

A methodological framework for mapping and assessment of ecosystem services provided by the natural heritage in Bulgaria

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ABSTRACT

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Natural heritage (NH) includes natural features that can be described as outstanding universal value at a national level. It refers to the importance of ecosystems, biodiversity, and geodiversity for their existence value, and the ecosystems can be considered as the spatial units for its mapping and assessment. The ecosystem services (ES) concept provides an appropriate basis in the form of assessment and mapping methods that enable linking the state of ecosystems with human well-being. Thus, it can be used as a platform to find solutions to the problems related to the conflicts between conservation and the use of the NH. In this paper, we aim to present the process of developing a methodological framework for mapping and assessment of ecosystem services provided by the natural heritage in Bulgaria for recreation and tourism. The conceptual framework of the ecosystem-based assessment of NH in Bulgaria is based on the assumption that the generation of NH for the needs of tourism can be presented as the linkages between the natural systems and tourism in the form of ES potential, flow, and demand. The results demonstrate that the NH can be presented as a spatial phenomenon conceptualized by the flows of benefits from ecosystems to people which contribute to human well-being. The mapping and assessment procedures are fully developed for application at a national level, while for the regional and local level, few pilot studies mark some basic foundations for further development.

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1. Introduction

Natural heritage (NH) includes natural features consisting of physical formations, geological features, and physiographical formations, natural sites, or precisely delineated natural areas of outstanding universal value from the point of view of science, conservation, or natural beauty (UNESCO 1972). The outstanding universal value at a national level can be described with the term “natural significance”. It refers to the importance of ecosystems, biodiversity, and geodiversity for their existence value and incorporates both biotic and abiotic elements. Thus, the ecosystems can be considered the spatial units representing the NH of the particular area in terms of their values to people (Ihtimanski *et al.* 2020). The NH can be related mainly to cultural services, such as outdoor recreation, tourism, cultural heritage, aesthetic experiences, but also to some regulating services, such as maintenance of habitats and local climate regulation as well as to some provisioning services such as water supply and crop production. These services provide significant input for many public and business sectors, especially for tourism and recreation, which rely very much on the NH for their functioning. Both tourism and recreation have an important role in human well-being and health. They provide physical, regulatory,

and cultural benefits and offer an opportunity to experience a direct relationship with nature. On the other hand, they also have a negative impact on ecosystems, necessitating finding approaches for sustainable use of the NH. The ecosystem services (ES) concept provides an appropriate basis for assessment and mapping methods that enable linking the state of ecosystems with human well-being. Thus, it can be used as a platform to find solutions to the problems related to the conflicts between conservation and the use of the NH. This necessitates the development of a methodological framework for mapping and assessment of the services provided by the NH.

Ecosystem assessment is defined as a social process through which the findings of science concerning the causes of ecosystem change, their consequences for human well-being, and management and policy options are brought to bear on the needs of decision-makers (UK NEA 2011). The methodological frameworks which focus on assessment are usually simplified in nature and consist of boxes covering the core activities associated with the actual assessment (Brown et al. 2018). The methodological framework for mapping of ecosystems and their services (MAES) provides typology for ecosystems, a set of indicators for assessment of ecosystem condition, and mapping of ES (Maes et al. 2013). The main elements of the framework which cover the core activities are presented in the conceptual scheme developed within the frame of the ES MERALDA project (Burkhard et al. 2018). This scheme is further developed into an integrated ecosystem assessment (IEA) framework, which builds on this by placing core elements within a broader set of activities that an assessment practitioner might want to undertake depending on the mandate and scope of the ecosystem assessment being undertaken (Brown et al., 2018). The MAES framework is used as a basis for other mapping, and assessment approaches focused on particular themes such as the multitiered approach for grassland ES (Villoslada et al., 2018) and the methodological approach for valuation at the national level in Czechia (Vačkář et al., 2018). The framework in Bulgaria includes nine methodologies corresponding to the main ecosystem types in MAES typology with a uniform structure, including third-level ecosystem typology, the mapping of ecosystem types, assessment of ecosystem condition, and assessment of ES (Zhiyanski et al., 2017; Nedkov et al., 2017; Bratanova-Doncheva et al., 2018). The MAES methodology gives the general framework for mapping and assessment of ES while the others focus on specific themes. However, no methodology can incorporate ES provided by NH and link it with recreation and tourism activities.

The main aim of this paper is to present the process of development of a methodological framework for mapping and assessment of ecosystem services provided by the natural heritage in Bulgaria. It describes the working process and summarizes the most relevant initial outcomes: (i) identification of ES related to recreation and tourism; (ii) identification of the objects of NH as an element of ecosystems; (iii) assessment of the potential of ecosystems to provide ES for recreation and tourism; (iv) integrated platform to support policy and decision making.

2. A conceptual framework for ecosystem-based assessment of NH in Bulgaria

2.1. Natural heritage, ecosystem services and tourism

Natural heritage can be described as a spatially explicit natural element of the social-ecological system, which incorporates material and spiritual values recognized by previous, present, and future generations (Nikolova et al., 2021c). The natural elements have their origin in the natural systems in the form of biotic and abiotic components. The natural systems at a different level of scale can be recognized as ecosystems (at a larger scale) or landscape (at

a smaller scale). A natural element becomes part of the natural heritage when it is recognized by people as a source of material or spiritual values. At the ecosystem or landscape level, these values can be represented as "the benefits people obtain from ecosystems" (MA, 2005). Therefore, the natural heritage can be conceptualized by the flows of benefits from nature to people. This logical chain is represented very well by the ecosystem services cascade model (Haines-Young et al., 2012; Haines-Young and Potschin, 2010) where the ecosystems and biodiversity in form of biophysical structures and functions generate services that contribute to human well-being in form of benefits and (economic) values. In this study, we focus on one specific aspect of human well-being which is tourism. The flows between the natural and social systems are reverse and can be conceptualized by the ES supply and demand. Burkhard et al. (2014) argue that it is important to distinguish between the potential supply and actual flow of ES. Therefore, the ES supply can be divided into ES potential (the hypothetical maximum yield of selected ES) and ES flow (de facto used set of ES). Thus, the generation of NH for the needs of tourism can be presented as the linkages between the natural systems and tourism in the form of ES potential, flow, and demand (Fig. 1). As is mentioned above, the natural heritage has clearly distinguished spatial dimensions. Therefore, every activity related to the mapping and assessment of the services provided by NH necessitates spatial data and a set of tools to manipulate them as well as appropriate means to reach the end-users. Thus, we designed a geospatial platform that can facilitate all phases of the work leading to sustainable evidence-based tourist products (Fig.1).

