PART A

Conceptual basis and principles of application

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

CONCEPTUAL BASIS AND PRINCIPLES OF APPLICATION

PART A

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1. Background

1.1. Why is it necessary to map and assess the ecosystems and their services

Human well-being depends on nature and its resources, which provide vital services including fertile soil, fresh water, pollination, natural flood protection and climate regulation. However, the ecosystems, habitats and species that form the natural capital providing these services are being degraded or lost as a result of human activity (Newbold, et al., 2015). There is therefore an urgent need to protect and enhance this natural capital, as recognised in the European Union's (EU's) Seventh Environmental Action Programme, which sets out the priorities for environmental policy until 2020 and includes an outlook up to 2050 (European Commission, 2014). For a number of years, the management of biodiversity was mostly directed towards assessing qualities in a more or less mechanical manner, for example by measuring the richness of species or groups of species (habitats). An ecosystem is more than the mechanical sum of its parts – it is a complex system of non-living (abiotic) and living (biotic) components. Its flora and fauna develop and change, in some cases negatively, due to changes of specific climatic, hydrologic and/or soil conditions, interactions between species, or human influence.

Biodiversity can be used as a tool for assessing the “health” of an ecosystem, but it is not sufficient to determine the state of the whole ecosystem. There is a variety of other important ecosystem parameters that can be monitored to detect changes in the natural environment, to detect and monitor pollution and its effects on the ecosystem; to monitor the progress of environmental clean-up, to test drinking water for the presence of contaminants, and other ecosystem trends (details can be found in Parts B and D of the Methodological framework).

Ecosystems provide services which are essential to human development and economic activity. Apart from the flow of commodities such as crop, timber, etc., ecosystems provide a wide range of less tangible services, such as pollination, erosion protection, waste absorption, carbon sequestration, and even aesthetic, cultural and scientific interactions. These services are not fully included in accounting systems and statistics, and are often underestimated in the traditional economic activities. This often leads to managerial decisions and social choices that promote unsustainable use of the ecosystems and cause their degradation. Changes in land use, urbanization, industrialization, and excessive exploitation of natural resources, population growth and other factors have led to the overuse and depletion of ecosystems. These trends are being exacerbated by an imprecise definition of ownership rights over the ecosystem services and a lack of markets for some of these services. The assessment of ecosystem services is an innovative way to tackle these problems and complements the current range of instruments used for nature conservation. Therefore, the ecosystems and ecosystem services mapping and valuation are in a position to inform decision making in a number of related policies, such as water and agricultural instruments, spatial planning, cohesion policy, the planning for development and maintenance of green infrastructure, etc. As shown by the experience of mapping and assessment projects with detailed pilots, the same ecosystem type can be used very differently in different places and contexts, and be subject to different pressures. Spatially explicit mapping and assessment is therefore needed to understand to what extent and where these processes take place.

1.2. EU and national policy

Recognizing the need of a holistic approach and the shift towards ecosystem level assessment, mapping, monitoring and reporting on ecosystem level, the European Biodiversity Strategy to 2020 (European Commission, 2011) in its **Target 2, Action 5** (*Improve knowledge of ecosystems and their services in the EU)*, requires the EU member states to map and assess the state of ecosystems and ecosystem services in their national territories by 2014, as well as to assess the economic value of the ecosystem services and integrate these values into accounting and reporting systems on EU and national level by 2020. To support this work, the Mapping and Assessment of Ecosystem services (MAES) working group of the EU developed guidance documents – an analytical framework (Maes, et al., 2013) and indicators (Maes, et al., 2016) for ecosystem assessments. These documents are mainly focused on biophysical valuation of ecosystem services since the work on their monetary valuation and inclusion into national accounts is still underway. The concept and goals of environmental accounting have been discussed for over two decades at international level, and even earlier in academic circles. The first global environmental-economic accounting standards (SEEA) were published by the United Nations Statistics Commission (UNSC) already in 1993 and revised in 2012/13. Natural capital accounting is also reflected in the 2012 Aichi targets under the global Convention on Biological Diversity (CBD). Global goals of environmental accounting are also integrated into EU legislation (notably Regulation 691/2011 which introduced three modules into EU accounting systems: air emission accounts, accounts on environmental taxes and material flow accounts).

In Bulgaria, a number of local pilot projects including ecosystem services were selected under several funding programmes and performed or underway in different regions[1]. These projects focused on single important natural ecosystems such as the Srebarna Lake – a UNESCO wetland site of rich biodiversity, as well as more or less limited scope of key ecosystem services and pilot PES schemes based on these services. On a national scale, the initial mapping and ecosystem assessment was performed in 2013 in the framework of the development of the national Prioritized Action Framework (PAF) (Ministry of Environment and Water, 2013). It was the first national scale exercise that highlighted the difficulties in scaling from local to national assessment, and including the entire range of ecosystem services rather than some of them, in particular with regard to services that are not traded and often remain underappreciated. Not surprisingly, the

[1] Such projects include: General ecosystems related projects: EnvEurope, www.enveurope.eu, projects on promoting assessment and payment for ecosystem services: Operational Potential of Ecosystems Research Applications (OPERAs), Promoting Payments for Ecosystem Services and Related Sustainable Financing Schemes in the Danube Basin, Linking nature protection with sustainable rural development.

report outlining the work under PAF identified a need for validation of the resulting map due to missing timelines for many data types, as well as inconsistencies between databases of different institutions, non-geolocated data and a number of other data related obstacles preventing mapping as a mainly cameral exercise. The active development of national methodologies for ecosystem services assessment and biophysical valuation was also not possible at that stage due to the ongoing work on EU level on the methodological foundations.

Significant decisions on the scope of further mapping and assessment work building on the PAF results had to be linked to the available funding and limitations it imposed. Since EU funding is not made available outside NATURA 2000 with favourable ratio of grant to own contribution of project promoters, the mapping and assessment had to identify other funding sources. It ultimately was divided between the OP Environment 2013-2020 for mapping inside NATURA 2000, and programme ***BG03 Biodiversity and ecosystem services***, supported financially by the European Economic Area Financial Mechanism (EEA FM) for mapping outside NATURA 2000. Differences in timing when different funding sources became available and the intervals of their availability also played a role in deciding the sequence of steps in developing the methodological foundation and performing the mapping and assessment. As a result, the first phase of preparing the National Methodological Framework (NMF) was limited to the following:

- To create a methodology of mapping and biophysical assessment, in line with MAES work on Conceptual Framework and Indicators for biophysical mapping and assessment
- To perform actual mapping and biophysical assessment of the nine ecosystem types in Bulgaria on the territory outside NATURA 2000 network.

The NMF aims at providing a synthesis between this past and ongoing work with respect to the mapping, assessment, in situ verification and monitoring of Cropland, Grassland, Heathland and shrubs, Sparsely vegetated land, Wetlands, Rivers and lakes, Marine, Woodland and forests, and Urban ecosystems in Bulgaria and their respective services. It also gives an outlook to the next steps to be undertaken in order to set up ecosystems based monitoring conceptually which would be linked to the Natural Capital Accounting and provide appropriate inputs to enterprise and national accounts.

2. Using an Ecosystem approach

This section is devoted to shortly explaining the holistic approach which lies at the basis of the NMF. It informs on definitions and main principles and elaborates on their rationale and mutual connection.

2.1. What is an ecosystems approach?

The Ecosystem Approach is a relatively new paradigm for biodiversity conservation and management as it links biodiversity conservation and restoration to wider delivery of benefits e.g. food, drinking water, sense of place etc. at a landscape scale (Box 1). It has the potential to reframe how we think about natural resources management and the complexity and the interdependences in our environment.

The shift towards an ecosystems approach was internationally acknowledged as part of the Convention on Biological diversity (CBD). The Convention introduces ecosystems as part of the definition of biodiversity (Art. 2) and obliges the parties to protect, rehabilitate, and restore them (Art. 8). Annex 1 to the CBD introduces also the notion of ecosystems monitoring as obligation of the parties. Other international initiatives (such as TEEB, 2010), the WAVES partnership (The World Bank, 2010) and many others) were started in parallel, attempting, among others, at a classification of ecosystem services.

The CBD defines the ecosystem approach as "*… a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. …An ecosystem approach is based on the application of appropriate scientific methodologies focused on levels of biological organization, which encompass the essential structure, processes, functions and interactions among organisms and their environment*" (COP 5 Decision V/6).

Box 1. Definition of the ecosystems approach

The Ecosystem Approach is a holistic, system-based, and participatory approach to ecosystem management, as defined and used by the Convention of Biological Diversity (CBD). The CBD provides 12 principles (the 'Malawi Principles') as a guide to implementation.

The Malawi Principles:

Principle 1: The objectives of management of land, water and living resources are a matter of societal choices.

Different sectors of society view ecosystems in terms of their own economic, cultural and society needs. Indigenous peoples and other local communities living on the land are important stakeholders and their rights and interests should be recognized. Both cultural and biological diversity are central components of the ecosystem approach, and management should take this into account. Societal choices should be expressed as clearly as possible. Ecosystems should be managed for their intrinsic values and for the tangible or intangible benefits for humans, in a fair and equitable way.

Principle 2: Management should be decentralized to the lowest appropriate level. Decentralized systems may lead to greater efficiency, effectiveness and equity. Management should involve all stakeholders and balance local interests with the wider public interest. The closer management is to the ecosystem, the greater the responsibility, ownership, accountability, participation, and use of local knowledge.

Principle 3: Ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems.
Management interventions in ecosystems often have unknown or unpredictable effects on other ecosystems; therefore, possible impacts need careful consideration and analysis. This may require new arrangements or ways of organization for institutions involved in decision-making to make, if necessary, appropriate compromises.

Principle 4: Recognizing potential gains from management, there is usually a need to understand and manage the ecosystem in an economic context.

Any such ecosystem-management programme should:
1. Reduce those market distortions that adversely affect biological diversity;
2. Align incentives to promote biodiversity conservation and sustainable use;
3. Internalize costs and benefits in the given ecosystem to the extent feasible.

The greatest threat to biological diversity lies in its replacement by alternative systems of land use. This often arises through market distortions, which undervalue natural systems and populations and provide perverse incentives and subsidies to favour the conversion of land to less diverse systems. Often those who benefit from conservation do not pay the costs associated with conservation and, similarly, those who generate environmental costs (e.g. pollution) escape responsibility. Alignment of incentives allows those who control the resource to benefit and ensures that those who generate environmental costs will pay.

Principle 5: Conservation of ecosystem structure and functioning, in order to maintain ecosystem services, should be a priority target of the ecosystem approach.

Ecosystem functioning and resilience depends on a dynamic relationship within species, among species and between species and their abiotic environment, as well as the physical and chemical interactions within the environment. The conservation and, where appropriate, restoration of these interactions and processes is of greater significance for the long-term maintenance of biological diversity than simply protection of species.

Principle 6: Ecosystem must be managed within the limits of their functioning.

In considering the likelihood or ease of attaining the management objectives, attention should be given to the environmental conditions that limit natural productivity, ecosystem structure, functioning and diversity. The limits to ecosystem functioning may be affected to different degrees by temporary, unpredictable of artificially maintained conditions and, accordingly, management should be appropriately cautious.

Principle 7: The ecosystem approach should be undertaken at the appropriate spatial and temporal scales.

The approach should be bounded by spatial and temporal scales that are appropriate to the objectives. Boundaries for management will be defined operationally by users, managers, scientists and indigenous and local peoples. Connectivity between areas should be promoted where necessary. The ecosystem approach is based upon the hierarchical nature of biological diversity characterized by the interaction and integration of genes, species and ecosystems.

Principle 8: Recognizing the varying temporal scales and lag-effects that characterize ecosystem processes, objectives for ecosystem management should be set for the long term.

Ecosystem processes are characterized by varying temporal scales and lag-effects. This inherently conflicts with the tendency of humans to favour short-term gains and immediate benefits over future ones.

Principle 9: Management must recognize the change is inevitable.

Ecosystems change, including species composition and population abundance. Hence, management should adapt to the changes. Apart from their inherent dynamics of change, ecosystems are beset by a complex of uncertainties and potential "surprises" in the human, biological and environmental realms. Traditional disturbance regimes may be important for ecosystem structure and functioning, and may need to be maintained or restored. The ecosystem approach must utilize adaptive management in order to anticipate and cater for such changes and events and should be cautious in making any decision that may foreclose options, but, at the same time, consider mitigating actions to cope with long-term changes such as climate change.

Principle 10: The ecosystem approach should seek the appropriate balance between, and integration of, conservation and use of biological diversity.

Biological diversity is critical both for its intrinsic value and because of the key role it plays in providing the ecosystem and other services upon which we all ultimately depend. There has been a tendency in the past to manage components of biological diversity either as protected or non-protected. There is a need for a shift to more flexible situations, where conservation and use are seen in context and the full range of measures is applied in a continuum from strictly protected to human-made ecosystems.

Principle 11: The ecosystem approach should consider all forms of relevant information, including scientific and indigenous and local knowledge, innovations and practices.

Information from all sources is critical to arriving at effective ecosystem management strategies. A much better knowledge of ecosystem functions and the impact of human use is desirable. All relevant information from any concerned area should be shared with all stakeholders and actors, taking into account, inter alia, any decision to be taken under Article 8(j) of the Convention on Biological Diversity. Assumptions behind proposed management decisions should be made explicit and checked against available knowledge and views of stakeholders.

Principle 12: The ecosystem approach should involve all relevant sectors of society and scientific disciplines.

Most problems of biological-diversity management are complex, with many interactions, side-effects and implications, and therefore should involve the necessary expertise and stakeholders at the local, national, regional and international level, as appropriate.

(Convention on Biological Diversity, 1995-2017)

The Ecosystem Approach links 'adaptive management' based on understanding ecosystem functions and processes, with arguments for decentralization, stakeholder participation and empowerment in decision-making. The aim of an ecosystem approach is to protect biodiversity, whilst ensuring sustainable resource use and equitable distribution of the benefits arising. The National methodological framework is based on the understanding that ecosystem services are the parts of ecosystem functions used by humans. Therefore, ecosystem services assessment must also be seen in the frame of the ecosystem approach. Should the ecosystem condition and ecosystem service concepts be detached from each other (i.e. due to segmentation of tasks among multidisciplinary teams), there's a significant risk that such assessment focuses on identifying and quantifying ecosystem services, resulting in a technical and systematic analysis of services, rather than the holistic and participatory ethos of an ecosystem approach. At the same time these services depend on the complex state of the ecosystem as a whole and the ethos of an ecosystem approach is to be used in decision making based on evidence derived from ecosystem service assessment.

