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Persistent inequities in global lake science

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Global lake research is skewed toward economically and socially developed regions, overlooking remote areas. Enhancing resilience and fostering synergistic approaches could help redress these inequities.

Despite only covering 1.8% of Earth's land surface, inland lakes store ~90% of the planet's surface freshwater, sustaining over 35% of the global population[1,2] and contributing to ~70% of the UN 2030 Sustainable Development Goal (SDG) targets. However, lakes are increasingly under threaten owing to climate change and other drivers. Together these factors contribute to surface shrinkage, nutrient enrichment, harmful algal blooms, and broad ecological degradation[3–6]. Growing demand for lacustrine ecosystem services, coupled with escalating natural and anthropogenic pressures, underscores the urgent need for targeted lake research and management. Yet which lakes should be prioritized remains unclear. Historically, limnological research has focused on lakes in economically developed regions, where perceived human utility is high. However, lakes in marginalized or low-income regions — often of unrecognized value for biodiversity, ecosystem resilience, and conservation — remain severely underrepresented in global research efforts.

Drivers of global research bias

There is an evident bias in research effort (a combination of the number of publications and citations for a given lake) in the 2,542 lakes covered across 58,024 peer-reviewed publications (1900–2020). The 74-fold exponential increase in global lake research since 1980 has been uneven (Fig. 1a), and the distribution of long-term lake records with a high research effort (termed well-studied lakes; details in Supplementary Information 1) has persistently remained skewed (Supplementary Fig. 1). In 1980, only 10 lakes met this criterion, with over half located in North America. By 2020, ~400 lakes met the criterion but were still mostly located in North America and Europe, with only 28% of them in other regions (Supplementary Fig. 2).

At the continental scale, North American lakes accounted for 50% of global research efforts in 2020, followed by Asian (21%) and European (16%) lakes. However, these lakes are not representative of global averages of lake area, depth, latitude, and temperature (Supplementary Fig. 3), with larger and deeper lakes in warm, wet basins being disproportionately represented. By contrast, small, shallow, or iced lakes are heavily under-represented and under-researched, likely leading to biased representation of global lake characteristics. These biases highlight the need to broaden the scope of limnological research to cover more lakes that represent the actual morphological and climatological diversity of global lakes.

Economic context is a dominant driver of these research biases. Per capita GDP, not population, most strongly influenced research effort, suggesting that a large proportion of the global population might receive little benefit from locally relevant lake research. However, beyond a per capita GDP of US $40,738 in constant 2005 prices, research effort declined (Supplementary Fig. 4).

Local environmental pressures also shaped research priorities. The Inequity Coefficient (IC) and Low Effort Coefficient (LEC) (definitions and details in Supplementary Information 1) were applied to explore the temporal and spatial patterns of global lake research across different research topics. A high IC for a given topic indicates high inequity within the specific lakes and a high LEC for a given topic indicates a high research bias between the specific lake and global lakes. The IC decreased from 0.99 to 0.92 between 1980 and 2020 (Fig. 1b), indicating a slight broadening of coverage but persistent structural bias. Topic-specific IC values varied, with all decreasing since 1980; among these, emergent topics (for example, emerging pollutants) decreased most slowly, emphasizing the higher research bias in emergent topics than that in traditional topics. Furthermore, LEC values in developing regions were markedly higher than those in developed regions (Fig. 1c), indicating a much higher research bias in topics like chemical processes, emerging pollutants, algae, and plants in developing regions.

Projected drivers under climate change

Projections of changes in the drivers of research effort under scenarios for 2030 and 2050 indicate that rapid economic growth in Asian and African countries could narrow global research gaps by 2050 (Fig. 1d). The influence of per capita GDP is expected to increase substantially, particularly in developing regions, implying a gradual shift of research attention towards less-developed regions. However, inequity is likely to persist. The IC is projected to remain high at 0.88 ± 0.02 in 2050 (−4.4% compared to 2020).

Addressing inequities in lake research

Although thematic gaps might narrow by 2050, notable bias is expected to persist. Substantial endeavours are needed to address bias within limnological research. Expanding research in developing regions will require targeted policy and funding mechanisms to incentivize global scientific engagement.

A global initiative (GlObal Ambition for Lakes, GOAL) with region-specific objectives (Supplementary Table 1) could help global lake research achieve resilience, equity, synergism and tradeoff (REST).

Resilience refers to keeping lakes within safe planetary boundaries by addressing the dual influences of anthropogenic pressures and climate change in developed regions. For example, early warning systems to monitor lakes and help communities adapt before ecosystems collapse should be established.

Equity in access to lake ecosystem services would promote healthy lives and human well-being in remote regions, through funding local researchers and providing equipment to gain site-specific knowledge and improve diverse outcomes.

