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Research Article

How individual scores affect the final expert-based assessments of ecosystem services: Range and mean scores analysis of natural heritage supply maps

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Abstract

Ecosystems representing the Natural Heritage (NH) are considered in this study as an important source of ecosystem goods and services for human well-being. On that spatial base, we conducted an expert-based assessment and mapping of their potential to provide ecosystem services (ES) for recreational purposes in Bulgaria. Twelve experts participated in the expert-based assessment by filling individual matrices for the potential of the NH to provide ES. We analysed the results i.e. individual scores by comparing them, and calculating the minimum, the maximum and the range scores between them. We calculated the mean individual experts' scores by ecosystem types and subtypes for nine prioritized ecosystem services for recreation – 2 provisioning, 2 regulating and 5 cultural. The results show that individual experts have different perceptions for some ecosystems and their services due to their different scientific expertise. This follows from the quite high ranges i.e., 4 or 5 units between maximum and minimum score per spatial unit. There are: (i) significant variations in scoring of Grasslands, Wetlands, Croplands, Rivers and lakes, and Urban ecosystems; and (ii) considerable similarities about Woodland and forest, Sparsely vegetated lands and Marine ecosystems. To compare the spatial discrepancies between the experts' scores, we map them individually. A final integrated map represents the potential of the NH in Bulgaria to provide ecosystem services for recreation with an average score above 3.00. The main outcomes of our study are the analyses we made on the individual and the group experts' scores.

Highlights:

- Experts have different perceptions for some ecosystems and ES due to different scientific expertise

- There are significant variations when scoring Grasslands, Wetlands, Croplands, Rivers and lakes, and Urban ecosystems

- There are considerable similarities when scoring Woodland and forest, Sparsely vegetated lands, and Marine ecosystems

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1. INTRODUCTION

Expert-based assessments are one of the most common approaches when it comes to assessing ecosystem services. For the last 10 years, the most used approach for expert-based assessments and mapping has become the matrix approach (Campagne et al., 2020). Originally developed by Burkhard et al. (2009) the matrix represents a "look-up table" (Campagne et al., 2017) where experts score the capacity of ecosystems to provide ecosystem services based on their knowledge about a selected area of interest. The matrix approach could be used in a tiered assessment since it was further developed by Burkhard et al. (2012) for that purpose in a particular case study for Malki Iskar River Basin in Bulgaria. In practice, the usage of look-up tables, allows researchers to assess different spatial units at various scales and characteristics. The most commonly used spatial units are the ecosystems and the land use land cover (LULC) layers. Ecosystems could represent the Natural Heritage and to be considered as an important source of ecosystem goods and services for human well-being.

Moreover, according to Nedkov (2017) and Nikolova et al. (2021a) the ecosystem services concept provides a scientific framework, which links the natural heritage with the social system. In addition, Nikolova et al. (2021b) note that the ecosystem approach is recommended for maintaining a good balance between the potential of the natural heritage to provide cultural ES and the need for recreation.

Hence, the research gap is how to apply the matrix approach and the expert-based assessment into mapping and assessment of the potential of the natural heritage to provide ecosystem services. This study seeks to address this gap and propose a new methodological approach for use of expert-based assessment.

Campagne et al. (2020) have analyzed more than 110 studies using the ES matrix approach to assess ES supply, demand or flows/use. The findings of their paper suggest that the number of the studies using the ES matrix approach has increased more than 10 times for the last 10 years (until 2019). Various studies applied the matrix approach for different assessments, for example in abandoned agricultural lands (Anpilogova and Pakina (2022), cross-border assessments (Sieber et al. 2021), local scale assessment (Nedkov et al 2017, Grigorov, 2021, Zhiyanski et al 2021), experimental mapping (Prodanova,2021), a tiered approach of urban ecosystems (Nedkov et al., 2018), and for studying the recreational ecosystem services from stakeholders' perspective by (Seijo et al. 2021, Bezak and Bezakova, 2014). Some of these studies, such as Jacobs and Burkhard (2017), Roche and Campagne (2019), Ma et al. (2019), Perrenes et al. (2020), Sieber et al. (2021) have analyzed the perceptions of different groups of people for ecosystems and the services they provide. Campagne et al. (2020) discussed that more comparative analyses are needed to explore different contexts of expert scoring to strengthen the applicability of the ES matrix approach. This paper addresses this gap and explores how the experts with various expertise across the Earth sciences influence the mapping and assessment of natural heritage.

The main objectives of the research are to:

(i) Mapping and asses the NH potential to provide ecosystem services for recreation with an application of expert-based matrix approach;

(ii) Analyze the differences between experts' assessments scores;

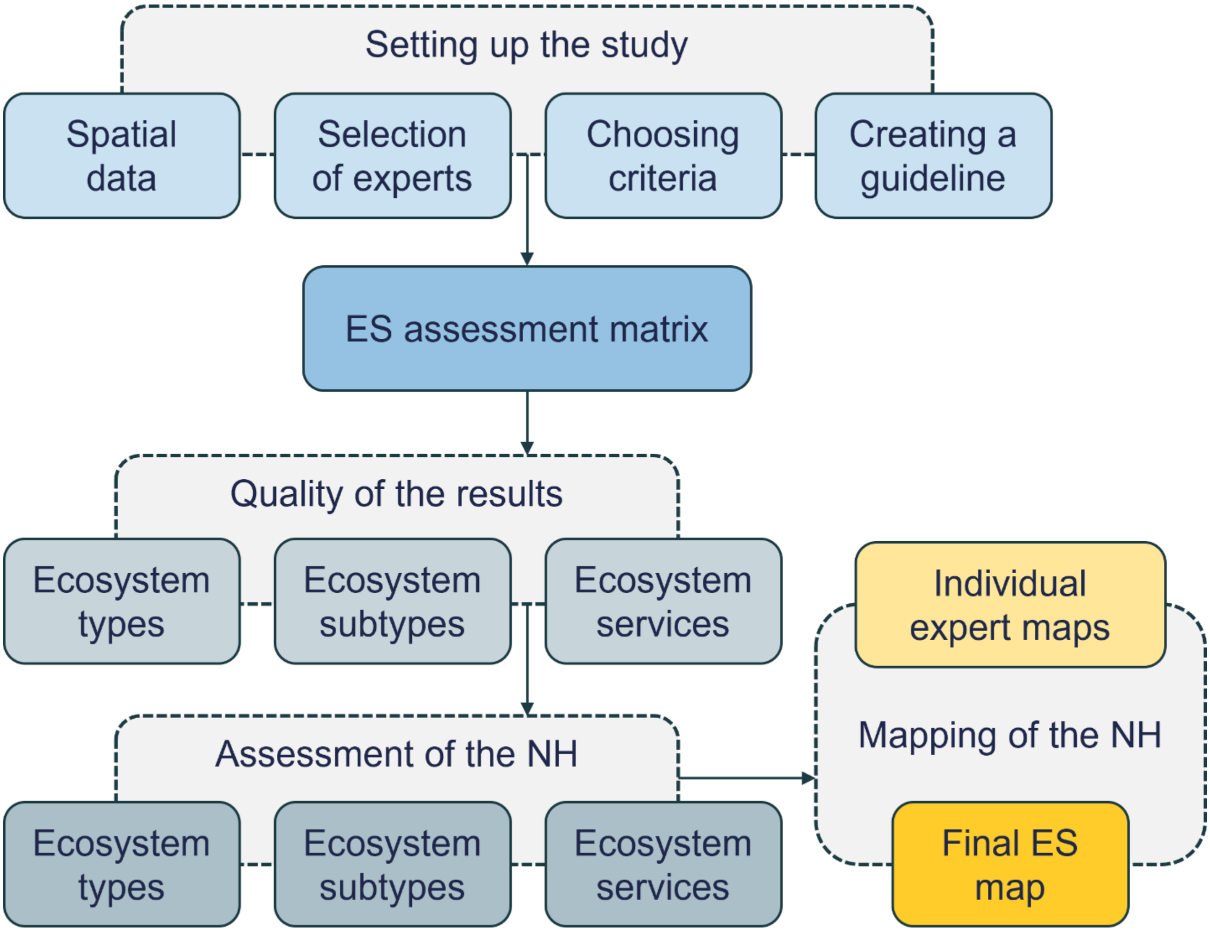
(iii) Evaluate the quality of the results and the application of the matrix approach into NH potential assessment.

The paper proposes a novel and original methodology that will contribute to the wider academic literature on subjective components of the ecosystem services experts-based assessments. Its implementation allows to reveal the variations between experts scores depending on the experts' experience and their field of study.

2. MATERIALS AND METHODS

Research on how individual scores affect the final expert-based assessments of ecosystem services was conducted in four main stages: 1) setting up the study; 2) analysis of the quality of the results; 3) assessment of the natural heritage; and 4) mapping of the natural heritage (see Fig. 1). The first stage of the study is described in the following methodological subparts, the second, third and fourth stages are presented in the results section.

Figure 1. Flow diagram of the study.



2.1. Case study area

Bulgaria is located on the Balkan Peninsula in South-Eastern Europe (Figure 2). It borders Romania to the north, Greece and Türkiye to the south, Serbia and North Macedonia to the west, and the Black Sea to the east. Bulgaria covers a total area of 110 994 km² which equals about 22% of the Balkan Peninsula (Penin, 2007). The main geomorphological regions, coincide with the principal morphographic regions, and namely: The Rila-Rhodope Mountain massif (A), the Transitional region of mountains and basins (B), Stara Planina Mountain chain system (C), and the Danube plain (D) (Zagorchev (2009). Bulgaria is located between the south periphery of the temperate climate zone and the subtropical Mediterranean climate zone - thus determining importance on the climate, water, soil and vegetation diversity (Kolev, 2002). The dominant Continental air masses, the Mediterranean and Oceanic air masses, in combination with the complexed relief are main factors forming various climate conditions. The average annual temperatures vary between 11 and 13 °C, and the average annual precipitation varies between 450-1300 mm. More than 540 rivers form the national freshwater resource belonging to 2 main drainage areas – Danubian to the north and Aegean to the south. Soil and vegetation diversity is very rich (Soil map of Bulgaria, 1956; Bondev, 1991). Typical soil types in Bulgaria are Umbrisols, Leptosols and Cambisols, according to the soil map of Bulgaria (Hristov and Filcheva, 2017).

