Benefit Accounting of Nature-Based Solutions for Watersheds

Guide

VERSION 2

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Abbreviations and Acronyms

AWS	**Alliance for Water Stewardship**
BMPs	**Best Management Practices**
CALCI	**Climate Altering Land Cover Index**
EPA	**Environmental Protection Agency (United States federal agency)**
ESII	**Ecosystem Services Identification & Inventory**
ESMC	**Ecosystem Services Market Place**
FAO	**Food and Agriculture Organization (United Nations)**
GERI	**Global Ecosystem Restoration Index**
GHG	**Greenhouse Gas**
GIZ	**Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH**
GSI	**Green Stormwater Infrastructure**
InVEST	**Integrated Valuation of Ecosystem Services and Tradeoffs**
IUCN	**International Union for the Conservation of Nature**
LULC	**Land Use/Land Cover**
M&E	**Monitoring and Evaluation**
NBS	**Nature-Based Solutions**
NGOs	**Non-Governmental Organizations**
NTT	**Nutrient Tracking Tool**
OECD	**Organization for Economic Co-operation and Development**
REDD+	**Reducing Emissions from Deforestation and Forest Degradation**
RUSLE	**Revised Universal Soil Loss Equation**
SDGs	**Sustainable Development Goals**
STAR	**Species Threat Abatement Restoration metric**
SWAT	**Soil and Water Assessment Tool**
TEV	**Total Economic Value**
TNC	**The Nature Conservancy**
UN	**United Nations**
UNFCCC	**United Nations Framework Convention on Climate Change**
USDA	**United States Department of Agriculture**
VWBs	**Volumetric Water Benefits**
VWBA	**Volumetric Water Benefit Accounting**
WWF	**World Wide Fund for Nature**

Executive Summary

The Benefit Accounting of Nature-Based Solutions for Watersheds Guide helps companies and other audiences better understand and accelerate implementation of nature-based solutions (NBS). The first version of the guide provided a starting point to identify, estimate and monitor the benefits that NBS provide. This second version builds upon the first by expanding upon which specific NBS activities can be implemented in various habitats, suggesting updated methods for estimating or measuring NBS benefits and introducing tools for NBS valuation. A multi-stakeholder project team, including the CEO Water Mandate, Pacific Institute, The Nature Conservancy and LimnoTech developed the guide, with additional elements provided by The Coca-Cola Company and denkstatt. Two expert advisory groups, comprising members of governments, the private sector, academia, non-governmental organizations (NGOs) and funding and financing institutions, provided additional strategic and technical input (Appendix A) into the benefit forecasting and valuation components.

Private sector decision makers (e.g. sustainability practitioners, water stewardship teams, financial officers) involved in the investment, implementation and evaluation of NBS interventions, and who need to identify and demonstrate the potential benefits of NBS, are the primary audience for this guide. The secondary audience includes public sector actors, NGOs, investment organizations, development banks and funding agencies, academia, civil society groups and local communities involved in supporting and/or developing effective policies, programs and projects to incentivize implementation of and investment in NBS.

THE OBJECTIVE OF THIS GUIDE

This guide helps users account for and measure the stacked water[1] carbon, biodiversity and socio-economic benefits of an NBS project. Accounting for these benefits will improve a company's impact reporting and help build the business case for green solutions, thereby supporting widespread investment, implementation and upscaling of NBS. This work will increase awareness of the value of NBS, not only for ecosystem health and community development, but also for companies directly.

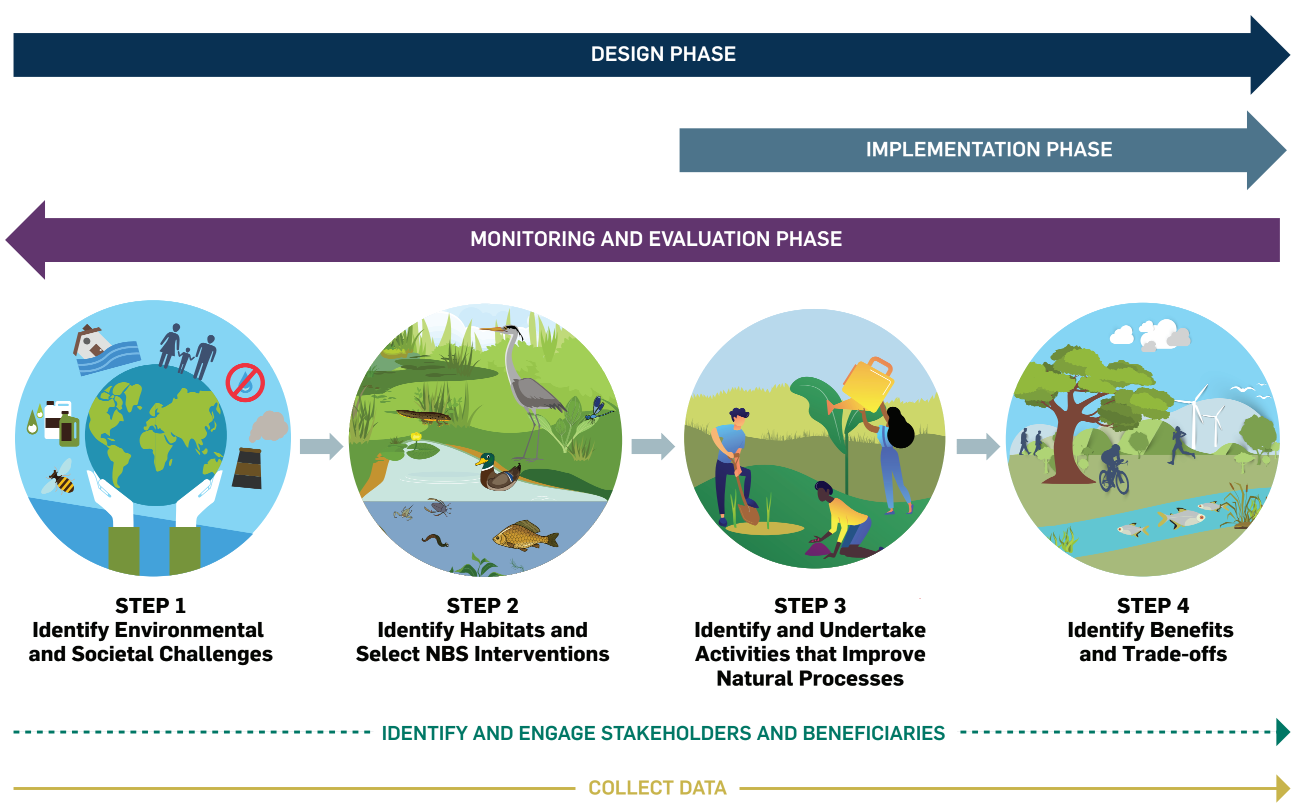
1 This guide focuses on freshwater. Benefits to seawater and marine life can also be realized through NBS but are not covered.

IDENTIFYING BENEFITS

This guide presents a step-by-step process to identify benefits accrued from NBS across the design and implementation phases of an NBS project.

The first step is to identify the environmental and societal challenges that can be addressed by NBS. Next, practitioners determine suitable habitat and intervention types in which NBS can be employed. Then, practitioners select relevant NBS activities which support natural processes (physical, chemical and biological) that occur within habitats, and which are essential to the healthy functioning of ecosystems. Based on the activities selected, the guide presents different categories of benefits that are likely to occur following the actions. These benefits span five key themes: water quantity (e.g. surface water storage, groundwater recharge), water quality (e.g. groundwater and surface water quality improvements), carbon (e.g. sequestration, climate adaptation), biodiversity (e.g. improved floral and faunal species, improved support for pollinators), and socio-economics (e.g. human health benefits, improved agricultural output). This guide explains the benefits, as well as potential trade-offs, in detail and pays special attention to the distribution of these benefits over space and time. The benefit identification steps have been included in the NBS Benefits Explorer tool, an online platform developed by the project team to support benefit identification, accounting and valuation, and help build the business case for NBS investment.

PROPOSED STEPS TO FOLLOW FOR BENEFIT IDENTIFICATION ACROSS THE DESIGN, IMPLEMENTATION AND MONITORING AND EVALUATION PHASES OF NBS PROJECTS



It is critical to identify and engage stakeholders and beneficiaries, as well as collect data, throughout all project phases. Additional NBS Stakeholder Engagement Guidelines have been developed to support equitable, inclusive engagement. This stakeholder engagement guide promotes the inclusion of frontline communities, Indigenous Peoples and local communities, and integrates a gender perspective throughout the analysis.

FORECASTING BENEFITS

An additional element of the benefit identification work is the benefit forecast. Forecasting predicts the magnitude of potential benefit accrual over three temporal (1-4 years, 5-9 years and 10+ years) and three spatial scales (property, municipal and watershed). This not only improves the accuracy of the benefit identification process, but also increases transparency on what types of benefits can be expected, the length of time it may take to achieve those benefits, and the spatial scales at which investors may experience those benefits. This enhanced understanding is crucial for mainstreaming and upscaling NBS projects, which often require long-term planning.

ACCOUNTING FOR BENEFITS

The guide presents a variety of indicators and calculation methods aligned with existing tools for NBS benefit accounting, corporate water stewardship approaches, and other frameworks that estimate and measure benefits. These estimations and measurements form a key component of a project, notably monitoring and evaluation[2] (M&E) efforts, ensuring that NBS are delivering the benefits identified through the benefit-identification and benefit-forecasting steps. It is important to note that indicators should be selected based on the local context and range of stakeholders involved with or impacted by the project. Ensure that the selected indicators are measuring the benefits that are of interest to all stakeholders, especially frontline communities.

VALUING BENEFITS

Benefit valuation is the final component of building the business case for NBS. Providing a social and economic figure for NBS benefits can help decision makers better understand the nature of their investment and potential returns on such investments. In many cases, these NBS can be seen as assets and added to balance sheets or asset registers. This unlocks additional funding for operational and maintenance budgets. The guide provides a variety of indicators that can be used to estimate the economic and social value of identified NBS benefits.

2 Monitoring is an ongoing process of collecting and analyzing data to check a project or program. This data is used to plan, monitor and improve programs. Evaluation is the process of checking whether a program has met its objectives.

