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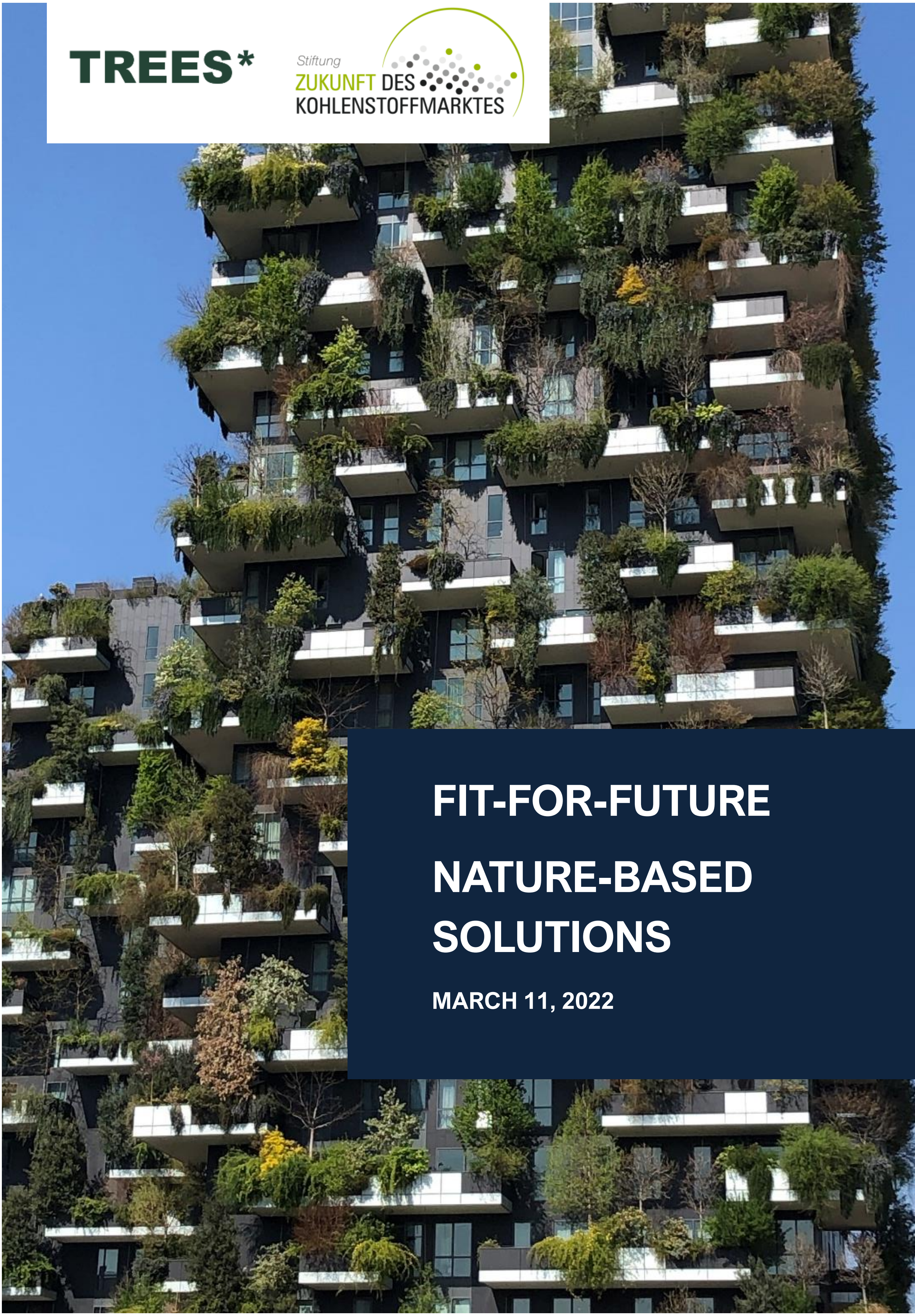

FIT-FOR-FUTURE

NATURE-BASED SOLUTIONS

MARCH 11, 2022

Foreword

This document is a follow-up study to the previous publication *Nature-based Solutions in Carbon Markets* commissioned by the Foundation Future of the Carbon Market to TREES. It is intended to complement and further expand the knowledge on nature-based solutions as one of the many solutions that help mitigate climate change and adapt to its adverse effects.

The aim of this publication titled "*Fit-for-Future Nature-based Solutions*" is to inform policy makers, practitioners and the broader carbon market community on (i) the impact potential of different types of nature-based solutions in terms of emission reduction and carbon sequestration but also in terms of co-benefits in order to prioritize investments, (ii) success criteria that help shape nature-based solutions to be "fit-for-future", and (iii) quantification methodologies through providing a first-of-its-kind overview on currently available methodologies across several carbon standards and recommendations for further development. The latter is accompanied by a spreadsheet listing the single methodologies according to several parameters, which allows respective filtering and searching.

Information on the Study Initiator and Funder

- The Foundation Zukunft des Kohlenstoffmarktes was established in 2011 to promote environmental and climate protection in developing and emerging countries. The Foundation aims to support innovative carbon market mechanisms and access emission reduction potentials that so far have barely been tapped by the carbon market. A particular focus has been set on programmatic activities as a means to develop more effective market mechanisms for global climate protection. For more information: http://www.carbonmarket-foundation.org/home

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- TREES - as solution architects and developers for traditional and new innovative NbS at quantification, program, and governance levels - is highly engaged to accelerate and expand the solid and long-term implementation of NbS based activities. Building on more than decade of NbS experience in compliance and voluntary carbon markets developing projects and programs, quantification methodologies, MRV systems, governance components, and corporate scope 3 value chain programs, TREES aspires to drive innovation in carbon markets and activities. For more information please visit: https://trees-consulting.com/

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Contents

Glossary of Terms and Abbreviations

ACR	American Carbon Registry
AGR	Agriculture
A/R	Afforestation / Reforestation
ARR	Afforestation, Reforestation, Forest Restoration
Baseline	Pre-project GHG emissions or carbon stock
BECCS	Bioenergy Carbon Capture and Storage
Biochar	Charcoal produced from pyrolysis of biomass, often used as a soil conditioner and under consideration for long-term carbon storage (in the soil).
Blue Carbon	Carbon stored in coastal and marine ecosystems
CAR	Climate Action Reserve
CCS	Carbon capture and storage
CDM	Clean Development Mechanism
CH_4	Methane
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
Crediting period	Time span in which SDG impacts can be accounted for and are subject to monitoring
DNA	Designated National Authority
EC	European Commission
EU	European Union
GHG	Greenhouse Gas
GS	Gold Standard for the Global Goals
IFM	Improved Forest Management
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
LIDAR	Laser Imaging, Detection, And Ranging: a method for determining ranges (variable distance) by targeting an object with a laser and measuring the time for the reflected light to return to the receiver
Livestock	Domesticated animals raised in an agricultural setting to produce commodities such as meat, eggs, milk
MRV	Monitoring Reporting and Verification
Net Zero	Cutting greenhouse gas emissions to as close to zero as possible, with any remaining emissions re-absorbed from the atmosphere, by oceans, forests, and soils for instance.
N_2O	Nitrous oxide
NbS	Nature-based Solutions
NCS	Natural Climate Solutions
NDC	Nationally Determined Contributions
NGO	Non-governmental organization
Plan Vivo	Plan Vivo Foundation – For Nature, Climate and Communities
REDD	Reducing Emissions from Deforestation and Forest Degradation
REDD+	Reducing Emissions from Deforestation and Forest Degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries
SB	Supervisory Body
SDG	Sustainable Development Goals
SOC	Soil Organic Carbon
t	metric tons
TSVCM	Taskforce on Scaling Voluntary Carbon Markets
UN	United Nations
UNEP	United Nations Environment Programme
US$	United States Dollar
USA	United States of America
USDA	U.S. Department of Agriculture
UK	United Kingdom
VCS	Verified Carbon Standard (Verra)
WEF	World Economic Forum
WWF	World Wide Fund For Nature

1 Introduction

Nature-based Solutions (NbS) are being broadly discussed regarding their potential to contribute to climate change mitigation and adaptation. Investigations into NbS feasibility – some of which we will discuss in this report – have also shown barriers for implementation. Identifying "Fit for Future" solutions is thus essential to prioritize and scale NbS activities.

In a previous study and articles (Gehrig-Fasel et al 2021a and Gehrig-Fasel et al 2021), we have looked into the potential of NbS in carbon markets, their implementation status, barriers, interaction with emerging governance under the Paris Agreement, and "building blocks" to foster implementation in developing countries. The reports conclude that NbS implementation can build on experience, structures and tools available in voluntary carbon markets, though gaps need to be closed and barriers eliminated in governance systems, policies and safeguards.

In this study, we focus on the global picture from a practical perspective, assessing what will make NbS systems Fit for Future and maximize their impact. We are looking into global GHG impact potential for a broad scope of NbS activities, success factors and incentive systems in various market and non-market environments, and, last but not least, at the scope of existing GHG quantification methodologies to quantify benefits from NbS.

We generally follow the definition for NbS from IUCN, stating that 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", including climate change as one of six broad societal challenges that nature can help address (the others are disaster risk, food security, water security, socio-economic development, and human health).

