Alam Cipta Int. J. Sustain. Trop. Des. Res. Pract. 19 S1 (1): 141-161 (2026)

ALAM CIPTA

Sustainable Tropical Design Research and Practice

Journal Homepage: http://alamcipta.upm.edu.my/

The Impact of Land Use Change on the Ecosystem Service Value of Wetlands: A Thematic Review

Gao Yuxuan[1], Adam Aruledwan S.Muthuveeran[1*],Liu Peng[2], Dai Na[1] and Ma Yali[1]

[1]*Department of Landscape Architecture, Faculty of Design and Architecture, Universiti Putra Malaysia, Serdang, 43400, Malaysia*

[2]*Rajamangala University of Technology Rattanakosin (RMUTR), Bangkok, 10900, Thailand*

ABSTRACT

Wetlands are among the most important indicators of ecosystem services, however, urban expansion and rapid land use change are threatening their ecological functions. Existing studies on wetland Ecosystem Service Value (ESV) are relatively limited, restricting a systematic understanding of wetland services. This study systematically reviews research conducted between 2015 and 2024 on the relationship between land use change and the ESV of wetlands. Based on predefined inclusion and exclusion criteria, 52 eligible studies were selected from the Web of Science, Scopus, Google Scholar, and ATLAS databases and analyzed through qualitative thematic synthesis. Five themes were identified: the impacts of land use change on wetland services, ecosystem service components, ESV assessment methods, urbanization effects, and conservation and management strategies. The results indicate that land use transition significantly reduces wetland biodiversity, climate regulation capacity, and ecological functions. The findings emphasize the need for integrated land use planning to support sustainable wetland management.

Keywords: Ecosystem Service; Land Use Change; Wetland; ATLAS.ti

INTRODUCTION

Ecosystem services arise from complex interactions between natural resources, animals, and human activities, as demonstrated by their biological processes, water purification functions, and recreational benefits (Blampied et al., 2022). Rojas Quezada & Jorquera (2021) indicate that the conservation of wetlands is essential for enhancing urban resilience and sustainability, providing cities with methods to cope with environmental changes while offering critical ecological advantages. The apparent benefits of these ecosystem services typically encompass improved air quality, increased property values, and greater recreational opportunities, exemplifying the functional worth of urban nature. However, these

ARTICLE INFO

Article history:
Received: 26 June 2025
Accepted: 28 April 2026
Published: July 2026

DOI: https://doi.org/10.47836/AC.19.S1.PAPER08

Email addresses:
aruldewan@upm.edu.my (Adam Aruldewan S.Muthuveeran)
gs65950@student.upm.edu.my (Gao Yuxuan)
liupeng19850809@gmail.com (Liu Peng)
gs62183@student.upm.edu.my (Dai Na)
gs64967@student.upm.edu.my (Ma Yali)
* Corresponding author

advantages pose obstacles to ecological conservation (Yosef et al., 2022). The balance between urban development and environmental preservation is influenced by the interactive relationship between environmental policy formulation and urban planning methodologies. However, rapid urbanization has intensified the deterioration of these biological services, converting several natural areas into perceived impediments to urban expansion, rather than resources. Furthermore, the pressures of climate change and land development exacerbate conservation challenges, hence jeopardizing the structural and functional integrity of wetland ecosystems. A comprehensive investigation of the impact of land use on wetland ecosystem services is essential (Marta-Pedroso et al., 2018). These findings will offer significant insights for decision-makers, promoting the sustainable management of wetlands and highlighting the necessity for a thorough reevaluation of existing urban growth policies (Materu et al., 2018).

LITERATURE REVIEW AND RESEARCH AIM

Ecosystem Service

Ecosystem services are essential components of environmental science, representing the numerous benefits that natural ecosystems provide to humans. These services can be classified into four main categories: provisioning, regulating, cultural, and supporting services. They play a critical role in climate change mitigation and ecological stability (Adger et al., 2018). Cultural services encompass the intangible benefits that individuals derive from ecosystems, including recreational, aesthetic, and spiritual experiences. Such services substantially enhance human well-being by improving quality of life and fostering a connection with nature (Willis, 2015).

The evaluation and assessment of ecosystem services are increasingly important for conservation and resource management decision-making. Numerous studies highlight the necessity of integrating economic and ecological evaluations for sustainable practices (Withey & Kooten; Marta-Pedroso et al., 2018). Furthermore, the consideration of social preferences and stakeholder participation in ecosystem service assessments is of paramount importance (Hatamkhani & Moridi, 2021). Research indicates that incorporating local knowledge and values into ecosystem service assessments can lead to more equitable and effective management strategies (Yadav et al., 2021). Ecosystem services underpin both economic and biological activities, rendering them essential for human well-being (Zairul et al., 2023). Policies that promote sustainability and strengthen ecosystem and community resilience can be developed through the integration of ecological assessments, economic valuations, and stakeholder engagement (Tassew & Eyasu, 2019).

Wetland Ecosystem Service

Wetland ecosystems are vital for maintaining biodiversity and providing multiple ecosystem services that are important for human well-being (Li et al., 2024). Costanza et al. (1997) classified global ecosystems and quantified wetland services, extrapolating national assessments from countries such as the United States and Indonesia to estimate their global value. In this context, Zorrilla-Miras et al. (2014) conducted research on the effects of land use change on the Doñana wetland in Spain. Their results indicate that land use changes play a critical role in the decline of ecosystem service value. Economic valuations further highlight the substantial benefits of wetlands: globally, they may provide over USD 47 trillion annually (L. Yang et al., 2023), contribute to water quality improvement (Adusumilli, 2015), and in the Liaohe Delta of China, reed wetlands generate approximately USD 2.68 billion per year (Ye et al., 2016). Local communities, such as those in Assam, India, rely heavily on wetlands for fishing, tourism, and fuelwood (Bhatta et al., 2016). However, wetlands face serious threats from development and misuse (X. Wu et al., 2023).

Meanwhile, a Malaysian study on willingness to pay (WTP) for lake and wetland conservation revealed that the public exhibited a notably high WTP for the protection of the Tasik Chini Wetland and the Paya Indah Wetland, amounting to approximately USD 39,022 and USD 151,626.90, respectively. This finding suggests that the public places considerable value on these natural assets, particularly in the context of climate change impacts (Sharip & Noor, 2021).

The relationship between biodiversity and ecosystem services is complex; higher biodiversity may enhance certain ecosystem functions, but not uniformly across all wetland types (Wei et al., 2024). Ecosystem degradation reduces the reliability and productivity of services, thereby undermining sustainable local practices. Ongoing research and monitoring are therefore essential to inform effective conservation and management strategies.

Management and Conservation

Effective management of wetlands necessitates continuous monitoring and comprehensive assessment of their ecological health. Shivakrishna et al. (2021) argue that geospatial technology can help us understand wetland dynamics and inform conservation measures. For the conservation of wetlands, remote sensing can detect land use changes and assess their ecological health (O'Leary, 2022). Additionally, the economic assessment of wetlands, as examined by Baral et al., highlights the necessity of acknowledging their many advantages, including providing, regulating, and cultural functions (Baral et al., 2016). This economic viewpoint can augment public awareness and backing for wetland

conservation efforts (Allahyari, 2024). Nevertheless, effective wetland management and conservation need community involvement, ecological comprehension, and economic assessment. The degradation and destruction of wetland habitats require solutions that benefit both local residents and the environment.