2.2. A conceptual scheme of ecosystem-based assessment of NH in Bulgaria

The core elements of the methodological framework for mapping of ecosystems and their services (MAES) are: 1) mapping of ecosystems; 2) assessment of ecosystem condition; 3) mapping and assessment of ecosystem services. However, every ecosystem assessment has to be relevant to a certain theme and address a broad range of questions pertaining to decision-making processes that occur at different levels of decision-making and across different actors of society (Burkhard et al., 2018). Therefore, the specifics of each element should be related to a certain theme. The first element includes the identification of ecosystem types and their mapping. The identification of ecosystem types should be relevant to a particular theme and consistent with the region of the study. The mapping could be based on CORINE Land Cover data, remote sensing data, national datasets, or modeling results and the choice depends again on the theme and also on the data availability. In our case, the identification of the ecosystem types should be relevant to the specifics of the NH in Bulgaria and its potential use in tourism. The assessment of ecosystem condition includes identification of relevant ecosystem condition aspects, selection of indicators, ecosystem condition indicators quantification, and mapping of ecosystem condition (Burkhard et al. 2018; Brown et al. 2018). In our case, it is necessary to start with the identification of elements and objects of the NH. The second step is the conceptualization of NH at the ecosystem level and the selection of indicators for the condition of NH at the ecosystem level. The last step is the assessment of ecosystem condition in relation to NH. The mapping of ES includes identification of ES delivered by ecosystems, selection of indicators, quantification of these indicators, and mapping. The identification of ES related to NH can be done by prioritization based on the CICES classification (Nedkov et al., 2021). The next three components are more or less similar to the general framework proposed by Burkhard et al. (2018) (Fig.2). The core elements of the proposed conceptual

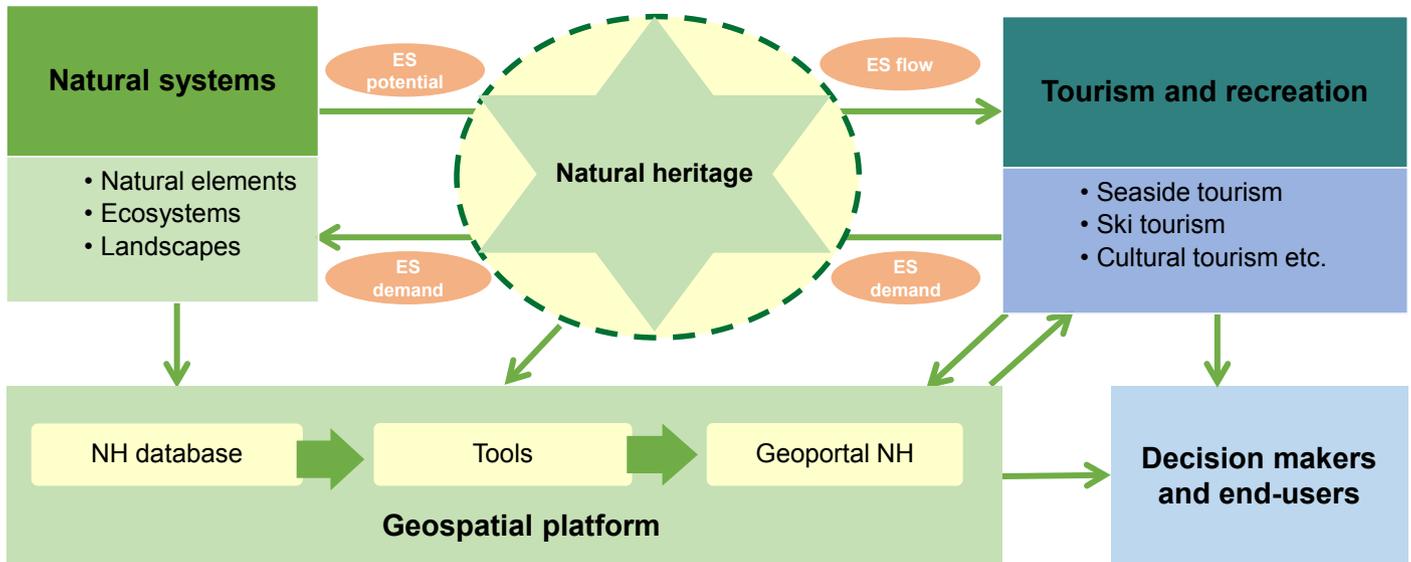


Figure 1. A conceptual scheme for ecosystem-based assessment of NH in Bulgaria for the needs of recreation and tourism.

