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Perspective

Ensuring that nature-based solutions for climate mitigation address multiple global challenges

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SUMMARY

The protection, restoration, management, and sustainable use of natural and modified ecosystems to address climate change mitigation have received much global attention in recent years. Those types of actions are, however, often not designed to also address other global challenges, and so they miss an opportunity to provide important non-mitigation benefits and compromise their mitigation potential. Here, we highlight the importance of planning Nature-based Solutions for mitigation while considering the suite of global challenges that societies face, and we propose a set of considerations to ensure that those types of solutions also provide climate adaptation, biodiversity, and/or human well-being benefits. Planning Nature-based Solutions for climate mitigation that can also address other global challenges is very timely because every nature-based effort should grasp the opportunity to address a variety of pressing issues in order to allow for the continued delivery of mitigation and other benefits in this critical decade.

INTRODUCTION

Nature-based solutions (NbS) are actions to protect, conserve, restore, sustainably use, and manage natural or modified terrestrial, freshwater, coastal, and marine ecosystems that address social, economic, and environmental challenges effectively and adaptively while simultaneously providing human well-being, ecosystem services and resilience, and biodiversity benefits.[1] The emergence of the NbS concept resulted from the need and willingness to proactively use nature's potential to address multiple societal challenges.[2] Implementing NbS can also provide the opportunity for "building back better"[3,4] in response to the COVID-19 pandemic that has exacerbated global challenges. Likewise, competing pressures on lands for fuel, food, and other ecosystem services[5] require optimum responses that can maximize the provision of benefits. The implementation of NbS can help societies by simultaneously addressing the most pressing global challenges, such as the climate change crisis, through climate mitigation and adaptation, the biodiversity[6,7] and ecosystem degradation crises.[8,9]

Actions that focus on the protection, restoration, management, and sustainable use of natural and modified ecosystems for climate mitigation are referred to as natural climate solutions,[10] NbS for climate change mitigation.[11] For clarity, the term NbS for mitigation will be used here to refer to the protection, restoration, management, and sustainable use of natural and modified ecosystems that are primarily designed and implemented for climate change mitigation. Those types of actions have been highlighted in global assessment reports such as those prepared by the Intergovernmental Panel on Climate Change (IPCC) and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES).[6,12] In addition, they have been included in the Nationally Determined Contributions of countries in response to the Paris Agreement and have been supported by major initiatives such as the Bonn Challenge (https://www.bonnchallenge.org/), the New York Declaration on Forests (https://forestdeclaration.org/), and the Trillion Tree Campaign (https://www.trilliontreecampaign.org/). The identification of a global mitigation goal provided by the Paris Agreement and the quantification of the mitigation potential of restoring, protecting, and managing natural and modified ecosystems[10,13–15] have likely contributed to the high number of strategies implemented by governments and non-governmental organizations and to the political support and resources that have been or are to be allocated to NbS for mitigation.[16]

The need to act quickly, to both take advantage of the current interest that exists around those types of solutions and respond to the alarming warnings of global warming,[17] has likely contributed to a narrow focus of NbS planning and led, in many cases, to negative impacts on people and ecosystems and generated little carbon sequestration.[18,19] A more thoughtful approach to plan NbS for mitigation that consider climate adaptation, biodiversity, and human well-being benefits, instead of assuming that NbS will effectively and indubitably provide such benefits, including carbon,[19] can help address the key global challenges of our times: climate change and biodiversity loss, which lead to major social impacts. Due to the interlinkages among those global challenges,[6] planning NbS for mitigation, while considering climate adaptation, biodiversity conservation, and ecosystem degradation and human well-being needs, can, in addition to climate mitigation, unlock the provision of several benefits and likely contribute to the success of mitigation efforts.

In this perspective, we aim at (1) highlighting the importance of planning NbS for mitigation considering the suite of global challenges that societies face today instead of just primarily focusing on reducing carbon emissions and sequestering CO_2 and (2) proposing a set of considerations and the types of information that can be used to incorporate other global challenges into the planning of NbS for mitigation. This perspective also identifies key actions that different stakeholders, including researchers and public and private donors, could take to further support the broad and consistent adoption of such type of planning. Considering multiple global challenges while planning NbS for mitigation can maximize the delivery of positive outcomes in the long term, outcomes which are so critical in this decade where every opportunity to address the challenges of climate change, biodiversity loss, and human well-being should be grasped.

