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PERSPECTIVE

Ambitious goals for global mangrove conservation and restoration

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Abstract Generic global conservation targets lack the ambition required for certain habitats of critical value for biodiversity and human well-being. Developing more challenging targets for such habitats may offer a solution. Mangrove forests provide an example: any and all future loss will have negative repercussions, while many impacts could be reversed through extensive restoration. The Global Mangrove Alliance, an international grouping of 100 civil society and academic partners, has set goals to halt anthropogenic losses, accelerate restoration and greatly enhance protection by 2030. Using global-scale data, we estimate that achieving these goals will avoid losses of some 1500 km^2; restore some 4000 km^2; and secure an additional 36 000 km^2 of mangroves under effective and equitable protection. Multiple benefits will follow, and we present values for carbon storage gains and avoided losses. Global datasets can guide broad approaches, while quantifying the challenges and benefits provides inspiration and impetus for change.

Keywords Biodiversity targets · Blue carbon · Fisheries · Mangrove forest · Protected areas · Restoration

INTRODUCTION

Under the Kunming-Montreal Global Biodiversity Framework (GBF), member states ratified two broad, temporally-bound challenges to conserve biodiversity. The first long-term goal is ensuring that "the integrity, connectivity, and resilience of all ecosystems are maintained, enhanced, or restored, substantially increasing the area of natural

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ecosystems" by 2050. The second shorter-term goal is ensuring, as a 2030 waypoint, that "at least 30 percent of terrestrial, inland water, and of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem functions and services, are effectively conserved and managed", and "at least 30 percent of degraded … ecosystems are under effective restoration, in order to enhance biodiversity and ecosystem functions and services, ecological integrity and connectivity" (Convention on Biological Diversity 2022).

While such goals are valuable as a general ambition, they lack specificity. There are many locations, indeed entire ecosystems, for which almost any loss at this stage in the Anthropocene is simply too much. Spatially limited coastal ecosystems are a case in point: ecosystems such as mangrove forests, coral reefs, tidal marshes and seagrasses are not only diverse, but also play a critical role in human survival and well-being. Allowing continued losses, with the protection of only 30%, and the restoration of only 30% of what is degraded will come at massive cost both to nature and to people.

Straddling land, sea and freshwater, mangroves are globally distributed from tropical to temperate zones, but occupy only 147 000 km^2, an area approximately the size of Bangladesh (Bunting et al. 2022). They are of global importance for their high levels of productivity and biodiversity (Yeo et al. 2021; Adame et al. 2024). There is a growing awareness of their role in carbon sequestration, climate change mitigation and adaptation (Howard et al. 2023); in coastal protection by means of wave attenuation, slowing storm surge inundation and binding coastal sediments (del Valle et al. 2020; van Wesenbeeck et al. 2022); and in supporting high productivity of key fisheries species contributing to food security and livelihoods (Zu Ermgassen et al. 2020; Mallick et al. 2021; Zu Ermgassen et al. 2025). There is also some evidence of their tolerance to rising temperatures (Naseef et al. 2024) and of at least a partial ability to maintain elevation to match sea-level rise (Saintilan et al. 2020). Additional ecosystem services, many of which are vital for local communities, include the provision of timber, fuelwood, tannins, salt, edible plants, honey, animal feed, medicines, nature-based tourism activities, groundwater protection, nutrient cycling, pollution reduction, as well as many cultural, educational, recreational, and existence values (Ruslan et al. 2022).

Despite these values, mangrove losses have historically been considerable, exacerbated by their often close proximity to human populations, bringing conflicting pressures of economic development, basic human needs, and ensuring environmental integrity (Thomas et al. 2017; Goldberg et al. 2020; FAO 2023). While conversion to aquaculture, agriculture or urban space dominate the drivers of loss, timber and fuelwood extraction, pollution and interruptions to hydrology and sediment flows are also key threats (FAO 2023). Uncertain land tenure and fragmented or overlapping regulatory regimes frequently compound these challenges (Mursyid et al. 2021; Arifanti et al. 2022). With a current estimated extent of 147 000 km^2 in 2020 (Bunting et al. 2022), annual losses during the 1980s and 1990s ranged from 0.7 to 1% of global mangrove coverage (FAO 2023). These declines have now largely stabilised, with some datasets suggesting a reversal in the second decade of the 21st century, although with more pronounced losses remaining in parts of Asia and the Caribbean (Bunting et al. 2022; Zhang et al. 2026).

In 2018 the Global Mangrove Alliance (GMA) was formed as a unique consortium of partners, largely from civil society and academic organisations, working in concert towards mangrove conservation. To set a framework for their efforts, the GMA devised a series of global goals for mangrove conservation. Such an ecosystem-centric approach, with large-scale buy-in from multiple partners, presents an interesting model for wider conservation targets and approaches. In this perspective, we first describe the role of target-based policies in mangroves and the formation of the GMA. We then look at the three goals defined by the GMA and (i) explore and further define the scope of each goal; (ii) discuss the challenges faced in achieving each goal; and (iii) analyze some of the benefits (climate change mitigation and fisheries) provided by achieving each goal.

Target-based ambitions

The GBF highlights the need to focus conservation and restoration efforts on "areas of particular importance for biodiversity and ecosystem functions and services"; however, it sets no higher target for such areas. Protected area coverage surpassed 30% for both coral reefs and mangroves over ten years ago (Spalding and Hale 2016). Not all protected areas are effective, but this still leaves such ecosystems looking vulnerable to the complacency of success, when in fact the need for both effective and more extensive conservation is considerable.

For mangroves, some countries have already made bold commitments, setting national targets for both protection and restoration (Friess et al. 2022). These commitments have been bolstered by international agreements such as the Paris Agreement overseen by the United Nations Framework Convention on Climate Change (UNFCCC), the GBF, the Convention on Wetlands of International Importance (Ramsar Convention), the Sustainable Development Goals, and the United Nations Decade on Ecosystem Restoration. In addition to protected areas, other national policies and laws, including restrictions on use or removal, help to maintain mangrove forests in many

countries (Slobodian et al. 2025, see Goal 3: Double protection). Restoration presents an important opportunity to further expand current mangrove area, although caution is needed: Hastily conceived and poorly planned mangrove restoration often has low success (Kodikara et al. 2017; Rodríguez-Rodríguez et al. 2021; Zimmer et al. 2022), and area metrics alone do not signify the ecological quality of the restored area.