At a global scale, it is evident that considering "modified ecosystems" is important in the endeavor to maximize impacts from Nature-based Solutions – or, as WWF (2020) phrases it, it is important to include all ecosystem types that can provide climate benefits such as wetlands, forests, mangroves, coral reefs, grasslands, working lands, and urban landscapes. Many such systems include potentially conflicting commercial interests that need to be aligned with NbS programs aiming for emission reduction or GHG removals – which is an important factor we will be discussing in this study in the context of realizable impact potential.

In the following sections, we first present an overview of global impacts from different NbS types, based on a number of recent studies. However, as this overall potential will not be realizable in the short term, and not in carbon market activities alone, we will assess the solutions presented against a set of "success criteria" for NbS implementation in carbon markets.

2 Global Impact Potential for NbS

A series of studies has assessed and quantified NbS impacts on GHG emission reduction and carbon sequestration and their co-benefits (compare also section 2.3), presenting impressive potential for NbS in medium to long-term implementations at global scale (Griscom et al. 2017, Girardin et al 2021, McKinsey & WEF 2021, Roe et al 2019, Roe et al 2021, Wilkiinson 2020) or for specific sectors (Forester et al 2021, König et al 2019 for forests, Miralles-Wilhelm 2021 for agriculture, Worthington and Spalding 2021 for mangroves, Bulkeley 2020 for the EU and a strong focus on urban NbS).

A recent synthesis of these publications (UNEP & IUCN 2021) summarizes global potential for NbS across a wide range of activities and impacts. The publication points out commonalities and differences in the estimates of global impacts and the uncertainties that all such estimates inevitably include.

Regarding NbS activities, these studies agree that:

- Across ecosystems, the overall mitigation potential is highest in forests, followed by grasslands and agriculture.
- Peatlands and coastal wetlands represent a very high potential per hectare but have a lower overall potential due to their smaller area.

This understanding is broadly reflected in NDCs, which more frequently put forward solutions for mitigation centered on forests, grasslands and agriculture than for other ecosystems.

NbS impacts encompass avoided emissions (from protection of forests and natural ecosystems), emission reductions (from improved management) as well as greenhouse gas removals (e.g. from afforestation and ecosystem restoration). Notably, the common activity categories in forest and ecosystem management "protect", "manage" and "restore" can each encompass different impacts (e.g. emission reduction and avoidance, as well as removals in a "restore" activity on degrading land).

In the impact quantifications, the various authors' estimates vary for several reasons, all of which have to be kept in mind when discussing absolute impact numbers (compare Figure 1):

- **Cost cut-off:** The cost threshold for "practical" NbS is a key factor in the determination of overall potential and directly impacts quantification of global potential. Griscom et al (2017) showed that when parameters were restricted to solutions that cost up to US$ 100/tCO_2e, 11.3 GtCO_2e per year was found to be possible, or 4.1 GtCO_2e per year if only budgeting for US$ 10/tCO_2e. Girardin et al (2021) estimates 2050 benefits at >18 GtCO_2e/year by 2050 at US$ 200/tCO_2e (post 2025) compared to ~10 GtCO_2e/year at US$ 100. McKinsey & WEF 2021 limited the assessment to "land rent" of US$ 45 and fewer practices (see below), thus presenting a lower overall impact.
- **Scope of activities:** McKinsey & WEF 2021 include only eight compared to Griscom's (Griscom et al 2017) nine response activities. Roe et al 2021[1] includes BECCS (bioenergy carbon capture and storage, see Box 1), which is technically not an NbS. Such differences in assessed activities significantly impact estimated impacts, even if these differences are at lower detail level that the overarching response types presented.
- **Timeframe and rate of implementation:** Due to the relatively short remaining timeframe until 2030, actual implementation potential is limited, resulting in differences between recent syntheses in 2021 and Griscom's original study in 2016. Notably, the development of NbS has not met the optimistic expectations set at that point. Roe et al 2019 uses slower scale-up estimate for NbS, resulting in lower 2030 impact.

Box 1: BECCS, a semi-natural Carbon Capture and Storage (CCS) approach

GHG removals, specifically carbon sequestration in plant biomass, is a key part of many NbS. Binding carbon from the atmosphere is not exclusive to biological systems, though, and various technological approaches for carbon capture and storage (CCS), also called "negative emission technologies", are in development or already operating pilots. A key difference between natural sequestration and technical CCS is the need for energy with the latter – energy which must be generated from renewable sources in order to achieve the desired reduction in CO_2.

Bioenergy Carbon Capture and Storage (BECCS) is a combination of carbon sequestration in biomass, energy production from this biomass by combustion or conversion to biofuels and capturing and storing the CO_2 produced in this process. Similar to NbS, a biological system is used to capture the CO_2 from the atmosphere. However, BECCS then use different approaches for carbon storage (e.g. CO_2 storage in deep geological formations) and can thus be considered an alternative approach to circumvent potential spatial restrictions for NbS to permanently store carbon in natural carbon pools such as forests and soils.

[1] Roe 2021 is not included in UNEP & IUCN 2021 but presented in section 3 of this study.

2.1 Estimated Global Impact

Figure 1 (from UNEP & IUCN 2021) compares different impact estimates for NbS by 2030 and 2050 by activity category (protect, manage, restore) and type (e.g. Avoided Forest Conversion, Conservation Agriculture, etc.).

Activities assessed include avoided emissions from forest or ecosystem protection, greenhouse gas removals in reforestation or wetland restoration, as well as mixed approaches in improved land management (natural ecosystems as well as agricultural lands).

Figure 1 (from: UNEP & IUCN 2021): Estimates of annual mitigation potential in GtCO2e for 2030 and/or 2050. Showing Protect (P), Manage (M) and Restore (R) summaries and response options (sources: Griscom et al. 2017 (mitigation <US$ 100/tCO2e); Girardin et al. 2021 (<+2°C scenario); McKinsey & Company 2021 (practical mitigation); Roe et al. 2019 (1.5°C wedges - nature-based solutions only))

From above results, several basic observations can be made:

- Short-term (2030) impacts depend more on protection (i.e. avoidance of carbon losses) while long-term (2050) impacts benefit from sustainable management practices and restoration (slower changes, e.g. in removals and long-term practice changes in agriculture and forestry).

- Forest related NbS types, including forest protection, sustainable management and reforestation activities dominate quantitative impacts.
- Avoided peatland and wetland impacts contribute considerable to the overall impact despite much smaller areas. These activities, bridging between terrestrial land use activities (agriculture) and aquatic systems (blue carbon), are thus expected to play an important role as high-value programs in the expansion of NbS.
- Contributions of improved agricultural activities varies, also in type of activities, and is seen rather as a long-term effect (in line with slower change in carbon sequestration, e.g. in soil).

2.2 Estimated Regional Impacts

A breakdown of NbS impact potential to regions and countries is presented in Roe et al. 2021. The authors identify regional differences in overall technical potential and cost-effective potential (max US$100/t$CO_2$e) with additional insight in NbS approaches[2] (Figure 2a):

- Similar to the overall impacts presented in the previous studies, the largest sectoral impact in all regions is in forests and natural ecosystems (except Eastern Europe and West Central Asia). Regional differences are identified in the type of activity and split between emission avoidance (ecosystem protection) versus removals (ecosystem restoration) or mixed approaches (ecosystem management).
- Generally, less than half of the "technical potential" is expected to be implemented at a cost efficiency of US$100/t$CO_2$e, with a significant loss in the contributions from ecosystem restoration (where implementation cost are often prohibitively high).
- In contrast to the earlier studies, agricultural practices make up 38% of cost effective GHG reductions (34% as carbon sequestration and 4% from emission reductions), corresponding to 44% when excluding demand-side measures and BECCS[3].
- Highest regional NbS impact potential is identified in Asia and Developing Pacific regions, followed by Latin America and the Caribbean. Lowest potential for NbS is seen in Eastern Europe and West Central Asia.
- Cost effective potential also shows differences between regions:
  - In developed countries, cost-effective potential focuses on carbon sequestration in agriculture and the ecosystem protection, management and restoration activities.
  - In Latin America and the Caribbean, forest protection is predominant, followed by carbon sequestration in agriculture
  - For Africa and the Middle East, ecosystem management is identified as the largest impact solution, also with carbon sequestration in agriculture with second most impact.
  - Asia and Developing Pacific show majority impacts from carbon sequestration in agriculture with ecosystem protection as second. Notably, the region also has the strongest mitigation potential in agricultural emission reductions worldwide.

