Exploring the role of Nature-based Solutions (NbS) in addressing climate change

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Climate Change and Nature-based Solutions (NbS)

Climate change, environmental degradation and biodiversity loss have informed recent efforts to re-conceptualize the relationship between development and sustainability. The recently released Sixth Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC) unequivocally confirms that anthropogenic greenhouse gas (GHG) emissions have increased global average temperatures to 1.2° C since the period 1850-1900. If we remain on the current development path, this will reach 1.5°C by 2030 (IPCC 2021). The AR6 sends a very clear message on how climate change affects biophysical conditions on Earth: "human-induced climate change is already affecting many weather and climate extremes in every region across the globe." It also corroborates that we are already experiencing runaway climate change through certain events that resemble "tipping points" (such as the melting of ice sheets, resulting in catastrophic sea level rise) after which averting worst-case climate scenarios will be impossible.

As such, rapid and enhanced climate action is required to stay within the 2ºC limit, preferably 1.5ºC, enshrined by the Paris Agreement. Despite the stark outlook, however, clear pathways to keep climate change within controllable scenarios have been identified. A low carbon, climate-resilient, green development trajectory can lead to the attainment of sustainable and inclusive development that has remained elusive thus far. Since the Rio Conference in 1992, the international community has launched various initiatives to tackle climate change through mitigation measures; adjust to its adverse impacts through adaptation measures; and reduce vulnerability through increasing socio-ecological resilience. The United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol and the Paris Agreement remain significant political milestones. They have induced state commitments as well as the development of various approaches, mechanisms, and tools to enhance communities' resilience with a clear focus on technical solutions aimed at decarbonizing the global economy.

The COVID19 pandemic is testament to the fact that that with the requisite political will, humanity can indeed rapidly undertake rapid and massive GHG emissions reductions as witnessed in 2020 on account of the drastic lockdowns undertaken all over the globe. Some experts have predicted this to be the largest decline in anthropogenic CO_2 emissions after World-War II (IEA 2020; I. Khan et al. 2021).

The NbS concept

Nature-based Solutions as a concept started gaining traction particularly on account of its potential to tackle climate change impacts while simultaneously restoring biodiversity and ecosystems. Although the term "nature-based solutions" entered scientific literature in a notable way in the early 2000s (Potschin et al. 2015), it was only in 2016 that the International Union for Conservation of Nature (IUCN) first adopted an actual definition. Accordingly, NbS are **"*actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits*.**" (IUCN 2016; WCC-2016-Res-069). This definition puts societal challenges and hence people at the center of NbS which marks a considerable shift in the traditional school of thought in conservation. Contrary to many engineered-based solutions, NbS tackle both climate mitigation and adaptation at a low-cost while providing several additional benefits to nature and people (Seddon et al. 2020). NbS is an "umbrella concept" that comprises a large scope including: (i) Ecosystem-Based Adaptation (EBA), (ii) Ecosystem-Based Disaster Risk Reduction (Eco-DRR), (iii) Integrated Land Management (ILM), (v) Reduced Emissions from

Deforestation and Degradation+ (REDD+) and (vi) Natural Climate Solutions (NCS), Nature-based Climate Solutions (NBCS) or Nature-based Solutions for Climate (NbS4C).

The IUCN clearly distinguishes nature-based from nature-derived and nature-inspired solutions. Nature-derived solutions rely on renewable natural resources such as wind, wave and solar energy. Nature-inspired solutions imitate biological processes and strategies found in nature, e.g., through biomimicry. Both do not **rely (directly) on functioning ecosystems** - in contrast to NbS (IUCN 2021). In 2020, IUCN published its Global Standard for Nature-based Solutions which consists of eight criteria and 28 associated indicators. The very first criterion is meant to ensure that a nature-based solution is chosen to address a specific societal challenge identified and prioritized by those who are affected by it. IUCN presents seven societal challenges of which climate change mitigation and adaptation is one. The implementation of NbS often addresses several challenges simultaneously, but it is crucial to define the major societal challenge to be addressed in order to balance co-benefits and trade-offs (Criterion 6). Next to increased or stabilized human well-being, biodiversity net-gain is a predetermined co-benefit of all NbS applications (Criterion 3). Additional guidelines for Nature-based Solutions underline that NbS are **no substitute for the decarbonization of our economies and for the rapid phase-out of fossil fuels** (Nature-based Solutions Initiative 2020).

