# ECOSYSTEM SERVICES IN ACHIEVING SDGs: A BIBLIOMETRIC OVERVIEW 2015-2024

DJANPULATOVA, Z. A.[1*] – JULIEV, M. K.[1,2] – ABDIKAIROV, B. E.[3] – KHOLMURODOVA, M. D.[1] – TURDALIEVA, S. R.[1] – KHADJIEVA, Z. B.[1]

[1]*Institute of Fundamental and Applied Research, National Research University TIIAME NRU, Kary-Niyaziy str. 39, Tashkent 100000, Uzbekistan*

[2]*Turin Polytechnic University in Tashkent, Little Ring Road Street 17, Tashkent 100095, Uzbekistan*

[3]*Institute of Agriculture and Agrotechnologies of Karakalpakstan, Darbent str. 140/3, Nukus 230109, Uzbekistan*

**Corresponding author*
*e-mail: zilolakhondjanpulatova@gmail.com*

(Received 7th Feb 2025; accepted 22nd Apr 2025)

**Abstract.** Ecosystem services are vital for humanity and are critical in achieving the United Nations Sustainable Development Goals (SDGs). Ecosystem services are the benefits nature provides to people and their integration into strategies is essential for achieving the SDGs. This research aimed to gather all English-language publications indexed in Scopus from 2015 to 2024 and assess how ecosystem services support SDGs through a bibliometric review. We present the survey findings on the role of ecosystem services in achieving SDG targets related to the environment and human well-being, emphasizing their interactions and relevance to Sustainable Development Goals. Understanding how these services support multiple development targets is essential for planning synergistic and cost-effective interventions. This bibliometric analysis highlights the critical role of ecosystem services in sustainable development. This article advocates for a shift in how we approach urbanization and development, placing ecosystem services at the core of sustainable policy and practice. This work will be beneficial to policymakers, urban planners, environmental scientists, and sustainable development practitioners. It provides valuable insights for integrating ecosystem services into policy and decision-making, guiding more effective strategies for achieving sustainability goals. This article advocates for a shift in how we approach urbanization and development, placing ecosystem services at the core of sustainable policy and practice.
**Keywords:** *sustainable development goals, climate change, challenges, contribution, Scopus*

## Introduction

The term "ecosystem services" (ES) was first used in the 1983 publication "Extinction, Substitution, and Ecosystem Services" by Ehrlich and Mooney (1983). Ecosystem services were later defined by Costanza et al., as the diverse products and benefits humans acquire from ecosystems, whether directly or indirectly (Costanza et al., 1998). The fundamental definition remains consistent: ecosystem products and services support the functioning of natural systems, thereby offering significant benefits to humanity (Deeksha and Shukla, 2022; Sonko et al., 2022). Ecosystem services, which are the advantages gained from healthy ecosystems (Maksymenko et al., 2023), play a crucial role in human well-being and sustainable development (Li and Lei, 2023; Nielsen, 2020; Scemama et al., 2024). These services include various functions, such as provisioning (food, water), regulating (climate, disease), supporting (nutrient cycling), and cultural benefits (recreation, spiritual enrichment) (Deeksha and Shukla, 2022). Their importance is increasingly acknowledged as vital for achieving the United


http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2304_62236246

Nations Sustainable Development Goals (SDGs) (Hawken et al., 2021), which seek to tackle global issues like poverty, inequality, and environmental degradation (Enahoro et al., 2023; Liu and Niu, 2015).

Despite increasing recognition of this relationship, notable research gaps remain in understanding how ecosystem services directly impact the achievement of specific SDGs, especially given the rapidly changing environmental conditions and socio-economic pressures. The link between ecosystem services and SDGs highlights the need to understand how these services contribute to sustainable development (Atchadé et al., 2023; Bhaduri et al., 2016). Previous studies highlight the importance of ecosystem services in tackling poverty (SDG 1), ensuring food security (SDG 2), building climate resilience (SDG 13) providing clean water and sanitation (SDG 6) and supporting life on land (SDG 15) (Jaramillo et al., 2019). Many studies fail to consider how ecosystem services interact and affect multiple SDGs simultaneously. Additionally, there is a lack of focus on local contexts and stakeholder perspectives, which are crucial for the success of these services in promoting sustainable outcomes (Safranov et al., 2022). This study aims to address these gaps through a comprehensive bibliometric literature review from 2015 to 2024. This research will provide insights into the evolving discourse surrounding ecosystem services and the SDGs by analyzing trends, methodologies, and key findings. In recent years, the concept of ecosystem services has attracted attention from global organizations, including the Millennium Ecosystem Assessment (MEA) (Millennium Ecosystem Assessment (Program), 2005). Reports from the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) outline how ecosystem services contribute to achieving the Sustainable Development Goals (SDGs), especially in fields such as poverty reduction, food security, and climate resilience (IPBES, 2019). The UN Environment Program (UNEP) discusses integrating ecosystem services into development policies to meet the SDGs (United Nations Environment Programme, 2023). The World Bank reports on natural capital emphasize the economic value of ecosystem services in fostering sustainable development (World Bank, 2018). The 2030 Agenda for Sustainable Development highlights the connections between ecosystems, biodiversity, and sustainable development, highlighting their significance for achieving the SDGs (Carpentier and Braun, 2020). Gangahagedara et al.’s (2021) study identified key connections between ES and topics like biodiversity and conservation planning. It reveals that the U.S., Canada, China, France, and Australia are leading contributors to ES research, with notable contributions from universities such as UC Santa Barbara (Gangahagedara et al., 2021). His findings emphasize the focus on terrestrial, urban, and marine environments within the research landscape (Gangahagedara et al., 2021). The focus on highly cited works might prioritize popular or mainstream topics over niche areas that are equally important but less cited. Wood et al. (2018) addressed the critical challenge of achieving well-being for all while protecting the environment, emphasizing the integration of ecosystem services into strategies for the UN Sustainable Development Goals (SDGs). The article presents findings from an expert survey that highlights how 16 ecosystem services contribute to 41 targets across 12 SDGs, suggesting potential for synergistic outcomes and identifying modelling tools that can aid in analyzing these interactions for effective planning (Wood et al., 2018).

Bibliometric reviews serve as effective tools for analyzing publication patterns, identifying key themes, and assessing the impact of research on ecosystem services and SDG integration (Bellanger et al., 2021; Hawken et al., 2021; Zhao and Li, 2022).


http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2304_62236246

Bibliometric analysis has been conducted to publish articles in various fields (Juliev et al., 2024; Jumaniyazov et al., 2023; Kannazarova et al., 2024; Khasanov et al., 2021). By systematically reviewing the literature, a bibliometric analysis can reveal research gaps, inform future inquiries, and provide insights for policymakers seeking to leverage ecosystem services for sustainable development (Gangahagedara et al., 2021; Li, 2022; Slizhe et al., 2023). The importance of this study lies in its potential to inform policymakers and stakeholders about the critical role of ecosystem services in sustainable development. Moreover, the novelty of this work lies in its focused bibliometric approach, combining quantitative metrics with qualitative insights. This comprehensive analysis not only highlights existing research trends but also identifies underexplored areas, ultimately paving the way for more integrative and context-sensitive approaches in future research. By doing so, this study seeks to enhance understanding of how ecosystem services can be effectively leveraged to achieve the SDGs, fostering a more sustainable future.

### *Objective*

The objective of this study is to conduct a systematic bibliometric review of English-language publications within the selected period on ecosystem services (ES) and their linkages to the Sustainable Development Goals (SDGs). By analyzing scholarly literature, this research identifies key themes, trends, and knowledge gaps in ES contributions to sustainable development. Specifically, it examines how ES support poverty alleviation, food security, climate resilience, and biodiversity conservation within the SDG framework. Additionally, this study highlights the most influential research, methodologies, and geographical contributions, offering insights to guide future research and policy formulation.

## Material and methods

### *Data collection*

This report used bibliometric and literary analysis to investigate the role of ecosystem services in achieving SDGs from 2015 to 2024 (*Table 1*). A total of 1135 publications in English at the final publication stage were selected using the search query *TITLE-ABS-KEY (“ecosystem service” AND sdg* OR “Sustainable development goal*”). Since publications in English at the final publication stage were selected, seven articles in the press and 44 articles written in other languages were excluded. The study includes a total of 1135 finalized and published papers and exported them to a CSV file. To extract the co-authorship and co-occurrence networks the VOS Viewer 1.6.19 software was produced by van Eck and Waltman at Leiden University in the Netherlands (Perianes-Rodriguez et al., 2016; Waltman and Van Eck, 2015).

## Results

Between 2015 and 2024, 1135 academic publications explored the role of ecosystem services in achieving the Sustainable Development Goals (SDGs), reflecting significant global interest in this topic. This research highlights the critical importance of ecosystem services in advancing sustainable development.


http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2304_62236246

***Table 1.*** *Research methodology*

| Filters | Results |
|---|---|
| Database | Scopus |
| Searching query | TITLE-ABS-KEY (“ecosystem service*” AND sdg* OR “Sustainable development goal*”) |
| Timespan | 2015-2024 |
| Publication stage | Final |
| Language | English |
| Number of publications | 1135 |

### *Trends in ecosystem services research*

Research trends provide valuable insights into how scholarly attention and resources shift over time within a particular field. Understanding these trends is important because it can reveal emerging topics, identify areas requiring further investigation, and inform policy and funding decisions. *Figure 1* illustrates the annual number of publications from 2015 to 2024. The data shows a steady increase, with publications rising from 11 in 2015 to 220 in 2024. Moderate growth occurred from 2015 to 2019, followed by a significant surge from 2020 onward. The highest increases were observed between 2020 (128 publications) and 2022 (195 publications). Growth slightly stabilized in 2023 (196) before reaching a peak in 2024 (220). This trend suggests a rising research interest, with a sharp expansion phase starting in 2020.

