity, abandonment	Fertilisers and pesticides, critical levels of ozone, nutrient enrichment

4.2.5. Data sources

Data sources include sources of spatial and quantitative/qualitative databases, as presented below.

Table 6. Data sources (qualitative and quantitative) and main stakeholders for cropland ecosystems

Subtype	DATABASE Sources – main stakeholders	
	Spatial	**Quantitative/Qualitative**
Annual crops (mostly cereals) **Perennial crops (fruit gardens and vineyards)** **Perennial crops (mostly legumes)** **Mixed cropland** **Livestock farms for large and small animals including bees**	Database– State Fund "Agriculture" – Land and Parcel Information System /LPIS/ and Integrated Administration and Control System /IACS/. Database– State Fund "Agriculture" – State Digital Orthophoto map. MoAF – Agrostatistic – BANSIK – statistical survey, Farm Structure survey, Annual bulletin. National Statistical Institute MOEW – ExEA – JICA project, National Database for Biodiversity, National Soil Monitoring Network. EUROSTAT – LUCAS project - Land Use/Cover Area frame statistical Survey. GMES - Global Monitoring for Environment and Security Master Plans, Site Development plans, State Cadastre. National Concept for Spatial Development 2013-2025. EEA – CORINE – Land Cover. JRC - ESTIMAP -Polliniation services model, MetEcoSMap - NINA/IBER project. JRC - Soil maps and their properties.	Master Plans, Site Development Plans, Maps of restored property, Action Plans for Programmes of Environmental protection, National Concept for Spatial Development 2013-2025, National Statistical Institute, Urban Atlas (EEA, MOEW), JRC, Publications, Project Reports, ME, MRD.MoAF – State Fund "Agriculture". Professional industry associations. Environmental NGO. Third parties – including survey private companies with high level of reliable data (actual insitu data and high precision model data will be welcome). MOEW – ExEA – Inventarization plans for pesticides storage.

4.2.6. Selection of indicators/parameters for monitoring

The selection should be made according to Agro ecosystem specialization and Agro ecosystem subdivision mentioned in the Methodology. Example of types of parameters and possible ways to be obtained on the field:

Table 7. Mandatory monitoring indicators for cropland ecosystems

CROPLAND ECOSYSTEMS					Monitoring
Ecological state indicators		**Indicator**	**Parameter (units)**	**Methodology**	
Type	**Indicator Group**				
Biotic Heterogeneity	Biotic diversity	Agricultural crop richness	Crop number or Percent	Estimation	Visible assessment of crop richness (kind and number of different crops
		Agricultural crop richness - soil cover by vegetation (annual, perennial and mixed crops)	Ratio/ Percents	Estimation	Visible assessment of land covered by crops (expert based or GPS based or Remote Sensing assessment of covered by crops area or empty places /if it is easier way/)
		Wild plants	Area [ha], number or % from all land] of wild plants associated to crops (buffer strips, strips from flowers supporting pollination for example)	Estimation [satellite images, observation]	Visible assessment of land covered by wild plants or no cultivated areas (expert based or GPS based or Remote Sensing assessment of covered by wild plants areas or areas without cultivation sights)
		Land use changes/ Land take	ha, ha/y, %		Visible field assessment or Remote Sensing survey of kind and area of land with changes.
		Area of natural habitat/s	Area or ratio [%]	Estimation [satellite images, observation]	Visible uncultivated spots within agricultural areas. Field observations and GPS measurements. Other external data based on protected areas register, for example.
Abiotic heterogeneity	soil heterogeneity	Soil quality	Land properties	Scale assessment by soil conditions (land category) regarding to soil properties	Expert base field survey
		Soil moisture capacity	%	Assessment by soil data	Expert base field survey
		Soil nutrient elements storage	mg[K]/100g. [%]	Assessment by soil data, measurements	Field assessment or measuring. Possible sources from model based GIS data from soil surveys.
	Hydrological heterogeneity	Area under irrigation/Water bodies presence	ha/% of cultivated land	Number per grid unit of national data	Visible assessment of irrigation facilities presence (expert based or GPS based assessment of kind of facility area irrigated by this facility)

	geomorphological heterogeneity	Slope and Expositions/Aspect	[%] or [degrees]	mostly for permanent crops	Visible field assessment or measuring or Remote Sensing survey of % or degree of slopes
	Disturbance regime	Significant occurrence of hail or late spring frosts or early autumn frosts.	Recorded records or damaged area or demaged production in tons	[ha] or [t]	Ex situ assessment
		Soil erosion degree	Scale or t/ha/yr, area	Estimation	Model based GIS assessment. Combination from field data measurements, soil data from soil surveys and topography.
		Polluted areas	Area polluted [ha]	Estimating, Field measurements, State records	Ex situ assessment
		Salted, swampy and acidic areas	Affected area [ha]	Estimation, Field measurements,	Expert based assessment from field soil surveys. Data records from previews soil surveys. Direct express field /in-situ/ measurements.
	metabolic efficiency	Temperature sum	Temperature sum for vegetation period [mainly for permanent crops - vineyards for example	Maps, Assessment,	Ex situ assessment
		Solar radiation intensity	kW/m2/yr or per growing period	Maps, Assessment, IPCC	Ex-situ assessment based on GIS models
	matter storage	Content of soil organic matter	% or [g, kg/ha]	National scale	Visible assessment of organic matter accumulation or modeled and mapped data
		Biomass	Volume of produced biomass [t]	Ex-situ assessment	Annual yield records from Agristatistical administration, local farmer organizations.
	Water budget	water balance (input, output)	Rate of Evapotranspiration	Ex-situ assessment	Expert based assessment based on soil properties data, crop type, precipitation, topography, etc.
		water storage	Soil water storage capacity	Direct field and Ex-situ assessment	Expert based assessment based mainly on soil properties data from field sol surveys.

Table 8. Optional monitoring indicators for cropland ecosystems

CROPLAND ECOSYSTEMS					
Ecological state indicators		**Indicator**	**Parameter (units)**	**Methodology**	**Monitoring**
Type	**Indicator Group**				
Biotic Heterogeneity	**Biotic diversity**	Wild animals	Number	Maps and in-situ surveys.	Expert base field survey. Ex situ assessment combined with Remote Sensing and scientific data records.
		Farmed animals (depend of kind)	Number per unit area/% [usually information about the species of animals accompanying information on the number of animals in each farm. Type of animals is important in terms of the different volumes and characteristics of waste generated by the farm, different types of structure and feed etc.]	Ex-situ assessment,	Data base sourse from MoAF, Agristatistic Directorate or local animal farming organizations.
	Invasive species	Invasive species presence	presence	In-situ surveys.	Number of records based on field study or data from scientific records and projects ESENIAS for example.
Abiotic Heterogeneity	Other abiotic heterogeneity indicators	Area under wind protection	Area/%	Number per grid unit of national data. Presence – length of tree shields and % of protected area.	Remote sensing estimation and GIS models. Data from local state municipality authority or forest state administration.
	Disturbance regime	fires (caused by burning of stubble for example)	Number of records or burned area [ha] (example is for burned crop area)	Estimating, Remote sensing, State reccords	Remote sensing estimation and GIS models. Data from local state municipality authority or fire brigades records.
		wind and storms (failed crops from hail for example)	Number of records or damaged area [ha], or lost harvest [t, kg], or scale assessment by hail vulnerability	Estimation.	Data from local state municipality authority or data from local farm organizations.
Energy budget	**energy balance**	Carbon storage	Soil carbon storage [t/C/ha or %]	Assessment scale	Ex-situ assessment from data obtained from soil surveys or fresh soil data from soil surveys.
Matter budget	**matter balance (input, output)**	Nutrients loss	Loss by leaching or by erosion [kg/ha]	Assessment scale	Ex-situ GIS based models.

4.3. Grassland ecosystems

The main criterion for selection of indicators for monitoring both for ecosystem condition and services is their ability to provide information about changes and trends of condition of grasslands and their capacity to provide ecosystem services. A list of parameters for monitoring ecosystem condition assessment and services provided is presented in Table 1. The list includes all obligatory indicators both for condition and services. Some are used for assessment different issues (e.g. plant biomass).

4.3.1. Data sources

The initial basis of monitoring data comprises the data available and collected during the 2016 mapping and valuation of grassland ecosystems in Bulgaria and the ecosystem services provided by them that represent a “snapshot” of the state of the ecosystems and the range of provided ecosystem services.

The following data sources are used during the first mapping process:

- Specialized data bases for biodiversity
- Data from National Environmental Monitoring (ExEA)
- Data provided by governmental bodies
- Data provided by nongovernmental bodies

4.3.2. Selection of indicators/parameters for monitoring

The main criterion for selection of indicators for monitoring both for ecosystem condition and services is their ability to provide information about changes and trends of condition of grasslands and their capacity to provide ecosystem services. A list of parameters for monitoring ecosystem condition assessment and services provided is presented in Table 6 and Table 7, respectively. The list includes all obligatory indicators both for condition and services. Some are used for assessing different issues (e.g. plant biomass).