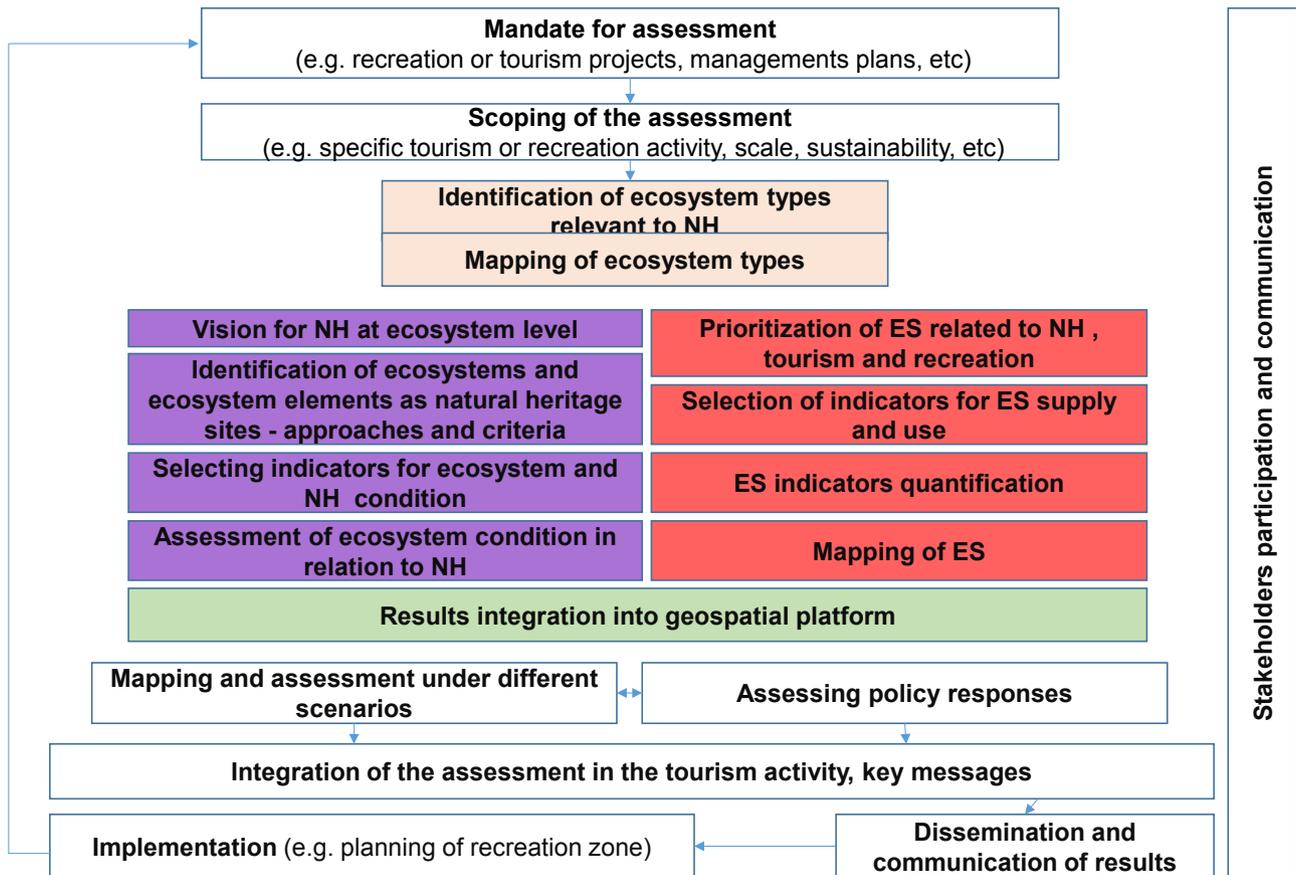


Figure 2. Conceptual scheme of an integrated ecosystem-based assessment of the NH for the needs of recreation and tourism in Bulgaria (based on Burkhard et al. 2018; Brown et al. 2018).

scheme (Fig.2) correspond to the linkages between natural systems and tourism through NH and ES potential, flow, and demand presented in Fig.1. Following the scheme of IEA proposed by Brown et al. (2018), we developed a sequence of “post-mapping” activities that are based on the use of the geospatial platform as integration, communication, and information tool (Fig.2).

2.3 Mapping and assessment of ES provided by NH at multiple scales

Maps of ES are made for a broad set of purposes including ecosystem assessment, decision support, priority settings, ecosystem accounting economic liability, etc. The main requirements for ES maps are reliability, accuracy, resolution, and clarity, whose importance

varies according to the mapping's purpose (Jacobs et al., 2017). The main purpose for mapping the ecosystem services provided by the NH in Bulgaria is decision support for the management of tourism and recreation activities at the national (country), regional (district), and local (municipality) levels. According to the methodological framework for mapping and assessment of ES in Bulgaria (Bratanova-Doncheva et al., 2017; Zhiyanski et al., 2017), ES maps should be prepared for the whole country on map sheets based on EEA reference grids at a scale of 1:125 000. The main requirements for such maps are clarity and reliability (Jacobs et al., 2017). The results from previous studies show that they are too large for national scale decision support and that they are too coarse and not sufficiently reliable for the local scale (Nedkov et al., 2019). Therefore, it is necessary to apply a more flexible approach to prepare appropriate maps at each scale and for the different decision-making purposes.

3. Methodology

3.1. Identification and mapping of ecosystem types

The methodological framework for mapping and assessment of ecosystems and their services at a European scale proposes a coherent typology which is designed: (i) to be used for the different types of broad ecosystems and; (ii) to be considered in the assessment to ensure consistency across the Member States (Maes et al., 2013). Information from a more detailed classification at higher spatial resolution could be combined with the European-wide classification and could be aggregated in a consistent manner. The typology is organized in two main levels and its structure enables CORINE Land Cover (CLC) data to be applied for spatial delineation. It is also adjusted with the European Nature Information System (EUNIS) habitat types, where necessary, to ensure that further subdivisions in the countries would be performed in a uniform and compatible manner. The first level is defined as "major ecosystem category" and includes three main classes: 1) Terrestrial; 2) Freshwater; 3) Marine. At the second level the major categories are subdivided into more detailed subclasses according to the character of their biophysical features 1) Urban; 2) Cropland; 3) Grassland; 4) Woodland and forest; 5) Heathland and shrub; 6) Sparsely vegetated land; 7) Wetlands. This typology is further developed in the methodological framework for mapping and assessment of ES in Bulgaria at the third level (subtypes) based on different sources for the nine ecosystem types (Bratanova-Doncheva et al., 2017; Zhiyanski et al., 2017). These subtypes were defined also in correspondence with EUNIS habitat classification (Davies et al., 2004). The mapping is made separately for each ecosystem type and it does not cover the whole country. Therefore, the results of MAES mapping in Bulgaria are still not applicable at a national level. One possible solution for this problem is to apply the classification at the third level using the CORINE Land Cover data. It is too coarse for local and even for regional-scale but at national scale, it is just fine. The CORINE classes were correlated to the ecosystem subtypes to develop a relevance table (Hristova and Stoycheva 2021). The correlated classes were incorporated into the CORINE GIS data and the resulting dataset is appropriate for mapping ecosystems in Bulgaria at the national scale. However, at the regional and local scale, more detailed and reliable sources are needed. The Forest Inventory database at the level of subdivisions provides good

quality data for forest ecosystems which are appropriate mapping units for this ecosystem type (Dodev et al., 2021).

3.2. Identification and condition assessment of NH at an ecosystem level

This methodological framework is entirely derived from the specificity of the project¹ within which it was developed: it aims to unleash the potential of geo-information services to increase knowledge and education on the value of natural heritage by stimulating the use of associated recreational ecosystem services. This feature determines the logic and characteristics of the proposed methodological steps.

3.2.1. Vision for NH at an ecosystem level

Based on the above-mentioned understanding of "natural heritage" (section 2.1.), the Methodology applies the systems approach by identifying, grouping, and assessing NH sites from the perspective of (Borisova 2020): At the intra-system level - the Methodology highlights the role of that component in the ecosystem which is the primary source of its distinctive "inherited" features but assesses "Natural Heritage" as the complex result of the interaction of all available factors and components in the formation and functioning of that ecosystem. On this basis, the Methodology assumes a consistent involvement in the analysis of diverse thematic information on environmental factors - physical, biotic, socio-cultural. At the inter-system level and in terms of the geographic scale of analysis and management of NH - the Methodology identifies ecosystems: 1. As an independent ecosystem, which in its entirety is a NH or includes in its composition a specific object/objects, carriers of NH, or 2. As a spatial composition of ecosystems, which in their spatial contiguity are carriers of NH (most clearly illustrated by the group of cultural landscapes commented below).

On this basis, the final results are related to the spatial highlighting of: 1. Distinct ecosystems, incl. sites within their range, with diverse genesis - carriers of NH; 2. Territorial combinations of heterogeneous ecosystems and elements within their range; 3. Integrated combinations of different types of NH sites with cultural heritage sites, including the urban environment. In terms of information provision, it should be pointed out that the Methodology is directly linked to the working environment of the developed GIS-based information platform for providing geo-information services. The proposed methodological approaches and operational steps are oriented towards thematic and/or complex extraction of targeted information from the information layers in the project database according to set criteria. This aims at forming spatially constrained and novel information with respect to the ecosystems and objects - NH sites, known to us so far. Thus, in addition to information on "ecological significance", information on the "spatial integration" of the NH sites is also extracted, which is essential for the subsequent assessment of their condition and potential to provide ES.