As spatial units that we used in the study, we selected previously driven and published data for the ecosystem types of Bulgaria by Hristova and Stoycheva (2021). In general, it presents a refined classification of the ecosystem types and subtypes based on the MAES and the CORINE Land Cover 2018 (Figure 2 and Table 1). A total number of nine ecosystem types and 28 ecosystem subtypes are represented according to Hristova and Stoycheva (2021). Two woodland and forest subtypes were indexed with "G1" instead of using G2. The reasons for that are that: (i) G2 is not represented in Bulgaria, and (ii) the Bulgarian MAES team working on the forest methodology differentiates between seed and coppice forests. Both subtypes correspond to the same species.

Figure 2. Location of the case study area in South-East Europe and distribution of the spatial units (ecosystem types).

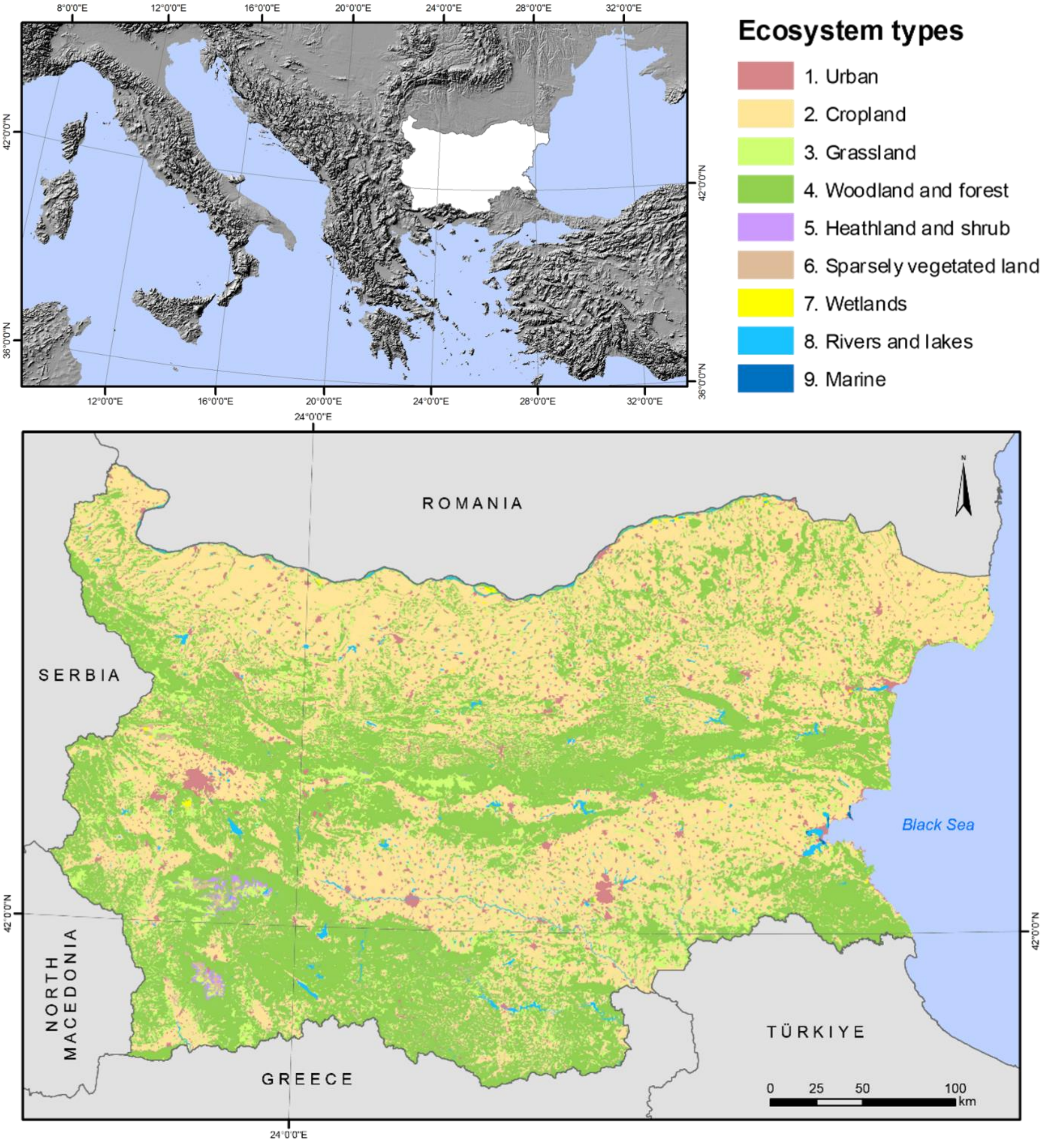


Table 1. Spatial units of the study. Based on Hristova and Stoycheva, 2021.

Ecosystem type	Ecosystem subtype (level 3)	Area [ha]	%
1. Urban	J1. Residential and public areas of cities and towns	814,21	0.01
	J3. Residential and public low-density areas	388046,20	3.50
	J5. Urban green areas (incl. sport and leisure facilities)	17720,45	0.16
	J6. Industrial sites (incl. commercial sites)	77928,02	0.70
	J7. Transport networks and other constructed sites	11479,95	0.10
	J8. Extractive industrial sites (incl. active underground mines and active opencast mineral extraction sites, and quarries)	32108,59	0.29
	J9. Waste deposits	4077,05	0.04
2. Cropland	I.1. Annual crops (mostly cereals)	3821663,00	34.43
	I.2. Perennial crops (fruit gardens and vineyards)	160997,90	1.45
	I.3. Perennial crops (mostly legumes)	36891,21	0.33
	I.4. Mixed cropland	1323850,00	11.93
3. Grassland	E2. Mesic grasslands	654404,10	5.90
	E3. Seasonally wet and wet grasslands	116989,10	1.05
	E4. Alpine and subalpine grasslands	28625,99	0.26
4. Woodland and forest	G1. Broadleaved deciduous woodland	2297472,00	20.70
	G1. Broadleaved deciduous woodland - coppice	762294,70	6.87
	G3. Coniferous woodland	533630,00	4.81
	G4. Mixed deciduous and coniferous woodland	644870,30	5.81
5. Heathland and shrub	F2. Arctic, alpine and subalpine shrub	22931,07	0.21
6. Sparsely vegetated land	B1. Coastal dunes and sandy shores	1898,04	0.02
	H2. Screes	12632,85	0.11
	H3. Inland cliffs, rock pavements and outcrops	38404,60	0.35
7. Wetlands	D2. Valley mires, poor fens and transition mires	8394,92	0.08
	D5. Sedge and reedbeds, normally without freestanding water	1318,18	0.01
8. Rivers and lakes	C1.1. Permanent oligotrophic lakes, ponds and pools	64847,68	0.58
	C2.3. Permanent non-tidal, smooth-flowing watercourses	32537,14	0.29
9. Marine	X2. Saline coastal lagoons	2352,76	0.02

2.2. ES assessment matrix

The ecosystem services assessment matrix is a table where the rows and columns intersect spatial units with selected ecosystem services. At the intersections, the numerical values of a 6-leveled scale (from 0 to 5) are usually filled in, which illustrates the degree of the capacity of a spatial unit to provide specific ES.

In our case, the ES assessment matrix includes the nine ecosystem services and 27 subtypes of ecosystems (Nedkov et al., 2021a, Nedkov et al., 2021b, Hristova and Stoycheva, 2021). We conducted the analysis on the basis of completed ES assessment matrices by a group of 12 experts. We used nine ecosystem services (Table 2) out of 15, previously identified as priority for recreation by Nedkov et al. (2021b). The choice we made was imposed by the lack of indicators that can be provided with data at a national level. As spatial units within the matrix we used subtypes of ecosystems, which were determined on the basis of the assessment methodologies at a national level in Bulgaria under the METECOSMAP project and refined by Hristova and Stoycheva (2021).

Table 2. Ecosystem services considered in the study.

Ecosystem service	ES group
Cultivated plants and animals used for nutrition	Provisioning
Wild plants used for nutrition	
Regulation of pollution and other harmful impacts	Regulating
Local climate regulation	
Scientific and educational value	Cultural
Cultural heritage	
Aesthetic experiences	
Symbolic and spiritual value provided by biotic systems	
Symbolic and spiritual value provided by abiotic systems	

We built the matrix in MS Excel with conditional formatting for the intersections using a selected color scheme. We sent a personal copy of the matrix to each of the selected experts.

2.3. Profile of the experts

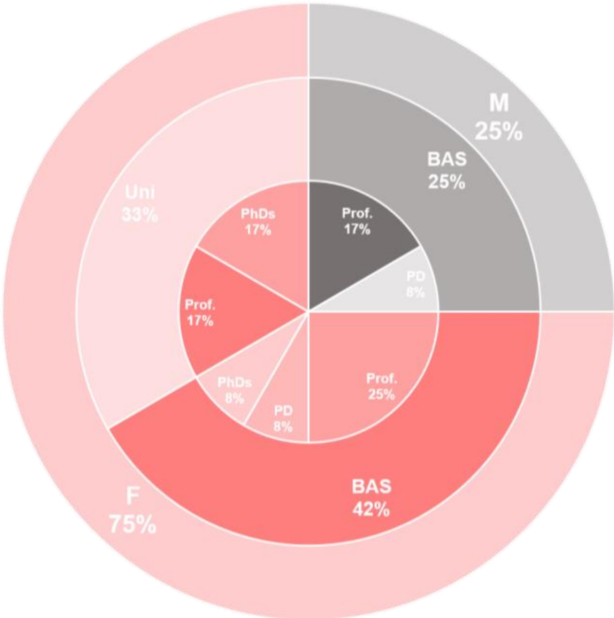
12 experts were purposefully selected to participate in an expert-based assessment with matrices. They belong to two research institutes of the Bulgarian Academy of Sciences (Forest Research Institute, and National Institute of Geophysics, Geodesy and Geography) and two Bulgarian universities (Sofia University “St. Kliment Ohridski” and University of Veliko Tarnovo “St. Cyril and St. Methodius”). All of the experts have knowledge in specific scientific areas (Table 3), which is required for the ES assessments. In order to achieve better representation of the results, while selecting the experts we tried to reach balance across the group according to gender, age and professional experience of the respondents, as shown on Figure 3.

Table 3. Experts’ field of knowledge.

Expert (№)	Landscape ecology	Ecosystem services	Forest studies	Social studies	Tourism
1				1	1
2		1	1		
3	1	1			
4	1				
5	1	1			
6	1				1
7	1	1			
8	1	1			
9				1	
10	1	1			
11			1		1
12		1	1		
Total	**7**	**7**	**3**	**2**	**3**

All of the experts have substantial research experience in their respective fields of interest. The minimum experience among the early-career researchers (e.g. PhD students) was five years, and the most experienced among the professors were individuals with more than 30 years. Early-career researchers tend to have expertise in landscape ecology and ecosystem services, while the professors cover landscape ecology and ecosystem services as well as forest and social studies, and tourism. All professors tend to have experience in physical geography - some of them have additional experience in climatology, and another in soil science and cartography. All 12 experts are familiar with the geographical specifics of Bulgaria.