Table 9. Parameters for grassland ecosystems monitoring - ecosystems condition

Condition	Parameter	Provides information for	Unit	Data source	Periodicity	Data availability
Biotic diversity	Vegetation cover	Ecosystem structure	%	Field collection	3 years	Specialized data bases for biodiversity
	Plant species richness	Biodiversity	number	Field collection	3 years	Specialized data bases for biodiversity
	Red list species (plant)	Naturalness	number	Field collection	3 years	Specialized data bases for biodiversity
	Fungi species richness	Biodiversity	number	Field collection	3 years	Specialized data bases for biodiversity
	Invertebrate species richness	Biodiversity	number	Field collection	3 years	Specialized data bases for biodiversity
	Amphibian species richness	Biodiversity	number	Field collection	3 years	Specialized data bases for biodiversity
	Reptile species richness	Biodiversity	number	Field collection	3 years	Specialized data bases for biodiversity
	Bird species richness	Biodiversity	number	Field collection	3 years	Specialized data bases for biodiversity
	Mammal species richness	Biodiversity	number	Field collection	3 years	Specialized data bases for biodiversity
	Red list species (animal)	Naturalness	number	Field collection	3 years	Specialized data bases for biodiversity
	Alien and invasive plant species presence	Disturbance	number	Field collection	3 years	Specialized data bases for biodiversity
	Ruderalization	Overexploitation	% coverage	Field collection	3 years	Specialized data bases for biodiversity
Abiotic heterogeneity	Soil quality	Soil type	Soil type	Field collection, soil map	Do not be monitored	Specialized data bases for biodiversity
	Soil organic matter	Soil fertility	% C	Field collection	5 years	Data from National Environmental Monitoring
	Soil organic matter	Soil fertility	% N	Field collection	5 years	Data from National Environmental Monitoring
	Soil erosion risk - water erosion	Physical disturbance	Score	Data analyses	5 years	Specialized data bases for biodiversity and Data from National Environmental Monitoring
	Concentration of pollutants in soil from surrounding areas	Pollution	number	Field collection	5 years	Data from National Environmental Monitoring
	Fire	Disturbance	number	Field collection	5 years	Data provided by governmental bodies
Matter budget	Matter storage	Ecosystem function	Biomass (air dry) in t/ha	Field collection	3 years	Specialized data bases for biodiversity

Table 10. Parameters for grassland ecosystems monitoring - ecosystems services

Services	Parameter	Provides information for	Unit	Data source	Periodicity	Data availability
Nutrition	Reared animals	Reared animals per municipality	livestock units/ha	Agro-statistics	3 years	Data provided by governmental bodies
	Primary biomass production from fungi for food	Production from fungi for food	t/ha	Field collection	3 years	No consistent data, Specialized data bases for biodiversity
	Wild animals for hunting	Number of species for hunting	species/ha	Field collection, national statistics	3 years	Specialized data bases for biodiversity, Data provided by governmental bodies
Materials	Biomass production of medicine plants for materials	production of medicine plants	t/ha	Field collection	3 years	No consistent data, Specialized data bases for biodiversity
	Biomass of plants for fodder	Forage capacity	t/ha	Field collection	3 years	No consistent data, Specialized data bases for biodiversity, Data provided by governmental bodies
Mediation of flows	Vegetation cover/Slope coefficient	Erosion prevention	Scale	GIS analysis	5 years	Specialized data bases for biodiversity, Data provided by governmental bodies
Lifecycle maintenance, habitat and gene pool protection	Pollination potential	Pollinators presence	Scale	Field collection	3 years	Specialized data bases for biodiversity
	Cummulative species number	Biodiversity maintenance	Number	Data analyses	3 years	Specialized data bases for biodiversity
Maintenance of physical, chemical, biological conditions	Mineralization index	Soil formation	Organic C/N g/kg	Data analyses	3 years	Data from National Environmental Monitoring
Physical and intellectual interactions with biota, ecosystems, and landscapes	Physical and intellectual interaction	Attitude to the grassland ecosystems	Number of events	Data bases	3 years	No consistent data, Data provided by nongovernmental bodies
Cultural services						

Indicators/parameters for which there is no data at the moment but that should be collected during the subsequent monitoring:

- Biomass of plants for fodder – Available data exist only for few polygons, the rest of assessment is based on a model spatially ranged to NUT2 regions. The parameter is important for assessment ecosystem condition and for forage capacity.
- Pollination potential – Available data is based on scarce field studies and modelling. The parameter is of primary importance and needs adequate data.
- Biomass production of medicine plants for materials – Available data exist only for few polygons.
- Primary biomass production from fungi for food – No field data.

4.3.3. Time frames of monitoring

1. Periodical monitoring – Frequency of the conducted monitoring according to the time periods outlined in Table and Table .

Data from National Biodiversity Monitoring and Governmental bodies are to be used as they are provided;
Field collection should be done in the vegetation maximum, as follows:

- Dry grasslands – from middle June to middle July;
- Mesic grasslands – during July;
- Wet and seasonally wet grasslands – from middle July to middle August;
- Sub-alpine and alpine grasslands – during August;
- Inland salt meadows – during August

2. Permanent monitoring: For the grassland ecosystems permanent monitoring is currently not applicable.

3. Extraordinary monitoring is to be implemented in case of disasters, force majeure phenomena or circumstances (e.g. fires, flooding, landslides or investment intentions). This is important to assess the rate of change and take decision if there is a need to change the permanent plot.

4.3.4. Criteria for selection of monitoring areas

Monitoring of grasslands is site-focused. The methodological basis is selection of plots/polygons systematically distributed to cover not less than 10% of the area from each grassland subtype over the country. The following additional criteria should be applied:

- Polygon area – advanced rating in three classes by area – small, medium and large;
- IP index score for condition – advanced rating in three classes by score – low, medium and high

The proposed selection provides opportunity for long term monitoring in representative sites and data interpolation on similar sites.
Same approach is applied to all grassland subtypes.
Any change in the area and ecosystem state reflects on the services provided.

4.3.5. Tracing and analysis of the changes of the areas occupied by grassland ES

- no area change – sustainability in time
- area decrease – fragmentation and decrease in services provision
- area increase – increase in capacity for ecosystem provision
- IP index decrease – ecosystem condition becomes worse
- IP index increase – ecosystem condition becomes better

Natural cycles/successions in most grasslands in the country leads to shrub and forest vegetation. This process is going on with different velocity within grassland subtypes.

Main reasons, other than the natural cycle of the ecosystem, that should be taken into account and traced over time are:

- Fragmentation
- Destruction/plowing
- Overgrazing/ruderalization
- Pollution
- Abandonment

4.3.6. Analysis of Drivers-Pressures-State change-Impact-Response (DPSIR) in grassland ecosystems

4.3.6.1. Main tendencies that affect grassland ecosystems and their services and that should be traced over time

4.3.6.1.1. Habitat change

- conversion from pasture to arable and permanent crops
- urban residential sprawl; sprawl of economic sites and infrastructure
- abandonment

Result of habitat change – fragmentation, habitat loss, biodiversity loss, loss of ecosystem services.

4.3.6.1.2. Overexploitation

- overtrampling
- overgrazing

Result of overexploitation – biodiversity loss, primary production decrease, increase of pollutants (fertilizers, pesticides).

4.3.6.1.3. Expansion of invasive alien species

Result of invasive species expansion – biodiversity loss, deterioration in the quality of services.

4.3.6.1.4. Environmental pollution

- organic chemicals
- heavy metals and metaloids

Result of environmental pollution – biodiversity loss, deterioration in the quality of services, habitat change.

Table 11. Drivers-Pressures-State change-Impact-Response in grasslands

	Driver	Pressure	State change	Impact	Response
Direct drivers	Land conversion	Habitat change	Fragmentation	Habitat loss	Policy decision
	Biological invasions	Expansion of invasive alien species	Quality decrease	Biodiversity loss	Control
	Climate change and other natural events	Extreme events (fires, floods)	Habitat change	Habitat and biodiversity loss	Mitigation
	Agricultural intensification	Fertilizers and pesticides, overexploitation	Ecosystem quality decrease	Pollution, Change in primary production	Sustainable management
Indirect drivers	Demographic	Ploughing	Land use change	Habitat loss	Regulation, Traditional management
	Economic growth	Urbanization	Grassland area decrease	Habitat loss	Appropriate legislation
	Cultural	Tourism	Ecosystem quality decrease	Degradation, Habitat loss	Sustainable tourism
	Scientific and technological	Acquisition of new knowledge	Good practices implementation	Ecosystem quality increase	Reducing negative tendencies

Table 12. Risk assessment in grassland ecosystems

	5 years					**50 years**				
Pressure	Very high	High	Medium	Low	Very low	Very high	High	Medium	Low	Very low
Habitat change		X							X	
Expansion of invasive alien species		X						X		
Extreme events (fires, floods)				X					X	
Fertilizers and pesticides			X					X		
overexploitation										
Urbanization		X					X			
Tourism				X					X	

4.4. Woodland and forest ecosystems

4.4.1. Data sources and organization of forest monitoring

Data use: Data as described is the Methodology is to be used. If new data are available, they should be official and scientifically proven. The data used for assessment should correspond to the data in forest management plans and those in EFA information system, following the relevant algorithm. Data sources are presented systematically in Table 1.

Table 13. Sources of spatial and quantitative/qualitative information about forest ecosystems

Subtype	DATABASE Sources – main stakeholders	
	Spatial	**Quantitative/Qualitative**
High deciduous forests **Coppice forests** **Coniferous**	Forest management plans, MOEW – ExEA – ICP Forests, National Database for Biodiversity, National Soil Monitoring Network. Cadastre www.icadastre.bg National Concept for Spatial Development 2013-2025 EEA – CORINE – Land Cover	Executive forest agency - forest information system – forest inventory data Maps of restituted property, Action Plans for Programmes of Environmental protection, National Concept for Spatial Development 2013-2025, National Statistical Institute, , JRC, Publications, Project Reports, Environmental NGO FRA 2015/FAO/UN Forest Europe – Quantitative assessment

Planning of the monitoring-related activities

Indicators to be assessed:

Ecosystem condition indicators to be assessed as described in the Methodology

Ecosystem services to be assessed according to the approved algorithms for mapping and assessment of forest ecosystems

The 5-score scale described in the Methodology is to be implemented

Processing of the mapping and assessment / in situ verification results and preparation for comparison in the field

Field work

Determination of ecosystem types presented in the field.

Selection of representative polygon;

Representativeness of the polygon:

- Forest species distribution
- EUNIS classification
- Altitude and biogeographical region of distribution of the forest stand
- The forest stand is accessible for field assessment
- The origin of the stand;
- Ecosystem functionality of the stand;

Full assessment of ecosystem condition (related polygon/stand) and provided ecosystem services, except indicators and parameters that could not be measured in the field.

Comparison of assessment based on the existing forest inventory data and assessment made in the field (ecosystem condition and services in related polygon).

Processing of the results

Analyses of the changes and tendencies of ecosystem condition and services and assessment of the emerged pressure.