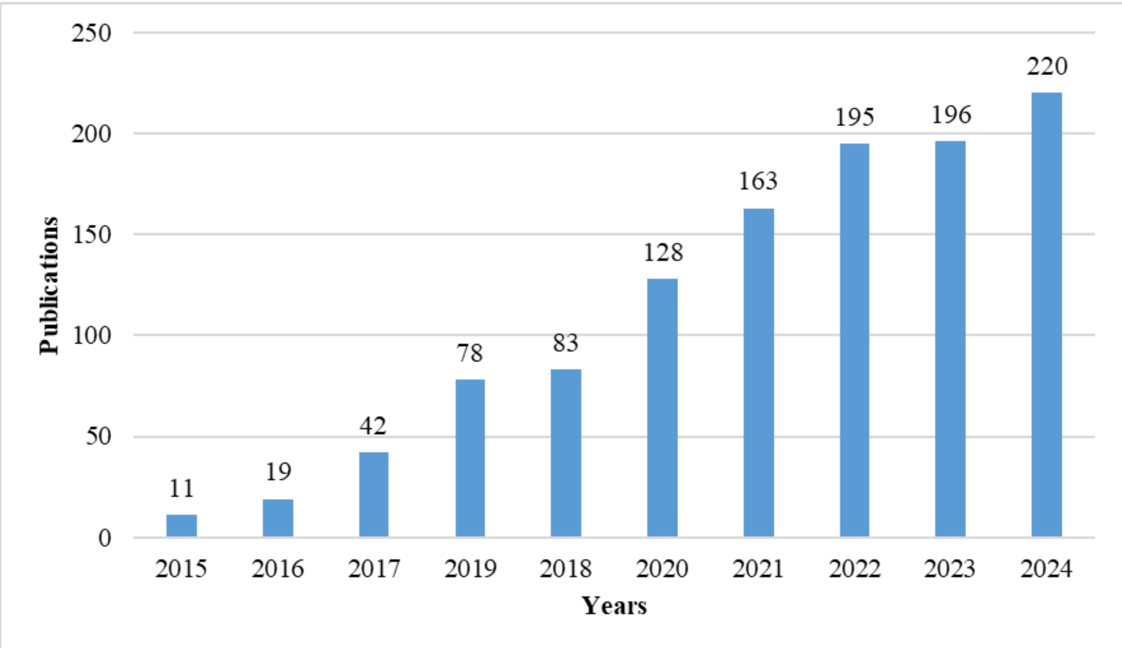


***Figure 1.*** *Global distribution of research publications on ecosystem services by publication year*


http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2304_62236246

### *Visual analysis of published literature*

*List of leading institutions globally in the field of ecosystem services*

*Figure 2* presents the number of research papers published by various institutions, revealing significant differences in research output. The Chinese Academy of Sciences stands out as the most prolific contributor, publishing 75 papers, far surpassing other institutions. Wageningen University & Research follows with 51 papers, while Beijing Normal University also demonstrates strong research activity with 40 papers. The University of Chinese Academy of Sciences and the Institute of Geographic Sciences and Natural Resources Research contribute at a moderate level, with 37 and 26 papers, respectively. Other institutions, such as the CNRS Centre National de la Recherche Scientifique and the Ministry of Education of the People's Republic of China, fall within a similar range, contributing 25 and 21 papers. At the lower end, Michigan State University produced 19 papers, making it the least prolific among the listed institutions, while the European Commission Joint Research Centre and the Research Center for Eco-Environmental Sciences each contributed 21 papers. The data highlights a strong research presence from Chinese institutions, with the Chinese Academy of Sciences leading by a substantial margin, underscoring China's significant role in academic research and publication output. *Figure 2* underscores the predominance of Chinese universities in ecosystem services research, while also highlighting the international nature of the field with contributions from various research organizations across Europe and other regions.

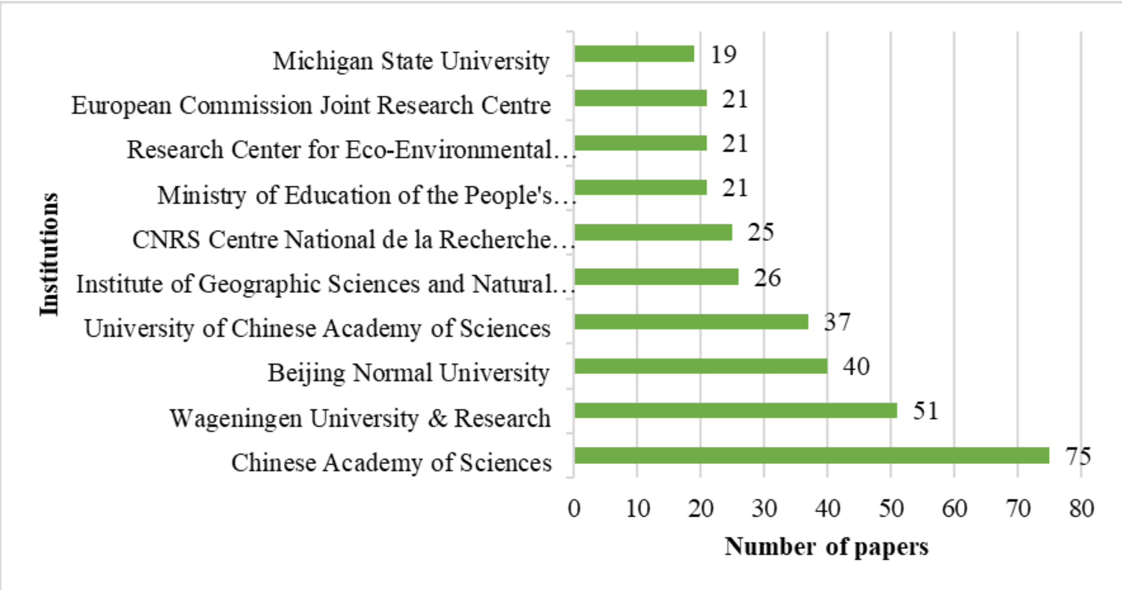


***Figure 2.*** *List of top institutions in Ecosystem services issue worldwide*

*Prominent authors in the field of ecosystem services research*

*Figure 3* The bar chart illustrates the number of publications by different authors, highlighting variations in research contributions. Bouma, J. is the most prolific author, with 19 publications, significantly ahead of others. Liu, J. follows with 12 publications, while Fu, B. has contributed 11. Pereira, P., Liu, Y., and Lal, R. each


http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2304_62236246

have 9 publications, indicating a moderate level of research output. At the lower end, Montanarella, L., Mao, D., Kubiszewski, I., and Giuliani, G. each have 7 publications. The data suggests that while contributions are relatively distributed among the authors, Bouma, J. stands out as the most active researcher in terms of publication count.

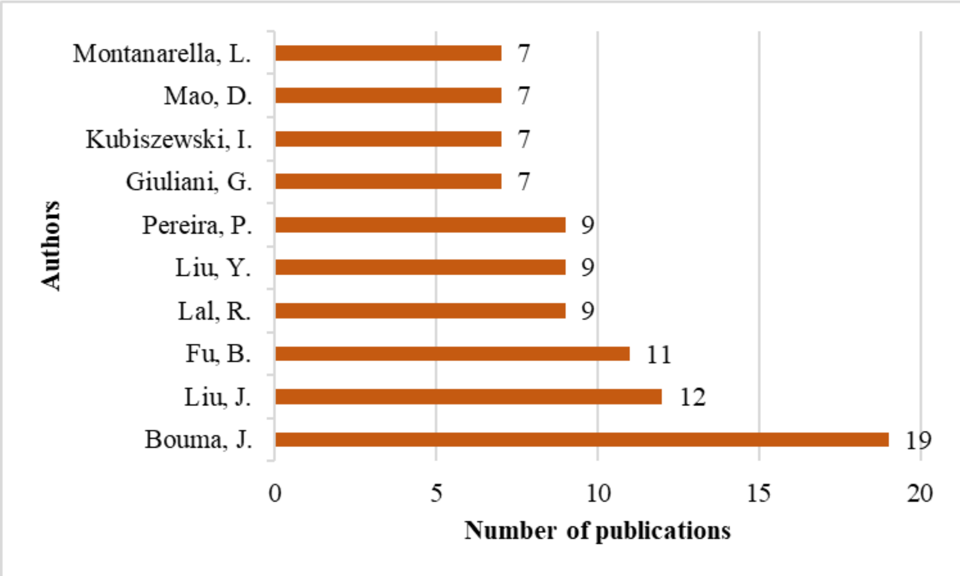


***Figure 3.*** *List of top authors published on ecosystem services*

*List of journals publishing research on ecosystem services*

*Table 2* provides a list of journals that have published research on ecosystem services, along with the number of publications and their quartile rankings. leads with 76 publications and is ranked in Q1, indicating its high impact in the field. Following this, *Science of the Total Environment* has 40 publications, while *Ecological Indicators* has 38, both also classified as Q1 journals. Other prominent Q1 journals include *Land* (28 publications), *Ecosystem Services* (20), *Journal of Environmental Management* (20), *Sustainability Science* (17), and *Journal of Cleaner Production* (16), all contributing significantly to research on ecosystem services.

***Table 2.*** *List of the journals on ecosystem services*

| Sources | Number of publications | Quartile (Q) |
|---|---|---|
| Sustainability | 76 | Q1 |
| Science of the Total Environment | 40 | Q1 |
| Ecological Indicators | 38 | Q1 |
| Land | 28 | Q1 |
| Ecosystem Services | 20 | Q1 |
| Journal of Environmental Management | 20 | Q1 |
| Sustainability Science | 17 | Q1 |
| Journal of Cleaner Production | 16 | Q1 |
| Frontiers in Environmental Science | 15 | Q2 |
| Sustainable Development Goals Series | 13 | Q4 |


http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2304_62236246

Among lower-ranked journals, *Frontiers in Environmental Science* has 15 publications and is categorized as Q2, while the *Sustainable Development Goals Series*, with 13 publications, is ranked Q4, indicating a relatively lower impact compared to the others. Overall, the data highlights that most research on ecosystem services is published in high-impact Q1 journals, demonstrating the strong academic relevance of the topic.

Ecosystem services research between 2015 and 2024 involved collaborations across 134 countries, highlighting the global nature of scientific efforts in this field. *Figure 4*, highlights 10 leading nations in ecosystem service provision, with China (240), the United States (231), and India (132) being the top three contributors. Other significant contributors include Italy (124), Germany (108), Australia (106), the Netherlands (92), France (68), and Spain (65). The color-coded representation offers a visual comparison of ecosystem service contributions worldwide.

