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SPATIAL QUANTIFICATION AND ECONOMIC VALUATION OF RECREATIONAL ECOSYSTEM SERVICES IN IRAN'S ZAGROS MOUNTAINS: A SUB-WATERSHED ANALYSIS USING THE RECREATION OPPORTUNITY SPECTRUM (ROS) FRAMEWORK

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Abstract. Recreational Ecosystem Services (RES) deliver critical non-material benefits, yet their spatially explicit valuation remains underexplored in the data-limited, mountainous landscapes of the Middle East. This study addresses this gap by presenting the first sub-watershed-level quantification and economic valuation of RES across the 20 hydrological sub-units of Chaharmahal-Bakhtiari Province, Iran a core part of the biodiverse central Zagros Mountains. We operationalize the Recreation Opportunity Spectrum (ROS) framework by integrating biophysical supply indicators (naturalness, protected area status, and hydrological attraction) with accessibility metrics (distance to settlements and roads) to derive a continuous Recreational Supply Index (RSI). Economic valuation was conducted via benefit transfer, using an inflation-adjusted (2011→2024, CPI-based) willingness-to-pay value from Zagros forests). The total annual RES value for the province is estimated at IRR 113.86 trillion (≈ USD 268 million at the 2024 official market exchange rate of IRR 425,000/USD), with a mean per-hectare value of IRR 69.39 million. Hotspots (sub-watersheds 5, 6, and 20) coincide with intact Quercus brantii forests and moderate-to-high remoteness, whereas eastern sub-watersheds show degraded recreational capacity due to agricultural expansion and urban encroachment. Our findings demonstrate that conserving Zagros woodlands concurrently sustains biodiversity, hydrological function, and cultural services providing a robust, transferable methodology for ecosystem accounting and spatial planning in socio-ecologically comparable regions.

Keywords: cultural ecosystem services, recreational, economic valuation, ROS- benefit transfer.

1. Introduction

Cultural Ecosystem Services (CES), as one of the four principal categories of ecosystem services defined under the Millennium Ecosystem Assessment (2005), represent the intangible and non-material benefits that humans derive from their interactions with nature. These services encompass experiences such as recreational enjoyment, cognitive enrichment, spiritual fulfilment, place identity, and a sense of belonging to the environment (Li et al., 2025). Among CES, the Recreational Ecosystem Service has received particular attention in ecological literature and environmental planning due to its direct role in enhancing physical and mental health (Baró et al., 2016), as well as its relatively higher potential for quantification and valuation compared to other cultural services (Cheng et al., 2019; Yang & Cao, 2022). Nevertheless, the assessment of recreational services has consistently faced conceptual and methodological challenges. On the one hand, the intangible, non-material, and context-dependent nature of these services makes their direct measurement difficult (Adhikary et al., 2025). On the other hand, recreation is influenced by multidimensional factors including environmental quality (degree of naturalness), physical accessibility (distance from population centers and transportation networks), and policy frameworks (such as the protection status of areas) which necessitate an integrated, multi-indicator approach (Small et al.,

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2017). In this regard, the Recreation Opportunity Spectrum (ROS) model has emerged as a standard framework in sustainable recreation planning. By integrating two key dimensions recreational potential and remoteness/accessibility ROS enables the classification of areas according to their capacity to provide recreational opportunities (Sun & Li, 2017). This framework has been widely applied in global literature to evaluate recreational ecosystem services in natural and semi-natural landscapes (Sun et al., 2018; Vallecillo et al., 2019), yet its application in Iran particularly within the mountainous watersheds of the Zagros region remains limited. While several studies have mapped cultural ecosystem services in Iran – such as those by Khosravi Mashizi and Sharafatmandrad (2023) or Mohammadyari et al. (2023a, b) on urban CES most rely on Land-Use/Land-Cover (LULC) proxies that implicitly equate forest/rangeland with recreation value, ignoring spatial demand, accessibility, and perceived naturalness. Moreover, these assessments operate at coarse administrative scales (e.g., county level), lacking hydrological relevance and sub-watershed granularity essential for integrated watershed management. Crucially, none integrate a structured recreation framework like ROS, which explicitly balances supply-side natural attributes with demand-side access constraints – a gap that limits their utility for spatial planning and PES design.

