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Review Article

Twenty years of ecosystem services research in Bulgaria: lessons learned and future directions from a geographical perspective

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Abstract

The ecosystem services (ES) concept has established itself in recent years as the predominant paradigm for framing environmental research and policy-making. The EU Biodiversity Strategy to 2020 with its task for member countries to map and assess the state of ecosystems and their services has contributed vastly to the development of the ES studies in the European countries. Bulgaria was among the countries that made substantial progress in its implementation and the contribution of the geographers was of vital importance. This paper aims to provide an overview and analysis of the ES research in Bulgaria focusing on the contributions of the geographers and the spatial aspects of the studies. The information on the ES research was performed through a literature review by collecting all available published works that address the main objectives of the study. To systematize and characterize the content of the reviewed papers, a special database with a standard nomenclature was constructed. The findings from the review allowed us to identify both achievements and research gaps in the ES studies conducted by Bulgarian geographers. This enabled us to define the main research priorities of the coming years which can trace the future directions of ES research in the country. They include the development of the spatial aspects in the methodological frameworks for mapping and assessment of ES, better use of GIS-based tools for mapping ES alongside models' integration, and improvement of the publication's quality and increase of the papers published in highly rated indexed journals.

Key words: Cultural services, literature review, mapping ES, provisioning services, regulating services

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Introduction

The ecosystem services (ES) concept has established itself in recent years as the predominant paradigm for framing environmental research and policy-making (Martin-Ortega et al. 2019). It has been introduced in scientific literature with the fundamental works of De Groot (1992), Costanza et al. (1997), and Daily (1997), and since the Millennium Ecosystem Assessment (2005) the number of publications has risen drastically. The ES concept provides an appropriate methodological basis that enables linking the state of ecosystems with human well-being which can be used as a platform to find solutions to various environmental problems (Danova 2023). The EU Biodiversity Strategy to 2020 with its

task for member countries to map and assess the state of ecosystems and their services in their national territory has contributed vastly to the development of the ES studies in the European countries. The working group on Mapping and Assessment of Ecosystems and their Services (MAES) has guided the process by establishing a methodological framework to ensure consistency across member states (Maes et al. 2013). According to the MAES barometer, which indicates each EU member state's stage of MAES implementation, Bulgaria was among the countries that made substantial progress in the implementation of Action 5 (Burkhard et al. 2018a). This is a result of significant efforts within several projects during the MAES process but it has also been determined by various research activities during the last 20 years. The spatial aspects of such works are very important and the contribution of the geographers is of vital importance.

The growing number of studies and publications both at global and national level lead to accumulation of knowledge which is stored in various types of publications and different databases. Furthermore, the ES label is used in a range of studies with widely different aims which poses problems to both researchers and policy-makers as it makes it difficult to assess the credibility of the results and reduces the compatibility of the studies (Seppelt et al. 2011). This raises the need for systematization and critical analyses of the published literature sources. The interdisciplinary of the ES concepts means also that the publications come from various disciplines and apply different methods from both natural and social sciences. The present work aims to analyze the contribution of geographers to the development of ES research in Bulgaria, especially in the field of mapping and assessment of ecosystems and their services.

Literature reviews on various aspects of ES have been conducted in many publications during the last few years. Several reviews focus on various methodological aspects such as the indicators for mapping ES (Egoh et al. 2012), and methods for mapping ES supply (Martínez-Harms and Balvanera 2012), mapping of ES values (Schägner et al. 2013), mapping of ES demand (Wolff et al. 2015), the matrix approach (Campagne et al. 2020), and the integration of ES indicators (Peng et al. 2023). ES provided by urban ecosystems has been reviewed by Haase et al. (2014), Luederitz et al. (2015), and Stoycheva and Geneletti (2023). The spatial aspects of ES research have been reviewed from the point of view of quantification and mapping of ES supply and demand (Ayanu et al. 2012), mapping of ES across scales and continents (Malinga et al. 2015), mapping ES demand (Wolff et al. 2015). Several reviews and overview studies are focused on ES research at the national level in specific countries such as Germany (Förster et al. 2019), the UK (Sing et al. 2018), the Czech Republic (Frélichová et al. 2014), Hungary (Vári et al. 2022).

Despite the undoubted achievements of ES research in Bulgaria, there is still no study that reviews the development of these fields in the country. The contribution of the researchers from different disciplines including geographers has also not been studied so far. It is necessary also to reveal the spatial aspects of the studies with a focus on the maps and mapping methods. This field of ES research has been very well developed especially after the MAES process in Europe (Burkhard and Maes 2017; Vári et al. 2024) and a study on maps and mapping methods presented in the publications from Bulgaria is much needed.