Building on the lessons learned through company interviews and analysis of 94 case studies, the guide identifies several best practices for NBS implementation and lessons learned for scaling NBS.

BEST PRACTICES

- Account for the specific local watershed context and its most important challenges;
- Consider spatial and temporal scales of implementation and benefit accrual;
- Consider potential trade-offs, including those between benefits achieved by different project designs (e.g. carbon vs. water benefits), adverse impacts (e.g. financial costs), or unintended consequences (e.g. water quantity impacts from increased vegetation, or unintentionally perpetuating inequities between local communities, vulnerable and excluded groups, and landholders);
- Identify legal, governance and financial mechanisms to manage and conserve natural resources effectively; and
- Implement robust M&E over time and space to assess project impacts.

LESSONS LEARNED

- Record and share data collected around the NBS implemented through feasibility studies and assessments. Companies can leverage mobile technology, big data analytics and citizen science for data storage and collection;
- Promote learning, build capacity and provide training for companies and communities where NBS are being implemented; and
- Improve policy and financing mechanisms by engaging with governments, communities and other institutions to implement small grants, loans, regulatory processes, public-private partnerships and market mechanisms.

This guide also includes principles and best practices from the NBS Stakeholder Engagement Guide, including:

- Engage a diverse range of stakeholders;
- Build long-term relationships and trust;
- Communicate with empathy;
- Prioritize transparency and accountability;
- Co-create rather than impose;
- Recognize mutual benefits;
- Remove barriers to engagement;
- Formalize relationships;
- Ensure adequate financial support; and
- Appoint well-trained, knowledgeable facilitators.

This guide and associated tool will help organizations identify, account for and value the benefits accrued from planned or existing NBS projects. The hope is that this will help upscale and mainstream NBS investments across both the public and private sectors, and help forge strategic partnerships to address several societal and environmental challenges. NBS is a tool to help meet these challenges and our Sustainable Development Goal ambitions, and this guide helps improve our understanding of how NBS can be beneficial to people and planet.

Outputs from this project have been downloaded thousands of times, and we look forward to reaching an even broader audience as we support building the business case for NBS globally.

SECTION 1: Introduction to Nature-Based Solutions for Watersheds

Human impacts, such as land use change and unsustainable water use, are degrading ecosystem and water catchment functions. These impacts often lead to the reduced ability of ecosystems to sequester carbon, regulate water flows, maintain biodiversity and healthy waterways, promote social well-being, offer economic opportunities, and sustain agricultural productivity. Climate change is exacerbating these impacts by shifting weather patterns, degrading habitats and increasing the frequency, intensity and probability of natural disasters (Kabisch et al., 2016).

Nature-based solutions (NBS) provide a mechanism to adapt to and mitigate climate and land use impacts. Interest and investment in NBS have grown significantly over the last five to ten years. However, barriers and opportunities remain for widespread implementation of NBS (Shiao et al., 2020) (see Appendix B). A key challenge for companies is the lack of a standardized method to account for the multiple benefits of NBS, which is needed to build the business case for NBS investments. This guide aims to fill this gap by providing a method to identify, account for and value the benefits of NBS across watersheds.

NATURE-BASED SOLUTIONS AS A CONCEPT

NBS are a promising option for adapting to and mitigating climate and other environmental and societal challenges. While several definitions of NBS have emerged (Shiao et al., 2020), there is no consensus over what should and should not be considered NBS. Box 1 presents several concepts related to NBS that are sometimes used interchangeably, but in some cases are not synonymous.

BOX 1: CONCEPTS RELATED TO NATURE-BASED SOLUTIONS

- Ecological engineering
- Ecological infrastructure
- Ecosystem-based adaptation
- Ecosystem-based approaches
- Ecosystem-based disaster risk reduction
- Engineering with nature
- Green infrastructure
- Natural climate solutions
- Natural infrastructure
- Natural solutions
- Natural systems agriculture
- Natural water retention measures
- Nature-based infrastructure

The concept of NBS arose out of an increasing recognition of the fundamental role ecosystems play in addressing key societal and environmental challenges. The definition of NBS has evolved over time, with a greater emphasis on taking a proactive role in supporting NBS versus being a passive beneficiary of the societal benefits ecosystems provide. Although the definition from the International Union for the Conservation of Nature (IUCN) (2016) is the most established and referenced, more recent definitions (UNEA, 2022; Nature-based Solutions Initiative, n.d.) explore broader considerations of habitats and the rights and inclusion of communities and Indigenous Peoples (see Appendix C). Given the reciprocal relationship between people and nature, it is critical to understand the nature and complexity of these relationships when investing in NBS to maximize the impacts and advantages of such investments.

ADVANTAGES OF NATURE-BASED SOLUTIONS

Investments in NBS offer a mechanism to restore degraded ecosystems and manage and protect intact ecosystems, leading to improved or maintained water quality and quantity, carbon sequestration and increased biodiversity, among many other benefits (Global Commission on Adaptation and World Resources Institute, 2019). NBS can reduce water-related risks, making them a tool to mitigate and adapt to climate change and other shocks, such as floods, droughts and extreme weather events (Kabisch et al., 2016; Nesshöver et al., 2017; Kapos et al., 2019). Due to the multiple benefits that NBS provide, implementing NBS can help advance progress toward achieving the UN Sustainable Development Goals (SDGs), particularly SDG 3 (good health and well-being), SDG 6 (clean water and sanitation), SDG 8 (decent work and economic growth), SDG 9 (industry, innovation and infrastructure), SDG 11 (sustainable cities and communities), SDG 13 (climate action), SDG 14 (life below water) and SDG 15 (life on land).

NBS are often more flexible and resilient than many traditional engineered solutions (Browder et al., 2019), can be applied at the landscape scale, and implemented alone or in an integrated manner with other solutions (i.e. combined with engineered solutions). There may be cases where NBS enhance the primary focus of a project, rather than being the main focus. For example, a project building solar arrays can use the land under and around the arrays for agriculture or conservation. Although the primary focus of the project is solar energy development, the project can leverage benefits from NBS such as food production, soil retention, biodiversity conservation and carbon sequestration, which enhances the overall benefits of the full project. See Box 2 for comparisons and complementarity between NBS and gray solutions, and Appendix D for linkages to agriculture.

BOX 2: NATURE-BASED SOLUTIONS VERSUS GRAY INFRASTRUCTURE SOLUTIONS

Due to the ability of NBS to deliver multiple benefits, NBS can be as much as five times more cost-effective than conventional engineered solutions, also known as gray infrastructure (Narayan et al., 2016). Although gray infrastructure is effective when meeting one goal (e.g. treat water or retain water), it can be extremely costly to build and to maintain (OECD, 2020) and, over time, its value may depreciate significantly. Meanwhile, investments in NBS may appreciate as more services are realized (Matsler, 2019). Often, the perverse incentives and negative impacts of grey infrastructure are not considered in decision-making or economic calculations. However, studies which compare the value of NBS to traditional engineering are rare, and economic appraisals often do not properly capture the full suite of NBS co-benefits (OECD, 2020; Matsler, 2019). It may still be necessary for NBS implementers to make a logical and convincing case to internal decision makers to scale NBS throughout their operations and supply chains (Shiao et al., 2020).

There are several tools that can help compare the costs and benefits of investing in gray and green infrastructure. These include the Sustainable Asset Valuation Tool from the International Institute for Sustainable Development, and WaterProof from The Nature Conservancy.

This guide does not propose that NBS should be considered above all gray infrastructure solutions. NBS can take significantly more time to deliver benefits than gray infrastructure. The combination of gray and green infrastructure can be highly successful under the right conditions, and those looking to invest in infrastructure to solve critical societal issues should explore all options available to them. This guide provides initial steps towards quantifying the value of NBS through identifying methods to calculate the multiple benefits of NBS for watersheds and through benefit valuation.

As NBS principles (see Appendix C) become more integrated into infrastructure and system design, their capacity to address environmental and societal challenges becomes more apparent to the public sector, private sector, academia and NGOs. The growing impact of climate change has also expedited investment in NBS by various organizations, due in part to the social and economic benefits of such investments. Estimated potential global economic benefits of NBS can be found in Box 3.

BOX 3: ESTIMATED MONETARY BENEFITS OF NATURE-BASED SOLUTIONS

- The World Resources Institute (Cook & Taylor, 2020) estimates that:
- Every dollar invested in restoring degraded forests would create between $7–$30 in benefits.
- Wetland ecosystem services are worth up to $15 trillion annually.
- Restoring 160 million hectares of land would create $84 billion in annual economic benefits globally.
- Restoring upland forests and watersheds could save $890 million each year for water utilities.
- Protecting/restoring mangroves could create $1 trillion in net benefits globally by 2030.

BENEFIT IDENTIFICATION, ACCOUNTING AND VALUATION

Benefit identification can be one of the biggest hurdles for companies, because those looking to make investments in NBS may not consider or be aware of all the possible benefits that can accrue across NBS projects, let alone know how to estimate or quantify them. Benefit accounting is the quantitative or qualitative estimation or measurement of each benefit that accrues when stakeholders undertake NBS activities (Shiao et al., 2020). Identifying and accounting for benefits enables NBS stakeholders to calculate the social and economic value of a project (Shiao et. al., 2020). This guide provides companies and other interested parties with the following (Figure 1):

- A method to **identify and forecast** a range of potential NBS benefits;
- Suggested **indicators and calculation options** for estimating and measuring benefits; and
- A method to **value** NBS benefits across different thematic areas.

FIGURE 1: BUILDING THE BUSINESS CASE FOR NATURE-BASED SOLUTIONS THROUGH BENEFIT IDENTIFICATION, ACCOUNTING AND VALUATION.

CORPORATE MOTIVATIONS FOR INVESTING IN NATURE-BASED SOLUTIONS

Companies are increasingly showing interest in supporting NBS for watersheds as part of their corporate water stewardship activities (Shiao et al., 2020). The process for implementing corporate water stewardship—sometimes referred to as the water stewardship journey—typically starts with addressing water management within a company's operations, then across its value chain, developing robust targets and strategies across a company's operations and value chain, and finally partnering with other stakeholders to advance (and track) projects that meet targets and address water risks in priority watersheds. NBS can fit into each of these steps, as shown in Figure 2, and NBS projects are generally considered a subset of water stewardship projects (South Pole, 2018).