Despite progress, more could be done to capitalise on the momentum provided by international agreements (Gajre et al. 2025). It remains essential that further mangrove deforestation is halted, that protections are both increased and better enforced, and that restoration efforts follow evidence-based approaches that are scaled up to reverse decades of degradation and conversion (Buelow et al. 2022). One such initiative has been led by the GMA, a consortium of mostly non-governmental organisations and academic institutions[1]. The GMA was formed in 2018 by five organisations, and by late 2025 membership had grown to over 100 organisations in 30 countries, actively supporting participation in mangrove conservation and restoration worldwide. Members include local non-profit organisations, scientific institutions, and major conservation organisations. Paralleling the general membership, the GMA has established national chapters in 15 countries with several more under development. The national chapters provide a conduit for the GMA's global membership to support and learn from on-the-ground actions more adapted to national and local priorities.

In 2022, GMA members devised a series of global goals for the conservation and sustainable use of the world's mangroves. These were intended to present a profound, yet achievable, short-term challenge to complement the aims of the GBF. Those goals sought, by 2030, to:

- **Halt loss.** Reduce mangrove losses driven by direct human actions to zero;
- **Restore half.** Restore mangroves to cover at least half of all recent loss; and to
- **Double protection.** Ensure long-term secure protection of mangroves, doubling where feasible, with a minimum of 30% in all countries (Leal and Spalding 2022).

A key resource both for developing these goals and for ongoing assessment and prioritisation is the Global Mangrove Watch (GMW), a data and mapping platform linked to the GMA, which hosts extensive science and policy-relevant data[2].

In the sections that follow we explore these broad goals, providing nuance and detail, considering the challenges and the benefits that could accrue from their implementation.

Goal 1: Halt loss

Rates of mangrove loss have slowed considerably in recent decades (Bunting et al. 2022), presenting an opportunity to meet the challenge of halting anthropogenic loss worldwide. This goal aligns with Target 1 of the GBF, which calls for "halting the loss of areas of high biodiversity importance…close to zero by 2030" (Convention on Biological Diversity 2022). Halting avoidable losses is of particular importance for emissions reductions, as mangroves have been identified as an ecosystem rich in "irrecoverable carbon" that may not be returned even following effective restoration (Goldstein et al. 2020). Clearly there may be circumstances in which some limited mangrove clearance is deemed critical; however these should be exceptional and where possible they should be offset by additional conservation and restoration measures.

Differentiating between diverse drivers of change in mangrove cover will be key to assess progress towards this goal. Mangroves are dynamic ecosystems (Murray et al. 2022), substantial areas of both loss and gain are driven by natural coastal processes (inundation, erosion and sedimentation). These dynamics may be further influenced by indirect human agency—climate-related sea level rise and storms, groundwater extraction, alteration of riverine flows and sediment supplies—although apportioning anthropogenic links to such observed changes is challenging. Nonetheless, direct human actions, including conversion to agriculture, aquaculture, urban growth and infrastructure development, remain the dominant drivers of change, estimated as accounting for 56–68% of losses in the 2010s (Goldberg et al. 2020; FAO 2023). Other drivers such as unsustainable harvesting, pollution, invasive species and impacts on hydrology, freshwater and sediment flows are locally important in many areas and also need to be factored into efforts to halt loss.

The Global Mangrove Watch (GMW) time series estimates an annual gross loss of approximately 548 km^2 in mangrove area between 2010 and 2020, though these losses are not evenly distributed. At the regional level, human-driven losses account for just 5% of these gross losses in the Pacific Islands and 18% in Australia and New Zealand, but exceed 80% in East and South-East Asia where coastal development pressures are highest. Halting anthropogenic loss therefore presents a geographically variable challenge across diverse socio-ecological contexts (Fig. 1). The countries with the highest anthropogenic losses during this period were Indonesia, Myanmar, Mexico and Malaysia, making up half of the global total. Although absolute losses are lower elsewhere, several countries show particularly

[1] https://www.mangrovealliance.org/.

[2] https://www.globalmangrovewatch.org/.