This paper aims to provide an overview and analysis of the ES research in Bulgaria focusing on the contributions of the geographers and the spatial

aspects of the studies. More specifically, we aim at: i) revealing the main stages in the ES research in Bulgaria through retrospective analysis; ii) analyzing the publications on ES and the distribution of the authorship among the geographical units in the country; iii) analyzing the distribution of ES and the methods used in the reviewed studies; iv) analyzing the spatial aspects of the ES studies focusing on the maps and the mapping methods in the reviewed studies.

General overview of the ES research in Bulgaria

The development of ES research in Bulgaria can be divided into four main stages: 1) first steps (2005–2010); 2) research stage (2010–2014); 3) MAES stage (2014–2018); post-MAES stage (after 2018). The first steps of the ES concept in Bulgaria were carried out both in academia and the public sector by two pioneering projects. The implementation of the project "Protection of Globally Significant Biological Diversity in the Landscape of the Rhodopes", a joint initiative of the United Nations Development Program (UNDP) and the Ministry of Agriculture and Food led to the first publication on ES by Zevurdakis et al. (2007). The participation of researchers from the Institute of Geography of the Bulgarian Academy of Sciences in the international project "Use of landscape sciences for environmental assessment" (2001–2006) led to the implementation of new approaches for environmental assessment including the promotion of the ES concept in 2005. As a follow-up to this work, the first research paper on the use of hydrological models for flood regulation ES assessment was published (Nedkov 2008). The first steps in the Faculty of Geology and Geography at the Sofia University "St. Kliment Ohridski" were the studies on natural capital assessment (Assenov 2009).

The second period (2010–2014) is characterized by significant development of the research methods for mapping and assessment of specific ES, as well as economic valuation approaches. The biophysical methods for mapping and assessment of flood regulation ES by application of GIS-based hydrological modeling were developed and applied in several case studies (Nedkov and Burkhard 2012; Boyanova et al. 2014). These works were further developed for other water-related ES and contributed to the concept at the international level on the development of the matrix approach (Burkhard et al. 2012) and for the blueprint of the mapping and modeling methods (Crossman et al. 2013). The economic valuation methods (especially contingent valuation) were developed and applied in several case studies mainly at the municipality level (Assenov 2010, 2012). Several studies explore the impact on ES by environmental changes in mountains (Bratanova-Doncheva et al. 2014), forest practices (Zhang et al. 2013; Grigorov et al. 2022).

The third period (2014–2018) is characterized by a significant rise in ES research which is determined mainly by the MAES process. In response to the requirements of the EU Biodiversity Strategy for member countries to map and assess the state of ecosystems and their services the Bulgarian Ministry of Environment and Waters (MOEW) initiated a national program for mapping ecosystems. It gathered researchers from various disciplines and institutions to develop methodologies for each of the nine main ecosystem types and organized projects for mapping ecosystems and their services (Bratanova-Doncheva et al. 2017). These activities led to a national information system for ecosystems

in the country, various publications, and a special issue in One Ecosystem journal (Nedkov et al. 2018). They also contributed to the development of the methodology at the European level through the systematization and development of biophysical methods (Vihervaara et al. 2019), generalization at the European level through comparative analyses (Geneletti et al. 2020), and the update of the methodological framework (Burkhard et al. 2018b).

The post-MAES period (after 2018) is characterized by further development of specific ES fields which led to important research contributions but on the other hand, the end of the MOEW program led to a decrease in interest among some of the participants in the MAES process. Therefore, the ES activities were driven back to the research groups that were active during the previous periods. The achievements of the Bulgarian geographers in the ES research were presented by significant contributions in the book (Smart Geography) dedicated to the 100th anniversary of the Bulgarian Geographical Society (Nedkov et al. 2020). The ES research is extended towards the application of new and innovative spatial approaches as well as the development of interdisciplinary research. These included the impact of climate change on the ES in Bulgaria (Bratanova-Doncheva and Gocheva 2020; Nikolova et al. 2021b), the implementation of ecosystem accounting (Nikolov et al. 2022), the implementation of the ES approach for nature-based sustainable tourism (Nikolova et al. 2021c), the nature heritage in forest areas as a source of economic, social and cultural benefits (Zhiyanski et al. 2021), the methodology for mapping of the capacity of landscapes to provide ES (Prodanova 2021), the relation between the urban and peri-urban landscapes, biodiversity and the flow of ES (Semerdzhieva and Borisova 2021) the relationship between the individual scores and final expert based assessment for natural heritage supply maps (Prodanova and Varadzhakova 2022). Another important tendency during this period is the integration of nature-based solutions into ecosystem services research.