It is important to bear in mind that the ecosystem approach requires the planning and decision making processes to consider complex environmental systems and how they change over time and in different settings.

2.2. What is Adaptive Management?

Adaptive Management is used in cases where insecurity is known to exist (Holling, 1996) and expected to interfere with any firm management plan. Therefore, instead of setting up a rigid sequence of steps to be followed, it prescribes a process wherein management actions can be changed in response to observed changes in the monitored system, so as to maximize restoration efficacy or achieve a desired ecological state.

The basic steps include:

1. **Plan**: Defining the desired goals and objectives, evaluating alternative actions and selecting a preferred strategy with recognition of sources of uncertainty;
2. **Design**: Identifying or designing a flexible management action to address the challenge;
3. **Implement**: Implementing the selected action according to its design;
4. **Monitor**: Monitoring the results or outcomes of the management action;
5. **Evaluate**: Evaluating the system response in relation to specified goals and objectives;
6. **Adjust**: Adjusting (adapting) the action if necessary to achieve the stated goals and objectives.

3. Introduction to ecosystems and ecosystem services

3.1. Ecosystem

An ecosystem is a 'dynamic complex of plant, animal and microorganism communities and their non-living environment interacting as a functional unit' (Convention on Biological Diversity, 1992-2017) (Box 2). Ecosystems can be of any size, from a single drop of water to the entire planet. Ecosystems can be of any size and even defined differently by different observers in terms of size, borders, composition, subsystems, etc. In this Framework, mapping and assessment refers to national and the European scale, which is based on broad land cover types such as 'woodland and forest'.

The concept of ecosystem services has great potential in adding value to current conservation approaches, in particular the maintenance and restoration of ecosystems enhancing their conservation status which is the primary objective of the nature directives.

As noted by Burkhard et al. (2012), „The longer the conceptual orientation phase of the ecosystem service approach has been lasting, the more obvious become the needs for practical applications of the concept." These applications are necessary in order to improve the concept and make it an acknowledged tool for natural resource management.

Box 2. Definition of ecosystem and biodiversity

Ecosystem: An ecosystem is usually defined as a complex of living organisms with their (abiotic) environment and their mutual relations. This definition applies to all hierarchical levels (from a single water drop with its microorganisms to Earth's biomes). Ecosystems are shaped by the interaction of communities of living organisms with the abiotic environment.

Ecosystems within each ecosystem type share a suite of biological, climatic, and social factors that tend to differ across categories. More specifically, there generally is greater similarity within than between each ecosystem type in: climatic conditions; geophysical conditions; dominant use by humans; surface cover (based on type of vegetative cover in terrestrial ecosystems or on fresh water, brackish water, or salt water in aquatic ecosystems); species composition; resource management systems and institutions.

Biodiversity - the variety of all life on earth - plays a key role in the structural set-up of ecosystems which is essential to maintaining basic ecosystem processes and supporting ecosystem functions. Ecosystem functions are defined as the capacity or the potential to deliver ecosystem services. People benefit from ecosystem (goods and) services. The governance of the coupled socio-economic-ecological system is an integral part of the framework: Institutions, stakeholders and users of ecosystem services affect ecosystems through direct or indirect drivers of change. Policies concerning natural resource management aim to affect drivers of change to achieve a desired future state of ecosystems.

3.2. Ecosystem condition (state)

The EU wide assessment of the condition of the various ecosystem types requires information about drivers, mainly land/sea use and management, and pressures such as land-take, fragmentation, pollution, and climate change as well as their impacts on the structure and function of each ecosystem type (Maes, et al., 2013), (Maes, et al., 2016)). It should make use of existing data, mainly the reported data under EU legislation and, in particular, from assessments under Art.

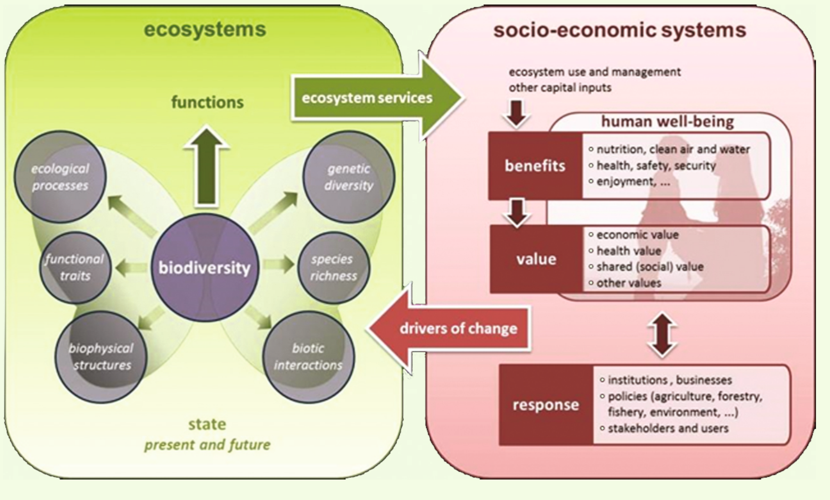
17 of the Habitats Directive and Art. 12 of the Birds Directive, the Water Framework Directive (2000/60/EEC), the Marine Strategy Framework Directive (2008/56/EEC) and other environmental legislation. For ecosystems without legislative reporting framework, such as forests, either national data or European monitoring data, e.g. from the European Forest Data Centre (EFDAC) 9 or the Copernicus program can be used. To complete and refine the ecosystem assessment, additional information indicating habitat connectivity or other functionalities as well as information on drivers and pressures reducing the capacity of ecosystems to provide services is needed and must be integrated in the assessment (Box 3). Again, national and sub-national data sources need to be used to provide more detailed and additional information to describe the variability of ecosystem condition across Europe.

Box 3. The concept of ecosystem state (condition)

Here the term 'condition' is used instead of 'state' to avoid confusion with the term 'status' (Maes, et al., 2016), which describes the legal aspects such as protection of ecosystems under Natura 2000, Water Framework Directive or Marine Strategy Framework Directive.

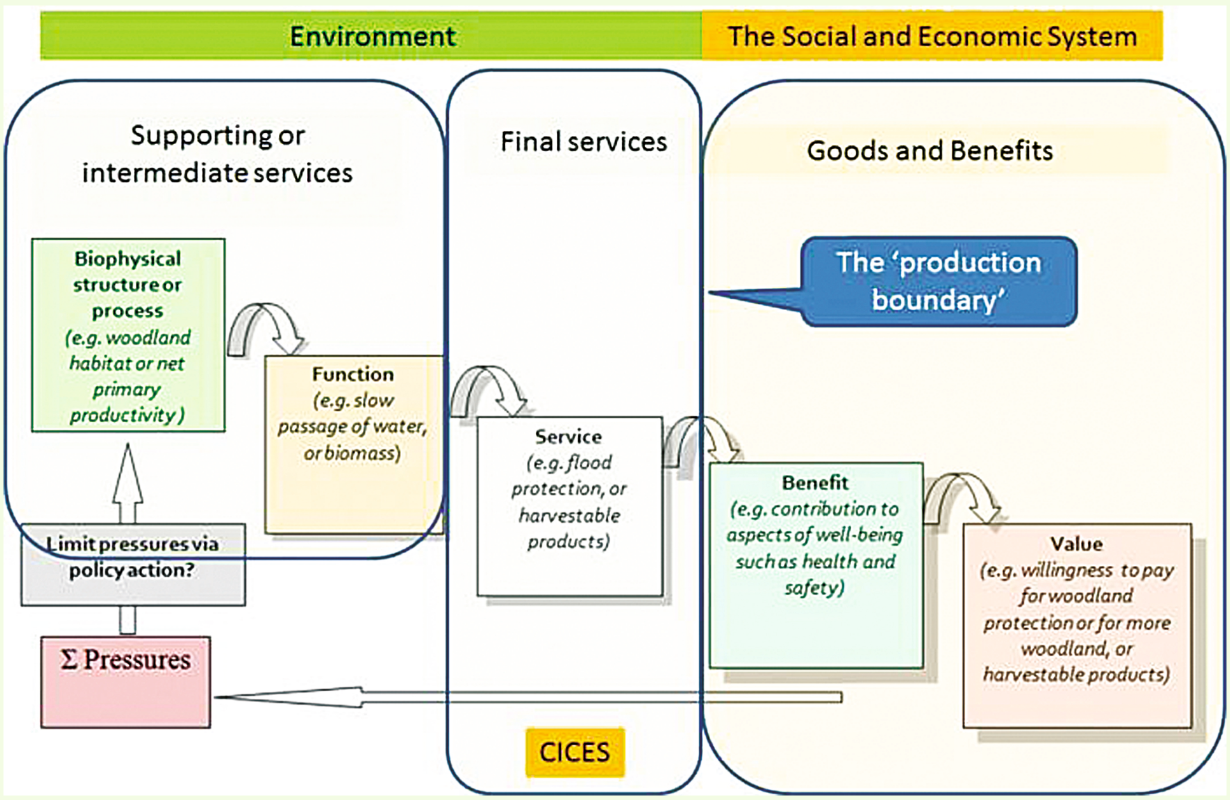
Ecosystem condition: The physical, chemical and biological condition of an ecosystem at a particular point in time. Healthy ecosystems (in good status) possess the full potential of ecosystem functions and ecosystem services delivery.

The capacity of an ecosystem to deliver different ecosystem services is related to the condition of this ecosystem. In a "healthy state", an ecosystem may provide more and a sustained flow of a variety of services compared to an ecosystem, which is managed to provide only a maximum amount of one specific service, e.g. fish, crops or timber. As a result, the overall capacity of such a system to provide services will be higher. Ecosystems in a "healthy state" are considered resilient systems, which are able to recover after disturbance and they are generally characterized by higher species diversity and a balanced trophic community (Müller et al., 2009; Müller & Burkhard, 2010). A socio-ecological system is represented in the picture:



Biodiversity has multiple roles supporting the delivery of ecosystem services and assessment the status of ecosystems. Connecting biodiversity to ecosystem state but also to particular ecosystem functions and ecosystem services entails thus defining multivariate combinations of these different dimensions of biodiversity and using them for mapping and assessment. (Maes et al., 2013; Maes et al., 2016)).

Provision of ecosystem services is the part of the ecosystems' functioning that is relevant to human wellbeing. It can be represented as a Cascade model developed by (Haines-Young & Potschin, 2010). For the purpose of the NMF, the Cascade model by the Common International Classification of Ecosystem Services (CICES) is adopted (European Environment Agency, 2016):



The scope of the National Methodological Framework currently covers the Environment component of the Cascade model, with further work still needed on the link between supporting and final services, as well as the implementation of DPSIR. The Socio-economic system is to some extent covered in its Benefits aspect (biophysical valuation of ecosystem services). The precise definition of production boundary, valuation of ecosystem serv ices and natural capital accounting aspects are subject to additional work to be provided in follow-up projects.

3.3. The concept of ecosystem services

Ecosystem condition comprise the "stock" or "potential" of ecosystem services, the 'flow' to 'beneficiaries' to become realized, now or in the future. Ecosystems functions such as pollination or erosion protection, inasmuch as they are used by beneficiaries, also provide a flow of ecosystem services (Box 4).

The ecosystem services (ESS) concept emphasizes the multiple benefits of ecosystems to humans (Millenium Ecosystem Assessment (MEA), 2005), and its use can facilitate collaboration between scientists, professionals, decision-makers, and other stakeholders.

The mapping work is therefore not targeted to identify the maximum potential of one service but to understand the spatial delivery of multiple services by interconnected ecosystems.

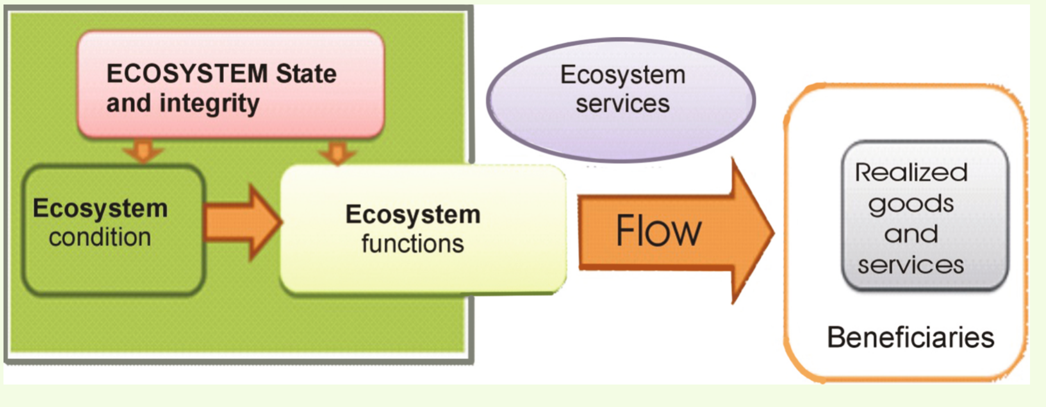
Box 4 The concept of ESS

Ecosystem services: The benefits that people obtain from ecosystems (MEA, 2005). The direct and indirect contributions of ecosystems to human wellbeing (The economics of ecosystems and biodiversity (TEEB, 2010). The concept 'ecosystem goods and services' is synonymous with ecosystem services. The service flow in our conceptual framework refers to the actually used service.

Ecosystem services are derived from ecosystem functions and represent the realized flow of services for which there is demand. For the purpose of MAES, ecosystem services also encompass the goods, which are derived from ecosystems. People benefit from ecosystem (goods and) services. These benefits are, among others, nutrition, access to clean air and water, health, safety, and enjoyment and they affect (increase) human wellbeing which is the key target of managing the socio-economic systems. The focus on benefits implies that ecosystem services are open to economic valuation. However, not all benefits to people from ecosystems can be measured in monetary terms. Therefore, it is important to include other values as well, such as health value, social value or conservation value.