PLANNING NbS FOR MITIGATION TO ADDRESS GLOBAL CHALLENGES

Today's most pressing issues of climate change, protecting biodiversity, and promoting an acceptable and equitable quality of life for all have been the mandates of several global initiatives, including the Strategic Plan for Biodiversity 2011–2020 of the Convention on Biological Diversity (CBD), the Paris Agreement to the United Nations Framework Convention on Climate Change (UNFCCC), and the UN Sustainable Development Goals (SDGs).[6] The seven global societal challenges identified as part of the IUCN definitional framework for NbS[2,20] are also strongly aligned with the pressing issues identified in those global initiatives. We summarize these global pressing issues and societal challenges into four global challenges to be discussed in this paper: (1) climate change mitigation, (2) climate change adaptation, (3) biodiversity conservation and reversion of ecosystem degradation, and (4) human well-being (Figure 1).

The protection, restoration, and management of natural and modified ecosystems have the potential to address those four global challenges. Although the protection of existing natural ecosystems, especially forests, is the highest priority for reducing greenhouse gas emissions,[10] ecosystem restoration sequesters carbon, and the improved management of natural and modified ecosystems can both reduce carbon emission and sequester carbon, thereby limiting global warming.[14] Although there is still debate around how much NbS for mitigation can contribute to achieving net-zero targets due to different assumptions taken and time frames used,[10,13–15] there is a consensus that the protection and restoration of forests, grasslands, and wetlands and improved management of agricultural lands are very important actions to limit temperature increase to below 2°C, per the Paris Climate Agreement. However, the potential of those types of actions in suppressing part of global warming can happen only if they are combined with immediate and aggressive actions on decarbonization of the energy and industrial sectors.[14,21] Without focusing on those two approaches, the limitation in global warming will be insufficient to avoid climate-related risks, which reduce the ability of ecosystems in contributing to climate mitigation.[6]

There is evidence that the protection, restoration, and improved management of natural and modified ecosystems can, in addition to providing climate mitigation benefits, contribute to climate resilience and adaptation of people and nature, to biodiversity conservation, and/or to an improvement in socio-economic and health conditions.[12,22–26] For example, the protection of intact forests, an important NbS for mitigation, can contribute to local climate regulation, provide water supplies, and maintain biodiversity.[23] The restoration of wetlands, important to increase carbon sequestration above and below ground, reduces coastal erosion and flooding risks[27,28] while enhancing the diversity of vertebrates, invertebrates, and vascular plants. Wetland restoration can also improve the provision of ecosystem services, such as water quality and supply of food and raw materials, thereby benefiting the human communities that depend on them.[29] The restoration of arid and semi-arid grasslands through reseeding and improving livestock management is not only an important measure for increasing carbon storage but also for improving water resources and supporting wildlife and livestock productivity.[30,31]

Furthermore, restoration initiatives for climate mitigation can reverse part of the 75% of land that is significantly altered and part of the 85% of wetlands that have been lost,[8] and can contribute to reducing biodiversity loss when species used are functionally diverse and native to the region.[32,33] Some on-farm management practices can contribute to climate mitigation and significantly enhance biodiversity and the ecosystem services provided.[34] For example, the use of agroforestry practices, such as the integration of woody vegetation with crops or livestock production, enhances carbon sinks by storing carbon in biomass and in the soil[35] and can increase biodiversity[36,37] and provide opportunities from the use of non-timber products,[38,39] providing an additional income to farmers[40] and increasing human well-being.[41]

However, there are potential trade-offs that can arise when NbS are implemented. Even though there are examples of interventions and practices that address many global challenges,[42] and many NbS projects and initiatives do not report on their primary goals and do not provide information on outcomes due to the limited and infrequent monitoring of outcomes or benefits,[43,44] there are several examples of how a narrow approach to plan NbS can lead to negative impacts and outcomes. Tree planting is one of the most widely promoted natural climate solutions,[45] but major tree-planting programs, despite the variety of goals that can motivate them,[16] have often emphasized tree-based targets rather than other outcomes, such as improvements in livelihoods or forest restoration.[46] This target-based focus of tree-planting projects has had consequences for people's livelihoods and biodiversity by, for example, using exotic species that can propagate easily but that are not valued