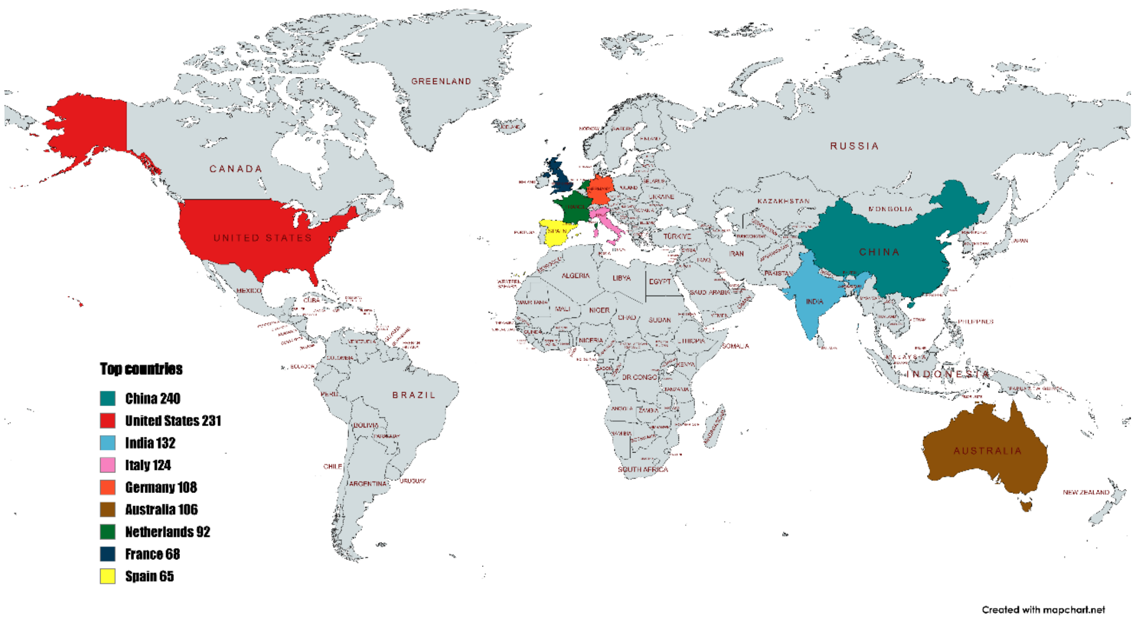


***Figure 4.*** *List of top countries on ecosystem services and sustainable development articles*

## *Analysis of keyword co-occurrence*

### *Network of co-occurrence based on the most commonly used author keywords*

*Figure 5* highlights the most commonly used author keywords in ecosystem services research, where 52 keywords that appeared at least 30 times were selected from a total of 6465 keywords. The network consists of three primary clusters. The red cluster focuses on policy and governance aspects, with key terms such as ecosystem services, sustainable development goals, environmental protection, and stakeholders, emphasizing the role of institutions and policies in sustainability. The green cluster is centered on ecological and conservation-related themes, including ecosystems, land use, forestry, conservation, and food supply, reflecting research on environmental management and restoration. The blue cluster represents urbanization and land-use change, featuring keywords like urbanization, remote sensing, water, land-use change, and human, indicating studies related to the intersection of human activities and ecological systems. This network showcases the


http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2304_62236246

interdisciplinary nature of ecosystem services research, linking governance, environmental conservation, and urban development.

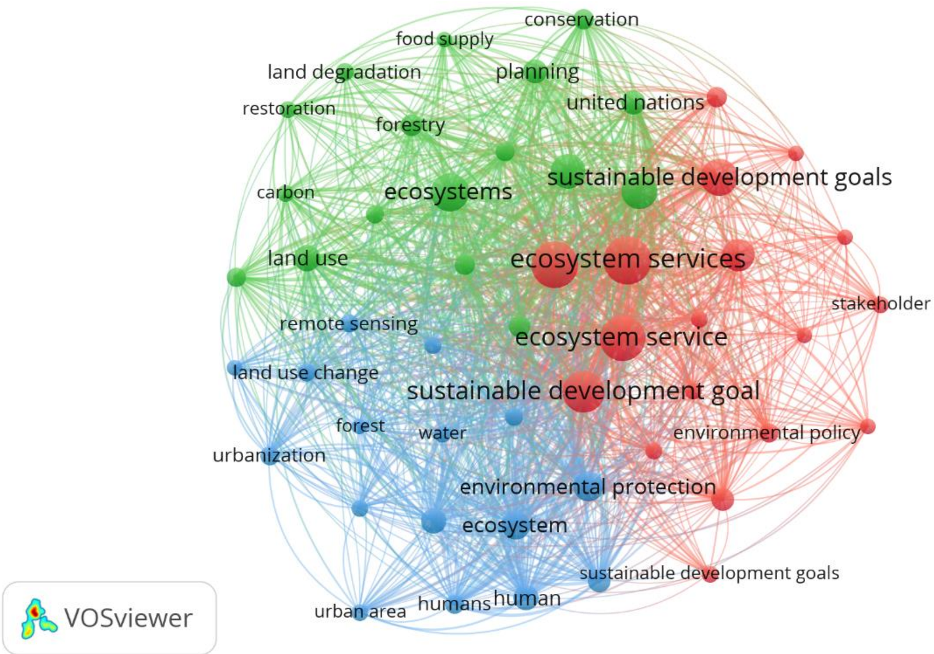


***Figure 5.*** *Co-occurrence based on the most commonly used author keywords*

*Figure 6* represents a co-authorship network of the most prolific authors in the field, highlighting their collaborative relationships. The network consists of 18 clusters, 550 links, and a total strength 807, indicating a dense and well-connected academic collaboration. A threshold of 454 out of 5045 authors from 1135 articles was applied. The size of the bubbles represents the number of highly referenced articles, while the line thickness and color indicate the strength of connections and clustering. The co-authorship network visualization highlights three main clusters, each representing a group of authors with strong collaborative ties. Red Cluster Liu, Yang, Zhang. It is one of the most interconnected groups, indicating a strong research collaboration. Yellow-Green Cluster includes Fu, Cui and Chen. Blue Cluster revolves around Pereira Paulo. It exhibits strong international collaboration, as indicated by the spread-out connections and diverse authors.

*Visual representation of the collaboration between the most active countries*

*Figure 7* illustrates the collaboration between the most active countries in publishing ecosystem services-related research, with 141 countries analyzed, 65 meeting the minimum threshold of 5 publications and 5 citations, and 6 selected for the final analysis. The visualization comprises 435 links with a total link strength of 396,339, highlighting strong global research interactions. Three main clusters emerge from the data. The red cluster, dominated by the United Kingdom, Belgium, Spain, and Japan, represents European and Asian collaborations, with the UK serving as a crucial link between the two regions. The green cluster, centered around Germany, Italy, the Netherlands, and Switzerland, reflects strong intra-European cooperation, with


http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2304_62236246

Germany and Italy playing key roles in sustainability research. The blue cluster, featuring the United States, China, India, Brazil, and South Africa, showcases global research powerhouses, emphasizing extensive international collaboration, particularly between the U.S., China, and India, while also highlighting emerging research hubs in the Global South. Collectively, this network underscores the interconnected nature of ecosystem services research, with the United Kingdom, Germany, and the United States acting as major hubs facilitating international cooperation.