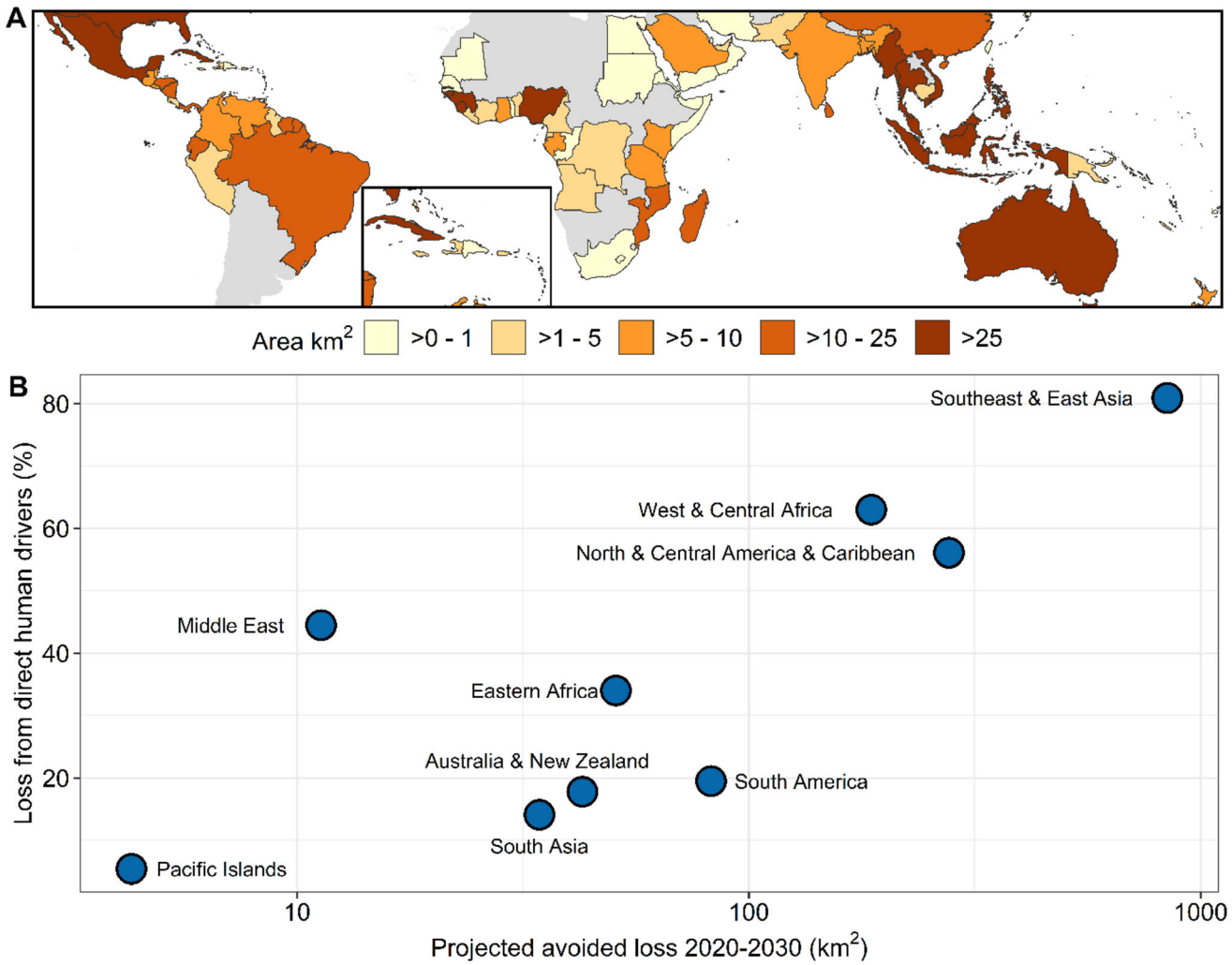


Fig. 1 Projected avoidance of loss if anthropogenic losses can be halted between 2020 and 2030 per country (**A**) and per region (**B**) versus the proportion of gross losses from direct human drivers. Insert in panel A shows an enlargement of the Caribbean. Supplementary Table S1 provides numerical estimates of projected avoided loss statistics for major mangrove countries

high proportional losses. Saudi Arabia, Sri Lanka, China and Ghana, for instance, each recorded average gross loss rates of over 1% per year over this decade (global average: 0.04% per year). Such countries could be prioritised for protection and policy actions that can halt loss, encouraging and facilitating the development of country-specific targets and plans with clear monitoring protocols and enforcement mechanisms.

While Goal 1 focuses on halting anthropogenic losses, it is important to note that natural dynamics will continue, and may even accelerate with climate change, leading to both losses and gains in different areas (Lagomasino et al. 2019; Saintilan et al. 2020; Murray et al. 2022). Although not factored into Goal 1, the natural gains in areas beyond the recent footprint of mangroves, such as the landward and poleward expansion of mangroves with rising and warming seas, or the colonisation of new sediment deposits in

Goal 1 Halt loss
Reduce mangrove losses driven by direct human actions to zero
Technical definition: Reduce avoidable mangrove loss from direct human activities to close to zero by 2030
Methodology: The total area of loss (i.e., gross losses) is calculated from reductions in mangrove extent from 2010 to 2020. This metric does not allow mangrove expansion to novel areas to offset ongoing loss. Within these gross losses, our current estimation of the proportion attributable to direct human impacts is assigned using data from Goldberg et al. (2020). Assessments of avoided loss of mangroves associated with this metric are based on an assumed linear decline from this gross loss rate (2010–2020) to close to zero loss in 2030 (see Supplementary Information S1 for full details)
Objective: Avoid losses of approximately 1500 km^2 of mangroves
Underlying global datasets: Mangrove cover from Global Mangrove Watch, and drivers of loss from Goldberg et al. (2020)

prograding deltas will be important to counter the impacts of natural losses which are likewise not included in our calculations.

Goal 2: Restore half

Efforts to restore mangroves date back to the beginning of the 20th century (Saunders et al. 2020), with project implementation increasing in both number and scale in the past few decades in response to multiple motives including coastal defence, fisheries enhancement, biodiversity benefits and carbon sequestration (Gatt et al. 2024). While historical mangrove extent and distribution remains debated, remote sensing shows total mangrove losses of over 11 325 km^2 since 1996 (Bunting et al. 2022), providing a footprint within which to consider restoration activities. Within the extent of recent loss are also areas where restoration is no longer realistic. This includes locations where mangroves have been replaced by permanent open water linked to erosion, subsidence, isostatic change, or dredging. Likewise, where mangroves have been replaced by infrastructure such as roads, ports and buildings, the high value of the current land use typically precludes restoration. When such areas are removed from consideration, an estimated 7939 km^2 of former mangrove area remains viable for restoration efforts (Worthington et al. 2020). Restoring half of these losses, or approximately 4000 km^2, by 2030, is highly ambitious. It links closely with existing global targets, such as the GBF call for "effective restoration" of "30 percent of areas of degraded terrestrial, inland water, and coastal and marine ecosystems" by 2030 (Convention on Biological Diversity 2022), but sets a higher bar, appropriate for such an important ecosystem. It also links with the Sustainable Development Goal 15; the UN Decade on Restoration; and the Bonn Challenge.

The largest extents for possible restoration are found, as might be expected, in the countries with the largest mangrove area. Within the global context, Indonesia stands out with a potential restoration extent of over 1000 km^2, three times more than any other country (Worthington et al. 2020). It is noteworthy that our estimate of restoration extent for Indonesia is broadly comparable, but perhaps more attainable, than other estimates of restoration potential (Sasmito et al. 2023). The remaining restorable area is more evenly distributed between regions, and lowest in the Pacific Islands (Fig. 2). Although the restoration goal is also low for the Middle East, it is notable that the proposed target of 61.4 km^2 represents a very high proportion (16%) of the total 2020 mangrove area (Fig. 2), with highest regional targets being in Saudi Arabia, Iran and the United Arab Emirates.

Headline spatial goals for restoration extents are valuable for communicating the challenge and aligning with current global biodiversity frameworks, but it is critical to set more detailed ecological and socio-economic criteria for ensuring success. Restoration must be effective, stable over the long term, equitable and ecologically positive (Beeston et al. 2023). It is important to communicate best practices approaches alongside these goals and to discourage efforts that have led many restoration efforts to fail, such as the mass planting of one or two species, often in the wrong locations. The selection and prioritisation of restoration efforts can be considered at several scales. The research of Worthington et al. (2020) provides insights into the biophysical potential for restoration at broad landscape scales, but site-scale information on topography, ecology and hydrological connectivity will underpin restoration feasibility (Twomey et al. 2024). Equally critical, restoration potential needs to be informed by cultural, legal and economic information (e.g., Grimm et al. 2024), including understanding of the original drivers of loss, the degree of engagement by local communities, and information on land tenure, local livelihoods, economic opportunities and pressures which will determine long-term viability (Lovelock and Brown 2019; Mursyid et al. 2021; Tinh et al. 2022; Sasmito et al. 2023). Enhancing governance to support fair and equitable restoration will aid in achieving Goal 2 (Dencer-Brown et al. 2022).