Chaharmahal-Bakhtiari Province, encompassing a significant portion of the forest and rangeland ecosystems of the central Zagros, constitutes one of the major recreational and eco-tourism potentials in western Iran. However, developmental pressures, land-use changes, and degradation of natural assets have, at times irreversibly, undermined the capacity of these ecosystems to provide recreational services (Mohammadyari et al., 2023a, b). Consequently, the spatial quantification and economic valuation of recreational services at the sub-watershed level of this province are essential not only as a diagnostic tool for understanding the baseline status of ecosystem services, but also as a foundation for targeted decision-making in environmental planning, sustainable land management, and the promotion of sustainable tourism. Building upon these considerations, the objective of this study is to quantify recreational services across 20 sub-watersheds of Chaharmahal-Bakhtiari Province using the ROS framework, and subsequently to estimate their economic value through the Benefit Transfer method.

To our knowledge, no prior study in Iran has applied the full ROS framework at the sub-watershed scale, particularly with economic monetization rooted in local valuation studies. This research bridges that gap. This research seeks to address the following key questions:

1. What is the spatial distribution of recreational potential across the province's sub-watersheds?

2. Which sub-watersheds can be identified as "hotspots of recreational service provision"?

3. What is the estimated annual economic value of this service at the regional scale?

The findings of this study are expected to contribute significantly to the development of regional ecosystem accounts, as well as to the design of compensatory and incentive-based policies for the conservation of natural ecosystems within the framework of provincial sustainable development programs.

2. Materials and methods

2.1. Study area

Chaharmahal-Bakhtiari Province (31°10′–32°47′ N, 49°44′–51°20′ E), covering approximately 1.64 million hectares, lies within the central Zagros Mountain range in western Iran. The province features a heterogeneous mosaic of temperate oak-dominated forests (Quercus brantii), semi-arid rangelands, seasonal rivers (notably the Karun River headwaters), and scattered rural settlements. This region constitutes a critical ecological and hydrological zone for southwestern Iran and supports diverse cultural landscapes shaped by centuries of pastoral and agro-pastoral land use. Its natural assets have long served as a backbone for both local livelihoods and recreational activities from seasonal nomadic migration corridors to highland ecotourism destinations (e.g., Koohrang, Shahr-e Kord highlands). However, recent trends in urban expansion, overgrazing, and infrastructural development have introduced increasing pressure on ecosystem integrity rendering fine-scale assessment of recreational ecosystem services both timely and essential.

2.2. The Recreation Opportunity Spectrum (ROS) framework

The ROS framework, originally developed for U.S. federal land management (Clark & Stankey, 1979) and later formalized for ecosystem service assessment (Sun & Li, 2017), operationalizes recreational capacity as the interaction between supply-side environmental attributes and demand-side accessibility. In this study, ROS was operationalized through two composite indices:

1. *Recreational Potential Index* (*RPI*). RPI synthesizes three biophysical determinants of recreation supply:

- Degree of naturalness, quantified using the homogeneity-heterogeneity index (HHI) approach (Früh-Müller et al., 2016), wherein land-cover classes (derived from 10-m Sentinel-2 imagery and validated by field surveys) were assigned naturalness weights (e.g., primary forest = 1.0, cropland = 0.2, urban = 0.0) following González-García et al. (2020).
- Protected area status, mapped using IUCN categories (Ia–VI) and overlaid with nationally designated protected zones (e.g., national parks, wildlife refuges) from the Iranian Department of Environment GIS database (Vallecillo et al., 2019). Protection level was encoded as a binary-ordinal variable (e.g., strict protection = 1.0; multiple-use = 0.6; unprotected = 0.0).

- Hydrological attraction, computed as a decay-weighted proximity to perennial rivers and permanent water bodies via Euclidean buffering (buffer decay kernel: $1/d^2$), reflecting empirical evidence that water features significantly enhance recreational appeal (Yang & Cao, 2022).