4.4.2. Selection of indicators/parameters for monitoring

The selection should be according to forest functionality:

i. Forest designated for wood supply
   - Provisioning ES - all parameters for assessment available in the field have to be selected.
   - Regulation and Cultural ES – the parameters are selected randomly by the verificator

ii. Special and Protective forests :
   - Provisioning ES - the parameters are selected randomly by the verificator.
   - Regulation and Cultural ES – all parameters for assessment available in the field. have to be selected

Note: *For forest ecosystems, there is no differentiation between mandatory and recommended indicators/parameters. All indicators and parameters are considered mandatory*.

The indicators and parameters are presented in the following tables:

Table 14. Forest ecosystem condition indicators

Monitoring type	Indicator	Parameter (unit of measurement)	Monitoring points	Monitoring frequency	Method Reference link
Periodical/extraordinary	Plant diversity	Grass cover, %	Forest stand (subcompartment)	Every 10 years	Empirical model
	Animal diversity	Red list species	10 km grid	Every 10 year	Empirical model
	Habitat diversity	Dead wood volume	Forest stand (subcompartment)	Every 10 years	Empirical model

Table 15. Forest ecosystem service indicators

Monitoring type	Indicator	Parameter (unit of measurement)	Monitoring points	Monitoring frequency	Method Reference link
Periodical/extraordinary	Pollination and seed dispersal	Number of plants, number of pollinators	Forest stand (sub-compartment)	Every 10 years	indirect methods – algorithm
	Micro and regional climate regulation	Complex parameter	Forest unit	Every 10 years	indirect methods – algorithm
	Experimental use of plants, animals and land-/forest in different environmental settings	Purpose of forest, Visitors,	Forest stand (sub-compartment)	Every 10 years Visitors' number per year	indirect methods – algorithm
	Physical use of land-/ forest in different environmental settings	Access into the forest, Visitors,	Forest unit	Every 10 years Visitors' number per year	indirect methods – algorithm
	Heritage, cultural	Purpose of forest ,cultural monuments	Forest unit	Every 10 years	indirect methods – algorithm
	Entertainment/ Aesthetic	number of visitors, number of hunters	Forest unit	Every 10 years	indirect methods – algorithm
	Symbolic	Aesthetic landscapes, Number of inhabitants	Forest unit	Every 10 years	indirect methods – algorithm
	Existence	Conservation significance, Number of sites in protected areas	Forest unit	Every 10 years	indirect methods – algorithm
	Bequest	Aesthetic land-scapes, Number of inhabitants	Forest unit	Every 10 years	indirect methods – algorithm

4.4.3. Periods of monitoring

The suggested periods for conducting **periodic** monitoring are:

Desk work – out of vegetation period*;*

Field work – during the vegetation period

Permanent monitoring: For the forest ecosystems permanent monitoring is currently not applicable

Extraordinary monitoring ought to be performed in cases of disaster and *force majeure* events, when interest of ecosystem services use in a given territory is being declared, upon land use change or other extraordinary circumstances.

4.4.4. Tracing and analysis of the changes of the areas occupied by grassland ES

Other than the general arguments for selecting monitoring sites, such as ensuring a representative selection of all ecosystem subtypes, the changes in forests sub-compartments (polygons), land use change; purpose of the forests must be considered when deciding the location of monitoring sites so the changes in the ecosystems following such socio-economic changes might be followed according to the DPSIR conceptual model.

4.5. Heathland and shrub ecosystems

4.5.1. Data sources

The initial basis of monitoring data comprises the data available and collected during the 2016 mapping and valuation of Heathland and shrub ecosystems in Bulgaria and the ecosystem services they provide and represent a “snapshot” of the ecosystem’s condition and the range of provided ecosystem services.

The following data sources are used during the first mapping process and should also, to the extent possible, be used for monitoring:

- specialized data bases for biodiversity;
- data from National Environmental Monitoring;
- data provided by governmental bodies;
- data provided by nongovernmental bodies;
- data from field collection.

4.5.2. Selection of indicators/parameters for monitoring

The main criterion for selection of indicators for monitoring of both ecosystem condition and services is their ability to provide information about changes and trends of condition of Heathland and shrub ecosystems and their capacity to provide ecosystem services.

4.5.2.1. Main/obligatory indicators

Obligatory indicators for monitoring the condition of Heathland and shrub ecosystems and services they provide are listed in Table 1 and Table .

4.5.2.2. Recommended indicators

The performers of monitoring may propose new indicators for monitoring of condition and services. Such indicators are *Other biotic diversity indicators (for example, naturalness, habitat diversity, etc.), Hydrological heterogeneity, Geomorphological heterogeneity, Other abiotic heterogeneity indicators, Energy balance (capture, storage), Metabolic efficiency, Matter balance (input, output), Element concentrations (other matter budget variables), Efficiency measures, Water balance (input, output), Water storage, Efficiency measures* etc. For details see the METHODOLOGY FOR ASSESSMENT AND MAPPING OF HEATHLAND AND SHRUB ECOSYSTEMS CONDITION AND THEIR SERVICES IN BULGARIA – Part B5.

For indicators of the Biotic Diversity group the data collected and reported under the Article 17 of HD 92/43/EEC may be used.

A list of parameters for ecosystem condition assessment and services provided is presented in Table 16 and Table 17.

Table 16. Ecosystem condition indicators/parameters for heathland and shrubs monitoring

Ecosystem condition indicators						
Indicators	**Parameters**	**Dimentions (units)**	**Provides information for**	**Data availability**	**Periodicity of measuring**	**Significance**
Cover of shrub layer	Vegetation cover	%	Ecosystem structure	Field collection; Specialized data bases for biodiversity	5 years	obligatory
Plant diversity	Plant species richness	Number of species per sample plot	Biodiversity	Field collection; Specialized data bases for biodiversity	5 years	obligatory
Animal diversity	Animal species richness	number of species	Biodiversity	Field collection; Specialized data bases for biodiversity	5 years	obligatory
Red list species	Number of red list species (plant/animal)	number of species	Naturalness	Field collection; Specialized data bases for biodiversity	5 years	obligatory
Alien and invasive species presence	Number of species per grid unit	number of species	Disturbance	Field collection; Specialized data bases for biodiversity	5 years	obligatory
Disturbance regime	Soil erosion risk	score	Disturbance	Data from National Environmental Monitoring; Erosion maps	5 years	obligatory
	Pollution	Number of dump sites	Pollution	Field collection; Data from National Environmental Monitoring	5 years	obligatory
Matter storage	Biomass	t/ha	Ecosystem function	Field collection	5 years	obligatory

Table 17. Ecosystem services parameters/indicators for heathland and shrubs monitoring

Ecosystem services indicators					
Class indicators	**Indicators**	**Parameters and units**	**Provides information for**	**Data availability**	**Periodicity of measuring**
Reared animals and their outputs	Reared animals	Livestock units/ha	Reared animals per municipality	Statistics; Data provided by governmental bodies	3 years
Wild plants, algae and their outputs	Primary biomass production for food	Products t/ha	Production for food	Statistics; Field collection	3 years
Wild animals and their outputs	Wild animals for hunting	Number/ha	Number of species for hunting	Statistics; Ecosystem condition assessment; Specialized data bases for biodiversity	3 years
Fibers and other materials from plants, algae and animals for direct use or processing	Harvest/Yield as % of country average depending on ecosystem condition	t/ha	Production of materials; Forage capacity	Statistics; Ecosystem condition assessment; Field collection; Data provided by governmental bodies	3 years
	% of primary biomass production for food	t/ha			
	Raw material inputs per capita	t per capita			
	Raw material consumption per capita	t per capita			
Mass stabilization and control of erosion rates	Vegetation cover + soil erosion risk	Area [ha]	Erosion prevention	Available map; Data provided by governmental bodies	5 years
Buffering and attenuation of mass flows	Vegetation cover	Area [ha]	Mass flows prevention	Scientific publications; Field collection	5 years
Pollination and seed dispersal	Pollination potential	Scale	Pollinators presence	Joint Research Center – IES data; Field collection	3 years
Maintaining nursery populations and habitats	Biodiversity maintaining	Total species richness; Number	Biodiversity maintenance	Specialized data bases for biodiversity	5 years

Table 17. *(cont.)*

Weathering processes	Soil organic matter content	g/kg	Soil formation	EU; Data from National Environmental Monitoring	5 years
Decomposition and fixing processes	Soil organic matter content	g/kg	Soil formation	EU; Data from National Environmental Monitoring	5 years
Experiential use of plants, animals and land-/seascapes in different environmental settings	Farm tourism, visitors (birdwatch, plant-watch, etc.)	Number per year	Tourism	National data	5 years
Physical use of land-/seascapes in different environmental settings	Visitors, farm tourism, walking and biking trails	Number per year	Tourism	National data	5 years
Scientific	Amount of scientific studies	Number of published papers, number of projects	Scientific interest	WEB, libraries	5 years
Educational	Educational activities (festivals, visiting centers, green school, etc.)	Number of activities per year	Scientific interest; Tourism	National data	5 years
Heritage, cultural	Cultural monuments, Products from traditional management landscapes	Number of monuments/ products	Tourism	National data	5 years
Entertainment	Festivals and other cultural events	Number of activities per year	Tourism	National data	5 years
Aesthetic	Aesthetic landscapes	Number of photos uploaded in Google Earth	Tourism	WEB	3 years
Symbolic	Symbolic species	Number of species	Biodiversity	National data	5 years
Sacred and/or religious	Monasteries, churches, places	Number	Religious tourism	National data	10 years
Existence	Conservation significance	Number of sites in protected areas (e.g. NATURA2000, Biosphere reserves, etc.)	Biodiversity maintenance	National data, MOEW	5 years

4.5.2.3. Indicators/parameters for which there is no data at the moment and that should be collected during the subsequent monitoring:

- biomass – the parameter is important for the assessment of ecosystem condition and services.
- pollination potential – available data is based on scarce field studies and modelling. This parameter is of primary importance and needs adequate data collection.
- primary biomass production for food – no field data.