Goal 3: Double protection

Some 40% of the 2020 extent of mangroves are located within protected areas or recognised as OECMs. This represents a considerable advance from 2010, when the value was 25% (Spalding et al. 2010). Despite the positive trajectory, more can be achieved. Conservation-centred protection (i.e., preserving the ecological value), which is effective and equitable, is critical for securing biodiversity and the diverse benefits mangroves provide to people.

Although protected areas are used here as a metric for effective conservation, legal designation does not always guarantee that places are "effectively conserved and managed" (Convention on Biological Diversity 2022). GMW data shows that mangrove losses still occur within protected areas, albeit at slower rates than outside their boundaries. Some of these losses are from natural mangrove dynamics (e.g., from storm impacts), which are not expected to change based on conservation interventions, while other losses may be linked to insufficient enforcement, limited resources, or conflicting management objectives (Heck et al. 2024). Effective protection should ensure that direct anthropogenic losses are prevented and thus form an important component of achieving Goal 1.

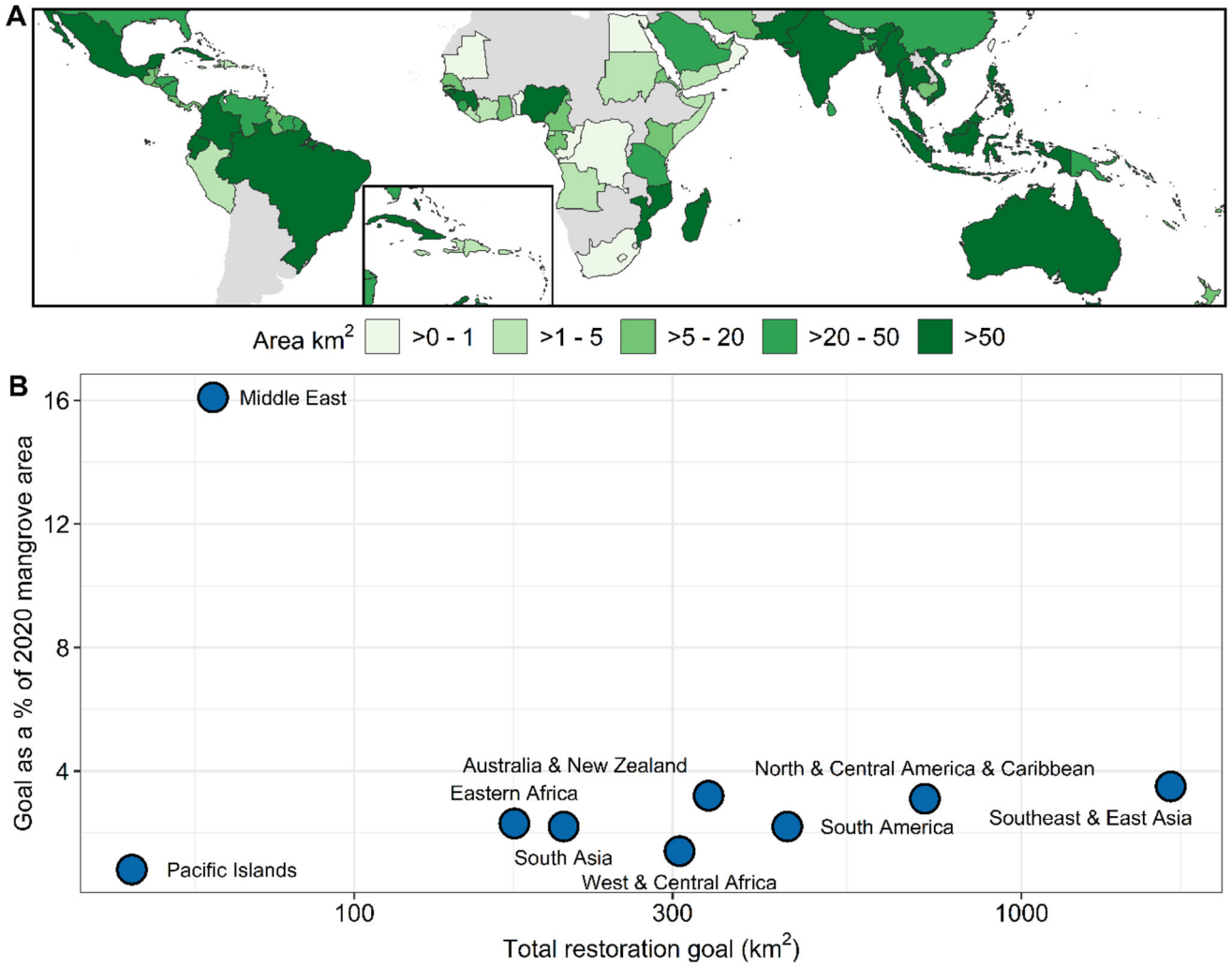


Fig. 2 Proposed restoration goal per country (**A**) and per region (**B**) assuming restoration of half of the biophysically restorable area. Plotted in panel **B** as a proportion of the area of mangroves in each region in 2020. Insert in panel **A** shows an enlargement of the Caribbean. Supplementary Table S1 provides numerical estimates of restoration goals for major mangrove countries

Goal 2 Restore half
Restore mangroves to cover at least half of all recent loss
Technical definition: Recent mangrove loss covers the mapped and measured period from 1996 to 2020. Recent losses are considered restorable by 2030 if they have not been lost to erosion or converted to high-value land uses such as urban areas or infrastructure. The goal is to restore half of these restorable areas
Methodology: Restorable areas are determined from Worthington et al. (2020), which summarises mangrove extent at the level of broad typological units (Worthington et al. 2020), rather than specific locations (see Supplementary Information S1 for further details). Progress is to be determined from a combination of GMW cover change 2010–2020 and available monitoring and reporting from multiple data sources
Objective: Effective restoration of approximately 4000 km^2 of mangroves by 2030
Underlying global datasets: GMW and global restoration potential map to define the objective. GMW change data, Mangrove Restoration Tracker Tool, and GMA member data will be used for tracking global restoration progress

While "double protection" provides a valuable headline, the details on how to implement it are critical. Among the 50 countries where more than half of their mangroves are already under protection, area limitations will clearly prevent fully doubling the area protected. However, these nations can still expand protected areas and enhance the effectiveness of existing conservation efforts. Conversely, countries with very low levels of protection would find that simply doubling their coverage remains insufficient. Therefore, while we propose doubling protection as a general guideline, we recommend a minimum protection target of 30%, in alignment with the GBF 2030 goals, for all countries where current protection is below 15%. For nations with 45% or more mangrove coverage already protected, achieving 90% protection would be ambitious yet attainable (Fig. 3). Using those guidelines, the overall outcome of achieving Goal 3 would be an additional 36 000 km^2 under effective conservation measures, giving

a total of 97 000 km^2 (two-thirds of global mangrove cover, Table S1).