These three normalized layers were integrated through Weighted Linear Combination (WLC), with equal weights assigned (sensitivity analysis confirmed robustness under ±0.2 weight perturbations). The resulting RPI was rescaled to [0, 1], where 1 denotes maximum recreational potential.

2. Remoteness/Accessibility Index (*RAI*). RAI captures the cost of access a key modulator of realized recreation demand. It was derived from two distance-based layers:

- Euclidean distance to the nearest urban/rural settlement center (population >1,000),
- Euclidean distance to the nearest paved or unpaved road (from national transport datasets).

2.3. ROS classification and spatial aggregation

Both layers were normalized inversely (i.e., greater distance → higher remoteness) and combined multiplicatively to penalize joint isolation (Sun et al., 2018). The final RAI spans [1, 5], corresponding to five accessibility classes: proximate, adjacent, semi-remote, remote, and very remote (Table 1).

Following Sun and Li (2017), the ROS map was constructed by intersecting the 3-tiered RPI classes (low: ≤0.25; medium: 0.25–0.75; high: >0.75) with the 5-tiered RAI classes, yielding a 3 × 5 classification matrix (Table 1). Each ROS cell was then assigned a final Recreation Opportunity Score (ROS-Score) from 1 (lowest opportunity: low supply, easy access) to 9 (highest opportunity: high supply, difficult access) a counterintuitive but well-documented convention, wherein the highest-quality wilderness experiences often occur in inaccessible, highly natural settings (e.g., backcountry trekking), while mass recreation clusters in accessible but moderately natural areas (e.g., picnic parks).

Table 1. Recreation Opportunity Spectrum (ROS) classification matrix: Integration of Recreational Potential Index (RPI) and Remoteness/Accessibility Index (RAI) to define nine opportunity classes (1–9)

RAI Class	Accessibility Level	RPI Class		
		Low (≤0.25)	Medium (0.25–0.75)	High (>0.75)
1	Proximate	1	4	7
2	Adjacent	2	5	8
3	Semi-remote	3	6	6
4	Remote	3	6	9
5	Very remote	3	6	9

To facilitate economic valuation, the ROS-Score was linearly re-scaled to a continuous Recreational Supply Index (RSI) ranging from 0 to 1, where value 1 corresponds to ROS-Score = 9 (i.e., high naturalness + high remoteness = premium nature-based recreation), and value 0 to ROS-Score = 1.

2.4. Economic valuation via benefit transfer

Monetary valuation was performed using the Value Transfer Method (VTM), a well-accepted technique in non-market valuation when primary data (e.g., from Contingent Valuation or Travel Cost studies) are unavailable (Brander, 2013). The baseline value was sourced from Moradi et al. (2011), who estimated the mean annual per-hectare Willingness-To-Pay (WTP) for recreational services in Zagros forests at IRR 58,450,000 (2011 prices). This figure was inflated to 2024 prices using the official Consumer Price Index (CPI) series published by the Statistical Center of Iran (average annual inflation rate: 24.7% over 2011–2024), yielding a baseline value of IRR 134,407,668 ha^{-1} yr^{-1}.

This unit value was spatially allocated across the study area by multiplying the inflation-adjusted unit value by the RSI at each 30-m grid cell:

$$V_{rec}\left(x,y\right)=RSI\left(x,y\right)\times Unit\ Value, \tag{1}$$

where, $V_{rec}\left(x,y\right)$ is the economic value of recreation (IRR ha^{-1} yr^{-1}) at location $\left(x,y\right)$. Zonal statistics were then applied to aggregate values to the 20 sub-watershed boundaries (defined by the National Watershed Management Organization), yielding total and per-hectare economic estimates for each unit.