FIGURE 2: COMPLEMENTARITY OF NATURE-BASED SOLUTIONS ALONG THE STEPS IN THE WATER STEWARDSHIP JOURNEY

NBS may be utilized within a company's operations to achieve water management goals. Examples include building a treatment wetland or installing green stormwater infrastructure on site.	NBS should be informed by key water challenges (watershed context) as well as related social and ecological challenges.	NBS should be incorporated into water stewardship plans from the outset. Commitments to NBS starting at the corporate strategy level will help support investments in and implementation of projects.

It is important for companies to form networks and partnerships to further their water stewardship goals. NBS are most often implemented beyond a company's boundaries. Staekeholder engagement throughout the project is key to successful NBS projects (Brill et al., 2022). By including a broad range of stakeholders in watershed management, there is a greater opportunity to learn and communicate effectively, share expertise, build capacity, and find ways to partner to build long-term ecological, social and economic resilience. Good communication of the outcomes, benefits and challenges of NBS projects required robust monitoring and evaluation throughout the poject timeline. These partnerships should be aligned with adaptative management and collaborative governance principles.

Multiple barriers, including lack of internal buy-in or corporate culture (Conti et al., 2019), have limited the amount of corporate investment in NBS (see Appendix B for details). Companies further along the water stewardship journey may be better suited to implement NBS projects, although NBS may apply at any point along the journey.

There are multiple ways that companies can arrive at a decision to invest in NBS. Entry points can include water stewardship, climate adaptation or mitigation, biodiversity and ecosystem health, or community development (see Table 1).

TABLE 1: ENTRY POINTS FOR COMPANY INVESTMENT IN NATURE-BASED SOLUTIONS, INCLUDING DEFINITIONS AND EXAMPLES

Entry Point	Definition	Examples
Water Stewardship (Within Facility Fence Line and Beyond Fence Line)	The socially equitable, environmentally sustainable and economically beneficial use of freshwater achieved through a stakeholder-inclusive process that involves site- and catchment-based actions, including activities to reduce corporate water risks (Alliance for Water Stewardship, 2017).	Watershed restoration, agricultural NBS and best management practices (see Appendix D), green stormwater infrastructure, water funds.
Climate Mitigation	Actions to sequester atmospheric carbon or avoid the release of additional carbon.	Natural climate solutions, forest protection, soil health practices.
Climate Adaptation	Helping communities, economies and ecosystems become more resilient in the face of climate change impacts.	Disaster risk reduction, green infrastructure, urban heat effect reduction, coastal resilience.
Ecosystem Stewardship Or Environmental Conservation	Efforts to protect or restore ecosystem health and/or biodiversity.	Habitat protection, restoration or management.
Community Development	Investments aimed at developing the economy and quality of life for local communities or urban areas.	Job creation, environmental education, improvement of local governance mechanisms, urban greening, agricultural practices that improve yield.

Within the private sector, there is growing recognition of the potential for NBS to address both water and climate risks. NBS can:

- Generate multiple benefits to help companies meet their sustainability targets, including economic, social, environmental and resilience targets (see examples in Appendix E), while providing additional benefits to the surrounding communities and environment;
- Present cost-effective solutions when multiple benefits are incorporated (Abell et al., 2017), and provide a greater return on investment compared to gray infrastructure projects (TNC et al., 2013);
- Reduce regulatory, reputational and physical water risks, all of which are growing concerns to companies facing climate change-induced challenges;
- Support long-term business continuity across direct operations and supply chains; and
- Align with the Task Force on Climate-related Financial Disclosures and Task Force on Nature-related Financial Disclosures, which helps companies understand what financial markets want from disclosure to measure and respond to climate change risks, and encourages firms to align their disclosures with investors' needs.

Complementarity with Other Approaches

Table 2 outlines how this guide complements some existing approaches which focus on water, carbon and biodiversity (see Appendix F for details on each approach). These complementarities demonstrate that many of the ideas and approaches defined in this guide can be applied more generally to other types of projects across multiple categories, even if NBS is not the focus of these projects.

TABLE 2: COMPLEMENTARITY OF THIS GUIDE TO EXISTING APPROACHES UNDER DIFFERENT CATEGORIES

Category	Existing Approaches	Complementarity
Site- And Project-Level Sustainability Certifications	Alliance for Water Stewardship Standard Gold Standard LEED Certification Living Building Challenge	This guide can help companies meet certification requirements by helping practitioners select NBS projects, track the multiple benefits of NBS, monitor progress, and enable stakeholders to understand an organization's contribution to water stewardship, carbon reduction, and improved biodiversity.
Benefit Identification	Pacific Institute's Multiple Benefits for Water Projects Think Nature's Nature-Based Solutions Handbook	This guide identifies multiple benefits, with a focus on water, carbon and biodiversity to inform investment in NBS projects.
Water Target Setting	Contextual Water Targets Science-Based Targets for Nature: Freshwater methodology	This guide helps stakeholders track the progress of NBS towards meeting water challenges by providing indicators and methods for water, carbon and biodiversity.
Impact Evaluation	Dow's ESII Tool EcoMetrics EKLIPSE Impact Evaluation Framework Forest Trend's CUBHIC Tool to Quantify Water Benefits Natural Capital Protocol Volumetric Water Benefit Accounting Net Positive Water Impact CDP disclosures	This guide informs outcomes, impacts and dependencies by identifying and estimating the magnitude of outputs of water, carbon, biodiversity and socio-economic benefits.

The steps for benefit identification presented in Section 2 are aligned with many of the approaches in Table 2. These steps could be considered as complementary to other approaches, or potentially added to other approaches. Similarly, these other approaches may support practitioners in assessing the effectiveness of existing or future NBS and could be reviewed or considered for inclusion when designing, implementing or monitoring and evaluating NBS projects using the steps suggested in this guide. Additional initiatives engaging the private sector in NBS or other related activities can be found in a report from the World Business Council for Sustainable Development (WBCSD, 2020).

LIMITATIONS AND CAVEATS

This guide presents the potential benefits of various NBS with a focus on water, carbon, biodiversity and socio-economic themes. But the ability for NBS to deliver on a specific benefit, at the right place and time, varies depending on local context, scale and timing. It should be noted that this guide provides a general overview of the types of benefits produced by NBS (see Section 2), but may not be fully representative of every possible habitat and type of intervention, and it does not factor in local conditions. Specifically, the benefit forecasts provided in this guide and in the NBS Benefits Explorer are estimates, not guarantees. Actual benefit accruals are dependent on site-specific conditions and processes, the size of the NBS project site/municipality/watershed, implementation methods for activities, etc. Investors and practitioners should pursue more precise means of forecasting benefits as they move past the pre-feasibility phase of a project.

Furthermore, this guide is not able to provide indicators and calculation methods for every possible benefit, due to the context-specific nature of some habitats, and/or the lack of existing methods. Additionally, the guide does not cover all possible indicators or methods, but rather provides a framework for identifying and measuring benefits.

This guide presents a high-level description of appropriate quantification methods for a wide range of NBS benefits. Detailed descriptions of method applications and the data needed to conduct the analyses are beyond the scope of this phase of work. Practitioners should focus on benefits that are most relevant to key stakeholders and for which there is a higher likelihood of delivery, rather than trying to quantify as many benefits as possible. Practitioners are also urged to use indicators and calculation methods that best suit local conditions and that will provide the level of detail and certainty key stakeholders need. Additional benefits not captured in this guide may also be accrued.

Finally, valuation estimates will also be dependent on context, nature and scale of NBS. In this phase of the work, some benefit categories are valued using proxy indicators, as there are insufficient methods to capture the social and economic values of all benefits. These values are provided as suggested return on investment potential and should be quantified or measured post-implementation to ensure that a context-specific value is obtained.

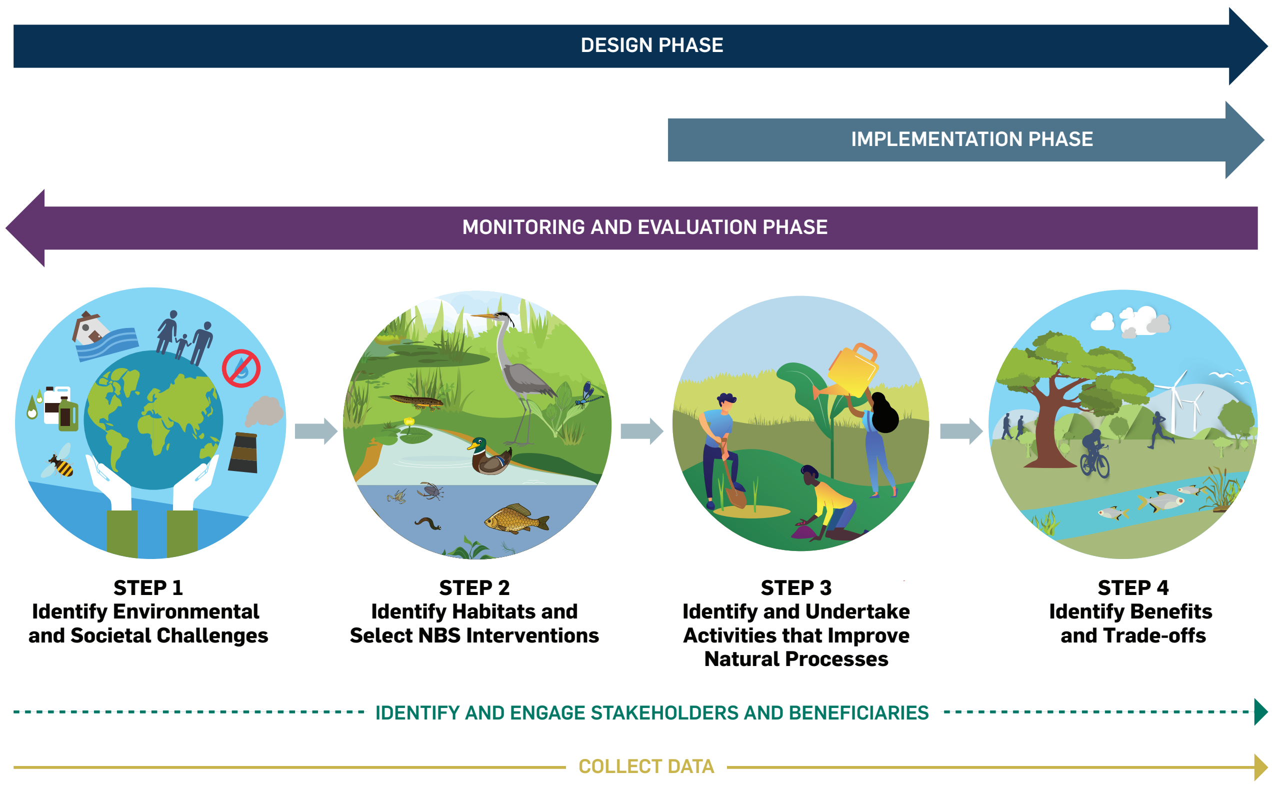
SECTION 2: **Identifying and Forecasting the Benefits of Nature-Based Solutions**