4.5.3. Periods of monitoring

4.5.3.1. Periodical monitoring

Field collection should be done in the vegetation maximum of Heathland and shrub ecosystems, as follows:

- Arctic, alpine and subalpine scrub – from July to August;
- Temperate and Mediterranean-mountain scrub – from May to June;
- Riverine and fen scrub – from May to June.

Frequency of the conducted monitoring is according to the time periods outlined in Tables 1 and 2. Data from National Biodiversity Monitoring and Governmental bodies are to be used as they are provided.

4.5.3.2. Permanent monitoring

For Heathland and shrub ecosystems permanent monitoring is not applicable.

4.5.3.3. Extraordinary monitoring

Extraordinary monitoring is to be implemented in case of disasters, force majeure phenomena or circumstances (e.g. fires, flooding, landslides or investment intentions). This is important to assess the rate of change and take a decision to change the monitoring plot.

4.5.4. Criteria for selection of monitoring areas

4.5.4.1. Approach in the selection of monitoring areas

The monitoring on Heathland and shrub ecosystems is site-focused. The methodological basis is selection of plots/polygons systematically distributed to cover not less than 10% of the area of **Temperate and Mediterranean-mountain scrub** ecosystem subtype, 20% of **Arctic, alpine and subalpine scrub** ecosystem subtype and 30% of **Riverine and fen scrub** ecosystem subtype over the country. The following additional criteria should be applied:

- polygon area – advanced rating in three classes by area: small, medium and large polygons;
- IP index score for condition – advanced rating in three classes by score: low, medium and high IP index score.

The proposed selection provides an opportunity for long term monitoring in representative sites and data interpolation on similar sites. The same approach is to be applied to all Heathland and shrub ecosystem subtypes. Any change in the area and ecosystem condition reflects on the services provided.

4.5.4.2. Tracing and analysis of the changes of the areas occupied by the Heathland and shrub ecosystems

- no area change – sustainability in time;
- area decrease – diminish the ability to provide services;
- area increase – increase the ability to provide services;
- IP index decrease – ecosystem condition become worse;
- IP index increase – ecosystem condition become better.

4.5.4.3. Tracing of the tendencies for fragmentation of the areas

Natural cycle/succession in many Heathland and shrub ecosystems in the country leads to forest vegetation. This process goes on with different rate and depends on the local environment. Main reasons, different than the natural cycle of the ecosystem, that should be taken into account and traced over time are:

- fragmentation;
- destruction;
- overgrazing/ruderalization;
- pollution;
- land abandonment/abandonment of traditional grazing;
- land use change;
- land take.

4.5.5. Analysis of Drivers-Pressures-State-Impact-Response (DPSIR) in Heathland and shrub ecosystems

4.5.5.1. Main tendencies that affect Heathland and shrub ecosystems and their services and that should be traced over time

4.5.5.1.1. Habitat change

- land use change/conversion from Heathland and shrub ecosystems to arable lands and permanent crops;
- urban development; spreading of economic sites and infrastructure;
- agriculture intensification;
- land abandonment/abandonment of traditional grazing;
- land take;
- fires;
- pollution.

Results of habitat change: ecosystem degradation, fragmentation, habitat loss, biodiversity loss, loss of ecosystem services.

4.5.5.1.2. Overexploitation

- overtrampling;
- overgrazing.

Results of overexploitation: biodiversity loss, primary production decrease, excess amount of nutrients in soil, nitrogen enrichment, increase of pollutants.

4.5.5.1.3. Expansion of invasive alien species

Results of invasive species expansion: biodiversity loss, deterioration in the quality of services, habitat change.

4.5.5.1.4. Environmental pollution

- organic chemicals;
- pollution from atmospheric nitrogen;
- heavy metals and metalloids;

Results of environmental pollution: soil pH change, biodiversity loss, deterioration in the quality of services, habitat change.

4.5.5.2. Types of pressure on Heathland and shrub ecosystems

The types of pressures on Heathland and shrub ecosystems is listed in Methology for mapping and assessment….B5.

Table 18. Drivers-Pressures-State-Impact-Response in Heathland and shrub ecosystems

	Driver	Pressure	State	Impact	Response
Direct drivers	Habitat change	Land use change; Land abandonment; Reduced grazing	Ecosystem quality decrease	Habitat loss	Policy measures to reduce impacts; Appropriate management
	Biological invasions	Alien invasive species; Disease agents	Ecosystem quality decrease	Biodiversity loss	Control and prevention; Mitigation measures
	Climate change and other natural events	Extreme events (fires, floods)	Degradation; Destruction; Ecosystem quality decrease	Habitat and biodiversity loss	Control and prevention; Mitigation measures
	Overexploitation	Agricultural intensification; Pollution and nutrient enrichment; Fragmentation	Ecosystem quality decrease	Biodiversity loss; Change in primary production	Sustainable land management; Pollution reduction
Indirect drivers	Demographic	Land use change; Land abandonment; Land take	Habitat change	Habitat loss	Regulation; Traditional land management
	Economic growth	Urbanization; Landscape fragmentation	Heathland and shrub areas decrease	Habitat loss	Appropriate legislation and management
	Cultural	Tourism; Pollution; Recreational disturbance	Ecosystem quality decrease	Degradation, Habitat loss; Biodiversity loss	Sustainable tourism; Pollution reduction
	Scientific and technological	Good practices implementation	Ecosystem quality increase	Increase ability to provide services	Reducing negative tendencies

4.5.5.3. Risks for the state of Heathland and shrub ecosystems

The risks of changes in Heathland and shrub ecosystem condition is specified in Table 20.

Table 19. Risk assessment - Heathland and shrub ecosystems

	5 years					50 years				
Pressure	Very high	High	Medium	Low	Very low	Very high	High	Medium	Low	Very low
Habitat change			X					X		
Expansion of invasive alien species		X					X			
Overexploitation			X					X		
Land use change		X					X			
Extreme events (fires, floods)				X					X	
Fertilizers and pesticides over-exploitation				X					X	
Urbanization				X				X		
Tourism				X					X	

4.6. Sparsely vegetated land

4.6.1. Data sources:

The following main data sources were used in during the first mapping process and should be re-used to the extent possible:

- Field collected data
- Specialized data bases and scientific collections for biodiversity
- Data from National Environmental Monitoring
- Data provided by governmental bodies
- Data provided by nongovernmental bodies

4.6.2. Selection of indicators/parameters for monitoring in sparsely vegetated lands:

The main criterion for selection of indicators for monitoring both for ecosystem condition and services is their ability to provide information for changes and trends of condition of sparsely vegetated land ecosystems and their capacity to provide ecosystem services.

4.6.2.1. Mandatory (obligatory)

Mandatory indicators for monitoring the condition and services provided by sparsely vegetated lands are selected of list of primary indicators that tend to change over time.

4.6.2.2. Recommended (optional)

As an optional new indicator for monitoring of condition of sparsely vegetated land should be used the data collected and reported under Article 17 of HD 92/43/EEC for the indicator group Biotic Diversity. Possible newly included indicators should be chosen for indicator groups Abiotic heterogeneity and Energy budget as well. In future monitoring the production of medicinal plants should also be taken into account.

4.6.2.3. Indicators/parameters for which there is no data at the moment but that should be collected during the subsequent monitoring

In future monitoring the production of medicinal plants should also be taken into account.

4.6.3. Periods of monitoring for sparsely vegetated lands:

4.6.3.1. Periodical

- Frequency of the conducted monitoring is according to the time periods outlined in Annex 6 and Annex 7 to the Methodology and next tables ….
- Seasonal distribution of the monitoring activities and field collection throughout the years should be done in the vegetation maximum, as follows:
    - Coastal dunes and sandy shores: from middle June to middle July;
    - Coastal shingle: July and August;
    - Costal rock cliffs, ledges and shores, including the supralittoral: from middle June to middle July;
    - Screes: July and August;
    - Inland cliffs, rock pavements and outcrops: July and August;

4.6.3.2. Permanent monitoring: N/A

Permanent monitoring is currently not applicable for Sparsely vegetated lands.

4.6.3.3. Extraordinary - in case of disasters, force majeure phenomena or circumstances

To be implemented in case of disasters, force majeure phenomena or circumstances (e.g. fires, flooding, landslides or investment intentions). This is important to assess the rate of change and take decision to change the permanent plot.

Table 20. Ecosystems condition - Sparsely vegetated lands

	Indicator Group	Indicator	Provides information for:	Unit	Periodicity	Methods	Data availability
Obligated	Biotic diversity	Vegetation cover	Ecosystem structure	%	3 years	Field collection	Biodiversity data bases
		Plant diversity	Biodiversity	number	3 years	Field collection	Biodiversity data bases
		Animal diversity	Biodiversity	number	3 years	Field collection	Biodiversity data bases
		Red list species (plant/animal)	Naturalness	number	3 years	Field collection	Biodiversity data bases
		Alien and invasive species presence	Naturalness; Disturbance	number	3 years	Field collection: Project ESSENIAS	Biodiversity data bases
	Abiotic heterogeneity	Concentration of pollutants from surrounding areas	Pollution	number	5 years	Field collection	Biodiversity data bases
	Matter budget	Matter storage	Ecosystem function	Biomass (dry) in t/ha	5 years	Field collection	Biodiversity data bases
Optional / New	Biotic diversity	Other biotic diversity indicators (for example, naturalness, habitat diversity, etc.) e.g. Conservation status of natural habitats according HD 92/43/EEC or presence of species included in Annexes in HD 92/43/EEC	Biodiversity; Naturalness; Disturbance		5 years	Field collection	Biodiversity data bases
	Abiotic heterogeneity	Other abiotic heterogeneity indicators			5 years	Field collection	
	Energy budget	Energy balance (capture, storage)			5 years	Field collection; Scientific studies	

Table 21. Ecosystem services - Sparsely vegetated lands

	Services Section & Division	**Service**	Provides information for:	Unit	Periodicity	Databases and Data sources	Data availability
Obligated	Provisioning/Nutrition	Wild animals for hunting	Presence and dynamics of species for hunting	species/ha	3 years	Government databases; Field collection; Scientific studies	
	Regulation & Maintenance /Lifecycle maintenance, habitat and gene pool protection	Pollination potential	Pollination capacity	scale	3 years	Field collection; Scientific studies	
		Biodiversity maintaining	Biodiversity maintenance capacity	Number of species	3 years	Field collection; Scientific studies	
	Cultural	Physical and intellectual interaction	Attitude to the ecosystems	Number of events	3 years	Field collection; Public available information	
New	Provisioning/Materials	Biomass production of medicine plants for materials	Recourses and capacity of medicinal plants	t/ha	3 years		

4.6.4. Criteria for selection of monitoring areas:

4.6.4.1. Approach in the selection of monitoring areas

Monitoring on sparsely vegetated lands is site-focused. The methodological basis is selection of plots/polygons systematically distributed to cover not less than 10% of the area of subtypes Screes and Inland cliffs, rock pavements and outcrops over the country, as well as of not less than 30% of the area of subtypes Coastal dunes and sandy shores, Coastal shingle and Costal rock cliffs, ledges and shores, including the supralittoral. The following additional criteria should be applied:

- Polygon area – advanced rating in three classes by area – small, medium and large;
- IP index score for condition – advanced rating in three classes by score – low, medium and high.