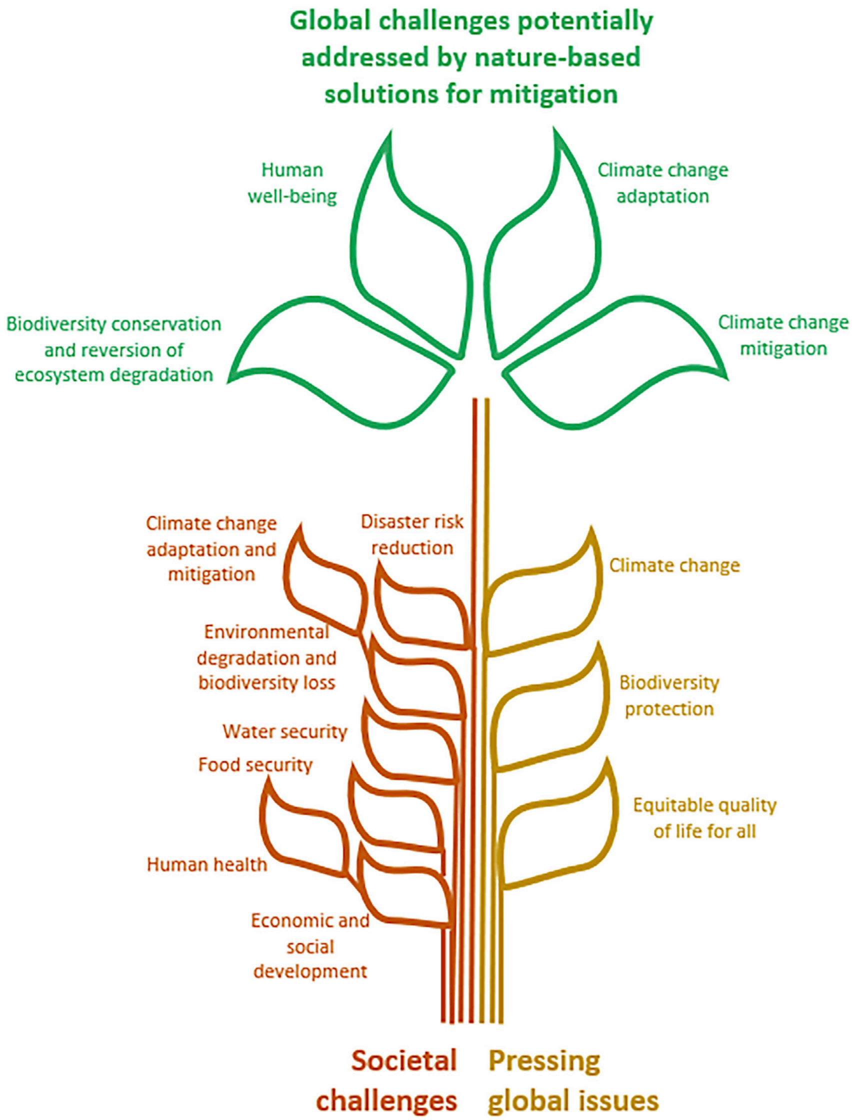

Figure 1. The four global challenges that could be addressed by NbS for mitigation

locally, limiting their livelihood benefits, that can be harvested later, or that are more vulnerable to climate change and disease-related disturbances, limiting their mitigation potential.[10,18,47–49] A review of tree-planting programs in India, which is home to the sixth largest tree-planting effort in the world, has shown unsubstantial climate mitigation and livelihood benefits over decades of project implementation[19] by, for example, restricting community access to natural resources.[50–52] An analysis of the social and biophysical conditions in plantation sites in India shows that a significant portion of trees were planted in locations where the potential for restoration and for carbon-storage benefits are limited,[46] pointing to the importance of planning and implementing forest-based climate mitigation initiatives in ways and locations that avoid or minimize potential harms to ecosystems and people.[24]

A narrow planning of other types of NbS can also lead to several trade-offs. A global review of over 300 case studies has shown a negative effect of recent forest restoration and other forms of forest cover expansion on water yield and groundwater levels, suggesting that the implementation of forest restoration projects, even when native species are used, may lead to unintended negative impacts on water availability for human use.[53] China's Conversion of Cropland to Forest program, the largest ecological restoration program implemented in a developing country, has substantially increased the size of the areas under forest cover and reduced flooding and soil erosion but has generated mixed results on socio-economic and biodiversity benefits, including social inequality and loss of overall income in some cases and negative impacts on biodiversity in others due to the establishment of inappropriate tree species or monoculture plantations.[54] Other studies focused on the same program have found that the restored and reforested areas are reducing river runoff,[55] which could lead to reductions in water availability for agriculture and human settlements to less than what is required.[56] In Uganda, projects promoting reforestation for carbon offsetting resulted in the uncompensated loss of land, property, and livelihoods of communities and smallholder farmers.[57]