This section provides a starting point for identifying and forecasting the potential benefits accruing from existing and future NBS investments. It details which NBS activities can be implemented across various habitat and intervention types to meet key societal challenges and provide multiple benefits, and presents how these benefits accrue over different spatial and temporal scales. Each step will include an "In Practice" example, looking at how Danone applied this guide to its work in the Rejoso Watershed, Indonesia.

STEPS TO IDENTIFYING THE BENEFITS OF NATURE-BASED SOLUTIONS

Figure 3 presents steps to follow when identifying the benefits of NBS across the design, implementation and monitoring and evaluation (M&E) phases of NBS projects. The design phase will start at step 1 and continue through step 4. The implementation phase will include steps 3 and 4. For the M&E phase, it is necessary to start at step 4 and work backwards to ensure optimal NBS benefits and address any trade-offs. Each step is described in more detail below.

FIGURE 3: PROPOSED STEPS TO FOLLOW FOR BENEFIT IDENTIFICATION ACROSS THE DESIGN, IMPLEMENTATION AND MONITORING AND EVALUATION PHASES OF NBS PROJECTS



STEP 1: IDENTIFY ENVIRONMENTAL AND SOCIETAL CHALLENGES

NBS provide multiple options for addressing environmental and societal challenges, covering social, economic and ecological concerns, across different geographies and scales. These challenges can include water quantity issues (too much or too little), water quality concerns, carbon or biodiversity problems, human- or climate-induced changes to ecosystem functioning and health or trying to meet socio-economic objectives (such as providing economic opportunities). These challenges could align with the focus of the SDGs, notably SDG 3 (good health and well-being), SDG 6 (clean water and sanitation), SDG 8 (decent work and economic growth), SDG 9 (industry, innovation and infrastructure, SDG 11 (sustainable cities and communities), SDG 13 (climate action), SDG 14 (life below water) and SDG 15 (life on land).

Often, those looking to invest in NBS are trying to address multiple challenges simultaneously. A practitioner should start by identifying the challenges impacting them, or the broader community or landscape, as well as the root causes of those challenges. Shiao et al. (2020) provide an overview of these challenges across multiple habitat types. To realize the maximum benefits of NBS, identify and assess all major environmental and societal challenges in the context of the landscape in which NBS projects are planned. This process should heavily incorporate input from relevant stakeholders, such as Indigenous Peoples and local communities, government agencies, private and public sector organizations, etc. If it is not possible to assess all challenges, work with stakeholders to prioritize the most critical challenges as a starting point. Starting with the relevant environmental challenges can still enable an organization to utilize NBS effectively.

IN PRACTICE: Based on various water risk assessments around Danone's production sites in the Rejoso watershed, the Pasuruan district of Indonesia was identified as a priority location for action at Danone. Unsustainable practices throughout the watershed are causing significant threats to the watershed, including forest encroachment, changing land use, unsustainable farming practices and unsustainable groundwater abstraction. Specifically, deforestation upstream is causing soil erosion and decreased water infiltration, reducing the availability of water. Unmanaged and rampant community drilling for groundwater for agricultural irrigation and domestic use is placing further stress on water supplies. In addition, the national strategic project of the Indonesian government to expand the coverage of clean water supply from Umbulan Spring to Pasuruan District and its surrounding areas (Sidoarjo District, Gresik District and Surabaya City in East Java) is exacerbating the water pressures in the Rejoso watershed.

STEP 2: IDENTIFY AVAILABLE HABITAT AND INTERVENTION TYPES

The next step is to identify appropriate habitat and intervention types (see Appendices G and I) to develop NBS that address the specified environmental and societal challenges. This guide presents nine habitat types: agricultural lands, estuaries and deltas, forests, grasslands, lakes and ponds, mangroves, rivers and floodplains, urban, and wetlands.

Based on the state of the habitat, different intervention types can be considered. There are four categories of interventions (see Appendix G): restoration, management, conservation and creation. Restoration and creation interventions typically require the most effort to physically alter a habitat type. Management and conservation efforts may require less physical effort to achieve multiple benefits, although they may be logistically challenging and resource intensive. It is important to note that these four intervention types are not mutually exclusive, and many interventions may require the inclusion of other intervention activities (e.g. habitat protection may require some degree of restoration and/or management activities).

IN PRACTICE: Danone partnered with Gadjah Mada University (Indonesia) and Montpellier University (France) to assess the hydrogeological conditions, and with World Agroforestry (ICRAF) to provide evidence-based information for selecting the target habitats for NBS interventions in the Rejoso watershed in East Java, Indonesia. A further partnership with Yayasan Konservasi Alam Nusantara, a local non-profit organization, was established to communicate with the local government to address Rejoso's watershed challenges. ICRAF developed the typology of the watershed by identifying clusters of landscapes with similar biophysical (i.e. land cover and management, farming practices, levels of access to water, environmental problems faced, etc.) and socio-economic (i.e. income status, source of income, productivity, etc.) characteristics. The main habitats considered were croplands (including small-scale potato farmers upstream), agroforestry practices (midstream), and rice cultivation (downstream). The beneficiaries of planned NBS projects are primarily smallholder farmers and local community groups across the watershed. Local ecosystems will also benefit significantly from such investments. Intervention types included restoration, management and protection, to return degraded ecosystems to a pre-disturbance state, manage natural resource use and limit excessive future human impact within the watershed.

STEP 3: IDENTIFY ACTIVITIES THAT IMPROVE NATURAL PROCESSES

Determining a clear set of habitat and intervention types is foundational to defining the types of NBS that can be implemented. Interventions comprise separate NBS activities (e.g. removing alien vegetation in a wetland or along a river to improve water flows) within a particular habitat-intervention combination (e.g. wetland restoration). The identification of such activities during the design phase will assist those planning to invest in NBS with resource allocation, budgeting and other operational elements needed during the implementation phase.

Multiple activities are proposed in Table 3, including relevant sub-categories and examples. During the implementation phase, these actions directly and indirectly influence the functioning and health of ecosystems. If successful, these activities will improve natural processes (e.g. production of clean air, filtering of water) in the landscape, which enhance the benefits healthy habitat provides. Importantly, not all activities will be suitable across all habitat and intervention types. Practitioners should therefore implement appropriate activities based on local conditions and contexts.

TABLE 3: NATURE-BASED SOLUTION ACTIVITY CATEGORIES AND SUB-CATEGORIES

Activity Categories	Sub-Categories/Examples
Harvest and Store Rainwater	Build retention/detention ponds, rain gardens, swales, green roofs, permeable paving diversion channels; captured rainwater can be infiltrated into the soil or captured for reuse
Construct Natural Treatment Systems	Construct treatment wetlands, stormwater capture/treatment systems (e.g. bioswales, rain gardens, conservation landscaping, bioretention, green roofs)
Recharge Aquifers	Build retention/detention ponds, infiltration ponds; dig wells; remove hard surfaces; undertake artificial recharge
Re-Establish Hydrologic Connection	Re-wet historical wetlands; undertake floodplain inundation, channel reconnection; install bioswales and permeable surfaces
Remove Hard Surfaces	Remove roads, pavements, canals, compacted substrate
Remove Hard Structures/ Barriers	Remove berms, seawalls, weirs, dams, buildings
Restore/Improve Soil Health	Increase organic matter and carbon content; enhance soil fauna populations and microbial activity; increase plant diversity; improve soil chemistry/pH
Restore/Improve/Stabilize Substrates	Fix erosion; add natural structures; stabilize slopes or sand dunes; provide substrate for aquatic and marine ecosystems
Dredge Substrate	Remove sediment to improve flow/local hydrology; improve exchange or connectivity between surface water and groundwater; remove contaminated sediments
Restore/Plant/Maintain Native Vegetation	Plant trees and buffer zones; undertake successional planting; restore habitats (restore agricultural lands to natural areas)
Manage/Repopulate Native Fauna	Reintroduce or increase number of indigenous animals to influence ecosystem functioning
Remove Invasive Species	Remove foreign flora and fauna (includes reducing evapotranspiration by alien vegetation)
Undertake Brush Control	Reduce fuel load; cut tall grass/weeds to allow seedlings to get enough light
Undertake Fire Management	Restore natural fire regime
Avoid/Limit Habitat Conversion	Implement conservation easements; purchase land for conservation
Reduce/Avoid Resource Abstraction	Implement legal and financial transactions/mechanisms; policing/anti-poaching activities; proactive engagement
Install Protective Barriers	Install fences, wire, grids to reduce livestock/animal impacts; reduce unwanted herbivory or foot traffic
Introduce Grazing Management Systems	Undertake silvopasture and rotational grazing; reduce overgrazing
Implement Terraced/Contour Planting	Follow natural gradients of landscape; no levelling of slopes
Plant Vegetation Buffers	Plant cover crops, grass strips, hedge rows, trees in croplands, filter strips
Undertake Mulching and Fertilizing	Distribute animal manure, biochar, organic matter; build compost pits; undertake conservation tillage

IN PRACTICE: Danone's project in the Rejoso Watershed included reforestation in upstream areas and densification of agroforestry in midstream areas to improve soil and water infiltration. Activities included restoring/planting native vegetation, removing invasive vegetation, restoring/improving soil health, and removal of hard surfaces. Additionally, several activities were aimed at increasing water efficiency and reducing greenhouse gas emissions from rice cultivation in paddies by downstream rice farmers in the watershed. These included building retention/detention ponds for rainwater harvesting and recharging aquifers, planting native vegetation, and improving soil health. These activities were paired with regenerative agriculture best management practices around optimizing irrigation and limiting chemical fertilizer application. All efforts combined will positively impact chemical and hydrogeological processes across the area. In addition, Danone supported local governance structures to reduce resource abstraction. Specifically, a new public-private partnership will support the implementation of local water resources regulation, including welling procedures, and enable payments for ecosystem services.