Same approach is applied to all sparsely vegetated land's subtypes.

The proposed selection provides opportunity for long term monitoring in representative sites and data interpolation on similar sites.

4.6.4.2. Tracing and analysis of the changes of the areas occupied by the respective ES

- no area change – sustainability in time
- area decrease – fragmentation and decrease in services provision
- area increase – increase in capacity for ecosystem provision
- IP index decrease – ecosystem condition becomes worse
- IP index increase – ecosystem condition becomes better
- Pollution
- Destruction
- Overexploitation

4.6.5. Analysis of Drivers-Pressures-State-Impact-Response (DPSIR) of Sparsely vegetated lands

4.6.5.1. Main tendencies that affect Sparsely vegetated lands and their services and that should be traced over time:

4.6.5.1.1. Habitat change:

- direct destruction by mining, quarrying, transport infrastructure and other activities;
- biodiversity and all condition changes by sport, leisure activities, urbanization, grazing by livestock, forestry, human disturbance as trampling, predation by other species such domestic animals (top pressure for birds);

4.6.5.1.2. Climate change:

- biodiversity and all condition changes;

4.6.5.1.3. Overexploatation:

- direct destruction by mining, quarrying, transport infrastructure and other activities;
- biodiversity and all condition changes by sport, leisure activities, urbanization, grazing by livestock, forestry, human disturbance as trampling;

4.6.5.1.4. Invasive alien species:

Results of invasive species expansion are biodiversity loss and deterioration in the quality of services.

4.6.5.1.5. Pollution and nutrition enrichment

As these ecosystems are often found on nutrition-poor terrains, they are sensitive and vulnerable to the effects of pollution and eutrophication. The responses to elevated nitrogen levels include changes in plant growth, phenology, and within the composition of communities (loss of nitrogen-sensitive species and expansion of nitrogen-loving species).

4.6.5.2. Types of pressure on ecosystems

Table 22. Pressure types for Sparsely vegetated lands

Main Pressures	Indicators of Ecosystem condition that are indicative	Parameter	Monitoring points	Periodicity	Response
Habitat change	Plant diversity; animal diversity; vegetation cover; red list species; matter storage	Loss of typical species; Occurrence of non typical species; Changes in biomass	Permanent after first selection	3 years	Sustainable economic; Sustainable tourism; Control; Appropriate legislation
Climate change	Plant diversity; animal diversity; vegetation cover; red list species species; matter storage	Loss of typical species; Occurrence of non typical species; Changes in biomass	Permanent after first selection	3 years	actively share of information on status, threats and management techniques for conservation and restoration through the EU members
Invasive alien species	Alien and invasive species presence	Changes in alien invasive species occurence	Permanent after first selection	3 years	Sustainable economic; Sustainable tourism; Control; Appropriate legislation
Overexploatation	Plant diversity; animal diversity; vegetation cover; red list species; matter storage; Alien and invasive species presence	Loss of typical species; Occurrence of non typical species; Changes in biomass; Changes in biomass; Enrichment of nitrogen-loved species; Changes in alien invasive species occurence	Permanent after first selection	3 years	Sustainable economic; Sustainable tourism; Control; Appropriate legislation
Pollution and nutrition enrichment	Concentration of pollutants from surrounding areas; Plant diversity; animal diversity; vegetation cover; red list species; matter storage	Changes in pollution levels; Loss of typical species; Occurrence of non typical species; Changes in biomass; Enrichment of nitrogen-loved species	Permanent after first selection	3 years	Sustainable economic; Sustainable tourism; Control; Appropriate legislation

4.6.5.3. Risks for the state of Sparsely vegetated lands

Table 23. Risks for the state of Sparsely vegetated lands

	5 years					50 years				
Pressures	Very high	High	Me-dium	Low	Very low	Very high	High	Me-dium	Low	Very low
Habitat change		X						X		
Destruction		X						X		
Expansion of invasive alien species					X					X
Climate changes				X					X	
Extreme events (fires, floods)				X					X	
Overexploitation			X					X		
Pollution and nutrition enrichment			X						X	
Urbanization					X				X	
Tourism			X						X	

4.7. Wetland ecosystems

The main criterion for selection of indicators for monitoring both for ecosystem condition and services is their ability to provide information about changes and trends of condition of wetlands and their capacity to provide ecosystem services. A list of parameters for ecosystem condition assessment and services provided is presented in Table 25 and Table 26.

The list combines all mandatory indicators. Some of them are used for assessment different issues (e.g. plant biomass).

Table 24. Ecosystem condition indicators - wetland ecosystems

Condition	Parameter	Provides information for	Unit	Data source	Periodicity	Data availability
Biotic diversity			**mandatory**			
	Ecosystem subtype cover within the polygon	Ecosystem structure	%	Field collection	3 years	Specialized data bases for biodiversity
	Plant species richness	Biodiversity	number	Field collection	3 years	Specialized data bases for biodiversity
	Wild animal species richness	Biodiversity	number	Field collection	3 years	Specialized data bases for biodiversity
	Alien and invasive plant species presence	Disturbance	number	Field collection	3 years	Specialized data bases for biodiversity
			optional			
	Red list species (plant/animal)	Naturalness	number	Field collection	3 years	Specialized data bases for biodiversity
Abiotic heterogeneity	primary					
	Soil quality	Soil type	Soil type	Field collection, soil map	Do not be monitored	Specialized data bases for biodiversity
	Proportion of organic C and total N in the soil	Soil fertility	% C/N	Field collection	5 years	Data from National Environmental Monitoring
	pH of the soil (for sedge and reed-beds)	Soil fertility	number	Field collection	5 years	Data from National Environmental Monitoring
	General chemistry of the water(pH, conductivity, dissolved oxygen, ammonium nitrogen, nitrate nitrogen, phosphate, BOD5)	Soil fertility	Score	Field collection	5 years	Data from National Environmental Monitoring
	Pollution	Disturbance	number	Field collection	5 years	Data from National Environmental Monitoring
	Fire	Disturbance	number	Field collection	5 years	Data provided by governmental bodies
Matter budget	Matter storage	Ecosystem function	Biomass (air dry) in t/ha	Field collection	3 years	Specialized data bases for biodiversity
Water budget	Water balance (input, output)	Ecosystem function	Quantity per time	Field collection	3 years	Data provided by governmental bodies

Table 25. Ecosystem services indicators - wetland ecosystems

Services	Parameter	Provides information for	Unit	Data source	Periodicity	Data availability
Nutrition	Consumption of groundwater	Water capacity and ecosystem sustainability	l/day per capita	National statistics	3 years	Data provided by governmental bodies
Materials	Biomass production of plants, fungi and animals for materials	Ecosystem productivity	t/ha	Field collection	3 years	No consistent data, Specialized data bases for biodiversity
	Total gross freshwater abstraction from fresh surface water	Water supply	mill m3/year	National statistics	3 years	Data provided by governmental bodies
	Total gross freshwater abstraction from fresh ground waters	Water supply	mill m3/year	National statistics	3 years	Data provided by governmental bodies
Mediation of flows	Vegetation cover/Slope coefficient	Erosion prevention	Scale	GIS analysis	5 years	Specialized data bases for biodiversity, Data provided by governmental bodies
Maintenance of physical, chemical, biological conditions	Biodiversity maintaining	Overlapping with protected areas in percentage	Scale	GIS analysis	5 years	Data provided by governmental bodies
Nutrition	Mineralization index Decomposition and fixing processes	Soil formation	Organic C/N g/kg	Data analyses	3 years	Data from National Environmental Monitoring
Physical and intellectual interactions with biota, ecosystems, and landscapes	Wilderness experiences	Attitude to the wetlands	Number of events	Data bases	3 years	No consistent data, Data provided by nongovernmental bodies

Indicators/parameters for which there is no data at the moment but that should be collected during the subsequent monitoring:

- Biomass of plants for fodder –The parameter is important for assessment ecosystem condition and for forage capacity.

- Hydrological cycle and water flow maintenance –The parameter is important for assessment ecosystem services related to the water availability and needs adequate data.

- Chemical condition of freshwaters – Available data exist only for rivers and ponds. The data for wetlands has not been collected systematically.

4.8. River and lakes ecosystems

4.8.1. Periods of monitoring – Rivers and Lakes

The frequency of monitoring is coordinated with Ordinance No 1/2011 on water monitoring (Art. 11) and respective typology of the water bodies according to Ordinance No H-4/2013 and the type of the monitoring – surveillance and/or operative. The monitoring of the freshwater ecosystems state (rivers and lakes/reservoirs) should be coordinated with these ones of general physical and chemical and hydro-morphological quality elements as well as with the programs of the National monitoring of the biodiversity state (see *Practical guidance on…*, as approved by Order No РД 20-10/20.04.2016 of the Minister)

On the sites designated for **surveillance/control monitoring** (periodical) the following frequencies of monitoring to be applied:

Table 26. Monitoring frequency of Rivers and lakes

Biological Quality Elements (BQE)	Rivers	Lakes/Reservoirs
Phytoplankton	6 months*	6 months
Macrophytes/Other aquatic flora	3 years	3 years
Macroinvertebrates	3 years	3 years
Fish	3 years	3 years

* *Applicable only for the Danube River.*

Concerning monitoring sites/stations within the programs for **operational monitoring** (permanent), these should coordinate frequencies to ensure enough data for assessment of the relevant BQEs; in general in intervals not larger than those in the table above.

