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Urban lakes for sustainable cities: From ecology to environment, society, and economy

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As important natural features that deliver diverse ecosystem services including temperature regulation, water purification, and habitat provision, urban lakes are among the most revealing artefacts of contemporary urbanization. Once peripheral, they are now located within cities as waterfront amenities, leisure lakes, and neighborhood parks. This shift reflects not only changing urban form but also the human nature to seek out bodies of water for openness, reflection, and relief. It also highlights why urban lakes merit distinct attention: their enclosed and relatively still waters within urban

Figure 1. Conceptual framework of urban lakes (A) The definition of urban lakes encompasses natural water bodies, human settlement, and urban infrastructure. (B) Their importances in ecological, social, and economic dimensions. (C) Future directions could focus on cross-disciplinary research, integrate multi-source datasets, and employ advanced analytical tools.

spaces make them especially sensitive to human and environmental pressures. Yet their proliferation has outpaced our understanding. Across the world, cities continue to infill, dredge, and excavate waterbodies without a shared definition of what constitutes an "urban lake". In China, for instance, our ongoing research has identified 16,522 urban lakes, but global hydrological datasets still treat them indistinguishably from other waterbodies. Despite their growing importance,[1] urban lakes remain conceptually underdefined. This commentary addresses this gap by proposing an integrated framework that clarifies what constitutes an urban lake, synthesizes its ecological, social, and economic functions, and outlines future research directions for understanding them within rapidly urbanizing environments.

Part of the difficulty lies in how different disciplines approach urban lakes: limnology views them as ecosystems, hydrology as water systems, ecology as habitats, and urban planning as public spaces.[1-3] Such divided perspectives obscure their multidisciplinary nature and hinder the development of global and regional inventories, leaving urban lakes conceptually adrift between nature and city. An urban lake is best understood not as a static feature but as a node in the city's wider metabolism, understood as the circulation of energy, materials, organisms, and human activities through urban space (Figure 1). It is a reservoir of ecological resilience, a current of social interaction, a pool of cultural memory, and a tide of economic development. Defining what an urban lake is and what it does is therefore essential for integrating these blue spaces into the broader agendas of sustainable and inclusiveurbandevelopmentenvisionedinSustainableDevelopmentGoals6,11and15.

ECOLOGICAL IMPORTANCE: SUSTAINING THE URBAN ENVIRONMENT

Urban lakes vary widely in size. Some, such as Hangzhou's West Lake in China or Lake Geneva in Europe, have long shaped the morphology of their cities, while smaller neighborhood ponds are newly constructed during suburban development. These lakes moderate local temperatures and mitigate micro-scale urban heat island effects through daytime heat absorption and nighttime release; they store stormwater, reducing surface runoff and the risk of urban flooding; they filter suspended solids and pollutants, improving water quality; and they provide habitats for fish, birds, and aquatic vegetation, sustaining biodiversity (Figure 1).[2,3] Through these processes, urban lakes improve air quality, enhance thermal comfort, and contribute to well-being of local residents. They are not peripheral features of the city but important components of its environments.

The proximity that gives urban lakes ecological value also exposes them to intense human pressures. Continuous inflows of nutrients and contaminants from impervious surfaces lead to eutrophication and oxygen depletion; shoreline modification and sediment accumulation disturb natural hydrodynamics; and biological stress, from invasive species to the loss of littoral vegetation, reduces habitat complexity. Over time, these pressures weaken the lakes' capacity for self-regulation, leading to an imbalance between ecological provision and resilience. Preserving their ecological capacity demands integrated management of water, land, and waste, for the quality of urban lakes mirrors the equilibrium of urban environment.

SOCIAL IMPORTANCE: URBAN LAKES AS PUBLIC SPACE

Urban lakes also hold social significance. They support diverse physical activities, offering respite to morning runners, evening walkers, anglers, swimmers, and families seeking relief from the intensity of city life.[4] As public spaces with air, sunlight, and vegetation, they soften the rigidity of steel-and-concrete materials. A growing body of research indicates that proximity to them can reduce stress and promote psychological restoration. In many cities, lakes shape everyday routines by hosting festivals, open air markets, and informal gatherings, weaving water into the rhythms of urban life. Through these practices, lakes become anchors of urban identity and memory, strengthening social cohesion. Urban lakes thus translate ecological benefits into experiences of health, leisure, and belongingness (Figure 1).[1]

Realizing the social value of urban lakes depends largely on equitable access. Physical design, land use, and transport connectivity determine who can reach and enjoy these spaces. In many cities, lakes near central or high-income areas are well maintained and easily accessed, while those on the urban fringe remain fragmented by infrastructure, industry, or private boundaries. Such spatial disparities translate into unequal opportunities for recreation, rest, and contact with water. Governance and management further shape these outcomes: maintenance quality, safety measures, and the provision of public activities influence whether a lakefront remains welcoming or becomes neglected. Promoting openness and accessibility is therefore essential to sustain their role as inclusive public spaces.

