

A BIBLIOMETRIC ANALYSIS OF ECOSYSTEM SERVICES ASSESSMENT IN PROTECTED AREAS AND NATURE RESERVES FROM 1997 TO 2025

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Abstract. Ecosystems play a crucial role in supporting human society; however, human activities are significantly disrupting their original balance. Due to the growing global attention to environmental security, a substantial number of studies have been conducted on ecosystem services. This study carries out a bibliometric and statistical analysis to enhance a comprehensive understanding of the key indicators of scientific research on ecosystem services. It reviews articles published between 1997 and the first half of 2025 concerning the assessment of ecosystem services in nature reserves and protected areas. The analysis includes aspects such as publication years, continents, types of data sources, timeframes, assessment methods, types of ecosystem services, ecosystem types, and practical research applications, accompanied by relevant graphs. The results reveal that 90% of the selected articles were published between 2013 and the first half of 2025. The majority of the research was conducted in Europe (44.44%) and Asia (30.77%). Among the different types of ecosystem services, cultural services had the largest share at 34%. Based on the findings, the researcher has developed their own recommendations for assessing ecosystem services.

Keywords: protected areas, ecosystem services, systematic analysis, bibliometric analysis, nature reserve, biodiversity.

Annotatsiya. Ekotizimlar insoniyat jamiyatini qo'llab-quvvatlashda muhim rol o'ynaydi, ammo inson faoliyati ularning dastlabki muvozanatini sezilarli darajada buzmoqda. Dunyo miqyosida ekologik xavfsizlikka bo'lgan e'tiborning ortib borishi natijasida ekotizim xizmatlari bo'yicha ko'plab tadqiqotlar amalga oshirildi. Ushbu tadqiqot ekotizim xizmatlari bo'yicha ilmiy tadqiqotlarning asosiy ko'rsatkichlari to'g'risida to'liq tasavvurni oshirish uchun bibliometrik va statistik tahlilni amalga oshiradi. Unda 1997-yildan 2025-yilning birinchi yarmigacha bo'lgan davrda qo'riqxonalar va muhofaza etiladigan hududlarda ekotizim xizmatlarini baholash bo'yicha chop etilgan maqolalar ko'rib chiqiladi. Tahlil nashr etilgan yillar, qit'alar, ma'lumotlar manbalarining turlari, muddatlar, baholash usullari, ekotizim xizmatlarining turlari, ekotizim turlari va amaliy tadqiqot ilovalari kabi jihatlarni o'z ichiga oladi va tegishli grafiklar bilan birga taqdim etiladi. Natijalar shuni ko'rsatadiki, tanlangan maqolalarning 90 foizi 2013-yildan 2025-yilning birinchi yarmigacha chop etilgan. Tadqiqotlarning aksariyati Yevropa (44,44%) va Osiyoda (30,77%) o'tkazilgan. Turli xil ekotizim xizmatlari orasida madaniy xizmatlar eng katta ulushga ega bo'lib, 34% ni tashkil etdi. Tadqiqotchi olingan natijalar asosida ekotizim xizmatlarini baholash bo'yicha o'z tavsiyalarini ishlab chiqqan.

Kalit so'zlar: qo'riqxonalar, ekotizim xizmatlari, tizimli tahlil, bibliometrik tahlil, qo'riqxona, bioxilma-xillik.

Аннотация. Экосистемы играют решающую роль в поддержании человеческого общества; однако, человеческая деятельность значительно нарушает их первоначальный баланс. В связи с растущим вниманием к экологической безопасности в мире, было проведено значительное количество исследований по экосистемным услугам. В данном исследовании проводится библиометрический и статистический анализ для повышения всестороннего понимания ключевых показателей научных исследований экосистемных услуг. В нем рассматриваются статьи, опубликованные в период с 1997 года по первую половину 2025 года, касающиеся оценки экосистемных услуг в заповедниках и охраняемых природных территориях. Анализ включает такие аспекты, как годы публикации, континенты, типы источников данных, сроки, методы оценки, типы экосистемных услуг, типы экосистем и прикладные исследования, сопровождаемые соответствующими графиками. Результаты показывают, что 90% выбранных статей были опубликованы в период с 2013 года по первое полугодие 2025 года. Большинство исследований было проведено в Европе (44,44%) и Азии (30,77%). Среди различных видов экосистемных услуг культурные услуги имели наибольшую долю - 34%. На основании полученных результатов исследователь разработал собственные рекомендации по оценке экосистемных услуг.