Materials and methods

Literature review

The literature review was performed to collect all available published works that address the main objectives of the study. The overview of the ES research in Bulgaria necessitates the finding of all literature sources that contributed to the development of this research. The review was conducted in several steps: 1. Identifying the geographical institutions in Bulgaria; 2. Identifying geographers (researchers) who work in ES-related fields; 3. Searching through institutions' official web pages and authors' scientific profiles (Scopus ID, WoS researcher ID; Google Scholar profile; ResearchGate profile) for ES-related papers. However, apart from the research papers published in scientific journals, many grey literature sources reveal valuable information for the overview we were aiming at. For instance, several methodological guidelines publications play an important role in shaping ES research in the country. It is also important to reveal the full scope of the Bulgarian geographers' publication activity to analyze its strengths and weaknesses and make recommendations for future development.

The initial search resulted in a total of 145 publications. Most of them we authored or co-authored by geographers but there were also some publications

with no geographer contribution. A specific part of these publications is related to the MAES process including the methodologies for mapping and assessment of ecosystems in Bulgaria and follow-up publications concerning the mapping of ecosystems itself. As there are methodologies and mapping-related publications with geographers' participation, we decided to keep all publications from this group. All other publications without a geographer as an author or co-author were omitted from the list. The remaining publications were the subject of preliminary screening for relevance to the topic of the study. Those that do not have any kind of ecosystem services research were also omitted from the list. Thus, the final number of publications to be reviewed was reduced to 123.

To systematize and characterize the content of the reviewed papers, a special database with a standard nomenclature was constructed (Nedkov et al. 2022). A template in the form of a structured MS Excel sheet that enables easy and convenient data entry was developed. Its design follows the common structure of such templates and comprises five main parts: 1) general characteristics of the publication; 2) ecosystem services; 3) methods; 4) case study; 5) mapping. When possible, the variables in the table were entered using the binary numerical system, otherwise, inputs were made in the form of text (Nedkov et al. 2022). The first part reflects the second specific aim of the study to analyze the publications on ES and the distribution of the authorship among the geographical units in the country. It contains bibliographic data for the publication (authors, journal, year, DOI, and journal or publisher), data for the authorship (distribution between geographical entities and international collaboration), the language of the publication, the case study, the purpose, and the dimensions of the study. The second and third parts are designed to support the achievement of the third specific objective of this review to analyze the distribution of ES and the methods used in the reviewed studies. In the second part, for each publication, we count the number of ES and their distribution among the three main ES groups (provisioning, regulating, and cultural). The supply-demand side of ES research is an important aspect of any assessment therefore the template contains columns that indicate if the study concerns supply, demand, or both. In the third part, the publications were reviewed according to the three main methods (biophysical, social, and economic) used for ES assessment. The fourth and fifth parts contain data entries reflecting the fourth specific objective to analyze the spatial aspects of the ES studies with a focus on the maps and the mapping methods. The fourth part considers the case studies of the publications: presence of a case study, number of case studies, location, and scale of the case study. The fifth part is dedicated to the mapping of ES. The presence of maps in the publications is an important indicator to evaluate the geographical aspects of the studies. The use of an established ES mapping approach is an indicator of the integrity of the internationally accepted methodologies. The next five categories enable us to define the methods used to develop the ES maps. The predefined categories include matrix approach, expert score, use of statistical data, spatial proxy methods, and modeling methods. There is also an option to select the "other" option and add the name of the method that does not fit the previous options. Columns for mapping of ecosystem types and ecosystem condition are also presented in this part.

Data analyses

The analyses of ES research in the reviewed publications were performed in three main aspects: i) the character of the ES research; ii) revealing what ES is/are studied; iii) the methods applied in ES studies. The character of the ES research was analyzed on one hand the presence or absence of specific ES and research on supply/demand and on the other hand by revealing if the study is focused on supply, demand, or both. The presence of the specific ES and supply/demand is an indicator that the publication presents results of real ES assessment. The papers that do not fulfill the requirements of this indicator could be either conceptual or editorial which cover general aspects of ES research or studies on broader environmental topics that mention ES in text but do not perform real ES research. The ES in the review template were reduced to the three main groups of services (provisioning, regulating, and cultural) following the CICES classification (Haines-Young and Potschin 2018). The analyses were focused on the distribution of the ES groups in the studied publications and the number of individual ES studied in them. The methods applied in the ES studies were systematized and analyzed using the most common classification of the methods into three major groups: biophysical, social, and economic).

The spatial dimensions of the ES research in Bulgaria were analyzed in two main aspects: the case studies in the publications and the mapping of ES. The presence or absence of a case study is an important indicator of the character of the ES studies, namely the geographical element in them. The mapping is a very important aspect of ES research as maps are very useful for raising awareness about areas of ecosystem goods and services supply and demand, and to provide information about interregional ES flows (Burkhard and Maes 2017). The analyses on mapping aspects of the publication were performed at two levels: for the whole set of publications and for research papers. Metrics about the number of publications with ES maps, general ES methods used in ES mapping, specific methods used for ES mapping, and methods applied with the matrix approach were calculated.