Relevance of NbS in addressing Climate Change

Addressing climate change requires efforts in greenhouse gas emission reduction, adaptation, and resilience building. As agriculture, forestry and other land use activities accounted for around 23% of total net anthropogenic GHG emissions globally during 2007-2016 (Seddon et al. 2020), successful GHG mitigation needs to take land management issues and ecosystems conservation into account. The potential contribution of NbS to emission reduction that keeps global warming under 2°C has been estimated as high as up to 30% (Seddon et al. 2019). Regarding adaptation, NbS enables people to reduce socio-economic vulnerability related to climate change. The three dimensions of vulnerability are (i) exposure, (ii) sensitivity to the impacts and (iii) adaptive capacity of the system. NbS can allow the reduction of exposure and sensitivity as it might enable securing water supplies, reducing flood risks and enhancing the delivery of ecosystem services on which livelihoods, wellbeing and economic activities depend. It might also help to support adaptive capacity, for instance, by providing a reservoir for wild species that allows them to face transforming conditions. Thus, NbS appears to be a relevant approach to address climate change in a holistic manner by combining efforts for emission reduction, increased carbon sink potential, cost-effective adaptation and improved resilience. But the effectiveness of NbS as carbon sinks and adaptation measures **strongly depend on how they are going to be affected by future climate change impacts**. Hence, limiting temperature rise through emission reduction is imperative for NbS to be effective in addressing climate change. Otherwise, NbS may even contribute to an *increase* in GHG emissions in the long term. This could be the case if for example reforested areas in certain climate zones become increasingly affected by wildfires in the future due to rising temperatures and droughts as a consequence of climate change.

NbS in practice

To explore the effectiveness of NbS in addressing climate change, this paper analyses and compares two case studies of NbS application by answering a broad range of guiding questions based on the IUCN Global Standard for NbS (detailed list of questions to be found in Annex 1). The main focus of the assessment lies in identifying climate change mitigation and adaptation benefits of each intervention, the bundle of co-benefits that comes with it, the role of community engagement and stakeholder buy-in, the bankability of the intervention as well as potential adverse impacts.

Case study 1: Nature based Solutions to reduce Climate Risks and build Social-Ecological Resilience in southern Cuba

Mangrove forests are found in the intertidal zone of the tropical and subtropical regions of the world, occupying less than 1% of the global coastal area (approximately 14 million hectares (Bunting et al. 2010). Despite mangroves' relatively low global coverage, they provide important ecosystem services to the world's coastal populations and support key biosphere functions such as coastal protection, carbon sequestration, and biodiversity conservation. They are highly productive ecosystems sequestering more carbon per unit area than any other tropical systems (Donato et al. 2011, Mcleod et al. 2011). It is estimated that mangrove forests provide over USD$80 billion per year in avoided losses from coastal flooding—and protect 18 million people. They also contribute almost as much ($40–50 billion per year) in non-market benefits associated with fisheries, forestry, and recreation. Combined, the benefits from mangrove conservation and restoration are up to 10 times the costs of their protection (Global Adaptation Commission 2019).

The vital role of mangroves is even more evident for Small Island Developing States (SIDS), where climate risks of rising seas, more frequent and intense tropical cyclones, and reductions in fisheries productivity comprise major threats to livelihoods, ecosystems, and infrastructure (Thomas et al. 2020). Societal challenges imposed by climate change – including significant reductions in livelihoods for coastal communities relying on small-scale fisheries, and increased impacts of extreme weather events such as hurricanes disproportionately affect SIDS. These constitute urgent challenges that require a proactive, solution-driven approach. Adaptation and survival of coastal communities are largely associated with the integrity of coastal marine ecosystems in Caribbean SIDS (Lincoln Lenderking et al. 2021) – and the conservation and restoration of mangroves constitutes a key NbS.