There is a strong overlap between Goal 3 Double Protection and Goal 1 Halting Loss. Where they differ is that, in calling for active protection, this goal looks beyond simple loss prevention. Conservation-centred protection with the participation of local communities and other actors would secure areas where degradation of ecosystem structure and integrity would also be avoided. It is also important that restored areas benefit from management and protection: where this occurs, actions in Goal 2 Restore Half could therefore further contribute to this goal.

Alongside traditional protected areas, OECMs are receiving increasing attention (IUCN-WCPA Task Force on OECMs 2019). These include lands used by Indigenous and local communities, and areas of sustainable use where mangroves are protected from conversion or unsustainable use (Jonas et al. 2023). While some such sites are already included in protection statistics, others likely exist that have not been recorded, including municipal or urban mangroves that often benefit from protection.

It is also the case that, aside from specific site-level protections, many countries designate varying degrees of protection through national restrictions on cutting or clearing mangroves; integration of mangroves into environmental impact assessment or coastal zone planning regulations; and mangrove-specific national policies (Canty et al. 2018; Slobodian et al. 2025). Such national-level

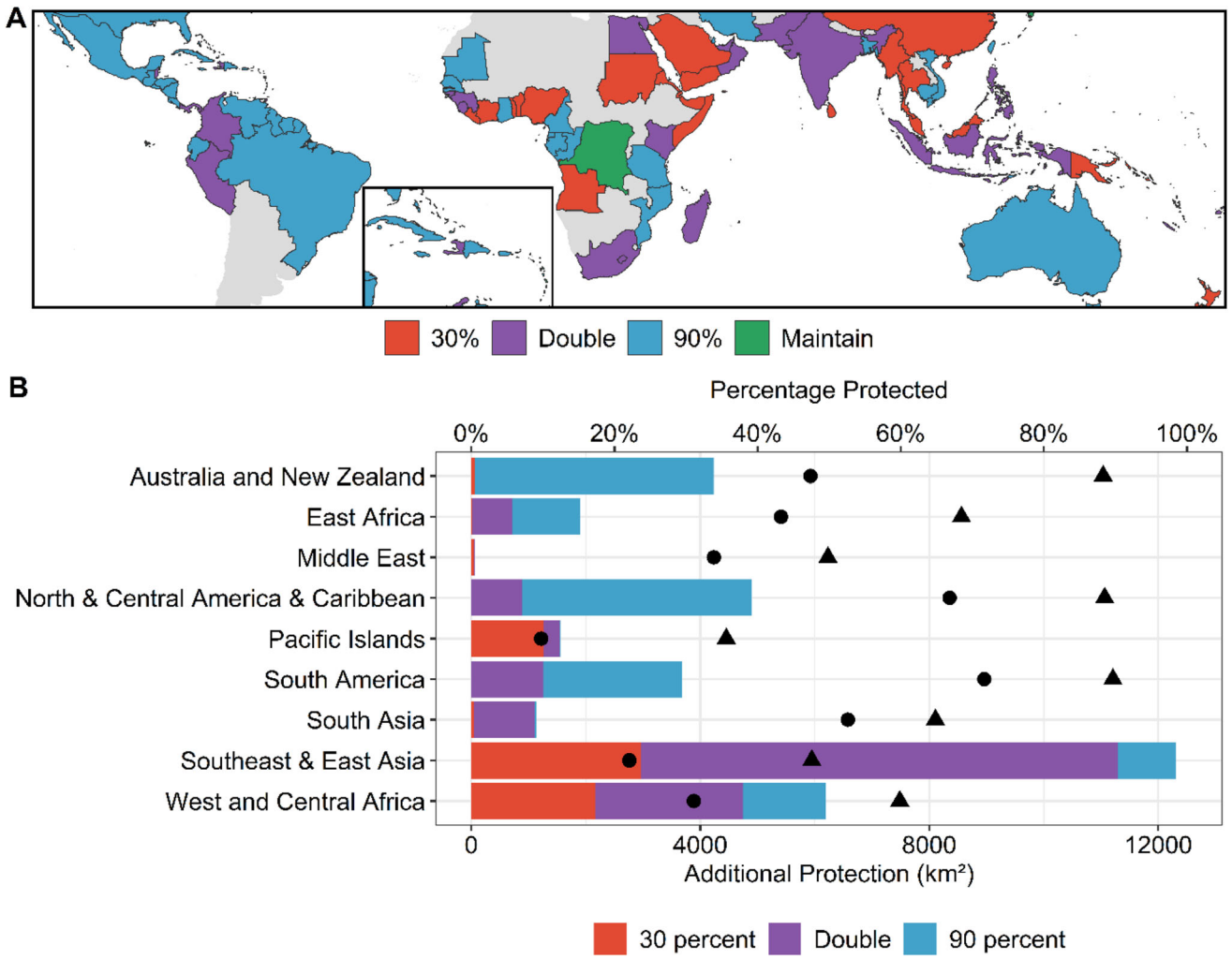


Fig. 3 The potential targets in terms of additional mangrove protection for different countries (**A**); and the additional protection per region if each country meets these targets (**B**). In Panel A these targets are set at 30% for all countries where current protection is below 15%; double for countries with a current protection level between 15 and 45%; 90% for any country already above 45% protection; and maintain for countries already over 90%. In Panel B, the bars represent the additional protected area in km^2 for the countries meeting the targets across the three proposed pathways. The circles represent the percentage of mangrove area in 2020 protected per region, with the triangles the percentage that would be reached if the potential targets were achieved. The insert in panel A shows an enlargement of the Caribbean. Supplementary Table S1 provides estimates of suggested protection goals for major mangrove countries