[2] The study also includes demand-side measures and BECCS which are not further commented in this review.
[3] Bioenergy with Carbon Capture and Storage – see also Box 1

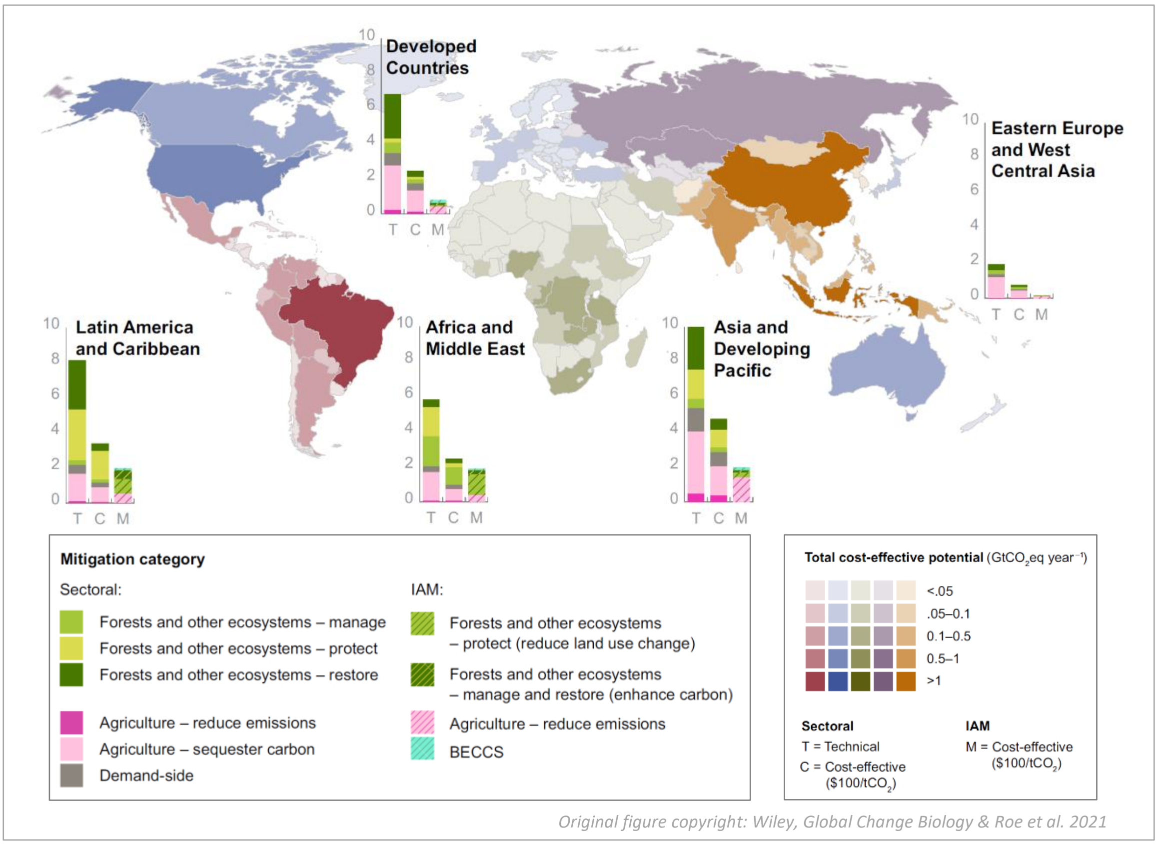

Figure 2a (extract from: Roe et al 2021): Country-level map of total cost-effective ($100/tCO$_2$e) mitigation potential. The five colors on the map correspond to the five IPCC regions assessed in the study. Bar charts show the share of mean technical (T), cost-effective (C), and integrated assessments model (IAM) mitigation by mitigation category, aggregated into the five IPCC regions (GtCO$_2$e/year).

Looking at per-hectare impacts (Figure 2b, below), regional differences can also be identified:

- In Developed Countries the importance of ecosystem protection stands out (highest average per-area impact worldwide).
- Africa and the Middle East show a lower potential for carbon sequestration in agriculture compared to other regions but a somewhat higher per-area impact of ecosystem restoration.
- In Asia and Developing Pacific relative increases in impact of agricultural emissions and ecosystem restoration have been observed.

Roe et al (2021) also present a more conservative assessment of impacts in integrated assessment models (IAM), derived from lower-end estimates across the study and therefore resulting in considerably lower overall potential for NbS (<50% for Developed Countries, Asia and Developing Pacific, and Eastern Europe and West Central Asia).

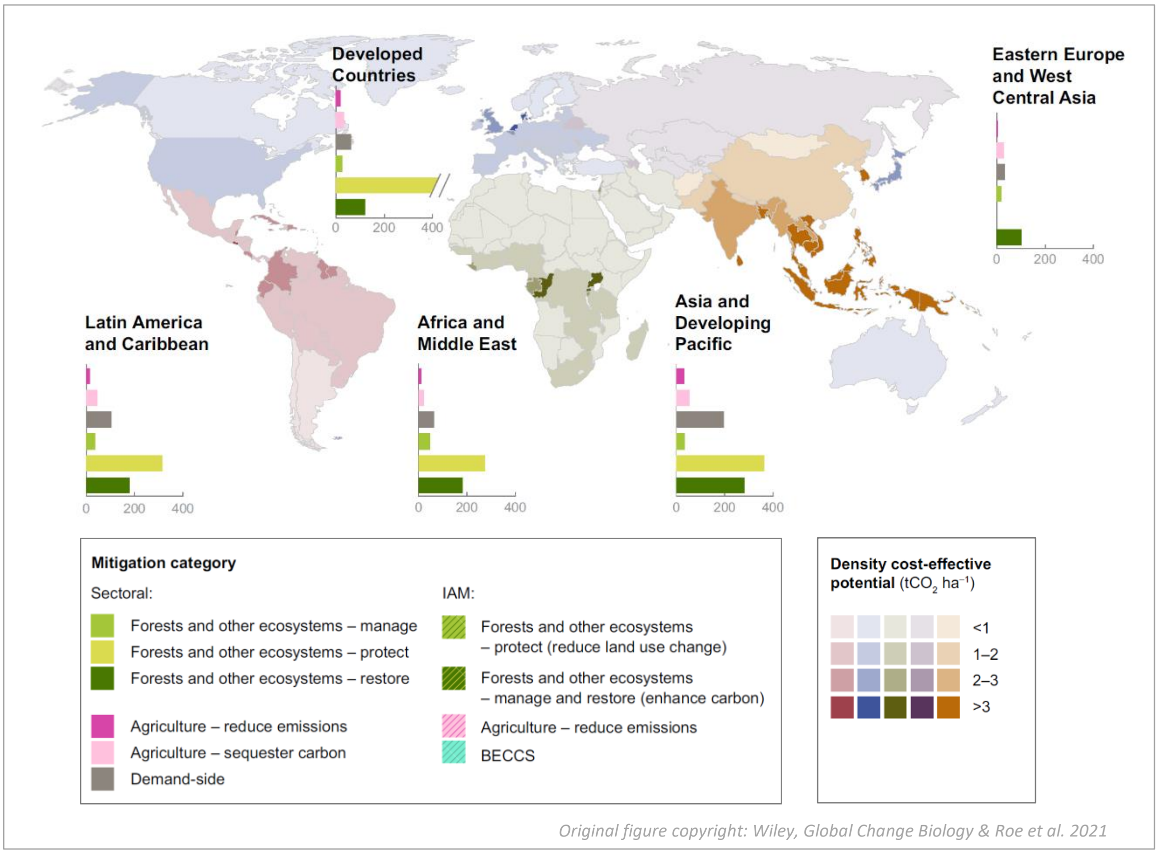

Figure 2b (extract from: Roe et al 2021): Country-level map of cost-effective mitigation potential density (potential per hectare in 2020–2050). Bar charts show the regional mitigation density by category (tCO_2e/ha) cumulative potential divided by total land area per measure per region) for 2020 to 2050. "Protect" measures in Developed Countries show high density due to the very small land area associated with high potential from peatland protection

2.3 NbS Activity Assessment

In the following, key NbS activities, from "conventional" to "innovative" are discussed in some more detail, expanding on conclusions from IUCN's assessment, including activities from all NbS sectors (forestry, agriculture, blue carbon). Also SDG contribution per activity is discussed.

REDD: UNEP & IUCN (2021) state that "there is a strong consensus that avoided forest conversion holds the greatest mitigation potential, because of the extent of forest that continues to be lost and the immediate benefits of retaining existing forest compared to waiting for new forest to grow. Preventing deforestation avoids a pulse of carbon emissions, which would take years to recover if the same site were then reforested. As the synthesis studies have been refined through time, estimates of the overall potential from options to restore ecosystems have decreased, especially for reforestation, while still remaining substantial. Estimates for the potential mitigation benefits from options that manage ecosystems are very variable, being influenced by the number of response options included and assumptions about how fast they can be scaled up."

On the other hand, REDD projects in carbon markets and jurisdictional approaches have shown the complexity and governance issues (stakeholders, policies) of such long-term approaches which often do not generate any other benefits to stakeholders than carbon money. While the technical potential is considered high, implementation and efforts are also high, operations often cost intensive and long-term protection under risk in areas with fast changing governments. This is also visible in synthesis studies that indicate a reduced impact from avoided ecosystem conversion when considering the cost effectiveness (e.g. Roe et al. 2021, cf. Figure 2a).

A key impact in REDD and REDD+ projects is the integration of social and environmental benefits (contributions to SDG 15 as well as various Aichi Biodiversity Targets[4]). They are thus often seen as more than climate change mitigation activities (SDG 13) but rather sustainable development initiatives, which is an incentive to continue the development of REDD(+) programs and address financial and operational challenges (UNEP 2018[5])

Afforestation/reforestation (A/R) encompasses a range of practices involving natural regeneration or active planting of trees to create forests. The latter commonly leads to more rapid absorption of CO_2 over the first twenty years - at higher implementation cost. When assessing the technical potential for afforestation, it must be considered that not all land that *can* be converted to forest, *should* be converted. Afforestation of natural grasslands, wetlands or savannas may have negative impacts on SDGs (e.g. biodiversity) and thus not meet the multi-benefit goals associated with NbS. Also, under the accepted carbon standards, projects must prove that their lands were not deforested within 10 years prior to project start. Thus, eligible lands for afforestation and reforestation activities targeting carbon credit certification are limited.