Impacts of Land Use Change on Wetland Ecosystem Services

Land use changes significantly impact biodiversity in wetland ecosystems. Conversion of wetlands to agricultural land has led to widespread wetland loss, as seen in the Heilongjiang River Basin (Q. Yang et al., 2020). Climate change and intensified agriculture further reduce wetland areas and compromise ecosystem functions (Cai et al., 2022). Changes in land use also alter soil properties and microbial communities, destabilising wetlands (Sui et al., 2019), while biodiversity declines and soil nutrient depletion result from agricultural expansion (Garedew, 2023). Wetland draining and urbanisation affect water levels, ecosystem dynamics, and socio-economic benefits (Saluja, 2023; X. Wu et al., 2023).

Biofuel policies and other land use changes have exacerbated wetland loss, affecting waterfowl and ecological processes (Withey & Kooten, 2012). Conversely, agricultural conservation practices may enhance wetland services, highlighting the role of sustainable land management (Hatamkhani & Moridi, 2021). Overall, transforming wetlands for agriculture or urban use compromises biodiversity, ecological balance, and essential ecosystem services. Implementing sustainable management, conservation, and restoration strategies is crucial to mitigate these impacts.

This study aims to undertake a thorough examination of literature about wetland ecosystem services published from 2015 to August 2024, highlighting the evolutionary trends of these services and the correlation between land use changes and wetland ecosystem services. The results aim to provide a theoretical foundation and practical recommendations for the sustainable conservation and management of wetlands.

The structure is delineated as follows: The introductory section analyzes the current state of research on wetland ecosystem services, outlines the research background, and identifies key research questions. The second section outlines the study methodology, including data collection strategies and analytical techniques. The third section integrates the findings of 52 selected studies through quantitative and qualitative analyses, focusing on five primary themes: (1) The impact of land use change on wetland ecosystem services; (2) Wetland ecological services; (3) Assessment methodologies for ecosystem services; (4) The effect of urbanization on ecosystem services; (5) Wetland conservation and management.

MATERIALS AND METHODS

Clarke and Braun (2008) defined thematic analysis as a technique of discovering patterns and building themes through a comprehensive examination of the subject. This study finds theme analysis effective for identifying new theories and concepts in a less-established subject. Thematic analysis is a versatile and valuable research tool that provides detailed and informative data descriptions and rational terms and methods for analysis (Braun & Clarke, 2006).

This study aims to analyze and elucidate the current research progress on ecosystem services in urban wetlands. Recently, this topic has garnered widespread attention; however, research on how to transform urban land use into controlled ecosystems that balance ecological needs with urban development remains limited. This thematic evaluation follows the methodology suggested by Zairul (2023), extracting critical data pertinent to the study issue via themes that embody recurring reactions or significances within the dataset (Clarke, Victoria, 2008). This research focuses on analysing and interpreting these findings while offering recommendations for further theoretical investigations into the integration of environmental services inside urban wetlands.

The literature was meticulously chosen according to the following criteria: Published from 2015 to 2024, featuring terms such as 'wetland,' 'land use change,' or 'ecosystem service value,' and addressing the effects of land use changes on the ecosystem service value of wetlands. A systematic methodological framework was utilized, encompassing the formulation of research questions, selection of data sources, data retrieval and preprocessing, theme extraction, analysis, synthesis, and ultimately, the visualisation and presentation of results.

The literature review was conducted using the SCOPUS and Web of Science databases. The preliminary search yielded 35 papers from SCOPUS and 42 from Web of Science. Due to content redundancy and the application of stringent selection criteria limiting inclusion to studies published within the past decade these papers were imported into ATLAS.ti 9 as the primary dataset. Each paper was categorized by author, issue number, journal, publisher, volume, and year of publication to facilitate the analysis of temporal research patterns. Although many articles were duplicated across SCOPUS and Web of Science, and some publications were inaccessible despite being labeled as open access, the final dataset analyzed in ATLAS.ti 9 comprised 52 articles. Only English-language manuscripts were included (see Table 1 and Figure 1).

Table 1
Search strings.

SCOPUS	Article title, Abstract, Keywords ("land use change" AND "Ecosystem service value" AND "wetland") AND PUBYEAR > 2015 AND PUBYEAR < 2025 AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (SOUTYPE,"jou"))AND (LIMIT-TO (Language, "English")) AND (LIMIT-TO (OA, "all"))	137 results
Web of Science (WoS)	Results for "land use change" AND " Ecosystem service value" AND "wetland" (All Fields) and Open Access and Article (Document Types) and English (Languages) and PubYear2015 and PubYear< 2025	166 results
Mendeley	Land use change" and "ecosystem service" and "wetland" AND DOCUMENT and TYPE: Article YEAR: [2015 TO 2024]	66 results

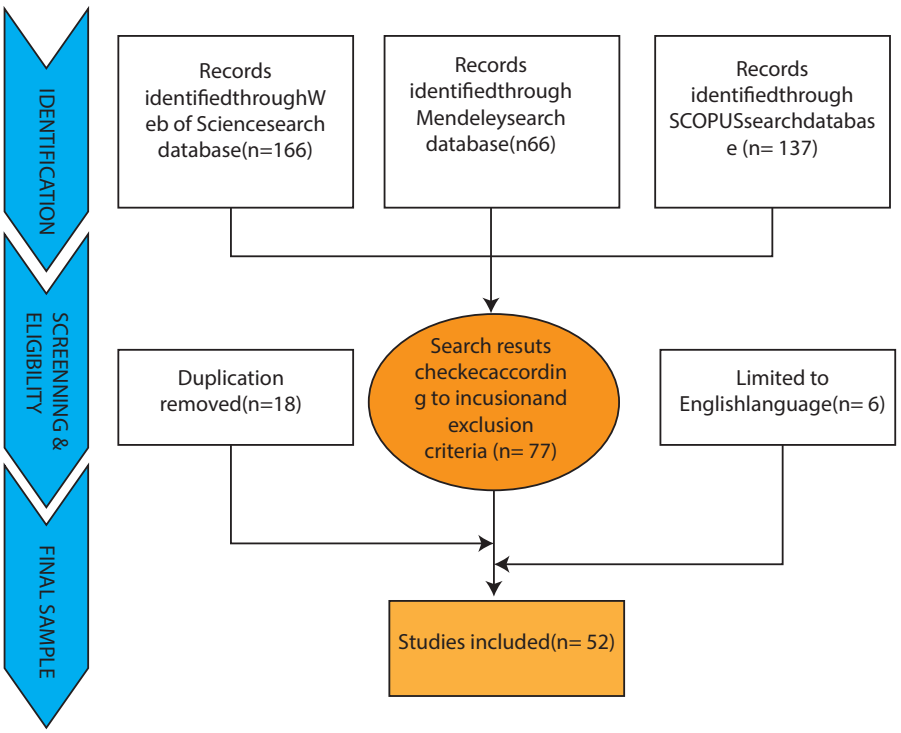

Figure 1. Inclusion and Exclusion criteria in the thematic review

RESULTS AND DISCUSSION

This section emphasizes the principal findings of the theme review. A combination of quantitative and qualitative analysis was employed to evaluate the effectiveness of 52 selected articles in addressing the research topics.

Quantitative Findings

The research trends on wetland ecosystem services and land-use change can be analyzed through word frequency, publication year, study location, publication source, and thematic focus. The quantitative analysis produced the word cloud shown in Figure 2, highlighting the most frequently used terms in the reviewed literature. Prominent terms include *land*, *ecosystem*, *wetland*, *service*, and *value*, reflecting their central role in the field. Among these, *land* appeared most frequently, followed by *ecosystem*, *wetland*, and *service*. Collectively, these keywords capture the primary focus of the research: land use change, wetland ecosystem services, and their interconnections, which are closely related to the overarching theme of this study.