The economic value of recreational ecosystem services at each 30-m pixel is determined by multiplying the Recreational Supply Index (RSI) by the inflation-adjusted baseline willingness-to-pay value of IRR 134,407,668 per hectare per year, derived from Moradi et al. (2011). For each sub-watershed, the total economic value is obtained by summing these pixel-level values across all pixels within the sub-watershed boundaries, accounting for the fixed pixel area of 0.09 hectares at 30-m resolution. The mean unit value per sub-watershed is then calculated by dividing the total economic value by the sub-watershed's total area, providing per-hectare estimates consistent with the study's results in Table 2.

3. Results

The spatial integration of RPI and RAI (Figures 1–2) yielded a province-wide ROS classification (Figure 3), revealing a distinct east-west gradient in recreational opportunity: higher RPI values concentrated in the forested highlands of the western and central Zagros (e.g., Koohrang, Lordegan districts), whereas low RPI prevailed in eastern plains dominated by agriculture and rangeland degradation. Conversely, RAI exhibited a

Table 2. Sub-watershed-level valuation of recreational ecosystem services in Chaharmahal and Bakhtiari Province: Area, mean recreational supply, and economic value (IRR/yr and IRR/ha/yr))

Sub-watershed ID	Area (ha)	Mean Recreational Supply Index (RSI)	Total Economic Value (IRR/yr)	Unit Economic Value (IRR/ha/yr)
1	72,375.55	0.58	5.64×10^{12}	7.80×10^{7}
2	53,225.56	0.49	3.52×10^{12}	6.61×10^{7}
3	108,258.17	0.53	7.77×10^{12}	7.18×10^{7}
4	51,837.50	0.47	3.24×10^{12}	6.25×10^{7}
5	267,307.30	0.58	2.08×10^{13}	7.77×10^{7}
6	53,169.26	0.60	4.34×10^{12}	8.17×10^{7}
7	88,059.51	0.47	5.54×10^{12}	6.29×10^{7}
8	91,485.76	0.56	6.84×10^{12}	7.48×10^{7}
9	59,935.15	0.53	4.26×10^{12}	7.11×10^{7}
10	127,789.18	0.53	9.09×10^{12}	7.11×10^{7}
11	94,679.80	0.46	5.86×10^{12}	6.18×10^{7}
12	42,943.30	0.46	2.67×10^{12}	6.22×10^{7}
13	124,254.84	0.44	7.43×10^{12}	5.98×10^{7}
14	39,688.34	0.48	2.58×10^{12}	6.50×10^{7}
15	24,062.23	0.47	1.52×10^{12}	6.33×10^{7}
16	72,774.68	0.46	4.56×10^{12}	6.26×10^{7}
17	64,869.42	0.45	3.89×10^{12}	6.00×10^{7}
18	31,485.24	0.48	2.05×10^{12}	6.51×10^{7}
19	104,637.55	0.47	6.61×10^{12}	6.32×10^{7}
20	68,185.81	0.62	5.67×10^{12}	8.32×10^{7}
Total	1,641,024.24		1.14×10^{14}	6.94×10^{7}

radial pattern lowest (i.e., most accessible) near urban centers (e.g., Shahr-e Kord, Borujen), increasing toward peripheral mountainous zones.

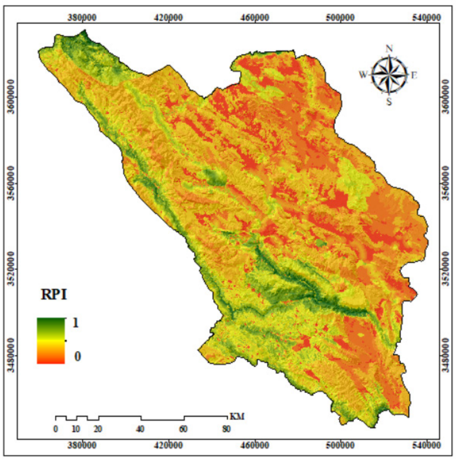

Figure 1. Spatial distribution of the RPI across sub-watersheds of Chaharmahal-Bakhtiari Province, Iran. RPI integrates naturalness, protected area status, and proximity to water bodies