Another challenge to A/R is the criticism that afforestation often leads to low-biodiversity monocultures with commercial goals. Safeguards are crucial for such activities to ensure that negative environmental impacts are avoided. Nevertheless, socio-economic benefits in a landscape approach balancing protection and production must also be considered as SDG contributions and even monocultures – when avoiding said negative impacts beyond the plantation - will contribute to climate impacts needed to meet 2030/2050 targets. But like forest protection activities, it is likely that actual impact potential for afforestation and reforestation will remain clearly below the technical potential (cf. Figure 2a).

Integration of co-benefits in A/R programs beyond basic environmental and social safeguards, i.e. contributing to a broader SDG impacts, enriches A/R activities. Depending on the setup (e.g. species planted, timber use, smallholder involvment), A/R activities can contribute to many SDGs beside just SDG 13 and 15. Close-to-nature forest structures create habitats and valuable, stable ecosystems thus increasing biodiversity, and balanced forest management systems including non-timber products improve livelihoods (SDG 8). Whether or not integrated into REDD+ schemes, A/R activities as true NbS have the potential to contribute a highly relevant portion of GHG removals in biomass and soil.

Agricultural activities to mitigate GHG impacts have become a major topic in carbon programs, driven by corporate supply chain interventions and large-scale programs to improve food production. Primary activities included in such programs are conservation agriculture approaches to increase soil organic carbon (e.g. conservation tillage, cover crops) and precision agriculture systems to reduce N_2O emissions from application of nitrogen fertilizer (Simelton et al 2021). As shown in the global impact papers, these activity impacts are rather low on a per-area basis but are expected to contribute a very significant portion of overall NbS impact potential due to the immense area targeted by these activities. Being able to link to corporate supply chains provides valuable governance and monitoring opportunities to implement large-scale programs efficiently and realize overall benefits despite long timeframes.

Agriculture is vital for food security and supports SDG 2 (zero hunger) and SDG 1 (no poverty). Improvements of activities on managed lands always face the challenge of balancing a very broad range of impacts on and beyond the actual fields. These impacts positively or negatively relate to a multitude of SDGs. Viana et al (2022) describe positive impacts to 11 other SDGs besides SDG 2 and 1 but also pointed out potential negative implications in the achievement of other goals such as Climate Action (Goal 13), Life Bellow Water (Goal 14) and Life on Land (Goal 15). To minimize the tradeoffs associated with agriculture impacts, they consider it vital to invest and

[4] https://www.cbd.int/sp/targets/
[5] UNEP Brief Highlights REDD+ Benefits for SDGs, Aichi Targets | News | SDG Knowledge Hub | IISD

develop new technologies for data acquisition (e.g., remote and proximal sensing) and create robustly and validated models that consider data from multiple sources.

Peatland restoration: Protection of remaining peatlands and restoration of degraded (drained) peatlands is another much-discussed option to mitigate GHG emissions. Compared to other activities that restore ecosystems and take many years to reach their full potential, restoring drained peatlands (or avoiding such degradation) is a special case. With the principal aim of restoring their hydrology to halt the ongoing emissions from oxidation of their organic soils and reduce the risk of fire, projects do not depend on (slow) increase from carbon sequestration. And due to the very high mitigation potential on a per-area basis, peatland protection and restoration can be a very important activity for carbon markets, despite the limited global potential when compared to e.g. forest ecosystem restoration areas.

As important ecosystems, restored peatlands contribute to several SDGs (Miles et al 2017), including by keeping carbon stocks in the ground (SDG 13), by avoiding health impacts associated with serious air pollution from burning drained peatlands (SDG 3), by protecting water-related ecosystems and improving water quality (SDG 6), and by ensuring conservation of ecosystems and threatened species, protecting life on land (SDG 15).

Mangrove ecosystems protection or restoration has been identified as another blue carbon activity with one of the highest per-hectare impacts from carbon sequestration in biomass and soil (Roe et al. 2021). These activities have also shown to have very strong SDG contributions/co-benefits which is reflected most clearly in SDG 14, which focuses on sustainably governing the oceans and coasts and recognizes mangroves' immense value to local communities. But restoring mangrove forests also supports the achievement of many other SDGs, including halting biodiversity loss (SDG 15), eliminating poverty and hunger (SDG 1 and SDG 2) and ensuring livelihoods and economic growth (SDG 8) by e.g. improvement of socioeconomic benefits from fishing. And while restorable mangrove areas are estimated around only 800,000 hectares globally, their carbon restoration volume in soil and biomass was estimated at a total up to 1.5 $GtCO_2e$ in project "Oceanwealth"[6] (see also Figure 3). Therefore, targeted mangrove restoration programs could provide solid carbon benefits (SDG 13) with credible and very significant co-benefits.

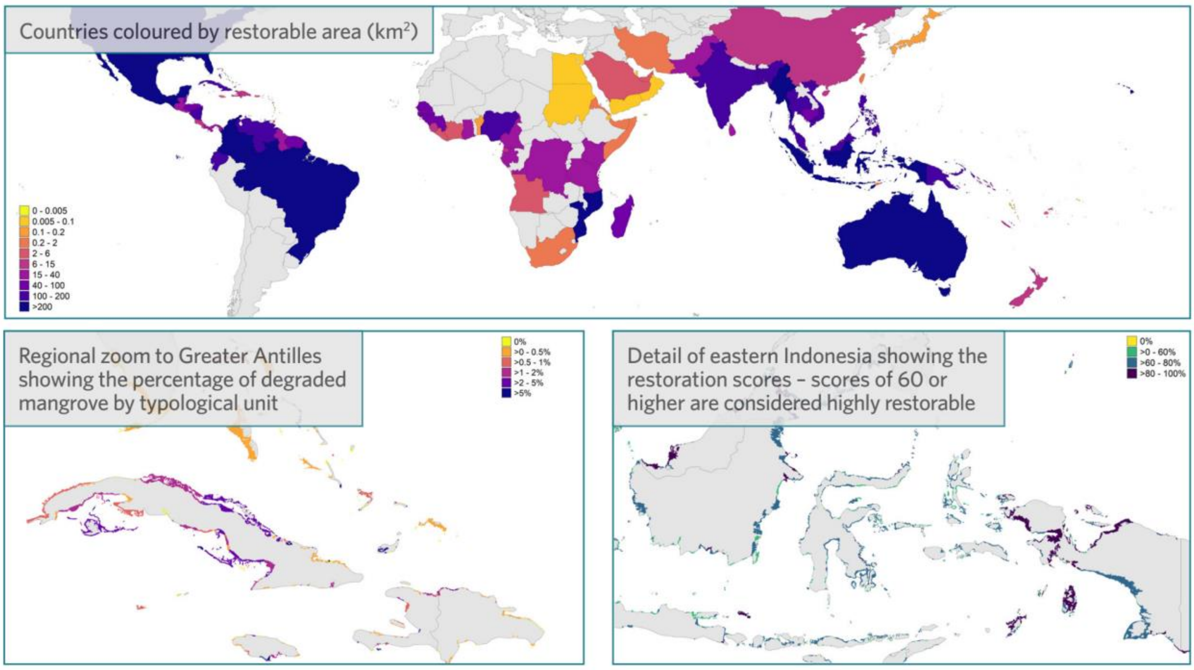

Figure 3: Mangrove restoration areas and potential as presented on Oceanwealth (https://maps.oceanwealth.org/#)

[6] https://oceanwealth.org/applications/mangrove-restoration/

3 Success Criteria for "Fit-for-Future" NbS

Most of the aforementioned studies consider limiting factors in their estimates for NbS impact (e.g. competing land use, food security, biodiversity impacts). However, addressing operational challenges at local level will be essential to implement NbS to scale, especially when working within market mechanisms. Or, as phrased in UNEP&IUCN 2021, "it is only when planning, implementing and monitoring a nature-based solution in a particular geographical context that it is possible to ensure that [success] criteria or other relevant safeguards are met in practice."

When assessing the practical implementation potential for NbS, interactions and challenges associated with changing land use practices - or preventing such change – must be considered. While such interactions can be identified and addressed in an NbS program, and critical barriers can be overcome (see also Gehrig-Fasel et al. 2021a), many implementations today still suffer from lack of such mitigation. Without additional incentives and support, critical factors such as lack of political will, rigid land use traditions or overwhelming economic interests will prevent NbS from being implemented at its full potential and prevent project implementation due to high risks for underperformance or reversals. It is thus crucial that, complementary to identifying global impact potentials as described in the previous sections, the prerequisites for successful NbS implementation as summarized below are addressed early at international and national level to foster NbS programs.

The critical prerequisites listed below do not represent the full scope of challenges and barriers faced by NbS but rather focus on the essential factors that are expected to influence (i.e. reduce) the "cost effective" impact potential presented the global synthesis publications presented in the previous section. For a broader assessment of challenges and their solutions, please refer to Gehrig-Fasel et al 2021a.

3.1 Long-term Quantitative Impact (Permanence)

All NbS aim to achieve long-term impact, either through storing carbon securely (removals) or reducing emissions (emission reductions) by changing land use practices. For NbS to deliver the expected sustainable impacts, both pathways must aspire "permanence" of their practice change to ensure a lasting contribution to limiting global warming, though with somewhat different impact:

- For emission reduction activities, any greenhouse gas reductions achieved remain fully accountable even if practices reverse to pre-project state (though any future contribution to GHG reduction, as well as SDG benefits achieved through the activity change will be lost). "Permanence" for such activities thus refers to the long-term practice change, preventing reversal to previous practices and associated emission increase.
- For carbon sequestration projects, permanence is even more crucial as any re-emission of bound carbon directly nullifies the project benefits. Consequently, ensuring permanence of carbon removals, i.e. maintaining carbon stocks for multiple decades, is a core responsibility for a program to have real impact.