Figure 3 shows the spatial distribution of studies on wetland ecosystem services and land-use change. China dominates the field with 38 publications, followed by India, whereas countries such as Ethiopia and Vietnam contribute comparatively fewer studies. The concentration of research in China reflects the country's strong policy emphasis on wetland conservation and sustainable land use management. This pattern indicates that wetland ecosystem services are a research priority in regions experiencing rapid land use changes and environmental pressures, revealing notable global disparities in research focus.

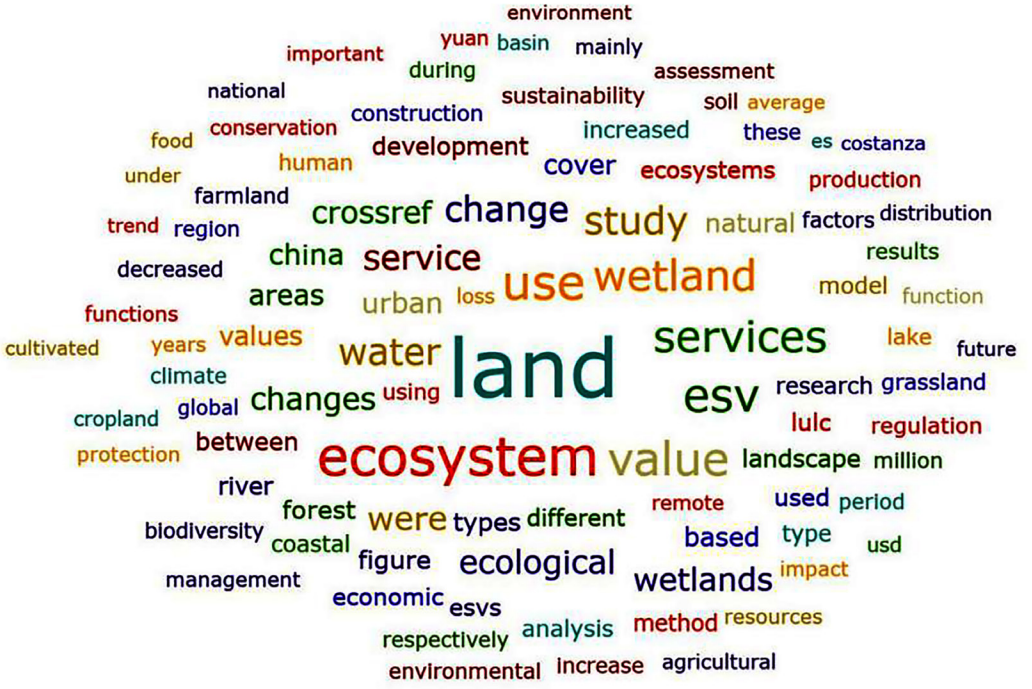

Figure 2. Word cloud generated from 52 articles.

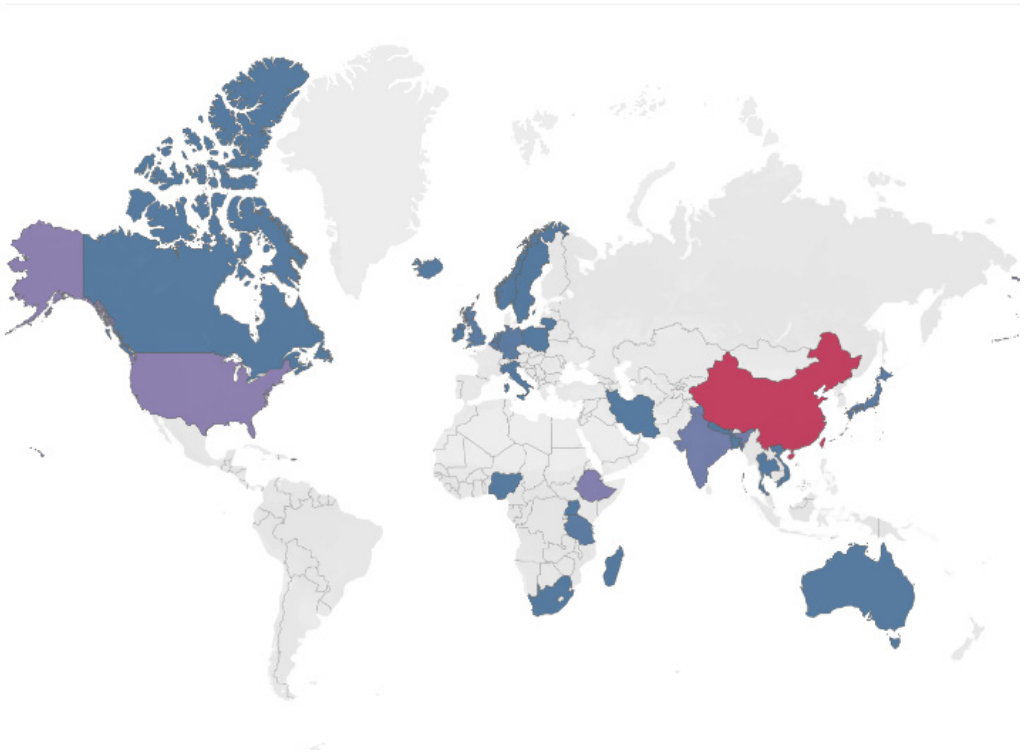

Figure 3. Papers by number of publications

Table 2 presents a preliminary analysis of keywords in wetland ecosystem studies. The frequency of articles highlights major research themes and conservation strategies. Keywords such as *Ecosystem Service Value (ESV)* and *Value/Benefit Transfer* reflect efforts to quantify wetland benefits for policy development and sustainable management. *Land Use/Cover Change (LUCC)* emphasizes anthropogenic impacts, underlining the need for careful land-use planning. Advanced modeling approaches, including Markov-FLUS and PLUS, facilitate scenario simulation and spatial forecasting. Research also focuses on urban wetlands, geospatial monitoring using remote sensing, and sustainability aligned with the SDGs. *Sensitivity Analysis* and *Ecological Risk* highlight the assessment of ecosystem vulnerability to support proactive conservation. Collectively, these keywords illustrate an interdisciplinary approach integrating ecological assessment, spatial analysis, sustainability, and predictive modeling to guide wetland management.

Table 2
Methodologies in wetland ecosystem services research (2015–2024)

Category	Keywords
Ecosystem Service Value (ESV)	Ecosystem Service Value Value transfer, Benefit transfer
Land Use/Cover Change (LUCC)	Land use change Land resource use Land cover change Land-use planning
Models and Methods	PLUS model FLUS model Linear optimization model Scenario simulation
Wetland Ecosystems	Wetland protection Urban wetland Landscape pattern Wetland ecosystem services
Remote Sensing and Spatial Analysis	Multi-source remote sensing data Remote sensing Geographically weighted regression Spatial autocorrelation
Sustainable Development	Sustainable Development Goals (SDGs) Ecological protection Sustainability Environmental planning
Sensitivity Analysis and Ecological Risk	Sensitive analysis, Sensitivity analysis Ecological risk

Published sources suggest that researchers investigating the impact of land use on wetland ecosystem services predominantly choose articles in environmental science, ecology, and land management. Table 3 demonstrates that Environmental Management, Ecological Indicators, and Land Use Policy are among the most often cited publications in this field of research. Utilizing only “wetlands” or “ecosystem services” as search criteria would provide a far higher number of retrieved articles. Integrating “land use change” into the search query produced more focused results, indicating that this research domain remains in its infancy and possesses much potential for additional exploration.