For all objects/sites remained outside monitoring programs for assessment of the ecological state of water bodies and/or those for biodiversity monitoring, special programs for investigative monitoring should be developed aiming at provision of primary data on BQEs state and on

biodiversity as a whole for further assessment of the state of relevant freshwater ecosystems type/subtypes – rivers and lakes.

While developing monitoring programs it should be considered also the specific phenology of given BQEs (periods/moments of plants flowering or mating, hatching, maturing, migrating of animal species, etc.), agreed with hydrological cycles and climatic features of each site or group of sites (watershed).

For lotic (riverine) ecosystems it is recommendable to held monitoring activities in the period of lower water levels (summer-fall) while for lentic (standing) ecosystems it's better to hold observation also during the spring/summer periods, which are of higher species diversity.

Provisioning of the freshwater ecosystems state relations monitoring activities should be in direct dependence on level of coordination between monitoring programs for water bodies and those for biodiversity state. This coordination is much more desirable because part of the sites for freshwater monitoring are into the National ecological network NATURA 2000, and they stayed outside the mapping and assessment activities within the Program BG03.

4.8.2. Criteria for selection of monitoring areas – Rivers and lakes

In accordance with the recommendations above, the freshwater ecosystems state monitoring should be coordinated with the relevant water bodies' sites network for monitoring of the ecological state by means of BQEs. When the sites are referent, belonging to the network of surveillance/control monitoring of each types of water bodies designated after Ordinance N4/2013, it should be adjusted with the respective ecotype too. By analogy, the sites of operational monitoring network could de be used for assessment of the freshwater ecosystems state being under humane pressures and impacts.

Selection of sites in the programs of surveillance and operation monitoring, incl. of ecological state of the surface/freshwater bodies, follows the nationally approved "Criteria for selection of monitoring sites…" (see River Basins Management Plans ,2016-2021, Chapter 4).

According to the Ordinance N-4/2013 (Art. 6, para 5), when determine specific biological referent conditions for ecosystems' sub-types, one should take into account the spatial and seasonal variability/ changeability of values of BQEs, which are relevant to the high ecological state for respective surface/ freshwater body type as well as the modeling methods for the type-specific biological referent t conditions.

Speaking about sites/points which may be object of a survey due to situations/accidents with unclear origins/reasons, they should became monitoring sites until clarification of the circumstances of the reasons and factors which have brough to the unfavourable situation. Depending on the given impact and its timing, such sites would be included later in operational monitoring programs.

Changes in already mapped freshwater ecosystems should be taken into account within regular monitoring of the hydro-morphological quality elements in rivers and lakes/reservoirs, such as changes of river bed and its continuity, of protecting constructions (dykes/ embankments), of various types of barraging (construction/demolishing of dams, water intakes, etc.)

and they should be introduced regularly into maps, but not more rare than ones for the program period of the River Basins Management Plans, 2016-2021 (6 years, see Ordinance No 1/2011 on water monitoring).

Methods for collection and processing of biological and other sample materials needed for assessment of the freshwater ecosystems' state are described in details in Annexes to the Ordinance N-4/2013. It should be emphasized that some of these methods are fully relevant to those ones as applied in the methods for biodiversity state assessment; however, adjustment of these methodic/methods requires clarification of possible misunderstandings and problems.

4.8.3. Analysis of Drivers-Pressures-State-Impact-Response (DPSIR) in Rivers and Lakes ecosystems

Drivers, which affect the freshwater ecosystems and ecosystem services should be monitored in time: Provision/Exploitation of biological resources; Land use (land cover); Industries; Agriculture & Stock Breeding; Fishery & Aquacultures; Industrial, communal/ household, agricultural and/or other water pollution Hydro-technical constructions (reservoir, irrigation/drainage canals, flood protection infrastructure, etc.); Tourism (type and number of object, number of visitors); Climate changes (floods and droughts); Protections of natural territories/aquatories.

Pressures on freshwater ecosystems: a) as a ***source of pressure***: Industrial, communal/ household, agricultural and/or other water pollution and contamination; Changes in hydrological regime (water abstraction, drying, shifts in seasonal dynamics; Morphological changes (rivers' barraging, corrections, changes in ecosystem type, i.e. shifts from lotic to lentic ecosystem, and *vice versa*), Direct withdrawal of biological resources (hunting, fishing, cutting, etc.); **b)** as a ***pressures category***: point source, diffusive, climate, hydro-morphological.

Main trends, concerning freshwater ecosystems and their services: Over-exploitation, both of biological and freshwater resources; Industrial, communal/ household, agricultural and/or other water pollution; Agriculture, Fishery & Aquacultures; Unsustainable land use and development; Forestry practices in watersheds; Hydroenergy production (Small Hydropower plants/stations); Transportation/Road infrastructures.

State Change and significant risks for freshwater ecosystems and services they used to provide (see the next table)

4.8.3.1. Risks for the state of Rivers and lake ecosystems

At the end of each monitoring period, the actual results obtained for the impacts of the indicators (and their parameters) and the positive and negative characteristics of the current situation of the respective ES and the services it provides should be presented /demonstrated and analyzed.

Table 27. Risk assessment and monitoring of Rivers and lake ecosystems

Groups/sub-types of freshwater ecosystems	Risk factors	Risk in 5 years				Risk in 50 years			
		H	S	M	L	H	S	M	L
Lotic (riverine) ecosystems	*Risks of pollution from industries, **agriculture** and/or communal/urban sources*	*				*			
	Risks of changes of hydrology and morphology of the floes due to engineer and/or infrastructural projects, (high)road infrastructural projects in regional and transport sectors, and hydro-energy power production.		*						
	Risks of extreme events (floods, droughts) due to wrong forestry practices (deforestation) and climate changes.		*			*			
	Risks of invasive alien species; changes in ecosystems energy+material flows; loss of bio-productivity and self purification capacity/potential.			*		*			
	Risks of over-exploitation of both biological and water resources		*			*			
Lentic (standing, lakes) ecosystems	*Risks of pollution from industries, **agriculture** and/or communal/urban sources*	*				*			
	Risks of high levels of eutrophication due to wrong agricultural practices with watersheds, incl. fishery and aquacultures.		*			*			
	Risks of extreme events (floods, droughts) due to wrong forestry practices (deforestation) and climate changes.		*						
	Risks of invasive alien species; changes in ecosystems energy+material flows; loss of bio-productivity.		*			*			
	Risks of over-exploitation of both biological and water resources		*			*			

4.9. Marine ecosystems

4.9.1. Selection of indicators/parameters for Marine monitoring

The selection of indicators and parameters for monitoring of the ecosystem condition is based on the available and implemented national monitoring programs in the Black Sea marine ecosystems, namely the Water Framework Directive monitoring of the ecological status of coastal water bodies and the Marine Strategy Framework Directive Article 11 monitoring program of the Good Environmental Status' of marine ecosystems in the Bulgarian territorial waters. A list of the main and mandatory (obligatory) marine ecosystem condition indicators and parameters is provided below.

Currently there is no developed and implemented national program for monitoring of the ecosystem services provided by the marine ecosystems. A list of obligatory and recommended ecosystem services parameters for evaluation is available in Table 8 of the 'Methodology for assessment and mapping of marine ecosystems condition and their services in Bulgaria'

4.9.1.1. Main/obligatory indicators

Table 28. Ecosystem conditions indicators and parameters - Marine ecosystems

Type	Indicators	Parameter (dimension)	Included in the NEM (yes/no)	Other databases	Availa-bility of data - evalua-tion	Methods and reference link
Obligatory	plant diversity	Phytoplankton numbers in summer (cell/l)	no	WFD; MSFD	yes*	Ord. No N-4/14.09.2012; MSFD Art. 11 monitoring program; http://www.bsbd.org/bg/msfd_monitoring.html
		Macroalgae and Angiosperms EEI-C (EQR)	no	WFD; MSFD	yes	Ord. No N-4/14.09.2012; MSFD Art. 11 monitoring program; http://www.bsbd.org/bg/msfd_monitoring.html
		Macrozooben-thos M-AMBI index (EQR)	no	WFD; MSFD	yes	Ord. No N-4/14.09.2012; MSFD Art. 11 monitoring program; http://www.bsbd.org/bg/msfd_monitoring.html
	Water Column heterogeneity	Water Trans-parency (meter)	no	WFD; MSFD	yes	Ord. No N-4/14.09.2012; MSFD Art. 11 monitoring program; http://www.bsbd.org/bg/msfd_monitoring.html