Consequently, especially for NbS programs seeking certification for carbon credits, priority should be given to programs that can ensure long-term change both for carbon sequestration and emission reduction activities, as well as significant SDG contributions. And while requirements on permanence vary between different governance systems and standard guidelines, the common goal is to maintain carbon sequestered in biomass or soil for the decades to come, which for active biological systems means that a new equilibrium with higher carbon stock levels is maintained through appropriated practices. Most important factors to ensure this are consistent land use governance systems and a commitment by programs to achieve real change through incentives beyond carbon programs, e.g. co-benefits that will convince stakeholders to maintain the changes also in future generations.

A second quantitative consideration is the prioritization of overall GHG reduction vs. per-area impact, quantified in solid metrics. Related to the "permanence" requirement above, quantitative impacts must be balanced against scale and risks. Low-risk, low-impact but large-scale activities can deliver equally valuable impacts to high-impact programs at limited scale or with higher risk of reversals. Therefore, when targeting maximum mitigation impacts for the future, impacts vs. scale and risks should be taken into consideration:

- For mature environments which allow large scale implementation and efficient program governance, consideration of overall long-term impact (i.e. maximizing total GHG reduction for the program) will be the key criterion.
- For smaller scale applications, e.g. in less mature environments that require more direct and effort-intensive project governance, high per-hectare impacts may be more important to achieve a feasible effort-benefit ratio.

3.2 Cost Effectiveness and Safeguards

As discussed, a key reason for the wide range of mitigation potential identified in global synthesis studies on NbS impact potential are the different assumptions made about the global willingness to fund climate change mitigation in general and NbS in particular. The funding needed – through public or private means – can be expressed a cost per tonne of emissions reductions and removals. A maximum cost of US$ 100/tCO_2e has commonly been used to estimate "feasible" or "cost-effective" mitigation potential. And while in some countries, emissions may be mitigated at considerably lower prices, Girardin et al (2021) envisaged that achieving a 1.5°C scenario would even require doubling the acceptable cost of mitigation to US$ 200/tCO_2e to achieve the needed global mitigation from NbS available by 2050.

Such prices are very high in comparison to available payments for NbS or carbon market prices today. While recent market reports indicate a continued willingness to pay premium prices for NbS (Forest Trends' Ecosystem Marketplace 2021), payments per tonne of CO_2 are still significantly below the above-mentioned thresholds. Even assuming a rise in prices due to increasing demand for carbon offsets and other GHG reduction schemes (e.g. corporate supply chain interventions), solutions targeting market mechanisms will have to be very cost-effective.

Cost-effectiveness across all cost is case-specific and must take into account local situation (e.g. need for governance, training, infrastructure, stakeholder mgmt, etc.). In this, agricultural practice improvements at scale are often most cost-effective programs as many of the changes have positive cost impacts (e.g. cost reductions). Implementation of solutions in this sector is often limited due to prevailing practices and thus, additionality can be claimed. However, focusing on NbS in commercial systems can bear considerable risks around social and environmental impacts.

In light of this and referring to the desired multi-benefit nature of NbS, it is all the more important to ensure environmental and social integrity of programs through safeguards and take into account non-financial benefits of sustainable solutions. High-rigor voluntary carbon standards have been consistently improving on respective safeguards and principles for carbon markets. Nevertheless, recent increase in demand for emission reductions has also allowed "quick benefit" approaches to become established in the carbon market and gain momentum. Enforcing safeguards and assessing all activity impacts (e.g. against SDGs) will thus continue to be a critical success factor for carbon market governance systems and related national legislation.

Notably, when tapping sustainable finance[7] through private green investments[8] or from public sources, e.g. through the European green deal investment plan, NbS with a range of benefits in addition to climate change mitigation can play to this strength. Even though not captured by traditional cost-benefits analyses, programs can leverage their sustainability impacts to access funding or to achieve higher prices on the carbon markets or in negotiations with their financiers.

This provides one of the strongest arguments to implement high-quality, multi-benefit NbS with proven impacts. For NbS in the long-term, cost-effectiveness must consider a full value of the programs, paving the road to higher impact pricing as needed according to the research cited in this study. If lower-cost NbS activities (e.g. in commercial agriculture and forestry systems) are needed to ensure short-term reductions, e.g. to meet 2025/2030 GHG reduction targets, programs must ensure that minimum safeguards ("do no harm") for social and environmental impacts are established.

3.3 Operational Success Factors

When looking at on-the-ground operations in NbS programs, a number of success factors impact scalability and effectiveness of implementation. In a previous study we identified several challenges that influence the feasibility and success of NbS implementation (Gehrig-Fasel et al 2021a). As stated there, many of these issues can be mitigated at project or program level with sufficient skills and organization, but some factors are outside of a project's control or capabilities. Table 1 summarizes such key success factors requiring additional support from outside the project, often from regulators, the lack of which hampers project implementation at scale. Addressing these issues will create strong incentives for NbS implementation (cf. Section 4) and is essentially a prerequisite to scale NbS to their potential.

[7] Overview of sustainable finance | European Commission (europa.eu) - https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/overview-sustainable-finance_en
[8] Green Investing Definition (investopedia.com) - https://www.investopedia.com/terms/g/green-investing.asp

Table 1: External success factors and prerequisites for NbS success

Success factor	**Operational approach**	**Prerequisites**
Availability of skills and knowledge for program setup and governance	▪ Training	▪ Funding ▪ Technical expertise
Local stakeholder support and willingness to change	▪ Intensive stakeholder management to address traditions and solutions ▪ Integration of programs at landscape level to identify economic dependencies and ensure livelihoods	▪ Strong incentives (e.g. financial, legal, social) ▪ Overarching support to set up and conduct stakeholder management, ▪ On-site competence ▪ Research on multi-activity impacts and interactions
Long-term land rights	▪ Clarify land governance with clear and enforced legal status ▪ Establish long-term leases for project land	▪ Government support ▪ Legal security
Policy environment and political will	▪ Align projects and programs with NDC commitments ▪ Collaborate or integrate with government programs ▪ Identify and discuss counter effective incentives (e.g. subsidies)	▪ Government cooperation and incentives, e.g. ▪ corresponding adjustments to allow carbon projects ▪ "NbS-friendly" governance frameworks ▪ program integration or delineation of activities ▪ Operational and competent DNA for carbon markets
Technical and operational competence for activity change	▪ Training for on-site program managers ▪ Long-term operational support ▪ Solid MRV and grievance process	▪ Funding ▪ Technical expertise On-site trusted partners ▪ Programmatic support for project setup
Funding for setup and implementation	▪ Project risk management to support investments ▪ Cost transparency ▪ Long-term agreements and governance to provide financial security	▪ Government cooperation (governance) ▪ Guarantee structures

In addition to above success factors, a true "Fit-for-Future" NbS system must be flexible to evolve to address new challenges, embrace new solutions, and respond to outside changes, including climate change impacts.

Room for innovation and a resilient setup are thus important characteristics of an NbS framework design:

Innovation in NbS programs includes methodological components, e.g. improved GHG quantification approaches (models, subnational parametrization) or technologies used for monitoring, reporting and verification (remote sensing, field measurement and/or data collection). Recent examples currently being evaluated by the scientific community include:

- Use of terrestrial LIDAR (Beyene et al 2020) or Apple iPhone 12 with integrated LIDAR technology (Gollob et al 2021) instead of airborne laser scanners to measure biomass in forests.
- Remote sensing tools to assess land cover and monitor practices (e.g. surface radiance over time to indicate tillage intensity or cover crops on agricultural land; Beeson et al 2020, Hively et al 2018).
- Combining remote sensing and machine learning classification (Barnes et al 2021) or remote sensing and modelling approaches (Mulla et al 2020) to assess cover crops and soil residue cover.
- Research into carbon sequestration in macroalgae and suitability for natural long-term storage in deep water (Hawken 2021, Krause-Jensen 2018) or replacement for fuels or terrestrial resources, e.g. animal feed or fertilizer (N'Yeurt et al 2012, Hoegh-Guldberg et al 2019).
- Use of NbS in urban or technical systems, e.g. for biomass or fuel production, waste management, urban climate control, air quality or water supply.

Resilience and flexibility in NbS programs is built on multiple pillars, from choosing approaches and activities suitable under future climate scenarios (Seddon et al 2020) to integrating multiple activities in NbS programs to share risks and benefits (e.g. landscape approaches; see also Gehrig-Fasel et al 2021a). Solutions should be customizable to fit the local situation, stakeholder expectations and surrounding activities (e.g. integration of NbS in urban development programs[9]) or linking NbS to commercial programs as core or "collateral" activities[10] (Tozer and Xie 2020, Bulkeley 2020).

4 Host country Incentive Systems to Make NbS a Success

Incentives for NbS align with the needs and preconditions of NbS implementation (see Table 1). We can differentiate activity or program-specific incentives for operational NbS challenges (e.g. stakeholder participation, quality assurance and impact permanence) from finance or governance-related actions which target prerequisites outside of project control (e.g. investment capital and associated guarantee mechanisms, policy alignment, government program incentives).