3.2.2. Identification of ecosystems and ecosystem elements as natural heritage sites - approaches and criteria

This methodology applies a selection of criteria reflecting both: 1. The biophysical perspective - natural heritage as a result of the natural formation of the distinctive features of an ecosystem/ ecosystem element (ecological representation) - expressed primarily

¹ "Conceptualization, Flexible Methodology, and a Pilot Geospatial Platform for Access of the Bulgarian Natural Heritage to the European Digital Single Market of Knowledge and Information Services" within the project BG05M2OP001-1.001-0001 Establishment and Development of "Heritage BG" Centre of Excellence (Operational Program "Science and Education for Intelligent Growth", priority Axis 1 "Research and technological development")

through the characteristics of physical and biological diversity; and 2. Cultural perspective - features of the NH derived from human actions: direct and purposeful human intervention in the formation of the relevant ecosystem (cultural representation), and human perceptions: societal or individual human preferences or subjective perceptions regarding a given ecosystem/ecosystem element (Borisova 2020).

The specific selection of criteria and parameters for identification is aimed at effectively reflecting the following significant aspects of the Natural Heritage: 'uniqueness', 'naturalness', 'diversity', 'cultural identity', and 'belonging to a particular system'. The significance of NH sites is assessed based on the following themes: 1. Ecological significance and conservation value; 2. Scientific and educational relevance; 3. Public importance: The site has a recognized and well-established role in terms of human health and psycho-physiological comfort; sacral and religious value; national symbol and national identity; proven and lasting cultural and/or historical significance over time; a source of inspiration for culture and art. Along with the identification criteria mentioned above, the methodology provides for the evaluation of the sites in accordance with additional significance criteria directly related to the formation of new values and the acquisition of traits of 'heritage'. Such a criterion is 'Proven and/or promising (business) potential for the purposes of the recreational and creative industries'. The following aspects have been taken into account here: 1. Prospective use of the site in terms of innovation and technology; 2. Prospective use in terms of recreation, sport, tourism; 3. Sites that are, or have the potential to be, at the heart of brand development.

On this basis, the methodology differentiates 4 groups of ecosystems and ecosystem elements - natural heritage sites in Bulgaria. The first group includes ecosystems identified in accordance with established international standards and criteria of national importance. These are : UNESCO World Heritage sites and UNESCO Man MaB Biosphere Reserves; Ramsar sites; protected sites under the National Protected Areas Act, the Biodiversity Act, the Medicinal Plants Act, the Water Act, and the Cultural Heritage Act. The first group also includes sites identified in thematic national and regional scientific databases, such as the Register and Inventory of Geological Phenomena in Bulgaria (edited by Sinyovsky 2009). The remaining three groups bring together sites that do not fall within the scope of the criteria for national and supranational significance, but have a role as "natural heritage" at a regional or local scale of impact. These are: 1. Biodiversity sites: The options developed include analysis of available data on Habitat Diversity, Flora and Fauna; 2. Geodiversity sites: based on analysis of Relief, Rocks, Water and Climate as natural factors - the primary sources of the features of the NH acquired in the course of evolutionary or cultural development of the territory; 3. Cultural landscapes: Landscapes - the product of traditional forms of land use; Urban landscapes integrating elements of NH or forming new ones; Landscapes of which cultural heritage sites are an integral part.

The choice of a GIS-based environment to power the geo-information platform raised specific methodological challenges related to the correct interpretation of diverse spatially georeferenced information and the fact that essential dimensions of the concept of 'heritage' may remain outside the operational capabilities of the working environment. For example, geo-sites or forest ecosystems may have sacred significance to society at local to regional scales, but without marks of distinctiveness in their origin or visual characteristics. In the context of the above - the methodology implies an active integration of literature data, data from historical-geographical studies, expert assessments from thematic studies or spatial analyses for the purpose of strategic territorial planning, etc.

3.2.3. Ecosystem condition in relation to NH

The topic of the assessment of the condition of ecosystems carrying natural heritage features is again directly related to the diversity and specificity of available data. Two possibilities are recognized here: 1. Sites in the first group (validated sites according to international standards and national criteria) are sites with conservation status. It is assumed that their ecological status is controlled by the relevant protection regimes and can be assumed to be favorable to the ecosystems' potential to provide ecosystem services. Regular ecological monitoring is available for these sites from the responsible institutions at the Ministry of Environment and Water and the Executive Environment Agency, whose data can be used for assessment purposes if necessary. 2. For the sites in the other three groups (Biodiversity, Geodiversity, and Cultural Landscapes) the condition assessment mechanisms used in the national ecosystem assessments in Bulgaria (outside Natura 2000) are applicable (Bratanova-Doncheva et al 2017).

3.3 Mapping and assessment of ES

3.3.1. Prioritization of ES related to NH, tourism and recreation

The mapping and assessment of ES includes identification of ES delivered by ecosystems, selection of indicators, quantification of these indicators and mapping. For the identification of ES related to NH we propose a prioritization approach. It aims to identify the ES and rank them according to their significance for recreation and tourism (Nedkov et al., 2021). It is a process of selection and differentiation of services into priority groups based on particular criteria. We propose application of ES prioritization matrix (ESPM) and a five-step algorithm designed to facilitate the mapping and assessment of ES provided by the NH. The differentiation of ES into priority levels is applied in order to: i) arrange the ES according to their significance to recreation and tourism and; ii) apply mapping and assessment of ES at multiple scales (national, regional, local). As a result of the prioritization, the ES based on CICES classification were divided into three groups: 1) high priority (15 services); 2) medium priority (15 services); 3) low priority (9 services) (Nedkov et al., 2021).

3.3.2. Selection of indicators for ES supply and use

Ecosystem service quantifications need a variety of information and long-term time series and data quality, which very often is not available to the extent required, so often only a small group of potentially representative variables can be used as indicators (Muller and Burkhard, 2012). The assessment of ecosystem services provided by NH requires analysis of all potential sources of data and the ecosystem parameters that can be represented by each of them. Furthermore, we analyzed the results from the identification NH elements and their conceptualization at ecosystem level as well as the relevance to recreation and tourism. For the mapping and assessment at national scale we adopted three main criteria applied for the choice of indicators for each individual service: (i) relevance to recreation at ecosystem level; (ii) NH elements related to the particular individual service and; (iii) ecosystems related to the particular individual service. The relevance to recreation is an important criterion to define the aspects which should be taken into account for the choice of indicators. For instance, the relevance of the cultivated crops has two main aspects. First, as a food supplier for the tourism industry, that relies very much on the surrounding areas especially for fresh fruits and vegetables. Second, as a basis for development of specific kind of tourism such as culinary tourism, healthy eating activities, plants growth as element of the cognitive

tourism etc. The NH elements related to particular service are selected from a classifier for identification of NH.