Table 3
Findings on land use and ESV (Ecosystem Service Values)

Category	Key Findings
Changes in ESV and LUCC	Evaluation of historical and projected LUCC and ESV changes; Sensitivity analyses of ecosystem services related to land use changes; Implications of LUCC changes on individual and grouped ecosystem services; Comparative analysis and temporal dynamics of LUCC and its impact on ESV; Spatiotemporal dynamics and landscape pattern changes in different ecosystems, including wetlands.
Methodological Approaches in Ecosystem Assessment	Development of a functional classification system for ecosystem services; Analysis of the spatial distribution and variation of ESV; Use of surface and planar area measurements to determine ESV; Sensitivity index of ecosystem service value and impact of land use transfer on ESV.
Ecological Protection and Management Suggestions	Recommendations for sustainable management and regeneration of ecosystems; Suggestions for improving ESV through strategic land use optimization; Policy implications for incorporating ESV into government programs; Ecological implications of land use change and land structure optimization.
Impact on Wetlands Specifically	Impact of landscape changes on the ESV of wetlands; Spatiotemporal changes in wetlands, including the effects of urbanisation; Protection and management implications for wetlands based on ESV assessments.
Drivers and Future Scenarios	Exploration of driving factors of land-use change including socio-economic and natural factors; Future perspectives of LUCC at the trans-boundary level; Simulation of land use spatial layout and prediction of ecosystem service values under different scenarios.

Qualitative Results

This section presents a qualitative analysis that elucidates the themes detected in response to the study question: "What are the contemporary trends regarding the impact of land use on wetland ecosystem services as discussed in the literature from 2015 to 2024?" The topics were categorized following a comprehensive analysis of pertinent literature, emphasizing both theoretical and practical dimensions widely examined in the discipline. The coding process was consolidated to reveal five principal themes: (1) the impact of land use change on ecosystem services, (2) wetland ecosystem services, (3) assessment of ecosystem services, (4) urbanization and ecosystem services, and (5) conservation strategies. Topics are interrelated and frequently overlap in the analyzed papers, with several researchers examining numerous topics concurrently. This section offers a thorough examination of each theme, citing the reviewed articles and supplementary sources as needed to effectively address the research question.

RQ: What are the current trends on the impact of land use changes on wetland ecosystem services discussed in the literature from 2015 to 2024?

Theme 1: Impact of Land Use Change on Ecosystem Services

A comprehensive review of the literature consistently indicates that land use change significantly impacts wetland ecosystem services across both spatial and temporal scales. Assessing the spatiotemporal dynamics of land use change is critical for understanding its impacts on wetland ecosystem services. Review studies indicate that land use alterations significantly affect the ecological functions and service provision of wetlands, with variations in the magnitude and direction of these impacts across different regions and ecosystem types. For instance, Yin et al. (2023) found that urban expansion and agricultural land conversion in China reduced regulatory and supporting services such as water purification and soil conservation, whereas forested areas contributed to increased carbon sequestration and habitat provision. Lu (2023) noted that changes in grassland and wetland coverage in the Yellow River Source Region influenced provisioning services, particularly forage supply, as well as regulatory services related to water resource balance.

Further comparative studies reveal that these impacts exhibit regional variations: Sujetoviene (2023) reported that agricultural intensification and wetland drainage in Lithuania led to reduced biodiversity and weakened nutrient regulation services, a pattern consistent with global trends. Jia (2020) found in Wuhu City that urbanization and land reclamation exacerbated ecological risks, resulting in a decline in local ecosystem service values. Han et al. (2024) assessed the Maqu alpine wetland using the emergy method, and the results showed that wetland degradation and pasture expansion altered energy flows and reduced regulating and supporting services. Mengist (2022) emphasized that in the Eastern Afromontane Biodiversity Hotspot, deforestation and agricultural expansion are closely associated with decreased habitat quality and reduced supply of ecosystem services. In summary, these studies demonstrate that land use changes impact wetland ecosystem services in multiple specific ways, including declines in regulating, supporting, and provisioning services, increased ecological risks, and shifts in biodiversity patterns.

These findings underscore the importance of integrating spatiotemporal analysis, predictive modeling, and regional assessments into wetland conservation and management. Concurrently, the understanding of these impacts provides a basis for the proposed analytical framework (Figure 9), which aims to maintain or enhance the value of wetland services by identifying key drivers of ecosystem service changes, quantifying their effects, and offering references for policy interventions.

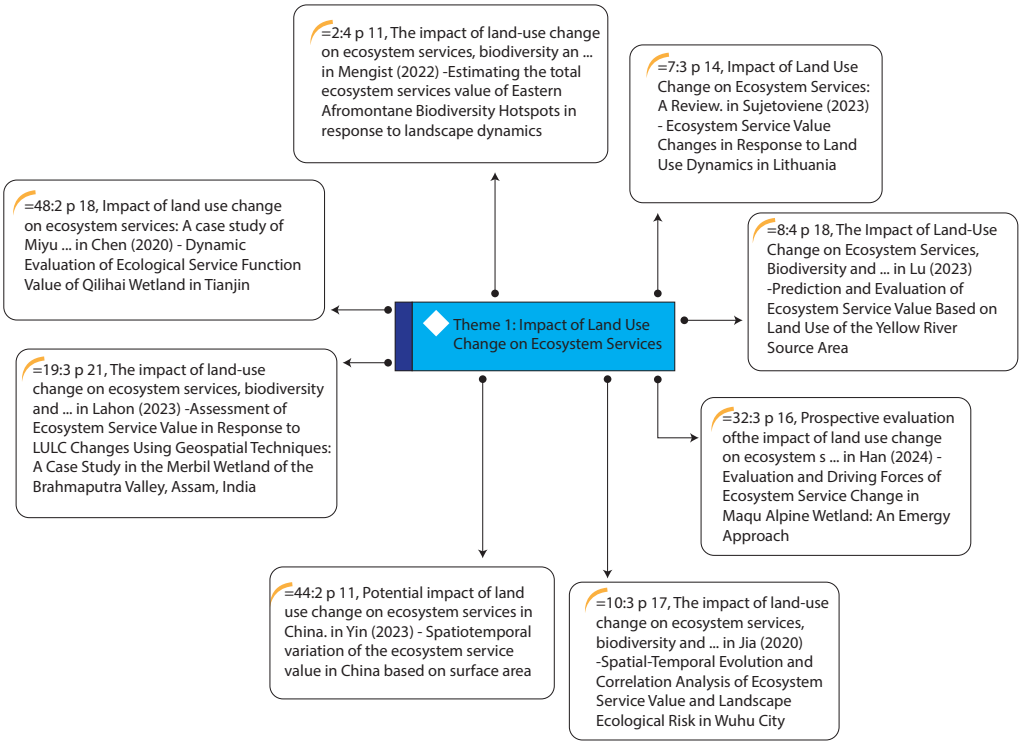

Figure 4. Overall network of themes related to land use changes and wetland ecosystem services.