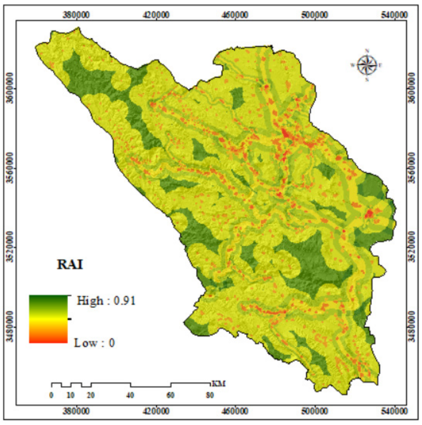

Figure 2. Spatial distribution of the RAI across sub-watersheds of Chaharmahal-Bakhtiari Province, Iran. RAI reflects distance-based accessibility to settlements and road networks

The RSI map (standardized ROS output) served as the spatial basis for valuation. Table 2 reports sub-watershed-level results:

- Sub-watershed 20 registered the highest mean RSI (0.62), attributed to its extensive coverage by relatively intact Quercus brantii forests and moderate remoteness (RAI = 4: remote). It ranked second in total economic value (IRR 5.67×10^{12} yr^{-1}) due to intermediate area (68,186 ha).
- Sub-watershed 5, though slightly lower in mean RSI (0.58), delivered the highest total economic value (IRR 2.08×10^{13} yr^{-1}) a consequence of its vast area (267,307 ha) and high naturalness (dominated by protected rangelands and forest patches near Zardkuh).
- Sub-watersheds 6 (RSI = 0.60) and 1 (RSI = 0.58) also emerged as high-potential zones, collectively forming a contiguous "recreational corridor" in the central-western highlands.

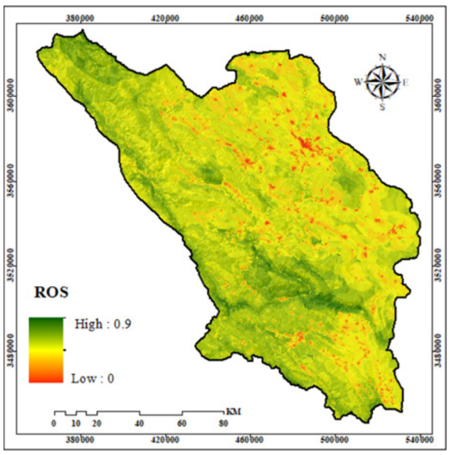

Figure 3. Spatial distribution of the ROS across sub-watersheds of Chaharmahal-Bakhtiari

– In contrast, Sub-watershed 13 showed the lowest mean RSI (0.44), reflecting extensive agricultural conversion, low tree cover, and proximity to urban sprawl indicators of anthropogenic landscape homogenization.
– Sub-watershed 15 had the lowest total economic value (IRR 1.52×10^{12} yr^{-1}), primarily due to its small size (24,062 ha), despite a moderate RSI (0.47).

At the provincial scale, the aggregate annual economic value of recreational services was estimated at IRR 113.86 trillion (≈ USD 268 million at market exchange rate), with a mean per-hectare value of IRR 69.39 million ha^{-1} yr^{-1}notably lower than the baseline unit value (IRR 134.41 million), reflecting the spatial average of sub-optimal RSI conditions across much of the province.

4. Discussion and conclusions

This study presents the first comprehensive, sub-watershed-scale application of the ROS framework for recreational ecosystem service assessment in the central Zagros, offering a methodologically replicable and policy-relevant approach for mountainous regions of the Middle East. Our results corroborate global findings that natural land covers particularly forests and semi-natural rangelands are the primary generators of recreational value (Sun et al., 2022; Mohammadyari et al., 2023a, b). The dominance of Sub-watersheds 5, 6, and 20 underscores the critical role of Quercus-dominated ecosystems not only in hydrological regulation and carbon sequestration but also in supporting nature-based recreation a co-benefit often overlooked in siloed conservation planning. Moreover, the inverse relationship observed between accessibility and perceived recreational quality (e.g., high RSI in remote zones) aligns with the psychological theory of "restorative environments" (Kaplan et al., 1989), wherein solitude and perceived naturalness significantly enhance restorative outcomes.