3.3.3. ES indicators quantification

The different ES need different data and resources for their assessment, which necessitates a particular approach for each individual service. This problem could be solved by implementing a tiered approach, which makes ecosystem services maps comparable across scales and can support the mapping for various purposes (Maes et al., 2014; Grêt-Regamey et al., 2015). It consists of three tiers, and both the level of detail of input data and the complexity of the analysis increase from tier 1 to tier 3. Following this approach, we have allocated the indicators and the methods for their quantification in accordance with the data availability and the level of details into these three tiers. Tier 1 includes the indicators with no uniform data at the national level, the assessment is based on data derived from the ecosystems spatial database and expert judgment. The indicators at tier 2 are provided with statistical data or biophysical parameters at the national level that could be interpolated using GIS spatial proxy analyses. The indicators at tier 3 are selected for more detailed analyses by modeling biophysical processes. They are applicable predominantly at local level, but there are also some indicators which can be supplied by data at national level. For instance, the assessment of the outdoor recreation can be assessed at national level using freely available data and the application of the ESTIMAP model (Ihtimanski et al., 2020).

3.3.4. Mapping of ES

ES maps quantify and visualize where and to what extent ecosystems contribute to human well-being (Burkhard and Maes 2017). To represent ES provided by NH in a spatial context, it is necessary to define both where ES are generated and where they are used. There are several methods that have been developed to map ES supply (potential or flow) and demand for ES (Burkhard et al. 2012). In the context of the mapping and assessment framework it is important to clarify the place of the spatial units outlined during the phase of ecosystem mapping (see the light-orange part of Fig.2). In some cases, when the quantification of ES is performed within the frame of the ecosystem types, the mapping should be based on these spatial units. However, there are methods for quantification which use different spatial patterns and the results are more or less different from the spatial outline of the ecosystem types. In this case, it is not necessary to integrate the results into the spatial frame of the ecosystem types. Such integration would decrease the quality of the result and increase their uncertainty. This is especially valid to modeling results which have inherited uncertainty as typical characteristic of this mapping method.

3.4. Integration in the geospatial platform, policy and decision making aspects

An integrated ecosystem assessment considers the condition of ecosystems and their capacity to deliver ES by bringing together these ecosystem assessment approaches and then linking the results to human well-being (Burkhard et al., 2018). These results should be relevant and accessible not only to the ES community, but also to broader audience. Therefore, they need to be organized in an appropriate manner and to be translated into information that is understandable for decision-makers and end-users from policy, business and society. The mapping results need also an appropriate platform for storage and visualization of spatial data. The geospatial platform (Fig.2) is designed to facilitate all phases of the ES mapping and assessment process and can meet all these needs. It is designed

to serve as a data storage, processing, analysis and visualization of spatial data which represents all aspects of the NH. Furthermore, the platform enables generation of information products directed to various end-users. These functionalities are designed to contribute to the adequate and successful positioning of the Bulgarian NH on the national and European market of digital products and services (Dimitrov, 2020). The platform has four interrelated components: 1) Module for inventory of information sources; 2) Geoinformation system “NH”; 3) Analysis and modeling module; 4) Products and information resources, generated in the platform. The module for inventory contains a database in the form of a register of information sources characterizing the category of natural heritage. The register aims to support the organization of primary information and the sources for its provision. The geoinformation system “NH” is built on the basis of a GIS server application with a three-tier service-oriented architecture that will provide the collection, processing, analysis and visualization of geospatial data and geospatial information of various NH elements. Through the application of standardized geographic information services, it enables sharing of different categories of products with potential users, which include both institutions and business entities, as well as individual users. The analysis and modeling module contains tools that ensure the implementation of the necessary spatial analysis and modeling operations that can be applied to geodata to generate information to supply geographic information services supported by the geoinformation platform. The main functionalities of this module include database queries, reclassification, spatial overlay functions and spatial modeling tools. The products that can be generated by the platform are geodata, map mashups and story maps.

4. Results

4.1. Mapping and assessment at national scale

4.1.1. Interlinkages between NH, ecosystems, ES and tourism

The prioritization of ecosystem services provided by NH for the needs of recreation and tourism resulted in identification of 15 high priority services that should be obligatory for each mapping and assessment activity at national level. The relevance of each of them to the tourism activities at ecosystem level was explored and the results are given in table 1. The provisioning services (I-IV) have mainly supporting function for the tourism by providing food and water as well as some specific benefits such as use of animal mechanical energy for attraction purposes. The Regulating services provided by NH (V-VIII) ensure good conditions for the tourism activities in the form of healthy environment for recreation, maintenance of the elements of NH, provision of climate comfort and microclimate with healing properties as well as some specific benefits such as means for extreme tourism development. The cultural ES have the most important links with the tourism activities as it is an integral part of this group of services. The relations vary from provision of recreation environment to interaction of natural elements and conditions for cognitive activities. The predominant part of the services (nine) has two obvious links with tourism. Four services have just one link and the other two services have more diverse linkages to tourism that reach to the number of four.

Another important characteristic that determines the mapping and assessment procedures is their relevance to the ecosystem types. The number of ecosystem types related to particular ES varies between 1 and 9 (all ecosystem types). The provisioning services in general are related to less ecosystem types (1 to 4) while the regulating services have quite different relations to a number of ecosystem types. The regulation of pollution (V) and natural

Table 1. Relevance between the high priority ES and tourism.

| No | High priority ES | Relevance to tourism at ecosystem level |
|------|--|--|
| I | Cultivated plants and animals used for nutrition | 1. Food supply for tourism industry; 2. Basis for development of specific tourism activities (culinary tourism, healthy eating activities, plants growth as element of the cognitive tourism etc |
| II | Wild plants used for nutrition | 1. Consumption of wild plants as additional attraction for tourists; 2. Collecting herbs and wild berries as motivation for hiking |
| III | Animals reared to provide energy | 1. Use of animal mechanical energy for attraction purposes; 2. Development of specific tourism activities (horse riding tourism) |
| IV | Surface water for drinking | 1. Drinking water for tourism industries; 2. Sacred waters for pilgrimage tourism; 3. Mineral water balneotherapy tourism |
| V | Regulation of pollution | 1. Provides healthy environment for recreation |
| VI | Regulation of natural hazards | 1. Maintaining the NH elements in good condition; 2. Factor for development of specific kinds of tourism |
| VII | Maintaining populations and habitats | 1. Maintaining the biodiversity components of NH in good condition for tourism; 2. As a source for ecotourism |
| VIII | Local climate regulation | 1. Provision of climate comfort; 2. Microclimate with healing properties |
| IX | Conditions for recreation by biotic systems | 1. Provision of recreation environment; 2. Provision of sports environment; 3. Provision of environment; 4. Conditions for cognitive activity |
| X | Science and education value | 1. Scientific value for tourism; 2. Provision of environment for outdoor education |
| XI | Cultural heritage | 1. Components of ecosystems that are deeply related to the local culture, way of life, traditions, rituals, cuisine, local breeds, etc. |
| XII | Aesthetic experiences | 1. Visual, sensitive and intellectual interaction with the natural elements of ecosystems as a factor for attracting tourists |
| XIII | Symbolic and spiritual value by biotic systems | 1. Biotic components of ecosystems that have a symbolic meaning; 2. Biotic components of ecosystems that have spiritual significance |
| XIV | Conditions for recreation by abiotic systems | 1. Provision of recreation environment; 2. Provision of sports environment; 3. Provision of environment; 4. Conditions for cognitive activity |
| XV | Symbolic and spiritual value by abiotic systems | 1. Abiotic components of ecosystems that have a symbolic meaning; 2. Abiotic components of ecosystems that have spiritual significance |