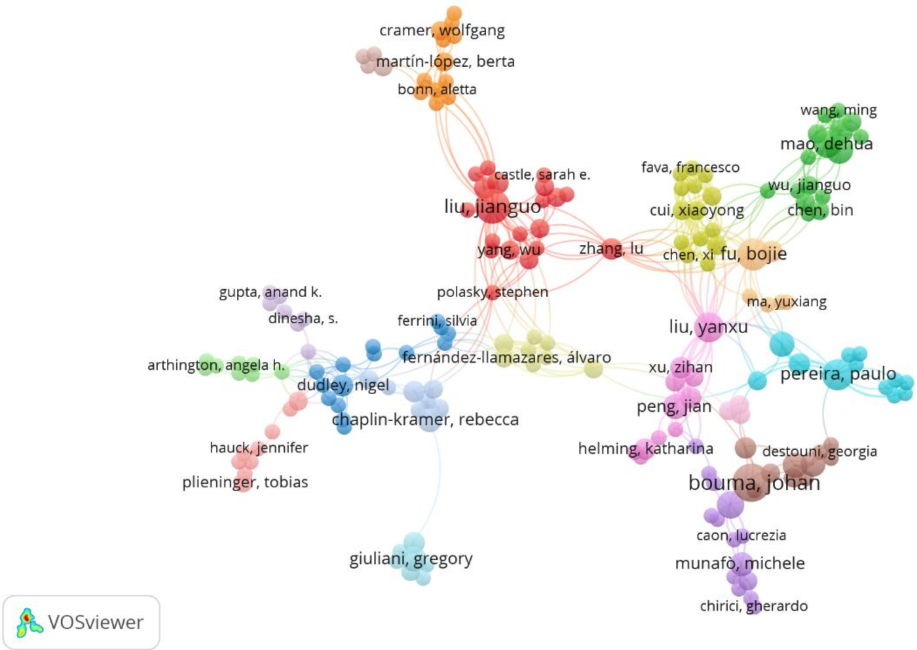


***Figure 6.*** *The co-authorship network of the most prolific writers*

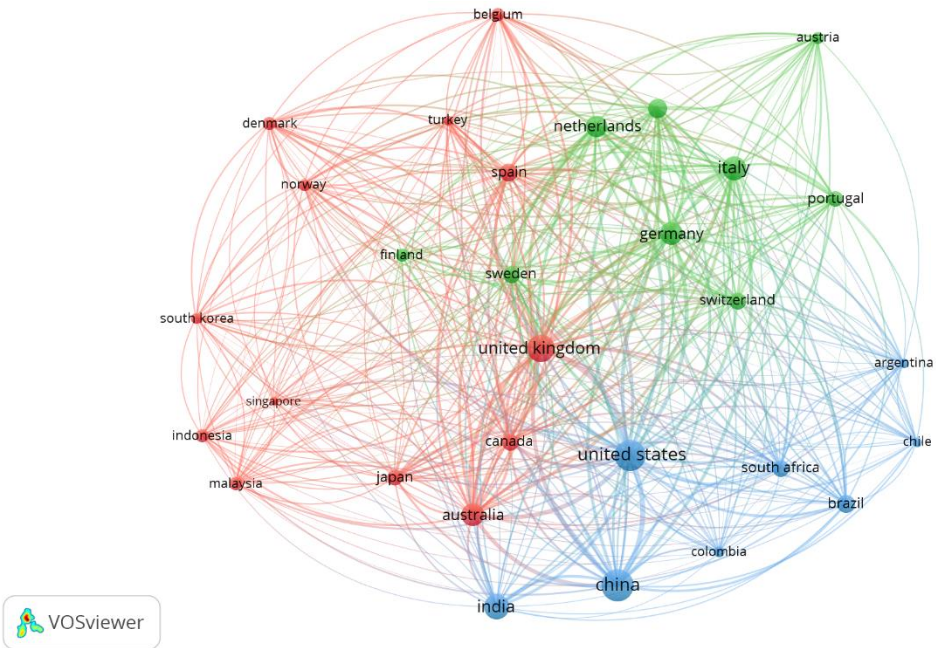


***Figure 7.*** *Collaboration between the most active countries*


http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2304_62236246

According to Costanza and Kubiszewski et al. (2012) ecosystem services related to issues and initiatives should also be obligated to include many disciplinary viewpoints and promote collaboration across different disciplines. The research examined a tribal-dominated socio-ecological patch in Eastern India’s Barind Region in Malda district. The millennium ecosystem assessment’s ESs and IEK evaluation were based on data from randomly chosen tribal families who completed a pre-tested questionnaire (Zang, 2021). The results were examined using social preference and statistical testing (Zang, 2021) Socio-demographic factors have also been examined in the general linear model (GLM) to determine Ecosystem Service Value (Zareen Ghafoor et al., 2023). Tribal members chose to supply Ecosystem services (water, fuel wood, medicinal plants) followed by cultural and regulating Ecosystem services (Liao et al., 2021). This research may help comprehend the socio-ecological nexus via Indigenous Ecological Knowledge in tribal-dominated ecological environments to better ecosystem and environmental management and maintain Ecosystem Services flow (Liao et al., 2021). Next, Eddy et al. (2021) focused on the potential of mitigating local impacts and attaining climate change emissions targets to alleviate the strain on coral reefs and ensure the continued existence of the ecosystem services they supply. At the same time, Beillouin et al.’s (2021) research emphasizes that although increasing the variety or species of cultivated crops in agroecosystems is a highly promising approach to achieving more sustainable land management by improving yields, biodiversity, and ecosystem services, certain crop diversification strategies support essential ecosystem services more effectively than others. Chen (2023) examined the correlation between land use/cover (LULC) and ecosystem service value (ESV) is crucial for effective land-management planning. Cao et al. (2021) uses remote sensing and GIS to study regional land urbanization and ecosystem distribution in China from 2000 to 2015, examining the relationship between economic growth and ecosystem service value. The study’s primary objective of Wang et al. (2021) was the concerns between poverty, cultural ecosystem service, perception, and green infrastructure. It anticipates the utilization of integrative research encompassing socio-cultural and biophysical components to bolster policymaking in the future progressively. Following such, Long et al. (2022) highlighted that limited attention has been devoted to the long-term changes and ecological significance of China’s inland lake wetlands. This study uses the Google Earth engine and Stacking algorithm to create Dongting Lake wetland land use/cover data from 1995 to 2020 (Long et al., 2022). The regional and temporal fluctuation of wetland types was then examined using dynamic analysis and land change correlation indicators. Yin et al. (2021) examined the significance of ESs to the Sustainable Development Goals (SDGs) and how to incorporate them into socio-economic development after the COVID-19 pandemic. Castellar et al. (2021) addresses Nature-Based Solutions (NBS) to resolve the social, economic, and environmental urban issues to promote sustainable development. However, much disagreement is still over NBS typologies, terminology, and performance assessments for ecological services (ES) and urban challenges (UC). A larger consensus was found on the function of NBS in addressing environmental UC, cultural, and regulating ES than socio-economic UC and supporting and provisioning (Bao et al., 2023). By harmonizing trade-offs between ecosystem services, determining conservation priorities and analyzing the spatiotemporal changes in ecosystem services. Using the InVEST model, water production, soil preservation, carbon sequestration, habitat quality, and ecological recreation were all quantified. Further, Liao et al. (2023) emphasize Farmland


http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2304_62236246

ecosystem service as an important output of agricultural production, but it has been incompletely reflected in current studies on eco-efficiency. In this study, the value of improved farmland ecosystem services is used as one of the expected outputs. The data envelopment method is used to evaluate the agricultural eco-efficiency (AEE) of 31 provincial administrative regions in China from 2006 to 2018 (Liao et al., 2023). The spatial autocorrelation method is used to explore the characteristics of AEE in China (Liao et al., 2023). The geographical detector model (Geodetector) is adopted to detect the driving factors of AEE spatial differentiation in China. Lin et al. (2021) studies focused on how agriculture, urban, and industry changed, increasing downstream freshwater demand. Extensive examination of freshwater ecosystem services flows from supply to recipients in a watershed aids integrated management and decision-making (Lin et al., 2021). This research shows how local and regional land-use change and ecosystem services flows may be combined for ecological compensation, water reallocation, and land-use management to maintain freshwater ecosystems (Lin et al., 2021). Deng et al. (2021) research examined the trade-offs that occur between urbanization and ecological construction by studying changes in land use and then investigating how these changes affect ecosystem services. Thus, the trade-off between ecological construction within the appropriate range and urbanization does not always reduce basin-scale ecosystem services. To protect ecosystems, rapidly urbanizing areas should include ecosystem services when planning and implementing land-use policies. Finally, the Jin et al. (2021) study demonstrates that ecological security is a pattern of sources and corridors, with the former providing security and the latter ensuring the continuation of ecological services. The spatial layout positions ecological security obstacles away from urban core development areas, following ecological security patterns and regional zoning functions (Jin et al., 2021). *Table 3* presents highly cited publications on ecosystem services, highlighting their impact through citation frequency. The most cited work, “The Significance of Soils and Soil Science Towards Realization of the United Nations Sustainable Development Goals” (Keesstra et al., 2016), has 1158 citations, followed by studies on nature-based solutions (Keesstra et al., 2018), 727 citations and protected areas (Xu et al., 2017) 583 citations. Other influential works address soil health, plastic pollution, and land degradation, reflecting the critical role of ecosystem services in sustainability and policy development.

## Discussion

### *Key topics of SDG associated with ecosystem services issue*

#### *SDGs connected with ecosystem services and land use/land cover change*

Land use and land cover (LULC) changes have diverse and significant implications for the natural environment and the delivery of ecosystem services. These changes vary in their impact, influencing biodiversity, water quality, carbon storage, and soil fertility in different ways, thereby shaping progress toward Sustainable Development Goals (SDGs). For example, the conversion of forests into agricultural land or urban areas fragments habitats, decreases biodiversity, and disrupts essential ecosystem services such as water purification, carbon sequestration, and soil fertility (Muche et al., 2023; Zhao and Shao, 2023). These transformations contribute to the degradation of ecosystem services, undermining the achievement of SDG 15 (Life on Land), which aims to halt biodiversity loss and protect ecosystems. Recent studies highlight the


http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2304_62236246

significant impact of LULC changes in specific regions. For instance, Assaye et al. (2023) used satellite data and community perceptions to categorize LULC changes in Ethiopia's Beles River Basin. They found a marked decline in forests (from 71.0% to 56.2%), woodlands (from 11.2% to 9.9%), and pasture lands (from 1.8% to 0.4%), while croplands, water bodies, and built-up areas increased. This shift led to a decrease in the basin's total ecosystem service value (ESV) from US$1.1 billion in 1986 to US$836.5 million in 2019, a loss of 22.9% or US$249.3 million (Assaye et al., 2023). These reductions in ecosystem services underscore the urgent need for sustainable land management practices, directly supporting SDG 12 (Responsible Consumption and Production) by promoting sustainable land use and conservation measures.

***Table 3.*** *Highly cited publication on ecosystem services and their citation frequency*

| Title | Authors | Publication year | Cited by |
|---|---|---|---|
| The significance of soils and soil science towards realization of the United Nations sustainable development goals | Keesstra et al. | 2016 | 1158 |
| The superior effect of nature based solutions in land management for enhancing ecosystem services | Keesstra et al. | 2018 | 727 |
| Strengthening protected areas for biodiversity and ecosystem services in China | Xu et al. | 2017 | 583 |
| Soil health and carbon management | Lal et al. | 2016 | 554 |
| Modelling and measuring sustainable wellbeing in connection with the UN sustainable development goals | Costanza et al. | 2016 | 520 |
| Impacts of plastic pollution on ecosystem services, sustainable development goals, and need to focus on circular economy and policy interventions | Kumar et al. | 2021 | 506 |
| The Hindu Kush Himalaya assessment: mountains, climate change, sustainability and people | Wester et al. | 2019 | 493 |
| Land in balance: the scientific conceptual framework for land degradation neutrality | Shrestha et al. | 2018 | 408 |
| Distilling the role of ecosystem services in the sustainable development goals | Wood et al. | 2018 | 379 |
| A global map of saltmarshes | Mcowen et al. | 2017 | 339 |
| Global decline in capacity of coral reefs to provide ecosystem services | Eddy et al. | 2021 | 317 |
| The Brisbane Declaration and Global Action Agenda on Environmental Flows (2018) | Arthington et al. | 2018 | 317 |
| Soil degradation in the European Mediterranean region: processes, status and consequences | Ferreira et al. | 2022 | 300 |
| China's wetlands loss to urban expansion | Mao et al. | 2018 | 299 |
| Economics of land degradation and improvement—a global assessment for sustainable development | Nkonya et al. | 2015 | 298 |

Similarly, urbanization has negatively impacted ecosystem services in wetlands. Sullivan et al. (2014) investigated the transformation of wetlands into urban spaces in the Florida Everglades, revealing detrimental effects on the region's ability to filter water and regulate floods. This study aligns with the growing body of research illustrating how human-induced changes in land use heighten the connections between groundwater and surface water, which has far-reaching consequences for ecosystem health and flood management (Harvey and McCormick, 2009; Sullivan et al., 2014). This issue ties into SDG 6 (Clean Water and Sanitation), as the loss of wetlands impairs natural water filtration and disrupts hydrological cycles. The role of Geographic Information Systems (GIS) in assessing the impact of LULC changes on ecosystem services has gained increasing attention. GIS-based models, such as those used by Behradfar and Cabezas (2022) can simulate the spatial relationships between LULC changes and ecological functions. These models integrate satellite imagery, land cover maps, and socioeconomic


http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2304_62236246

data to help policymakers assess trade-offs in land use planning and inform decisions that balance development with ecosystem preservation. For instance, the Integrated Valuation of Ecosystem Services and Trade-offs (InVEST) model, commonly used in GIS, estimates the supply of ecosystem services under different land use scenarios, aiding the design of policies that support sustainable development (Behradfar and Cabezas, 2022). In China's Yangtze River Basin, GIS-based models have been employed to forecast the impacts of land use changes on water quality and flood management, providing insights into how to maintain or restore ecosystem services in rapidly urbanizing regions (Liu et al., 2014; Wang et al., 2022). Such models can be particularly valuable in developing countries, where urbanization often outpaces ecological conservation efforts. For example, Liu et al. (2014) applied a GIS-based approach to assess flood vulnerability in Wuhan, China, highlighting the relationship between land-use changes and urban flood risks. These studies contribute to the achievement of SDG 11 (Sustainable Cities and Communities) by guiding the development of land-use policies that mitigate the risk of natural disasters such as floods, which disproportionately affect vulnerable urban populations (Liu et al., 2014; Wang et al., 2022).