The island nation of Cuba in the insular Caribbean comprises wide-ranging mangroves, seagrass beds, and coral reefs (Galford et al. 2018). Resulting from a strong environmental agenda and slow development due to complex bilateral relations with the USA, Cuba has a large proportion of its land and coasts protected. About 70% of the coasts of Cuba are covered by mangroves (Galford et al. 2018). Cost-benefit assessments placed Cuba as one of the top countries receiving the greatest benefits from mangroves in averted land flooding and damages to people and property (Menendez et al. 2020). A large extent of Cuba's southern coasts is protected through a network of 29 marine protected areas (Perera-Valderrama et al. 2020). Of these, the Ciénaga de Zapata Biosphere Reserve (Cissell & Steinberg 2019) stands out for its vast extension and high ecological integrity. As the largest coastal wetland in the insular Caribbean, the Ciénaga de Zapata Biosphere Reserve encompasses a transition of ecosystems from forests and scrubland to marshes and mangrove swamps, to reefs. The approximate 340 km^2 of coastal mangroves covering Zapata's coastline buffered the impact of several hurricanes over the last decades. The costs of coastal natural defense provided by mangroves (e.g., costs of protection and / or restoration) are significantly lower when compared to building and maintaining hard engineered structures for coastal protection (e.g., seawalls; see Narayan et al. 2016) along Zapata's over 450 kilometers of coastline. Especially for extensive and highly conserved coastal ecosystems, the price difference increases even more when considering the range of additional co-benefits provided. Zapata's mangroves and seagrass beds shelter juvenile stages of various reef fish and are recipients of planktonic larvae from the open sea (Roman 2018) – supporting connected reefs and enhancing adjacent fisheries within the Gulf of Batabanó. 75 % of the total annual production of spiny lobster in the country is produced in this Gulf alone (Piñeiro et al. 2017). Additional co-benefits include high biodiversity and endemism, and recreational fishing and bird watching, (Galford et al. 2018; Kirkconnell et al. 2017). Because of its relatively low population (9,000 people in the entire 5,000 km^2 Zapata Peninsula) and large amount of temporarily flooded, no-usable lands, the restoration of Zapata's mangroves constitutes a rare win-win opportunity where nature and people benefit alike.

Mangrove restoration as an NbS offers a direct linkage to climate change adaptation benefits (e.g., protection against flooding), climate change mitigation (e.g., storing of blue carbon), and a bundle of co-benefits (e.g., coastal fisheries and aquaculture, biodiversity, etc.). However, if the social-ecological context is not considered from the design phase, these could fail or be unsustainable. Further, the early engagement of local communities as well as creating opportunities for direct engagement and benefiting from implementing mangrove-based NbS are key. For example, in Australia and New Zealand, traditional landowners partnered with scientists and government authorities in developing effective models for seagrass restoration - from seedling collection to replanting (Tan et al. 2020). Moreover, the assessment of potential negative effects from this NbS is also paramount. If mangrove restoration encroaches on other land use types / ecosystems, or affects people's livelihoods (e.g., some types of aquaculture), compensation schemes may be important elements within the NbS design. Active communication and wise selection of restoration sites are also crucial. Finally, quantification of adaptation and mitigation benefits derived from this NbS are key for its sustainability and scalability.

Case study 2: Nature Based Solutions for Water/Energy Infrastructure and Community Resilience in Ethiopia)

Covering approximately 1.14 million km^2 of landmass, Ethiopia is endowed with diverse natural resources and biodiversity. Historically, most of its highlands were richly forested. Yet, the highlands' ecosystems have been rapidly degraded on account of widespread deforestation, increased human and livestock populations, poor agricultural practices as well as unsustainable utilization of natural resources and land use practices. Consequently, the country is experiencing major environmental challenges including unprecedented soil erosion, gully formation, loss of soil fertility, biodiversity loss, decreased levels of ground water, and acute degradation of grazing lands. Climate change induced drought, flooding, and rainfall variability (erratic rainfall as well as shifts in seasons) have recently been exacerbating these challenges. Gebreselassie et al. (2016) calculates that the cost of action, over a 30-year horizon, to rehabilitate degraded lands during the 2001–2009 period is about $54 billion, whereas the resulting loss from inaction may amount to almost $228 billion. Moreover, land degradation in the face of a changing climate could place further severe stress on infrastructure related to energy, food production and water management, threatening economic development and the well-being of communities and ecosystems.