STEP 4: IDENTIFY BENEFITS AND TRADE-OFFS

The NBS activities in watersheds lead to outcomes that can be both positive (benefits) and negative (trade-offs). Generally, however, the results arrive in the form of multiple benefits, with some trade-offs that may be unavoidable or unintended. Benefits can be delineated by themes (e.g. water, carbon, environment, etc.) as presented in Table 4. NBS activities yield different magnitudes of benefits over different spatial and temporal scales (see benefit forecasting sub-section). During the pre-feasibility and design phases of the project, NBS investors and practitioners should identify the scales and magnitudes of benefits needed for project success. After NBS activities have been undertaken during the implementation phase, the previously identified benefits should then be estimated or measured during the M&E phase (see Section 3 on benefit accounting) to ensure that the project is accruing appropriate benefits for multiple beneficiaries.

TABLE 4: IDENTIFIED PRIMARY NBS BENEFITS CATEGORIZED ACROSS FIVE THEMES

Theme	Benefits
Water Quantity	• Reduced/avoided surface runoff and associated erosion • Improved/maintained surface water storage • Increased/maintained groundwater recharge and storage • Improved/maintained flow regime • Improved/maintained flood protection and mitigation (inland and coastal)
Water Quality	• Improved/maintained surface water quality • Improved/maintained groundwater quality
Carbon	• Improved/maintained carbon sequestration • Reduced carbon emissions
Biodiversity and Environment	• Improved/maintained terrestrial habitat availability and quality (including soil health (see Box 4)) • Improved/maintained aquatic habitat availability and quality • Improved/maintained terrestrial habitat connectivity • Improved/maintained aquatic habitat connectivity • Improved/maintained support for local pollinators • Improved/maintained natural pest control • Increased/maintained abundance and diversity of native plant species • Increased/maintained abundance and diversity of native animal species
Socio-Economics	• Improved/maintained climate adaptation and mitigation • Improved/maintained livelihood opportunities • Improved/maintained human health • Improved/maintained agriculture/agricultural output • Expanded/maintained religious/spiritual settings • Enhanced/maintained microclimate regulation • Improved/maintained opportunities for education/scientific study • Increased/maintained food security • Improved/maintained recreation/tourism opportunities • Increased/maintained property/land value

BOX 4: SOIL HEALTH

Many companies, particularly those with an agricultural component to their business, are significantly concerned about soil health. Sustainable management practices, most of which include NBS, build soil health by increasing water infiltration and retention, increasing nutrient supply through increased organic forms of nutrients, and buffering against changes in soil pH. Soil health improvements provide agricultural benefits like greater yield resilience under extreme weather events and, in some cases, enhanced crop and forage nutritional quality. Some agricultural practices that build soil health, like incorporating native vegetation into farm fields and edge-of-field areas, can also increase habitat for biodiversity. Practices such as no-till, cover crops, intercropping, agroforestry, silvopasture and targeted nutrient management are examples of in-field best management practices that can improve soil health.

Soil health is a fundamental element in healthy ecosystems. Environmental benefits include improvements to biotic and abiotic soil communities, avoided greenhouse gas emissions, increased carbon sequestration and improved water quality. Mulching and fertilizing, in urban and rural areas, can also improve soil health.

Across the benefit themes (see Table 5), soil health influences water quality, water retention, carbon, biodiversity and various socio-economic areas. Soil health is thus a common theme and can be measured by a combination of metrics within these themes. Practitioners looking to invest in NBS should pay attention to soil health to ensure that ecological processes and functions are restored, maintained or improved.

BOX 5: HYDROLOGIC VERSUS GEOMORPHIC FLOOD PROTECTION

Flood protection is a major benefit of NBS. Historically, flooding and flood protection have predominantly been assessed using hydrological variables (flow regimes, inflow rates, etc.). Recent environmental flow research has called for techniques that incorporate hydrologic and geomorphic processes, which are important for ecological and riverscape health.

The activities, processes and benefits of flood protection span both hydrologic and geomorphic domains (see Appendix G). For example, the dynamic interaction between a river and its floodplain is important for a variety of hydrologic and geomorphic processes (Stone et al., 2017) and it is important to assess the potential and realized levels of flood protection across both. Beyond hydrologic variables, the topography of river corridors and habitat heterogeneity are important geomorphic aspects to consider (Stone et al., 2017).

BOX 6: FIRE MANAGEMENT

Wildfires are destructive events that impact many habitat types and can have significant impacts on many natural, chemical and biophysical processes, and influence the magnitude and temporal dynamics of benefit accrual. Wildfires go beyond just burning vegetation and infrastructure. For example, wildfires can have both short- and long-term impacts to water quality and peak flow. Wildfires that destroy vegetative groundcover reduce a habitat's capacity to intercept precipitation before it hits the ground, leading to increased volume and velocity of surface runoff. Depending on the characteristics of the fire, vegetation type, and soil, certain wildfires can burn soil such that it is more likely to repel water, which reduces infiltration and leads to higher amounts of runoff. The resulting high velocity and high volume of surface flows can lead to physical damage throughout the watershed (Aregai & Neary, 2015).

The impact from wildfires on water quality is also a concern. Physically, wildfires can increase erosion, turbidity and water temperatures. Chemically, they can increase the production of nutrients, interrupt balances of basic and acidic ions, decrease oxygen levels, and introduce chemical contaminants. If not managed, wildfires can cause extreme damage to downstream ecosystems and subsequently adversely affect socio-economic conditions (Aregai & Neary, 2015).

Fire management, through thinning of vegetated areas, brush control and prescribed/planned fires, is an important activity that can prevent or limit the damage caused by wildfires. Prescribed fires have particularly proved to be a useful tool to manage large forests in areas where economic resources are limited. Aside from preventing the damaging effects of uncontrolled wildfires, controlled burns can also help to manage invasive species and facilitate the colonization or recovery of keystone species (Francos & Úbeda, 2021).

Fire management can be seen as a preventative measure that mitigates against potential negative impacts to the watershed, rather than an activity that is actively improving watershed conditions. In some cases, fire management can cause an increase in positive benefits as the spatial scale increases.

The identification of benefits and trade-offs for NBS is based on a scientific understanding of the processes and flows affected within each ecosystem, but many factors can impact the actual delivery of the benefits and trade-offs. These factors include the quality of implementation (using native species, using scientifically-designed plantings, etc.), the degree to which the implementation on the ground matches the plans or directives for implementation, the scale of implementation, land use change or other human-related impacts outside of the intervention area of the NBS, extreme events, climate influences, natural plant inconsistencies in growth and survival rates, and the quality and frequency of maintenance of the NBS over time.

To understand when and where benefits are most likely to occur, a growing body of research has collated and analyzed field-based studies for insights that can inform implementation and investment. Some examples include:

- Oxford University's NBS Evidence Platform
- The Nature Conservancy's AgEvidence (for Agricultural NBS and best management practices)
- Literature review of agricultural NBS from The Nature Conservancy and the Food and Agriculture Organization (FAO)
- The Nature Conservancy, Wildlife Conservation Society and the National Center for Ecological Analysis and Synthesis' SNAPP working group on water quantity impacts of NBS or NBS for sanitation.

IN PRACTICE: Danone identified a wide range of benefits across the water quantity, carbon, biodiversity and environmental, and socio-economic themes:

Water Quantity	• Improved groundwater recharge • Reduced surface runoff and erosion • Improved surface water storage and quality • Improved flood mitigation
Carbon	• Carbon sequestration • Avoided methane emissions
Biodiversity and Environmental	• Improved terrestrial habitat quality (including soil health) • Increased abundance and diversity of native plant species • Increased abundance and diversity of native animal species
Socio-economic	• Improved agricultural output • Increased food security • Improved livelihood opportunities • Increased land value

These benefits would increase if actions were to be scaled up across a larger area. Trade-offs appeared within the economic impact category for rice farmers, as they had to prioritize improved quality over productivity (higher yields). These trade-offs are minimized by linking the farmers with better access to agricultural financing and markets.

IDENTIFYING AND ENGAGING STAKEHOLDERS AND BENEFICIARIES

It is crucial that stakeholders are engaged from the outset of any NBS project (pre-feasibility/feasibility). Engagement should then be an ongoing practice throughout each step of the NBS design and implementation phases, as well as during M&E. This engagement should aim to assess and reassess the needs and societal challenges of communities adjacent to the habitats where NBS are planned, identify who the beneficiaries of NBS are across different spatial and temporal scales, and ensure trade-offs are not unfairly distributed. It is important to understand which benefits and trade-offs are most important to different beneficiaries. By understanding benefit or trade-off priorities, practitioners can better understand how to evaluate benefit and trade-off distribution. Inclusion of historically excluded groups (based on gender, race or socio-economic status, etc.) should be prioritized.

It is also key to understand how beneficiaries articulate their benefit needs. Some stakeholders may indicate that certain activities influence environmental processes and functions, which they may not perceive as direct benefits. For example, restoring forest habitat may enhance soil stability and soil health. To the environment, that may result in better water retention, less erosion, more soil carbon sequestration, etc. To a potential stakeholder, these may not be considered a benefit. To them, the benefits may be reduced flooding, income from carbon credits, improved crop productivity, etc. This nuance is therefore an important consideration to note during the stakeholder identification and engagement phases and may inform how benefits are reported and measured.