Theme 2: Wetland ecosystem services

Previous studies indicate that wetland ecosystem services are highly sensitive to land use change, mainly through alterations in wetland area, landscape structure, and anthropogenic disturbance intensity (Figure 5). Changes in wetland extent strongly affect regulating services such as water regulation, flood mitigation, and carbon storage, as demonstrated by spatiotemporal variations observed in large river basins (Yun et al., 2022). Even when total wetland areas remain relatively stable, landscape fragmentation and structural modification can reduce habitat continuity and biodiversity support, thereby weakening supporting services.

Urbanization and agricultural expansion further exert pressure on provisioning and cultural services. Urban development has been shown to degrade ecological functions while simultaneously reducing recreational and cultural values of wetlands (Alikhani et al., 2021). Valuation studies also reveal that regulating services contribute the largest share of wetland ecosystem service value, whereas cultural services are the most sensitive to human disturbance (Han, 2024). In addition, wetland services are closely aligned with regional sustainability objectives, including flood control and climate regulation, highlighting their contribution to the United Nations Sustainable Development Goals (Long, 2022).

Overall, the reviewed literature suggests a consistent pathway in which land use change modifies wetland area and spatial configuration, leading to changes in ecosystem functions and associated service values. The integration of LUCC data, remote sensing, and modelling approaches provides an effective means to assess and predict these impacts under future development scenarios.

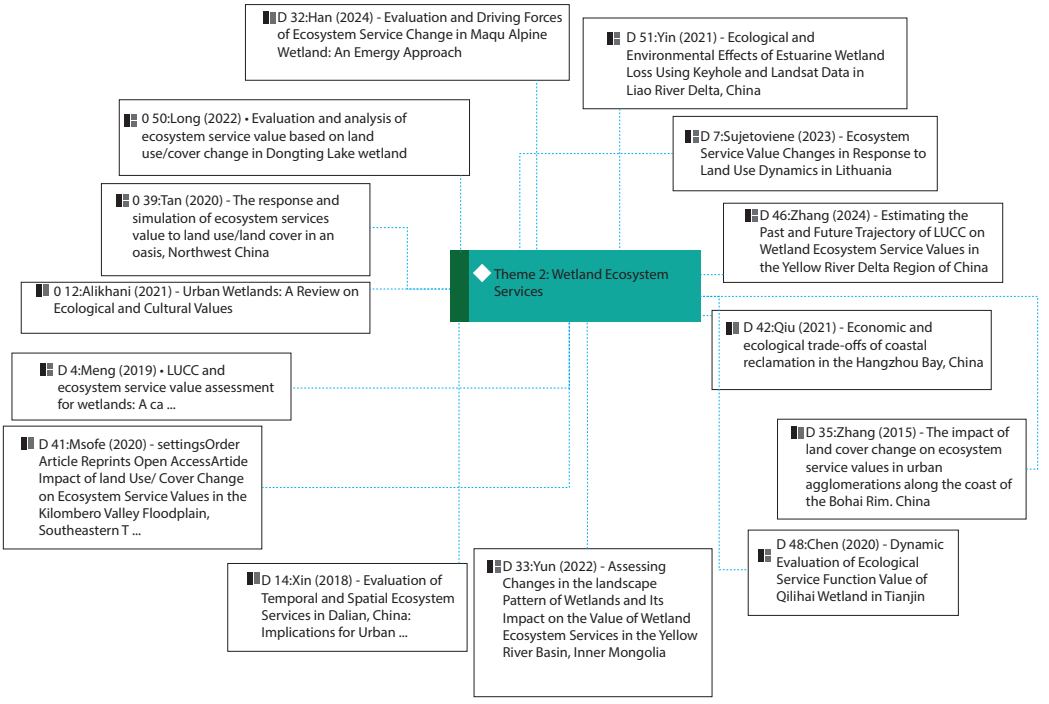

Figure 5. Thematic Network of Wetland Ecosystem Service

Theme 3: Assessment of Ecosystem Services

The reviewed literature indicates that ESV (Ecosystem Service Values) changes systematically in response to land use transformation through alterations in landscape composition, development intensity, and management strategy (Figure 6). Conversion of ecological land, particularly wetlands and cropland, into construction land generally results in continuous ESV decline, whereas ecological restoration and optimized land allocation can significantly enhance service value (Wu et al., 2020; Yang, 2021). Spatial analyses consistently show that regulating services dominate total ESV variation, meaning hydrological regulation, climate regulation, and environmental purification are the most sensitive functions under land conversion.

Scenario-based simulations further reveal that policy intervention plays a decisive role in future ESV trajectories. Ecological protection boundaries and land use control measures effectively slow service degradation and improve regional ecological stability (Hu, 2020). These findings suggest that ESV is not only a passive result of land change but also a manageable outcome influenced by planning decisions.

Urban–wetland transition zones represent the most sensitive areas to land transformation. Rapid urban expansion intensifies the trade-off between economic development and ecological conservation, weakening ecological functions and accelerating service loss, while wetland protection significantly stabilizes regional service value (Chen, 2020). Across different regions, the decline in regulating services is typically faster than provisioning services, indicating higher vulnerability of ecological regulation capacity to human disturbance.

Overall, the literature reveals a consistent pathway: land use change alters landscape structure and human activity intensity, which drives ecosystem functional variation and ultimately determines ESV dynamics. Integrated spatial modelling and planning approaches are therefore essential to balance development and conservation and to maintain long-term ecosystem resilience.

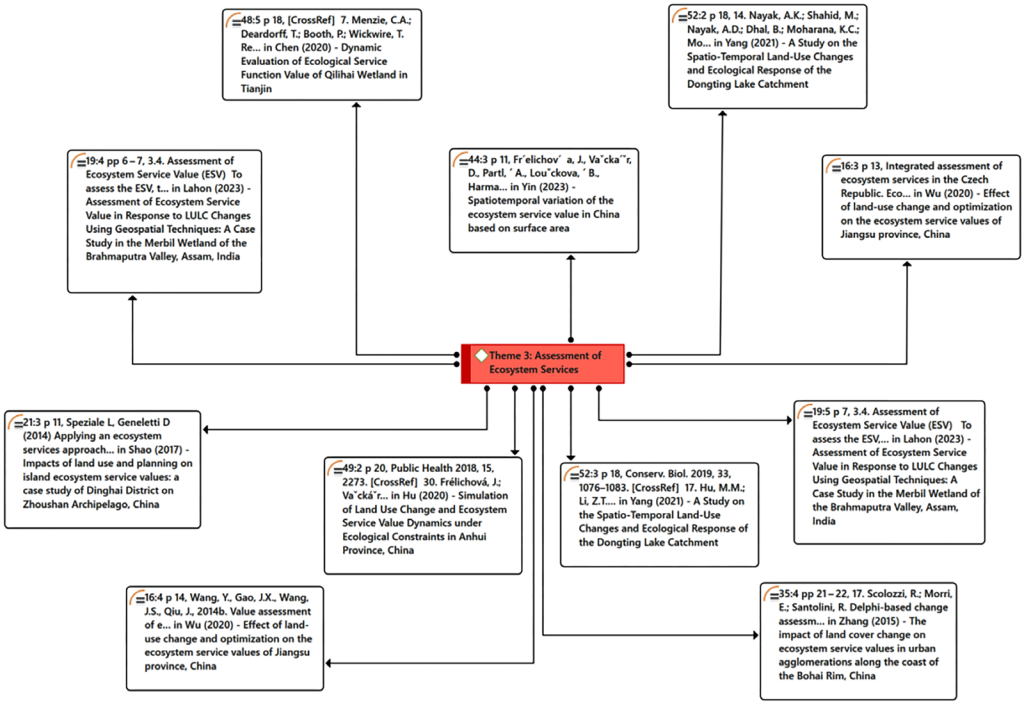

Figure 6. Network of Themes on the Assessment of Wetland Ecosystem Services

Theme 4: Urbanisation and Ecosystem Service

The reviewed studies indicate that urbanisation reshapes ecosystem services primarily through land conversion intensity, spatial expansion pattern, and planning policy intervention (Figure 7). Rapid expansion of construction land generally leads to declines in ecosystem service value (ESV), particularly in regulating and supporting services, due to vegetation loss, surface sealing, and habitat fragmentation (Zuo, 2023; Wang, 2021). Urban growth therefore weakens ecological regulation capacity, especially climate regulation and water retention functions.