Recognizing the extent of land/forest degradation and their far-reaching adverse impacts, the Ethiopian government, with the support of several international agencies, initiated several land/forest rehabilitation programs, including large scale afforestation and reforestation schemes. In this regard, Ethiopia has made a strong voluntary commitment within the context of the Bonn Challenge to implement forest landscape restoration on 15 million hectares (ha) with the aim of improving the resilience of ecosystems, infrastructure, and communities. The Bonn Challenge commitment aligns well with the long-term objectives of the country's Climate Resilient Green Economy strategy (CRGE 2011) of achieving net zero greenhouse gas emissions by 2030 and building resilience against the impacts of climate change.

Hydropower dams in Ethiopia have enormous economic, social, and ecological benefits. Being a leader in renewable energy-based energy production on the continent, hydroelectric power is the backbone of the nation's energy infrastructure. Yet, the dams' sustainability continues to be threatened, inter alia, by unprecedented siltation. Hence, reclaiming degraded areas around its water reservoirs through afforestation and reforestation programs is strategically pivotal to build ecosystem, social and infrastructure resilience while simultaneously contributing to Ethiopia's ongoing climate mitigation efforts of reducing greenhouse gas emissions.

The proposed interventions in this project, a joint undertaking of the UN Economic Commission for Africa (UNECA) and the Ministry of Water & Energy (MOWE) of Ethiopia seek to build climate resilience of infrastructure, communities, and ecosystems in the surrounding areas of the hydropower dams in Ethiopia through NbS **-** integrated natural resource management. The interventions target, as a pilot, 5 regions of Ethiopia, namely Amhara, Oromiya, Somali, Afar and Addis Ababa, with plans to scale up contingent upon the success thereof as well as, crucially, the availability of finance). The implementation of the NbS will, *inter alia*, increase forest cover and carbon sequestration (by planting 50,000 multipurpose tree seedlings); minimize siltation by reducing soil erosion; and enhance livelihoods through participatory community forest management activities including youth and women groups. Moreover, the project will capacitate the implementing institutions as well as the local communities through knowledge exchange forums, training, and technology transfer schemes (such as improved fuel saving cook stoves and bee keeping). However, achieving the full potential of such interventions requires partnership with bilateral and multilateral development partners as well as contributions from the private sector.

More specifically, the **four major intervention** areas include:

- Increase carbon sequestration by managing 10,000 ha of indigenous and exotic tree species within the country's ongoing Green Legacy Initiative campaign;
- Rehabilitate up to 10,000 ha of degraded lands through the construction of various soil and water conservation structures;
- Build resilience of infrastructure, ecosystems and local communities by reducing siltation and improving the livelihoods of 10,000 households through the provision of energy saving stoves and other economic diversification (livelihood) options (e.g., fruit trees, fodder trees, beehives);
- Enhance the capacity of institutions and local communities (especially youth and women groups) involved in the project implementation through various interventions.
- Reduce the carbon footprint of the UN Economic Commission for Africa and other UN operations in the country by 50% via carbon-offsetting scheme

Preliminary lessons are being currently drawn from the pilot project although COVID-19 has undoubtedly delayed the implementation of certain activities. In light of its ambitious and long-term nature, the necessary calibrations are being made going forward as there are plans to not only *scale up* within the country, but *scale out* for replication to other African countries, contingent upon success thereof as well as, and crucially, availability of financing.

- '**Whole-of-society' approach with early multi-stakeholder involvement to create ownership**: Regional and local institutions (watershed committees, natural resource departments), local communities, youth and women groups, among others, were identified, consulted and included in project formulation from the onset towards long-term sustainability as well as forging synergies among similar initiatives. Moreover, all activities were gender informed and attempts were made to reach out to persons with disability to attain wide ownership.
- **Building awareness for buy-in:** During inception, deliberate efforts were made to brief stakeholders about the objectives and expected long-run benefits of the project. Awareness creation trainings were widely provided. These efforts have borne fruit as more communities requested to be involved in the project, necessitating an expansion. Some farmers are now readily offering their land as open spaces for afforestation purposes.