For both categories, **national institutions can provide valuable support** by promoting and actively setting up frameworks or programs facilitating NbS implementation:

Guide NbS scope: Having consistent policies and explicit objectives for NbS will focus projects on the activities best-suited for the area. In addition, proactively assessing possible integration and participation of NbS programs in overarching strategic plans, e.g. long-term land use planning, urban design and development plans, will not only facilitate implementation for project stakeholder but also ensure alignment with the respective programs.

Provide institutional support: As part of national NbS strategy, e.g. to realize in-country NDC commitments, providing guidance and targeted support to project stakeholders can greatly increase implementation efficiency and avoid conflicts, e.g. by proactively and clearly stating the "do's and don'ts" for NbS in a given governance system (such as legal requirements, subsidies or other funding sources, administrative requirements and

[9] e.g. https://naturvation.eu/cities

[10] e.g. Insurance companies raising client's awareness for climate risks and supporting NbS related to housing (green roofs) to reduce damage risks (Tozer and Xie 2020).

contacts for specific NbS practices and changes). This will incentivize not only projects aiming for carbon markets but also facilitate corporate programs. Explaining and aligning policies for involved sectors (including handling of potential conflicts and prioritization of various incentives), either by proactive assessment or by providing respective expert support, will accelerate NbS program design and implementation. Support can also include operational components such as providing a platform for multi-stakeholder exchange and alignment to facilitate contacts with relevant government and civil society organizations and thus foster landscape-level (inter)action[11].

Facilitate funding: Especially for smaller projects or less experienced organization (e.g. community projects), access to funding for initial NbS setup and design is challenging. Providing seed funding to trigger project setup can overcome initial financial barriers, and providing organizational support, starting with clearly designated government contacts, will help with the choice for a suitable setup. For countries with high inherent risks (e.g. governance risks, operational risks, social challenges), financial guarantees or risk insurance backed by national or international institutions would improve access to capital and long-term investments.

Support baseline and impact quantification: Host countries can facilitate activity implementation and program governance by establishing national baseline data (e.g. stock inventories, providing parameters and/or developing models for higher-tier quantification, i.e. IPCC Tier 2 or Tier 3 models and data reducing uncertainty of impact). This not only reduces efforts for NbS activities to quantify impacts but also ensures consistency in (national) GHG accounting and improves quality of impact monitoring, facilitating integration with national programs.

Trigger corporate engagement: Linking NbS to corporate activity and/or supply chains (national or international) can provide valuable governance support, incentivization and potential funding for small to large-scale activities, especially in productive land use systems. In international supply chains, government programs can be aligned with corporate activities and carbon markets, broadening access to funding and creating value from joint communication and shared responsibilities. Through trade relations and contractual commitments corporates can provide long-term governance, incentivized by reduced supply chain emissions in corporate GHG accounting (e.g. to meet corporate reduction pledges). In support of such programs, governments can ensure that double counting is avoided, and programs are aligned with current and future national agendas. Deeper integration of corporate activities in national programs, e.g. by setting up "hybrid systems" which facilitate private sector actions embedded within a government framework with shared financing and governance, can strengthen overall program governance and transparency while leveraging private investments to cover operational costs (see Gehrig-Fasel et al 2021a). In systems which directly incentivize corporate action through taxation or domestic carbon schemes, governments can create opportunities for non-regulated sectors to participate in domestic carbon markets providing in-country offsets for taxed or capped market participants (i.e. incentivizing voluntary GHG emission reductions)[12].

5 NbS Quantification Methodology Overview

To achieve GHG reduction goals on a national, subnational or project scale, practice changes need to be implemented on the ground – be it in a localized project or on a landscape approach. These long-term practice changes need to be quantified and monitored in order to calculate their GHG emission reductions or sequestration potential and their contribution in reaching the set goals. GHG emissions are quantified using

[11] At the time of writing this report, development of a "Network for nature: multi-stakeholder dialogue platform to promote nature-based solutions" is in preparation under the Horizon Europe program.

[12] Examples for voluntary market integration in national programs are South Africa and Colombia who are allowing domestic Gold Standard and VCS credits to be used to offset emissions within their carbon tax systems.

either direct measurement or calculation methods. The selection of a quantification method will depend on the data and information that is available for each source. Once a method has been chosen, it is best practice to use it year after year to ensure the comparability of emissions data over time.

5.1 GHG Quantification Methodologies

GHG quantification methodologies (ACR, VCS) or also called protocols (CAR), approaches (Plan Vivo) or SDG impact quantification methodologies (GS) define the rules that a project developer needs to follow to establish a project baseline, to calculate emission reductions and to monitor the parameters used to quantify a specific emission reduction or carbon sequestration activity. Besides the quantification approach methodologies also often define additional requirements to determine project boundaries and assess additionality (if this is not regulated on a standard level). In addition, they set out criteria to determine whether a particular project is eligible to apply the methodology.

A robust and thoroughly reviewed scientifically backed methodology is a generic recipe that can be applied to different projects within a given project type (e.g. agriculture: livestock management) and applicability conditions (e.g. application of a feed additive to reduce enteric fermentation). If no approved methodology exists for a specific project type, a project developer can submit a new methodology for approval to the selected carbon standard. Methodologies are registered under a specific carbon standard and can only be applied under this standard. An exception to this are CDM methodologies which can be directly applied under VCS and are accepted by Gold Standard after review and approval of special applicability conditions. CAR and ACR do not accept CDM methodologies while Plan Vivo is generally open for existing methodologies from other standards. Planned updates to legacy CDM methodologies for use in the context of Paris Agreement Art 6, which are expected to take the progress from voluntary carbon markets into account, will further expand the landscape of quantification approaches available for NbS.

5.2 NbS Methodology Assessment

In this study all currently registered NbS quantification methodologies of the voluntary carbon standards with NbS scopes namely VCS, ACR, CAR, Gold Standard, Plan Vivo and the former compliance standard CDM were categorized in an Excel file (for an extract of the Excel file see chapter 9 Annex and the separate excel file “NbS VCM Methodology Overview March 11 2022.xlsx”) according to scope (e.g. agriculture, forestry, blue carbon), activity (e.g. IFM, REDD, ARR, rice, fertilizer, grassland, livestock), geographical scope, applicability, and crediting period. This mapping of currently available NbS carbon methodologies across different standards then allows the identification of gaps and indicates the current intentions for expansion to certain scopes and types, as well as recommendations for further development.

5.3 Methodology Overview by Carbon Standard

Table 2: Number of registered NbS methodologies per carbon standard, scope and activity by March 11, 2022.

Standard	***Forestry***			***Agriculture***					***Blue Carbon***
Activity	ARR	REDD	IFM	Livestock (CH_4)	Grassland (SOC)	Cropland (SOC)	Rice water management (CH_4)	Fertilizer reduction (N_2O)	Wetland restoration, mangroves
Primary impact type [1)]	R	AV	AV, R	ER	AV, R, ER	AV, R, ER	ER	ER	ER, R
Verra/VCS	2	6	7	3	3	2	1	2	4
CAR	2 [2)]	2	2	3	2	1	1	1	
ACR	1		3		1				2
GS	1			2		2			
Plan Vivo	1	1				1			1
CDM	2						1		2

[1)] *R = GHG removals; AV = Avoided GHG emissions, ER = GHG emission reductions*

[2)] *ARR activities under CAR are currently limited to urban planting approaches.*

- *Some comprehensive methodologies allow several practices in different scopes (e.g. forestry and agriculture) or in different project types (e.g. IFM, REDD) and thus a methodology may be counted multiple times in the above table.*
- *Individual standards may categorize methodologies differently than listed in above table (e.g. CDM is listing several AGR methodologies which in essence are not NbS activities but would be categorized under the energy scope, e.g. diesel production from plant residues or manure handling in bionenergy plants).*
- *CDM methodologies are also applicable under GS and VCS but not added to the standards' own methodologies above.*

5.4 Methodology Scope and Limitations: Current Status

As shown in Table 2 and the underlying supporting Excel file "NbS VCM Methodology Overview March 11 2022.xlsx", methodologies are available for a broad scope of NbS activities, though not under all carbon standards. Also, many methodologies are limited in their applicability either due to explicit geographical applicability conditions, ownership, or practice restrictions.

Verra VCS currently provides the highest number of globally applicable methodologies within the NbS activity scope, covering all forestry activities, core agricultural activities (cover crops, conservation tillage, fertilizer reduction, livestock, methane reduction in rice management, grassland activities, SOC) as well as wetland and mangrove restoration. Most other carbon standards are more limited in NbS scope or methodology applicability.

Climate Action Reserve (CAR) provides a series of forestry and agricultural methodologies limited to application in the USA and Canada or Mexico with further restrictions to specific regions or ownership types for forest management and, in a very specific case, to the California rice growing regions for emissions from rice.

The same is true for American Carbon Registry (ACR) whose NbS methodologies are limited to US, Canada or even specific states, with the exception of the afforestation methodology for degraded lands which is globally applicable.

Gold Standard provides global methodologies for A/R, livestock (reduction of methane emissions from enteric fermentation) and a soil carbon framework methodology, currently covering reduced tillage impacts and organic soil improvers – limited to Europe). While most of the GS NbS methodologies have global reach, it must be noted that they are focused on a limited number of specific activities.