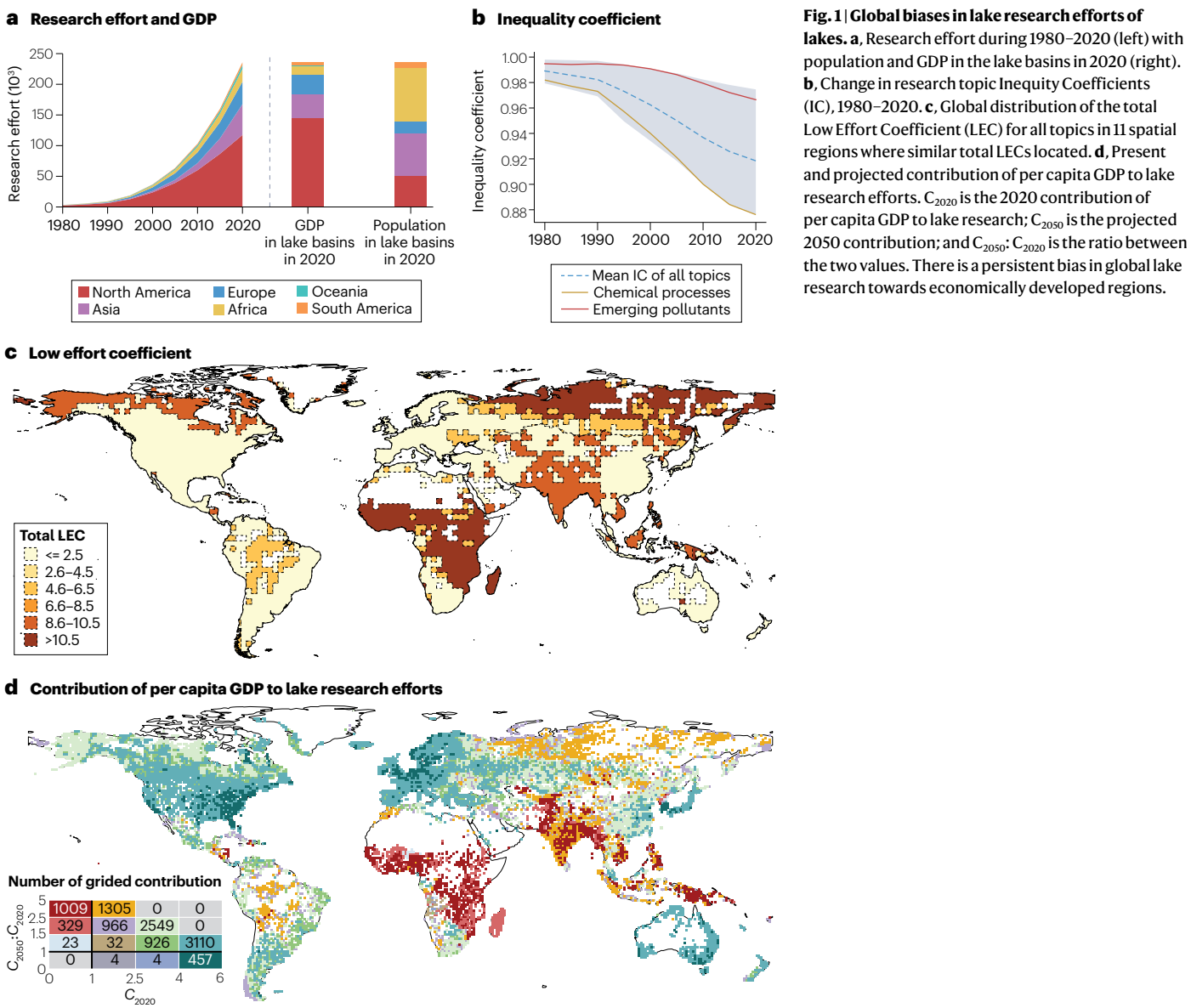

Fig. 1 | Global biases in lake research efforts of lakes. a, Research effort during 1980–2020 (left) with population and GDP in the lake basins in 2020 (right). **b**, Change in research topic Inequity Coefficients (IC), 1980–2020. **c**, Global distribution of the total Low Effort Coefficient (LEC) for all topics in 11 spatial regions where similar total LECs located. **d**, Present and projected contribution of per capita GDP to lake research efforts. C_{2020} is the 2020 contribution of per capita GDP to lake research; C_{2050} is the projected 2050 contribution; and C_{2050}: C_{2020} is the ratio between the two values. There is a persistent bias in global lake research towards economically developed regions.

Synergism with interdisciplinary perspectives would provide better understanding of the nature–society–economy complexity in developing regions[7]. Bringing together ecologists, economists, limnologists, and indigenous knowledge holders could holistically solve lake problems. For example, multi-centre, interdisciplinary platforms that integrate scientific monitoring with assessing community needs could advance solutions to harmonize ecosystem conservation and local livelihoods.

Finally, considering the tradeoffs between nature-positive and people-positive conservation in impoverished regions would support sustainable development in communities dependent on lakes for drinking water and food, and ensure ecological health[8]. For example, this could be achieved through restoring wetlands, establishing buffer zones, and implementing decentralized water treatment systems (Supplementary Fig. 5). Based on these actions, GOAL would shift resources toward underrepresented regions. The outcome would be a more complete understanding of global lakes, with research benefits reaching all regions that depend on these vital freshwater resources.

Overall, global lake research remains constrained by persistent socioeconomic and geographic biases, with economic context emerging as the dominant driver of inequity. To achieve the goals of resilience, equity, synergism, and tradeoff, international and multi-disciplinary cooperation is essential to support equitable data collection and research collaboration, and to enhance representation of lakes in developing and remote regions.

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Competing interests

The authors declare no competing interests.

Additional information

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