- **NbS costs much less than other engineered interventions:** If an NbS intervention is done well, the benefits can far outweigh the costs; more so compared to other interventions. Although an exact figure of economic value has yet to be calculated, some estimates postulate $54 billion (NbS) vs. $228 billion (without NbS); almost a 4-fold saving.
- **Linking project with livelihood and economic diversification objectives by creating employment opportunities:** The Ethiopian NbS has underscored the need for a *holistic approach* that balances restoration of nature/biodiversity and ecosystem integrity with the need to create *economic benefits for communities through job creation* - people, planet and prosperity. So far, more than 400 local communities participated in seedling planting and post-management activities who were all compensated monetarily as an incentive for engagement and maintaining buy-in. Notably, the majority of these were youth and women. Further, it appears that demand for fruit trees is high – it is viewed as an advantage to poor farmers, improving their nutrition and health status, while concomitantly playing a role in changing the microclimate of the surrounding area.
- **Enhancing financial sustainability for long-term success:** Introducing ecosystem services payment whereby communities in the upper watershed protect the forested slopes, moderate run-off and limit erosion and sedimentation, thus protecting the quantity and quality of the water supply for downstream users.
- **Inclusive training and capacitation of surrounding communities:** Community capacity building and training activities in site preparation, planting and post-planting management have massively improved the survival rate of planted multi-purpose tree seedlings (MPTS). Upon reaching maturity, siltation will significantly reduce, enhancing the life span of hydropower dams. There are plans to provide additional training going forward, particularly on fuel saving improved cook stoves.
- **Carbon markets, including international voluntary markets:** Accessing global emissions markets for carbon sequestration as one of the ways of attaining long term sustainability of the project will be key, particularly within the framework of innovative financing mechanisms given the limited levels of climate financing available to developing countries.

Table 1: Comparison of case studies

	Mangrove restoration in Cuba	**Energy infrastructure and community resilience in Ethiopia**
Societal challenge / Scale	Climate-change driven coastal flooding and loss of livelihoods / Zapata Peninsula	Climate change exacerbating already degraded lands / 3 key hydro-facility catchment areas and 2 other regions.
CC Adaptation / Mitigation benefits	Flood protection, erosion control, livelihoods / blue carbon storage	Soil erosion control, reforestation, livelihoods / carbon storage
Biodiversity benefits / Bundle of co-benefits	Increase quality and quantity of habitat for biodiversity (mangroves) / Fisheries, recreation, coastal protection	Increase quality and quantity of habitat for biodiversity
Primary NbS beneficiaries / community engagement	Coastal communities, country (NDCs) **/** **high community engagement**	Local communities, country (NDCs) / **high community engagement**
Investible/bankable potential of NbS	**Low** (due to limited access to international markets)	**High**

Cost-effectiveness compared to engineered or other solutions	Several levels of magnitude **more cost effective** than building and maintaining extensive sea wall or similar	Considered **more cost effective** than non NbS solution
Risks/potential negative impacts of the NbS	**Low participation, uneven benefit distribution, post project management**	**Low participation, uneven benefit distribution, post project management**

See detailed version of comparative table in Annex 1.

Conclusion & recommendations

The two case studies have shown that NbS can indeed be an effective tool to address climate change. The major strength of the concept lies in the accounting of the various co-benefits that NbS may provide. Choosing an NbS also incentives bottom-up approaches that focus on actual needs of the final beneficiaries and requires to engage them from the very beginning of the intervention. Effective stakeholder engagement is a prerequisite for any NbS to work. The case study comparison also strengthens the argument of NbS being more cost-effective than other, e.g., engineered solutions.

More **benefits of the NbS concept** include:
- Incentivizes multi-stakeholder, multi-level, land- and seascape approach
- Encourages needs-based, cost-effective, functional, integrated and sustainable approaches
- Applies at various scales
- Aligns with global goals such as those of the 2030 Agenda for Sustainable Development

But the application of the NbS framework comes with some fundamental **challenges** as well. The major risks and potential negative impacts identified in both case studies are low participation, uneven benefit distribution and insufficient post-project management. Also, the economic viability of the NbS chosen were assessed quite differently. In the Ethiopian case, the bankable potential was considered high while this was considered low in the case of Cuba. This has to do with Cuba's limited access to international markets but this may also be due to services expected to be provided by a state's government being less investible than those that are widely privatized.