Figure 3. Profile of the experts.
Legend: M – male; F – female; BAS – Bulgarian Academy of Sciences; Uni – Universities; Prof. – Professors (full and associated); PD – Postdocs; PhDs – PhD students.



2.4. Assessment technology: criteria and guidelines

The main criteria, we asked the experts to follow during assessment of each ecosystem subtype, was the presence of natural heritage sites (NHS) within the ecosystem subtype and its relation to a certain ecosystem service. Each of the 12 experts was asked to score the intersection between spatial units and ES with 0 to 5. Ecosystem subtypes that have no potential to provide specific ecosystem services for recreational purposes were scored “0”. Those with very low potential were scored with “1”, those with low potential scored with “2”, those with medium potential scored with “3”, high potential scored with “4”, and those with very high potential scored with “5”.

We provided all experts with guidelines on how to fill the matrix. More specifically, we send them a look-up table with synthesized information about the relations between the ecosystem services and natural heritage sites, following the methodological framework of Nedkov et al., (2021a). The table includes 5 major columns titled: (i) Priority ES, (ii) Relation with the recreation and specificity of the ES (at ecosystem level), (iii) Ecosystems related to the priority ES, (iv) Natural heritage sites related to the priority service, (v) Additional comments.

2.5. Structure of the analysis

Once the matrices were completed by the experts, their individual mean scores were summarized and recalculated arithmetically again on the 6-point scale. We transferred the individual experts scores in a new general table where each expert was given a personal number from 1 to 12. This way we both anonymized the results and simplified the titles of the columns.

We performed two different set of analysis. First, we calculated the average score of a certain ES for ecosystem subtype among the 12 experts. The final average score was calculated in a new column titled “Average” as shown on Table 4 and Table 5. Second, we calculated the range, the minimum and the maximum scores across the experts. By doing that, we expected to find out if the experts have similar perceptions about the ES and the spatial units or if there are some discrepancies due to the different levels and field of expertise.

2.6. Mapping of the ES

We made two types of mapping for the selected nine ecosystem services. First, we map the mean individual expert scores for ecosystem type in GIS. We made that in order to show the spatial dimensions and the discrepancies between the experts. We exported 12 maps showing the individual perceptions of the experts about the ecosystems and their services in Bulgaria. Second, we map the final average scores calculated from all 12 individual scores for the selected 9 ES. By choosing those two types of mapping, we expected to see and compare the spatial dimensions of the expert-based assessment. Moreover, to see on a map how the mean individual scores correlate with the final average for the group.

3. RESULTS

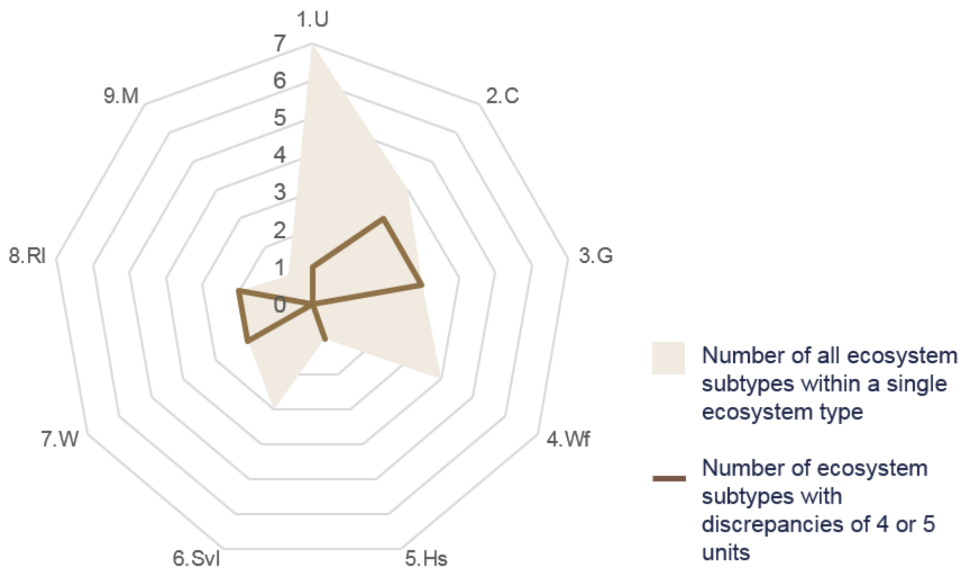
3.1. Quality of the results

This analysis is based on the differences in the assessment given by the experts to types and subtypes of ecosystems, and to ecosystem services. Each expert was asked to rate them with the scores from 0 to 5. The maximum difference between the scores is 5 and the minimum is 0. The subject of discussion in the analysis are the final states, namely discrepancies in the ratings of 4-5 units in over six of the nine ecosystem services. The logical sequence ecosystem - subtype ecosystem and ecosystem services, which are embedded in the matrix of the expert form, is followed.

3.1.1. Ecosystem types

The largest discrepancies in the experts' assessments are observed in grasslands, wetlands, cropland, rivers and lakes, and parts of urban ecosystem types (Figure 4).

Figure 4. Discrepancies in experts' assessments by 4 or 5 units per ecosystem subtype.



Among the grasslands, all subtypes of ecosystems show a significant discrepancy in expert assessments. In more than six ecosystem services out of the nine analyzed, the differences in the expert assessments are by 4 or 5 units. In wetlands, the two analyzed subtypes - “D2. Valley mires, poor fens and transition mires” and “D5. Sedge and reed beds, normally without freestanding water”, show the same results. The analysis of cropland shows that in three of the four ecosystem subtypes considered, there is a significant discrepancy in the assessments of experts in more than six of the nine ES. Rivers and lakes ecosystems also cause disagreement among experts. In two of the three ecosystem subtypes, significant differences are observed with respect to over six of the nine ES analyzed. Regarding the Heathland and shrub ecosystem, one of its subtypes was analyzed - “F2. Arctic, alpine and subalpine scrub”. The results of the expert assessment are also contradictory. In urbanized ecosystems, only one of the 7 subtypes of the ecosystem has a discrepancy of 4 or 5 units in seven of the nine assessments of individual ecosystem services.

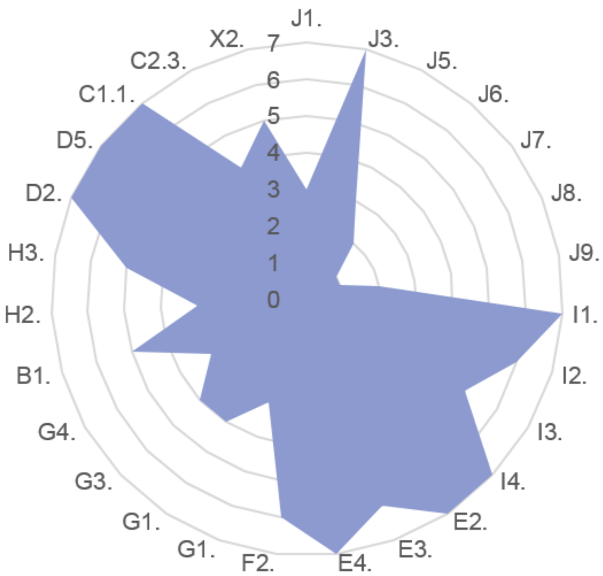
Without a significant difference in the expert assessments regarding the offered ecosystem services from the analyzed ecosystems are the Woodland and forest, the Sparsely vegetated land and the Marine ecosystems. For this reason, they will not be considered at the subtype level. Based on the provided expert assessments for the mentioned ecosystems, it can be concluded that the experts have appropriate expertise for their assessment.

3.1.2. Ecosystem subtypes

Urban

The urban ecosystem subtype “J3. Residential and public low density areas” is among the most controversial in terms of its ecosystem services. In 5 of them the difference between the expert evaluations is 5 units. These are (i) Cultivated plants and animals used for nutrition, (ii) Scientific and educational value, (iii) Cultural heritage, (iv) Symbolic and spiritual value provided by biotic systems, and (v) Symbolic and spiritual value provided by abiotic systems. With 4 units the difference between the assessments of the experts is the ES Aesthetic experiences. In the other 6 urban ecosystem subtypes there are not so many significant differences in the expert assessments of individual ecosystem services.

Figure 5. Discrepancies in the experts’ assessments by 4 or 5 units per ecosystem subtype.



Cropland

Within the cropland ecosystem subtypes, significant differences in the expert assessments the annual crops, perennial crops (fruit gardens and vineyards) and mixed croplands are distinguished. The subtype "I.1.Annual crops" shows the maximum difference of 5 units in the assessments of the experts in relation only to the Cultural heritage as a recreational ecosystem service. Regarding six of the ecosystem services, the differences in the opinions of the experts are also high with a discrepancy of 4 units. These are (i) Wild plants used for nutrition, (ii) Regulation of pollution and other harmful impacts, (iii) Local climate regulation, (iv) Scientific and educational value, (v) Aesthetic experiences, and (vi) Symbolic and spiritual value provided by biotic systems. The subtype I.2. Perennial crops (fruit gardens and vineyards) noted maximum differences in expert assessments of 5 units for four ecosystem services. These are (i) Regulation of pollution and other harmful impacts, (ii) Local climate regulation, (iii) Cultural heritage, and (iv) Symbolic and spiritual value provided by biotic systems. Two ecosystem services - (i) Wild plants used for nutrition and (ii) Scientific and educational value, mark 4 units difference in expert assessments. In the subtype ecosystem I.4. Mixed cropland only in one ecosystem service - Cultural heritage, there is a maximum difference of 5 units in the assessments of experts. However, for as many as six ecosystem services the discrepancy in the expert assessments remains high and is 4 units. These are Wild plants used for nutrition, Regulation of pollution and other harmful impacts, Local climate regulation, Scientific and educational value, Aesthetic experiences, and Symbolic and spiritual value provided by biotic systems.