Specific NBS stakeholder engagement guidelines (Brill et al., 2022) have been developed to complement this NBS guidance and support investors and practitioners in ensuring equitable and inclusive stakeholder engagement. This guide takes a pragmatic approach to stakeholder engagement by presenting general principles and best practices that should be considered throughout all stages of an NBS project, as well as outlining specific steps for incorporating stakeholder engagement throughout NBS project stages. The identified principles and best practices include engaging a diverse range of stakeholders; building long-term relationships and trust; communicating with empathy; prioritizing transparency and accountability; co-creating rather than imposing; recognizing mutual benefits; removing barriers to engagement; formalizing relationships; ensuring adequate financial support; and appointing well-trained, knowledgeable facilitators.

IN PRACTICE: To ensure that all relevant stakeholders were included in all project phases, Danone and ICRAF conducted a stakeholder mapping and capacity-building exercise. Consequently, regular meetings were established with farmers, farming committees and organizations, traders and other relevant local groups. The aim was to collectively identify gaps and solutions, build clear action plans and conduct capacity-building workshops. Campaigns, events and other communication assets were aimed at raising local awareness on project actions and disseminate best practices. During the Covid-19 pandemic, Danone and ICRAF produced interactive videos to train farmers virtually and ensure the project continued. Danone has found it especially impactful to make this project a fully community-driven initiative, rather than corporate-led, to ensure widespread inclusion and engagement. The multi-stakeholder movement for watershed protection has a local office and supporting staff.

COLLECTING DATA

Data collection should also start during the NBS pre-feasibility/feasibility and design phases and continue throughout subsequent project phases. Interviews with internal and external stakeholders will form the basis of what challenges the project will address, as well as what the project aims to achieve. This includes the need to conduct socio-economic and hydrogeological studies, to measure environmental and societal baseline data before project implementation, and to ensure that the project addresses real-world challenges. Data collection should continue with operational and maintenance benchmarks during and after implementation. These data will allow for analyses of benefits accrued from NBS and to determine improvements in the watershed over time. The nature and scale of the project and the resources and funds available to those collecting data will influence the frequency and intensity of data collection, as well as the type of data collected (e.g. qualitative versus quantitative, in-depth samples versus superficial, etc.).

IN PRACTICE: Danone started collecting data during the project's design phase to understand local pressures and water risks, and to tailor actions to optimally address them. The company conducted extensive hydrogeological studies cooperatively with Gadjah Mada University (Indonesia) and Montpellier University (France). Several post-graduate students assessed the watershed to understand water flow regimes and collect primary data. A socio-economic study was conducted with ICRAF to identify the needs of potential beneficiaries. M&E was taking place throughout project implementation to evaluate project impacts. While actions were initially aimed at the entire watershed, it became clear that NBS in agricultural landscapes had the largest potential impact on the watershed. Therefore, project actions were adapted to focus increasingly on rice farmers downstream. To measure the multiple benefits accrued from this NBS project, farmers received technical support for monitoring systems and water meters, which were used to collect and analyze data around resource use efficiency, water quality, soil health and greenhouse gas emissions. Indicators on farmers' livelihoods were also measured, such as productivity and profits, and qualitative household surveys were conducted to assess awareness to conservation agriculture, network improvements and more.

FORECASTING BENEFITS AND TRADE-OFFS

As part of the benefit identification steps, this guidance presents a methodology to project NBS benefit accrual over multiple spatial and temporal scales. These forecasts, presented in the NBS Benefits Explorer tool, predict the magnitude of potential benefit accrual over three temporal scales (1–4 years, 5–9 years and 10+ years) and three spatial scales (property, municipal and watershed). This not only improves the accuracy of the benefit identification process, but also increases transparency on what types of benefits can be expected, the length of time it may take to achieve those benefits, and the spatial scales at which investors may experience those benefits. This enhanced understanding is crucial for mainstreaming and upscaling NBS projects, which often require long-term planning. These forecasts will ultimately be integrated into the NBS Benefits Explorer tool. A full methodological overview of the forecasting work is presented in Appendix H. This work will be ongo-ing. The next steps for the forecasting component of this project revolve around validating data points and building certainty. Once the NBS Benefits Explorer tool has been updated with the forecasting outputs, expert reviewers who implement and/or research NBS, ecological processes, landscape management, and other relevant areas of study will input empirical data based on real-world project parameters; this will support data verification and validation. Their feedback, along with feedback from the expert advisory group (EAG) and other stakeholders, will be incorporated into the forecasting work. Additionally, the project team will annually review gray and academic literature to ensure forecasts are up to date with current research to retain their accuracy.

SECTION 3: **Valuing the Benefits of Nature-Based Solutions**

To further determine the effectiveness of NBS, one can continue along the benefit accounting progression (see Figure 1) and determine the monetary benefits and return on investment. Valuation of benefits requires significantly more data over different time periods (e.g. short-term monetary benefits vs long-term monetary benefits) and sometimes requires a different approach than those used to only quantify benefits.

Economic valuation of the benefits of NBS is founded on the theory of welfare economics, which aims to assign a monetary value that society assigns to a given (environmental) quality. In many cases, this value is not directly observed in market prices. For example, the value of trees for timber has a market price, but the benefits of forests for flood control, carbon sequestration, or providing opportunities for recreation do not. Nevertheless, ecosystems are scarce, and their non-market benefits can be substantial—estimated in trillions of dollars globally (Constanza et al., 2014).

While there have been increasing efforts to express nature's value in both monetary and non-monetary terms, there remains a significant gap between demonstrating the value of nature and finding private sector actors who are willing to pay for nature. Economic valuation is a useful tool for illustrating the benefits of NBS in a language that is understood by the private sector: monetary value. However, conducting economic valuation studies can be technically complex and time-consuming—a significant barrier for companies which are only just getting started with NBS investment.

In this work, we present a rapid assessment of some of the benefits of NBS at the pre-feasibility stage, as seen in the NBS Benefits Explorer tool. This tool aims to give a ballpark estimate of benefits for practitioners who are in the early stages of considering, designing or implementing an NBS project. It is important to note that the estimates provided here are not a substitute for more detailed project cost-benefit assessments. For organizations seeking a detailed economic valuation, there are several organizations supporting efforts to provide valuation of benefits (e.g. EcoMetrics LLC and Denkstatt). We encourage practitioners to review economic approaches offered by these organizations.

SUMMARY OF VALUATION APPROACHES

The valuation component of this work as reflected in the NBS Benefits Explorer tool is based on an approach originally developed by The Coca-Cola Company (TCCC), in partnership with Denkstatt and Easton Consult (The Coca-Cola Company, 2021). TCCC's approach applies the Natural Capital Protocol's process of materiality assessment to arrive at a subset of NBS benefits to be valued that most often occur in a water replenishment context.

The TCCC approach, and by extension that of our tool, aims to:

- Allow rapid assessment of the benefits for NBS with little data inputs
- Be globally applicable
- Illustrate the value of a subset of NBS benefits

The approach does not purport to be exhaustive in its scope; certain benefits may be relevant for certain projects in their individual contexts that are not currently covered in our tool. Results measured on-the-ground reflecting local project contexts in detail may also differ from the results of our tool.

Some adjustments have been made to the methodologies as originally applied by TCCC. TCCC's approach is meant to be applied at the project scale, while our tool aims to be global in scope; some methods have been substituted with alternatives where global data is more readily available. These alternative methods are used internally by TCCC for sensitivity analysis of results. The scope of the tool is presented below, while its methodological details are elaborated in Appendix I.

Economic valuation by design measures the value of nature for people only—i.e. the so-called "anthropocentric" value perspective. This is conceptualized via the framework of Total Economic Value (TEV), presented below.

FIGURE 4: TOTAL ECONOMIC VALUE FRAMEWORK

Explanation of Total Economic Value terms:

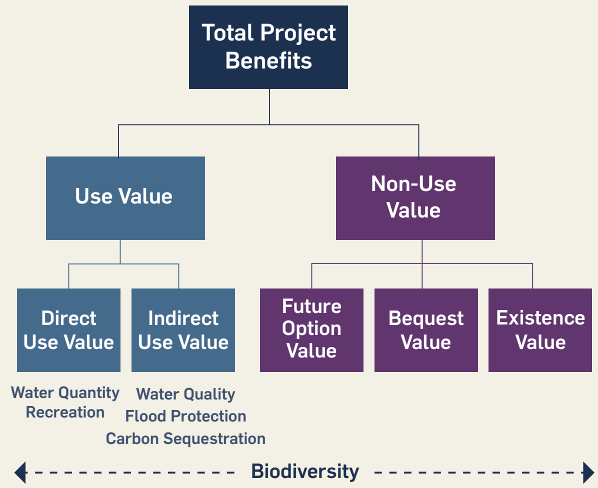
Direct use value: Benefits obtained from current use of a particular resource. Can be consumptive (resource is extracted) or non-consumptive (resource is exploited but not consumed).

Indirect use value: Benefits obtained from ecological functions.

Option value: Benefits from having the opportunity to use a resource in the future.

Bequest value: Benefits from satisfaction of preserving natural environment for future generations.

Existence value: Benefits from satisfaction that an aspect of nature exists, even if it will never be used or directly experienced.



Our current approach focuses exclusively on the use values of nature's benefits—both directly (via resources or non-consumptive interactions with nature), and indirectly (benefits of ecosystem functions such as carbon storage). As non-use values are excluded, results should be interpreted as lower bounds for the value of NBS. The value of nature is different for different stakeholders, depending on what aspect of their relationship with nature is valued, and very often also depending on the practical methodology applied. Where possible, our tool aims to present the results from multiple approaches. The actual results in individual project contexts would depend on local conditions. Our tool aims to show at least some of the range of values that may be observed.

When it comes to applying monetary valuation to the benefits of NBS, some caveats are also necessary. Valuing the contribution of nature (ecosystem services) to human well-being is not the same as commoditization or privatization of nature. Most ecosystem services are public goods and cannot (or should not) be privatized. Their monetary value expresses the benefits to society that would be lost in the absence of nature, or alternatively the value created via investing in NBS. In addition, monetary valuation by design reflects on the value of nature for people. In certain contexts, different value perspectives (such as Indigenous knowledge) may be incompatible with valuation of nature, and different (non-monetary) approaches to assessing value would be more appropriate in such contexts.