Importantly, low RSI values in eastern sub-watersheds (e.g., 13, 17, 12) serve as early-warning signals of ecosystem service degradation driven by cropland expansion and infrastructure development. These areas, while supporting provisioning services (e.g., food, fiber), exhibit trade-offs in cultural service provision a pattern consistent with land-use intensification gradients documented in Mediterranean and semi-arid regions (García-Nieto et al., 2018). Such trade-offs warrant explicit integration into provincial spatial planning instruments (e.g., the Chaharmahal-Bakhtiari Sustainable Development Strategy 2030), to avoid undervaluing cultural services in cost–benefit analyses of development projects.

The benefit transfer approach, though pragmatic, carries acknowledged limitations namely, context dependency and potential transfer errors (e.g., regional differences in income, cultural preferences, or substitution effects). While we mitigated this via CPI adjustment and landscape similarity (Zagros-wide baseline), future work should prioritize primary valuation (e.g., discrete choice experiments) for high-priority sub-watersheds to refine unit values.

In policy terms, the economic estimates produced here enable monetized ecosystem accounting a prerequisite for Payment for Ecosystem Services (PES) schemes, green infrastructure investment, and inclusion of natural capital in provincial GDP-adjusted metrics (e.g., Inclusive Wealth Index). For instance, the IRR 20.8 trillion value of Sub-watershed 5 could justify targeted conservation financing (e.g., eco-tourism concessions, forest stewardship contracts), while low-value, high-degradation zones may benefit from restoration incentives linked to CES recovery.

While benefit transfer enabled timely valuation, it assumes homogeneous preferences across the Zagros region – an assumption potentially violated by income disparities (e.g., urban vs. nomadic users) or cultural differences in recreation types (e.g., spiritual vs. recreational use). To reduce transfer error, we recommend future primary studies using discrete choice experiments (DCEs) in high-value sub-watersheds (e.g., 5, 6, 20), incorporating attributes such as trail quality, safety, and cultural heritage. Furthermore, dynamic land-use scenarios (e.g., climate-driven forest loss) were not modeled. Coupling ROS with Markov-CA or In VEST scenarios could project RES trajectories under climate and policy change – a critical next step for adaptive watershed management. In conclusion, this study demonstrates that integrating biophysical modelling (ROS) with economic valuation provides a robust, scalable framework for making the invisible visible translating ecological attributes into tangible metrics for decision-makers. Protecting Chaharmahal and Bakhtiari's natural heritage is not merely an environmental imperative; it is an investment in human well-being, regional resilience, and sustainable economic diversification.

References

Adhikary, M., Ghosh, D., Mandal, B., & Das, S. (2025). Estimating and mapping the value of cultural ecosystem services in an urban landscape context. *Applied Geography*, *177*, Article 103556. https://doi.org/10.1016/j.apgeog.2025.103556.

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

Brander, L. (2013). *Guidance manual on value transfer methods for ecosystem services*. UNEP. https://gwp.org/globalassets/global/toolbox/references/guidance-manual-on-value-transfer-methods-for-ecosystem-services-unep-2013.pdf

Cheng, X., Van Damme, S., Li, L., & Uyttenhove, P. (2019). Evaluation of cultural ecosystem services: A review of methods. *Ecosystem Services*, *37*, Article 100925. https://doi.org/10.1016/j.ecoser.2019.100925

Clark, R. N., & Stankey, G. H. (1979). *The recreation opportunity spectrum*: *A framework for planning*, *management*, *and research* (General Technical Report PNW-98). Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. https://www.umt.edu/media/leopold/pubs/58.pdf

Früh-Müller, A., Hotes, S., Breuer, L., Wolters, V., & Koellner, T. (2016). Regional patterns of ecosystem services in cultural landscapes. *Land*, *5*(2), Article 17. https://doi.org/10.3390/land5020017