CONTRIBUTION OF CO-BENEFITS PROVISION TO MITIGATION EFFORTS

The use of an approach for planning NbS for mitigation that considers several global challenges can, in addition to contributing to the provision of climate adaptation, biodiversity, and/or socio-economic and health benefits, favor and allow the continued provision of mitigation services. Climate change is directly impacting people's lives and livelihoods, which can indirectly impact species and ecosystems through people's adaptation responses.[58] Unsustainable practices as a response to climate change can compromise the long-term mitigation benefits of NbS. For example, changes in precipitation and temperature patterns are negatively affecting crop productivity[59,60] and increasing the incidence of pests and diseases that lead to yield losses.[61] Those impacts can drive agriculture expansion into forests as an unsustainable adaptation strategy to maintain crop and livestock productivity[62,63] for food security and livelihood resilience, compromising the mitigation potential of forest conservation efforts. Likewise, projected sea-level rise and the increased frequency of storms associated with climate change can lead to disaster risks such as coastal flooding,[64,65] affecting the lives and assets of hundreds of millions of people in coastal areas.[66] In some cases, those impacts lead to reactive, and sometimes unsustainable, adaptation responses, such as human migration to other areas close by.[67,68] Coastal flooding and erosion can also lead to anticipatory responses such as the installation of levees, sea walls, and rock revetments,[69,70] which threaten the survival of coastal and marine ecosystems as those types of infrastructure are often constructed seaward of coastal vegetation.[71] Coastal and marine ecosystems, such as mangroves, seagrasses, and salt marshes, are highly efficient carbon sinks and have the potential to contribute substantially to long-term carbon sequestration and storage. Their carbon-storage potential is comparable to terrestrial ecosystems, despite their smaller aboveground biomass and area coverage, as they store more carbon in the soil compared with other terrestrial ecosystems.[72] Therefore, planning NbS for mitigation without considering the potential impacts of climate change on people's lives, livelihoods, and assets can compromise the long-term sustainability of mitigation efforts.

Likewise, climate change is directly impacting species distribution and survival,[73] which can compromise the mitigation capacity of NbS, as diverse plant and animal communities are more resilient to disturbances, such as climate change.[74] The most promising NbS for mitigation to hold warming below 2°C are those related to forests, including reforestation, avoided forest conversion, and improved forest management.[10] However, climate change is leading to disturbances that could generate substantial losses in forest carbon stocks. For example, climate-induced tree mortality has been observed in the past few decades in several regions due to high levels of plant stress caused by droughts, heat waves, and associated increased vapor-pressure deficits,[75–77] leading to a declining trend in the carbon-sink potential of intact tropical forests.[78] Other forest disturbances such as fire can then amplify the incidence and severity of disease and insect outbreaks[79,80] and tree mortality.[81] Those interactions and biological disturbances are expected to continue in the future[80] and be exacerbated by other drivers, such as land-use changes, compromising forest permanence and, consequently, the provision of mitigation benefits from forest-based climate mitigation actions.[82] Therefore, including information on the potential impacts of climate change on people, ecosystems, and species and the contribution of the NbS to climate adaptation during the planning of NbS for mitigation can improve the long-term success of mitigation efforts, even though measuring adaptation is particularly challenging.[83,84]

NbS for mitigation can directly enhance biodiversity by protecting and restoring ecosystems and, indirectly, by reducing the loss in biodiversity that would be expected from climate change.[85] Focusing on increasing biodiversity conservation can also increase CO_2 sequestration of NbS for mitigation as, in general, more diverse systems are more resilient to disturbances.[74] For example, species-rich forests have a higher productivity, absorbing more CO_2 from the atmosphere than tree monocultures, and are more resilient to climate extremes than plots of single species.[48,86] In subtropical and tropical forests, tree-species richness increases ecosystem total carbon storage by promoting high resource use and nutrient retention that allow larger carbon stocks per area.[87,88] Conserving native tree species diversity by efforts to mitigate climate change can then preserve the ability of ecosystems to store carbon.[85] The protection of other taxa is also crucial for maintaining the mitigation potential of natural ecosystems. Given the limited ability of plants to track their environmental optimum under global warming,[89] the conservation of other taxa, such as seed dispersers, is key to maintain the diversity of plant species, even though mammal and bird defaunation have already considerably reduced the capacity of plants to track climate change.[90] The improved management of agricultural lands is an NbS for mitigation that can increase biodiversity. For example, conservation agriculture, i.e., the use of a variety of crops, crop rotation, and cover crops, can rebuild soil organic matter and restore soil biodiversity, contributing to carbon sequestration in the long term.[91] Therefore, conserving and restoring biodiversity across all trophic levels—from genes to ecosystems—and across natural and modified ecosystems are important contributors to climate stabilization.[18,92]

Likewise, as some NbS for mitigation can lead to socio-economic benefits by improving the lives and livelihoods of people, addressing socio-economic needs can also increase the success of mitigation efforts. As presented earlier in this section, many NbS for mitigation can help people adapt to climate change by reducing the risks associated with flooding, landslides, and coastal erosion and providing food and water security during droughts. There are, however, many other social, economic, and health benefits that can be provided by NbS for mitigation that go beyond climate adaptation. For example, planting native tree species in agricultural lands increases soil carbon stocks and aboveground biomass while diversifying farmer income,[93,94] which is important for farmers to respond to changes in markets and non-climatic shocks.[40] The protection and restoration of forests for climate mitigation can improve forest-based livelihoods through ecotourism opportunities and the use and sell of non-timber products, increasing the stewardship of forests by those that strongly rely on them for their food security or livelihoods. Restoring grasslands for climate mitigation can improve livestock production and water regulation, improving the income of pastoralists[30] that are more likely to conserve restored ecosystems. Nature conservation and restoration can provide recreation, spirituality, and health benefits,[95,96] and contact with nature improves social cohesion, increases collaborations among members of a community, and reduces conflicts,[97] even though those connections have not been broadly studied. Ignoring the needs and interests of local communities from efforts to conserve, restore, or improve the management of natural and modified ecosystems, as well as the underlying social process that led to ecosystem degradation, are missed opportunities to help fulfill human needs through those actions. Furthermore, supporting local livelihoods has been shown as an additional motivation for adopting NbS for mitigation.[98] Therefore, understanding the needs of communities and the social processes that may lead to ecosystem degradation,[99] and co-planning NbS for mitigation considering those needs and processes, can increase the success of climate mitigation efforts.