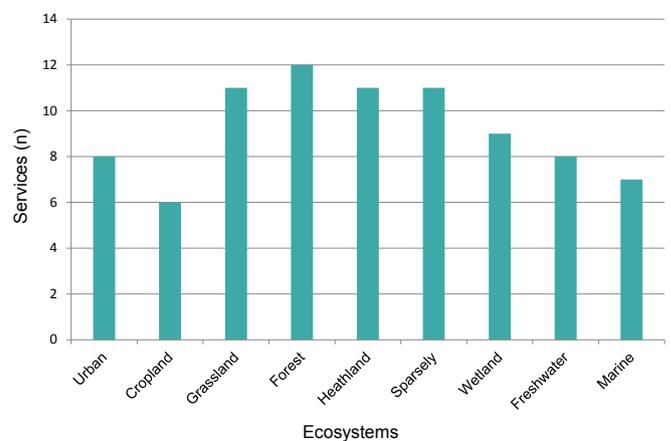
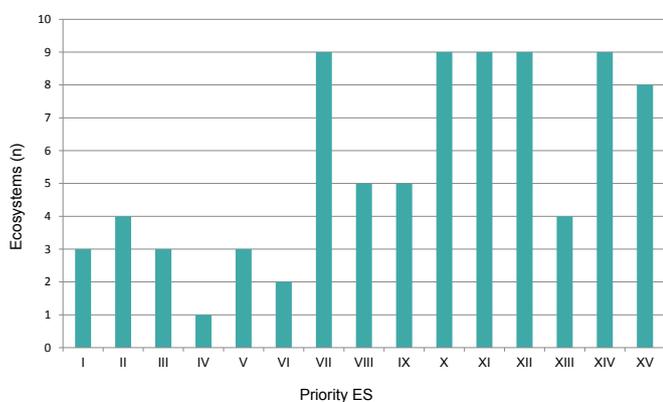


Figure 3. Number of ecosystems related to the high priority ES

Figure 4. Number of ecosystems related to the high priority ES

hazards (VI) have low number of links (2-3), the local climate regulation (VIII) is related to five ecosystems while the maintenance of populations and habitats is related to all ecosystem types. The cultural services are related to most of the ecosystem types with the exception of condition for recreation by biotic systems (IX) and symbolic and spiritual value by abiotic systems that had links to five

and four ecosystem types respectively.

The opposite relation from the ecosystem types to the high priority ES is presented in Fig.4. The results show that no ecosystem type is linked to all ES. The forest ecosystems have the highest number of links to 12 ES, while the cropland ecosystems are linked to the lowest number of ES (6).

4.1.2. Available indicators and methods at national scale for mapping and assessment of NH

At the current stage of the development of the methodology a total of 39 potential indicators for assessment of the high priority ES at national level were proposed by the experts working in this study (Table 2). Appropriate methods for each indicator at different tiers were assigned. Next, these indicators were ranked into four categories following the quality label scheme proposed by Maes et al. (2016). The high quality label (green) is assigned to indicators that can rely on freely and easy available data and methods which ensure mapping and assessment at appropriate level of quality. The medium quality label (yellow) is assigned to indicators that could not rely on available data within this study due to the lack of resources but can be ensured for further studies. The low quality label (red) is assigned to indicators that could not be supplied due to the lack of data at national level or lack of appropriate methods which could give appropriate results. The unknown quality label (grey) is assigned to unknown availability of reliable data without appropriate methods for assessment and mapping.

4.1.3. Expert based mapping and assessment at a national level

Expert based assessment corresponding to methods at tier 1 (Table 1) was applied for mapping of the potential of NH to supply ES for recreation and tourism. The mapping was performed by widely used matrix approach. The ecosystem subtypes derived from the CLC land cover data (Hristova and Stoycheva 2021) were used as spatial units in the left column of the matrix. The total number of ecosystem subtypes was 28. Nine priority ecosystem services (I, II, V, VIII, X, XI, XII, XIII, XIV – Table 2) were placed in the first row of the matrix. The choice is based on the analyses of the data available for quantification of the indicators at tier 2 and 3. The selected services were those with less available data, therefore the expert based assessment was the only possible method for mapping at the national level at this stage of the study. The scores in the matrix were given by experts asked to estimate the potential of the NH of each ecosystem subtype to provide ES. The average scores summarized for ecosystem types revealed the highest potential of NH in the forest ecosystems (Table 3). However, the value (3.41) corresponded to medium potential which means that there was no

Table 2. Indicators and methods for mapping and assessment of NH at national scale. The colors of the methods correspond to the scale proposed by Maes et al. (2016), green – high quality; yellow – medium quality; red – low quality; grey – unknown quality (the name of high priority ES are given in table 1). LCZ – Local Climate Zone.