From a conceptual point of view, a few more challenges became apparent. Firstly, biodiversity gain is defined as one of two basic conditions of a NbS. Biodiversity loss and environmental degradation have ultimately also been defined as a societal challenge within IUCN Global NbS Standard, following the request by IUCN members. This seems to disturb the original logic of the standard and leads to post-reframing of conservation projects as NbS. This does not make them less effective but may require or lead to profound changes in the intervention logic. Looking at NbS that address climate change, the integration of adaptation and mitigation in one societal challenge as suggested by the IUCN may ignore potential trade-offs between these two. Another challenge in assessing the effectiveness of NbS is the limited availability of lessons learnt and best practices regarding the concept as well as the lack of clearly defined indicators, safeguards and standardized methodologies for impact assessment and cost-effectiveness evaluation of NbS. As use of the concept accelerated very recently following the presentation of the global standard by IUCN, new NbS interventions do not have access to a broad basis of lessons learnt yet.

The review of benefits and challenges allows for several general conclusions:

- NbS is **not a "one size fits all" solution**. It has its own **risks and trade-offs** that should be further discussed and researched on. Going back to the definition and qualifiers of NbS, it can be deduced that each solution will have a unique set of preconditions, though the solution must strive towards replicability and scalability.
- NbS does **not equal conservation**. NbS as an approach is intertwined with climate change discussions, wherein the balance between biodiversity and people relying on ecosystems will always be a point of discussion and debate. Striking this balance is critical to achieve sustainability (Stabinsky 2021).
- Selecting NbS can be a **cheap and effective option**; but it also can be less effective in specific circumstances. NbS for flooding were estimated to be two to five times cheaper than infrastructure or gray solutions. However, there are other aspects that should be considered together with the overall economic value of NbS such as urgency and duration for any solution to fully provide the intended service. Hence, the decision-making process in selecting NbS can be different on **a case-by-case basis.**
- NbS also functions with no standardized approach to cost-benefit-analysis, ecosystem service valuation, and cost-effectiveness assessment. NbS is inherently **complex to assess in terms of co-benefits**.
- NbS is **not perfect**. It has its fair share of **criticism even among practitioners** (too technical; no new concept, does not address root causes, risk of "green-washing"/misuse, no global definition accepted by states yet, risk to lower mitigation efforts in key sectors (transport, industry, energy) while **phase out fossil fuels must remain a priority**, etc.). NbS is often criticized as being manipulated by developed countries to deliver on carbon offsets and in the process reduce the importance of community-led adaptation efforts (Stabinsky 2021).
- NbS is **just one of the tools** in the toolbox. It is unnecessary to pit NbS against other solutions in absolute terms because these solutions could actually work in complementarity with each other. Pitting green (NbS) against gray (hard) infrastructure should be avoided especially in coming-up with comprehensive development plans (Seddon et al. 2020). NbS can **contribute** to a socio-ecological transformation but cannot be considered **a silver bullet**.

Key recommendations for practitioners and policy makers:

- ✓ Start with and do not lose focus on the **societal challenge**.
- ✓ Be aware of **root causes**.
- ✓ Define the **level and boundaries** of your intervention.
- ✓ Apply a holistic **land- or seascape** approach.
- ✓ Ensure equal and continuous **engagement of all stakeholders** from the very start.
- ✓ Be clear about **trade-offs and limitations**.
- ✓ Ensure **sustainability** of the intervention (inter alia through secured funding, creation of employment opportunities and stakeholder buy-in).
- ✓ Take **future climate change impacts** into account.