CONSIDERATIONS TO ADDRESS THE MOST PRESSING GLOBAL CHALLENGES

Negative outcomes of NbSs for mitigation have been found in studies that looked at their effectiveness, costs, and provision

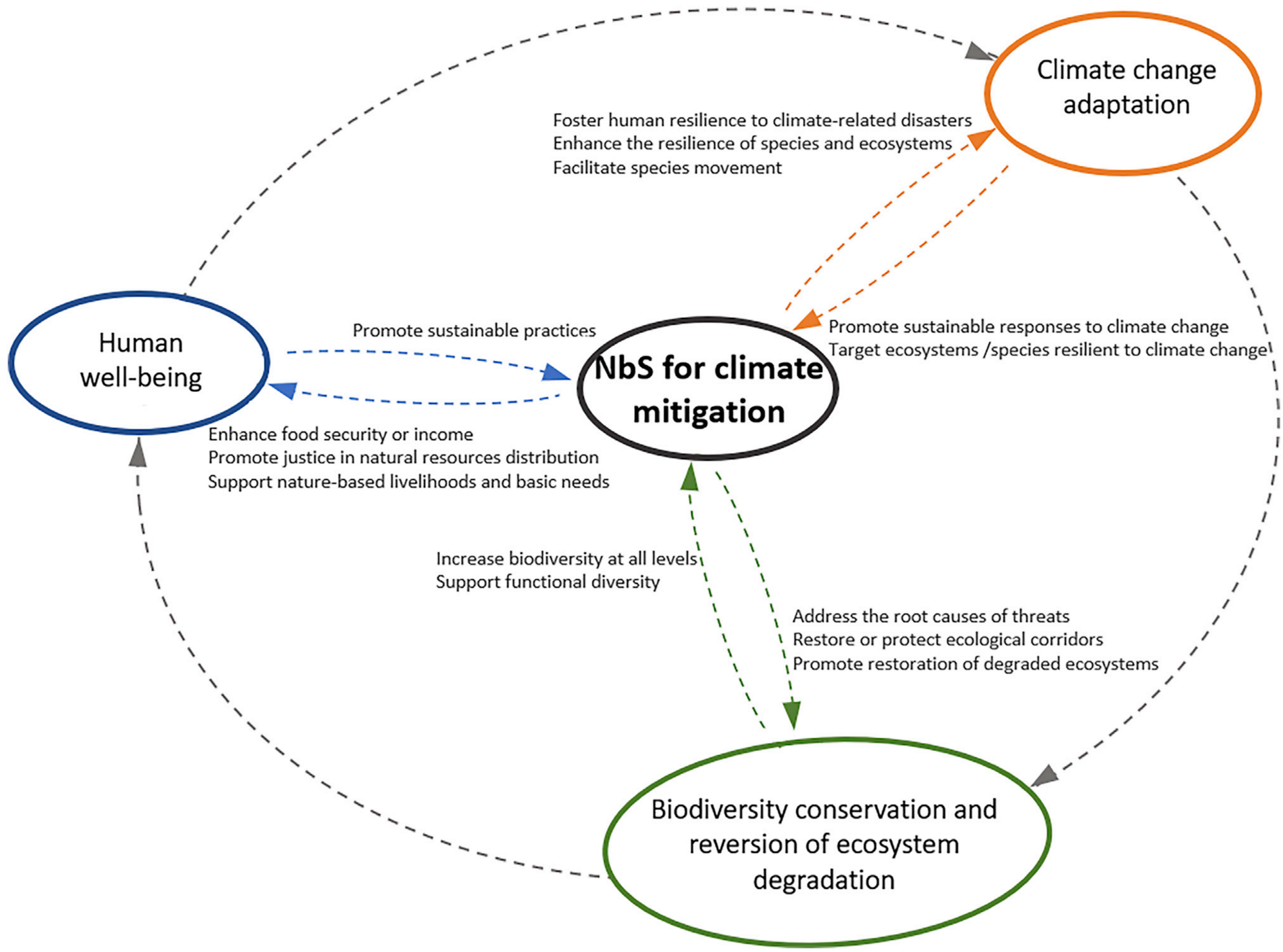

Figure 2. Potential outcomes of NbS for mitigation that considers several global challenges

