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Editorial: Drivers of mangrove forest change and its effects on biodiversity and ecosystem services

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Editorial on the Research Topic
Drivers of mangrove forest change and its effects on biodiversity and ecosystem services

Mangroves occupy a global area of 137,600 km^2, roughly the same area as Greece (Bunting et al., 2018). They are one of the most threatened ecosystems on Earth predominantly due to human impacts that have caused over 62% of mangrove loss (Goldberg et al., 2020). Their loss contributed 0.6% of global greenhouse gas emissions related to tropical forest deforestation, despite occupying <0.1% of all land area (Harris et al., 2021). Even with a small footprint, over 200 million people live within 10 kilometers of mangrove forests (Menéndez et al., 2020; Hooijer and Vernimmen, 2021). Mangroves are directly protecting 3.5 million people from the impacts of climate change, including storm surges, flooding, sea-level rise, and erosion (Blankespoor et al., 2017). In addition, mangroves provide habitat to immense coastal and marine biodiversity, offer food and jobs to local communities, and sustain cultural practices and identity. Conservation efforts globally are on the rise, with around 42% of all remaining mangroves being found within protected areas (Spalding and Leal, 2021). However, they may still experience loss related to natural causes and inadequate management (Spalding and Leal, 2021). While this progress spells hope, examples of integrating mangroves into coastal management and policy are still rare. This Research Topic contains a collection of studies (including global assessments, deep dives into issues in eight countries and an author group representing 16 countries), that provide an improved understanding of biophysical, socio-economic, and political drivers of mangrove forest change and their impacts on the provision of ecosystem services. It aims to provide a robust scientific evaluation of the links between enabling conditions—both positive and negative—and conservation and restoration impacts. Thus, identifying successful strategies and sociopolitical drivers that guide cost-effective mangrove conservation and restoration efforts.

When considering management strategies, the saying goes, "you cannot manage what you cannot measure." To that end, many papers in this topic focused on refining mangrove monitoring and carbon pool measurements for informing policy, including carbon and sediment dynamics crucial for assessing climate mitigation potential. For example, Cinco-Castro et al. studied sediment accumulation rates in the Yucatan Peninsula in Mexico. They found high variation in sedimentation rates seasonally and across a salinity gradient. Additionally, a global-scale database compiled from a literature review by Mugi et al. further highlights the importance of mangrove's dead organic matter carbon pool.

A study by Castellanos-Galindo et al. compares multiple assessment approaches where they evaluated mangrove forest structure derived from direct measurement, drone imagery, and satellite-based radar data in a Colombian mangrove. It weighs the efficiency and effectiveness of assessment approaches against the required costs, time, and logistics to produce reliable data. In addition, a national-scale database of Colombian mangrove forest structure provides biophysical information and sets baselines to assess the impacts of changes on ecosystem dynamics (Blanco-Libreros et al.). In Brazil, work by Rovai et al. highlights the importance of mangroves as blue carbon hotspots of global significance. They provide an integrated carbon inventory for Brazil and find the country holds about 8.5% of global mangrove carbon stocks with 15–30% above average carbon sequestration rates—highlighting the importance of protecting mangroves in Brazil. Unfortunately, a second study by Lacerda et al. documents the long-term environmental impacts on mangroves from semi-arid coastal ecosystems, such as salt pan areas and mangrove conversion to aquaculture ponds for shrimp farming. They found that these practices drove direct mangrove loss and lowered productivity, functionality, and services provided by adjacent mangroves and related habitats. Given the increasing demand for aquaculture products, solutions to maintain productivity without expanding production area are crucial.

The effects of land-use changes, such as conversion to aquaculture, on mangrove cover and carbon stocks are well documented (Sasmito et al., 2019; Goldberg et al., 2020). However, the impacts of forestry are less well defined. A study from the Niger Delta in West Africa confirms that wood exploitation in mangrove forests where larger stems are preferentially removed promotes colonization of invasive species like Nypa palm (*Nypa fruticans*) (Nwobi and Williams). These findings emphasize the importance of considering impacts across biophysical characteristics when estimating climate mitigation potential and show that detailed tracking of land-use activities and methods is essential to support national commitments for climate action.