ECONOMIC IMPORTANCE: BALANCING VALUE AND SUSTAINABILITY

Urban lakes also act as catalysts for economic development. By raising nearby property values, they influence investment patterns and support local industries that thrive on proximity to water (Figure 1). Waterfront views and surrounding amenities attract both commercial and residential development, while leisure economies, including boating, festivals, cafés, and cultural events, provide job opportunities and contribute to municipal revenue. Moreover, urban lakes deliver environmental services with economic benefits. Their capacity to moderate temperature, absorb runoff, and improve air and water quality reduces infrastructure and public health costs. These benefits are increasingly recognized in urban policy as long-term economic gains that strengthen resilience and efficiency.

The accumulation of economic value, however, introduces its own contradictions. As lakefronts become desirable, land speculation and privatization can restrict public access and disrupt ecological processes through excessive construction or the replacement of natural shorelines with artificial surfaces. Commercial redevelopment often treats the lake as a visual commodity, seeking short-term returns while undermining long-term sustainability. Balancing economic gain with social and ecological integrity therefore requires governance that recognizes their interdependence. The long-term economic value of an urban lake lies not in its ability to attract investment alone, but in sustaining the environmental quality and social vitality that make urban development itself possible.

CHALLENGES AND FUTURE DIRECTIONS

Growing attention to urban lakes has not yet produced a coherent research agenda, largely because data, methods, and disciplinary perspectives remain disconnected. The first challenge concerns data and typology. Existing inventories seldom distinguish between natural, modified, and artificial lakes. High-resolution surface water delineation is now highly reliable with modern remote sensing;[5] the remaining bottleneck lies in identifying urban lakes and classifying them. Progress depends on integrating multi-source spatial data, including built-up areas, infrastructure, human settlement, population density, mobility footprints, land use, and human-activity proxies (e.g., POIs). Reproducible pipelines should link satellite-derived water masks to explicit criteria of urban proximity, services, and functions. Beyond spatial datasets, artificial intelligence (AI) and large language models (LLM) offer new techniques for interpreting unstructured information, from planning documents and environmental reports to news archives and social media posts, that record how urban lakes are described, visited, perceived, and developed. Open, standardized datasets derived from these multiple sources, validated through field surveys and official records, would enable global and regional identification of urban lakes.

The second challenge is to strengthen cross-disciplinary work among ecology, environmental science, and social science. Bridging these fields requires multi-scalar frameworks that link biophysical processes with socioeconomic dynamics. For instance, temporal changes in water quality can be examined alongside visitation patterns and resident well-being, as improvements in water quality often reshape the frequency, duration and social composition of water contact. Such integration can be advanced through modelling, spatial econometrics, and machine-learning approaches that evaluate both ecological performance and social benefit. Studies combining environmental monitoring with survey or human-centered mobility data would further reveal how ecological improvement translates into social experience. Through the conceptual lens of social infrastructure, these approaches could link spatial and temporal patterns of human activity with the planning and design of inclusive blue spaces. Cross-disciplinary research must also confront the question of equity. Who gains access to clean, restorative, and aesthetically valued urban lakes, and who remains excluded? Integrating environmental justice, multidimensional equity, and social inclusion into ecological and spatial analysis is essential for advancing a human-centered understanding of sustainability agenda.

A third and equally important challenge is to move beyond identification toward mechanism analysis such as causal understanding. Most studies remain cross-sectional, capturing lakes at a single moment, even though the interactions between hydrological change and urban growth evolve continuously. Future research should employ longitudinal and causal-inference designs that combine time-series remote sensing, climate reanalysis, and urbanization data to trace interaction among environmental, ecological, and social processes. Comparative research across climatic zones and governance regimes could then identify both general and context-specific mechanisms, offering insight into the processes that drive urban lake transformation over time.

REFERENCES

1. Shi R., Peng X., Cui Y., et al. (2025). Dynamic exposure to urban lakefront spaces: Unveiling the role of social infrastructure in shaping visitation. *Landsc. Urban Plan.* **264**:105465. DOI:10.1016/j.landurbplan.2025.105465
2. Woolway R. I., Kraemer B. M., Lenters J. D., et al. (2020). Global lake responses to climate change. *Nat. Rev. Earth Environ.* **1**:388–403. DOI:10.1038/s43017-020-0067-5
3. Su H., Li Y., Zhong M., et al. (2024). No positive effects of biodiversity on ecological resilience of lake ecosystems. *Innov. Geosci.* **2**:100064. DOI:10.59717/j.xinn-geo.2024.100064
4. Zhang H., Nijhuis S., Newton C., et al. (2024). Healthy urban blue space design: Exploring the associations of blue space quality with recreational running and cycling using crowdsourced data. *Sustain. Cities Soc.* **117**:105929. DOI:10.1016/j.scs.2024.105929
5. Li L., Long D., Wang Y., et al. (2025). Global dominance of seasonality in shaping lake-surface-extent dynamics. *Nature* **642**:361–368. DOI:10.1038/s41586-025-09046-3

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AUTHOR CONTRIBUTIONS

All authors contributed to the manuscript and approved the final version.

DECLARATION OF INTERESTS

The authors declare no competing interests.