Monetary valuation of ecosystem services usually relies on the analyses of demand (beneficiaries) and the application of economic valuation techniques and ideally involves all relevant stakeholders. However, valuations can also be expressed in human health units, or biophysical terms. There are different methods to determine shared social values, most of them discursive and with involvement of stakeholders and/or the general public. When analysing demand it is important to consider that it is scale dependent, as some services can be 'transported' over long distances (*e.g.* food provision) while others have a local level demand (*e.g.* soil protection).

The flow of services from ecosystems as benefits to people does not come for free. Ecosystem services in order to be beneficial and valuable to humans normally require additional investments (*e.g.* energy, labour, management) by humans. The energy content of ecosystem services is therefore in almost all cases a combination of natural (ecosystem processes based) energies and human based energies. Therefore, these inputs are also explicitly addressed in the MAES framework.



Every ecosystem delivers multiple services. Three international classification systems are available to classify ecosystem services: Millennium Ecosystem Assessment (MA), The economics of ecosystems and biodiversity (TEEB) and Common International Classification of Ecosystem Services (CICES). In essence, they relate to a large extent to each other; all three include provisioning, regulating and cultural services (Box 5).

Box 5. Classification of ESS

- **The Millennium Ecosystem Assessment** (MA) was the first large scale ecosystem assessment and it provides a framework that has been adopted and further refined by TEEB and CICES. The MA organizes ecosystem services into four well known groups:
  1. provisioning services
  2. regulating services
  3. cultural services
  4. supporting services
- ***TEEB*** proposes a typology of 22 ecosystem services divided in 4 main categories, mainly following the MA classification:
  1. provisioning services
  2. regulating services
  3. habitat services
  4. cultural and amenity services

An important difference TEEB adopted was the omission of supporting services, which are seen in TEEB as a subset of ecological processes. Instead, habitat services have been identified as a separate category to highlight the importance of ecosystems to provide habitat for migratory species (e.g. as nurseries) and gene-pool "protectors" (e.g. natural habitats allowing natural selection processes to maintain the vitality of the gene pool). The availability of these services is directly dependent on the status of the habitat (habitat requirements) providing the service. In case commercial species are involved, such as fish and shrimp species which spawn in estuarine and coastal nursery areas but of which adults are caught far away, this service has an economic (monetary) value in its own right. Also the importance of the gene-pool protection service of ecosystems is increasingly recognized, both as "hot spots" for conservation (in which money is increasingly invested) and to maintain the original gene-pool of commercial species (which we are increasingly imitating through the creation of botanic gardens, zoos and gene banks).

- **The Common International Classification of Ecosystem Services** (***CICES***) offers a structure that links with the framework of the UN System of Environmental-Economic Accounts (UNSD, 2003). CICES builds on the existing classifications but focusses on the ecosystem service dimension. In the CICES classification, the ecosystem services are either provided by living organisms (biota) or by a combination of living organisms and abiotic processes. ***Abiotic*** outputs and services, e.g. provision of minerals by mining or the capture of wind energy, can affect ecosystem services but they do not rely on living organisms for delivery. They are therefore considered as part of overall natural capital (which comprises sub-soil assets, abiotic flows and ecosystem capital and services). The individual types of natural capital possess different key characteristics (e.g. renewable or not) that translate into specific management challenges (Maes, et al., 2013).

4. The process of mapping and assessment of ES and ESS

ES and ESS form two sides of the same phenomenon – the integrity of the socio-ecological system (SES) in which human activities benefit from nature and impact its condition. However, as detailed in the next sections, much is still to be done before the relationships between the two components of ESS – ecosystem functioning and human activities – is fully clarified. We assessed and mapped the ecosystem condition and ecosystem services, using two different indicators sets, for each ecosystem and polygon, and expect this data to become the foundation for a better understanding of the integral nature of SES.

4.1. Assessment of ecosystem condition

Ecosystem condition is defined as the effective capacity of an ecosystem to provide services, relative to its potential capacity (MEA, 2005). The Millennium Assessment calls for a well-defined ecosystem that has strong interactions among its components and weak interactions across its boundaries. It defines a useful choice of ecosystem boundaries — the place where a number of discontinuities coincide, such as in the distribution of organisms, soil types, drainage basins and depth in a water body (MEA, 2005). The EEA has used this approach by developing an ecosystem-specific assessment, as set by the MAES ecosystem categories.

Ecosystem service capacity depends on the physical, chemical and biological condition of an ecosystem at a particular point in time, and is controlled by both the natural condition (affected by factors, such as soil, elevation and aspect) and the anthropogenic pressures to which it is exposed, such as land take, fragmentation and pollution. The effect of the flow of pressures through time affects the ecosystem condition measured at a specific moment in time, and so pressures can be used as a proxy for assessing trends in the change of ecosystem condition. Note that there might be a time lag between the application of the pressure and the resulting impact on ecosystem condition.

There are, therefore, two complementary approaches to assess ecosystem condition: an indirect approach based on evaluation and mapping of the pressures acting on ecosystems, as described in section 4.1, and direct assessments of habitat condition, biodiversity and environmental quality, as described in section 4.2. Ideally information from both approaches is available, and data sets can be used for comparison and validation and for interpreting how pressures affect current conditions.

The next stages in the assessment would then be to produce a baseline of our knowledge about the ecosystems in the form of spatial maps of ecosystem condition, assess trends in ecosystems change by including the impact of multiple pressures, and to use the knowledge of ecosystem condition to model and assess the current ability of the ecosystems to supply ecosystem services and possible trends in this supply.

Mapping and assessment of ecosystems condition and ecosystem services is a multilevel process:

- EU wide mapping and assessment. This is a cooperative process between the EU and the member states in the framework of the MAES working group and some dedicated initiatives. In the frame of this process, the parties exchange information and take stock of ongoing national research and EU Wide initiatives and high profile projects. Also, the EU agencies responsible for methodological guidance and data collection (JRC and the European Environment Agency, respectively) define and communicate their data needs and collaborate with member states on shaping the reporting process. So far, the results of this work are a number of overview publications, the EU wide maps of ecosystem types, and other guidance documents (Maes et al., 2013), (Maes et al., 2016).
- National scale process: ecosystems mapping and assessment efforts vary widely according to the national policy approach, institutional framework and data availability.

4.2. The DPSIR framework

Drivers of change, such as population growth and increased consumption, create environmental pressures that have the capacity to change the condition of habitats, the health of species and the species composition of ecosystems (biodiversity), decreasing their resilience and affecting their capacity to supply services. Information on these pressures can be used as a proxy for assessing the condition of ecosystems. It is also essential for informing policies to reduce the pressures and to avoid crossing ecological 'tipping points', namely critical levels of pressure that, if crossed, will result in an entire ecosystem shifting into a new state / condition, which may have a different species composition and changed level of resilience and is often less conducive to human wellbeing (European Environment Agency, 2015).

Pressures (pressures of change) alter the condition of ecosystems and, consequently, affect their service capacity, habitat quality and biodiversity across Europe.

The mapping and assessment process can be coherently structured using the well-established DPSIR (Drivers, Pressures, State, Impact and Response) framework (Fig. 1). This framework is used to classify the information needed to analyse environmental problems and to identify measures to resolve them (Turner, Morse-Jones, & Fisher, 2010). Drivers of change (D), such as population, economy and technology development, exert pressures (P) on the state (condition) of ecosystems (S), with impacts (I) on habitats and biodiversity across Europe that affect the level of ecosystem services they can supply. If these impacts are undesired, policymakers can put in place the relevant responses (R) by taking action that aims to tackle negative effects. This framework is particularly useful, as it can be adapted and applied for any ecosystem type at any scale and in Fig. 2 it is shown how ecosystem assessment canfit within the DPSIR framework.

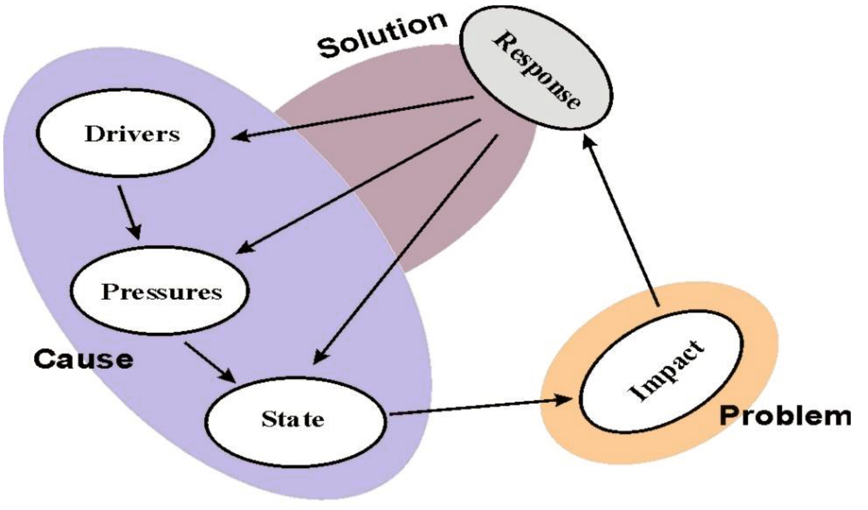
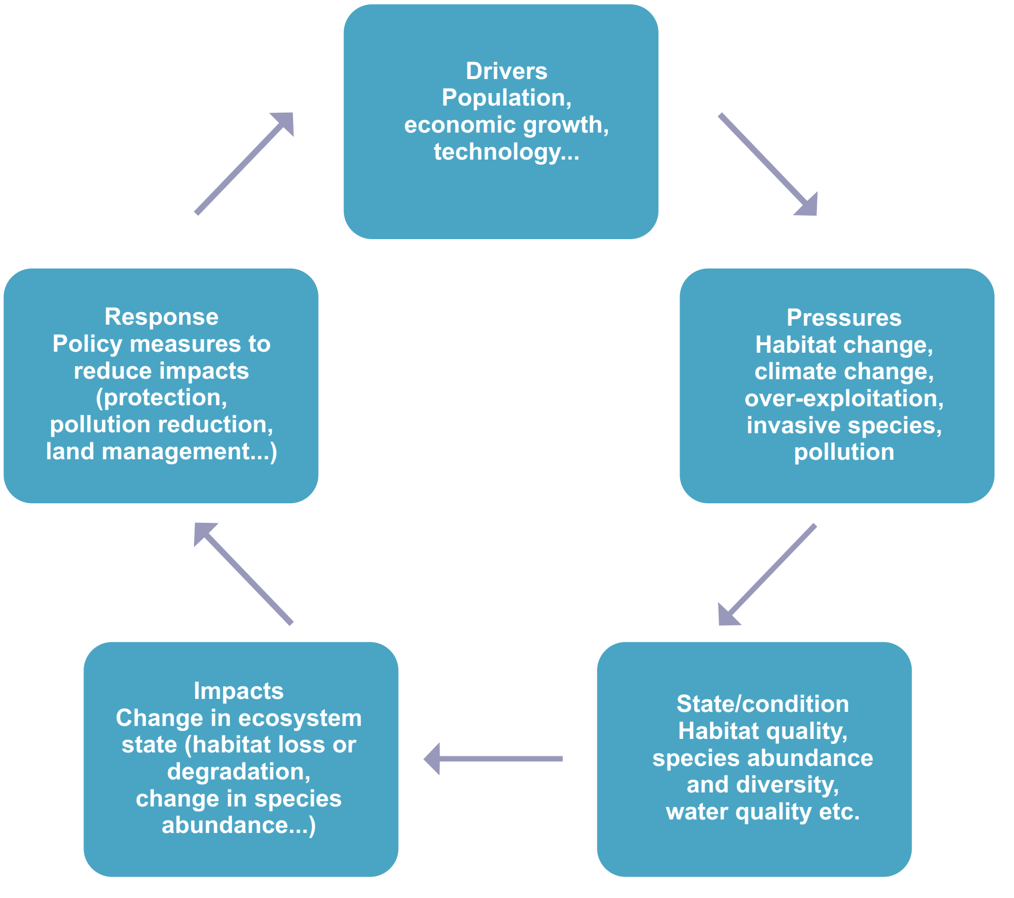


Fig. 1. The DPSIR framework



Source: Adapted from EEA, 2015a.

Fig. 2. Assessment of ecosystem condition within the DPSIR framework

Overall anthropogenic pressures are mostly increasing (MEA, 2005); European Environment Agency, 2015), despite efforts to reduce them through measures to reduce pollution and to meet objectives such as the Aichi Targets and the Sustainable Development Goals. In Europe, the two most frequently reported pressures and threats for terrestrial habitats listed in the Habitats Directive are agriculture (both intensification and abandonment) and the modification of the natural conditions of water bodies, mostly through hydrological changes (EEA, 2015). For marine ecosystems, the main pressures are (over-)fishing, modification of natural habitat conditions and pollution (EEA, 2015). The Millennium Ecosystem Assessment (MEA, 2005) identified the most important pressures, and these have been combined into five major groups as part of the MAES framework (Maes et al., 2016), as shown in Table 1.

Table 1. Main pressures causing ecosystem change

Pressures	Description
Habitat change	The main pressure causing habitat change in terrestrial ecosystems is land take. This causes impacts, such as fragmentation, soil sealing, soil erosion and soil degradation that can cause direct degradation of a habitat or its loss and replacement by another habitat type. For some areas, abandonment of farmland leading to replacement by shrub or forest is also significant. For marine and coastal ecosystems, the main pressures are destructive fishing techniques and coastal development, and, for fresh water ecosystems, they are human modifications such as the creation of dams and diversion of rivers
Climate change	Anthropogenic climate change causes fluctuations in the life cycles of plants and animals and extreme events such as floods, droughts and fires that change the health and characteristics of habitats and the species present
Overexploitation (unsustainable land or water use or management)	Pressures arise from the use of ecosystems for production of food, fuel and fibre. Intensive land management and overexploitation of natural resources, including overfishing and over-extraction of water, has already seriously reduced habitat quality and biodiversity in Europe
Invasive alien species	Invasive alien species can replace native species, occupying their habitats, reducing their survival and abundance and leading to loss of biodiversity
Pollution and nutrient enrichment	Pollution and nutrient enrichment occur when excessive harmful components such as pesticides, fertilisers and industrial chemicals are introduced into an ecosystem, exceeding its capacity to maintain their natural balance and resulting in their ending up in the soil, groundwater, surface water and seas, leading to ecosystem changes

5. A conceptual view on Bulgaria's ecosystem mapping, assessment, monitoring and valuation

This section outlines the concept that determined the selection of indicators for mapping and biophysical assessment. The connection of ecosystem integrity, mapping and assessment, the DPSIR framework and the future ecosystem based monitoring is conceptualized.