However, the impact of urbanisation is not uniformly negative. Scenario analyses show that different land-use planning strategies produce significantly different ecological outcomes, and compact development or ecological zoning can reduce ESV loss and even enhance certain services (Lu, 2023). This suggests that urbanisation acts as a controllable driver rather than an inevitable threat.

At the regional scale, economically developed metropolitan areas show strong trade-offs between economic benefits and ecological services, but coordinated regional planning can mitigate these conflicts (Wang, 2021). Proper spatial allocation of ecological land, green infrastructure, and protected areas stabilizes ecosystem functions despite population growth.

Overall, the literature demonstrates a consistent mechanism: urban expansion alters land structure and human activity intensity, which drives ecosystem service decline, while ecological planning moderates or reverses this trend. Thus, urbanisation simultaneously represents a pressure on ecosystems and an opportunity for improving ecosystem services through strategic land-use management.

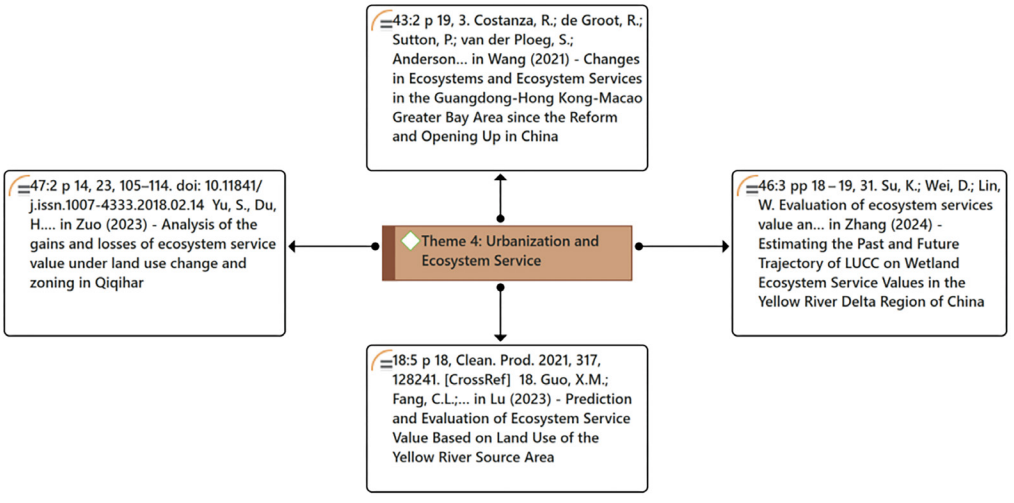

Figure 7. Network for urbanisation and Ecosystem Services

Theme 5: Conservation and Management

The reviewed literature shows that wetland conservation and management directly determine the stability of ecosystem services through hydrological regulation, habitat protection, and land-use control (Figure 8). Urban and peri-urban wetlands provide key services including water purification, carbon storage, habitat provision, and urban heat mitigation, but these functions decline when hydrological connectivity is disrupted or pollution pressure increases (Alikhani, 2021). Land-use and land-cover change (LUCC) is identified as a primary driver altering ecosystem service value (ESV), particularly in ecologically fragile regions where conversion of natural land significantly reduces service capacity (Tan, 2020).

Across different regions, wetland degradation commonly results from drainage, wastewater discharge, invasive species, and habitat fragmentation, leading to simultaneous declines in biodiversity and regulating services. Spatial monitoring studies further show that remote sensing and statistical modelling effectively detect these functional changes and support adaptive management decisions.

Overall, the literature suggests a clear pathway: land-use disturbance modifies wetland hydrology and habitat conditions, which reduces ecosystem functions and consequently lowers ecosystem service value. Integrating conservation measures into land-use planning is therefore essential to balance development and long-term ecosystem sustainability.

Figure 8. Network for Conservation and Management

Framework for Understanding Land Use and Wetland Ecosystem Service

To address the lack of an analytical framework identified in previous sections, the proposed framework is derived directly from the synthesis of the five thematic findings rather than conceptual assumption (Figure 9). The thematic review consistently demonstrates a causal pathway in which land use change modifies wetland structure and landscape configuration (Themes 1–2), alters ecosystem functions and service value (Theme 3), is intensified by urbanisation processes (Theme 4), and can be mitigated through adaptive conservation and planning strategies (Theme 5). Therefore, the framework integrates these recurring relationships into a unified mechanism linking drivers, processes, impacts, and responses. as shown in Figure 9.

Source Problem: Rapid population growth increases demand for housing, infrastructure, and resources, driving urban expansion. This growth alters land use patterns by converting

natural ecosystems, often through vegetation removal and wetland loss, into built environments, placing significant pressure on ecological systems.

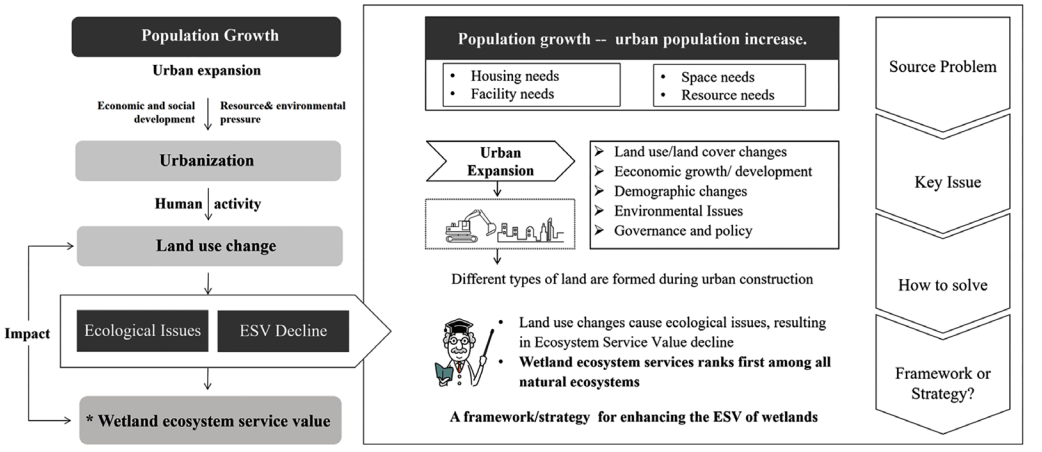

Figure 9. Relationship between land use change and wetland ecosystem services.

Key Issue: Urbanization intensifies human activities and land-use modifications, leading to habitat loss, reduced biodiversity, and declining ecosystem services. Changes in land cover, economic development, population dynamics, environmental stressors, and governance decisions collectively undermine the ecological functions of wetlands.