In conclusion, the conversion of natural landscapes into urban, agricultural, or industrial areas significantly alters the capacity of ecosystems to provide essential services. These changes are closely linked to several SDGs, particularly SDG 15 (Life on Land), SDG 6 (Clean Water and Sanitation), SDG 12 (Responsible Consumption and Production), and SDG 11 (Sustainable Cities and Communities). GIS-based tools and models offer valuable insights into the complex relationships between land use and ecosystem services, enabling more informed policy decisions that can help safeguard these services for future generations.

*Urbanization and its impacts on ecosystem services and SDGs*

Urbanization, characterized by the expansion of cities and infrastructure development, has profound negative effects on natural ecosystems. It damages habitats, reduces green spaces, and leads to the pollution of air, water, and soil through the replacement of natural landscapes with impermeable surfaces such as concrete and asphalt (Chen, 2023; Wang and Chen, 2022). As urban areas grow, the provision of essential ecosystem services, such as air and water purification, climate regulation, and recreational spaces, often diminishes, leading to a loss of environmental quality and a decline in human well-being (Cao et al., 2021a). These issues are directly linked to several Sustainable Development Goals (SDGs), particularly those related to sustainable cities, climate action, and responsible consumption (Cao et al., 2021b). Yang and Xie (2021) emphasized the need for more comprehensive and quantitative studies on the relationship between urbanization and ecological services in representative cities to prevent the destructive cycle of urban expansion followed by ecological restoration efforts. In their study of Weifang City, they used advanced analytical tools, including partial least squares-discriminant analysis, kernel density estimation, and correlation analysis, to quantify how urbanization affects ecosystem services. Their findings underscored that during urbanization, increases in population, GDP, and built-up areas corresponded with a significant decline in ecosystem service values (ESVs), with services like food production, raw material production, nutrient cycling, and soil conservation suffering the most (Yang and Xie, 2021). These results highlight the critical tension between urban growth and the preservation of ecosystem services, a key challenge in achieving SDG 11 (Sustainable Cities and Communities), which aims to


http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2304_62236246

make cities inclusive, safe, resilient, and sustainable (Yang and Xie, 2021). The study's findings, particularly the negative correlation between built-up areas and ecosystem service values, reinforce the importance of incorporating ecological considerations into urban planning and development strategies (Yang and Xie, 2021). Without careful management, the expansion of cities can lead to irreversible damage to natural systems, undermining the quality of life for urban populations and eroding essential services that cities depend on for sustainability (Yang and Xie, 2021; Zang and Mao, 2019)

In line with SDG 12 (Responsible Consumption and Production), which promotes the efficient use of resources and reduction of environmental impacts, the study also points to the need for urban areas to adopt more sustainable practices. By improving urban planning, promoting green infrastructure, and integrating ecosystem services into urban development, cities can work to reduce the environmental impacts associated with rapid urbanization. The loss of ecosystem services during urban growth, particularly in terms of nutrient cycling and soil conservation, is especially concerning, as it threatens the long-term sustainability of food production systems (SDG 2: Zero Hunger) and the natural resources that are essential for human livelihoods. Moreover, the degradation of air and water quality due to urbanization directly impacts SDG 6 (Clean Water and Sanitation), which aims to ensure the availability and sustainable management of water and sanitation for all. Cities facing rapid urban growth must address pollution and invest in infrastructure that supports ecosystem services, such as wastewater treatment and air purification systems, to safeguard public health and environmental quality. The need to prevent and mitigate the harmful effects of urbanization also aligns with SDG 13 (Climate Action), as urban areas are significant contributors to climate change. Urbanization can exacerbate the urban heat island effect, increase carbon emissions, and reduce the ability of cities to sequester carbon, contributing to global warming. Integrating climate-responsive urban planning and the restoration of green spaces can help mitigate some of these impacts.

In conclusion, the urbanization process, while necessary for economic and population growth, must be managed in a way that preserves and enhances ecosystem services. The study of Weifang City exemplifies how urban expansion negatively impacts critical ecosystem services, highlighting the need for integrated policies that promote sustainable development. Aligning urbanization strategies with SDGs—particularly SDGs 11, 12, 13, 6, and 2—is essential for creating cities that are not only livable and resilient but also environmentally sustainable and capable of supporting the long-term well-being of their populations.

### *Climate change, ecosystem services, and SDGs*

Climate change affects ecosystem services in diverse and interconnected ways, with varying consequences for biodiversity, human well-being, and global ecosystem stability. These changes are increasingly (Jing et al., 2022) evident in many regions, influencing the ability of ecosystems to provide essential services such as carbon sequestration, water regulation, and soil fertility (Van Der Geest et al., 2019). To fully understand the impacts of global climate change on land ecosystems, it is essential to examine how ecosystem services respond to varying climate factors, such as temperature, rainfall, and solar radiation (Zareen Ghafoor et al., 2023). This understanding is critical for developing adaptive strategies that align with the Sustainable Development Goals (SDGs), particularly those related to climate action, biodiversity, and ecosystem health. For instance, Jing et al. (2022) analyzed how


http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2304_62236246

climate factors such as rainfall, temperature, and solar radiation affected ecosystem services on the Loess Plateau in China from 2000 to 2020. Their findings revealed that while rainfall had increased significantly, solar radiation had decreased, and the average annual temperature showed little variation. Notably, the trends for net primary productivity (NPP) and soil conservation (SC) increased, whereas water yield (WY) showed a decline (Jing et al., 2022). Precipitation emerged as the most influential factor affecting these ecosystem services, with all three services showing an upward trend as rainfall increased. However, beyond certain thresholds of precipitation (490–600 mm), the benefits of increased rainfall began to diminish. This occurred because areas with adequate rainfall had less capacity for further growth in NPP, and excess moisture led to increased evaporation, reducing the positive effects on water yield (Jing et al., 2022). Soil conservation, terracing, and watershed management, as discussed by Jing et al. (2022) are examples of traditional practices that have been proven to sustain land productivity and biodiversity while mitigating the impacts of climate change. These practices not only help to conserve ecosystem services but also promote SDG 15 (Life on Land), which aims to halt biodiversity loss and ensure sustainable land use practices. Avoiding deforestation through initiatives like Reduced Emissions from Deforestation and Degradation (REDD+) provides additional benefits by protecting forest-dependent ecosystem services and fostering carbon sequestration, directly supporting SDG 13 (Climate Action) and SDG 15 (Life on Land). Nagy et al. (2023) provide further insights into the contribution of mountain ecosystems to the supply of ecosystem services. Their study emphasizes the necessity of incorporating mountain vegetation into dynamic global vegetation models (DGVMs), which are central to predicting how ecosystems will respond to global environmental changes. Mountains play a pivotal role in providing water, regulating climate, and supporting biodiversity, particularly through treeline dynamics, which have largely been neglected in current Earth System Models (ESMs) (Nagy et al., 2023). By enhancing models to incorporate these dynamics, we can improve our understanding of how mountain ecosystems contribute to ES under changing climate conditions, directly linking to SDG 6 (Clean Water and Sanitation), SDG 13 (Climate Action), and SDG 15 (Life on Land). Nagy et al. (2023) highlight the need for a more nuanced approach to modelling that considers the interplay between species distribution, climatic variables, and ecosystem services, thus aiding in more effective decision-making for sustainable development. Integrating this knowledge into Earth System Models can not only refine predictions of ecosystem services but also inform climate policies and adaptation strategies, contributing to SDG 13 (Climate Action) and SDG 15 (Life on Land). Furthermore, the recognition of mountain ecosystems' critical role in global biodiversity conservation and the delivery of ES presents an opportunity to strengthen conservation policies, especially in regions where deforestation and land degradation threaten ecosystem health. This aligns with the targets of SDG 15 to protect, restore, and promote the sustainable use of terrestrial ecosystems. In conclusion, the integration of Indigenous knowledge with modern scientific understanding, alongside enhanced modelling of mountain ecosystems, offers a comprehensive framework for addressing the challenges posed by climate change to ecosystem services. The strategies outlined by Jing et al. (2022) and Nagy et al. (2023) underscore the need for multidisciplinary approaches that combine traditional wisdom, advanced technologies, and ecosystem-based solutions to achieve the SDGs, particularly those focused on climate action, sustainable land use, and biodiversity conservation.


http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2304_62236246

*Ecosystem services and sustainable development*

The integration of ecosystem services (ES) assessments into sustainability policy varies across regions and governance structures, influencing their effectiveness in achieving long-term environmental and societal goals. However, as identified by the Agrifood Solutions to Climate Change (2023) many of these assessments often fail to translate effectively into actionable decision-making because they are not sufficiently aligned with local concerns and context. A critical step in improving the implementation of ecological research is ensuring that the problem definition aligns with the specific needs of local communities. This issue is particularly relevant when addressing sustainability concerns in diverse ecological settings, such as the European outermost regions of the Canary Islands, French Guiana, and Reunion Island, as explored by Bitoun et al. (2023). Their research emphasizes the importance of context-specific ES-based solutions for achieving the United Nations' 2015 Sustainable Development Goals (SDGs) (Bitoun et al., 2023). Bitoun et al. (2023) highlighted the potential of using ecosystem service evaluations to drive sustainability efforts in these regions, specifically in contributing to SDGs such as Life on Land (SDG 15), Zero Hunger (SDG 2), Life Below Water (SDG 14), and Sustainable Cities and Communities (SDG 11). Their findings underscore the importance of engaging with local stakeholders in the process of defining and assessing ecosystem services to ensure the relevance and practicality of the proposed solutions. Engaging stakeholders is key to understanding local needs and promoting the successful integration of ES-based strategies in sustainable development plans. These strategies aim to deliver benefits across multiple ESs, such as food provision, water purification, biodiversity conservation, and cultural services, thus fostering holistic progress toward the SDGs.