Indicators for the mapping and assessment exercise are selected among the indicators developed by MAES (Maes et al., 2016). Each indicator received a set of parameters that allow for its assessment. In order to get the full picture of Bulgaria's natural capital, all condition indicators and all ecosystem services are included. Indicators were, however, divided into mandatory (key indicators for understanding the ecosystem) and optional indicators (important indicators for whose assessment data is not available and should be collected in the future). These indicators diverge between ecosystem types and are detailed as annex to each ecosystem type in section B.

More work is needed on linking the ecosystem indicators in part B to the DPSIR framework and ultimately, to indicating the condition, properties and integrity of the SES. This topic is a work in progress, and no final results on the DPSIR indicators are available in this first edition.

5.1. Ecosystem integrity concept and it's partial implementation in this Methodological framework

Human evolution is characterized by the expansion of humankind's functioning as an ecosystem engineer species both on a spatial scale and in terms of an even increasing number of pathways to influencing the environment as technologies developed. This development ultimately led to over-imposing of different social structures (economy, technology, culture, etc.) as additional levels of complexity over natural ecosystems to form a socio-ecologic system.

Although human-centric views on the natural environment gained momentum together with civilization's impact on Nature, humans cannot survive outside the environment, and need to form an integral part of it. Therefore, using reductionist approaches to fragment study of the socio-ecologic system, i.e. into natural and social sciences, by necessity leaves important research areas out and diminishes the information gain in studying the whole system as compared to a holistic point of view.

Having in mind both the time constraints and the need to accommodate the information needs of a wide area of stakeholders about a range of very different aspects of Bulgarian ecosystems, we adopted the holistic approach to the socio-ecologic system. At its core is the understanding that indicators are manifestations of different aspects of the system's current state and can help deductions on the degree of ecosystem integrity. Ecosystem integrity, in turn, is understood, in the sense of (Kay, 1991) as a spatio-temporal continuum of ecosystem states (state space) in which the ecosystem is able to self-organize. This definition is different from the approach taken by (Burkhard & Maes, 2017) who look at the ecosystem integrity from the point of view of "naturalness", in recognition of the fact that it would render a very bad condition measurement for key ecosystems with high human population and/or degree of modification (such as urban and cropland ecosystems). Adopting a systemic point of view at ecosystem integrity further enables the systematic consideration of state transitions between ecosystem condition at different points in time, and placing other ecosystem characteristics (such as ecosystem resilience and vulnerability) in the context of the ecosystems' movement within the state space of ecosystem integrity.

The approach should, in further editions of this Framework, be extended beyond the ecosystem considerations to the socio-ecologic system (SES) of natural environment being modified by humans. Such considerations are beyond the scope of this first edition since a significant body of research has to be completed both at EU and national level before it can be conceptualized in sufficient detail so as to be of practical use to non-scientific stakeholders such as policymakers and local communities. The assessment of socio-ecological integrity, however, is key to conceptualizing the trade-offs in ecosystems management since it includes the notion of maximizing the benefits to human if ecosystem state changes due to human interventions, catastrophic events, steady pressures such as climate change, or the ecosystems' internal dynamics. A simplified depiction of the integrity of socio-ecologic systems across state change and disturbances is presented in Fig. 3.

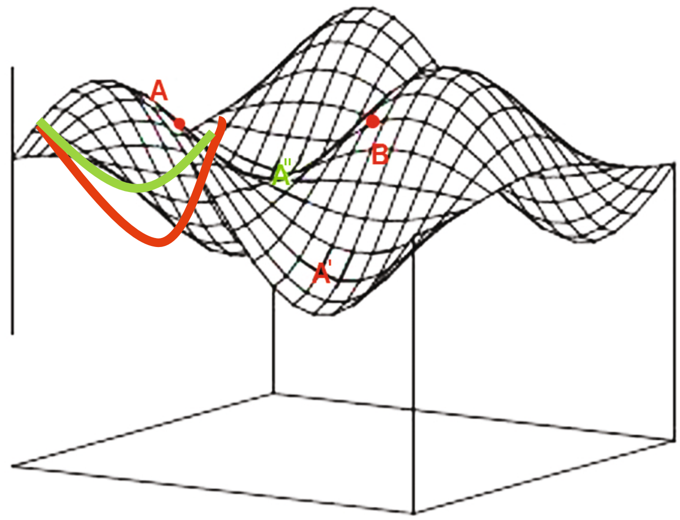


Fig. 3. State change within the ecosystem integrity paradigm. State change from state A to state B could be predicted to lead to sharp decline in integrity (path A-A'-B) and subject of adaptive management so as to lead the socio-ecological system's development along a less vulnerable path (A-A”-B)

Since ecosystem integrity is influenced by a huge number of factors, the complete description of its condition space would necessarily amount to expressing it in terms of a multidimensional model. Such models cannot be visualized but are capable to be described in multidimensional spaces in order to understand and ideally, also predict ecosystem integrity.

When integrity within the SES forms the basis of understanding its dynamics, both spatial and temporal changes are internalized into the model. Geo-referenced state of the ecosystem at a given time corresponds to an ecosystem map, whereas the differences in state measured in its various points (but not on its entire territory) allow for judging the dynamics of the SES integrity. In this framework, the DPSIR framework (see 4.3 and more details in Part D) is a measure of interaction within a self-governing social-ecologic system, such as a municipality. For example, if a very simplified municipal SES is formed by an urban ecosystem and its surrounding grassland ecosystem, consumption demand for food in the urban ES (driver) could result in partial transformation of grassland to cropland ES (pressure). Changing the ecosystem type in some parts of the ecosystem from grassland to cropland may result in diminished biodiversity in these areas, with fragmentation of some habitats. This is a state change in the SES integrity space affected by its human actors. The impact of such state change is a diminished integrity of both the grassland and the new cropland ecosystems. However, it does not necessarily mean a diminished integrity of the SES which may still be sustainable if, for example, urban green infrastructure providing species refugia is created through adaptive management to offset for the incurred loss of biodiversity in the grassland and cropland parts of the SES. In this manner, the result of the trade-off between increased supplies of provisioning services (new cropland) and loss of grassland biodiversity in such scenario is mitigated by adaptive management so as to not imperil the integrity of the SES.

Since mapping and assessment of the SES is not feasible yet, the current edition of the Methodological framework is limited in scope to some of its elements – mapping and assessment of ecosystem condition and services (part B), verification of data (part C) and the general understanding of the relation to the complex DPSIR indicators that need to be developed (part D). Outstanding work is discussed in part 7.

5.2. Gaps and uncertainties

Like all EU member states in the process of mapping, assessment ad valuation of ecosystems and ecosystem services, Bulgaria faces a number of challenges outlined shortly in this section:

- Gaps in the data sets and lack of time series data on main indicators for condition (state) of the different types of ecosystems are a main constrain in the assessment and mapping process. Gaps exist also in the state, trends and spatial distribution of species (the assessment is restricted to areas outside the Natura 2000 sites, e.g. 67% of national territory).
- There is poor availability of indicators for the impacts of some of the pressures on biodiversity, such as pollution, climate change and invasive alien species.
- Not always a clear connection between ES condition and services, and understanding of causality. At present there is not enough information and research to assess functional relationships between ecosystem condition and ecosystem service supply. Thus, all indicators used in the assessment process have equal weight.
- In the process of assessment of ecosystem services there might be a need to group a long list of services in functional ecosystems bundles (or "baskets" providing co-benefits), or failing that, to prioritize certain ecosystem services, such as those for which there is a high demand, or those that are particularly vulnerable to current pressures. However, this carries the risk that important services, or those that interact with important services via synergies or trade-offs, would be omitted.

This short listing of challenges facing the ecosystem level of management highlights the importance of extending our knowledge on interactions between ecosystem services. The remaining part of this section is devoted to the current approach taken in this Methodological framework and the needs of improvement and further research.

5.3. Indicators for the purposes of ecosystems management: structure and selection by service type

Indicators in the NMF are suitable to be modified in its future editions in line with the approach adopted in Finland, as described by Mononen et al. (2015). Their work, based on the cascade model, proposed a four-component structure of each ecosystem service indicator, consisting of:

- A structural component, relating to the ecosystem type and baseline (for example, habitat in ha for harvesting of berries and mushrooms);
- A functional component describing the biophysical gain of the service (for example, kg/ha/year for berries and mushroom harvest);
- A benefits component containing the composite biophysical gain, such as kg harvested berries and mushrooms entering the market and households;
- A value component describing the monetary value of different aspects of the service, such as sales of berries/mushrooms, number of berry and mushroom pickers, health and intrinsic values.

Such approach is well balanced from the point of view of socio-ecologic systems (SES) where the flows of ecosystem services are part of the SES and therefore, apart from valuing the ecosystem services, can also be used as indication of the SES integrity and trigger steps in adaptive ecosystem management. Due to the limited scope of the NMF to be produced with the support of EEA Grants 2009-2014 – project MetEcoSMap, the NMF currently does not provide details on the value component of each indicator; this is subject to further work, to be funded by another financial instrument (EEA Grants 2014-2021 or OP Environment 2014-2020 were under discussion). However, it is impossible to create a coherent framework without considering the minimum requirements of future monetary valuation, and therefore the indicator framework discussed in this document includes requirements to the future components of the indicators describing the benefits and value components outlined above.

The development and adaptation of the indicator approach was performed by a research team at the Institute of Biodiversity and Ecosystem Research at the Bulgarian Academy of Sciences (IBER-BAS) with regard to the Bulgarian prioritization approach adopted in NMF. Our indicator system has some essential characteristics:

1) There is no *a priori* prioritization of some ecosystem services over others and selection of such services to compose indicators on. This is so due to several considerations:
   a. The NMF is based on the concept of ecosystem integrity and it is not feasible to ignore some of the ecosystems' functions because of the lack of current economic demand for the services they provide;
   b. Highlighting some ecosystem services that are already known as economically important is likely to further focus attention on them, resulting in modification of these ecosystems in order to optimize the provision of the desired services at the costs of biodiversity, or else overexploitation. Overexploitation of economically relevant services may also lead to a *circulus viciosus* and degradation rather than conservation of the ecosystems;
   c. Innovation and greening of the manufacturing processes, energy production, transport, housing and other aspects of human activities are both of high priority for European businesses. Therefore it is expected that over time, some ecosystem services previously not interesting to the businesses may gain in relevance and should therefore be accounted for. In this manner, their commercial potential will be highlighted to existing and potential future stakeholders to facilitate informed decisions on business development and trade-offs between ecosystem services. 2) Like all Member states, Bulgaria faces the insufficiently, and in some cases lack of data for assessing all ecosystems and all ecosystem services (see 6.1 above). Other factors contributing to data being not immediately available for ecosystem assessment include interrupted time series, proprietary or incompatible data formats, non-digitalized legacy information from paper registries, etc. Therefore, some of the services' valuation should be inferred based initially on existing knowledge and expert judgment about ecosystems functioning, and during the

monitoring phase – on multi-parameter holistic modelling of the ecosystem services production.

To overcome the immediate limitations caused by lacking or incomplete data, the Methodological Framework (including the methodologies in Part B and the Monitoring guide – Part C) has instead adopted the approach of selecting mandatory and complementary parameters and indicators. In this manner, newly obtained ecosystems knowledge will be incorporated seamlessly into the existing framework.

Another methodological difficulty was caused by the multi-functionality of ecosystems in the situation of human interference and the number of classifications and concepts reflecting different viewpoints that have developed over time, sometimes in parallel and not always coherent with each other, to cope with this high level of complexity. Such classifications contain parts of the features important for the monitoring process, namely:

- a set of essentially static structural classifications to define ecosystems' extent and describe their biological, biochemical or biophysical functioning on various levels of abstraction but without considering to a significant extent the human intervention. Examples include the EUNIS habitat classification, the broad ecosystems classification adopted by CICES, and a number of other concepts from specialized management of ecosystems components, such as the ecological status measured by descriptors in the Marine Strategy Framework Directive.
- a set of functional concepts like the Cascade model and the DPSIR framework that discuss the trends in ecosystems development and treat mainly the ecological aspects of human impact on ecosystems (such as waste and pollutants introduction and removal, ecosystems fragmentation, land grabbing and habitat destruction, etc.). These concepts either consider ecosystem as a black box or focus upon the higher level of abstraction about ecosystems functioning such as water, energy, nitrogen or carbon balance. In this manner, the functional aspects are added to the concepts at the expense of the level of detail in ecosystems description inherent to static classifications
- a set of extensions to economical and statistical instruments such as diverse valuation methods and capital accounts that are mainly considering ecosystems from an anthropocentric point of view, as extensions to the socio-economic system. These consider both ecosystems structure and their functioning as a black box and are mainly concerned with this black box' outputs in the form of ecosystem services.