Grassland

The three subtypes of the grassland ecosystem included in the expert form show significant differences in the expert assessments. In the ecosystem subtype “E2. Mesic grasslands” the maximum discrepancy of 5 units between expert assessments is available for three ecosystem services. These are Cultivated plants and animals used for nutrition, Wild plants used for nutrition, and Aesthetic experiences. For four ecosystem services the difference is 4 units. These results are observed in the ES Regulation of pollution and other harmful impacts, Scientific and educational value, Cultural heritage, Symbolic and spiritual value provided by biotic systems. In subtype “E3. Seasonally wet and wet grasslands” there is a maximum difference of 5 units in three ecosystem services - Wild plants used for nutrition, Aesthetic experiences, and Symbolic and spiritual value provided by biotic systems. In three of the expert assessments there is a difference of 4 units. These differences are observed in Cultivated plants and animals used for nutrition, Regulation of pollution and other harmful impacts, Scientific and educational value. In the ecosystem subtype “E4. Alpine and subalpine grasslands” has only one ecosystem service, in which the experts have the maximum discrepancy of 5 units in their assessments. This is a Symbolic and spiritual value provided by abiotic systems. For as many as six ecosystem services, the difference between the assessments of the experts is 4 units. These are observed in Wild plants used for nutrition, Regulation of pollution and other harmful impacts, Local climate regulation, Scientific and educational value, Cultural heritage, and Symbolic and spiritual value provided by biotic systems.

Heathland and shrubs

In the subtype “F2. Arctic alpine and subalpine scrub” only the ecosystem service Symbolic and spiritual value provided by abiotic systems has led to a maximum difference of 5 units between the opinions of experts. In five ecosystem services there is a difference in expert assessments of 4 units. These are Wild plants used for nutrition, Regulation of pollution and other harmful impacts, Local climate regulation, Scientific and educational value, and Cultural heritage.

Wetland

In subtype “D2. Valley mires, poor fens and transition mires” there is a maximum difference of 5 units in the experts’ opinions regarding four ecosystem services. These are Regulation of pollution and other harmful impacts, Local climate regulation, Aesthetic experiences, and Symbolic and spiritual value provided by biotic systems. In the ecosystem services Scientific and educational value, Cultural heritage and Symbolic and spiritual value provided by abiotic systems the difference between the expert assessments is 4 units. In subtype D5. Sedge and reed beds, normally without freestanding water three ecosystem services noted differences of 5 units between the given assessments. These are Local climate regulation, Scientific and educational value, and Aesthetic experiences. A difference of 4 units in the experts' assessments is observed in four ecosystem services - Regulation of pollution and other harmful impacts, Cultural heritage, Symbolic and spiritual value provided by biotic systems, and Symbolic and spiritual value provided by abiotic systems.

Rivers and lakes

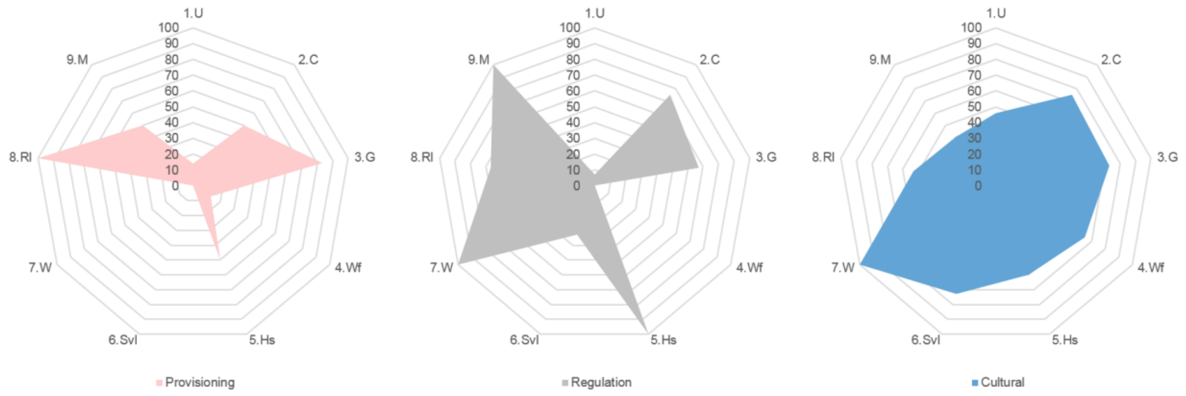
In the ecosystem subtype "C2.3. Permanent non-tidal, smooth-flowing watercourses" five ecosystem services are observed with a maximum difference of 5 units in the experts' assessments. These are Wild plants used for nutrition, Regulation of pollution and other harmful impacts, Local climate regulation, Cultural heritage, and Symbolic and spiritual value provided by biotic systems. Only two ecosystem services - Cultivated plants and animals used for nutrition, and Aesthetic experiences are those with 4 units range in the experts' assessments.

3.1.3. Ecosystem services

In the analysis of the discrepancies frequency with 4 and 5 units in percentages by types of ecosystems, a relatively equal share of high discrepancies is observed - in over 50% of the cases.

The most serious discrepancy (in 100% of the cases in the matrix of expert assessments) is observed in the regulatory and cultural ecosystem services provided by the wetland ecosystem (Figure 6). There is also a 100% discrepancy between experts' assessments regarding the regulatory ecosystem services offered by Heathland and shrub ecosystems, the provisioning ecosystem services provided by Rivers and lakes ecosystems and the regulatory ecosystem services offered by Marine ecosystems. A significant percentage of discrepancies (over 50%) is observed in the provisioning, regulatory and cultural ecosystem services provided by croplands, grasslands, provisioning and cultural ecosystem services provided by Heathland and shrub ecosystems, cultural ecosystem services provided by Woodland and forest ecosystems, regulatory and cultural ecosystem services provided by Rivers and lakes ecosystems and provisioning ecosystem services provided by Marine ecosystems.

Figure 6. Frequency of discrepancies in experts' assessments by 4 or 5 units per ecosystem service group.



3.2. Assessment of the natural heritage

3.2.1. Ecosystem types

The average assessments by types of ecosystems were derived from the matrices with the experts' assessments (Table 4) in order to differentiate the recreational potential of the individual types of ecosystems. For the purposes of the analysis, the average ratings from 0 to 1.99 show low recreational potential of the provided ecosystem services by the different types of ecosystems. Average scores between 2.00 and 3.49 show medium potential, and from 3.50 to 5.00 - high potential. Table 1 provides the average estimates of all ecosystem services by ecosystem type. It is noteworthy that there is no score above 3.50, i.e. no ecosystem can be identified that has a clearly high recreational potential of the provided ecosystem services offered for assessment. According to experts' assessments Woodland and forest (3.41), Rivers and lakes (3.29), and Marine (2.88) ecosystems have medium potential with values close to high potential. The urban ecosystems with an average rating of 1.07 stands out with the weakest recreational potential of the provided ecosystem services.

Table 4. Individual mean scores of the 12 experts per ecosystem type.

Ecosystem type	Experts' individual mean scores for all 9 ES												Average
	1	2	3	4	5	6	7	8	9	10	11	12	
1. Urban	1,11	1,16	0,90	0,94	1,02	1,52	1,44	0,62	0,48	0,89	1,35	1,44	1,07
2. Cropland	2,33	1,69	2,17	2,17	3,08	3,08	3,00	2,67	1,78	2,14	1,64	2,33	2,34
3. Grassland	1,33	1,74	1,22	1,52	3,19	3,37	2,56	3,70	2,78	1,41	1,67	3,33	2,32
4. Woodland and forest	2,42	2,97	3,50	3,86	3,86	3,69	4,00	3,22	2,97	3,47	3,08	3,72	3,40
5. Heathland and shrub	2,00	1,89	1,67	2,33	3,00	2,89	3,00	3,11	2,11	2,11	1,89	3,11	2,43
6. Sparsely vegetated land	1,48	1,33	2,04	2,22	2,63	2,07	2,67	1,78	1,26	1,89	1,48	2,41	1,94
7. Wetlands	1,39	1,22	2,67	2,11	2,78	2,06	3,39	2,00	1,06	2,67	1,39	2,56	2,11
8. Rivers and lakes	2,67	2,44	3,11	3,74	3,44	4,44	3,81	3,59	3,26	3,33	3,33	2,33	3,29
9. Marine	2,78	2,22	3,11	3,11	3,00	3,67	3,89	3,00	1,89	3,11	2,44	2,33	2,88

3.2.2. Ecosystem subtypes

The average scores by ecosystem subtypes are shown in Table 5. Within the urban ecosystems, there are no ecosystem subtypes with high recreational potential. The highest values are the Urban green areas, which according to the average assessment of the experts (3.02) fall into the group with medium potential. In addition to ecosystem subtypes J1. Residential and public areas of cities and towns (in large cities) and J3. Residential and public low-density areas (in small towns and villages), which show values in the higher part of the low potential, the other Urban ecosystems subtypes definitely fall into those with low recreational potential.

Within the cropland ecosystems subtypes there are no ones with high recreational potential. The highest values are of the ecosystem subtype I.2. Perennial crops (fruit gardens and vineyards), which has an average expert score of 2.73. The other cropland ecosystems subtypes also have values above 2.00, which ranks them among those with medium potential (Table 5).

Among the considered grassland ecosystems subtypes, there are no ones with high recreational potential. All of them have an average rating of over 2.00, which ranks them among the ecosystems' subtypes with medium potential.

Within the Heathland and shrub ecosystems, only one subtype is proposed - F2. Arctic, alpine and subalpine shrub. According to experts' assessments (2.45), it is among the subtypes with average recreational potential.

Within the Woodland and forest ecosystem, four ecosystem subtypes have been assessed in the expert matrix. Three of them - G1. Broadleaved deciduous woodland, G3. Coniferous woodland and G4. Mixed deciduous and coniferous woodland have average ratings close to 3.50, which defines their recreational potential as medium to high. The fourth ecosystem subtype G1. Broadleaved deciduous woodland - coppice have an average recreational potential with a score of 2.75.

The ecosystem type of Sparsely vegetated land is presented in the experts' matrix with three ecosystem subtypes. Two of them – B1. Coastal dunes and sandy shores (2.56) and H3. Inland cliffs, rock pavements and outcrops (1.88) have an average recreational potential. Subtype H2. Screes has a low recreational potential according to experts' assessments.

The two wetland ecosystems subtypes that are included in the expert assessment matrix have average recreational potential.

Rivers and lakes ecosystem is included in the expert matrix with three subtypes. Two of them - C1.1. Permanent oligotrophic lakes, ponds and pools and C2.3. Permanent non-tidal, smooth-flowing watercourses have medium to high recreational potential according to the average experts' assessments.

Among the marine type ecosystems, there is one subtype - X2. Saline coastal lagoons. It is assessed with an average recreational potential by the experts and average score of 2.74.

Table 5. Individual mean scores of the 12 experts per ecosystem subtype.