Hu et al. (2022) further explored the relationship between ecosystem service values (ESV) and SDG progress in the Beijing-Tianjin-Hebei (BTH) region over the past two decades. Their analysis revealed how land use changes—such as declines in cropland, grassland, and wetland from 2000 to 2010—resulted in a loss of critical ecosystem services, including those related to food, water, and climate regulation (Hu et al., 2022). However, by 2020, ecological restoration efforts, such as the expansion of forestland and waterbodies, led to an increase in the value of several ESs, including those tied to water retention and biodiversity. This shift illustrates the significant impact that proactive environmental management can have on improving ecosystem service provision and, by extension, advancing the SDGs.

One key takeaway from Hu et al.'s (2022) study is the fluctuating relationship between ecosystem services and SDG progress, as evidenced by the changes in the ES-SDG Index score in the BTH region. While the score initially declined between 2000 and 2010 due to land degradation, the subsequent recovery of certain ecosystem services between 2010 and 2020 shows how strategic environmental actions can mitigate the negative impacts of urbanization and land-use change. Their work suggests that SDGs related to water (SDG 6), sustainable cities (SDG 11), and responsible consumption and production (SDG 12) should be prioritized in regions like BTH to foster coordinated progress across multiple goals (Hu et al., 2022). This analysis also emphasizes the need for continuous monitoring and adaptation of strategies to maintain or enhance ESs, which directly influences various SDGs, including those related to climate action and biodiversity (Hu et al., 2022).

Overall, these studies underscore the importance of aligning ecosystem service evaluations with sustainability policies that address local ecological and socio-economic


http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2304_62236246

contexts. As demonstrated by Bitoun et al. (2023) and Hu et al. (2022) integrating ecosystem services into the broader framework of the SDGs not only provides insight into the state of the environment but also serves as a tool for decision-making. By prioritizing SDGs such as those focused on water, biodiversity, food security, and sustainable urbanization, stakeholders can work toward achieving a more resilient and sustainable future. Furthermore, incorporating local knowledge, engaging communities, and continuously adapting policies to address emerging environmental challenges are all crucial steps in realizing the full potential of ecosystem services in sustainable development.

*Biodiversity and ecosystem services in sustainability*

As cities and regions face growing pressures from rapid urbanization, climate change, and biodiversity loss, their approaches to sustainable development differ in addressing these challenges within socio-ecological systems (Yin et al., 2021). Yin et al. (2021) emphasize the importance of comprehensively understanding biodiversity, ecosystems, and the services (BES) they provide to guide the development of more sustainable urban landscapes. This knowledge is crucial not only for informing policies but also for designing cities that are resilient, biodiverse, and in harmony with the environment.

Riffat et al. (2023) explore the potential of BES dashboards as tools to support decision-making in urban and landscape planning. These dashboards integrate a range of BES indicators, offering valuable insights into the health and function of ecosystems, biodiversity, and the quality of green and blue spaces. By assessing 12 advanced BES dashboard applications from diverse regions across the globe, Riffat et al. (2023) reveal significant trends in how BES information is utilized in the planning and design of landscapes and urban areas. The dashboards evaluated in their study cover a wide range of indicators, including tree health, forest conditions, the connectivity of green and blue areas, and various aspects of biodiversity. This information can be instrumental in fostering urban designs that integrate nature and promote sustainability. The incorporation of BES dashboards into urban planning is particularly important as cities worldwide are becoming increasingly populated and vulnerable to the effects of climate change. Cities adopt varied strategies to reduce environmental pressures and enhance climate resilience. Green infrastructure mitigates pollution and buffers floods but requires space and investment. Technological solutions offer efficiency but can be costly. Policy-driven approaches ensure long-term impact but rely on enforcement. A balanced, integrated strategy is key to sustainable urban development. The ability to visualize and assess the state of local ecosystems and biodiversity through BES dashboards provides urban planners with the necessary data to make informed decisions that balance the needs of both people and nature. However, as Riffat et al. (2023) note, that while these dashboards offer promising insights into urban ecosystem management, there is still a need for further research to improve their usability and effectiveness. Understanding user needs, refining the design and functionalities of these tools, and ensuring their real-world applicability is essential for maximizing their impact. Moreover, engaging local stakeholders in the process of designing BES dashboards could enhance their relevance and effectiveness in guiding urban planning and biodiversity conservation efforts. Cities could benefit from this participatory approach by ensuring that urban designs reflect the aspirations and needs of the people who inhabit them while also promoting ecological sustainability. The role of BES


http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2304_62236246

dashboards in urban planning aligns with broader sustainability goals, particularly those related to biodiversity conservation, climate resilience, and the integration of nature into urban spaces. As cities strive to become more sustainable, they must recognize the importance of protecting biodiversity and ecosystem services not only as a matter of conservation but as essential components of urban resilience and quality of life. Incorporating BES indicators into decision-making processes can help mitigate the negative effects of urban expansion, such as habitat loss, pollution, and the fragmentation of ecosystems while promoting a more sustainable and resilient urban future.

In conclusion, the use of BES dashboards, as discussed by Riffat et al. (2023), offers a promising avenue for enhancing urban planning and landscape design in ways that support both biodiversity and human well-being. These tools vary in their effectiveness in guiding sustainable urban development and preparing cities for climate change, population growth, and biodiversity loss. While advancements between 2015 and 2024 have improved data integration and predictive modelling, challenges remain in accessibility, functionality, and real-world application across diverse urban settings. Some cities have successfully incorporated Biodiversity and Ecosystem Services (BES) data into planning, enhancing resilience and sustainability, while others face barriers due to limited resources or policy constraints. Comparing these approaches highlights the need for further research and refinement to maximize BES integration and foster more livable, environmentally resilient cities.

### *Limitations of the study*

One of the key limitations of this study is that it solely relies on Scopus-indexed materials, which may not fully represent the broader range of relevant literature available in other databases. However, this choice ensures a high level of quality and credibility, as Scopus is a well-regarded database known for its rigorous selection criteria. Additionally, the analysis is restricted to articles published between 2021 and 2023, limiting the scope to a relatively short time frame. While this may overlook earlier foundational research and emerging trends prior to 2021, it allows for a focused examination of the most recent developments and current state of research in ecosystem services, offering valuable insights into the latest trends and advancements in the field.

## Conclusion

In conclusion, this study underscores the fundamental role of ecosystem services (ES) in driving sustainable development globally. Our comprehensive review of publications over the past decade highlights how Ecosystem Services spanning water purification, soil fertility, carbon sequestration, and biodiversity support are essential for human well-being, economic stability, and environmental health. However, the transformation of natural landscapes into urban, agricultural, and industrial areas disrupts these services, significantly impacting key Sustainable Development Goals (SDGs), particularly SDG 6 (Clean Water and Sanitation), SDG 13 (Climate Action), SDG 15 (Life on Land), and SDG 2 (Zero Hunger). Comparing different strategies, we find that green infrastructure and climate-responsive urban design enhance resilience and mitigate environmental degradation, whereas unsustainable land-use practices accelerate biodiversity loss and resource depletion. In mountain ecosystems, where ecosystem services play a crucial role, integrating traditional ecological knowledge with


http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2304_62236246

modern scientific approaches emerges as a key strategy for strengthening conservation efforts and advancing SDG 15.

The findings of this decade-long review highlight that preserving and enhancing ecosystem services is central to SDG achievement. As climate change, population growth, and resource depletion intensify, cities and nations must integrate ES into urban and environmental policies to build a sustainable and resilient future. A paradigm shift is needed one that acknowledges ecosystem services as the foundation of a balanced relationship between development and the environment, ensuring long-term sustainability for both human and ecological systems.

## REFERENCES

[1] Agrifood Solutions to Climate Change (2023): FAO. – https://doi.org/10.4060/cc8055en.

[2] Assaye, Y., Desta, G., Molla, E., Bekele, D., Kindu, M. (2023): Assessment of ecosystem service value variation over land use and land cover dynamics in the Beles River Basin, Ethiopia. – Remote Sens Earth Syst Sci. https://doi.org/10.1007/s41976-024-00106-2.

[3] Atchadé, A. J., Kanda, M., Folega, F., Atela, J., Dourma, M., Wala, K., Akpagana, K. (2023): Urban ecosystem services and determinants of stakeholders' perception for sustainable cities planning in Cotonou (Benin). – Sustainability (Switzerland). https://doi.org/10.3390/su15129424.

[4] Bao, J., Wang, W., Zhao, T. (2023): Spatiotemporal changes of ecosystem service values in response to land cover dynamics in China from 1992 to 2020. – Sustainability (Switzerland). https://doi.org/10.3390/su15097210.

[5] Behradfar, A., Cabezas, J. (2022): The Role of the Geospatial Information System (GIS) in Achieving the Sustainable Development Goals (SDGs): A Spatial Framework for Sustainable Planning Processes. – In: Castanho, R. A. (ed.) Practice, Progress, and Proficiency in Sustainability. IGI Global, Hershey, PA, pp. 451-481. https://doi.org/10.4018/978-1-7998-8482-8.ch027.

[6] Beillouin, D., Ben-Ari, T., Malézieux, E., Seufert, V., Makowski, D. (2021): Positive but variable effects of crop diversification on biodiversity and ecosystem services. – Global Change Biology. https://doi.org/10.1111/gcb.15747.

[7] Bellanger, M., Fonner, R., Holland, D. S., Libecap, G. D., Lipton, D. W., Scemama, P., Speir, C., Thébaud, O. (2021): Cross-sectoral externalities related to natural resources and ecosystem services. – Ecological Economics. https://doi.org/10.1016/j.ecolecon.2021.106990.

[8] Bhaduri, A., Bogardi, J., Siddiqi, A., Voigt, H., Vörösmarty, C., Pahl-Wostl, C., Bunn, S. E., Shrivastava, P., Lawford, R., Foster, S., Kremer, H., Renaud, F. G., Bruns, A., Osuna, V. R. (2016): Achieving sustainable development goals from a water perspective. – Front. Environ. Sci. 4. https://doi.org/10.3389/fenvs.2016.00064.