The conceptual difficulty of aligning the above consists in the fact that an objective and well informed natural capital accounting needs to resort to the results of all three types of considerations about ecosystems. Their current state is to be recorded as ecosystem stocks, whereas the trends of their developments (improvement, degradation or even destruction) form the components of ecosystems flows that also need to be accounted for in the system of national accounts. Furthermore, the NCA's requirement to avoid double counting means that we need a clear and detailed understanding of the production boundary for each ecosystem service. Since national capital accounts are compiled based on company accounting, its correct implementation ultimately means that the statistical framework about ecosystem services has to be unequivocal enough to provide a clear guidance on enterprise level accounting records for each type of ecosystem services. These would in the majority of cases require more complex records than the mere purchase of goods. All ecosystem stocks owned by an entity that were previously not recorded, ought to be entered into the accounting books either as new capital, or as materials/perishable goods, etc. if of shorter lifetime. Depending on the nature of service itself and the flows it produces, its accounting interpretation may involve the concepts of rent, borrowed capital, non-use compensation, or other forms that have a different legal treatment in matters such as ownership rights and value added tax. Double counting should further be avoided when considering the ecosystem services' relation to existing national accounts. For example, fossil fuels are in their nature a huge accumulation of highly energetic organic matter produced by past provisioning ecosystem services and collected over millions of years. They already are treated in separate accounts and as such do not need to be regarded from the natural capital accounting point of view; however, their use is closely related to the release of atmospheric carbon and as such influences the balance of ecosystems carbon accounts. A similar relation exists between land ownership as traditionally accounted by an enterprise, and the same enterprises' share in the new ecosystems extent account. Division between enterprises of costs and benefits incurred by the production of an ecosystem service involving cross-landscape and cross-boundary service flows can also be heavily influenced by the nature of the service – for example migrating birds may create revenues from bird watching tourism in places other than their nesting and feeding places where they use natural resources. All of these links cannot be considered unequivocally from the natural capital accounting and statistics' point of view merely using a black box approach towards the ecosystems' structure and functioning.

Bringing together sufficiently multidisciplinary teams to tackle the issues arising in such unification of concepts from different branches of science and human activities also meets practical limitations. These limitations arise, among others, from the diverging value systems inherent to these different branches of science, and their varying conceptual and methodological approaches. There are also inherent limitations of human cognition that prevent both single researchers from grasping all aspects of the matter at hand, and huge research groups from being efficient enough in interdisciplinary communication.

With the emergence of new technologies, however, both acquisition and processing of information become increasingly easier to automate and complex computational tasks can be performed by machines quicker and cheaper than ever before. This development has the potential of lifting the information processing burden from scientists, GIS experts and practitioners. This automation is likely to open up new avenues for processing multi-indicator models, prioritizing indicators and calculating their relative importance and weight in the final assessment.

The trend towards automating increasingly complex tasks is illustrated in ecology by the widening adoption of remote sensing data for ecosystem assessment and the increasing interest to processing it with machine learning techniques for solving a number of repetitive and time consuming expert tasks such as pattern recognition to identify properties on landscape level, ecosystem, habitat and population levels, as well as study the trends in ecosystems dynamics, such as parameters of the species distribution.

The same machine learning modelling techniques and tools have also been used in engineering, economics and finance to solve very different tasks, such as energy consumption prediction, computer vision, natural language processing and machine translations, econometrical calculations and even predicting the stock prices fluctuations.

The variety of tasks being solved by the same toolbox of techniques suggests that technology applying these techniques has the potential to bridge the cognitive gaps between disciplines in a qualitatively new way. Different knowledge domains can much easier be combined to create holistic, multi-parameter socio-ecologic models involving all three conceptual sets listed above, as there is no need any longer to sacrifice details in order to reduce complexity. Such models are also increasingly capable to handle huge amounts of data, while at the same time the amount of available data from terrestrial sensors, remote sensing and many other domains can be handled efficiently by these models. The coincidence of these developments leads towards a singularity of exponentially increasing potential to better perceive the socio-ecologic systems in nearly real-time, discover dependencies that become apparent with the abundance of data, and use these for more precise modelling and informed decision making.

Following the holistic concept outlined above, the NMF adopts a multiple classification approach to the indicators that will allow their use in different modelling contexts. Indicators in parts B and C are grouped by the ecosystems functioning principle, i.e. in groups like Biotic diversity, Abiotic heterogeneity, etc. that reflect the ecosystem integrity view. However, they can also be classified according to their place in the Cascade model; in this manner the relationship between ecosystem structure, functioning and service provision is clarified and the entire class of regulating ecosystem services is measured by functional indicators that are also useful for monitoring the ecosystems' condition. Without getting into methodological discourse, we note that the selected approach to some extent bridges the conceptual gap between the CICES and NESCS (Lander, 2012) classifications adopted in the EU and the United States, respectively. The conceptual difference between the two is that CICES is a classification enumerating all ecosystem traits (structural, material and functional) that are used by humans, whereas NESCS focuses on extracting the Final flows of ecosystem services (FFES) in order to avoid double counting when a regulating service is also used as input for providing a provisioning service. While we see the merits of both systems, the approach in NMF does not classify indicators in full accordance with neither of them because we recognize that if an ecosystems function provides both inputs for other ecosystem services and final ecosystem services for direct use by humans (especially when separating quantitatively both uses – intermediate for sustaining the ecosystem, and final for human use – does not appear possible at this time), ignoring either of these flows may distort the final natural capital accounting balance to be produced at a later stage. It is therefore highly desirable to use modelling and/or more direct calculations to determine the exact proportion of both ESS uses in each particular context.

Even less straightforward is the connection between the indicators and the information they provide for estimating the different stages of the DPSIR framework. Due to the DPSIR framework's circular nature, the same indicator may be used, for example, as State indicator in the baseline measurement, as impact indicator upon the first monitoring and combined impact/response indicator in following monitoring observations. This ambiguity is also visible in the Technical report on typology and overview of environmental indicators (European Environment Agency, 1999) where yet another qualification of indicators is introduced, dividing them in Type A (Descriptive indicators), Type B (Performance indicators), Type C (Efficiency indicators), and Type D (Total welfare indicators). It is notable that in all four groups of indicators (A, B, C, and D), there's a mix between indicators described as Driver, Pressure, State, Impact and Response. The authors of the technical report further note that different member states use different indicators. In the report, too, similar indicators are qualified differently in different contexts even if they measure similar quantities (i.e. the Danish CO_2-emissions in key sectors are classified as a pressure indicator, whereas the Austrian comparison of Per-capita CO_2-emissions of EU member states is seen as a response indicator).

In the NMF, indicators are grouped in the same manner both in Part B Methodologies and Part C Monitoring Guide, and aim to measure the changes in ecosystems state and condition. The rationale for such approach is that indicators' values can be processed to derive DPSIR qualification and, once the production functions for ecosystem services are known, also to calculate the changes in ecosystem services provision. For example, the nitrate pollution measurement in water bodies resulting from the run-off of its surrounding agricultural areas could be measured as a baseline during the initial mapping and assessment (Part B), and thereafter each five years as per Monitoring Guide (Part C). The same type of measurement (nitrate pollution for example) could then be used to deduct the corresponding DPSIR indicators, as illustrated in Fig. 4 below:

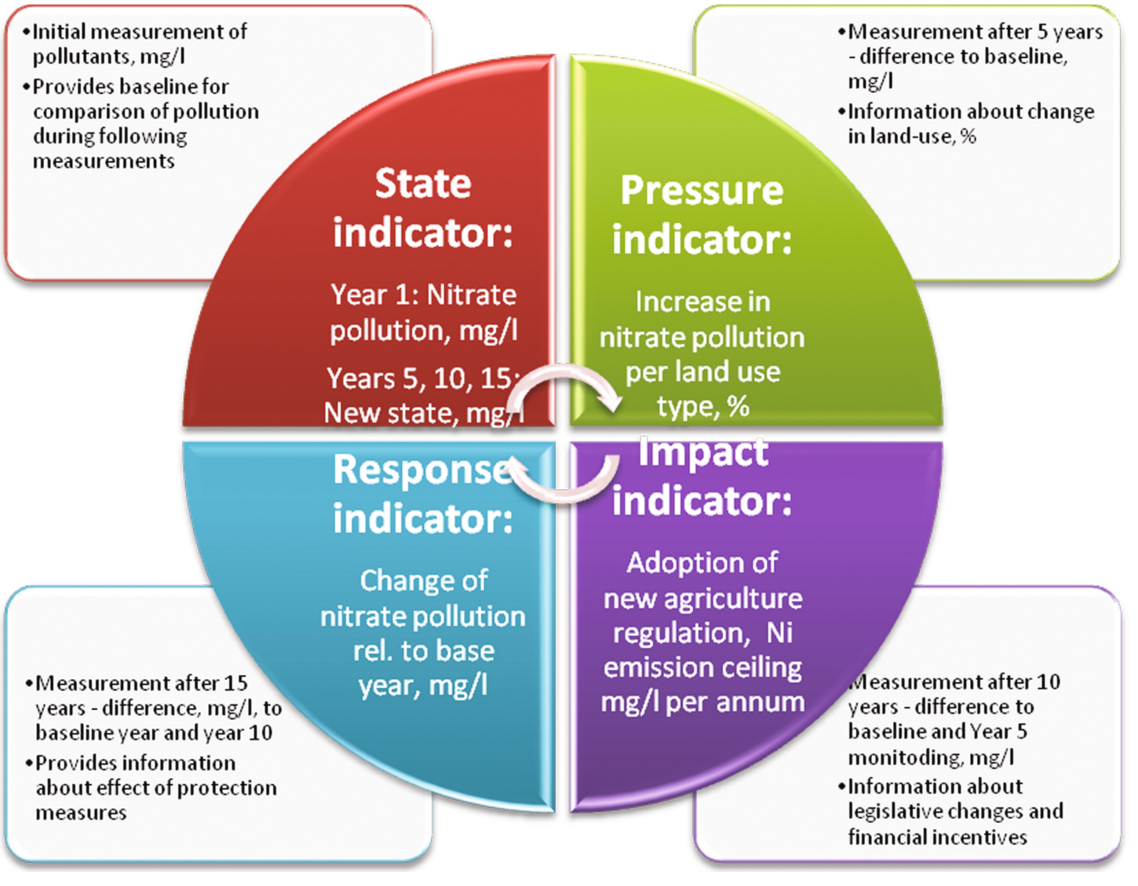


Fig. 4. The relation between ecosystem condition indicators and DPSIR indicators. The condition indicators, measured over time, can act as different types DPSIR indicators, as illustrated on the example of nitrate diffuse pollution for water ecosystems

Indicators for ecosystem condition and ecosystem services can in this manner be considered as part of a common framework shown in Fig. 5 below which reflects the considerations outlined in this chapter. The interrelations between indicators, if not estimable by experts, are to be modelled at a later stage to achieve a more fine-grained interpretation of the socio-ecologic system.

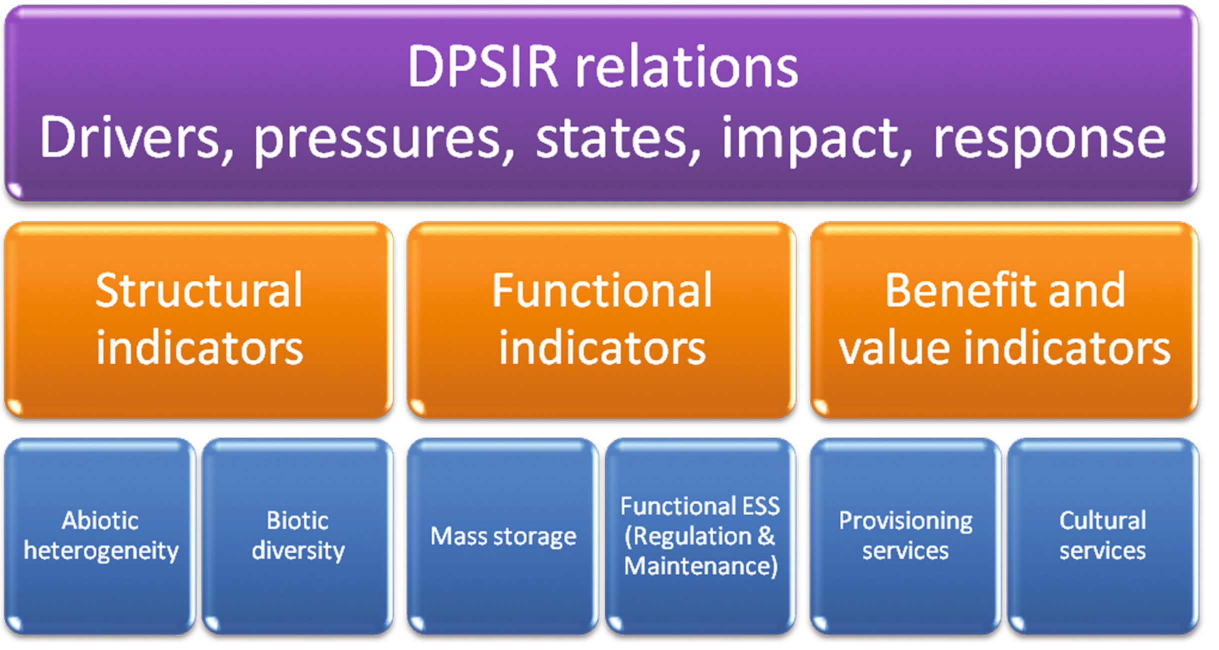


Fig. 5. Common indicator framework combining indicators derived on basis of the cascade model and the DPSIR relationships between them

Based on this understanding, relationships were established between ecosystem integrity indicators and the benefit and value components of ecosystem services by applying the division principles proposed by Gocheva et al. (2016) on the CICES 2 ecosystem service level. Where feasible, a qualitative risk assessment is also made based on expert inputs, in order to guide the monitoring process. The monitoring cycle is organized as follows:

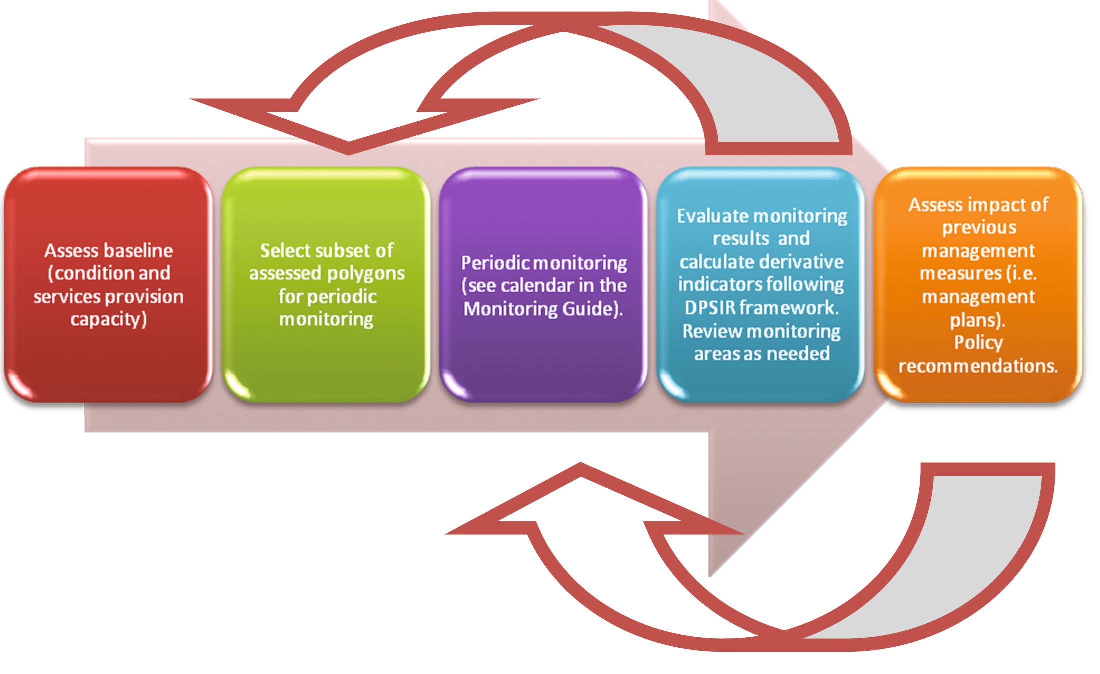


Fig. 6. Proposed organization of the ecosystems monitoring cycle

A more specific example of this approach for a single provisioning service is given below as illustration. It shows the transition between the CICES classification for a single ecosystem service (Cultivated crops) and indicators from part B, used to monitor the cropland ecosystem. Each indicator is measured by one or several parameters, as detailed in the Methodology.