SECTION 4: **Calculating the Benefits of Nature-Based Solutions**

Calculating benefits and trade-offs from NBS is an important step in ensuring that these projects provide adequate benefits for investors and beneficiaries across appropriate temporal and spatial scales. This section provides a variety of indicators and calculation methods to estimate or quantify water, carbon and biodiversity benefits, as well as some socio-economic benefits, based on existing NBS approaches that have been adopted extensively around the world.

Accounting for NBS benefits is a key component of a project's M&E efforts, helping to ensure that NBS are delivering the benefits identified and forecasted through the steps proposed in Section 2. It is important to note that the selection of indicators depends on the local context, data availability and stakeholders. Take care to ensure that the indicators selected are measuring the benefits of interest to stakeholders, including local communities and Indigenous Peoples.

WATER QUANTITY BENEFITS

Hydrologic processes are fundamental to the performance of natural systems, and consequently hydrologic benefits are an important part of the characterization of overall NBS benefits. Water enables and sustains a host of processes essential to the life cycles of plants and animals, both terrestrial and aquatic. Hydrologic processes act at many scales: from the water budget of an entire watershed to the action of tiny capillaries in plant roots, water's effects can be observed and quantified. Hydrologic processes also operate in many different settings, including sheet flow and rill (shallow channel) formation in a watershed's headwaters, slow moving groundwater, surface water flow in creeks and rivers, and tidal exchange in estuaries.

Water benefits relate to the many ways that water cycles through natural systems: as flowing water that cleanses and provides nourishment, as groundwater that provides filtration and root zone replenishment, or as stored water that provides buffering against dry periods and protection from flooding. Hydrologic benefits are characterized using metrics and tools that are based in hydrologic sciences, which provide ways to observe, measure and record the way water flows through natural systems.

The methods provided below (Table 5) are drawn from the *Volumetric Water Benefit Accounting* (VWBA): *A Method for Implementing and Valuing Water Stewardship Activities* (Reig et al., 2019). Volumetric water benefits (VWBs) are defined as "the volume of water resulting from water stewardship activities, relative to a unit of time, that modify the hydrology in a beneficial way and/or help reduce shared water challenges, improve water stewardship outcomes, and meet the targets of Sustainable Development Goal 6." The VWBA report provides water stewardship practitioners with a standardized approach and set of indicators to quantify and communicate the VWBs of effective water stewardship activities that increase the likelihood of generating social, economic and environmental benefits and solving shared water challenges. This guide has adapted the activity column (Table 5) to align with the activity list in Table 3, as well as added a habitat intervention column to indicate where these activities are relevant.

TABLE 5: WATER QUANTITY BENEFITS AND ASSOCIATED ACTIVITIES, INDICATORS AND CALCULATION METHODS

Benefit	Habitat Intervention	Activity	Indicator	Calculation Method
Reduced/Avoided Surface Runoff and Associated Erosion **Improved/ Maintained Flood Protection and Mitigation (Inland and Coastal)**	Terrestrial protection	Avoided habitat conversion	Avoided runoff	Curve number method
	Terrestrial restoration and management	Plant/restore native vegetation	Reduced runoff	Curve number method
	Agricultural management	Agricultural NBS (e.g. plant vegetation buffers including cover crops)	Reduced runoff	Curve number method
Improved/ Maintained Surface Water Storage	Wetland creation (artificial or introduced)	Construct treatment systems (treatment wetlands, rain garden treatment systems)	Volume treated	Volume treated method
	Urban habitat creation, wetland creation	Store rainwater (retention/ detention ponds, rain gardens, etc.)	Volume captured	Runoff reduction method
	Terrestrial and wetland restoration	Remove invasive and aggressive indigenous species	Reduced evapotranspiration*	Evapotranspiration method
Improved/ Maintained Flood Protection and Mitigation (Inland and Coastal)	Aquatic restoration and management	Re-establish hydrologic connection (floodplain inundation, rewetting of historical wetland)	Increased inundation volume	Inundation method
Increased/ Maintained Groundwater Recharge and Storage	Wetland protection	Avoided habitat conversion (wetland)	Maintained recharge	Recharge method
	Urban habitat creation, agricultural creation	Store rainwater and recharge aquifers	Increased recharge	Capture and infiltration method or recharge method
Improved/ Maintained Flow Regime	Aquatic restoration	Reduced/avoided resource abstraction	Reduced withdrawal or consumption	Withdrawal or consumption method
	Aquatic restoration	Remove hard structures (in-stream barrier removal)	Improved flow regime	Hydrograph method
	Terrestrial and aquatic restoration	Remove invasive and aggressive indigenous species	Reduced evapotranspiration*	Evapotranspiration method

Source: Volumetric Water Benefit Accounting (VWBA): A Method for Implementing and Valuing Water Stewardship Activities (Reig et al., 2019)
**Where site-specific modeling or monitoring data are available to support the analysis, volumetric benefit associated with invasive species removal may be quantified based on improved flow regime.*

As shown in Table 5, indicators and calculation methods for each benefit vary by activity. In the application of these methods, it is important to keep in mind the temporal and spatial scale of the activity. The calculation methods can be applied to estimate or measure the direct volumetric benefit of a particular activity when the improved habitat is fully functional, rather than an immediate benefit or the benefit at a watershed scale. As an example, baseflow may be improved by activities that are implemented in upland areas, such as activities that reduce runoff and enhance surface storage. Most restoration activities are not of sufficient spatial scale to improve baseflow in a stream, and there are many other factors such as climate and other watershed activities that increase or reduce the magnitude, timing and duration of baseflow. But the calculation methods can be applied to estimate the volume of water that does not run off the land or that is captured and stored as a direct result of the activity when the project is fully functional.

A brief description of each water quantity benefit calculation method listed is in Appendix J. These pragmatic approaches can be applied using readily available information with a reasonable level of investment. More detailed descriptions of each method including required inputs, applications and example illustrations are provided in the VWBA report (Reig et al., 2019). It should be noted that the VWBA methods are not designed to provide a detailed and prescriptive "how to" manual for quantifying VWBs; rather, it serves as general guidance to inform the quantification process. Also, the VWBA report is published as a working paper, which means the VWBA can be enhanced with lessons learned from piloting the methods, monitoring, data collection, and analysis to strengthen hydrological models and validate assumptions. Where appropriate, other documents and approaches that report on or support volumetric benefits should also be considered.

WATER QUALITY BENEFITS

Disturbance of natural land cover from developed and agricultural landscapes contributes to degradation of surface water quality in multiple ways. First, reduction of natural land cover increases the rate of runoff by reducing natural infiltration capacity. Second, the quality of runoff deteriorates due to increased soil erosion, and in many cases from non-point source pollution due to specific land uses. A range of protection, restoration, management and creation interventions may be implemented to avoid or reduce these impacts, with a corresponding benefit of improved surface water quality. The mass of avoided or reduced pollutant load (sediment, excess nutrients, fecal matter, heavy metals and oils, etc.) per time unit is calculated using monitoring, modeling methods or a combination of the two.

Table 6 provides recommended indicators and calculation methods by activity for water quality benefits. These calculation methods can be applied to estimate the benefits of completed projects after monitoring data and other information has been collected and is available for analyses. A company may want to estimate the rough order-of-magnitude water quality benefits for a project as part of the selection process before this information is available. In this case, monitoring data collected from similar systems in the same region or simplified model results may be used to estimate pre-project benefits.

Appendix K provides details on the numerous methods to quantify the water quality benefits from an NBS project.

TABLE 6: ACTIVITIES THAT CONTRIBUTE TO IMPROVED WATER QUALITY AND CORRESPONDING INDICATORS AND CALCULATION METHODS

Benefit	Habitat Intervention	Activity	Indicator	Calculation Method
Improved/ Maintained Surface Water Quality	Terrestrial Protection	Avoided habitat conversion	Avoided pollutant load	Modified simple method; Revised Universal Soil Loss Equation (RUSLE)
	Terrestrial Restoration and Management	Plant/restore native vegetation	Reduced pollutant load	Modified simple method; RUSLE
		Remove hard surfaces	Reduced pollutant load	Modified simple method; RUSLE
	Aquatic Restoration and Management	Restore/improve/stabilize substrates (streambank stabilization)	Reduced pollutant load	Stream bank recession rate
	Agricultural Management	Agricultural NBS (e.g. restore/improve soil health, grazing management systems, terraced/contour planting, mulching and fertilizing)	Reduced pollutant load	RUSLE or agricultural best management practice models under development (e.g. Nutrient Tracking Tool)
		Agricultural NBS (e.g. plant vegetation buffers)	Reduced pollutant load	Pollutant reduction efficiency method
	Wetland Creation	Construct treatment systems (constructed wetland treatment systems, stormwater capture/ treatment systems with well-defined inlets and outlets (e.g. bioswales))	Reduced pollutant load	Direct monitoring
		Construct treatment systems (stormwater capture/treatment systems without well-defined inlets and outlets: rain gardens, conservation landscaping, bioretention, green roofs)	Reduced pollutant load	Modified simple method

BOX 7: CALCULATION METHODS FOR NATURE-BASED SOLUTIONS AND GROUNDWATER QUALITY

Groundwater is an essential resource, used for supplying potable water to urban and rural areas, agricultural production and for supporting groundwater-dependent ecosystems. Groundwater is used for irrigation, potable supply and economic development, and plays a fundamental role in the functioning of natural systems (Baoxiang et al., 2012; Kumar et al., 2015). The quality of groundwater globally is decreasing, due to anthropogenic impacts such as contamination from various pollutants, over-abstraction leading to saltwater intrusion in coastal areas, and major subsidence in some areas, among others.