[9] Bitoun, R. E., David, G., Devillers, R. (2023): Strategic use of ecosystem services and co-benefits for Sustainable Development Goals. – Sustainable Development 31(1296-1310. https://doi.org/10.1002/sd.2448.

[10] Cao, Y., Kong, L., Zhang, L., Ouyang, Z. (2021a): The balance between economic development and ecosystem service value in the process of land urbanization: a case study of China's land urbanization from 2000 to 2015. – Land Use Policy 108(105536. https://doi.org/10.1016/j.landusepol.2021.105536.

[11] Cao, Y., Kong, L., Zhang, L., Ouyang, Z. (2021b): The balance between economic development and ecosystem service value in the process of land urbanization: a case study of China's land urbanization from 2000 to 2015. – Land Use Policy. https://doi.org/10.1016/j.landusepol.2021.105536.


http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2304_62236246

[12] Carpentier, C. L., Braun, H. (2020): Agenda 2030 for sustainable development: a powerful global framework. – Journal of the International Council for Small Business 1: 14-23. https://doi.org/10.1080/26437015.2020.1714356.
[13] Castellar, J. A. C., Popartan, L. A., Pueyo-Ros, J., Atanasova, N., Langergraber, G., Säumel, I., Corominas, L., Comas, J., Acuña, V. (2021): Nature-based solutions in the urban context: terminology, classification and scoring for urban challenges and ecosystem services. – Science of the Total Environment. https://doi.org/10.1016/j.scitotenv.2021.146237.
[14] Chen, W. (2023): Spatial–temporal evolution and spatial differentiation of ecosystem service value in Ningxia at the grid scale. – Environmental Science and Engineering. https://doi.org/10.1007/978-3-031-25284-6_44.
[15] Costanza, R., Kubiszewski, I. (2012): The authorship structure of “ecosystem services” as a transdisciplinary field of scholarship. – Ecosystem Services 1: 16-25. https://doi.org/10.1016/j.ecoser.2012.06.002.
[16] Costanza, R., d’Arge, R., De Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O’Neill, R. V., Paruelo, J., Raskin, R. G., Sutton, P., Van Den Belt, M. (1998): The value of the world’s ecosystem services and natural capital. – Ecological Economics 25: 3-15. https://doi.org/10.1016/S0921-8009(98)00020-2.
[17] Deeksha, Shukla, A. K. (2022): Ecosystem services: a systematic literature review and future dimension in freshwater ecosystems. – Applied Sciences 12(8518). https://doi.org/10.3390/app12178518.
[18] Deng, C., Liu, J., Nie, X., Li, Z., Liu, Y., Xiao, H., Hu, X., Wang, L., Zhang, Y., Zhang, G., Zhu, D., Xiao, L. (2021): How trade-offs between ecological construction and urbanization expansion affect ecosystem services. – Ecological Indicators. https://doi.org/10.1016/j.ecolind.2020.107253.
[19] Eddy, T. D., Lam, V. W. Y., Reygondeau, G., Cisneros-Montemayor, A. M., Greer, K., Palomares, M. L. D., Bruno, J. F., Ota, Y., Cheung, W. W. L. (2021): Global decline in capacity of coral reefs to provide ecosystem services. – One Earth. https://doi.org/10.1016/j.oneear.2021.08.016.
[20] Ehrlich, P. R., Mooney, H. A. (1983): Extinction, substitution, and ecosystem services. – BioScience 33: 248-254. https://doi.org/10.2307/1309037.
[21] Enahoro, D., Kozicka, M., Pfeifer, C., Jones, S. K., Tran, N., Chan, C. Y., Sulser, T. B., Gotor, E., Rich, K. M. (2023): Linking ecosystem services provisioning with demand for animal-sourced food: an integrated modeling study for Tanzania. – Regional Environmental Change. https://doi.org/10.1007/s10113-023-02038-x.
[22] Gangahagedara, R., Subasinghe, S., Lankathilake, M., Athukorala, W., Gamage, I. (2021): Ecosystem services research trends: a bibliometric analysis from 2000-2020. – Ecologies 2: 366-379. https://doi.org/10.3390/ecologies2040021.
[23] Harvey, J. W., McCormick, P. V. (2009): Groundwater’s significance to changing hydrology, water chemistry, and biological communities of a floodplain ecosystem, Everglades, South Florida, USA. – Hydrogeol J 17: 185-201. https://doi.org/10.1007/s10040-008-0379-x.
[24] Hawken, S., Rahmat, H., Sepasgozar, S. M. E., Zhang, K. (2021): The sdgs, ecosystem services and cities: a network analysis of current research innovation for implementing urban sustainability. – Sustainability (Switzerland). https://doi.org/10.3390/su132414057.
[25] Hu, C., Wright, A. L., He, S. (2022): Public perception and willingness to pay for urban wetland ecosystem services: evidence from China. – Wetlands. https://doi.org/10.1007/s13157-022-01538-6.
[26] Hu, Y., Liu, Y., Yan, Z. (2022): Research regarding the coupling and coordination relationship between new urbanization and ecosystem services in Nanchang. – Sustainability (Switzerland). https://doi.org/10.3390/su142215041.
[27] IPBES (2019): Summary for policymakers of the global assessment report on biodiversity and ecosystem services. – Zenodo. https://doi.org/10.5281/ZENODO.3553579.


http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2304_62236246

[28] Jaramillo, F., Desormeaux, A., Hedlund, J., Jawitz, J., Clerici, N., Piemontese, L., Rodríguez-Rodriguez, J., Anaya, J., Blanco-Libreros, J., Borja, S., Celi, J., Chalov, S., Chun, K., Cresso, M., Destouni, G., Dessu, S., Di Baldassarre, G., Downing, A., Espinosa, L., Ghajarnia, N., Girard, P., Gutiérrez, Á., Hansen, A., Hu, T., Jarsjö, J., Kalantari, Z., Labbaci, A., Licero-Villanueva, L., Livsey, J., Machotka, E., McCurley, K., Palomino-Ángel, S., Pietron, J., Price, R., Ramchunder, S., Ricaurte-Villota, C., Ricaurte, L., Dahir, L., Rodríguez, E., Salgado, J., Sannel, A., Santos, A., Seifollahi-Aghmiuni, S., Sjöberg, Y., Sun, L., Thorslund, J., Vigouroux, G., Wang-Erlandsson, L., Xu, D., Zamora, D., Ziegler, A., Åhlén, I. (2019): Priorities and interactions of sustainable development goals (SDGs) with focus on wetlands. – Water 11: 619. https://doi.org/10.3390/w11030619.
[29] Jin, X., Wei, L., Wang, Y., Lu, Y. (2021): Construction of ecological security pattern based on the importance of ecosystem service functions and ecological sensitivity assessment: a case study in Fengxian County of Jiangsu Province, China. – Environ Dev Sustain 23: 563-590. https://doi.org/10.1007/s10668-020-00596-2.
[30] Jing, P., Zhang, Donghai, Ai, Z., Wu, H., Zhang, Dingming, Ren, H., Suo, L. (2022): Responses of ecosystem services to climate change: a case study of the Loess Plateau. – Forests 13(2011). https://doi.org/10.3390/f13122011.
[31] Juliev, M., Abdikairov, B., Kholmurodova, M., Djanpulatova, Z., Mingboyeva, M., Makhmudova, M. (2024): Mapping the landscape: a bibliometric analysis of digital education research. – E3S Web of Conf. 590(03009. https://doi.org/10.1051/e3sconf/202459003009.
[32] Jumaniyazov, I., Juliev, M., Orazbaev, A., Reimov, T. (2023): Marginal lands: a review of papers from the Scopus database published in English for the period of 1979-2022. – Soil Sci. Ann. 74: 1-13. https://doi.org/10.37501/soilsa/169657.
[33] Kannazarova, Z., Juliev, M., Muratov, A., Abuduwaili, J. (2024): Groundwater in the commonwealth of independent states: a bibliometric analysis of scopus-based papers from 1972 to 2023, emphasizing the significance of drainage. – Groundwater for Sustainable Development 25(101083. https://doi.org/10.1016/j.gsd.2024.101083.
[34] Keesstra, S. D., Bouma, J., Wallinga, J., Tittonell, P., Smith, P., Cerdà, A., Montanarella, L., Quinton, J. N., Pachepsky, Y., van der Putten, W. H., Bardgett, R. D., Moolenaar, S., Mol, G., Jansen, B., Fresco, L. O. (2016): The significance of soils and soil science towards realization of the United Nations Sustainable Development Goals. – Soil 2: 111-128. https://doi.org/10.5194/soil-2-111-2016.
[35] Keesstra, S., Nunes, J., Novara, A., Finger, D., Avelar, D., Kalantari, Z., Cerdà, A. (2018): The superior effect of nature based solutions in land management for enhancing ecosystem services. – Science of the Total Environment 610-611: 997-1009. https://doi.org/10.1016/j.scitotenv.2017.08.077.
[36] Khasanov, S., Juliev, M., Uzbekov, U., Aslanov, I., Agzamova, I., Normatova, N., Islamov, S., Goziev, G., Khodjaeva, S., Holov, N. (2021): Landslides in Central Asia: a review of papers published in 2000–2020 with a particular focus on the importance of GIS and remote sensing techniques. – GeoScape (Sciendo) 15 (2) 134-145. https://doi.org/10.2478/geosc-2021-0011
[37] Li, J. (2022): An assessment of ecological protection importance based on ecosystems services and vulnerabilities in Tibet, China. – Sustainability (Switzerland). https://doi.org/10.3390/su141912902.
[38] Li, X., Lei, L. (2023): Evaluating rural sustainable land use from a system perspective based on the ecosystem service value. – Regional Sustainability. https://doi.org/10.1016/j.regsus.2023.03.002.
[39] Liao, G., He, P., Gao, X., Lin, Z., Fang, C., Zhou, W., Xu, C., Deng, L. (2021): Identifying critical area of ecosystem service supply and demand at different scales based on spatial heterogeneity assessment and SOFM neural network. – Frontiers in Environmental Science. https://doi.org/10.3389/fenvs.2021.714874.