The section on Bulgarian extension uses the methodology proposed by Gocheva et al. (2016) to perform a basic trade-off analysis as guidance to the specific monetary assessment. In the last columns, a valuation method and link to the respective (future) ecosystems account is provided through the company accounting of the enterprise that produces the crops. The last part of the table provides a link to the (future) DPSIR indicator framework via risk assessment of the various pressures.

6. The methodological framework of mapping and assessment of ES in Bulgaria

The creation of this Methodological framework is a work of a big group of experts who co-authored its chapters. They acted as an interdisciplinary working group within the MetEcoSMap project in order to unify the approach across ecosystem types and resolve, together with the mapping projects and the Executive Environment Agency, conceptual difficulties that became apparent during the mapping. In parallel, the draft of the Framework was published on the programme's website, communicated on international meetings within the MAES working group and international forums.

In addition, a dedicated stakeholder group was constituted as one of the project activities, and their comments were solicited. These included representatives of state authorities, NGOs, business, as well as the seven teams performing the actual mapping and assessment of nine ecosystem types on the ground and representative of the Executive Environment Agency – the institution hosting the Bulgarian Biodiversity Information System (BBIS) who also lead a project to create a dedicated ecosystem services module in BBIS which will host all maps produced by the seven mapping projects. Under the umbrella of MetEcoSMap projects, stakeholder meetings in different composition were held to identify the information needs, relevant policy questions and correct shortcomings in the draft of this Framework. The stakeholders provided insights into the policy questions to be addressed in the ecosystem management. The last step – a peer review, was provided by a Scientific council composed of Bulgarian and international experts who have not participated in preparing the Framework. They provided feedback on the scientific completeness of the draft of this Framework.

We thank all these parties for their constructive comments that helped to greatly improve the text.

6.1. Biodiversity in Bulgaria

Bulgaria is one of the European countries with high biological diversity at all the three key levels: genetic diversity, species diversity and ecosystem diversity.

Data for 2013 indicated that forests occupy 4,180,121 ha or approximately 37,7 % of the territory of Bulgaria and thus it is one of the most forested countries in Europe).

Bulgaria is among the three European countries (together with Croatia and Slovenia) with the highest percent of Natura 2000 territories.

6.2. Typology of ecosystems in Bulgaria

Following the EU 2010 Biodiversity Baseline, the MAES WG addressed the question of defining an adequate ecosystem typology for the selection of broad habitat types or ecosystems that can be characterized by their status and their contribution in delivering ecosystem services (Maes, et al., 2013). An approach was identified to ensure both a balanced representation of important European ecosystems and meaningful aggregation of current continental or national land and marine unit(s) and of habitats that are listed under Annex I of the HD and the predominant and special habitat types of the MSFD.

The ecosystem types are proposed as basic units for ecosystem mapping at European scale. These main classes should allow for consistent assessments of state and services from local to national, regional and European scale. Information from a more detailed classification and at higher spatial resolution should be compatible with the European –wide classification and could be aggregated in a consistent manner if needed (Maes, et al., 2013).

The 1st MAES report (Maes et al., 2013) proposes a typology for ecosystem mapping based on the key databases available at EU level. At the same time, the typology should allow integration of assessments on national or sub-national levels based on more detailed classifications. According to MAES typology there are three major types of ecosystems at level 1: **terrestrial, fresh water** and **marine.** At level 2 the major ecosystem types are further subdivided (Table 3). The proposed typology combined the CORINE Land Cover (CLC) classes with the European Nature Information System (EUNIS) habitat classification types.

Table 3. General ecosystem typology

Level 1	Level 2	Level 3 EUNIS2 BG specific
Terrestrial	Urban	1 – 10 (10 subtypes)
	Cropland	1 – 5 (5 subtypes)
	Grassland	1 – 5 (5 subtypes)
	Woodland and forest	G1 – 4 (4 subtypes) (level 4)
	Heathland and scrub	F2,3,9 (3 subtypes)
	Sparsely vegetated land	1 – 5 (5 subtypes)
	Wetlands	D1,4,5 (3 subtypes)
Fresh water	Rivers and lakes	C,J,X (16 subtypes)
Marine	Marine The typology of marine ecosystems reduces the 3-dimensional structure of the ocean to the 2 dimensions of the seabed (benthic) habitats, attributing the 3rd dimension, the water column (pelagic habitats), to depth zones. Brackish water and marine ecosystems in the land-sea interface are grouped together in a single type.	1 – 8 (8 subtypes)

The 5 steps of elaborating the ecosystem typology in Bulgaria include:

Step 1 – Identify the ecosystem type - levels 1 and 2 MAES (Table 3)

Step 2 – Identify the ecosystem levels 3 and 4 of the given type

Step 3 – Collect data (national data sets)

Step 4 – Identify the gaps of data and areas with uncertainty of data

Step 5 – Mapping (Maps of ecosystem types) and monitoring of trends

6.3. The process of mapping and assessment of ecosystem condition and services in Bulgaria

Ecosystems can be mapped by building up a series of overlays of significant factors, such as the distribution of different communities of organisms, the biophysical environment (soil types, drainage basins, depth of water bodies) and spatial interactions (e.g. migration patterns). Ecosystem boundaries are likely to coincide with discontinuities in these factors. Thus, ecosystems within each category share a suite of climatic, geophysical and biochemical conditions, biological conditions (including species composition and interactions) and socio-economic factors shaping land cover (as dominant uses by humans tend to differ across ecosystems).

In Bulgaria, the ecosystems mapping and assessment process performed following a National Methodological Framework (Fig. 7), as a step-by-step process depicted in Fig. 8 below. The scheme and steps proposed by MAES (Fig. 9) were followed. The National Methodological Framework has to be extended and modified in order to follow the next steps as the ecosystem research evolves and relevant EU legislation and guidance documents are adopted.

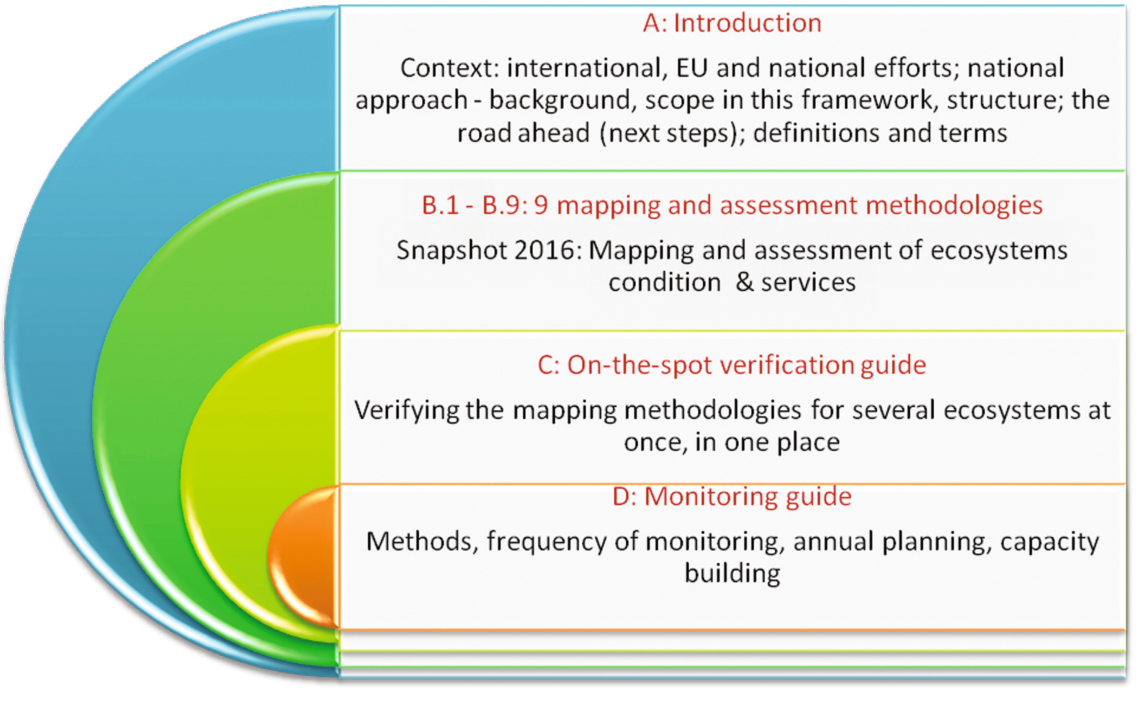


Fig. 7. Structure of the National Methodological Framework as of 2017. The parts of the framework are closely related and cross-references are made between its parts.

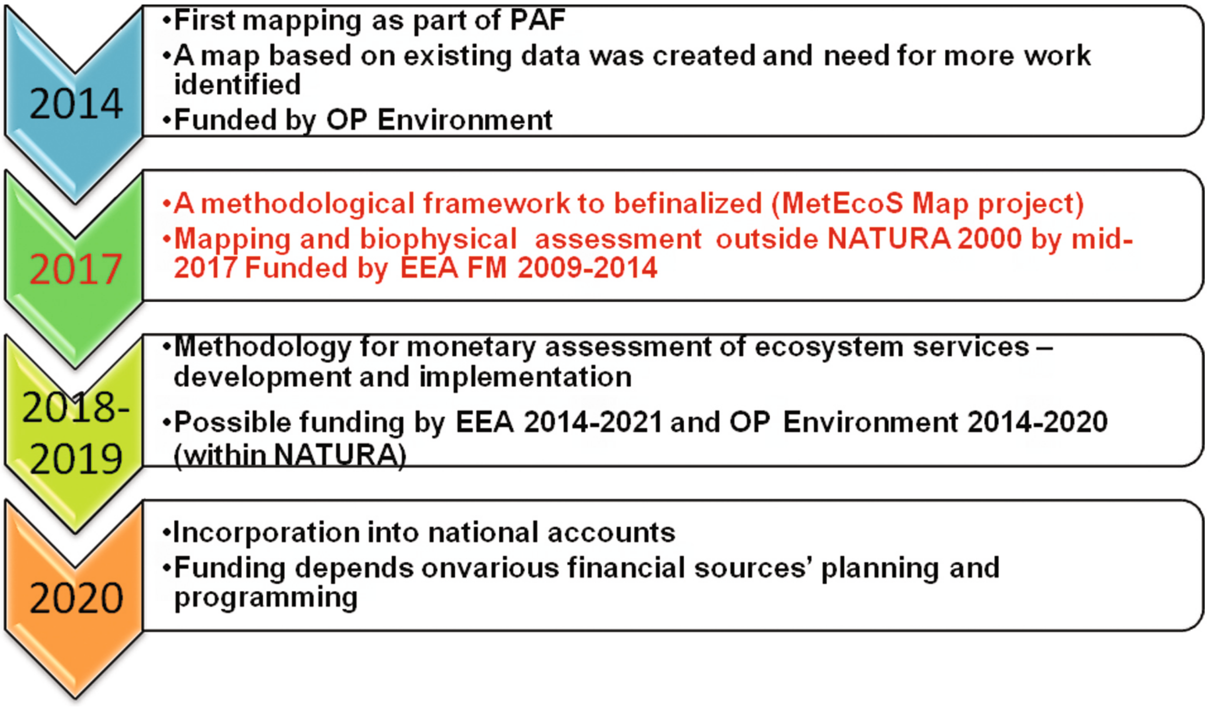


Fig. 8. The Bulgarian mapping and assessment process for ecosystems and ecosystem services (Timeline and steps in the Bulgarian ecosystems mapping and assessment process. The level of implementation corresponding to this version of the Methodological framework is Stage 2 (red font))

The legal basis for ecosystems mapping and assessment is contained in different pieces of EU legislation. The preservation of biodiversity and ecosystems as a horizontal topic emerges in a number of other legal provisions, such as the Water Framework Directive (WFD), Marine Strategy Framework Directive (MSFD), and the recently adopted Directive (EU) 2016/2284 of the European Parliament an of the Council of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC. With the development of Natural Capital Accounting, it is expected that further legal basis for the ecosystem accounting will be provided by Regulation 691/2011. On national scale specific provisions for the inventory and monetary valuation of forest ecosystems uses is provided by a dedicated chapter in the Forestry Act and its sub-legislation. Monitoring of a number of ecosystems components is regulated in the Environment Protection Act and its sub-legislation, as well as in the implementing legislation of related EU legislation, such as the Biodiversity Protection Act, the Water law and their sub-legislation. However, the inclusion of ecosystems monitoring as a holistic approach has not, so far, been part of these acts and it is to be expected that they will need to be modified appropriately and synchronously to each other, in line with the change of the relevant EU legislation.