Ecosystem type	Ecosystem subtype	Experts' individual mean scores for all 9 ES												Average
		1	2	3	4	5	6	7	8	9	10	11	12	
1. Urban	J1. Residential and public areas of cities and towns	1,44	2,11	0,44	0,56	1,33	1,67	1,78	0,56	0,22	0,33	2,00	1,78	1,19
	J3. Residential and public low density areas	1,44	2,11	1,89	1,89	1,67	3,89	3,56	0,67	0,44	1,78	2,33	2,11	1,98
	J5. Urban green areas (incl. sport and leisure facilities)	3,22	3,11	2,67	3,33	2,44	4,22	3,11	2,67	2,67	2,78	3,11	2,89	3,02
	J6. Industrial sites (incl. commercial sites)	0,89	0,11	0,00	0,22	0,56	0,00	0,67	0,11	0,00	0,22	0,44	1,00	0,35
	J7. Transport networks and other constructed…	0,33	0,22	0,78	0,11	0,33	0,00	0,22	0,11	0,00	0,56	0,67	1,00	0,36
	J8. Extractive industrial sites	0,44	0,00	0,56	0,44	0,56	0,33	0,67	0,11	0,00	0,56	0,44	0,78	0,41
	J9. Waste deposits	0,00	0,44	0,00	0,00	0,22	0,56	0,11	0,11	0,00	0,00	0,44	0,56	0,20
2. Cropland	I.1. Annual crops (mostly cereals)	2,22	1,44	2,33	2,22	3,11	2,78	2,78	2,22	1,56	2,11	1,44	2,22	2,20
	I.2. Perennial crops (fruit gardens and vineyards)	2,78	2,11	2,44	2,33	3,22	4,00	3,67	3,22	2,33	2,22	2,11	2,44	2,73
	I.3. Perennial crops (mostly legumes)	2,22	1,56	1,78	1,78	3,00	2,78	2,67	2,00	1,22	1,78	1,44	2,44	2,02
	I.4. Mixed cropland	2,11	1,67	2,11	2,33	3,00	2,78	2,89	3,22	2,00	2,44	1,56	2,22	2,33
3. Grassland	E2. Mesic grasslands	1,11	1,44	1,22	1,44	3,33	3,22	2,44	3,89	2,89	1,44	1,56	3,33	2,23
	E3. Seasonally wet and wet grasslands	0,89	1,67	1,33	1,44	3,22	3,00	2,56	3,78	2,89	1,33	1,56	3,33	2,20
	E4. Alpine and subalpine grasslands	2,00	2,11	1,11	1,67	3,00	3,89	2,67	3,44	2,56	1,44	1,89	3,33	2,40
4. Woodland and forest	G1. Broadleaved deciduous woodland	3,00	3,00	3,78	4,00	3,89	4,33	4,22	3,78	3,67	3,78	3,11	3,78	3,58
	G1. Broadleaved deciduous woodland - coppice	1,78	2,44	3,00	3,56	3,89	3,44	3,67	2,00	1,33	3,00	2,67	3,56	2,75
	G3. Coniferous woodland	2,33	3,00	3,67	4,00	3,78	3,67	4,11	3,44	3,33	3,56	3,11	3,78	3,38
	G4. Mixed deciduous and coniferous woodland	2,56	3,44	3,56	3,89	3,89	3,33	4,00	3,67	3,56	3,56	3,44	3,78	3,45
5.Heathland and shrub	F2. Arctic, alpine and subalpine shrub	2,00	1,89	1,67	2,33	3,00	2,89	3,00	3,11	2,11	2,11	1,89	3,11	2,45
6. Sparsely vegetated land	B1. Coastal dunes and sandy shores	2,22	2,56	2,78	2,78	2,78	2,44	3,22	3,22	2,22	2,33	2,56	3,22	2,56
	H2. Screes	0,33	0,22	1,22	1,44	2,44	0,78	2,00	0,33	0,22	1,22	0,33	2,11	1,01
	H3. Inland cliffs, rock pavements and outcrops	1,89	1,22	2,11	2,44	2,67	3,00	2,78	1,78	1,33	2,11	1,56	1,89	1,88
7. Wetlands	D2. Valley mires, poor fens and transition mires	1,44	1,22	2,67	2,22	2,78	2,33	3,56	2,56	1,67	2,67	1,44	2,56	2,19
	D5. Sedge and reedbeds	1,33	1,22	2,67	2,00	2,78	1,78	3,22	1,44	0,44	2,67	1,33	2,56	1,86
8. Rivers and lakes	C1.1. Permanent oligotrophic lakes, ponds and pools	2,44	2,56	3,33	4,00	3,44	4,44	3,89	3,56	3,22	3,78	3,33	2,33	3,14
	C2.3. Permanent non-tidal, smooth-flowing watercourses	2,89	3,00	3,11	3,67	3,44	4,44	3,89	3,78	3,44	3,22	3,33	2,33	3,27
9. Marine	X2. Saline coastal lagoons	2,78	2,22	3,11	3,11	3,00	3,67	3,89	3,00	1,89	3,11	2,44	2,33	2,74

3.2.3. Ecosystem services

Average expert assessments of ecosystem services show that there is no clearly defined service with a high recreational potential (Table 6). The highest average expert assessments are the cultural ecosystem services – "Scientific and educational value" (3.25) and "Aesthetic experiences" (3.23), which rank them among the ecosystem services with average recreational potential.

However, the experts have identified the recreational potential of some ecosystem services in certain ecosystem subtypes as high. With the highest number of maximum scores by experts - 5.00 are regulatory services and in particular those provided by the forest ecosystem. With a maximum expert assessment of 5.00 of the provisioning ecosystem services is "Food products from agriculture and animal husbandry", provided by the subtype of ecosystems I.1. Annual crops (mostly cereals). Although cultural ecosystem services have the highest average rating by experts, they do not show any maximum rating.

Table 6. Average ecosystem services scores.

	Ecosystem services								
	1	2	3	4	5	6	7	8	9
Average scores	0,91	1,58	2,43	2,31	3,25	2,45	3,23	2,28	1,76

3.3. Mapping of the natural heritage potential to provide ecosystem services at national level

The results from the first type of mapping we performed, reflected the spatial dimensions of the range analysis from the previous stages of work. The reported discrepancies from the statistical analysis of the individual experts' assessments are shown in a categorical way (Figure 7).

According to the first expert (Figure 7.1) the overall capacity of the ecosystem types in Bulgaria to provide the selected 9 ES is equal to 1.85 which means that the potential is low. It can be easily seen on the map that for expert 1 most of the territory (about 95%) has low potential to provide ES, and the rest of the area has very low or medium potential. When comparing the maps of the first expert with the ones of the fifth and the sixth (Figure 7.5-7.6), the discrepancies become more obvious. For example, the mountainous areas in Bulgaria, mostly covered by forest ecosystems, were highly scored by the fifth and the sixth expert, but lowly scored by the first one. That equals to range 3.

There are some similarities within the individual maps of the experts. Three subgroups can be identified according to spatial and statistical similarities as follows: (i) between experts 3, 4 and 12; (ii) between the expert 5, 6 and 7; and (iii) between the expert 9, 10 and 11. Only one expert scored the urban ecosystems with "0", which means that there is no potential to provide ES related to recreation (Figure 7.9). The average score of the urban ecosystems is 1.07 and all 11 experts scored between 0.62 and 1.44. Thus it can be concluded that they have more or less the same perceptions for the urban ecosystems. If we look at the maps of the expert 5, 6 and 7, it is obvious that they are giving much higher scores for all ecosystem types compared to the other experts, especially the first one.

The second mapping we performed shows the final overall potential of the ecosystems in Bulgaria to provide recreational ES (Figure 8). Its spatial distribution is very similar with the individual maps of the third subgroup of experts (Figure 7.9-7.11). It was interesting to find that their fields of expertise represent all the above mentioned in Table 3. Expert number 10 is experienced in landscape ecology and ecosystem services, while expert 9 is experienced in social studies, and number 11 is expert in the fields of forest studies and tourism. From the perspective of the expertise, the second subgroup seems to be the most homogenous, i.e. all presented experts are experienced in the fields of landscape ecology, two experts (number 5 and 7) are experienced in ecosystem services, and one expert (number 6) have additional expertise in the field of tourism. Within the first subgroup (experts number 3, 4 and 12) no one is experienced in the fields of social studies and tourism.

Figure 7. Maps of the individual experts' assessments showing the overall capacity of the ecosystem types to provide all 9 selected ES. 1-6 numbers of experts.

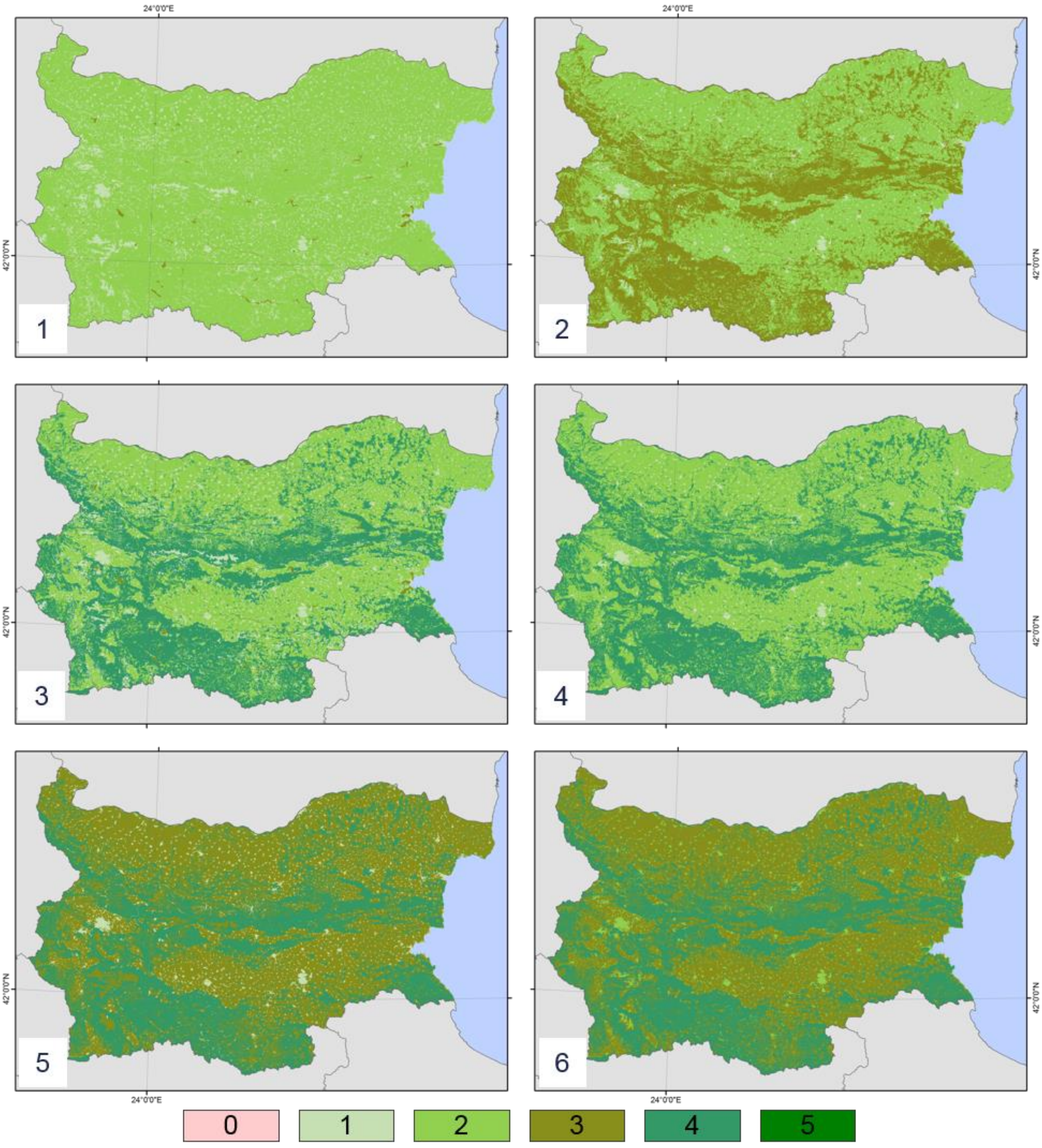


Figure 7. Continued. 7-12 numbers of experts.