Results

Characteristics of the publications

The literature search resulted in 123 publications in total that were authored or co-authored by Bulgarian geographers. Their list consists of various types of peer-reviewed publications and grey literature sources published between 2007 and 2023. Ten major types of papers were identified during the review process (Table 1) where research and review papers have the highest share of 40% (49 publications). One type of publication is not presented in the reviewed publications—norm documents (Category 7). Category "10", other types of publications refer to one discussion paper and one blog post. The highest number of papers were published in 2017 and 2021 (Fig. 1A). Those papers refer to two national projects that ended in the reference years—the nine national mapping projects under the MAES framework (ESMERALDA project) and the project Heritage.BG. The only year without any publications for the studies period of 2007–2023 is 2009. Out of the 123 publications 43% are indexed in Scopus or Web of Science

Table 1. Distribution of the reviewed publications by type.

Type of publication	Number of papers	%
1. Research and review papers in scientific journals	49	40
2. Other types of papers in scientific journals	11	9
3. Papers in conference proceedings	23	19
4. Books	2	1.3
5. Book chapters	17	14
6. Methodologies	11	9
7. Normative Documents	0	0
8. Publications in popular scientific magazines	2	1.3
9. Doctoral dissertations	6	5
10. Other types of publications	2	1.3

while most of them are not indexed 57% (Fig. 1C). Analysis of the accessibility of publications shows that 66% of all documents are available online with open access, 19% are with paid access, and 15% are counted as grey literature since they do not appear online (Fig. 1E). All publications are published in English, Bulgarian, or both languages (Fig. 1I). The English language is the primary publishing language with 69% of all, followed by Bulgarian language (21%). Only 10% of the publications are bilingual. The top three of the most impactful journals or publishers are the Journal of the Bulgarian Geographical Society with 16 papers, One Ecosystem with 13 published papers, and Clorind Publishing House with 11 published methodologies (Fig. 1J). Six out of ten are periodical journals, two are book series, one is conference proceedings, and another is a publishing house.

Authors profile/background

Results of the affiliation of the lead author show that most publications were authored by researchers from the National Institute of geophysics, Geodesy and Geography at the Bulgarian Academy of Sciences (NIGGG-BAS) with 41% (56) and Sofia University with 26% (35), while only 9% (12) were authored by foreign authors (Fig. 1F). Only one of the studied institutions—Shumen University, has zero authors publishing about ES. The most active lead author is Nedkov with 19 publications, followed by Assenov with 10. Five out of the ten most active authors are affiliated with the NIGGG-BAS, four with Sofia University, and only one is affiliated with a non-geographical institution (Fig. 1B). Results on the international collaboration show that only 18% (22) of the publications have foreign co-authors, and the majority of the publications 82% (101) were authored entirely by Bulgarian scholars (Fig. 1D). The geographical distribution of the foreign authors shows that the most collaborative country is Germany with 15 publications, followed by Spain with six publications (Fig. 1G). Most of the foreign co-authors are based in countries in Europe such as Finland, Italy, Sweden, Romania, and France. Authors from only two countries besides Europe appear in the publications—those are Australia with four publications and the USA with three publications. The most frequent number of authors per publication varies between one (24 publications) and three (20 publications). The highest number of authors per publication is 83 and appears for only one publication, which is out of the range (Fig. 2H).