6.3.1. Indicators of ecosystem condition

The overarching concept of the assessment of ecosystem condition in Bulgaria is the concept of ecosystem integrity (Fig. 7), defined in Kay (1991) and described in Burkhard et al. (2012). The key indicators for assessing condition within the ecosystem integrity concept should allow: Representation of key elements of ecosystem integrity, High sensitivity to environmental changes, Critical relevance for environmental modelling. The Bulgarian indicators vary from ecosystem type to ecosystem type, and are listed in part B.

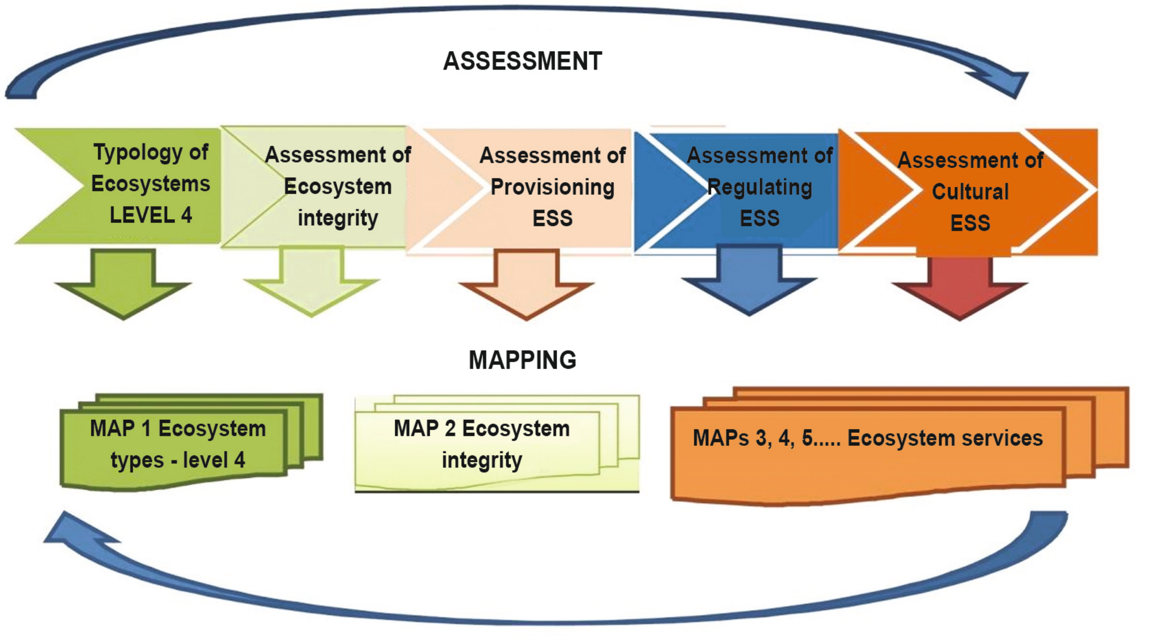


Fig. 9. General scheme of the assessment and mapping process

In order to achieve a holistic framework for ecosystem condition assessment (and management and/or protection) it is necessary to provide a comprehensive suite of indicators that adequately cover the structure and functioning of the entire ecosystem and its components at different hierarchical levels. In order to achieve this goal, we distinguished between structures and processes in the ecosystem.

An indicator can be defined most simply as *observed value* representative of a phenomenon under study. In general, indicators *quantify* or at least *qualify* information by aggregating different and many items of different data. The resulting information is therefore *synthesized*. It is recommended to distinguish between indicators as ecological components, i.e., ecological units, structures, or processes and as measures, i.e., properties of a phenomenon, body, or substance to which a magnitude can be assigned, and between descriptive and normative indicators (Heink, 2010). We distinguished indicators that describe the structure of the ecosystem in terms of its physical/chemical characteristics, while the biotic components are described according to the hierarchical levels: *population* and *community*. "Habitat" is defined as: *the total of all the environmental (i.e. physical/chemical) conditions present in the three-dimensional structural configuration occupied by an organism, population, or community*. Therefore it is considered a combination of the physical and chemical ecosystem components in combination with one or more of the biotic components, which are strongly associated with this physical/chemical environment or may even be the structural habitat agents. The functioning of the ecosystem is described at the ecosystem level. Altogether, this provides a generic framework that distinguishes the ecosystem components and processes and together covers all aspects of ecosystem structure and functioning.

6.3.2 Introducing the Index of Performance (IP) of ecosystems

In order to assess the condition of ecosystems in Bulgaria, scores are assigned (from 1 to 5) depending on the measured/assessed values of every indicator (by expert evaluation made during the preparation of Par B methodologies and applied during the mapping for each specific polygon), thus reflecting the "condition" of the process or the structure element of the ecosystem for which the indicator is relevant. The scores correspond to the scale from 1 (bad condition) to 5 (very good condition). In order to collate all separate indicator scores into one single measure of ecosystem structural-functional condition, we introduced an Index of Performance (IP) for a particular ecosystem. The IP is calculated as the ratio of the sum of the indicator scores to the maximum possible indicator sum:

$$\mathbf{IP} = \Sigma ni / \Sigma ni_{(max)}$$

Where:

Σni – sum of the scores, assigned to every indicator

$\Sigma ni_{\mathbf{(max)}}$ – sum of the maximum possible indicator score (score 5) for every indicator.

Thus, the **IP** indicates the overall condition of the ecosystem, as reflected by the separate indicator scores. The IP takes values between 0 and 1, according to the following scale:

IP = 0,00 ÷ 0,20 – very bad condition;

IP = 0,21 ÷ 0,40 – bad condition;

IP = 0,41 ÷ 0,60 – moderate condition;

IP = 0,61 ÷ 0,8 – good condition;

IP = 0,81 ÷ 1,00 – very good condition.

The IP index allows the use of a single measure of ecosystem condition (integrating all indicator values, both quantitative and qualitative) which can be then mapped.

Having in mind the complexity of ecosystems, the IP index is currently based on expert judgment and therefore presents a first approximation of ecosystem integrity in the context of the momentary condition being mapped. To improve the conceptual model's accuracy, multi-parameter modelling should be performed in order to identify the importance of single ecosystem condition indicators for the overall ecosystem condition, in line with the ongoing work at MAES and the single European bodies (European Environment Agency, the Joint Research Center). This will allow both to attribute more precise weights to the single indicators, and to establish the links between ecosystems condition and the ecosystem services produced (production function), therefore allowing for precise estimate of the ecosystems stocks and flows to be entered in ecosystems accounts.

6.3.3. Assessment, mapping and monitoring of ecosystem services

The current methodology and other relevant parts of the national methodological framework will contribute to the practical implementation of the ecosystem approach in the assessment of ecosystem services on a national scale:

Step 1: would be to list, using the CICES classification, the ecosystem services that could be supplied by a given ecosystem type. I**n the National Methodological Framework, Step 1 is to be developed in the nine methodologies by ecosystem type and their annexes.** Prioritization is made by expert assessment, based on the importance of the single indicators/parameters and data availability at the chosen scale.

Step 2: would be to list the components of the ecosystem or ecosystem mosaics that would supply each service or service bundle relevant to the respective landscape and purpose. Ecosystem components can include particular species, habitats, communities or functional groups (such as 'large trees' or 'pollinators'). For example, in woodland and forest ecosystems, the service of climate regulation through carbon storage would be provided by trees, soil, soil organisms, herbaceous vegetation and dead wood, but cultural services could be linked to particular iconic species, or forest ecosystems would need to be assessed in the context of their spatial context with other ecosystem types as landscape mosaics. **In the National Methodological Framework, Step 2 is to be developed in the nine methodologies by ecosystem type and their annexes.** Additional specification can be made following the provisions of the *In situ* verification guide.

Step 3: is to identify those components that make the greatest contribution to the service supply (i.e. the critical ecosystem components). Sometimes (as shown by Harrison et al., 2014) the critical components for a given ecosystem service will be just one or two species, habitats, communities or functional groups, but often multiple components play a role. However, for a manageable assessment, it will be necessary either to produce a consistent and precise model, or to select just a few key components. For some services, there may be critical ecosystem components that are common across a range of ecosystem types. For example, soil will contribute to carbon storage in all terrestrial ecosystem types, but trees will be the most critical ecosystem component in most woodland and forest ecosystems. **In the National Methodological Framework, foundations for Step 3 are laid in the Monitoring Guide.** Further work is needed for clarifying the relationships between ecosystems components and the provision of single services or service bundles (production functions). It is to be aligned to EU level research within MAES.

Step 4: is to establish the relationship between the condition (state) of the critical ecosystem components and the supply of the service, which is important in selecting the indicators used to assess condition on the basis of data from statistics, environmental monitoring or reporting under EU environmental legislation. For example, 'trees' would be a critical ecosystem component in the case of climate regulation in woodland and forest ecosystems, where tree biomass is proportional to carbon storage. This stage would therefore look at how tree biomass per unit area, and so carbon storage per unit area, depends on the condition of woodland and forest ecosystems (e.g. described by age class distribution per species), leading to the identification of indicators of woodland and forest condition from the most appropriate sources. Establishing the ecosystem condition–service supply relationship is more important when there are several critical ecosystem components involved in the supply of a given service, as aggregating their condition into one 'service supply' is not necessarily a case of simply adding them together. In most cases it may be difficult to find consistent quantitative indicators from the sources available and so qualitative indicators may have to be used. The choice of indicators will also be constrained by the available reporting data on habitats and species from EU environmental legislation, and, if these are inadequate, it would then be necessary to look at other sources of information available at the EU level. This applies to both condition (state) and pressure indicators (see step 6). **In the National Methodological Framework, foundations for Step 4 are laid in the Monitoring Guide.** Further work (in particular multivariate spatio-temporal modelling) is needed for clarifying the impact of drivers and pressures on the ecosystems components, trends in the ecosystems' condition and the provision of single services or service bundles (production functions).

Step 5 is divided into two parts:

Step 5a is the assessment of the baseline condition of the critical ecosystem components (i.e. ecosystem service supply) using the indicators from relevant EU environmental directives selected above. The 'status' assessments of these indicators are used to evaluate the ability of the critical ecosystem components to supply the ecosystem service of interest, in terms of whether the indicators 'pass' or 'fail' in meeting the objectives of the relevant directive (e.g. favourable conservation status). This would mean that the critical ecosystem component is in 'good' or 'bad' condition, respectively, and reflects its ability to supply the service of interest. In the example of carbon storage by trees, the main source of these status assessments would be the Habitats Directive for the condition of woodland habitats and tree species of interest (indicators), but often this information is incomplete, and other sources available at the EU level will have to be used, such as the EU Forest Strategy, although the sources chosen need to include some sort of target or status classification of ecosystem condition. **This work is performed within the seven mapping and assessment projects funded by the Programme BG03 “Biodiversity and ecosystem services” (for territories outside NATURA 2000) and will be performed with funding by OP Environment for the territories within NATURA 2000.**

Step 5b uses information on the pressures acting on ecosystems, the trends in those pressures and the link between pressures and condition to establish the potential impacts on the supply of the ecosystem service over time, at least qualitatively. **This is subject of the practical testing and adjustment of the Monitoring Guide in further projects, in accordance with the hypothesis presented in part 6 below.**

Step 6: Combining the above two steps (**Step 5a,b**) and aggregating all the critical ecosystem components along the state–service relationship (from step 4) would result in an assessment of the ability of the ecosystem to supply the service, also considering the DPSIR framework.

The final step will be to assign scores (by expert assessment) indicating the capacity of the given ecosystem to deliver a particular service – scores from 1 (very low capacity) to 5 (very high capacity)(for examples see Burkhard et al. (2012). Scores are assigned to the baseline and where possible, also to the monitoring measurements. A zero score means that the service is not relevant for this ecosystem. A baseline for this assessment is provided by **the seven mapping and assessment projects funded within the Programme BG03 ''Biodiversity and ecosystem services" (for territories outside NATURA 2000) and will be performed with funding by OP Environment for the territories within NATURA 2000.** The identification of trends is subject to the practical testing and adjustment of the Monitoring Guide in further projects.

7. The road ahead

Although the specific form, scope and timing of the steps listed below is to be decided on a policy level and in close collaboration with stakeholders, it is obvious that several measures have to be undertaken in order to close the loop between ecosystem condition assessment and the natural capital accounting that has to be in place by 2020. In the following, we list the necessary steps and provide a few proposals on how to address them.

Although they are included in strategic documents, notably the NATURA 2000 PAF, in the forest sector legislation and financed by several funding programmes, ecosystem services are not yet mainstreamed in the wider policy context in Bulgaria and the understanding of their potential as a policy instrument is vague. Misunderstandings lead to mixing up of ESS and economic categories (i.e. "tourism ecosystem services"). Despite the stakeholder work done in project MetEcoSMap, the seven mapping projects and project IBBIS, awareness raising activities with proper communication of this complicated topic are still much needed. A better understanding by stakeholders on all levels will allow to better structure the policy objectives to be addressed. In the absence of a clear policy context, the following sections outline proposed steps to mainstreaming ESS.

7.1. Need of further conceptual, scientific and practical work

The work on implementing the ecosystems approach is currently progressing in many directions. The most important challenges this simultaneous work puts to researchers, stakeholders and the society as a whole lie, in our view, in the need to combine and advance at the same time a wide set of very diverse activities:

1. Understanding the working mechanism of ecosystems, as described in length in the previous sections
2. Using and combining data of different sources, incomplete and insufficiently well matched, in order to reconstruct time series and approximate past and present states of the ecosystems. At present such data is used insufficiently or not at all when it is produced and held by different stakeholders, some of them under legal restrictions to share it in sufficient detail (i.e. statistics has to anonymize data for privacy considerations, populations of endangered but commercially interesting species ought not to be disclosed widely). There is a knowledge deficit about such "buried" data, and some of it is less detailed or not georeferenced at all. In addition, spatial data is produced at different scales and in different file formats; the need for transforming it before it can be used in modelling is prohibitively

high in terms of available human experts. Automating these tasks would lead to great gains in productivity, and presents a wide area of research in how to provide a coherent set of tools across all practical needs related to data discovery.