Goal 3 Double protection
Ensure long-term secure protection of mangroves, doubling where feasible, with a minimum of 30% in all countries
Technical definition: Increase effective and equitable protection of mangroves by 2030, with nationally determined targets setting a minimum of 30% for all countries. This includes a doubling of protection for any countries with more than 15% current protection, but with a suggested target of 90% for any country already above 45% protection. Protection should achieve conservation benefits for mangrove ecosystems, through protected areas or other effective area-based conservation measures (OECMs), recognising Indigenous and customary tenure where applicable.
Methodology: Protection is here measured based on inclusion in the World Database of Protected Areas (WDPA) which includes the World Database of OECMs (see Supplementary Information S1 for further details). Future assessments should attempt to incorporate equity and effectiveness, utilising existing data or developing new metrics where available. In some cases, national-level legal protection to mangroves may give equivalent levels of conservation benefits as protected areas, and could also be included.
Objective: Approximately an additional 36 000 km^2, to reach a total of 97 000 km^2 of mangroves under protection.
Underlying datasets: GMW mangrove cover and the WDPA. With additional sources needed to ascertain conservation effectiveness and equity.

protections are present in 75 countries and territories and include over 80% of the world's mangroves, though the strength of this protection varies widely and in many cases implementation of these more generic forms of protection is poor (Slobodian et al. 2025). Thus, while protected areas and OECMs are widely considered to be central to assessing protection, there may be some merit in assessing some of these other protection metrics for tracking progress, provided the protection provided is long-term effective and equitable.

While encouraging the expansion of protection, it is important to emphasise the need to go beyond simple expansion of extent. IUCN guidelines highlight the key components of protected areas—protection must target areas of importance for biodiversity and ecosystem services (Dabalà et al. 2023); and it must be effective, equitable, and representative, with positive conservation outcomes that are secured over the long-term (Spalding and Hale 2016). Ensuring effectiveness and equity needs to be considered not as a filter for assessing progress but as part of the goal itself, encouraging improvements in existing protection efforts and best standards in new protections. Considerable challenges remain in defining effectiveness and equity; however tools have been developed such as the Management Effectiveness Tracker Tool (METT, Stolton et al. 2021) and the Site-level Assessment of Governance and Equity (SAGE, Legh-Smith et al. 2026) which provide standardised approaches and key metrics including critical social, legal and economic settings as well as ecological and social outcomes. Selecting and applying these at the country site level will help to ensure appropriate and reliable indicators can be assessed in the highly variable settings of mangroves worldwide.

In areas where mangroves are integral to extractive activities such as fisheries, timber and fuelwood, it remains important to recognise the need for long-term sustainability and biodiversity protection, as highlighted in GBF Target 10 (Enhance Biodiversity and Sustainability in Agriculture, Aquaculture, Fisheries, and Forestry). In many cases, the incorporation of adjacent and connected ecosystems such as estuaries, tidal marshes or offshore coral reefs may be a critical component of effective conservation.

More effort will also be required to track progress towards this goal to ensure that diverse forms of protection are counted, all species and ecological processes are incorporated in protection regimes, and ecological and social benefits of protection are evaluated, while attempting to exclude ineffective areas from any inventories.

Prioritising sites and considering returns

The adoption and implementation of global goals and targets at national scales can generate a range of diverse challenges for countries (see Supplementary Material S1 for an interpretation of goals at national scales for larger mangrove nations). Patterns of mangrove loss and gain, and current progress in restoration and conservation are highly variable (Buelow et al. 2022). Furthermore, the associated costs of conservation and restoration vary based on local biophysical conditions, site-specific threats and variation in community engagement (Bayraktarov et al. 2016). Even where natural colonisation is sufficient and actual planting of mangroves is not required, hydrological restoration often adds considerable expenses. Unclear or conflicting policies, regulations, or institutional responsibilities relating to activities connected to mangroves bring further challenges (Friess et al. 2016; Rog and Cook 2017).

Given the complex realities that underlie the GMA goals, an improved understanding of the value of benefits associated with achieving the goals is important (Su et al. 2021). This may help motivate actions and develop economic models and funding streams. Such understanding may also help in prioritising the placement of protection and/or restoration interventions (Dabalà et al. 2023). While such details may be best developed at national or site levels, large-scale models of ecosystem service benefits are improving. Here we present additional information about potential benefits relating to carbon and fisheries.

Benefits of achieving conservation and restoration goals

Carbon

Mangroves contain rich carbon stores, and in most cases provide continuous net carbon sequestration, due to the long-term accumulation of soil carbon. When lost or degraded, much, but not all, of the carbon stock can be released back into the atmosphere. Likewise, in the short term, not all biomass or soil carbon will be returned with restoration (Sasmito et al. 2019; Bourgeois et al. 2024). Rates of carbon loss or gain will vary with location, climate, coastal stability, mangrove species composition and land use pre-restoration or post-conversion (Song et al. 2023).

Here, for Goals 1 (Halt loss) and 3 (Double protection), we highlight "secured" carbon: The current fixed carbon stocks that will remain or be secured by meeting these goals. For restoration (Goal 2), we differentiate the "secured carbon" from "restored carbon", which is the potential gain in carbon biomass and soil stocks as a result of restoration (see Supplementary Information S1 for more information). Assuming national average values, the avoided loss of 1534 km^2 by 2030 from Goal 1 will secure over 27.4 Mt (9.6–53.2 Mt) of carbon from soil and biomass that might otherwise be lost by 2030 (Table 1). As carbon emissions following conversion are a gradual process, further avoided losses would accrue beyond this timeframe. Based on the assumption that not all carbon is lost under land use conversion and that the amount lost varies between different land use types, restoration of the 3970 km^2 from Goal 2 would secure some 71.3 Mt (71.2–71.5 Mt) of the remaining carbon that might otherwise be lost. Further, that same restoration should, over time, lead to the additional sequestration of 23.2 Mt (14.8–32.3 Mt) of carbon in biomass and the soil. This additional carbon value is calculated based on the same assumption that not all carbon is lost under land use conversion, but also that, even after 40-years, the carbon stored in restored mangrove forests does not reach full equivalence with natural stands (Bourgeois et al. 2024). Improved protection to 61 000 km^2 from Goal 3 will further secure some 1196.1 Mt (354.2–2370.0 Mt) of biomass and soil carbon. While this does not represent avoided losses, avoided degradation as a result of protection would reduce carbon losses.