Ключевые слова: охраняемые территории, экосистемные услуги, системный анализ, библиометрический анализ, природный заповедник, биоразнообразие.

Introduction. Protected areas are defined by the International Union for Conservation of Nature (IUCN) as clearly designated geographical spaces, recognized, dedicated, and managed-through legal or other effective means-to achieve the long-term conservation of nature with associated ecosystem services and cultural values (IUCN, 2008). Since they are designated as natural areas-such as national parks, nature reserves, and

marine parks-the primary goals of protected areas include conserving biological resources and natural heritage, preserving representative ecosystems, safeguarding habitats of endangered species, and protecting genetic resources. Currently, protected areas cover approximately 16.64% of the world's terrestrial and inland water ecosystems, and about 7.74% of coastal waters and the ocean (UNEP, 2021).

Research on ecosystem services assessment began globally in the 1970s, when it was first recognized that biodiversity loss could impact ecosystem services (Holdren JP, 1974). These services are generally categorized into four broad groups: provisioning, regulating, cultural, and supporting services (VanderWilde et al., 2021). The global context of developing protected natural areas involves the establishment and management of designated zones aimed at conserving biodiversity, safeguarding ecosystems, and delivering various ecosystem services. However, protected natural areas face numerous challenges in achieving conservation goals. Using ecosystem services as a foundation for managing protected areas addresses issues such as biodiversity loss, habitat degradation, harmful human activities, pollution, climate change, limited resources, and conflicting interests, thereby aiming to enhance the effectiveness of conservation efforts. Research on ecosystem services in protected areas has been conducted since 2002 (Saxena et al., 2002; Augustine & McNaughton, 2004; Elmqvist et al., 2004), with a primary focus on forest and wetland ecosystems. Early research directions were relatively fragmented and generally included the quantification of service values, the impact of human activities, and natural variability in the delivery of ecosystem services. This study specifically covers the period from 2014 to the first half of 2025. As the number of published articles increased, the quality of research also improved. Stakeholder perspectives on ecosystem service and biodiversity attributes have been widely used in various studies for planning protected areas (Carcamo et al., 2014; Darvill & Lindo, 2016; Solomonsz et al., 2021).

The classification of ecosystem services described in the Millennium Ecosystem Assessment cannot be effectively used in decision-making processes, as it confuses «means» (how to achieve a goal) with «ends» (the goal to be achieved) (Wallace, 2007). Moreover, the concept of ecosystem services has not yet been widely adopted in the management of protected natural areas, and such an approach is not always enthusiastically received (Hummel & Poursanidis, 2019). As a result, decision-making based on ecosystem services often remains particularly challenging and uncertain, which has led to low practical effectiveness (Xu et al., 2022).

In this study, we conducted a bibliometric and statistical analysis of scientific articles published over the past 28 years (1997–2025) on ecosystem services in nature reserves and protected areas. The aim of this analytical paper is to uncover the scope and challenges of previous research in order to inform and guide future scientific investigations. Utilizing ecosystem services to inform management and decision-making in protected areas has the potential to significantly enhance both environmental protection and human well-being.

Materials and Methods. In this analytical study, literature published between 1997 and the first half of 2025 was retrieved from the *Web of Science*, an international database of peer-reviewed scientific articles, using key terms such as “ecological services,” “ecosystem services,” “nature reserve,” “protected natural areas,” and “conservation areas.” The search was limited to articles published in English. A total of 117 articles were identified, of which 84 were classified as empirical research papers, while the remaining 33 were analytical or review articles.

The 84 empirical articles were analyzed using bibliometric and statistical methods, focusing on the number of applied studies by year, continents, temporal scales, types of data sources, primary data characteristics, research findings, and the types of ecosystem services studied.