of benefits,[10,25] with those that focus on providing a single or few benefits having a higher risk of overlooking trade-offs.[6] Therefore, planning NbS for mitigation considering other global challenges, in addition to climate mitigation, can highlight potential trade-offs and more efficiently help us tackle the climate and biodiversity crises and reduce their impacts on people's well-being, leading to the long-term provision of mitigation benefits. However, planning appropriate actions to address multiple global challenges is not an easy task. This is due to the many interactions among climate, biodiversity, and people, to the different temporal and spatial contexts on which they operate,[8] and to the lack of information at the relevant scale in many cases.

Nevertheless, using a practical set of considerations can help project managers and governments to plan NbS for mitigation that can optimize the provision of mitigation and non-mitigation benefits and help address today's global challenges. More specifically, our recommendation is to plan NbS for mitigation considering not only their climate mitigation potential but also their capacities to provide other benefits (Figure 2). This can be done by using, during the planning phase, information on the impacts of climate change on people, ecosystems, and species, the immediate need to reduce biodiversity loss and ecosystem degradation, and the dependence of people on ecosystems and the services they provide (Table 1). The set of considerations presented here builds on existing guidelines, including evidence-based guidelines for delivering successful, sustainable NbS with long-term benefits for people and nature (https://nbsguidelines.info), guidelines for planning NbS for climate adaptation,[100] IUCN's global standard for planning, implementing, and assessing NbS projects,[20] and on overall recommendations from existing social and environmental safeguards. For each of the considerations, we have identified the types of information that can be used while planning NbS for mitigation and examples of online platforms, tools, and datasets that could provide such information. Even though these considerations were identified to specifically help planning NbS for mitigation, they can be applied to any NbS implemented to primarily address other global challenges (e.g., biodiversity loss, climate adaptation, human well-being). In those cases, one additional consideration would be to reduce the release of greenhouse gases (GHGs) and/or to enhance CO_2 removal. For all three considerations, local, regional, and national plans and strategies for climate change mitigation and adaptation, biodiversity conservation, and human development should be consulted to gather existing information and to ensure the alignment of NbS for climate mitigation with local, regional, and national targets and goals.

Table 1. Factors to consider while planning NbS for climate mitigation to address global challenges

Factors to consider while planning NbS for mitigation	Types of information suggested to be gathered and reviewed	Specific outcomes that could be achieved through NbS for mitigation	Examples of where suggested information could be gathered
Consideration 1: contribute to climate adaptation	(1) current and future climate impacts on people	reduce current or future climate-related disasters, such as landslides, wildfires, coastal erosion, and/or flooding on people's lives and assets; help people adapt to the negative impacts of climate change on food and/or water security; minimize heat stress in urban areas	* platforms that provide climate indicators, such as temperature and precipitation, water discharge, and runoff in the target area, can help identify the potential climate impacts on local people and unsustainable adaptation responses that may be happening * information on riverine flood, coastal flood, and drought risks can be used to understand how and where the implementation of NbS for mitigation can facilitate the adaptation of people where water-related risks exist (e.g., Aqueduct, wri.org/aqueduct) * platforms that provide models to identify risks, such as a coastal vulnerability model, can be combined with population density to identify where people face higher risks of storms and surges (e.g., InVEST, naturalcapitalproject.stanford.edu/software/invest) * initiatives that identify areas where ecosystems can provide adaptation and mitigation benefits such as hotspots where the protection or restoration of mangrove and coral reefs can likely provide those benefits where most needed[101] * efforts that estimate species movement in response to climate change, such as the SPARC project (sparc-website.org), can help identify areas that are projected to conserve species or facilitate species movement in future climate conditions (e.g., SPARC project, sparc-website.org) * information from census data can help understand the livelihoods of people around and within the target area * local, regional, and national plans and strategies for climate adaptation, such as National Adaptation Plans (NAPs), N ational Adaptation Plans of Actions (NAPAs), and Nationally Determined C ontributions (NDCs)
	(2) current and future climate impacts on species distribution	facilitate species movement under climate change	
	(3) current and future climate threats on the integrity and/or function of ecosystems	enhance the resilience of ecosystems in the face of climate change	

(*Continued on next page*)