How to Solve: Solutions should enhance wetland ESV through integrated urban planning, stricter land-use regulations, and innovative conservation measures. Sustainable development policies are needed to balance economic growth with ecological protection.

Framework or Strategy: An effective strategy should combine governmental action, ecological restoration, and community-based conservation. Integrating wetlands into urban design, promoting sustainable development, and increasing awareness of their ecological value can support their protection and restoration.

CONCLUSION

frameworks to provide policymakers and stakeholders with scientifically sound strategies.

This review examines 52 papers published between 2015 and August 2024, focusing on ecosystem services related to land use change and wetlands, with the aim of characterizing the current research landscape and emerging trends. Literature searches were conducted using ATLAS.ti 9 software. The results reveal that, despite increasing scholarly attention, comprehensive review articles addressing the impacts of land-use change on wetland ecosystem services remain limited. This highlights the need for further investigation into the complex interactions between land use change and wetland functions. Anthropogenic

alterations in land use can significantly affect the provision of wetland ecosystem services, posing risks to water quality, biodiversity, and flood regulation. Integrating land-use dynamics with ecosystem service frameworks is recommended to inform policymakers and stakeholders with evidence-based strategies for sustainable wetland management.

RESEARCH CONTRIBUTION

This study incorporates data from 2015 to 2024 into a thematic analysis of the impact of land use change on the Ecosystem Service Value (ESV) of wetlands. The study's six main themes examine land use change and wetland management strategies, providing a comprehensive understanding of the complex relationship between human activities and ecological services. The report examines trends, challenges, and opportunities in the assessment of wetland ecosystem services research to identify knowledge gaps. It enhances the scientific discourse by providing a systematic framework for analysing the impacts of land use on wetlands and by highlighting the need to integrate socio-ecological systems into decision-making processes. Future researchers can use the data to explore the complex and diverse facets of wetland ecosystem services.

PRACTICAL CONTRIBUTIONS

This study demonstrates the impact of land use changes on wetland ecosystem services, facilitating the development of sustainable management strategies. Urbanisation and ecological services illustrate the necessity of reconciling economic development with environmental conservation. The analysis indicates that advanced valuation methods assist stakeholders in making informed decisions on ecosystem services. This study advocates enhanced land-use planning, ecological restoration, and the fortification of wetland ecosystem resilience against urbanisation and climate change.

ACKNOWLEDGEMENT

We appreciate the financial support of this study from Carbon Sink Efficiency and Incremental Optimisation of Green Spaces in High-Density Urban Areas of Chongqing: A Study Towards Carbon Neutrality (Project Number: KJQN202302502).

REFERENCES

Adger, W. N., Adams, H., Kay, S., Nicholls, R. J., Hutton, C. W., Hanson, S., Rahman, M. M., & Salehin, M. (2018). Ecosystem services, well-being and deltas: Current knowledge and understanding. In R. J. Nicholls, C. W. Hutton, & M. Adger (Eds.), *Deltas in the Anthropocene* (pp. 1–22). Springer. https://doi.org/10.1007/978-3-319-71093-8_1

Adusumilli, N. (2015). Valuation of ecosystem services from wetlands mitigation in the United States. *Land, 4*(1), 182–199. https://doi.org/10.3390/land4010182

Alikhani, S., Nummi, P., & Ojala, A. (2021). Urban wetlands: A review on ecological and cultural values. *Water, 13*(22), Article 3301. https://doi.org/10.3390/w13223301

Allahyari, M. S. (2024). Unlocking the power of public awareness: Paving the way for sustainable wetland management in Anzali, Iran. *Frontiers in Environmental Science, 11*, Article 1277154. https://doi.org/10.3389/fenvs.2023.1277154

Baral, S., Basnyat, B., Khanal, R., & Gauli, K. (2016). A total economic valuation of wetland ecosystem services: Evidence from Jagadishpur Ramsar Site, Nepal. *The Scientific World Journal, 2016*, Article 2605609. https://doi.org/10.1155/2016/2605609

Bhatta, L. D., Chaudhary, S., Pandit, A., Baral, H., Das, P. J., & Stork, N. E. (2016). Ecosystem service changes and livelihood impacts in the Maguri-Motapung wetlands of Assam, India. *Land, 5*(2), Article 15. https://doi.org/10.3390/land5020015

Blampied, S. R., Sheehan, E. V., Binney, F. C. T., Attrill, M. J., & Rees, S. E. (2022). Value of coastal habitats to commercial fisheries in Jersey, English Channel, and the role of marine protected areas. *Fisheries Management and Ecology, 29*(5), 734–744. https://doi.org/10.1111/fme.12571

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Cai, W., Liu, X., Zhang, D., & Akter, F. (2022). Impact of land cover changes on the wetland ecosystem water environment using soft computing methods. *Mathematical Problems in Engineering, 2022*, Article 3673758. https://doi.org/10.1155/2022/3673758

Chen, C., Shao, C., & Shi, Y. (2020). Dynamic evaluation of ecological service function value of Qilihai Wetland in Tianjin. *International Journal of Environmental Research and Public Health, 17*(19), Article 7108. https://doi.org/10.3390/ijerph17197108

Clarke, V., & Braun, V. (2008). Thematic coding and analysis. In L. M. Given (Ed.), *The SAGE encyclopedia of qualitative research methods* (pp. 867–868). SAGE Publications, Inc. https://doi.org/10.4135/9781412963909.n451

Garedew, K. F. (2023). *Spatio-temporal change of wetland and their effects on wetland biodiversity in Dinsho District, Bale Mountain Eco-Region, Southeast Ethiopia* [Preprint]. Research Square. https://doi.org/10.21203/rs.3.rs-3174257/v1

Han, Z., Zhao, R., Zhang, L., Chen, X., Wang, J., Lu, H., & Liu, F. (2024). Evaluation and driving forces of ecosystem service change in Maqu alpine wetland: An emergy approach. *Land, 13*(3), Article 366. https://doi.org/10.3390/land13030366

Hatamkhani, A., & Moridi, A. (2021). *Optimal water allocation based on agricultural and environmental water value* [Preprint]. Research Square. https://doi.org/10.21203/rs.3.rs-730925/v1

Hu, T., Liu, J., Zheng, G., Zhang, D., & Huang, K. (2020). Evaluation of historical and future wetland degradation using remote sensing imagery and land use modeling. *Land Degradation & Development, 31*(1), 65–80. https://doi.org/10.1002/ldr.3429

Jia, Y., Tang, X., & Liu, W. (2020). Spatial-temporal evolution and correlation analysis of ecosystem service value and landscape ecological risk in Wuhu City. *Sustainability, 12*(7), Article 2803. https://doi.org/10.3390/su12072803

Li, W., Chen, X. X., Zheng, J., Zhang, F., Yan, Y., Hai, W., Han, C., & Liu, L. (2024). A multi-scenario simulation and dynamic assessment of the ecosystem service values in key ecological functional areas: A case study of Sichuan Province, China. *Land, 13*(4), Article 468. https://doi.org/10.3390/land13040468

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*, Article 108619. https://doi.org/10.1016/j.ecolind.2022.108619

Lu, H., Shang, Z., Ruan, Y., & Jiang, L. (2023). Study on urban expansion and population density changes based on the inverse S-shaped function. *Sustainability, 15*(13), Article 10464. https://doi.org/10.3390/su151310464

Lu, Z., Song, Q., Zhao, J., & Wang, S. (2023). Prediction and evaluation of ecosystem service value based on land use of the Yellow River source area. *Sustainability, 15*(1), Article 687. https://doi.org/10.3390/su15010687