It should be noted that values generated here for secured carbon through both avoided loss and protection focus on stocks secured by 2030. An additional carbon value arises from ongoing sequestration in areas of both avoided loss and improved protection. Over decadal timescales this will represent an important additional contribution to stocks, with one estimate suggesting a global rate of accrual of 1.5 Mg C ha^{-1} $year^{-1}$ (Adame et al. 2021). Finally, while the carbon mitigation benefits of the goals are real and measurable, it should be noted that these values may not easily be incorporated into carbon market values.

Fisheries

There are an estimated 4.1 million small-scale fishers who rely on mangrove-associated fisheries (Zu Ermgassen et al. 2020). The total dependency of those whose food security or livelihoods rely on mangrove fisheries is likely to be several times this value. These fishers and fisheries benefit from the abundance of fish and invertebrates that rely on mangroves, often as juveniles, to complete their life history. For a subset of the species, it has been estimated that mangroves support the annual recruitment of nearly 735 billion individual commercially important young-of-year fish and invertebrates worldwide (Zu Ermgassen et al. 2025). Halting loss and improving protection will help to secure this productivity and the associated benefits to employment and food security. Notably, many of the restorable areas are located in areas of potentially high fish production such as Southeast Asia and therefore the projected benefits from fish production are higher than might be expected from global average figures.

These fisheries and carbon benefits are only part of the story. For example, one study estimated that mangroves worldwide provide flood risk reduction to 15 million people and over US$65 billion worth of property (Menéndez et al. 2020). Furthermore, mangroves are known to provide food and habitat for many terrestrial and marine fauna species (Rog et al. 2017; Sievers et al. 2023). These and many other benefits to people and biodiversity will arise as the goals for mangrove protection and restoration are pursued.

DISCUSSION

Ambitious targets set under the framework of international conventions and agreements are powerful tools to drive change: Governments use them to signal intent, and many national policies and efforts are justified by such targets. At the same time, these targets are often not met. The Aichi Biodiversity Targets for marine protection, for example, were widely missed, and this may in turn have had some role in the long delay in setting new targets under the GBF.

The three goals described here, however, are different. Firstly, they focus on a particular ecosystem. Mangroves are clearly "ecosystems of particular importance" as described under the GBF, and should be prioritised in protection and restoration efforts. Compared to many other coastal and marine ecosystems they are also well

Table 1 Estimated potential "secured" or "restored" total mangrove ecosystem carbon stock at the regional scale assuming success of the three described Goals. Restored carbon gains are estimated totals 40 years after successful restoration with lower and upper 95% probabilities in parentheses (further details in Supplementary Information)

Region	Halt loss–secured carbon (Mt)	Restore half–secured carbon (Mt)	Restore half–restored carbon (Mt)	Double protection–secured carbon (Mt)
Australia & New Zealand	0.47	6.70	0.29	115.48
	(0.23–0.78)	(6.68–6.72)	(0.09–0.73)	(41.98–209.4)
Eastern Africa	0.63	3.51	0.43	55.03
	(0.25–1.21)	(3.50–3.52)	(0.16–0.75)	(15.19–120)
Middle East	0.05	0.61	0.03	0.90
	(0.02–0.09)	(0.60–0.62)	(0.01–0.06)	(0.35–1.56)
North & Central America & Caribbean	3.50	12.89	1.99	143.27
	(0.96–6.54)	(12.87–12.91)	(0.93–3.03)	(31.97–283.83)
Pacific Islands	0.06	1.26	0.14	58.96
	(0.03–0.12)	(1.26–1.27)	(0.06–0.27)	(16.95–122.14)
South America	1.32	9.80	2.11	125.40
	(0.36–2.67)	(9.79–9.81)	(1.29–3.07)	(26.92–262.8)
South Asia	0.31	3.32	0.44	25.14
	(0.18–0.46)	(3.31–3.32)	(0.21–0.71)	(12.16–39.77)
Southeast & East Asia	18.62	27.37	16.72	481.89
	(6.29–37.69)	(27.31–27.42)	(11.68–22)	(117.67–1035.23)
West & Central Africa	2.45	5.88	1.04	190.00
	(1.33–3.64)	(5.88–5.89)	(0.41–1.71)	(91.04–295.33)
Grand total	27.42	71.33	23.2	1196.07
	(9.65–53.20)	(71.19–71.47)	(14.83–32.34)	(354.22–2370.05)

documented and monitored, which enables the ability to accurately quantify achievable targets using ecosystem-specific data, and to identify where actions might best succeed (e.g., Worthington et al. 2020). Since the establishment of these three Goals, the value of an ecosystem-centric approach has also been recognised by the UNFCCC's High-Level Climate Champions, who have adopted these same Goals as part of a "Mangrove Breakthrough" (Climate High Level Champions 2025). Furthermore, similar approaches are being endorsed for other critical ecosystems, for example, for coral reefs[3].

Although framed and clearly linked to the Convention on Biological Diversity, and with reference to UNFCCC, another unique facet of these goals is that they have been developed by a large and rapidly growing community of non-governmental organisations and partners, backed not only by science, but also by important local knowledge. The prominent role of civil society in developing these recommendations has the potential to foster heightened commitment and command greater scrutiny.

While this work has highlighted ecosystem service benefits from mangrove conservation and restoration, their importance for biodiversity should also be considered. Although mangroves contain a relatively small number of constituent tree species (68 full species listed in Duke and Lee 2024), other terrestrial and marine fauna species are abundant and diverse, and often have tight ecological linkages to adjacent ecosystems (Rog et al. 2017; Yeo et al. 2021). To maximise biodiversity gains from conservation and restoration efforts, the principles of "representative protection" should be encouraged—this might include using wider biogeographic classifications (Spalding et al. 2007) and more refined typological classes (Worthington et al. 2020) as a guide to further prioritise site selection. Furthermore, while the Goals in this paper target a single ecosystem, it is critical to encourage the protection of adjacent ecosystems in a holistic approach, and to avoid any restoration efforts that may damage other habitats.