Table 1. *Continued*

Factors to consider while planning NbS for mitigation	Types of information suggested to be gathered and reviewed	Specific outcomes that could be achieved through NbS for mitigation	Examples of where suggested information could be gathered
Consideration 2: enhance biodiversity conservation, at all levels, reduce ecosystem degradation, and improve ecosystem integrity	(1) main threats that affect ecosystems and associated species	reduce the root causes of threats to specific species and/or ecosystems	* local-level information on species distribution, especially those classified as vulnerable, endangered, and critically endangered * world database of protected areas (protected planet.net/en) can support planning of NbS for mitigation in areas adjacent to those already protected or in areas that can work as ecological corridors * initiatives that identify degraded areas can help place restoration activities where they can contribute to land-degradation neutrality and reverse ecosystem degradation (e.g., Land Degradation Neutrality [LDN] target setting Program from United Nations Convention to Combat Desertification [UNCCD], unccd.int/actions/ldn-target-setting-programme; global degradation layer of resilienceatlas.org) * local, regional, and national biodiversity conservation plans
	(2) potential for ecological corridors or buffer zones that link protected areas, natural ecosystems, and/or lands owned by Indigenous peoples	restore or protect ecological corridors and buffer zones	
	(3) potential to reverse degradation of ecosystems with high biodiversity	reverse the degradation of ecosystems with high biodiversity that can provide mitigation, adaptation, and well-being benefits	
Consideration 3: address human well-being	(1) direct dependency of people on ecosystems for water and food security and other basic needs, such as shelter and wood for cooking	enhance food security or income; support the provision of basic needs to local communities	* information on the dependence of people on nature for basic needs[102] can guide the implementation of NbS for climate mitigation that can lead to both conservation and development outcomes and result in more just and effective actions (e.g., nature-dependent people mapping, ndp.resilienceatlas.org) * spatial planning and web-based tools that provide information on ecosystem services provision, such as non-wood forest products, water provisioning, nature-based tourism services, and grazing and fodder, can also be used to identify NbS for mitigation that can allow the provision of those benefits (e.g. Co$ting nature, policysupport.org/costingnature) * utilizing and following environmental and social safeguards and manuals for environmental peacebuilding are important resources to avoid any potential adverse environmental and social impacts of NbS for mitigation and to maximize social benefits * local, regional, and national development plans that consider the protection, restoration, and improved management of natural and modified ecosystems
	(2) reliance of people on nature-based livelihoods and/or nature-based income	support or diversify nature-based livelihoods and income sources	
	(3) potential conflicts that may arise with the NbSs for mitigation	reduce possible injustices or inequities in natural resources distribution	

Types of information suggested to be gathered and reviewed while planning NbS for mitigation, specific outcomes that could be achieved if consideration is taken and information is used, and examples of platforms, tools, and datasets, where suggested information could be gathered.

Contribute to climate adaptation

Understanding the negative impacts of climate change on people, species, and ecosystems and using that information to plan NbS for mitigation can lead to climate change adaptation benefits and contribute to long-term climate mitigation benefits. More specifically, the following information for the target area of implementation could be used to plan NbS for mitigation that could also provide adaptation benefits: (1) current and future climate impacts on people, (2) current and future climate impacts on species distribution, and (3) current and future climate threats on the integrity and/or function of ecosystems. With that information, NbS for mitigation could be designed in a way that, in addition to reducing the release of GHGs and/or enhancing CO_2 removal, could also (1) reduce the impacts of current or future climate-related disasters, such as landslides, wildfires, coastal erosion, and/or flooding, on people's lives and assets; (2) help people adapt to the negative impacts of climate change on food and/or water security; (3) minimize heat stress in urban areas; (4) facilitate species movement under climate change; and/or (5) enhance the resilience of ecosystems in the face of climate change. Those outcomes contribute to mitigation benefits in the long term by promoting sustainable human responses to climate change and by targeting ecosystems more resilient to climate change and/or species that are less likely to experience distribution retractions in future climate conditions.

Enhance biodiversity conservation and ecosystem integrity

Identifying key areas for the protection and restoration of biodiversity can increase the climate mitigation potential of NbS (see section 2). Such identification can be done by gathering and considering the following information for the target area of implementation while planning NbS for mitigation: (1) main threats that affect ecosystems and associated species, (2) potential for ecological corridors or buffer zones that link protected areas, natural ecosystems, and/or lands owned by Indigenous Peoples, and (3) potential to reverse degradation of ecosystems with high biodiversity. With that information, planning NbS for mitigation could be done in ways that, in addition to reducing the release of GHGs and/or enhancing CO_2 removal, could also (1) reduce the root causes of threats to specific species and/or ecosystems, (2) restore or protect ecological corridors and buffer zones, and/or (3) reverse the degradation of ecosystems with high biodiversity that can provide mitigation, adaptation, and well-being benefits. Those outcomes contribute to the provision of long-term mitigation benefits by increasing biodiversity at all levels and supporting ecosystems functional diversity.