		TRIX index (Index units)	no	WFD; MSFD	yes	Ord. No N-4/14.09.2012; MSFD Art. 11 monitoring program; http://www.bsbd.org/bg/msfd_monitoring.html
		P-PO4, summer (mg.l-1)	no	WFD; MSFD	yes	Ord. NoN-4/14.09.2012; MSFD Art. 11 monitoring program; http://www.bsbd.org/bg/msfd_monitoring.html
		N-NH4, summer (mg.l-1)	no	WFD; MSFD	yes	Ord. No N-4/14.09.2012; MSFD Art. 11 monitoring program; http://www.bsbd.org/bg/msfd_monitoring.html
		N-NO3, summer (mg.l-1)	no	WFD; MSFD	yes	Ord. No N-4/14.09.2012; MSFD Art. 11 monitoring program; http://www.bsbd.org/bg/msfd_monitoring.html
		N-NO2, summer (mg.l-1)	no	WFD; MSFD	yes	Ord. No N-4/14.09.2012; MSFD Art. 11 monitoring program; http://www.bsbd.org/bg/msfd_monitoring.html
		BOD-5, summer (mg.l-1)	no	WFD; MSFD	yes	Ord. No N-4/14.09.2012; MSFD Art. 11 monitoring program; http://www.bsbd.org/bg/msfd_monitoring.html
	Water column heterogeneity	O2 concentration, summer (mg.l-1)	no	WFD; MSFD	yes	Ord. No N-4/14.09.2012; MSFD Art. 11 monitoring program; http://www.bsbd.org/bg/msfd_monitoring.html
	bottom heterogenity	02 saturation summer (%)	no	WFD; MSFD	yes	Ord. NoN-4/14.09.2012; MSFD Art. 11 monitoring program; http://www.bsbd.org/bg/msfd_monitoring.html
	matter storage	phytoplankton biomass (EQR)	no	WFD; MSFD	yes	Ord. No N-4/14.09.2012; MSFD Art. 11 monitoring program; http://www.bsbd.org/bg/msfd_monitoring.html
		Chloropyl A (EQR)	no	WFD; MSFD	yes	Ord. No N-4/14.09.2012; MSFD Art. 11 monitoring program; http://www.bsbd.org/bg/msfd_monitoring.html
					*http://www.bgodc.io-bas.bg/Monitoring-%D0%9C%D0%9E%D0%A1%D0%92	

4.9.1.2. Periodical monitoring

The frequency of the conducted monitoring according to the time periods outlined in Annex 6 and Annex 7 to the Methodology. Most of the parameters related to the condition of the marine ecosystems are measured annually in the appropriate season determined for each of these parameters (e.g. summer for nutrient concentrations). The monitoring programs should be carried out by the responsible national authorities (Ministry of Environment and Waters) in accordance with the accepted national monitoring programs for the Water Framework Directive (Ord. No N -4/14.09.2012) and the Article 11 MSFD Monitoring program guidelines (http://www.bsbd.org/bg/msfd_monitoring.html).

Results from recent monitoring activities in the coastal zone of the Black Sea are available in the annual reports published by the Basin Directorates and available in the IO-BAS online database : http://www.bgodc.io-bas.bg/Monitoring-%D0%9C%D0%9E%D0%A1%D0%92

Table 29. Periods of Marine monitoring

Type	Indicator	Parameter (dimension)	Monitoring stations	Frequency	Methods Reference Link
Periodical	plant diversity	Phytoplankton numbers in summer (cell/l)	acc. to Ord. No N-4/14.09.2012; MSFD Art. 11 monitoring program		Ord. No N-4/14.09.2012; MSFD Art. 11 monitoring program; http://www.bsbd.org/bg/msfd_monitoring.html
		Macroalgae and Angiosperms EEI-C (EQR)	acc. to Ord. No N-4/14.09.2012; MSFD Art. 11 monitoring program	yearly , in summer	Ord. No N-4/14.09.2012; MSFD Art. 11 monitoring program; http://www.bsbd.org/bg/msfd_monitoring.html
		Macrozoobenthos M-AMBI index (EQR)	acc. to Ord. No N-4/14.09.2012; MSFD Art. 11 monitoring program	yearly , in summer	Ord. No N-4/14.09.2012; MSFD Art. 11 monitoring program; http://www.bsbd.org/bg/msfd_monitoring.html
	Water column heterogeneity	Water Transparency (meter)	acc. to Ord. No N-4/14.09.2012; MSFD Art. 11 monitoring program	once a month, between April and September	Ord. No N-4/14.09.2012; MSFD Art. 11 monitoring program; http://www.bsbd.org/bg/msfd_monitoring.html
		TRIX index (Index units)	acc. to Ord. No N-4/14.09.2012; MSFD Art. 11 monitoring program	once a month, between April and September	Ord. No N-4/14.09.2012; MSFD Art. 11 monitoring program; http://www.bsbd.org/bg/msfd_monitoring.html
		P-PO4, summer (mg.l-1)	acc. to Ord. No N-4/14.09.2012; MSFD Art. 11 monitoring program	once a month, between April and September	Ord. No N-4/14.09.2012; MSFD Art. 11 monitoring program; http://www.bsbd.org/bg/msfd_monitoring.html
		N-NH4, summer (mg.l-1)	acc. to Ord. No N-4/14.09.2012; MSFD Art. 11 monitoring program	once a month, between April and September	Ord. No N-4/14.09.2012; MSFD Art. 11 monitoring program; http://www.bsbd.org/bg/msfd_monitoring.html

		N-NO3, summer (mg.l-1)	acc. to Ord. No N-4/14.09.2012; MSFD Art. 11 monitoring program	once a month, between April and September	Ord. No N-4/14.09.2012; MSFD Art. 11 monitoring program; http://www.bsbd.org/bg/msfd_monitoring.html
		N-NO2, summer (mg.l-1)	acc. to Ord. NoN-4/14.09.2012; MSFD Art. 11 monitoring program	once a month, between April and September	Ord. NoN-4/14.09.2012; MSFD Art. 11 monitoring program; http://www.bsbd.org/bg/msfd_monitoring.html
		BOD-5, summer (mg.l-1)	acc. to Ord. No N-4/14.09.2012; MSFD Art. 11 monitoring program	once a month, between April and September	Ord. No N-4/14.09.2012; MSFD Art. 11 monitoring program; http://www.bsbd.org/bg/msfd_monitoring.html
	Water column heterogeneity	O2 concentration, summer (mg.l-1)	acc. to Ord. No N-4/14.09.2012; MSFD Art. 11 monitoring program	once a month, between April and September	Ord. No N-4/14.09.2012; MSFD Art. 11 monitoring program; http://www.bsbd.org/bg/msfd_monitoring.html
	bottom heterogenity	02 saturation summer (%)	acc. to Ord. No N-4/14.09.2012; MSFD Art. 11 monitoring program	once a month, between April and September	Ord. No N-4/14.09.2012; MSFD Art. 11 monitoring program; http://www.bsbd.org/bg/msfd_monitoring.html
	matter storage	phytoplankton biomass (EQR)	acc. to Ord. No N-4/14.09.2012; MSFD Art. 11 monitoring program	once a month, between April and September	Ord. No N-4/14.09.2012; MSFD Art. 11 monitoring program; http://www.bsbd.org/bg/msfd_monitoring.html
		Chloropyl A (EQR)	acc. to Ord. No N-4/14.09.2012; MSFD Art. 11 monitoring program	once a month, between April and September	Ord. No N-4/14.09.2012; MSFD Art. 11 monitoring program; http://www.bsbd.org/bg/msfd_monitoring.html

4.9.1.3. Permanent monitoring

Due to the specific nature of the ecosystems that are being monitored in the marine environment, no permanent and continuous monitoring of any of the ES contidion is possible.

4.9.1.4. Extraordinary monitoring

In case of *force majeoure* phenomena, disasters and other unforseen circumstances leading to significant disturbances of the marine ecosystems conditions and the provided ecosystem services, certain elements of the monitoring programs can be carried out in order to evaluate the impacts of these events. These monitoring activities should be planned in accordance with the monitoring guidelines and carried out by qualified and authorized authorities and scientific organizations.

4.9.2. Criteria for selection of monitoring areas

The monitoring of the ES condition in the Black Sea coastal zone water bodies should be carried out in the permanent monitoring stations for each of the biological quality elements and chemical elements that are included in the list of parameters of this Methodology. 37 monitoring stations cover all 16 water bodies and take into consideration the spatial extend of the main impacts in the coastal marine environment. The network includes stations in areas in good environmental status that can serve as reference (Cape Maslen Nos area), as well as areas under severe anthropogenic stress with degraded ecosystems condition (Varna Bay, Burgas Bay).

The monitoring of the ES condition of ecosystems in the shelf zone and open seas zone should use the network of monitoring stations developed in the MSFD Art. 11 monitoring program. The network consists of 17 stations in the shelf area and 9 stations in the open seas where parameters linked with the condition of the pelagial are monitored mainly.

4.9.3. Analysis of Drivers-Pressures-State-Impact-Response (DPSIR) in Marine ecosystems

The DPSIR framework is the logical framework in which the MSFD monitoring program is developed, calibrated and implemented. This monitoring program is nationally accepted and is directly applicable for the purposes of the current Methodology.

4.9.3.1. Main tendencies that affect Marine ecosystems and their services and that should be traced over time

The drivers of changes in the marine environment can be biological or physical processes, as well as the release of substances, litter and energy. These drivers can be described by a number of anthropogenic pressures, including physical disturbance of animals, extraction and killing of wild species, physical destruction and loss of benthic species and habitats, release of nutrients and harmful substances from diffuse and point land sources, release of marine litter, release of nutrients, introduction of anthropogenic noise and other forms of energy. The impacts from these diverse pressures and resulting changes in the state of the elements of the marine ecosystems are described in details in the MSFD Initial Assessment report (BSBD, 2013), subdivided in eleven descriptors of the ecosystems state. The evaluation of the ecological state, equivalent to the ecosystems' 'ecological condition', serves as a basis for the monitoring programs that are elaborated in the MSFD Art. 11 Monitoring program documents and which should be used in the current monitoring methodology.

5. Use of monitoring information by policymakers and stakeholders

As was observed above, the environmental monitoring in Bulgaria is currently limited to ecosystem components and not ecosystem services; it is, further, decentralized and in some cases there is a potential of incoherency and even controversy in the objectives between single agencies in charge of implementing different policies in the same ecosystem.