[40] Liao, Q., Li, T., Wang, Q., Liu, D. (2023): Exploring the ecosystem services bundles and influencing drivers at different scales in southern Jiangxi, China. – Ecological Indicators. https://doi.org/10.1016/j.ecolind.2023.110089.

[41] Lin, J., Huang, J., Hadjikakou, M., Huang, Y., Li, K., Bryan, B. A. (2021): Reframing water-related ecosystem services flows. – Ecosystem Services. https://doi.org/10.1016/j.ecoser.2021.101306.

[42] Liu, C., Niu, J. (2015): Spatial heterogeneity of ecosystem services supply-demand and economic development in China. – International Journal of Earth Sciences and Engineering.

[43] Liu, J., Wang, S., Li, D. (2014): The analysis of the impact of land-use changes on flood exposure of Wuhan in Yangtze River Basin, China. – Water Resour Manage 28(2507-2522. https://doi.org/10.1007/s11269-014-0623-1.

[44] Long, X., Lin, H., An, X., Chen, S., Qi, S., Zhang, M. (2022): Evaluation and analysis of ecosystem service value based on land use/cover change in Dongting Lake wetland. – Ecological Indicators 136(108619. https://doi.org/10.1016/j.ecolind.2022.108619.

[45] Maksymenko, N. V., Voronin, V. O., Burchenko, S. V. (2023): Geoecological assessment of forest landscapes as a basis for the evaluation of ecosystem services. – Visnyk of V. N. Karazin Kharkiv National University Series "Ecology" 37-47. https://doi.org/10.26565/1992-4259-2023-29-04.

[46] Millennium Ecosystem Assessment (Program) (ed.) (2005): Ecosystems and Human Well-Being: Synthesis. – Island Press, Washington, DC.

[47] Muche, M., Yemata, G., Molla, E., Adnew, W., Muasya, A. M. (2023): Land use and land cover changes and their impact on ecosystem service values in the north-eastern highlands of Ethiopia. – PLoS ONE 18: e0289962. https://doi.org/10.1371/journal.pone.0289962.

[48] Nagy, L., Eller, C. B., Mercado, L. M., Cuesta, F. X., Llambí, L. D., Buscardo, E., Aragão, L. E. O. C., García-Núñez, C., Oliveira, R. S., Barbosa, M., Ceballos, S. J., Calderón-Loor, M., Fernandes, G. W., Aráoz, E., Muñoz, A. M. Q., Rozzi, R., Aguirre, F., Álvarez-Dávila, E., Salinas, N., Sitch, S. (2023): South American mountain ecosystems and global change—a case study for integrating theory and field observations for land surface modelling and ecosystem management. – Plant Ecology & Diversity 16: 1-27. https://doi.org/10.1080/17550874.2023.2196966.

[49] Nielsen, S. N. (2020): Sustainable Development Indicators: An Exergy-Based Approach, 1st ed. – CRC Press, Boca Raton, FL. https://doi.org/10.1201/9780429289583.

[50] Perianes-Rodriguez, A., Waltman, L., Van Eck, N. J. (2016): Constructing bibliometric networks: a comparison between full and fractional counting. – Journal of Informetrics 10(1178-1195. https://doi.org/10.1016/j.joi.2016.10.006.

[51] Riffat, M., Adem Esmail, B., Wang, J., Albert, C. (2023): Biodiversity and ecosystem services dashboards to inform landscape and urban planning: a systematic analysis of current practices. – Ecosystems and People 19(2263105. https://doi.org/10.1080/26395916.2023.2263105.

[52] Safranov, T., Berlinsky, N., Hadri, Y. E., Slizhe, M. (2022): Assessment of ecosystem services of the north-western part of the Black sea: state, problems and prospects. – Visnyk of V. N. Karazin Kharkiv National University, Series Geology. Geography. Ecology 255-263. https://doi.org/10.26565/2410-7360-2022-56-19.

[53] Scemama, P., Kermagoret, C., Astruch, P., Boudouresque, C.-F., Changeux, T., Harmelin-Vivien, M., Ourgaud, M., Ruitton, S., Verlaque, M., Charbonnel, E., Alban, F., Accornero-Picon, A., Le Direach, L. (2024): Impact assessment of multiple pressures on ecosystem services with state and transition model: application to Posidonia Oceanica Seagrass Meadows. – https://doi.org/10.2139/ssrn.4757000.

[54] Slizhe, M., Safranov, T., Berlinsky, N., Hadri, Y. E. (2023): Impact of climate change factor on the resource (providing) ecosystem services of the Lower Danube wetlands. –


http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2304_62236246

Visnyk of V. N. Karazin Kharkiv National University, series Geology. Geography. Ecology 307-319. https://doi.org/10.26565/2410-7360-2023-59-23.
[55] Sonko, S., Maksymenko, N., Shiyan, D., Cherkashyna, N., Zozulia, I. (2022): Impact of Climate Change on Energy Relations in Agroecosystems. – In: Proceedings of the 5th International Scientific Congress Society of Ambient Intelligence. Presented at the V International Scientific Congress Society of Ambient Intelligence. Scitepress - Science and Technology Publications, Kryvyi Rih, Ukraine, pp. 5-13. https://doi.org/10.5220/0011340400003350.
[56] Sullivan, P. L., Gaiser, E. E., Surratt, D., Rudnick, D. T., Davis, S. E., Sklar, F. H. (2014): Wetland ecosystem response to hydrologic restoration and management: The Everglades and its urban-agricultural boundary (FL, USA). – Wetlands 34: 1-8. https://doi.org/10.1007/s13157-014-0525-2.
[57] United Nations Environment Programme (2023): State of Finance for Nature 2023: The Big Nature Turnaround - Repurposing $7 Trillion to Combat Nature Loss. – United Nations Environment Programme. https://doi.org/10.59117/20.500.11822/44278.
[58] Van Der Geest, K., De Sherbinin, A., Kienberger, S., Zommers, Z., Sitati, A., Roberts, E., James, R. (2019): The Impacts of Climate Change on Ecosystem Services and Resulting Losses and Damages to People and Society. – In: Mechler, R., Bouwer, L. M., Schinko, T., Surminski, S., Linnerooth-Bayer, J. (eds.) Loss and Damage from Climate Change, Climate Risk Management, Policy and Governance. Springer International Publishing, Cham, pp. 221-236. https://doi.org/10.1007/978-3-319-72026-5_9.
[59] Waltman, L., Van Eck, N. J. (2015): Field-normalized citation impact indicators and the choice of an appropriate counting method. – Journal of Informetrics 9: 872-894. https://doi.org/10.1016/j.joi.2015.08.001.
[60] Wang, J., Chen, T. (2022): A multi-scenario land expansion simulation method from ecosystem services perspective of coastal urban agglomeration: a case study of GHM-GBA, China. – Land. https://doi.org/10.3390/land11111934.
[61] Wang, X., Pan, T., Pan, R., Chi, W., Ma, C., Ning, L., Wang, X., Zhang, J. (2022): Impact of land transition on landscape and ecosystem service value in northeast region of China from 2000-2020. – Land. https://doi.org/10.3390/land11050696.
[62] Wang, Y., Zhang, X., Peng, P. (2021): Spatio-temporal changes of land-use/land cover change and the effects on ecosystem service values in Derong county, China, from 1992-2018. – Sustainability (Switzerland). https://doi.org/10.3390/su13020827.
[63] Wood, S. L. R., Jones, S. K., Johnson, J. A., Brauman, K. A., Chaplin-Kramer, R., Fremier, A., Girvetz, E., Gordon, L. J., Kappel, C. V., Mandle, L., Mulligan, M., O’Farrell, P., Smith, W. K., Willemen, L., Zhang, W., DeClerck, F. A. (2018): Distilling the role of ecosystem services in the sustainable development goals. – Ecosystem Services 29: 70-82. https://doi.org/10.1016/j.ecoser.2017.10.010.
[64] World Bank (2018): Atlas of Sustainable Development Goals 2018: From World Development Indicators. – – World Bank, Washington, DC. https://doi.org/10.1596/978-1-4648-1250-7.
[65] Xu, W., Xiao, Yi, Zhang, J., Yang, W., Zhang, L., Hull, V., Wang, Z., Zheng, H., Liu, J., Polasky, S., Jiang, L., Xiao, Yang, Shi, X., Rao, E., Lu, F., Wang, X., Daily, G. C., Ouyang, Z. (2017): Strengthening protected areas for biodiversity and ecosystem services in China. – Proc. Natl. Acad. Sci. U.S.A. 114(1601-1606. https://doi.org/10.1073/pnas.1620503114.
[66] Yang, M., Xie, Y. (2021): Spatial pattern change and ecosystem service value dynamics of ecological and non-ecological redline areas in Nanjing, China. – International Journal of Environmental Research and Public Health. https://doi.org/10.3390/ijerph18084224.
[67] Yin, C., Zhao, W., Cherubini, F., Pereira, P. (2021): Integrate ecosystem services into socio-economic development to enhance achievement of sustainable development goals in the post-pandemic era. – Geography and Sustainability. https://doi.org/10.1016/j.geosus.2021.03.002.

[68] Zang, C., Mao, G. (2019): A spatial and temporal study of the green and blue water flow distribution in typical ecosystems and its ecosystem services function in an arid basin. – Water (Switzerland). https://doi.org/10.3390/w11010097.

[69] Zang, Z. (2021): Conceptual model of ecosystem service flows from carbon dioxide to blue carbon in coastal wetlands: an empirical study based on Yancheng, China. – Sustainability (Switzerland). https://doi.org/10.3390/su13094630.

[70] Zareen Ghafoor, G., Ghafoor Shahid, M., Ali, M., Ghafoor, N. (2023): Ecosystem Services in the Changing Climate: Calling Attention for the Conservation of Tropical and Subtropical Forests. – In: Cano Carmona, E., Maria Musarella, C., Cano Ortiz, A. (eds.) Tropical Forests—Ecology, Diversity and Conservation Status. IntechOpen, London. https://doi.org/10.5772/intechopen.109800.

[71] Zhao, J., Li, C. (2022): Investigating ecosystem service trade-offs/synergies and their influencing factors in the Yangtze River Delta Region, China. – Land. https://doi.org/10.3390/land11010106.

[72] Zhao, Q., Shao, J. (2023): Evaluating the impact of simulated land use changes under multiple scenarios on ecosystem services in Ji’an, China. – Ecological Indicators. https://doi.org/10.1016/j.ecolind.2023.111040.


http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2304_62236246