García-Nieto, A. P., Geijzendorffer, I. R., Baró, F., Roche, P. K., Bondeau, A., & Cramer, W. (2018). Impacts of urbanization around Mediterranean cities: Changes in ecosystem service supply. *Ecological Indicators*, *91*, 589–606. https://doi.org/10.1016/j.ecolind.2018.03.082

González-García, A., Palomo, I., González, J. A., López, C. A., & Montes, C. (2020). Quantifying spatial supply-demand mismatches in ecosystem services provides insights for land-use planning. *Land Use Policy*, *94*, Article 104493. https://doi.org/10.1016/j.landusepol.2020.104493

Kaplan, R., Kaplan, S., & Brown, T. (1989). Environmental preference: A comparison of four domains of predictors. *Environment and Behavior*, *21*(5), 509–530. https://doi.org/10.1177/0013916589215001

Khosravi Mashizi, A., & Sharafatmandrad, M. (2023). Cultural services in arid landscapes. A comparative study based on people's perception, southeast of Iran. *Arid Land Research and Management*, *37*(4), 619–636. https://doi.org/10.1080/15324982.2023.2213671

Li, J., Yang, Z., Guo, J., Zhou, J., Wang, J., & He, K. (2025). Seasonal variation of cultural ecosystem services in urban blue-green spaces based on the SoLVES model and social media data. *Ecological Indicators*, *181*, Article 114393. https://doi.org/10.1016/j.ecolind.2025.114393

Millennium Ecosystem Assessment. (2005). *Ecosystems and human well-being*: *Current state and trends*. Island Press.

Mohammadyari, F., Zarandian, A., Mirsanjari, M. M., Suziedelyte Visockiene, J., & Tumeliene, E. (2023a). Modelling impact of urban expansion on ecosystem services: A scenario-based approach in a mixed natural/urbanised landscape. *Land*, *12*(2), Article 291. https://doi.org/10.3390/land12020291

Mohammadyari, F., Tavakoli, M., Zarandian, A., & Abdollahi, S. (2023b). Optimization land use based on multi-scenario simulation of ecosystem service for sustainable landscape planning in a mixed urban-Forest watershed. *Ecological Modelling*, *483*, Article 110440. https://doi.org/10.1016/j.ecolmodel.2023.110440

Moradi, M., Sadrolashrafi, S., Moghadasi, R., & Yazdani, S. (2011). Estimation of recreational value of Yasuj Forest Park using conditional valuation method. *Agricultural Economics Research*, *4*(4), 173–191.

Small, N., Munday, M., & Durance, I. (2017). The challenge of valuing ecosystem services that have no material benefits. *Global Environmental Change*, *44*, 57–67. https://doi.org/10.1016/j.gloenvcha.2017.03.005

Sun, X., Crittenden, J. C., Li, F., Lu, Z., & Dou, X. (2018). Urban expansion simulation and the spatio-temporal changes of ecosystem services, a case study in Atlanta Metropolitan area, USA. *Science of the Total Environment*, *622*, 974–987. https://doi.org/10.1016/j.scitotenv.2017.12.062

Sun, X., & Li, F. (2017). Spatiotemporal assessment and trade-offs of multiple ecosystem services based on land use changes in Zengcheng, China. *Science of the Total Environment*, *609*, 1569–1581. https://doi.org/10.1016/j.scitotenv.2017.07.221

Sun, Y., Liu, D., & Wang, P. (2022). Urban simulation incorporating coordination relationships of multiple ecosystem services. *Sustainable Cities and Society*, *76*, Article 103432. https://doi.org/10.1016/j.scs.2021.103432

Vallecillo, S., La Notte, A., Zulian, G., Ferrini, S., & Maes, J. (2019). Ecosystem services accounts: Valuing the actual flow of nature-based recreation from ecosystems to people. *Ecological Modelling*, *392*, 196–211. https://doi.org/10.1016/j.ecolmodel.2018.09.023

Yang, L., & Cao, K. (2022). Spatial matching and correlation between recreation service supply and demand in the Ili River Valley, China. *Applied Geography*, *148*, Article 102805. https://doi.org/10.1016/j.apgeog.2022.102805