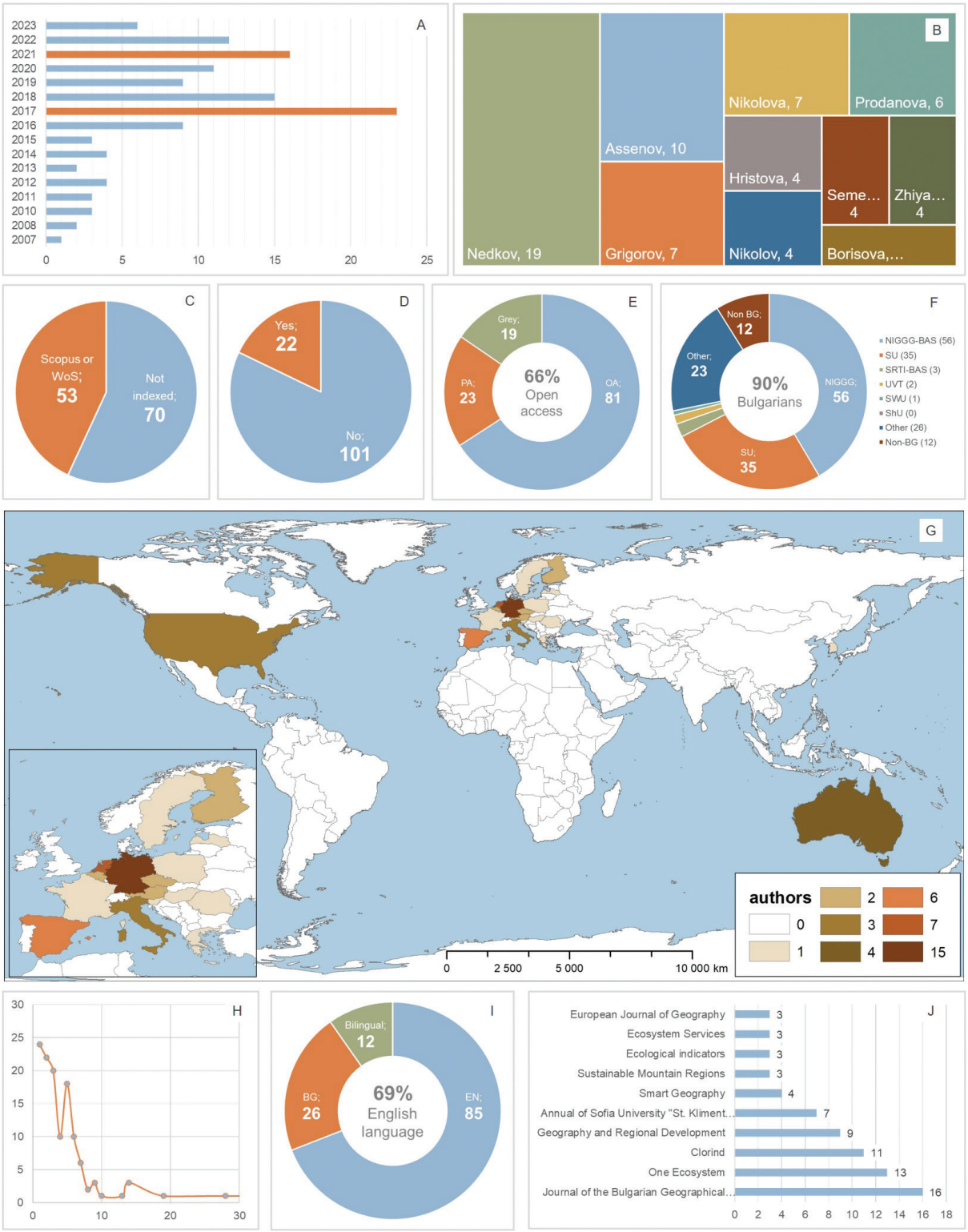

Figure 1. Characteristics of the publications and authors **A** number of publications per year **B** top 10 Bulgarian lead authors **C** number of indexed publications **D** number of publications with international collaboration **E** number of accessible publications online **F** number of publications per institution **G** global distribution of foreign co-authors **H** number of authors per publication **I** language of the publication **J** most contributing journals and publishers to the ecosystem services research in Bulgaria. Abbreviations (1F): NIGGG-BAS—National Institute of Geophysics, Geodesy and Geography - Bulgarian Academy of Sciences, SU—Sofia University "St. Kliment Ohridski", SRTI-BAS—Space Research and Technology Institute - Bulgarian Academy of Sciences, UVT—"St. Cyril and St. Methodius" University of Veliko Tarnovo, SWU—South-West University "Neofit Rilski", ShU—"Konstantin Preslavsky" University of Shumen.