Annex 1: Comparison of case studies

a) Guiding questions

- What's the scale?
- What NbS can be applied (design)?
- What are the biodiversity benefits?
- What are other co-benefits?
- What are potential negative impacts and trade-offs of the NbS?
- How does the NbS interact with the broader land- or seascape?
- Are future climate change impacts taken into account?
- Who is affected by the NbS? Which stakeholders need to be engaged?
- Is the NbS investible/bankable?
- How is the cost-effectiveness (long-term vs. short-term) of the NbS, compared to engineered or other solutions?
- How sustainable is the NbS?

b) Comparative table (long version)

	NbS to reduce climate risks and build social-ecological resilience in southern Cuba	**NbS for water/energy infrastructure and community resilience in Ethiopia**
Societal challenge to be addressed	Climate-change driven coastal flooding and loss of livelihoods (reduction of fisheries productivity)	build climate resilience of infrastructure, communities, and ecosystems in the surrounding areas of hydropower dams in Ethiopia through integrated natural resource management interventions.
Scale	Ciénaga de Zapata Biosphere Reserve (6282 km^2)	3 key hydro-facility catchment areas in the Amhara, Afar and Oromiya regions of the country – Nile Sub basins (Mugar, Guder and Jemma watersheds) as well as 2 other regions: Somali and Addis Abeba
NbS type	Community-based mangrove protection and restoration; blue carbon financial mechanisms	Integrated natural resource management Nbs intervention (infrastructure, ecosystems, community livelihoods)
Biodiversity benefits	Landscape and seascape wide benefits including conservation of mangroves, seagrass, and coral reefs; sustenance of endemic and migratory species	Increased biodiversity due to re-afforestation and reforestation of degraded lands; improved soil fertility; improved diversification of tree species will contribute to increased variety of flora.
Other co-benefits	Fisheries, recreation, coastal protection	Increased carbon sequestration (national and international benefits); employment for local community, youth and women groups; creation of market linkage opportunities; better watershed management; decreased vulnerability to climate shocks; improved ecosystem services; improved livelihoods

Potential negative impacts/trade-offs of the NbS	**Lack of community involvement;** NbS not effective if sea level rise is not considered in restoration planning; uneven distribution of benefits from blue carbon finance	**Lack of community involvement**; Lack of sufficient funding; lack of sufficient human and institutional capacity; Insufficient survival rate of planted tree seedlings; inadequate post tree planting management and soil/water conservation activities
NbS interactions with the broader land- or seascape	Inland interactions: mangrove forests will take on salt marshes as sea level rises; mangroves supporting healthy seagrass and coral reef ecosystems	Reduction in greenhouse gas emission through increased carbon sequestration will have far-reaching benefits, even beyond national borders...
Future climate change impacts	Sea level rise	Potential droughts - lack of sufficient rainfall
Primary NbS beneficiaries	**Local coastal communities**; and country's NDCs	**Local communities** in the targeted watershed; youth and women groups for whom temporary employment will be created. indirect beneficiaries range from regional states to international communities through increased carbon sequestration, ecosystem integrity and biodiversity restoration.
Stakeholder engagement	Local communities; local, provincial, and national environmental agencies, tourism sector, NGOs	Local communities in the targeted watershed; UNECA; Ministry of Water, Energy & Irrigation, development partners (Sweden), UNEP; UN-REDD; watershed communities; Zone/Wereda natural resource departments
Investible/bankable potential of NbS	**Low potential** due to 1) mangroves not at high risk of deforestation, and 2) economic embargo on Cuba affecting any possible global or bilateral market involvement	**High potential**
Cost-effectiveness compared to engineered or other solutions	NbS several levels of magnitude **more cost effective** than non NbS solution (considering co-benefits)	This particular NbS is considered **more cost effective** than non NbS solution (considering wide range of co-benefits)
NbS sustainability	If NbS implementation considers social-ecological context from the onset, sustainability can be achieved	Sustainability can be achieved through: Community institutional development and capacity building; economic sustainability: livelihood diversification and creating market linkages for both domestic; financial sustainability: by introducing ecosystem service payment where communities in the upper watershed protect the forested slopes, moderate run-off and limit erosion and sedimentation, thus protecting the quantity and quality of the water supply for downstream users. Carbon markets, including international voluntary markets: By utilizing the global emissions markets through the projects carbon sequestration activities

Annex 2: Literature

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