As with any global targets, the challenges of implementation vary enormously across a highly diverse suite of political, social and economic settings. In many countries, mangrove cover has already stabilised or may be increasing (Zhang et al. 2026); restoration projects may be increasing,

[3] The Ocean Breakthroughs, emerging from the Marrakech Partnership for Global Climate Action, define five pivotal targets for 2030 across marine conservation, ocean renewable energy, shipping, aquatic food, and coastal tourism, to ensure a healthy ocean by 2050. These science-based targets aim to enhance climate mitigation and adaptation, supporting global campaigns like the Race to Resilience and Race to Zero.

and protected areas may be extensive. But for others, deep-seated challenges remain. Authority over, or legal tenure of, mangrove and former mangrove areas can be highly complex (Lovelock and Brown 2019; Mursyid, et al. 2021). Powerful interests may oppose interventions. Integrating these targets into national policy, and making use of international frameworks such as Nationally Determined Contributions under the UNFCC, or National Biodiversity Strategies and Action Plans under the CBD, may help to incentivise future efforts (Gajre et al. 2025). A growing array of financial mechanisms are also available which may support conservation interventions and even lead to stable financial flows: These may include risk-transfer instruments such as parametric insurance; debt for nature swaps; and market instruments such as carbon and resilience credits (Bill-Weilandt, et al. 2026).

A further challenge for consideration in conservation and restoration planning is the naturally dynamic nature of coastal sediments, compounded by the influence of climate change and sea level rise (Lagomasino et al. 2019). Neither the colonisation of new sediments, nor the landward and poleward expansion by mangroves are formally included in these Goals, and yet these will have important implications on mangrove extent, biodiversity, and ecosystem service benefits. A particular concern is coastal squeeze, which occurs where human or topographic barriers constrain wetland lateral movement in response to sea level rise (Schuerch et al. 2018). Future iterations of these Goals may need to consider natural mangrove expansion into new areas, and potentially set targets to encourage such expansion if required, through processes of managed retreat. It may further include approaches already used in some restoration work, such as the enabling of appropriate hydrological and sediment flows. More immediately, knowledge of these risks and of the potential management approaches to reduce their impact should be encouraged, and the engagement of civil society groups such as the Global Mangrove Alliance may be critical to draw attention to such measures.

Challenges will arise in tracking progress towards these goals; however these are already being actively considered. Extent change is being monitored at the global scale through the work of Global Mangrove Watch and should be of sufficient resolution to assess efforts towards "Halt Loss". The World Database on Protected Areas is under constant refinement and it should enable improved tracking of protected areas and OECMs, although there can be challenges in obtaining timely reporting and in assessing efficacy of protection. Since 2020, there have already been considerable restoration efforts, but there is no single repository of efforts. Much information is held by GMA members, and the Mangrove Restoration Tracker Tool may lead to further enhanced reporting (Gatt et al. 2024). Successful restoration cannot simply be measured in terms of extent of restoration attempted, but must consider ecological and hydrological recovery and resilience. This may take years to ascertain, leading to a lag in tracking progress.

The most influential sources of uncertainty impacting our results are the future trajectory of human-driven mangrove loss; the long-term effectiveness of mangrove restoration; and the identification of degraded mangroves. More recent estimates of global mangrove area than used in this study provide different absolute global and regional numbers although they are converging on similar trajectories (Bunting 2022; Zhang et al. 2026), these may provide an opportunity to update our analysis and track progress towards the midway point. Unfortunately, our knowledge of the specific drivers of mangrove loss often represents a single time point or is limited to a few broad categories (Goldberg et al. 2020; FAO 2023).

Mangrove restoration success is difficult to quantify. It can only be assessed over time-periods of years and varies widely across different regions. It is also unknown how improvements in technology may change success rates (Saunders et al. 2020).

Limited global data on mangrove condition presents another challenge, as mangrove degradation—from timber harvest, pollution, defaunation or storm damage—may be increasing even where total extent remains (Adame et al. 2024; Zhang et al. 2026). In a similar way, restoration targets under the current framework focus on the restoration of lost mangroves, although the halting of degradation in, and the restoration of, degraded mangroves could be built into future iterations of these global goals.

While this work focuses on global-scale goal setting and assessment, it is critical to consider local and national data, which are likely to provide greater detail and accuracy than global datasets. Assuming consistent and equitable approaches can be verified, such data sources should be encouraged and incorporated into future assessments. They may indeed be critical for determining aspects of success that cannot be easily determined from global datasets, including tracking social equity and benefit sharing across management interventions, assessing management effectiveness and reviewing restoration success, biodiversity condition and ecological outcomes. Further thought needs to be given to connecting information across scales, and to considering options for using local datasets to set local goals and/or to verify goals driven by global datasets. A growing number of tools are greatly simplifying such data generation at local scales (e.g., Yancho et al. 2020); however the development of maps and statistics using diverse methodologies often creates challenges of compatibility.

Timely information on small-scale change, including datasets such as mangrove loss alerts (Bunting et al. 2023), provided by the GMW platform, can also be powerful tools for management. Even with the availability of good data, however, challenges remain. Actions on such alerts are likely to be time sensitive, but can be limited by resources, governance structures or low motivation.

Interest in mangrove conservation and restoration has never been higher, yet significant challenges remain. Despite considerable engagement from government and civil society, large funding gaps remain. The Mangrove Breakthrough Financial Roadmap estimates a US$4 billion investment is needed to reach 2030 goals. Traditional conservation funding will be an important component of such funding; however novel financing mechanisms will be critical, including green bonds, carbon markets, payments for ecosystem services, debt conversions, corporate and impact investments, as well as the growing array of international and multi-partner trust funds (Flammer et al. 2025; Bill-Weilandt et al. 2026). Even if raising the financial capital is achieved, aligning the technical capacity, skills and political will to directly match locations or activities in greatest need of attention will be challenging. Mangrove protection and conservation, typically, depends on small-scale actions at local scales. As such it is often initiated by local communities and the engagement of, or indeed leadership by, such communities is paramount to success. Further challenges in the targeting of effort may arise, notably around competing interests for land use, and around tenure and permitting (Rog and Cook 2017; Lovelock and Brown 2019).

While the goals explored in this paper are challenging, we believe they are realistic and measurable, and their implementation will be highly effective in safeguarding a globally important, yet spatially restricted ecosystem. Similar approaches are being considered for other spatially restricted but highly important marine ecosystems such as coral reefs, seagrass beds and saltmarshes (Coral Breakthrough 2023; Brook et al. 2025; Seagrass Breakthrough 2025). Success will depend on engagement by national governments, as well as the bottom-up support of civil society and by growing calls for such action at the highest possible levels of international policy and agreements. The partnership behind the GMA has a unique role to play in bridging across these scales, being deeply connected to mangrove communities around the world, but also having the reach to influence governments and the international community.

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Data availability The data used in this paper, including mangrove cover and change, protected areas, and carbon stocks, are all available from public sources referenced in the main text and Supplementary Material S1.

Declarations

Conflict of interest The authors declare no conflict of interest.

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