Marta-Pedroso, C., Laporta, L., Gama, I., & Domingos, T. (2018). Economic valuation and mapping of ecosystem services in the context of protected area management: Natural Park of Serra de São Mamede, Portugal. *One Ecosystem, 3*, Article e26722. https://doi.org/10.3897/oneeco.3.e26722

Materu, S. F., Urban, B., & Heise, S. (2018). A critical review of policies and legislation protecting Tanzanian wetlands. *Ecosystem Health and Sustainability, 4*(12), 310–320. https://doi.org/10.1080/20964129.2018.1549510

Mengist, W., Soromessa, T., & Feyisa, G. L. (2022). Estimating the total ecosystem services value of Eastern Afromontane biodiversity hotspots in response to landscape dynamics. *Environmental and Sustainability Indicators, 14*, Article 100178. https://doi.org/10.1016/j.indic.2022.100178

O'Leary, F. (2022). *Wetland loss in the Ñeembucú wetlands complex, Paraguay, using remote sensing* [Preprint]. bioRxiv. https://doi.org/10.1101/2022.01.03.474818

Rojas Quezada, C., & Jorquera, F. (2021). Urban fabrics to eco-friendly blue–green for urban wetland development. *Sustainability, 13*(24), Article 13745. https://doi.org/10.3390/su132413745

Saluja, R. (2023). Assessment of community dependence and perceptions of wetlands in the Upper Chindwin Basin, Myanmar. *Resources, 12*(10), Article 112. https://doi.org/10.3390/resources12100112

Shivakrishna, A., Ramteke, K., Kesavan, S., Prasad, P., Naidu, B. C., Dhanya, M. B., & Abidi, Z. J. (2021). Monitoring of current land use pattern of Ramsar designated Kolleru Wetland, India using geospatial technologies. *Journal of Environmental Biology, 42*(1), 1–10. https://doi.org/10.22438/jeb/42/1/mrn-1404

Sui, X., Zhang, R., Frey, B., Yang, L., Li, M., & Ni, H. (2019). Land use change effects on diversity of soil bacterial, acidobacterial and fungal communities in wetlands of the Sanjiang Plain, Northeastern China. *Scientific Reports, 9*, Article 55063. https://doi.org/10.1038/s41598-019-55063-4

Sujetovienė, G., & Dabašinskas, G. (2023). Ecosystem service value changes in response to land use dynamics in Lithuania. *Land, 12*(12), Article 2151. https://doi.org/10.3390/land12122151

Sharip, Z., & Noor, A. G. A. (2021). Perception and willingness-to-pay on conservation of lake basin under the impact of climate change—A comparison between urban and rural tropical lake. *Malaysian Journal of Society and Space, 17*(3), 74–85. https://doi.org/10.17576/geo-2021-1703-04

Tan, Z., Guan, Q., Lin, J., Yang, L., Luo, H., Ma, Y., Tian, J., Wang, Q., & Wang, N. (2020). The response and simulation of ecosystem services value to land use/land cover in an oasis, Northwest China. *Ecological Indicators, 118*, Article 106711. https://doi.org/10.1016/j.ecolind.2020.106711

Wang, X., Yan, F., Zeng, Y., Chen, M., Su, F., & Cui, Y. (2021). Changes in ecosystems and ecosystem services in the Guangdong-Hong Kong-Macao Greater Bay Area since the reform and opening up in China. *Remote Sensing, 13*(9), Article 1611. https://doi.org/10.3390/rs13091611

Wei, R., Fan, Y., Wu, H., Zheng, K., Fan, J., Liu, Z., Xuan, J., & Zhou, J. (2024). The value of ecosystem services in arid and semi-arid regions: A multi-scenario analysis of land use simulation in the Kashgar region of Xinjiang. *Ecological Modelling, 488*, Article 110579. https://doi.org/10.1016/j.ecolmodel.2023.110579

Willis, C. (2015). The contribution of cultural ecosystem services to understanding the tourism–nature–wellbeing nexus. *Journal of Outdoor Recreation and Tourism, 10*, 26–32. https://doi.org/10.1016/j.jort.2015.06.002

Wu, C., Chen, B., Huang, X., & Wei, Y. H. D. (2020). Effect of land-use change and optimization on the ecosystem service values of Jiangsu province, China. *Ecological Indicators, 117*, Article 106507. https://doi.org/10.1016/j.ecolind.2020.106507

Wu, X., Bu, X., Dong, S., Yan, M., Ma, Y., Ma, Y., Liu, Y., Wang, H., Wang, X., & Wang, J. (2023). The impact of restoration and protection based on sustainable development goals on urban wetland health: A case of Yinchuan Plain urban wetland ecosystem, Ningxia, China. *Sustainability, 15*(16), Article 12287. https://doi.org/10.3390/su151612287

Yadav, R., Chand, T., & Nautiyal, R. (2021). Valuation of water purification service of Renuka wetland, India: A Ramsar site. *Glasnik Šumarskog Fakulteta, 42*(2), 219–226. https://doi.org/10.2298/GSF2123219Y

Yang, L., Zhang, Z., Zhang, W., Zhang, T., Meng, H., Yan, H., Shen, Y., Li, Z., & Ma, X. (2023). Wetland Park planning and management based on the valuation of ecosystem services: A case study of the Tieling Lotus Lake National Wetland Park (LLNWP), China. *International Journal of Environmental Research and Public Health, 20*(4), Article 2939. https://doi.org/10.3390/ijerph20042939

Yang, Q., Hu, P., Wang, J., Zeng, Q., Zhan, Y., Liu, H., & Dong, Y. (2020). *An evaluation and regulation method for stereoscopic spatial connectivity of a wetland system based on hydrological change: A case study of the Heilongjiang River Basin in China* [Preprint]. Authorea. https://doi.org/10.22541/au.158981140.09782982

Yin, C., He, Q., Xie, P., Liu, Y., Zhang, Y., Chen, W., & Bi, Q. (2023). Spatiotemporal variation of the ecosystem service value in China based on surface area. *Ecological Indicators, 148*, Article 110067. https://doi.org/10.1016/j.ecolind.2023.110067

Yosef, R., Rakholia, S., Mehta, A., Bhatt, A., & Kumbhojkar, S. (2022). Land surface temperature regulation ecosystem service: A case study of Jaipur, India, and the urban island of Jhalana Reserve Forest. *Forests, 13*(7), Article 1101. https://doi.org/10.3390/f13071101

Yun, J., Liu, H., Xu, Z., Cao, X., Ma, L., Wen, L., Zhuo, Y., & Wang, L. (2022). Assessing changes in the landscape pattern of wetlands and its impact on the value of wetland ecosystem services in the Yellow River Basin, Inner Mongolia. *Sustainability, 14*(10), Article 6328. https://doi.org/10.3390/su14106328

Zairul, M., Azli, M., & Azlan, A. (2023). Defying tradition or maintaining the status quo? Moving towards a new hybrid architecture studio education to support blended learning post-COVID-19. *Archnet-IJAR: International Journal of Architectural Research, 17*(3), 554–573. https://doi.org/10.1108/ARCH-11-2022-0251

Zuo, Z., Yang, Y., Wang, R., Li, J., & Zhang, P. (2023). Analysis of the gains and losses of ecosystem service value under land use change and zoning in Qiqihar. *Frontiers in Ecology and Evolution, 11*, Article 1192952. https://doi.org/10.3389/fevo.2023.1192952