Plan Vivo actually only lists two methodologies (and two additional tools) covering a number of activities. Limitations here include the applicability to smallholder and community projects with native species only for afforestation/reforestation and agricultural land use, and community-managed forests for REDD.

CDM methodologies are available for A/R and mangrove restoration (both as large scale and small-scale methodologies) as well as methane reductions from rice cultivation (small scale only), all of which provide global applicability.

In summary, while GHG quantification methodologies for a broad scope of NbS activities are available, many are restricted in their geographic application, their quantification approach (only direct measurements or modelling requiring extensive on-site data) and can only be applied under a specific carbon standard (lack of cross-standard methodologies). While the latter is inherent to the nature of the voluntary carbon market setup it prevents - in combination with the geographic and the quantification approach limitation - the scaling up to the landscape level under a carbon market approach. However, these robust and scientific backed methodologies are publicly available and can also be used for corporate scope 3 accounting (under GS this is even required for the GS scope 3 value chain program) or under any other GHG reduction setup (e.g. in country NDC accounting).

5.5 New Methodologies under Development

Various methodologies within the NbS scope are under development, including expansions into additional project types and activities:

- VCS, CAR and Gold Standard are developing or have announced the development of methodologies to include biochar application in their AGR scope (notably ACR has an inactive biochar methodology).
- VCS also lists revisions and new development for IFM, REDD, ARR, SOC, and livestock practices, expanding practice scope, quantification and monitoring approaches, showing a trend towards modeling approaches instead of onsite measurement, especially in agriculture activities.
- Gold Standard does not generally publish methodologies under development/review, though a development process has been announced for a methodology to quantify N_2O emissions from fertilizer application[13]. Gold Standard has also announced a collaboration with IUCN to develop a collaborative certification scheme dedicated to Nature-based Solutions[14] though no information was provided what scope of activities would be included in such a certification and if/how this would be applicable to carbon markets. Upon personal communication, Gold Standard revealed that several SOC methodologies are currently under development (cover crops, zero tillage, biostimmulants, and sustainable grassland management).
- ACR is currently expanding their NbS scope and is developing a first REDD methodology, though restricted to US projects only.

[13] Request for Proposals: Co-develop new methodology for efficient Nitrogen fertilizer | The Gold Standard
[14] IUCN to develop collaborative certification scheme for Nature-based Solutions | IUCN

5.6 Methodology Gaps and Challenges

To further develop and maximize benefits from NbS, limitations and gaps in the current activity scope and methodologies need to be closed and key challenges in their application addressed. Provisions by the newly established supervisory body (SB) for Paris Agreement Article 6 implementation can support this preparatory work as outlined in a technical guidance document on the role of the Supervisory Body[15]. Special focus should be granted to the establishment of rules and incentives for innovative NbS scopes around blue carbon and urban NbS.

Blue Carbon

With NbS activities expanding, especially in the "blue carbon" scope, new methodologies will need to be developed. Currently most discussed is the envisaged expansion into marine ecosystems with (macro)algae in focus. Such algae form "kelp forests", and their protection as well as "ocean afforestation" have been mentioned as opportunities to avoid emissions and sequester carbon, respectively (UNEP & IUCN 2021, Hawken 2021, Filbee-Dexter et al 2020, Krause-Jensen et al 2018). The use of algal biomass as biomass for energy production, alternative fertilizer, or as feed supplement to reduce methane emissions from enteric fermentation in ruminants (N'Yeurt et al 2012, Hoegh-Guldberg et al 2019). A current example is a recent grant by the USDA supporting a multi-year research program assessing various algal sources as feed supplement for cattle.[16]

Urban Nature-based Solutions

The urban sector is another scope where additional methodologies need to be developed, currently only represented by CAR's urban tree planting protocol. Guidance is still limited for other urban NbS mitigation activities such as green roofs and facades, community gardens, green indoor areas, sustainable urban drainage system, bioretention infrastructure or even urban blue carbon with algae applied in carbon sequestration in building coatings. Nevertheless, such activities not only present options for urban NbS for climate change adaptation but also provide substantial social, economic and environmental co-benefits and enhanced human wellbeing (Dushkova et al 2020, Bulkeley 2020).

The growth in urban NbS can be witnessed across the globe: in urban and peri-urban areas, in global mega-cities and villages, in coastal zones and inland areas, including cities and towns bordering agriculture habitat and biodiversity hotspots, such as forests and wetlands. In their success story showcasing eight existing and successfully implemented NbS programs in urban and peri-urban contexts WWF aims to raise awareness of city decision and policymakers, urban planners and developers about urban NbS (WWF International 2021). The report shows how NbS can help to foster sustainable urban development, while meeting climate adaptation and mitigation goals. They help biodiversity to thrive and human habitats to become more resilient. Building nature into cities improves their livability, particularly for the economically vulnerable, by reducing temperatures, filtering water and cleaning air. However, WWF also points out the need for capacity building to create respective monitoring methodologies and tools to effectively monitor NbS outcomes over the long term.

[15] Technical Guidance Document for NbS Supervisory Body Oct 19 2021.pdf: http://www.carbonmarket-foundation.org/userfiles/zdk/file/Technical%20Guidance%20Document%20for%20NbS%20Supervisory%20Body%20Oct%2019%202021.pdf

[16] https://www.bigelow.org/services/seafood-solutions/coast-cow-consumer.html

6 Conclusions and Recommendations

Nature-based Solutions are crucial to meeting climate targets by 2030 and 2050. Highest potential was identified (compare chapter 2) in forest protection (avoided emissions, REDD) and restoration (removals), followed by carbon sequestration in agricultural soil (removals). With major studies on NbS (UNEP & IUCN 2021) concluding that less than half of the “technical potential” can be implemented cost-efficiently it is important that these NbS do not face additional barriers in implementation. Also, only about one third of these NbS impacts are direct emission reductions, with avoided emissions and removals making up another third each. Both avoided emissions and removals require long-term governance over decades to ensure permanence and performance. Nevertheless, as countries and corporates are committing to Net Zero[17], realizing these very NbS benefits, including substantial GHG removals, will be vital.

Scaling up NbS to the high impact potentials outlined by the discussed global studies - even when only aspiring “cost-effective” levels - will require several success criteria to be met (compare chapter 3):

1) Funding: With carbon prices estimated at up to US$100/$tCO_2e$ - or even US$200 as estimated by Girardin et al (2021) to meet 1.5° targets – funding will only be partially possible through carbon markets at today’s low prices. Setting up “hybrid programs” combining government or grant money with corporate/private investments in a program framework could increase overall financial means and lower risks for an NbS program.
2) Host country policy: A key challenge for NbS at scale are inconsistent, conflicting or preventive land use policies, including land ownership and sectoral legislation. Clarifying and aligning policies and legal framework for NbS greatly facilitates implementation
3) Stakeholder engagement: NbS projects are multi-stakeholder environments, in which various opinions and interests need to be aligned. Instruments to simplify stakeholder interaction, e.g. the presence of associations, existing and functional local governance organizations or NGOs help project NbS setup and operations.
4) SDG contribution and safeguards: NbS activities not only provide GHG impacts but also provide multiple SDG benefits. It is thus all the more important to ensure environmental and social integrity of programs through respective safeguards. Enforcing safeguards (e.g. as implemented by the voluntary carbon standards) and assessing all activity impacts (including SDGs) will thus continue to be a critical success factor for carbon market governance systems and related national legislation.
5) Skills and knowledge: If no capabilities for NbS implementation are available on-site for a project, training is required. Any previous experience in staff and stakeholders will make projects more efficient and lower operational risks. Areas and teams with existing NbS already implemented will have an advantage.
6) Activity fit to organizational and governance setup: By selecting and prioritizing of activities, programs can achieve GHG benefits efficiently, whether through the inclusion of large areas, even at moderate per-hectare mitigation effects, or with smaller areas and high per-hectare impacts. To achieve similar benefits, large-scale projects will have to set up efficient project organizations and monitoring processes. If local risks or governance require intensive control and support, they may suffer failure due to high operational cost. Smaller projects with high per-ha benefits can invest more effort into on-site engagement.
7) Risk management: Project-specific risk management (e.g. on permanence) and high-integrity program designs with appropriate social and environmental safeguards (or better: social and environmental benefits) create long-term value.

[17] https://www.un.org/en/climatechange/net-zero-coalition and https://zerotracker.net/

We conclude that a successful NbS project is not depending on the type of activity, nor the per-area GHG reduction impact it can achieve but rather the right fit of governance, stakeholder engagement and organizational setup to match the local social, environmental and risk conditions.

7 Prioritization

In the short term, it will be key to implement projects in areas where the prerequisites for quick implementation are already met, i.e. areas with well-established civil society, consistent governance and without major risks to long-term performance. However, as NbS potential also depends on the value of natural systems and their potential for change, the prioritization cannot be on “developed countries only” but rather requires careful assessment of the situation in the project region. Naturally, when having the choice, high-impact activities such as wetland protection or restoration or large-scale forestry projects (REDD, A/R) should be a preference.

Setup and documentation of “best practice” examples and/or guidebooks for national NbS setup and capacity building for Designated National Authorities would be an important short-term action. Programs to train and/or inform interested parties on NbS program planning activity design and stakeholder management (including government liaisons) for project setup will accelerate implementation. Ideally, such information should be collected and published in a “NbS implementation guidebook” to leverage experiences in different political and socioeconomic environments. Online training tools and webinars will be key to quickly reach interested project stakeholders.