| ES | Potential indicators | Methods tier 1 | Methods tier 2 | Methods tier 3 |
|------|--|-----------------------------------|----------------------|----------------------------|
| I | 1. Capacity for provision of agricultural products; 2. Climate/soil condition | 1. Expert Ass. by type/subtype | | 2. Climate/soil model |
| II | 1. Capacity of the ecosystem to provide herbs and forest fruits; 2. Climate condition | 1. Expert Ass. by type/subtype | | 2. Climate/elevation model |
| III | 1. Capacity for provision of mec. energy; 2. Number of animals | 1. Expert ass. by type/subtype | 2. Statistics data | |
| IV | 1. Capacity for provision of water; 2. Available water bodies; 3. Available underground water; 4. Available mineral water | 1. Expert ass. by type/subtype | | 2-4. Spatial proxy |
| V | 1. Capacity of the ecosystem to remove pollutants and other harmful substances; 2. Area presence; 3. topography/vegetation analysis | 1. Expert ass. by type/subtype | 2. Statistics data | 3. Spatial proxy |
| VI | 1. Capacity for water flow regulation and flood protection; 2. Capacity for regulation of climate hazards; 3. Area presence | 1, 2. Expert ass. by type/subtype | 3. Statistics data | |
| VII | 1. Capacity for habitat maintenance; 2. Hemeroby index; 3. Protected areas; 4. Protected sites and species | 1. Expert ass. by type/subtype | | 2-4. Spatial proxy |
| VIII | 1. Capacity of ecosystems for microclimate regulation; 2. LCZ index | 1. Expert ass. by type/subtype | | 2. LCZ model |
| IX | 1. Capacity of the ecosystem to provide space for recreation; 2. Hemeroby index; 3. Protected areas | 1. Expert ass. by type/subtype | | 2-3. ESTIMAP |
| X | 1. Capacity of the ecosystem; 1. Number of publications; 3. Provision of environment for education activities | 1. Expert ass. by type/subtype | 2-3. Statistics data | |
| XI | 1. Capacity of the ecosystem elements to provide material for local culture | 1. Expert ass. by type/subtype | | |
| XII | 1. Aesthetic value of the ecosystem; 2. Number of photos | 1. Expert ass. by type/subtype | | 2. InVEST |
| XIII | 1. Symbolic value of the biotic elements; 2. Spiritual value of the biotic elements | 1, 2. Expert ass. by type/subtype | | |
| XIV | 1. Capacity of the ecosystem to provide space for recreation; 2. Water bodies; 3. Elevation | 1. Expert ass. by type/subtype | | 2-3. ESTIMAP |
| XV | 1. Symbolic value of the abiotic elements; 2. Spiritual value of the abiotic elements; 3. Unique rocks | 1, 2. Expert ass. by type/subtype | 3. Statistics data | |

Table 3. Average scores of the expert assessment by ecosystem type.

| Ecosystem type | Average scores |
|----------------------------|----------------|
| 1. Urban | 1.11 |
| 2. Agricultural | 2.35 |
| 3. Grassland | 2.31 |
| 4. Heathland and Shrubs | 2.60 |
| 5. Forest | 3.41 |
| 6. Sparsely vegetated land | 2.09 |
| 7. Wetlands | 2.24 |
| 8. Rivers and lakes | 3.46 |
| 9. Marine | 3.13 |

ecosystem type assessed by high potential by the experts. The scores per forest ecosystem subtypes varied from 3.71 (Broad-leaved forest) to 2.86 (Broad-leaved coppice forest). The lowest scores were given to the urban ecosystems which have quite low potential to provide ecosystem services for recreation and tourism. The scores per urban

ecosystem subtype varied from 3.1 (Urban green areas) to 0.15 (Dump sites).

The average scores per ecosystem services revealed that there was no single service with clearly defined high potential. The scientific and educational value (3.25) and aesthetic values (3.23) had the highest scores but they were still in the category of moderate potential. However the scores of some services in particular ecosystem subtype had values corresponding to very high potential. The regulation services provided by broad-leaved ecosystems were assessed by the maximum score of 5. The same score was given to Cultivated plants and animals used for nutrition in the subtype Annual crops.

The results from the expert based assessment enabled us to prepare maps of ecosystem services provided by the natural heritage in Bulgaria at a national scale. The maps of three selected provisioning, regulating and cultural services -visualize quite different patterns of ES potential throughout the country. The areas with high potential of the provisioning service are located in the northern and south-eastern parts of the country where the topography is predominantly flat and the agriculture ecosystems are widespread. The regulating service has just the opposite pattern with higher potential in the southern and central mountainous areas. The cultural service has higher overall potential with slightly higher values in the mountains.