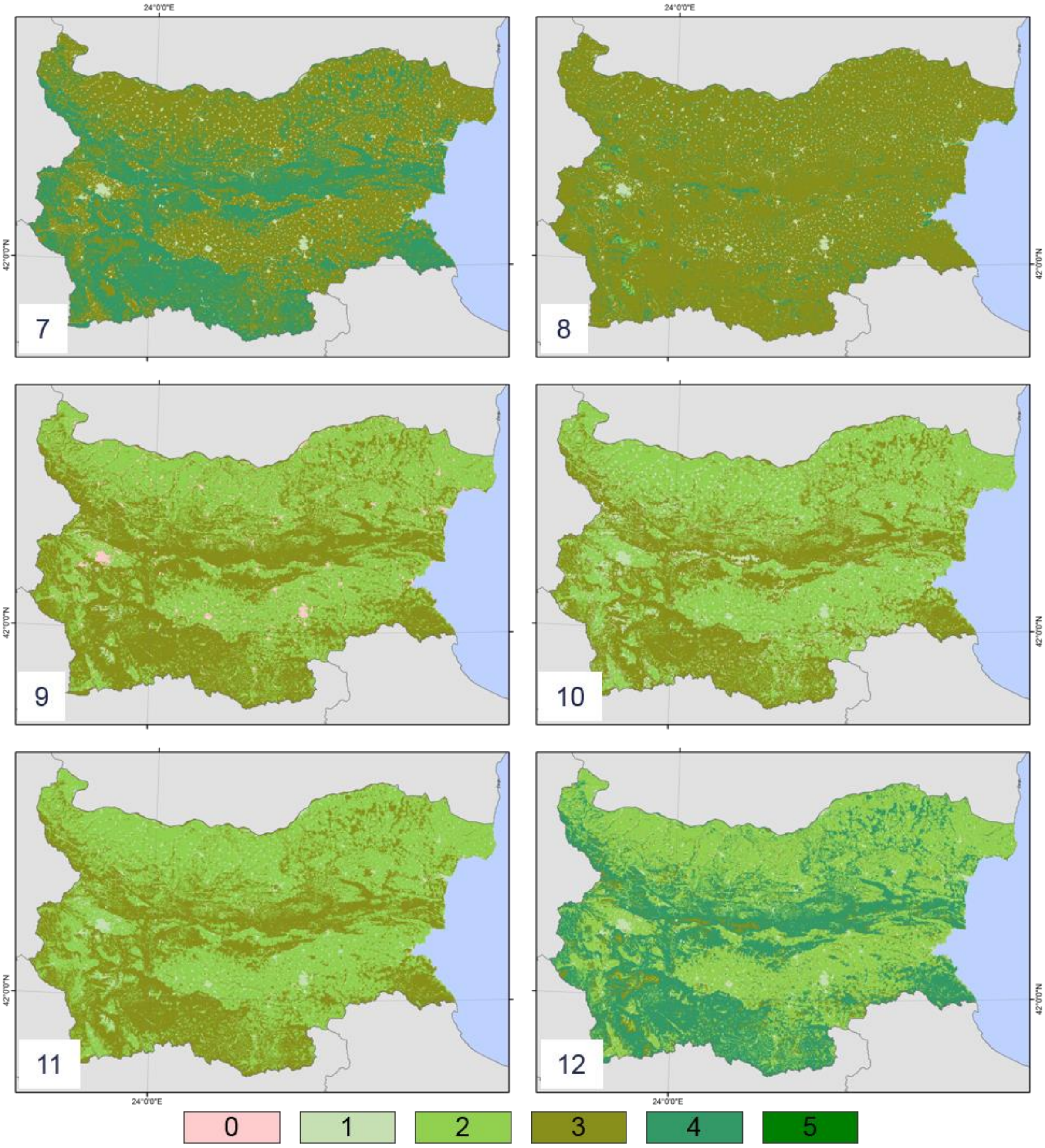
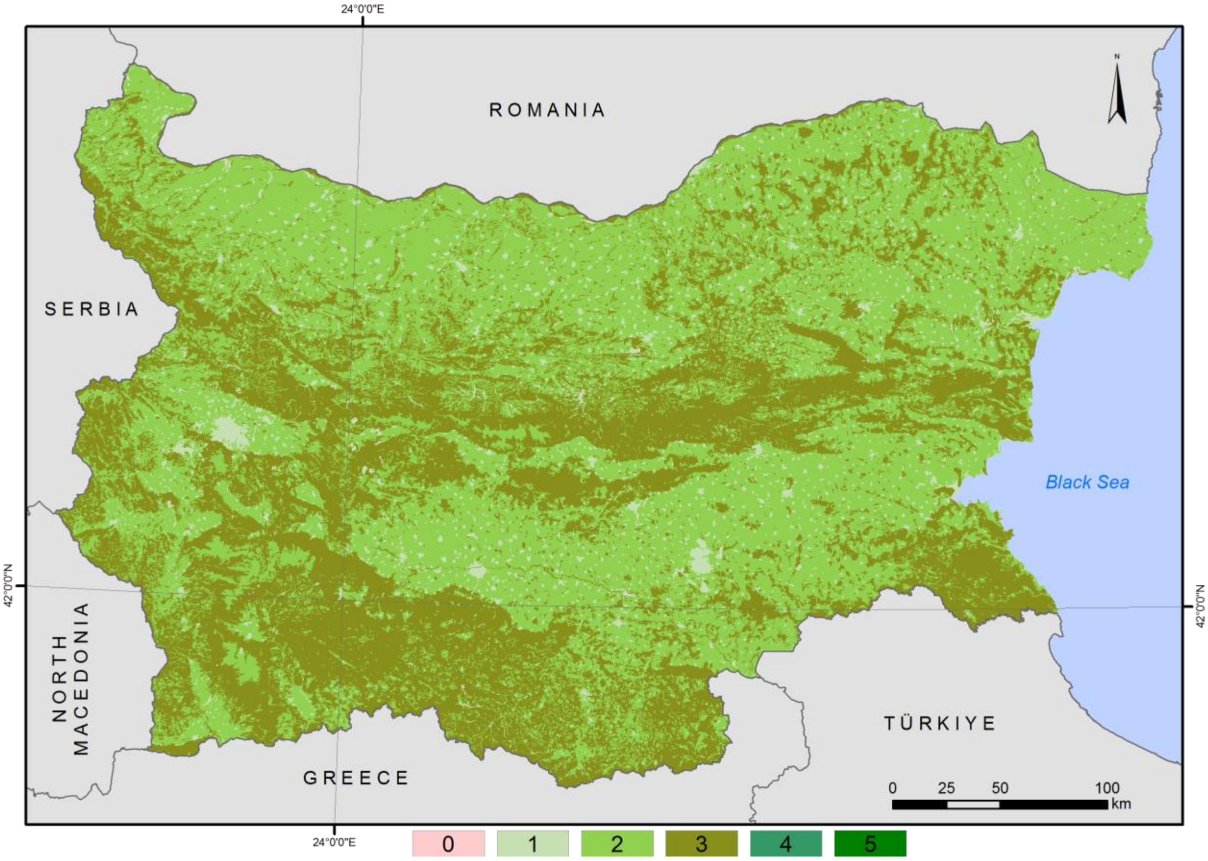


Figure 8. Overall potential of the ecosystems in Bulgaria to provide priority ES for recreation according to all 12 experts' assessments.



4. DISCUSSION

4.1. Range of the experts' scores

The discussion focuses on two areas, namely the existing discrepancies between expert assessments and their significance for the quality of the results, and the potential of the natural heritage at national level to provide ecosystem services for recreational purposes. The range of the expert assessments are addressed at the level of ecosystem types, ecosystem subtypes and ecosystem services. The analysis shows that the Woodland and forest, the Sparsely vegetated land and the Marine ecosystems are without a significant difference in the expert assessments regarding the offered ecosystem services from the analyzed ecosystems. The biggest range in the experts' assessments are observed in Grassland ecosystems, Wetlands, Cropland, Rivers and lakes ecosystems, and parts of Urban ecosystems.

Serious discrepancies are observed in the expert assessments in all subtypes of grassland ecosystem. In the case of the Heathland and shrub ecosystem, there is a significant range of expert assessments of most ecosystem services. The high degree of discrepancy in almost all cropland ecosystem subtypes is a reason for additional discussions before conducting further assessments, as well as for additional analysis on other indicators in order to establish their recreational potential.

Such discrepancies are reported in the individual subtypes of the wetland ecosystem, as well as in the subsystem "Permanent non-tidal, smooth-flowing watercourses". There are no significant differences among the assessments of experts only in the Woodland and forest, the Sparsely vegetated land and the Marine ecosystem subtypes. For them, it can be assumed that the assessment given by the experts is adequate. The urban ecosystems subtypes can be considered as recognizable by experts and realistically and adequately assessed by them. Only for ecosystem subtype J3. Residential and public low-density areas (villages and small towns) further clarification is needed in subsequent assessments.