In medium to long-term, improvement of governance, stakeholder engagement mechanisms and establishment of distributed knowledge on practical NbS implementation must be prioritized. The single most important precondition for NbS to be implemented at scale is the creation of NbS friendly governance environments by host countries, including designated contacts, clear rules on NbS activity implementation, and the clarification of conflicting legislation and/or sectoral incentives.

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9 Appendix

9.1 Mitigation Potential and Density per Activity and Region

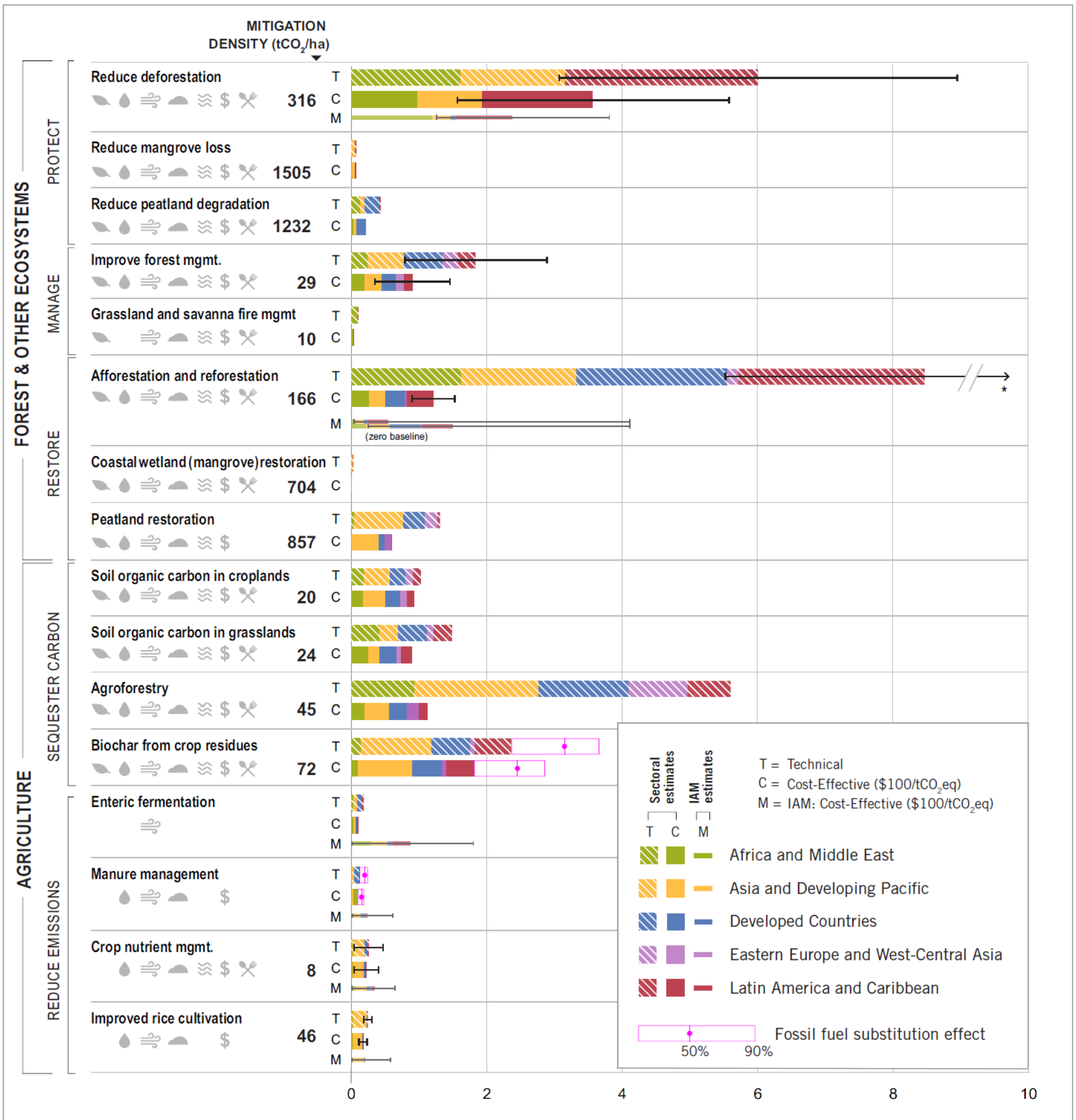

Figure 9-1 (modified from: Roe et al 2021): Climate mitigation potentials for 20 land-based activities in 2020–2050, by region. Technical and cost-effective ($100/ tCO_2eq) mitigation potentials are provided for each measure using a sectoral approach. The 20 measures are grouped into four systems-level mitigation categories, and seven management-level categories. For measures with more than one dataset, the bar graph represents the mean estimate, and the error bars represent the min and max potential range. Global mitigation potentials of substituting fossil fuels were estimated for BECCS, biochar, and manure management, shown in pink outline bars, illustrating the median and 90th percentile values. IAM estimates (range and median, up to $100/$tCO_2$eq) are provided for the seven measures where data are available in the ENGAGE database (Riahi et al., 2021). Potential co-benefits are indicated with icons, and the average global mitigation "density" (cumulative mitigation potential divided by total hectares in 2020–2050) is noted for measures with available data.

9.2 Methodology Overview (Extract)

Figure 9-2 shows an extract of the methodology analysis table developed for this study, available as an Excel spreadsheet provided separately ("NbS VCM Methodology Overview March 11 2022.xlsx").

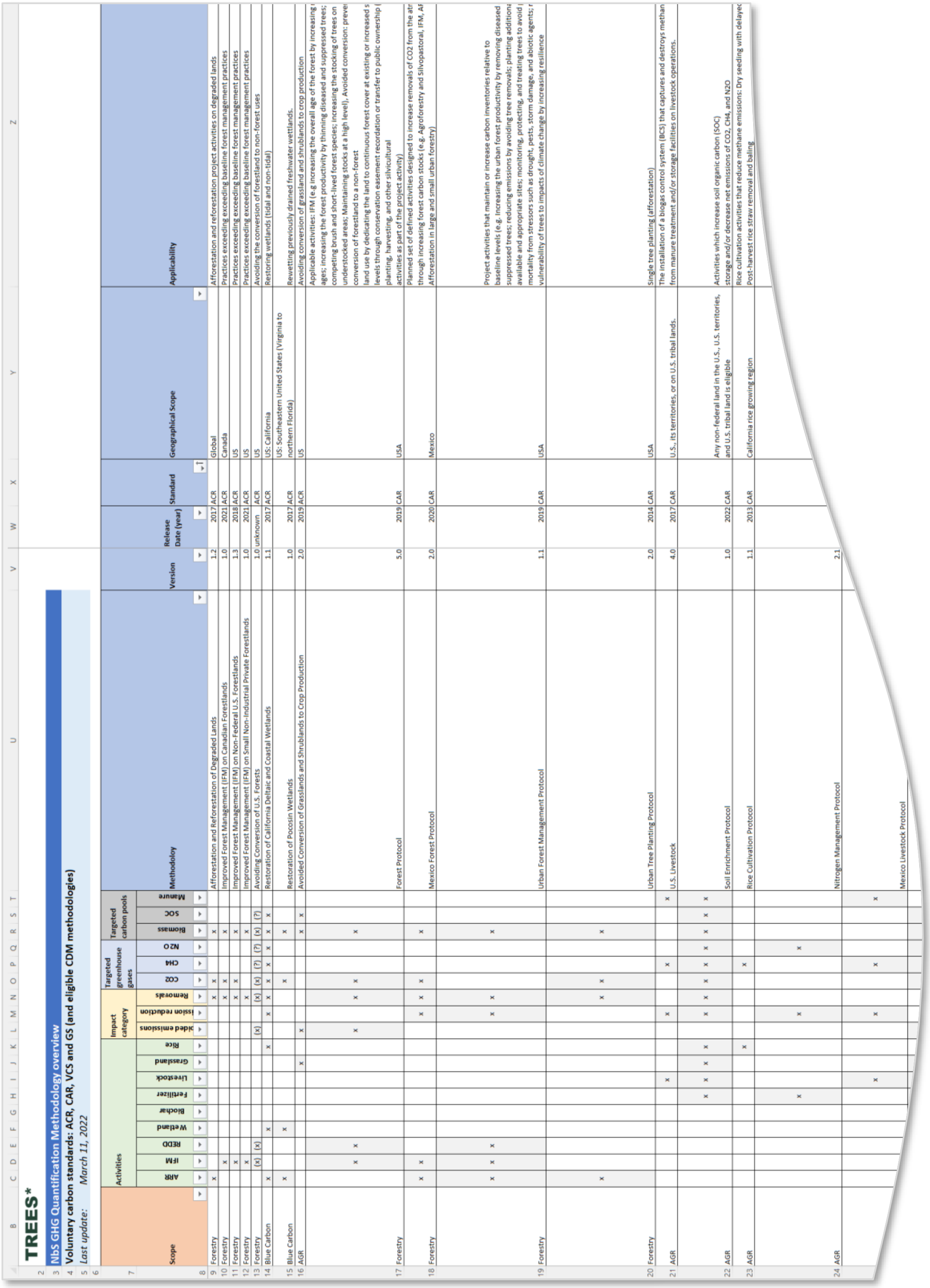

Figure 9-2: Methodology overview table (extract)