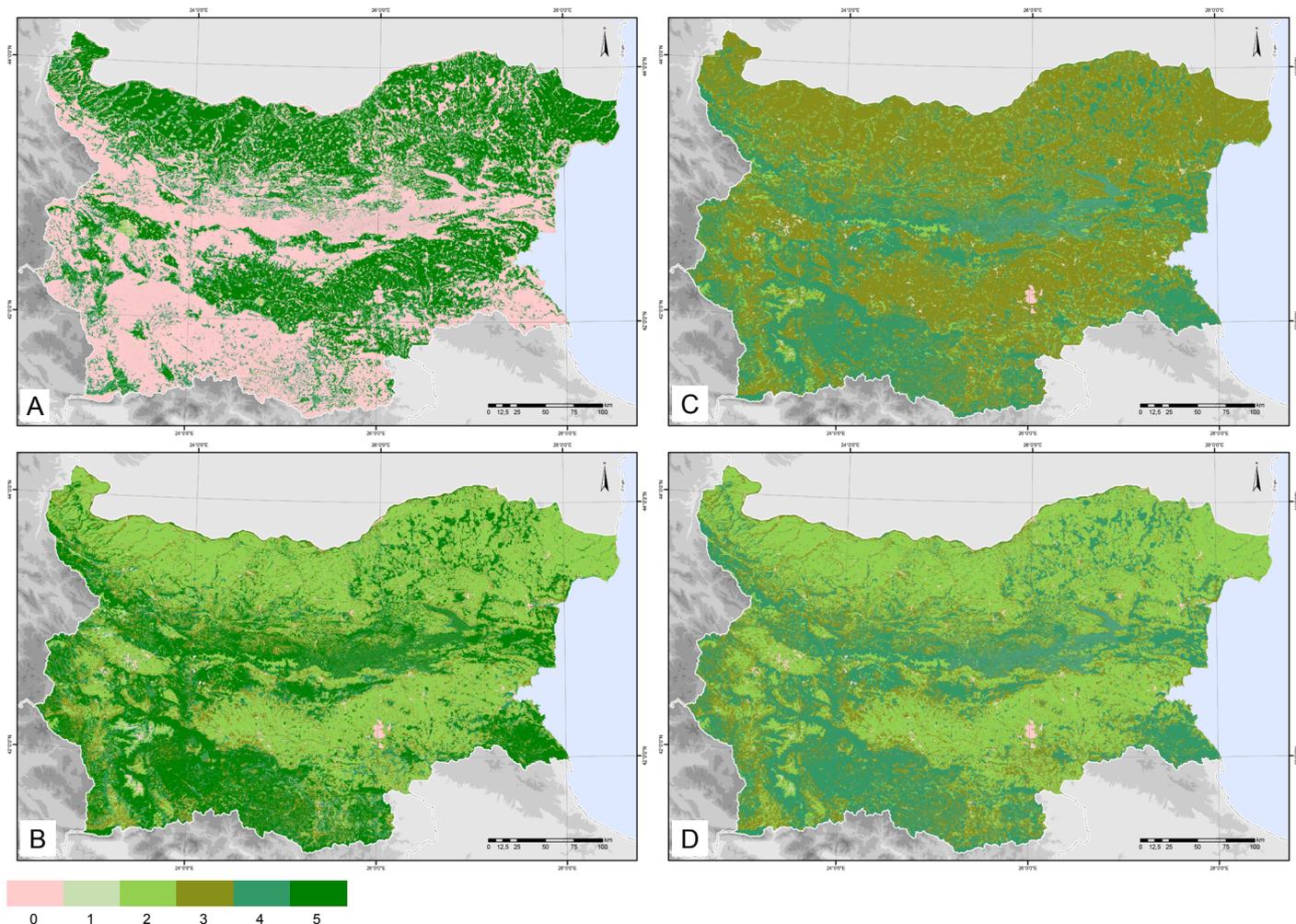


Figure 5. Maps of the potential of the NH for selected ecosystem services and an integral potential of the nine assessed services: A - I. Cultivated plants and animals used for nutrition; B - VIII. Local climate regulation; C - XI. Cultural heritage; D - All ES. Legend: 0 – no potential; 1 - very low potential; 2 – low potential; 3 – moderate potential; 4 – high potential; 5 – very high potential.

4.2 Indicators and methods per thematic pilot studies at regional and local scale

The methodological framework at regional and local level is still to be developed. Here we synthesize the first attempts to apply the ecosystem services in NH assessment for particular tourism activities in several case studies throughout the country. The six case studies provide valuable information how the methodological framework can be applied for specific tourism activities in different natural and social-economic conditions (Table 4.). The case studies vary from administrative units at different levels (district and municipality) to protected areas (national park) to specific natural areas. Two of the case studies are focused on the assessment of ES for the needs of specific tourism activities such as forest therapy and speleological tourism. One of them makes the assessment for a range of tourism activities (hiking, ski, nature education tourism). The other two have broader view on the tourism activities and assess the potential of specific ecosystem types (forest and urban) for tourism in general. Most studies are focused on one or two ES and only two cover bundle of services. Forest ecosystems are the most frequently studied ecosystem type. The mapping units are different for most of the studies and only the forest subdivisions are used in two studies. The indicators used in the studies vary from 2 to 25 and all of them are derived specifically for the particular study. Expert based assessment and spatial proxy are the most used methods which determine tier 1 and 2 as predominant.

5. Discussion

The work on the development of a methodological framework for mapping and assessment of ecosystem services provided by the natural heritage in Bulgaria –provides the means for: (a) establishing the structure, analytical framework, and the conceptual approach for mapping of ES provided by NH; (b) gathering knowledge and test how the freely available data can be used to apply the methodology at the national scale; (c) testing the applicability of the methodology in case studies at a local and regional level. The indicators framework at the national level proposed in this study as well as the testing phase

using easily available data -are based on the experience gained from the implementation of the MAES process in Bulgaria and the efforts of researchers from different disciplines. Such a joint effort guarantees that the scientific achievements based on ecosystems could support policy and decision-making in the fields towards sustainable use of the NH in recreation and tourism activities. However, it has still some shortcomings that lead to a number of additional challenges which need to be addressed in future works.

First, the conceptualization of NH at the ecosystem level is based mainly on theoretical assumptions that need to be further tested in studies focused on particular ecosystem types and case studies. The inventory and classification of the NH objects are almost finalized and their links to the ecosystem types are used for the assessment of the ecosystem services. But, it is necessary to explore the linkages between the ecosystems and the objects of the NH in more detail so as to reveal the spatial arrangements within the spatial units used for ES mapping. Secondly, the indicators drawn in this study rely too much on expert assessment, which is a fast and easy but quite subjective method. Thus, the current results are limited to application for general planning purposes at a national level. The search for new indicators and methods which will ensure quantification at tier 2 and 3 with higher accuracy and lower uncertainty is very much needed. For instance, the use of freely available satellite data from Sentinel2 could be a valuable source for deriving various parameters for both ecosystem condition and services (Sarafova, 2021).

6. Conclusion

This paper demonstrates that the NH can be presented as a spatial phenomenon conceptualized by the flows of benefits from ecosystems to people which contribute to human well-being. We developed a methodological framework for mapping and assessment of the ES provided by natural heritage for one specific aspect of human well-being which is tourism. It is designed to ensure integrated ecosystem-based assessment of the NH for the needs of recreation and tourism in Bulgaria and incorporates the main principles of the MAES framework (Maes et al., 2013; Burkhard et al., 2018; Brown

Table 4. Summary of applications of the methodological framework at regional and local level. *The ES are studies at the level “section” from CICES classification; **The study is focused on caves which are located mainly in forest areas. FUA – functional urban area.

| Case study | Tourism | ES (n) | ES | ES types | Mapping units | Indicators (n) | Method/s | Tier | Reference |
|---------------------------------------|--|---------|--------------|--------------------------|----------------------------------|----------------|---|---------|--------------------------------|
| Velingrad Municipality | General | 2 | XI, XII | Fr | Forest subdivision | 2 | Spatial proxy, photoelucidation | 2, 3 | Zhiyanski et al., 2021 |
| Smolyan Municipality | Forest therapy | 1 | XV | Fr | Forest subdivision | 22 | Expert score, spatial proxy, GIS modeling | 1, 2, 3 | Dodev et al., 2021 |
| Maliovica Range, ‘Rila’ National Park | Hiking, Nature education, Tourism, Ski touring | 10 (15) | All cultural | Urb, Fr, Gr, Sp, Rl, Wt, | Landscapes | 25 | Expert score, spatial proxy | 1, 2 | Silvestriev et al., 2021 |
| FUA Burgas | Biodiversity | 1 | VII | Urban | Urban Atlas Landover/ GRID units | 5 | Spatial proxy, species data | 2 | Semerdzhieva and Borisova 2021 |
| Strazhata and Melovete | Recreation, Ecotourism | 2 | IX, XIV | All | Landscapes | 7 | Expert-based scores, Spatial proxy | 1, 2 | Prodanova 2021 |
| Smolyan Dystrict | Speleological tourism | 6 | All* | Fr** | Caves | 7 | Expert-based scores | 1 | Nikolova et al., 2021b |

et al., 2018). The mapping and assessment procedures are fully developed for application at a national level while for the regional and local level few pilot studies mark some basic foundations for further development.

A set of indicators for mapping and assessment at a national level are proposed and the methods for their quantification are arranged following the tiered approach. They allow producing ES maps for the priority ES which can be used for planning purposes in sustainable tourism. However, substantial data gaps remain to be filled before a fully integrated and complete ecosystem-based NH assessment can be carried out which is in line also with the findings at the European level by Maes et al. (2014). The indicators at regional and local level can be supplied by higher resolution and quality data but some of them have a limited extent and the data processing needs more resources. The pilot studies for several tourism activities such as forest therapy, speleological tourism, hiking, and ski touring demonstrate the potential of the methodology.

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