According to the results of the analysis, the frequency of ranges of 4 and 5 units by types of ecosystems in percentages is observed in over 50% of cases. Because of this it is not possible to determine which type of ecosystem services (provisioning, regulatory or cultural) causes the greatest discrepancy in the experts' assessments. There is a complete discrepancy in 100% of the cases in the matrix of expert assessments, which is observed in the regulatory and cultural ecosystem services provided by the wetland ecosystem, in the regulatory ecosystem services provided by Heathland and shrub ecosystems, in the provisioning ecosystem services provided by Rivers and lakes ecosystem, in the regulatory ecosystem services offered by marine ecosystem. This fact shows that it is necessary to create or use some additional criteria to improve the adequacy and effectiveness of the expert-based assessment method. Based on the analysis of expert assessments, it can be concluded that with regard to cropland, grassland, Heathland and shrub ecosystems, wetlands and rivers and lakes ecosystems, as well as with regard to cultural ecosystem services provided by woodland and forest ecosystems and sparsely vegetated land, another research approach needs to be applied to assess their potential to provide ecosystem services for recreation.

The lack of consensus among experts may be due to the different specialization of the experts and the better knowledge of the different ecosystem types and ecosystem services, which lead to different levels of depth in knowledge of all of them. There are likely to be differences in experts' understanding of the concepts of recreation and tourism and ecosystem services for recreation, respectively.

Although the ES matrix approach is defined as efficient, fast, successful, flexible and useful for decision-making (Campagne et al., 2020; Jacobs et al., 2015), the present analysis shows significant differences between assessments of recreational potential in many of the ecosystems, ecosystems subtypes and ecosystem services. This proves the need of use of additional techniques to overcome the extreme values in the matrix and increase the scientific credibility and legitimacy of the ES matrix results. These could be measures of confidence, traceability, reliability, consistency and validity (Jacobs et al., 2015) or in particular confidence scores (Campagne et al., 2017).

4.2. Recreation potential

4.2.1. Ecosystem types

The capacity of the individual ecosystems to provide ecosystem services differs depending on their natural characteristics (Burkhard et al., 2009). The analysis of ecosystems in the present study shows that no ecosystem has a clearly high recreational potential of the provided ecosystem services proposed for assessment. As ecosystems with high recreational potential, we understand "those that offer the optimal conditions given by its biophysical attributes and cultural elements for use in recreation activities, regardless of these being actually carried out" (Weyland et al., 2014). This paper examines the expert-based assessment, without considering the level of use of recreational ecosystem services, measured by recreationists flow (Weyland et al., 2014).

The subject of discussion are those ecosystems that are characterized by highest recreational potential. Experts identify Woodland and forest, Rivers and lakes and Marine ecosystems with the highest recreational potential in Bulgaria. Sieber et al. (2021) note similar results in Suriname and French Guiana, where rivers and creeks, forest tree cover and ocean have the highest potential for recreational activities. According to the recreational potential index calculated in Slovakia by Makovnikova et al. (2021), forests have the highest score, followed by water bodies and grassland. In Bulgaria, grassland ecosystems are scored with medium close to low recreational potential and rank 6th on this indicator out of 9 analyzed ecosystem types. The matrix for the assessment of the different land cover types capacities to provide ES of Burkhard et al. (2009) also validates our results. They define the water bodies, water courses, coastal lagoons, the different kinds of forests with the highest score for recreation and aesthetic value.

Based on a study carried out in Lithuania, Kaziukonyte et al., 2021 find that forest ecosystems have highest total ES potential. According to Orsi et al., 2020, recreation is one of the most important forest ecosystem services. The ecosystem with a very high score for recreation potential in Bulgaria is the woodland and forest (3.41). A similar result is observed in the study of the recreational potential of ecosystem services in Slovakia in the model regions Brezno district and Krupina district (Makovníková et al., 2021). However, a study conducted in Argentina finds that forests had a positive effect only in some regions. Baró et al. (2016) also establish a high recreational potential of forest ecosystems, but also report fluctuations in their scores depending on the proximity between ES providing areas and benefiting areas. This fact shows that the assessment of recreational potential is influenced by many additional factors such as transport accessibility, specific landscape, extreme weather, etc. However, these factors, as well as the preferences of the tourists who visit the specific places, can be taken into account only when researching specific areas and not when generally assessing the recreational potential (Weyland et al., 2014), what the purpose of the present study is.

One of the most important ecosystem services of the rivers and lakes is recreation. Recreational services of rivers and lakes are numerous. Some of the most important are activities like boating, swimming, recreational fishing, water sports, etc. (Schallenberg et al, 2013). Rivers and lakes offer two kinds of recreation: passive (nature observation and relaxation) and active (water sports, walking or hiking at the area of the lakes, etc.) (Schirpke et al., 2021). For example, Schripke et al. (2021) find that visitors prefer the passive recreation than recreational activities when at mountain lakes. This fact shows the need for more detailed analysis and assessment of the rivers and lakes, considering their specific characteristics and their location.

At Suriname and French Guiana rivers and creeks show higher ES potential for recreational activities than the lakes. In French Guiana, the lakes have a lower score at the expert-based assessment, close to the average for the analyzed ecosystems (Sieber et al., 2021). The average score of rivers and creeks and lakes in Suriname is 3.7 and in French Guiana - 3.5. These scores are very similar to the Bulgarian ones, measured at our study. According to our expert-based assessment this ecosystem shows the highest recreation potential with a score of 3.29.

4.2.2. Ecosystem subtypes

At the level of ecosystem subtypes, there are mostly those with medium potential. The highest scores have the Broadleaved deciduous woodland (3.58), the mixed deciduous and coniferous woodland (3.45) and the coniferous woodland (3.38). Another study conducted in Bulgaria (Kamenov et al., 2017) with a focus on different forest ecosystems subtypes show that G1. Broadleaved deciduous woodland and Broadleaved deciduous woodland - coppice have a higher score than G3. coniferous woodland and G4. Mixed deciduous and coniferous woodland forest ecosystem subtypes in terms of provisioning ecosystem services for recreation. In the same study the different classes of woodlands don’t show significant score differences about the regulating ecosystems services for recreation that they provide. The mixed deciduous and coniferous woodland (G4.) show a little higher score at the assessment of the forest ecosystem subtypes than the coniferous woodland (G3.) in Kamenov et al. (2017) study and confirm the result that our experts presented.

4.2.3. Ecosystem services

The highest scores of the ecosystem services for recreation are in the range of medium potential (scores between 2.00 and 3.50). According to the expert assessment these are the “Scientific and educational value” (3.25) and “Aesthetic experiences” (3.23). There are many studies regarding the assessment of the ecosystem's potential to provide ES (Anpilogova et al., 2022; Grigorov, 2021; Kaziukonyte et al., 2021; Burkhard et al., 2009, etc.), but there is limited research about the potential of the ES for recreation (Nikolova et al., 2020; Kamenov et al, 2017, Osipova et al., 2014). Most of the studies focus only on the potential of the cultural ES "recreation", but don't discuss the potential of the provisioning and regulatory ES for recreation. The limited research about the ecosystem services potential for recreation are not enough to be an in-depth discussion made.

The results and analysis of the assessments of the recreational potential of the natural heritage show that summary studies, such as the present one, can be a starting point for further detailed studies of individual ecosystems located in specific areas. In this way, planning and decision-making by stakeholders in the field of regional development, sustainable natural heritage management, recreation and tourism can be supported.

5. CONCLUSION

The present study shows results on expert-based assessment of the natural heritage to provide ecosystem services for recreation. It also provides an overview on the perceptions of experts with different scientific expertise and the discrepancies between their individual scores derived from statistical and spatial analysis. The results are considered as the basis for future research and discussions.

Our study on the recreational potential of ecosystems to provide services proves that the expert-based assessment method is better to be used together with additional indexes to minimize the risk of unrealistic assessment. It is recommended to adjust it with a confidence index and other indicators to reduce the uncertainty of individual expert opinions. The methodology used in the study gives a basic idea of the recreational potential of ecosystem services. However, the discussion shows that the same types of ecosystems, depending on their location, may be characterized by different recreational potential. For this purpose, it is necessary to analyze factors such as transport accessibility, uniqueness of ecosystems, the presence of extreme climatic phenomena in ecosystems territory, etc. This approach is especially recommended when studying a particular area, which will increase the practical and applied research aspects. Woodland and forests, Rivers and lakes and Marine ecosystem types in Bulgaria have the highest recreational potential and these results correspond with other case study countries. In particular, all of the woodland subtypes have similar results and it is difficult to distinguish which one has the highest potential for recreation. Since, there are not enough studies discussing the potential for recreation of the provisioning and the regulating ES at ecosystem services level, and it is difficult to compare and analyze the scores of the Bulgarian expert-based assessment. The future research of this topic should be focused on the uncertainty analysis of the expert-based assessments using a comprehensive confidence score. Thus, it will help to distinguish the level of the subjective component.

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REFERENCES

Anpilogova, D., Pakina, A. (2022). Assessing ecosystem services of abandoned agricultural lands: a case study in the forested zone of European Russia. *One Ecosystem* 7: e77969. https://doi.org/10.3897/oneeco.7.e77969

Baró, F., Palomo, I., Zulian, G., Vizcaino, P., Haase, D., Gómez-Baggethun, E. (2016). Mapping ecosystem service capacity, flow and demand for landscape and urban planning: A case study in the Barcelona metropolitan region. *Land Use Policy*. 57. 405-417. https://doi.org/10.1016/j.landusepol.2016.06.006

Bezák, P., Bezáková, M. (2014). Landscape capacity for ecosystem services provision based on expert knowledge and public perception (case study from the north-west Slovakia. *Ekologia* 33 (4), 344-353. https://doi.org/10.2478/eko-2014-0031

Bondev, I. (1991). The vegetation in Bulgaria. Map 1:600 000 with explanatory text. St. Kliment Ohridski University Press, Sofia (in Bulgarian)

Burkhard, B., Kroll, F., Müller, F., Windhorst, W. (2009). Landscapes' Capacities to Provide Ecosystem Services – a Concept for Land-Cover Based Assessments. *Landscape Online* 15, 1-22. https://doi.org/10.3097/LO.200915

Burkhard, B., Kroll, F., Nedkov, S., Müller, F. (2012). Mapping ecosystem service supply, demand and budgets. *Ecological Indicators*, 21: 17-29. https://doi.org/10.1016/j.ecolind.2011.06.019

Campagne, C.S., Roche, P., Gosselin, F., Tschanz, L., Tatoni, T. (2017). Expert-based ecosystem services capacity matrices: Dealing with scoring variability. *Ecological Indicators*. 79, 63-72, http://dx.doi.org/10.1016/j.ecolind.2017.03.043