Results

3.1. Bibliometric analysis

Bibliometric analysis was employed to investigate global trends in ecosystem service research within protected natural areas (Mengist et al., 2020; Aryal et al., 2022). All relevant articles addressing the value of ecosystem services in protected areas were searched through the Web of Science database from the year 1997 onward. However, the results showed no significant research output between 1997 and 2001, with the first relevant study published in 2002.

3.2. General characteristics of the empirical studies

The first empirical study on ecosystem services in protected natural areas was published in 2002. However, by 2010, only five such studies had been published. Overall, 90% of the selected articles were published between 2013 and the first half of 2025, while the remaining 10% appeared between 2009 and 2014 (Figure 1). The rate of publication has shown a steady increase over the years.

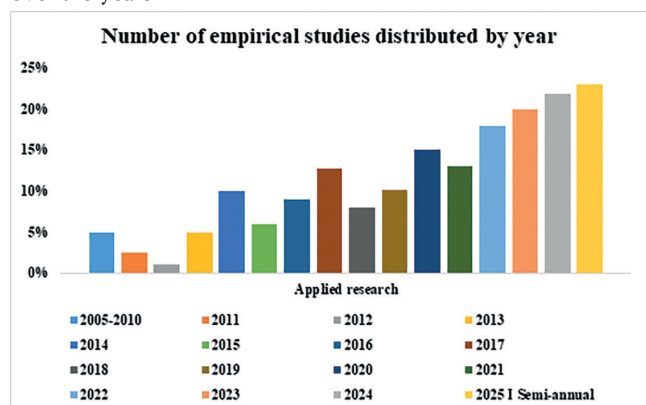


Figure 1. Number of empirical studies distributed by year.

A total of 117 publications (including 84 empirical studies) were selected for in-depth review and analysis. A significant portion of the empirical studies were conducted in the protected areas of Spain (16), China (11), the United Kingdom (8), Italy (7), Malaysia (6), and South Africa (5), prompting discussions regarding the geographic distribution of research efforts (Figure 2). Our analysis indicates that ecosystem services were first addressed in the management of protected areas in 2002, with a gradual increase in relevant studies, particularly in the last three years after 2013. In general, the integration of ecosystem services into protected area management remains relatively limited (Hummel & Poursanidis, 2019), and methods and approaches vary widely across studies. In North America, research has highlighted the role of protected areas in providing various ecosystem services such as water purification and recreational opportunities (Van Riper & Kyle, 2014; Johnson & Van Riper, 2019). In South America, studies have focused on the contribution of protected areas to carbon storage and watershed protection, emphasizing biodiversity and ecosystem

service conservation (Cárcamo & Garay-Flühmann, 2014; Rossi & Barros, 2020). In Europe, research has emphasized the role of protected areas in delivering cultural ecosystem services, such as heritage preservation and recreation (Cebrián-Piqueras & Filyushkina, 2020; Schirpke & Scolozzi, 2018). In Africa, studies have explored the value of protected areas in tourism, cultural heritage, and provisioning services, reflecting their role in both economic and cultural contexts (Ament & Mur, 2016; Roux & Smith, 2020). Similarly, research in Asia has focused on the role of protected areas in ensuring ecosystem services such as water supply, carbon sequestration, and biodiversity conservation (Zhang & Yin, 2020; Fan & Shibata, 2016). Overall, the findings from ecosystem services research in different types of protected areas are diverse, reflecting the heterogeneity of ecosystems, socio-economic conditions, and management practices across regions (Chjao, 2022). At the global scale, empirical research has been conducted predominantly in Europe (44.44%) and Asia (30.77%).