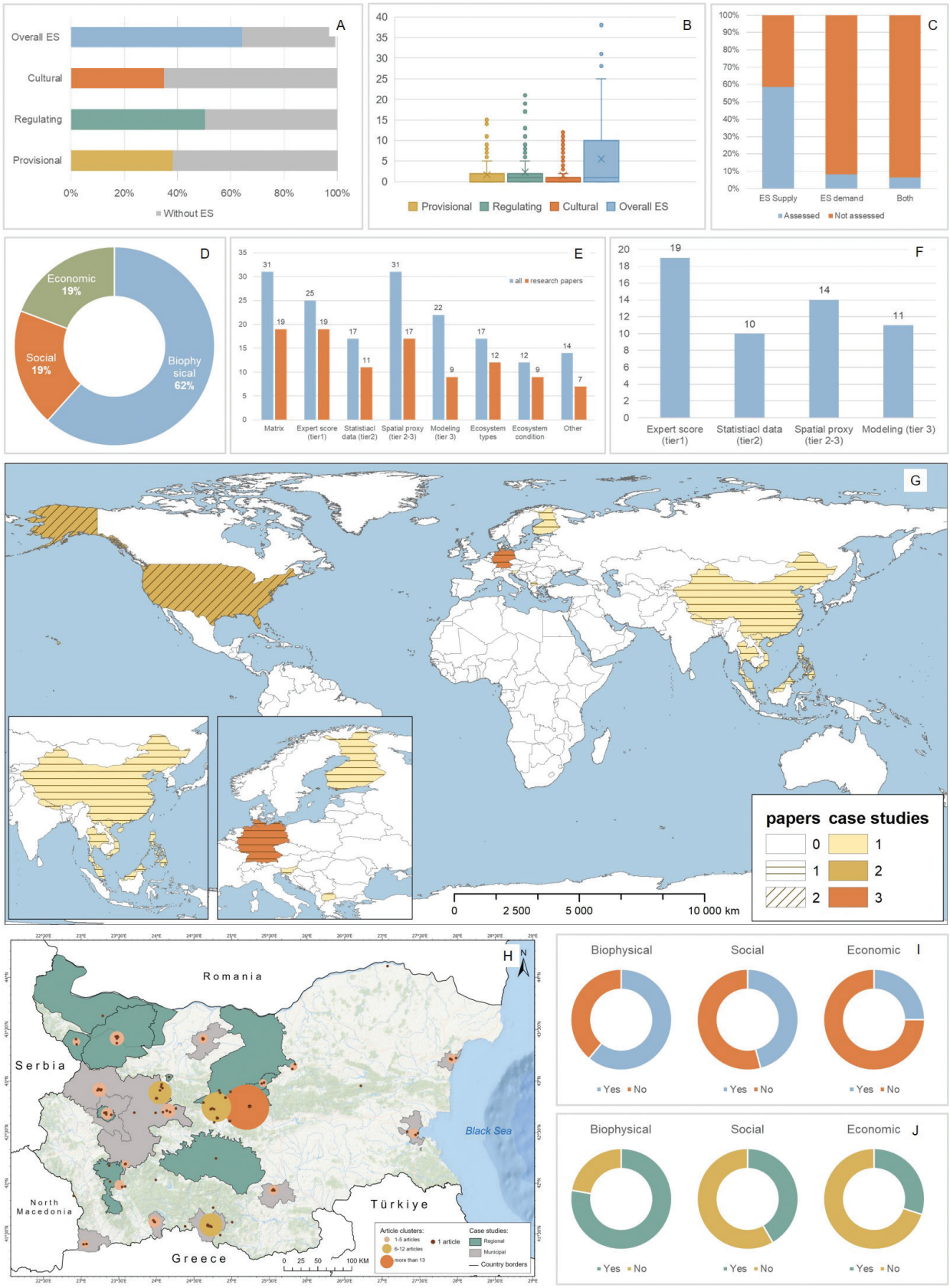

Figure 2. Characteristics of the ecosystem services research **A** assessed ES types in studied publications **B** distribution of the assessed ES **C** assessed supply-demand **D** ES assessment methods **E** mapping methods **F** matrix mapping methods **G** international case studies **H** Bulgarian case studies **I** distribution of all publications with ES maps between assessment methods **J** distribution of research papers with ES maps between assessment methods.

Ecosystem services research

The results on the character of the ES research showed that 64% (80), of the reviewed publications have assessed ES whereas the rest 36% (43) had no ES assessment. Further analyses of the latter group revealed that some of these papers are either editorial papers (five) from special issues containing ES assessment papers (such as Nikolova et al. 2021a) or conceptual papers (nine) that deal with methodological aspects of ES research. Another group contains five publications that present ES assessment without focusing on particular services. Four publications deal with ecosystem mapping (such as Hristova and Stoycheva 2021; Petkova et al. 2022) and assessment of ecosystem conditions (Uzunov et al. 2017). The largest group (21) consisted of publications that deal with broader environmental topics mentioning ES in the text but do not perform real ES research. Although these publications are evenly distributed between the four periods, their share during the first two is much larger (33% and 31%) than in the third (12%) and the fourth (17%) period. The number of studied ES (provisioning, regulating, cultural, or a bundle of ES) differs within each study.

The most studied ES group is the regulating (50% overall), followed by provisioning (38% of all papers) and cultural (35% of all papers) ones (Fig. 2A). The publications that focus only on one of the ES groups number 36 and those assessing all three ES groups number 30. The publications with two ES groups number 13. Almost all of them contain the combination provisioning-regulating, while only one contains the combination provisioning-cultural. The distribution of the number of ES in each paper varies from mostly studying one ES (mainly regulating ES) to 38 in two methodological publications that address 38 ES (Karamfilov et al. 2017; Kostov et al. 2017). The biggest difference is within regulating ES, which ranges from one to 21 ES within one paper (Fig. 2B). Research papers mainly study a bundle of ES from each ES group, varying from five up to 21 ES. The studies of the ES supply-demand side have a well-defined trend for assessing mainly ES supply (59%). The lack of research on ES demand, as well as studies assessing both supply and demand, is evidence knowledge gap (Fig. 2C). Biophysical methods are the most used ones for ES assessment (62%), while the social and economic have a similar presence in the studied papers (19% each) (Fig. 2D).