Address human well-being

Enhancing the provision of socio-economic and health benefits to people can minimize further degradation of ecosystems and contribute to mitigation efforts. To incorporate socio-economic and health needs into the design of NbS for mitigation, the following information for the target area of implementation could be used: (1) direct dependency of people on ecosystems for water and food security and other basic needs, such as shelter and wood for cooking, (2) reliance of people on nature-based livelihoods and/or nature-based income, and (3) potential conflicts that may arise from implementing the NbS for mitigation. In addition to accessing this information, including local communities in the planning process to co-identify whether and how the NbS for mitigation can help them in the short and long terms is key to maximizing the success of the implementation. With that information, the NbS for mitigation could be designed in a way that it could, in addition to reducing the release of GHGs and/or enhancing CO_2 removal, also (1) enhance food and water security and support the provision of other basic needs to local communities, (2) support or diversify nature-based livelihoods and income sources, and/or (3) reduce possible injustices or inequities in natural-resources distribution, contributing to the provision of long-term mitigation benefits by promoting sustainable actions and the use of sustainable practices.

SUPPORTING NbSs FOR MITIGATION TO ADDRESS GLOBAL CHALLENGES

Here, we suggest a set of considerations, targeting project implementers and governments, that can facilitate the planning of NbS for mitigation in ways that they can also contribute to climate adaptation, reverse biodiversity loss and ecosystem degradation, and/or enhance human well-being, thereby contributing to address global challenges and to the success of mitigation in the long term. However, there are a set of actions that researchers and public and private donors could take to further support the broad and consistent adoption of such type of planning.

The first recommendation is to build on the set of considerations proposed here to further operationalize the planning of NbS for mitigation to provide multiple benefits. The set of considerations included in this perspective is the result of the collective experience of a small group of researchers and practitioners. This set of considerations could be used by different organizations and governments when implementing NbS for mitigation and then updated based on feedback to make it more operational, detailed, and adaptable to a variety of local contexts. The evidence around effective NbS, especially for climate adaptation and human well-being, is still limited, although it is growing. Therefore, as NbS for mitigation are implemented and synergies and trade-offs are being quantified and documented, that information can be used to further guide the planning of NbS for mitigation to also lead to adaptation, biodiversity, and/or socio-economic and health benefits.

The second recommendation is to provide free access to datasets and platforms that can be used for local-level planning. The complex linkages between the causes and consequences of global challenges, and the different time and spatial scales at which those different challenges—and solutions to those challenges—operate, require a variety of data and information to be considered during local-level planning. A better understanding of the impacts of climate change on ecosystems and species that can provide information on current and future hotspots for adaptation, biodiversity, and human well-being benefits, on the impacts of climate change on people that can shed light into potential responses that may affect ecosystems, and on the provision of ecosystem services that can highlight the reliance of specific beneficiaries on ecosystems is critical for planning NbS for mitigation that can also provide local-level benefits.

Therefore, making datasets and platforms that can be used to facilitate the planning of NbS openly available and continuing to produce spatially explicit data that can guide such planning should be priorities.

The third recommendation is to prioritize support to NbS for mitigation that have the potential to provide multiple benefits and that are aligned to views and priorities set at the local, regional, or national levels in addressing different global challenges. If NbS for mitigation can be planned and implemented to deliver multiple benefits and to contribute to local, regional, and national climate, biodiversity, and development goals and targets, the limited financial resources available for climate adaptation and mitigation and to address biodiversity loss and human development could be more efficiently used. Likewise, funds that still target the protection, restoration, and management of natural and modified ecosystems for carbon sequestration could reach more synergetic outcomes if NbS can be planned and implemented with multiple goals in mind. For those reasons, donors and funding streams could give priority to NbS for mitigation that have been planned to also provide adaptation, biodiversity, and/or well-being benefits and that can contribute to local, regional, and national goals. Furthermore, resources for demonstrating and monitoring benefits beyond climate mitigation are key for upscaling the use of effective NbS for mitigation that can help achieve multiple global challenges.

CONCLUSIONS

In this perspective, we highlight the importance of planning NbS for mitigation considering today's global challenges instead of just primarily focusing on reducing carbon emissions and sequestering CO_2. NbS for mitigation that also contribute to climate adaptation, enhance biodiversity conservation, reduce ecosystem degradation, improve ecosystem integrity, and/or address human well-being can help address one or more global challenges and favor the continued provision of mitigation services. Whereas this importance has been highlighted by other studies, this perspective presents a more practical guidance for project implementers and governments on how to incorporate those considerations while planning NbS for mitigation, by identifying the types of information that can be gathered, and by providing examples of online platforms, tools, and datasets that could be used to access such information. Those considerations were identified to specifically help plan NbS for mitigation, but they can be applied to any NbS interventions implemented to primarily address any other global challenges. Every nature-based effort should grasp the opportunity to address a variety of pressing issues to allow the continued delivery of mitigation and other benefits in this critical decade. A way to start is ensuring that a variety of global challenges are considered and factored in during the planning phase.

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AUTHOR CONTRIBUTIONS

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DECLARATION OF INTERESTS

The authors declare no competing interests.

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