3. Creating/using/calibrating models, based on incomplete and insufficiently well matched data, that would be used to reduce monitoring costs and resource needs, complete the DPSIR assessments, and make sufficiently reliable predictions of ecosystems' trends and trade-off scenarios. Such models have to be interrelated and each of them to be optimized for solving specific tasks (such as comparison of scales, visual recognition from satellite and other remote observation imagery, comparing lesser resolution and higher resolution data to derive time series, interpretation, running trade-off scenarios, identifying trends, etc.). This area offers also a wide potential for future work having in mind the much better resolution provided by modern satellite imagery and the emergence of a number of derivative products based on remote sensing.

4. Redesign the monitoring process to collect volunteer data on biodiversity, abiotic factors and even ecosystem services' demand and actual use. The data provision does not need to span the entire gamut of possible information collection techniques which is arguably beyond the scope of most volunteers' engagement, time and/or capacity. Instead, people in different situations could be motivated to provide different inputs by seeing their role in a "big picture" of inputs to understand nature. Examples in this respect are presented both in the practical aspects by a number of strategy papers and practical guides on citizen science, and in the scientific community where the potential of volunteer inputs is being studied and gauged to innovative uses (Theobald et al., 2015; Bagstad et al., 2017). In Bulgaria, citizen science is mostly project funded and only few examples exist of species evaluations, whereas the use of citizen science on an ecosystems scale has not been attempted yet. The challenge is therefore twofold: to find and inventory sources of citizen science about Bulgaria *even if not produced by Bulgarian projects/volunteers), and to extend the existing species-focused citizen science approach along the lines of best practices in other countries, or EU wide. A good example of the latter is the Marine litter watch smartphone application of the European Environment Agency:

   https://play.google.com/store/apps/details?id=com.litterwatch

5. Better cost estimate and cost reduction of the ecosystems based monitoring and management considering the points listed above.

6. Efficient communication tools for mainstreaming the new findings of p. 1-5 above and ongoing dialog with different stakeholder groups. The objective should be making ecosystem services at least as familiar to all parties concerned as the climate change currently is.

7.2. Policy objectives and legislative regulation of ecosystems monitoring and management

As noted in the analysis of monitoring regulations that can be found in the Monitoring Guide, currently the ecosystems are being monitored not as a whole but in parts. Such information is undoubtedly valuable but clearly insufficient for measuring the ecosystem integrity, understanding the trends of its changes and the drivers behind such trends in the changing world, and finally mapping Bulgaria's natural capital in a spatially explicit manner.

Therefore, we propose:

1. That **ecosystems monitoring is recognized as part of the management activities within National environmental network as defined in Art. 3 of the Biodiversity law, as well as outside the protected areas and zones**. In particular, the following should be observed:

   1.1. Acknowledging the holistic approach in the core environmental legislation. In particular, the scope of Environment Protection Act currently contains the obligation to protect "the components of environment" (Art. 1, para. 3) but paradoxically, the protection of the compositions of such elements or entire environment may be construed as outside its scope, especially in the situation of budget shortages. This is also mirrored in the structure of the National system for environmental monitoring which is expressly dedicated to monitoring specific abiotic components, such as air, soils, rainfalls, surface and groundwater, as well as monitoring of forests, protected territories and biodiversity but does not include ecosystems monitoring at any scale, inside or outside the protected areas and zones. To achieve this, changes in some texts of the Environment Protection Act appear to be necessary, including the definitions and monitoring objectives (Art. 144-147). A similar situation exists in the legal texts about the control and management of factors that harm the environment (Art. 1, p. 4) which are also compartmentalized.

   1.2. **Adjusting the national monitoring to scale from species and habitats to ecosystems monitoring.**

   The structure of the national environmental monitoring system closely mirrors the structure of EU legislation being implemented. So far, the EU legislation does not make any mention of ecosystems monitoring, its scope, organization and line of reporting by member states. This legislative situation is reflected in the national legislation and organization of monitoring activities which still focus on single elements of environment rather than considering the big picture. Consequently, no funding is allocated for environmental monitoring. However, the ecosystems approach is being gradually implemented in other legislation, the latest example being the new National Emission Ceilings Directive (Directive (EU) 2016/2284 of the European Parliament an of the Council of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC) where the monitoring of emissions impact is to be performed on ecosystems level and not on species or habitats level.

Another potential problem is the division of environmental monitoring from environmental management in some areas. A notable example is forestry where monitoring is performed by Executive Environment Agency (ExEA) following the ICP methodologies but the management decisions and regulation of forest activities by private and public bodies, as well as the forest inventory and the valuation of some select ecosystem services is delegated to the Executive Forestry Agency (EFA). The existing good coordination between ExEA and EFA needs to be backed by a coherent legal framework if ecosystem monitoring is to become part of national legislation, in particular with regard to the special provisions of the forestry legislation that biodiversity studies **may be (but not necessarily are)** part of forest inventory and anthropogenic pressures are being assessed in relation to the hunting stock management (Ordinance Nr. 18/2015 on the inventory and planning of forest territories, Art. 25 and Art 124); also, the Forestry law foresees an assessment of ecosystem benefits (seen as subset of ecosystem services) which is to be integrated in the Natural capital accounting considerations once the respective ordinance is adopted, and other forest management activities prescribed by special law may also be of interest to the ecosystem monitoring (for example, forest health studies, wildfire protection action plans, erosion protection measures). Forest inventories further have the potential of yielding information about other ecosystems mixed into the forest areas since the inventory is to present information on objects such as mires and bogs, sparsely vegetated areas, meadows, etc. They can also be used for inferring DPSIR related information due to the information on ownership and management measures information in the inventory forms.

Similarly, well regulated and potentially informative as sources for ecosystems information but not, currently, compatible with the ecosystems approach, are other policies, such as agriculture, urban planning, coastal zones management. The proposed road is to create coherence between monitoring as a horizontal activity and the sectoral policy instruments in a manner that:

1.2.1. Considers the different data outputs of these policies as inputs for ecosystems based monitoring, and

1.2.2. Mandates the provision of such data by all relevant authorities for its processing (or possible mutual exchange via a data hub), and regulates the role of different stakeholders, the manner of re-use of existing information collected by various bodies, mutual sharing of information as appropriate, and its use.

1.2.3. Appoints a scientific body for processing the data thus collected in a manner similar to the monitoring designation made in Art. 171 (2) of the Water Law.

2. **Application of the same conceptual framework and approach within and outside the protected areas and zones**, in order to obtain compatible results. Based on the understanding that socio-ecologic systems are guided by the same principles everywhere and a uniform approach is needed as prerequisite for national capital

accounting, the present Methodological framework is the first document of national scope that does not make the distinction whether an ecosystem is or is not protected by law. Using the same approach, of course, does not preclude the considerations of legislative and management impact on the state of ecosystems; on the contrary, a consistently unified conceptual approach will create the base for better assessment of legislative impacts based on the comparison of state and development trends in similar ecosystems inside and outside the protected areas/zones.

3. **Application of the ecosystems approach to the creation of management plans.** Since the ecosystem as a natural phenomenon has a wider scope than both species and habitats and includes them, the direction of international research and international policy efforts suggest that ecosystems monitoring and management policies will increasingly provide important feedback on the conservation of species and habitats both in and outside NATURA 2000. It further has the potential to streamline the process of creating management plans for protected zones and areas. Currently, protected zones and territories may have management plans that ought to be updated fairly frequently – 10 years for most of the protected zones, and 5 years for protected wetlands. The experience of the last decades shows that creating management plans and their update is a process that faces many challenges due to difficulties in appointing the organization(s) who are to prepare the initial versions of the plans, as well as the diversity of stakeholders participating in this draft's review and the many controversies that these stakeholders engage in during the public consultations.

   Besides being anything but smooth, the process of creating management plans has so far not been subject to unification of the requirements to the end results. In the primary legislation, the only requirement to the plans' contents is that they contain measures to prevent decline in the conditions of natural and species' habitats, endangering and disturbance of species listed for the respective territory (Art. 29 of the Biodiversity protection law); the consideration of anthropogenic influence is optional and to be made where feasible. The corresponding sub-legislation – Ordinance on the condition and procedures for developing management plans for protected zones, promulgated by Ordinance of the Council of Ministers Nr. 349/30.12.2008, is largely concerned with the procedure of appointing the organization who will elaborate the plan, its public consultations and adoption but does not elaborate on the requirements. In this manner, the legislation leaves it mostly to the discretion of the Minister of environment which proposed structure and contents to approve for funding. This also means that lacking any legal framework, the Minister is vulnerable to political or other stakeholder attacks on the merit of the end product which can also objectively be missing some important pressures and therefore create the basis for the wrong management decisions.

   This discretionary principle is apparent also from the very different structure and content of the approved management plans. The assessment of pressures in the respective protected area or zone is made based on very different considerations. Since the anthropogenic factors are not mandatory for including in the management plans, the degree to which they are analyzed differs between plans. The structure of the plans is also different, with some of them being more academic in nature while other emphasize the conservation management aspects, and yet others are more or less heavily influenced by spatial planning considerations related to different stakeholders. We argue that including the ecosystems approach in the process of creating management plans will provide for a better reflection of the Response principle of the DPSIR framework and allow for improved coherence between ecosystems monitoring, ecosystems management, spatial planning, greening of the economy and sustainable development by providing stimuli for green innovations.

4. A further step in the same direction, in line with relevant legislative changes at the EU level, could be the **introduction of the ecosystems approach to compliance assessment of plans, programmes, investment projects in construction, activities and technologies and their modifications.**

8. Glossary

Assessment: The analysis and review of information derived from research for the purpose of helping someone in a position of responsibility to evaluate potential actions or think about a problem. Assessment means assembling, summarising, organising, interpreting and possibly reconciling pieces of existing knowledge and communicating them so that they are relevant and be helpful to an intelligent but inexpert decision-maker (Parson, 1995).

Biodiversity: The variability among living organisms from all sources, including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems (see Article 2 of the Convention on Biological Diversity, 1992).

Biophysical structure: The architecture of an ecosystem as a result of the interaction between the abiotic and physical environment and the biotic communities, in particular vegetation. Biotic: Living or recently living, used here to refer to the biological components of ecosystems, that is, plants, animals, soil microorganisms, leaf litter and dead wood.

Conservation status (of a natural habitat): The sum of the influences acting on a natural habitat and its typical species that may affect its long-term natural distribution, structure and functions as well as the long-term survival of its typical species (European Commission, 1992).

Conservation status (of a species): The sum of the influences acting on the species concerned that may affect the long-term distribution and abundance of its populations (European Commission, 1992).

Drivers of change: Any natural or human-induced factor that directly or indirectly causes a change in an ecosystem. A direct driver of change unequivocally influences ecosystem processes and can therefore be identified and measured to differing degrees of accuracy; an indirect driver of change operates by altering the level or rate of change of one or more direct drivers (MEA, 2005).

Ecological value: Non-monetary assessment of ecosystem integrity, health or resilience (TEEB, 2010).

Ecosystem: Ecosystems are defined in the Convention on Biological Diversity (CBD) as 'a dynamic complex of plant, animal and microorganism communities and their non-living environment interacting as a functional unit' (Convention on Biological Diversity, 1992). In the same context, ecological science defines ecosystem as a complex of living organisms (biotic factors) with their non-living physical environment (abiotic) and their mutual relations (Christopherson, 1997)

Ecosystem assessment: A social process through which the findings of science concerning the causes of ecosystem change and their consequences for human well-being and management and policy options are brought to bear on the needs of decision-makers (UK-NEA, 2015). EEA-39: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovenia, Slovakia, Spain, Sweden, Switzerland, Turkey and the United Kingdom, plus the six cooperating countries: Albania, Bosnia and Herzegovina, Kosovo under the UN SCR 1244/99, the former Yugoslav Republic of Macedonia, Montenegro and Serbia.

Ecosystem condition: The physical, chemical and biological condition of an ecosystem at a particular point in time. The capacity of an ecosystem to yield services, relative to its potential capacity (MEA, 2005). For the purpose of MAES, ecosystem condition is, however, usually used as a synonym for 'ecosystem state'.

Ecosystem degradation: A persistent reduction in the capacity to provide ecosystem services (MEA, 2005).

Ecosystem function: A subset of the interactions among biophysical structures, biodiversity and ecosystem processes that underpin the capacity of an ecosystem to provide ecosystem services (TEEB, 2010).

Ecosystem integrity: The combination of ecosystem states (state space) in which the ecosystem retains its ability of self-organization. (Kay, 1991).

Ecosystem service: The benefits that people obtain from ecosystems (MEA, 2005). The direct and indirect contributions of ecosystems to human well-being (TEEB, 2010). The expression 'ecosystem goods and services' is synonymous with 'ecosystem services'. The service flow in our conceptual framework refers to the services actually used by humans.

Green infrastructure: Defined as 'a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services' (Benedict, 2006).

Habitat: The physical location or type of environment in which an organism or biological population lives or occurs. Terrestrial or aquatic areas distinguished by geographic, abiotic and biotic features, whether entirely natural or semi-natural.

Indicator: Observed value representative of a phenomenon under study. In general, indicators quantify or at least qualify information by aggregating different and many items of different data.The resulting information is therefore synthesised.

Natural capital: The System of Environmental-Economic Accounting (SEEA). Experimental Ecosystem Accounting (EEA) defines ecosystem assets as spatial areas containing a combination of biotic and abiotic components and other characteristics that function together. Components of the natural capital include non-renewable abiotic assets (such as minerals, elements, fossil fuels), renewable abiotic assets (such as solar, wind or geo-thermal energy), as well as ecosystems capital consisting of assets (spatial areas providing ecosystem functions), and ecosystem services flows (provisioning, regulation and cultural services used by humans).

Natural capital accounting: An internationally-agreed method to account for material natural resources, as described in SEEA EEA (UNSD, 2012).

Pressures of change: Pressures alter the condition of ecosystems and, on consequently, affect their service capacity, habitat quality and biodiversity across Europe.

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