Geographical scope

The analyses showed that 86 (70%) of the publications have clearly defined and spatially outlined case studies while the rest 37 (30%) had no case study. The case studies are predominantly in Bulgaria but there are also several case studies in other countries such as Germany, USA, Finland, North Macedonia etc. (Fig. 2G). The scale of the case studies is predominantly local with 57 of the publications dealing with such cases. Regional and national level case studies number 12 and 14 respectively. There are only two multiscale studies in Bulgaria combining local–regional and local–national scales, and one international study combining all three scales. Apart from the multiscale studies, six local studies cover between two and four separate sites. Thus, the whole number of studied sites in the above-mentioned 86 publications became 109. 97 of them are in Bulgaria and the rest are located in ten other countries. The local

scale case studies in Bulgaria form several visible clusters that can be divided into three groups (Fig. 2H). The first one contains only one but the far biggest cluster located in the area around the Central Balkan National Park combining 19 cases. The second group contains three moderate size clusters combining between nine and 12 cases. The third group contains 12 clusters combining between two and five cases. The highest number (20) of local-scale case studies were municipalities. Natural objects were chosen as research objects in 18 case studies, which comprise seven mountain areas, four lakes, and six other natural objects. River basins as a spatial unit were used in 16 case studies, while urban areas (city/town) were used in 13 cases.

The publications with ES maps were 58 which comprise almost half (47%) of the reviewed sources. The figures in the research paper are slightly different with 59% of the papers presenting some kind of ES maps and 41% without ES maps. The respective distribution between the main groups of ES assessment methods showed a significant difference in the number of publications containing ES maps (Fig. 2E). The studies that use biophysical methods are predominantly with ES maps, which are presented very well in the research papers with 78% share of the publications containing ES maps (Figs 2I, 2J). The respective distribution for the publications applying social methods is almost equal but for research papers, the share of no ES maps publications is even higher which is opposite to the general trend defined for the total dataset. The ES maps in the publications applying economic methods are even lower with only one-third presenting by maps the results of their studies.

The ratio between publications with and without maps changed during the different periods. During the first period, the publications with no maps are predominant (83%). During the second period, the predominance is not so pronounced (62%). The third period is characterized by balance (52% to 48%) while during the fourth period, the share of no ES maps publications is no more predominant (47%).

The ES mapping methods applied in the studies were evenly distributed among the publications with a slight dominance of the matrix approach, expert score, and spatial proxy methods (Fig. 2F). The matrix approach and the spatial proxy methods were the most popular for the total dataset, while for the research papers, the expert score replaced the spatial proxy methods as the second best used. Modeling methods are also well represented in the total dataset but their use in the research papers rapidly declines. The studies with ecosystem types and ecosystem condition maps comprise about 25% of the mapping publications and such maps are presented predominantly in research papers.

Discussion

Lessons learned

The case studies used in ES assessment reveal three important topics for discussion. Firstly, the municipality and river basin appear as the most appropriate spatial units that ensure a clear extent and policy relevance. Both of them have clearly defined boundaries (administrative or natural) which ensure a strong rationale for the study and comparability to other studies. The river basin is the main spatial unit in water management, while the municipalities are the main ob-

jects of the local government. Therefore, both units ensure a direct relationship between research findings and decision-making. Secondly, natural objects such as mountains, lakes, and karst areas appear as quite popular case studies. However, they vary a lot in the dimensions and the definitions of their extent. Their boundaries are mostly case-specific and hardly correspond in extent to other studies. Such studies can have high research contributions but their uptake necessitates further work to be adjusted to the policy needs and decision-making. The methodological frameworks for mapping and assessment of ES give some guidance but their development at regional and local level is still in the beginning (Nedkov et al. 2021). Thirdly, the nature protection areas are rarely selected as case studies which is an obvious research gap. The recent studies on the provision of ES by the nature heritage in Rila mountain (Silvestriev et al. 2021) and the habitat maintenance ES in mountain-protected areas (Borisova et al. 2023) are positive examples but much more research in this direction is needed.

The predominance of local case studies and the limited number of multiscale studies show that the researchers prefer to focus on relatively small areas that can easily be provided by data and expertise. The efforts during the national mapping under the MAES process resulted mainly in methodological publication which applicability in the real research is still to be proved. The limited number of research papers in high-ranked journals presenting results from the national mapping (the only exception is Nedkov et al. 2017) is clear evidence of the need for further development of these methodologies. Therefore, despite the undoubtable achievements during these 20 years ES research in the country is still a relatively new field that is still to be fully come of age.