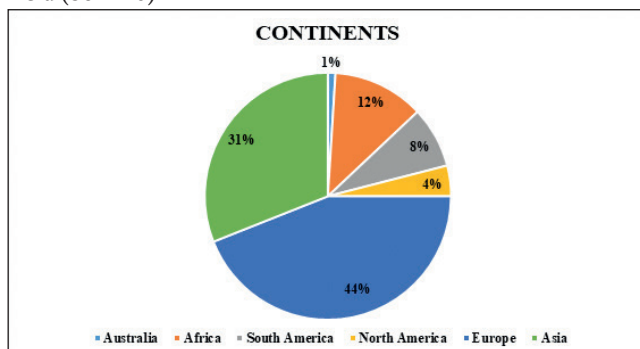
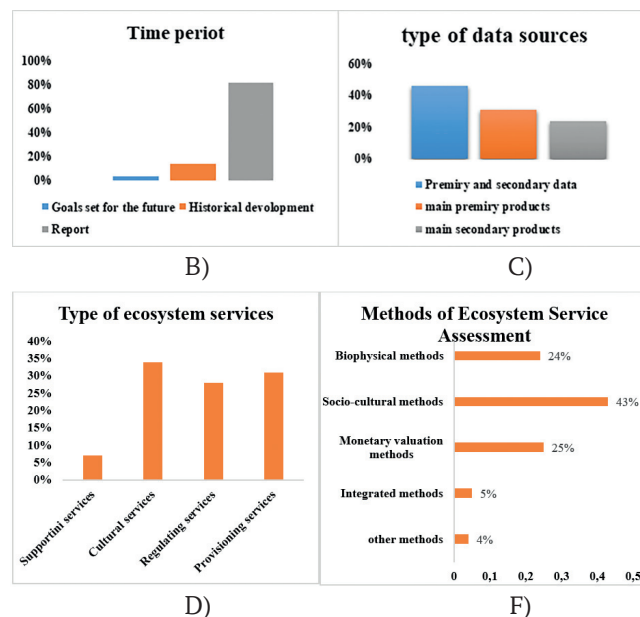


Figure 2. Percentage of ecosystem services studies conducted at specific factor levels across six continents.

This chart presents the proportion of scientific studies on ecosystem services carried out globally, categorized by continent. As previously illustrated in the graph above, the majority of these studies have been conducted in Europe and Asia. On a global scale, the research topics were distributed as follows: 82% focused on assessment, 14% on historical development, and only 4% on future goals. This indicates that most studies are centered on evaluating existing conditions rather than forecasting or shaping future conservation strategies. The outcomes of these studies contribute to reducing or preventing environmental problems in protected areas, strengthening social support for conservation management, and improving the well-being of local communities.

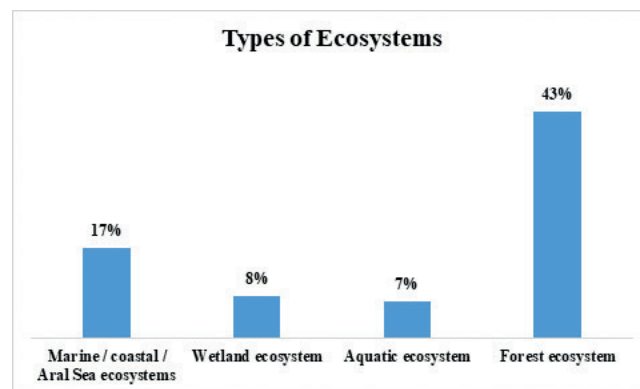
The chart illustrates the percentage distribution of ecosystem service types and the methods used to assess them. Ecosystem services are categorized into four main types, with each category's proportion represented in percentages. Cultural ecosystem services account for the largest share at 34%, reflecting their aesthetic, recreational, and cultural value to people. The second part of the chart presents the various assessment approaches used to evaluate ecosystem services. Among these, socio-cultural methods dominate with 43%, making them the most widely applied. The chart clearly indicates that cultural services and socio-cultural assessment methods prevail, highlighting the growing recognition of the aesthetic and cultural importance of ecosystems to human well-being. At the same time, scientific

and technically based approaches are applied less frequently, suggesting a need to further integrate these methodologies into ecosystem service assessments.



Figures 1B and 1C. Types of data sources for ecosystem services conducted in protected natural areas globally, and the percentage of studies focused on achieving goals within a specific time period and advancing toward those goals through development-oriented research.