A transition from ecosystem components monitoring to a holistic ecosystem monitoring is necessary in order to provide a number of benefits of scale:

1. Economy of funds by optimizing the monitoring. Fieldwork can be planned so as to achieve more results with each mission if together with species or habitats monitoring, data on ecosystem levels is also being collected.
2. Better information for policymakers (all relevant authorities, in a uniform manner), as well as a wider circle of stakeholders, about:
   - 2.1. **The ecosystem monitoring and reporting to EU authorities**. This benefit would support both the increased quality of reporting by providing coherent data across policies, and from reduced administrative costs to report due to eliminating reporting redundancy between authorities.
   - 2.2. **Informed and argumentative dispute handling**. An improved ecosystems monitoring could support both the work of authorities in forming the national position on proposed EU legislation, and the arguments on the overall environmental impact in infringement cases against Bulgaria on the breach of regulations in single environmental policies
   - 2.3. **Possible co-benefits for business from the use of ecosystem services**. Evolving new technologies with an enhanced use of ecosystem services could be used to reduce both initial investments and maintenance costs for key urban infrastructure such as water purification, sewerage processing, waste, flood and erosion protection infrastructure.
   - 2.4. **The likely consequences of trade-offs**. This would support participative decision-making, from local and regional to national scales, in cases where a course of action in terms of land and resource use may lead to significant negative externalities for humans and the environment. Providing systematic, accessible and increasingly reliable information based on predictive modeling would allow a better informed societal discussion on natural resource management. In turn, the better informed discussion could streamline the decision-making process in cases such as the adoption of environmental impact assessment or management plans (often the subject of prolonged appeal procedures).
   - 2.5. **The likely consequences and efficiently of ecological spending**. For example, better information about the ecosystems effect of environmental subsidies could support the channeling of Common Agricultural Policy green subsidies to achieve the best effect for restoring ecosystems and therefore reaching conservation objectives and ecosystems restoration in a more cost effective manner

3. **Timely information of policymakers**. Currently, management plans and provisions are made for a mid- to long-term horizon, and typically are only reviewed every 10 years. This leaves policymakers with a lack of day-to-day information and consequently less prepared in cases of emergency when the lack of continuous data from continuous monitoring becomes especially apparent. Continuous observation and accurate short-term prediction not just of single ecosystem responses (such as deforestation, degradation, etc.) could support a more accurate short to mid-term time prediction of disaster and force-majeure situations caused by ecosystems degradation, and improve emergency preparedness.

To achieve these objectives, a national, semi-centralized data management and sharing infrastructure is indispensable. Its architecture could be provided by various players in the manner depicted in Figure 2.

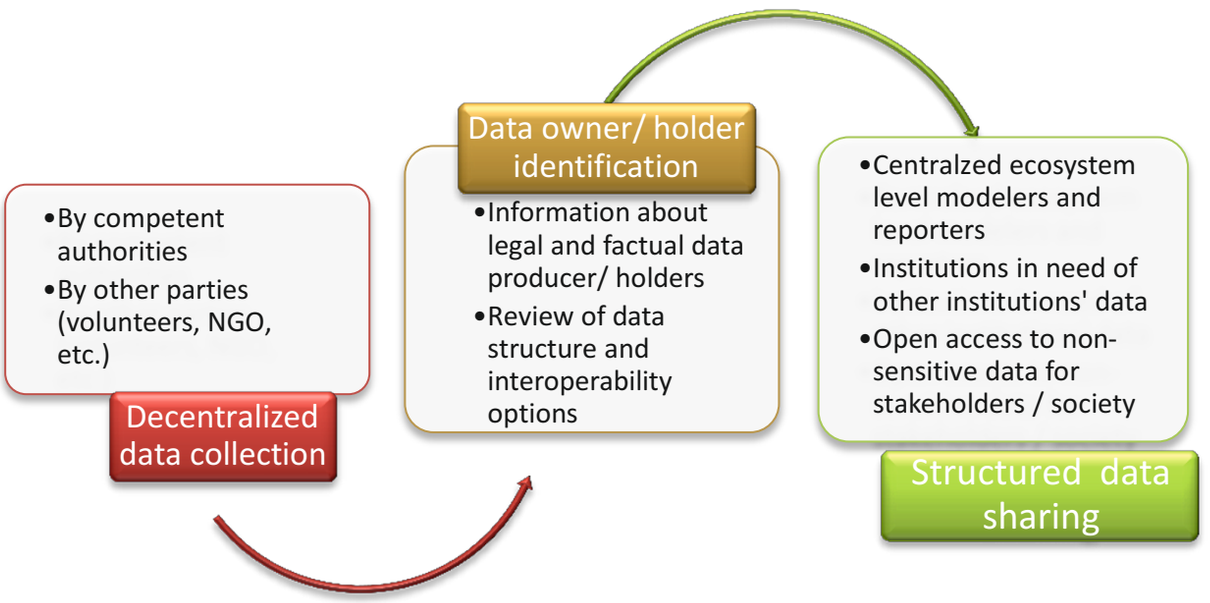


Figure 10. Structure of data collection, processing and exchange for ecosystem monitoring

The creation of such infrastructure is already underway due to the increasingly interlinked EU policies and the reporting needs they create. It is in Bulgaria's best interest to not merely "comply with EU legislation" but to make this process its own in order to analyze the processes in the socio-ecological system in our country and to develop the suitable policy for sustainable development.

6. Inputs to the Natural Capital Accounting

According to the definition given by (European Environment Agency, 2016), "Natural Capital Accounting" (NCA) is a tool to measure the changes in the stock and condition of natural capital at a variety of scales and to integrate the value of ecosystem services into accounting and reporting systems. From NCA one can develop macro indicators that provide relevant environment-related information alongside GDP and employment. NCA would mainstream biodiversity and ecosystems in economic decision-making and ensure that natural capital continues delivering ecosystem services to our economy and society in the long term. Overall, it should contribute to the better management of the Union's natural capital and achievement of sustainable development of the society,

To achieve this objective, the EEA proposes that a shared pool of ecosystem reference data is built to inform on ecosystem accounts, ecosystem assessment and policy evaluation. The basis of such pool of reference data is comprised by EU level data sources such as Copernicus, CORINE Landcover data, LUCAS, ESTAT, Sentinel 2 data collections, as well as biodiversity, species and ecosystems data (MAES).

The EU Ecosystems accounts can be compiled with or without the active participation of Member states. However, maintaining a national Member state data collection and sharing information as described in the previous chapter and depicted in Figure 2, will be able to support some important national and regional processes between Member state's policymakers, stakeholders and population at large, for example:

1. A better understanding of Bulgaria's natural capital and its outflows will provide for better arguments in international negotiations for securing funding to maintain this capital and the appropriate ecosystem service provision

2. Having more detailed and well researched data about ecosystems capital will allow to match the national level stocks and flows to single owners' accounting so as to provide for a smooth transition to national ecosystem accounting with a minimum of bureaucracy and red tape, especially for small and medium sized businesses.

To achieve these co-benefits of the timely creation of Bulgaria's Natural capital accounts, a pro-active position is needed for understanding both the ecosystem services' benefits (discussed in the previous chapter) and the possible losses from biodiversity loss. In this context, the development of full-fledged and coherent DPSIR indicators is necessary to inform on the role of different drivers and pressures on ecosystems, the potential loss of wealth and other societal losses in case of ecosystems' deterioration, and the distribution of losses between persons and organizations. The DPSIR framework is flexible and depends on the objects to be addressed. In some cases, pressures in the context of a specific ecosystem assessment, e.g. terrestrial, might be considered as a condition in a different context, e.g. freshwater, or vice versa.

In any case, the contextual linkages should be visible and the DPSIR framework should help to put these linkages in the right place. In many cases, knowledge and data availability may determine which element of the DPSIR framework is used to describe the impacts to be investigated. Finally, the impact as the target of the assessment (in our case, the impacts of environmental change on biodiversity) triggers the overall design of the assessment. (*Turner* et al., 2010,).

These socio-economic relations within and outside Bulgaria in the dual contexts of NCA and human habitation as part of the nature, are represented schematically in Figure 3. Tipping the balance in any direction at the expense of the other would lead the country away from the win-win situation of optimal and sustainable use of ecosystems services.

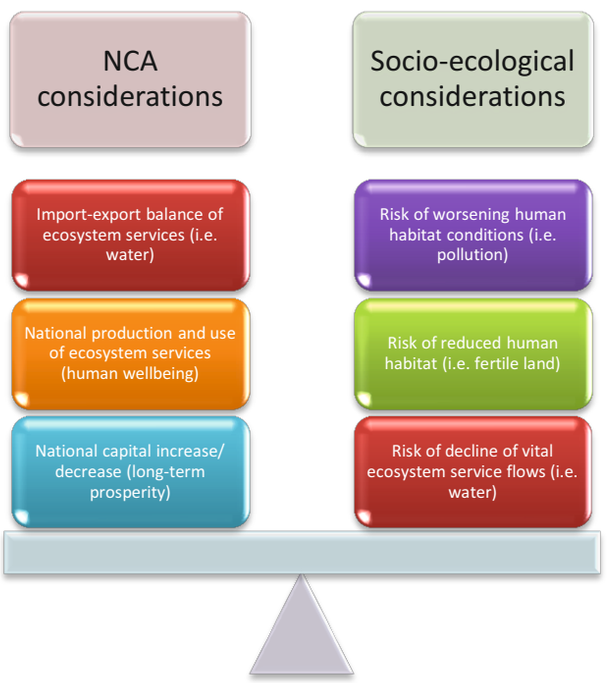


Figure 11. Considerations related to socio-ecological balance and NCA's contribution to that balance

While no national ecosystems accounts are yet set up in Bulgaria, it can be foreseen that their structure will have to be compatible with the EU Methodology for ecosystem accounting based on SEEA EEA that is likely to emerge in the coming years in compliance with the EU Biodiversity Strategy to 2020. Therefore, any national NCA effort must ensure compatibility with any common valuation and quality assurance methods.

It is the task of ecosystems based monitoring to go beyond the purely ecosystems based considerations and provide data and models that allow for the transition to NCA.

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ЗАПОВЕД РД-210/20.04.2016 г. за утвърждаване на Националната система за мониторинг на състоянието на биологичното разнообразие (НСМСБР) и Практическо ръководство, съдържащо методики за мониторинг и методики за оценка на обектите от НСМСБР.

НАРЕДБА № 1 от 11.04.2011 г. за мониторинг на водите. *обн. ДВ, бр. 34 от 29.04.2011 г., в сила от 29.04.2011 г.*