The share of publications containing specific geographical elements in the form of ES maps and spatial analyses has gradually risen from the first to the fourth period. Two main reasons are behind this tendency. The first one came from the MAES process that stimulated the mapping studies all over Europe and the Bulgarian researchers were among the most active which was proven by the results in the MAES barometer indicating the leading role of the country (Burkhard et al. 2018a). The second one is the development of the spatial aspects in ES research inspired by the activities in the Ecosystem Services Partnership (ESP) working group on mapping and modeling of ES where the Bulgarian geographers were also present (Burkhard et al. 2013; Crossman et al. 2013). However, even in the last period the share of the publications without maps remains high (47%) which is not reasonable for the geographical community. Therefore, more attention on the spatial aspect of the ES research by the Bulgarian geographers is needed.

The disproportion between the ES supply and demand studies is another important finding of our review. Although it corresponds to the general trend defined in international studies (Campagne et al. 2020) the lack of studies focused on the demand side, especially on the supply/demand balance, remains a significant research gap. In the Bulgarian case, this disproportion corresponds also to the predominance of biophysical methods at the expense of social and economic. The latter (especially the social) are more appropriate for the studies on ES demand. This is a clear message on the need for the development and application of more social methods in ES research by geographers. This need is even more pronounced taking into account the existence of the social-economic branch of geography.

Future directions

The findings from the review allow us to identify both achievements and research gaps in the ES studies conducted by Bulgarian geographers. This enables us to define the main research priorities of the coming years which can trace the future directions of ES research in the country. The main priority should be directed towards the development of the spatial aspects in the methodological frameworks for mapping and assessment of ES. This includes problems such as the identification of relevant scales for the implementation of particular indicators and the methods for their quantification, a precise statement on the spatial scale and extent of the ecosystem services assessment, a clearer and more precise definition of the spatial units used in the assessment, application of more spatially explicit indicators including those for assessment of ecosystem condition, include a sensitivity analysis to understand the effects of varying spatial resolutions, include potential trade-offs between different spatial scales and their implications on ecosystem service, etc. The achievement of such objectives will ensure both scientifically robust mapping of ES and relevance to policy and decision-making.

The next priority should be in the use of GIS-based tools for mapping ES which are developing very fast in recent years. Particularly the development of specialized ES tools such as InVEST, ESTIMAP, and ARIES ensures a variety of spatial options for a wider range of individual ES (Nedkov 2018). The tendency for models' integration in the ES research is another aspect that can be used also to incorporate more social and economic methods and further development to ES demand and supply demand studies which would contribute to overcoming this research gap. Another important priority should be the improvement of the publication quality and increase of the papers published in highly rated indexed journals. This could be achieved by focusing on internationally recognized topics, application of modern methods, and abandonment of the grey literature as a publication option.

Conclusions

The development of ES research in Bulgaria during the last 20 years has led to the accumulation of significant scientific production in the form of publications that cover almost all important aspects of the ES concept. Bulgarian geographers have the leading role in this development, especially in the mapping of ES that covers all spatial aspects of the ES research including spatial data acquisition, GIS analyses, and preparation of maps. The variety of publications reviewed in this study reveals significant achievements both in the geographical extent and the methodological robustness of the research. The case studies of the reviewed publications cover 10 countries in three different continents. Even more pronounced is the significance of international collaboration given the scope of the authors who come from 21 different countries. The studies cover a variety of ES from all three main groups of services and apply a variety of methods with a focus on the biophysical. The contributions to the mapping methods are also important with significant achievements in the development of the matrix approach, spatial proxy, and modeling methods. However, despite the undoubted achievements during these 20 years, ES research in the country is still a relatively new field, and there are still many gaps to be filled.

The perspectives of the ES research in Bulgaria, and the geographers in particular, are related to the development of several priorities. The development of the spatial aspects in the methodological frameworks for mapping and assessment of ES is necessary to ensure scientifically robust mapping of ES and relevance to policy and decision-making. Better use of GIS-based tools for mapping ES alongside models' integration is needed to ensure a variety of spatial options for a wider range of individual ES and incorporation of more social and economic methods for further development of ES demand and supply/demand balance studies. The improvement of the publication's quality and increase of the papers published in highly rated indexed journals will ensure better visibility and impact of the research.

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

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Author contributions

Conceptualization: SN, HP, VS. Data curation: HP, SN, IA, VS. Formal analysis: SN, VS, HP, YY, IA. Funding acquisition: HP, SN. Investigation: YY, HP, VS, IA. Methodology: VS, SN. Resources: HP, VS, SN. Supervision: SN. Validation: IA, HP, VS. Visualization: SN, HP. Writing - original draft: SN, VS, HP. Writing - review and editing: SN, VS, HP.

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Data availability

All of the data that support the findings of this study are available in the main text or Supplementary Information.

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Supplementary material 1

Database of the reviewed publications on ecosystem services

Authors: Stoyan Nedkov, Vanya Stoycheva, Hristina Prodanova, Ivaylo Ananiev, Yordan Yordanov

Data type: xlsx

Explanation note: Literature database on ecosystem services containing 123 records of publications reviewed in this work.

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