Campagne, C.S., Roche, P. (2018). May the matrix be with you! Guidelines for the application of expert-based matrix approach for ecosystem services assessment and mapping. *One Ecosystem* 3 https://doi.org/10.3897/oneeco.3.e24134

Campagne, C.S., Roche, P., Müller, F., Burkhard, B. (2020). Ten years of ecosystem services matrix: Review of a (r)evolution. *One Ecosystem* 5: e51103. https://doi.org/10.3897/oneeco.5.e51103

Grigorov, B. (2021). Capacity of Zlatitsa Municipality (Western Bulgaria) to provide ecosystem services. *European Journal of Geography* 12 (2): 6–19. https://doi.org/10.48088/ejg.b.gor.12.2.006.019

Hristov, B., Filcheva, E. (2017). Soil organic matter content and composition in different pedoclimatic zones of Bulgaria. *Eurasian Journal of Soil Science* 6(1): 65-74. http://ejss.fess.org/10.18393/ejss.284267

Hristova, D., Stoycheva, V. (2021). Mapping of ecosystems in Bulgaria for the needs of natural heritage assessment. *Journal of the Bulgarian Geographical Society* 45: 89-98. https://doi.org/10.3897/jbgs.e76457

Hou, Y., Burkhard, B., Müller, F. (2012). Uncertainties in landscape analysis and ecosystem service assessment. *J. Environ. Manag.* 127, S117–S131, http://dx.doi.org/10.1016/j.jenvman.2012.12.002

Jacobs, S., Burkhard, B., Van Daele, T., Staes, J., Schneiders, A. (2014). The Matrix Reloaded: a review of expert knowledge use for mapping ecosystem services. *Ecol. Model*. 295, 21–30, http://dx.doi.org/10.1016/j.ecolmodel.2014.08.024

Kamenov, K., Horozova, R. Trichkov, L., Tinchev, G., Raychinov, V., Gogushev, G. (2017). Assessment and mapping of forest ecosystems, their condition and the condition of the provided ecosystem services outside National Ecological Network Natura 2000. *Eastern Academic Journal*, vol. 1 (March): 42-59 (In Bulgarian)

Kaziukonytė, K., Lesutienė, J., Gasiūnaitė, Z.R., Morkūnė, R., Elyaagoubi, S., Razinkovas-Baziukas, A. (2021). Expert-Based Assessment and Mapping of Ecosystem Services Potential in the Nemunas Delta and Curonian Lagoon Region, Lithuania. *Water*, 13, 2728. https://doi.org/10.3390/w13192728

Kolev, B. (2002). Geographical location. In Kopralev, I., Yordanova, M., Mladenov, Ch. (Ed.) Geography of Bulgaria. Bulgarian Academy of Sciences, Sofia, pp. (13-20). For-Com Publishing house. (in Bulgarian)

Makovníková, J., Pálka, B., Kološta, S., Orsagova, K. (2021). Application of Matrix Approach for Evaluation and Assessment the Potential of Recreational Ecosystem Service in Model Regions in Slovakia. *Open Journal of Ecology*. 11. 437-450. https://doi.org/10.4236/oje.2021.114028

Müller F, Bicking S, Ahrendt K, Bac DK, Blindow I, Fürst C, Haase P, Kruse M, Kruse T, Ma L, Perennes M, Ruljevic I, Schernewski G, Schimming C-G, Schneiders A, Schubert H, Schumacher J, Tappeiner U, Wangai P, Windhorst W, Zeleny J (2020). Assessing ecosystem service potentials to evaluate terrestrial, coastal and marine ecosystem types in Northern Germany – An expert-based matrix approach. *Ecological Indicators*, Volume 112, 106116. https://doi.org/10.1016/j.ecolind.2020.106116

Nedkov, S. (2017). Ecosystem services – a different approach towards sustainable development. *E-journal "Geograf"*, vol. 2, year 2: 6-18. https://geograf.bg/sites/default/files/emagazine/emagazine2017.pdf (in Bulgarian)

Nedkov, S. (2018). GIS tools and models for mapping and assessment of ecosystem services. *Journal of the Bulgarian Geographical Society* 39: 17-24.

Nedkov, S., Zhiyanski, M., Dimitrov, S., Borisova, B., Popov, A., Ihtimanski, I., Yaneva, R., Nikolov, P., Bratanova-Doncheva, S. (2017). Mapping and assessment of urban ecosystem condition and services using integrated index of spatial structure. *One Ecosystem* 2: e14499. https://doi.org/10.3897/oneeco.2.e1449

Nedkov, S., Zhiyanski, M., Borissova, B., Nikolova, M., Bratanova-Doncheva, S., Semerdzhieva, L., Ihtimanski, I., Nikolov, P., Aidarova, Z. (2018). A geospatial approach to mapping and assessment of urban ecosystem services in Bulgaria. *European Journal of Geography* 9 (4): 34–50. https://eurogeojournal.eu/showPaper.php?id=1512

Nedkov, S., Borisova, B., Nikolova, M., Zhiyanski, M., Dimitrov, S., Mitova, R., Koulov, B., Hristova, D., Prodanova, H., Semerdzhieva, L., Dodev, Y., Ihtimanski, I., Stoyanova, V. (2021a). A methodological framework for mapping and assessment of ecosystem services provided by the natural heritage in Bulgaria. *Journal of the Bulgarian Geographical Society* 45: 7-18. https://doi.org/10.3897/jbgs.e78680

Nedkov, S., Mitova, R., Nikolova, M., Borisova, B., Hristova, D., Semerdzhieva, L., Zhiyanski, M., Prodanova, H. (2021b). Prioritization of ecosystem services related to the natural heritage of Bulgaria. *Journal of the Bulgarian Geographical Society* 45: 19-30. https://doi.org/10.3897/jbgs.e73687

Nikolov, S. (2018). Ecosystem services and their valuation – brief review. *Journal of the Bulgarian Geographical Society* 39: 51-54.

Nikolova, M., Nedkov, S., Borisova, B. (2020). Natural heritage and recreational ecosystem services. *Sociobrains*, issue 66: 252-259.

Nikolova, M., Nedkov, S., Borisova, B., Zhiyanski, M., Dimitrov, S. (2021a). Natural heritage as a source of ecosystem services for recreation and tourism in Bulgaria. *Journal of the Bulgarian Geographical Society* 45: 3-6. https://doi.org/10.3897/jbgs.e79485

Nikolova, M., Stoyanova, V., Varadzhakova, D., Ravnachka, A. (2021b). Cultural ecosystem servicesfor development of nature-based tourism in Bulgaria. *Journal of the Bulgarian Geographical Society* 45: 81-87. https://doi.org/10.3897/jbgs.e78719

Orsi, F., Ciolli, M., Primmer, E., Varumo, L., Geneletti, D. (2020). Mapping hotspots and bundles of forest ecosystem services across the European Union, *Land Use Policy*, Volume 99, 104840, https://doi.org/10.1016/j.landusepol.2020.104840

Osipova, E., Wilson, L., Blaney, R., Shi, Y., Fancourt, M., Strubel, M., Salvaterra, T., Brown, C., Verschuuren, B. (2014). The benefits of natural World Heritage: Identifying and assessing ecosystem services and benefits provided by the world's most iconic natural places. Gland, Switzerland: IUCN. vi + 58 pp.

Peng, L.C., Lien, W.Y., Lin, Y.P. (2020). How Experts' Opinions and Knowledge Affect Their Willingness to Pay for and Ranking of Hydrological Ecosystem Services. *Sustainability* 12, no. 23: 10055. https://doi.org/10.3390/su122310055

Perennes, M., Campagne, C.S., Müller, F., Roche, P., Burkhard, B. (2020). Refining the Tiered Approach for Mapping and Assessing Ecosystem Services at the Local Scale: A Case Study in a Rural Landscape in Northern Germany. *Land* 9(10): 348. https://doi.org/10.3390/land9100348

Prodanova, H. (2021). Experimental mapping and assessment of ecosystem services based on multi-level landscape classification. *Journal of the Bulgarian Geographical Society* 45: 31-39. https://doi.org/10.3897/jbgs.e78692

Roche, P.K., Campagne, C.S. (2019). Are expert-based ecosystem services scores related to biophysical quantitative estimates? *Ecological Indicators* 106, 105421, https://doi.org/10.1016/j.ecolind.2019.05.052

Schallenberg, M., Winton, M.D., Verburg, P., Kelly, D., Hamill, K., Hamilton, D. (2013). In book: Ecosystem services in New Zealand - Conditions and trends, Chapter: 15, Publisher: Manaaki Whenua Press, Lincoln, New Zealand, Editors: J.R. Dymond

Schirpke, U., Scolozzi, R., Kiessling, A., Tappeiner, U. (2021). Recreational ecosystem services of mountain lakes in the European Alps: Preferences, visitor groups and management implications, *Journal of Outdoor Recreation and Tourism*, Volume 35, 100421, ISSN 2213-0780, https://doi.org/10.1016/j.jort.2021.100421

Sarafova, E. (2021). How green the urban development units in Sofia are: Earth observation and population time series analysis. *Journal of the Bulgarian Geographical Society* 44: 25-37. https://doi.org/10.3897/jbgs.e69814

Seijo, C., Calado, H., McClintock, W.J., Gil, A., Fonseca, C. (2021). Mapping recreational ecosystem services from stakeholders' perspective in the Azores. *One Ecosystem* 6: e65751. https://doi.org/10.3897/oneeco.6.e65751

Sieber, I.M., Campagne, C.S., Villien, C., Burkhard, B. (2021). Mapping and assessing ecosystems and their services: a comparative approach to ecosystem service supply in Suriname and French Guiana, *Ecosystems and People*, 17:1, 148-164. https://doi.org/10.1080/26395916.2021.1896580

Tanov, E. (1956). Soil map of Bulgaria. Scale of 1:1 000 000. Kartproekt, GUGK, Sofia. https://esdac.jrc.ec.europa.eu/content/soil-map-bulgaria

Weyland, F., Laterra, P. (2014). Recreation potential assessment at large spatial scales: A method based in the ecosystem services approach and landscape metrics, *Ecological Indicators*, Volume 39, Pages 34-43, ISSN 1470-160X, https://doi.org/10.1016/j.ecolind.2013.11.023

Zhiyanski, M.K., Glushkova, M., Dodev, Y., Bozhilova, M., Yaneva, R., Hristova, D., Semerdzhieva, L. (2021). Role of the cultural ecosystem services provided by natural heritage in forest territories for sustainable regional development. *Journal of the Bulgarian Geographical Society* 45: 61-66. https://doi.org/10.3897/jbgs.e72766