Mangroves' role in climate mitigation has also translated into carbon finance opportunities. Ensuring durable and well-financed outcomes from mangrove conservation and restoration projects is a significant theme for three studies in this Research Topic. Firstly, Pham et al. considers the role of financial incentives in mangrove conservation in Vietnam. They find that contradictory policies, inequitable distribution of power and benefits, and low value of incentives all lead to low levels of compliance. They conclude that while financial incentives can play a role in mangrove conservation, addressing conflicting policies, targets, and governance issues are essential. Secondly, Gatt et al. presents a holistic monitoring framework of key mangrove restoration indicators. Based on >120 restoration reports, they find that studies commonly report on the intervention used and the ecological outcomes, but site conditions before restoration and social and governance outcomes were often missing. Finally, Duncan et al. provides a detailed breakdown of potential return on investment from mangrove restoration and rehabilitation work in the Philippines. They compared natural regeneration vs. assisted natural regeneration—urging caution, as neither approach was highly profitable based on current voluntary market carbon prices.

While addressing governance issues and enabling conditions will be more impactful than focusing only on finance mechanisms—where much of the attention is currently (Pham et al.), competing government agendas challenge mangrove management. For example, Panama's national policy documents recognize mangroves, but economic development is often prioritized over wetland conservation because of a perceived higher return on investment from coastal zone development (Chamberland-Fontaine et al.). The result is conflicting policy objectives, inadequate resources, and institutional structures that struggle to include local communities and stimulate action on the ground (Chamberland-Fontaine et al.). Even when communities are enaged, Chamberland-Fontaine et al. found that often it was the richer and more powerful community members that were engaged, creating a power embalance and a need for a more participatory approach. Further, Scemama et al. demonstrated that different coastal communities in French Guiana provided different perceptions on how they valued mangrove ecosystem services and threats and thus, improved national mangrove management policy should recognize subnational stakeholders.

Actions must be taken now to ensure that mangroves will persist into the future. Government agencies should align and build mangrove management into national conservation, monitoring and climate plans that maximize benefits while allowing local access. Decision-making power should shift to multi-party institutions that allow local communities to lead and promote a collaborative approach to mangrove management.

The private sector should look beyond climate neutrality pledges and expand their investments in these ecosystems as natural coastal defenses for disaster risk reduction, for example to protect supply chains or critical coastal assets. Environmental researchers, policy makers, and practitioners need to do more to build capacity and share knowledge globally. Finally, the public must advocate for their mangroves, reminding elected officials and financial backers of what is at risk and demand their protection.

This Research Topic aimed to capture the variety of drivers and incentives related to mangrove change, however, carbon and climate mitigation was the predominant issue addressed. It is important to continue to expand our understanding around all of the ecosystem service values such that carbon does not overshadow the larger conversation around all the natural capital mangroves provide. For example, further research valuing the high biodiversity of mangroves is needed to promote their protection to support achievement of the goals of the Convention on Biological Diversity's post-2020 Global Biodiversity Framework. The ultimate goal is to promote multiple values held by a diverse range of stakeholders to leverage transformative change and sustainable development (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, 2022).

Equally critical as the activities the world will take to conserve and restore mangroves are leadership and innovation for adopting and amplifying solutions at scale. While the world is waking up to the importance of conserving mangroves, policies and financial mechanisms are only now catching up. However, multinational, cross-sectoral groups such as the Global Mangrove Alliance, Ramsar, and the National Committee on Wetlands champion large-scale, science-driven mangrove protection, sustainable management, and restoration. Collaborative, transdisciplinary efforts will be essential to increase effective and equitable protection and expand restoration. However, this is not enough. Our ability to succeed is relient on active leadership from local communities that take a proactive, instead of reactive, approach. The many values mangroves provide mean that actions to preserve them are not just climate strategies. They are "no-regret" strategies. That message must be communicated and internalized—but more importantly, it must be acted upon.

Author contributions

JH was the lead author with substantive input from DA-B, VH, and SS. All authors provided insight on the aim of the Research Topic, highlighted key points from the papers they reviewed, and contributed to the conclusions and research needs expressed in the editorial. JB as a contributing editor, provided recommendations and comments related to submissions that were integrated into the editorial text. All authors contributed to the article and approved the submitted version.

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