Between 2019 and the first half of 2025, a significant increase in the number of methods used was observed, indicating a growing interest in the assessment of ecosystem services during this period. The highest number of studies was recorded in 2021, with particular emphasis on biophysical and socio-cultural methods. In the first half of 2025, biophysical (5), economic (2), applied (3), socio-cultural (1), and integrative (2) approaches were used. The graph shows a consistent increase in scientific and practical research related to ecosystem service assessment over the years. Notably, biophysical and socio-cultural approaches have remained stable and dominant, while economic and integrative methods have shown increased activity in specific years. This trend reflects a growing interest in taking a comprehensive approach to evaluating ecological challenges.



It was found that cultural services (73 cases) and provisioning services (67 cases) were the most frequently represented

ecosystem service categories. Among the cultural services, the most commonly addressed were recreation and tourism (60 cases), aesthetic values (29 cases), spiritual experiences (14 cases), and information for cognitive development (3 cases). For provisioning services, the most frequently represented were food (53 cases), raw materials (39 cases), water (25 cases), and medicinal resources (7 cases). The second most represented category was regulating services, including climate regulation (34 cases), water regulation (25 cases), maintenance of soil fertility (19 cases), erosion control (20 cases), air quality regulation (19 cases), regulation of extreme events (12 cases), and pollination (10 cases). Supporting services were the least represented in studies on the management of protected areas, likely due to their overlapping nature with regulating services. Among the supporting services, genetic diversity conservation (9 cases) and life cycle maintenance (5 cases) were most commonly addressed.

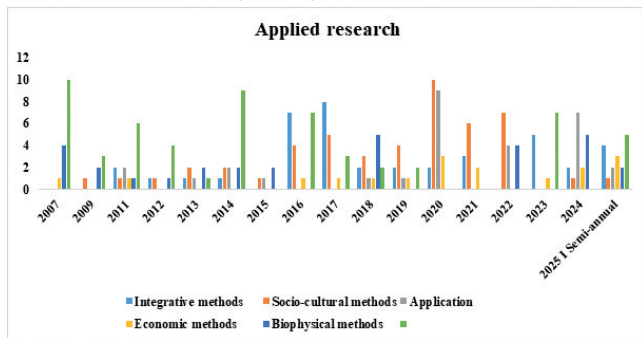


Figure 3. Proportions of methods used in ecosystem services assessment research between 2007 and the first half of 2025.

Conclusion. Although we believe that biodiversity conservation should remain at the core of nature protection strategies, conservation plans should also give greater attention to ecosystem

services considered important by different stakeholders, as well as to conflicting perspectives. Properly accounting for the trade-offs between multiple ecosystem services—including the needs and expectations of local communities—can be a crucial step toward collaborative management of protected areas. Moreover, more efforts are needed to assess the link between protected areas and human well-being. The findings of this systematic review can support better policymaking in protected natural areas, guide sustainable natural resource planning for future generations, encourage collaborative initiatives, and foster future research in conservation science by promoting sustainable pathways that benefit both ecosystems and people.

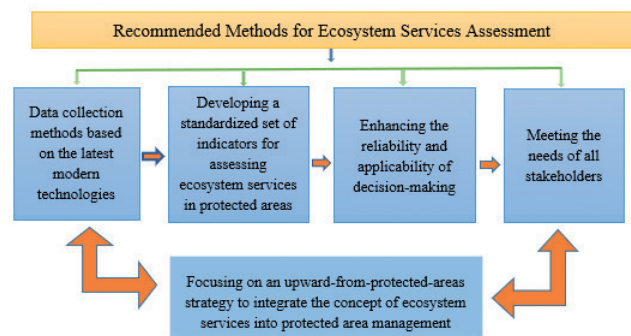


Figure 4. Recommended methods for ecosystem services assessment.

This chart presents several recommended methods for assessing ecosystem services. These methods highlight the importance of integrating the concept of ecosystem services into the management of protected areas—specifically, serving as a foundation for strategic-level decision-making. The axes in the chart illustrate how these stages are interconnected, emphasizing their strong interrelation and the necessity of a comprehensive, integrated approach.

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