There are many indicators and methods for assessing groundwater quality (e.g. Groundwater Quality Index for human consumption, groundwater state indicator, groundwater balance), but these methods cannot currently quantify the changes in groundwater quality because of implementing a particular NBS. This is because groundwater systems are heterogeneous, with contaminant distributions that are particularly challenging to map. Also, contaminant transport and remediation of pollution in these systems often involves long timescales, which are influenced by variability of soil chemistry and composition, the spatial extent of the aquifer, and location of point sources of potential contamination, as well as other parameters, such as hydrodynamic and transfer parameters of aquifers and their spatial distribution (Mohamed et al., 2019). Hence, groundwater quality is more complex to understand, assess and remediate than surface water quality (World Water Quality Alliance, 2021), and therefore, it may take several years or even decades for the impacts of an NBS project to be observed in groundwater quality. Groundwater monitoring programs should be targeted to the specific purpose of the activity or intervention, which might include tracing and remediating specific contaminants, focusing on short-term campaigns to understand local contamination issues, or creating longer-term, larger-scale systematic monitoring programs to identify general spatial patterns and long-term temporal trends in groundwater quality (World Water Quality Alliance, 2021).

The degree of groundwater pollution risk which influences water quality has a direct connection to the pollution discharge and environmental vulnerability of the watershed. Strict control of pollution sources (e.g. industrial and domestic effluent, diffuse source pollution linked to agriculture, etc.) is necessary to improve the status of groundwater and implement suitable solutions to address these pollutants. NBS can often be a cost-effective and efficient means of addressing and improving groundwater quality (Bergkamp & Cross, 2006; UNWWWAP, 2018). In the absence of data, we recommend defining representative water points (wells, springs, etc.) within the watershed where NBS activities are implemented to carry out monitoring at least twice a year (under high and low water stages). Important new monitoring technologies and practices are developing, that include earth observations and geographic information systems, citizen science, machine learning, and numerical modelling of contaminant fate and transport (World Water Quality Alliance, 2021).

However, information and data on groundwater quality are very variable across the globe, with often less information available in countries of the Global South. For a comparable global assessment, substantial efforts are needed to improve data collection and develop the capacity and knowledge base of groundwater modelers and planners, with particular focus on developing countries, as well as develop international standards. A dedicated global groundwater quality assessment is necessary and timely. It will provide a comprehensive and coordinated overview of the knowledge base pertaining to groundwater quality, including mapping of main drivers, pressures, trends and impacts, and current and prospective management approaches (World Water Quality Alliance, 2021).

CARBON SEQUESTRATION AND AVOIDED CARBON EMISSION BENEFITS

Biological carbon sequestration is the process of capturing and storing atmospheric carbon dioxide in vegetation such as grasslands or forests, as well as in soils. Carbon is sequestered in soil by plants through photosynthesis and can be stored as soil organic carbon. Interventions and activities that involve terrestrial, wetland or mangrove restoration, management or conservation, as well as some agricultural NBS and best management practices (BMPs), can sequester carbon.

TABLE 7: CARBON BENEFITS AND ASSOCIATED ACTIVITIES, INDICATORS AND CALCULATION METHODS

Benefit	Habitat Intervention	Activity	Indicator	Calculation Method
Improved/ Maintained Carbon Sequestration	Terrestrial restoration, wetland and mangrove restoration	Plant/restore native vegetation, introduce grazing management systems	CO2 removals by above- and below-ground biomass and soil	Stock-change or gain-loss methods
	Agricultural management	Agricultural NBS (introduce grazing management systems, plant vegetation buffers)	CO2 removals by above- and below-ground biomass and soil	Stock-change or gain-loss methods
Reduced Carbon Emissions	Terrestrial (forest, grassland) protection	Avoided habitat conversion (forest, grassland)	Avoided CO2 emissions (metric tons) from above- and below-ground biomass and soil	• Stock-change or gain-loss methods • Land cover and climate altering land cover indicator
	Agricultural management	Agricultural NBS (activities relating to rice management like restoring/improving soil health)	Avoided CH4 emissions from soil (rice fields)	Stock-change or gain-loss methods
	Wetland protection	Avoided habitat conversion	Avoided CH4 emissions from soil at wetlands	• Stock-change or gain-loss methods • Land cover and climate altering land cover indicator

Most carbon quantification protocols describe several critical but nuanced factors that are important to consider, including the concepts of “leakage” and “additionality.” Leakage refers to a spillover effect where carbon-friendly measures in one place are undone by relocated actions elsewhere (e.g. one acre of rainforest is protected, which leads to a different acre of rainforest being logged). The additionality concept refers to a net “additional” carbon benefit, or whether an existing benefit is just being counted as a new one (e.g. not cutting down an acre of rainforest is counted as a credit, when nothing really changed; preventing a loss is not the same as adding a gain). With the increasing stakes of carbon markets and climate-friendly investments, these issues have led to debates about what counts. Resources such as those from the European Commission and the GHG Management Institute offer further details and guidance on these concepts.

Appendix L provides an overview of methods to quantify the carbon-related benefits from NBS projects.

The authors, and civil society in general, strongly endorse that claims of "offsetting a footprint" can only be made if the carbon sequestered and/or the avoided emissions are third-party verified. These offsets could be a carbon credit, but should be transparently and permanently registered.

BIODIVERSITY AND ENVIRONMENTAL BENEFITS

Many NBS that protect, expand or improve natural areas can provide habitat and improve biodiversity (Kazemi et al., 2011). These benefits stem from improving the availability, size, connectivity or quality of habitats and by reducing invasive species, halting or limiting the overexploitation of resources and stopping the spread of wildlife diseases, among other factors. There are many potential indicators and metrics for measuring biodiversity benefits to the environment, including those listed in Table 8.

Biodiversity and environmental outcomes are often the foundation for other types of benefits from NBS. The benefits of NBS to the environment are quantifiable and qualifiable, and, in some cases, can be monetized (e.g. value of pollinators for crop yield). This is especially true for NBS that are implemented on existing natural landscapes (as opposed to in urban areas). For example, at a basic level, an altered landscape can be evaluated by measuring the total area impacted. More complex analyses can quantify a change in habitat quality or impact on a variety of biodiversity indices.

There are a range of existing tools and resources available for quantifying the NBS benefits to habitat and biodiversity. Colléony and Shwartz (2019) developed a framework for modeling social and ecological outcomes of NBS, including identifying spatially explicit biodiversity outcomes. While the framework differs slightly from the one presented here, the ecological indicators presented can help to determine metrics for measuring benefits to biology and ecology. For agricultural settings, the FAO developed a review of indicators and methods to assess biodiversity focused primarily on applications to livestock production (Teillard et al., 2016).

Importance of High Priority or Highly Threatened Landscapes

Degradation and loss of natural habitat is the major driver of the current global biodiversity crisis (Mokany et al., 2020), leading to many species becoming threatened, endangered or extinct. Some habitats and landscapes must therefore be prioritized over others for interventions and activities that ensure the maintenance of biodiversity representation and resilience. Some areas are also more impacted than others, such that species and habitats are more exposed to risks and can be considered as highly threatened. Some efforts have taken place to categorize and identify the status of critical ecosystems, such as the IUCN Red List of Ecosystems (IUCN, 2016b) and BirdLife's Important Bird and Biodiversity Areas. Analysis has also been undertaken to integrate both intact and highly modified regions to identify high-value biodiversity habitat globally (Mokany et al., 2020).

TABLE 8: BIODIVERSITY BENEFITS, INDICATORS AND CALCULATION METHODS

Benefits	Habitat Intervention	Activity	Indicator	Calculation Method
Improved/ Maintained Terrestrial Habitat Availability and Quality	Terrestrial management, protection	Avoided habitat conversion	• Total protected habitat • Protected habitat in high priority or highly threatened areas	Measured or estimated hectares of land protected
	Terrestrial restoration, management, protection	• Plant/restore/maintain native vegetation; • Restore/improve/stabilize substrates	• Total restored habitat • Available habitat for species	Measured or estimated hectares of land restored
	Terrestrial restoration, management, protection, creation	• Remove hard surfaces • Remove hard structures/barriers • Restore/improve soil health • Restore/improve/stabilize substrates • Plant/restore/maintain native vegetation • Manage/repopulate native fauna • Remove invasive (or aggressive indigenous) species • Undertake brush control • Undertake fire management • Avoid/limit habitat conversion • Reduce/avoid resource abstraction	Extent/coverage and condition of habitats	• Species habitat index • Biodiversity habitat index • Biodiversity intactness index • Proportion of land degraded over total land area • Global ecosystem restoration index (GERI) • Coverage of protected areas
	Terrestrial management	• Remove hard surfaces • Remove hard structures/barriers • Restore/improve soil health • Restore/improve/stabilize substrates • Plant/restore/maintain native vegetation • Manage/repopulate native fauna • Remove invasive (or aggressive indigenous) species • Undertake brush control • Undertake fire management • Avoid/limit habitat conversion • Reduce/avoid resource abstraction	Area of habitats under sustainable management	• Species habitat index • Biodiversity habitat index • The species threat abatement restoration metric (STAR) • GERI • Coverage of protected areas
Improved/ Maintained Terrestrial Habitat Connectivity	Terrestrial restoration, management, protection	• Remove hard structures/barriers • Restore/improve/stabilize substrates • Plant/restore/maintain native vegetation • Remove invasive (or aggressive indigenous) species • Avoid/limit habitat conversion • Reduce/avoid resource abstraction	Habitat connectivity/ fragmentation	• Species habitat index (a proxy for habitat connectivity) • Biodiversity habitat index • Proportion of land degraded over total land area • GERI • Coverage of protected areas

Benefits	Habitat Intervention	Activity	Indicator	Calculation Method
Improved/ Maintained Aquatic Habitat Availability and Quality	Aquatic protection	Avoided habitat conversion	• Total protected area, shoreline or river length • Protected area or length in high priority or highly threatened areas	Measured or estimated protected area or river length
		Restore/improve/stabilize substrates	• Total restored area, shoreline or river length • Restored area or length in high priority or highly threatened areas	• Measured or estimated restored area or river length • Proportion of land degraded over total land area
		Plant/restore/maintain native vegetation	• Total restored area, shoreline or river length • Restored area or length in high priority or highly threatened areas	Measured or estimated restored area or river length
	Aquatic restoration, management, protection	• Remove hard surfaces • Remove hard structures/barriers • Restore/improve soil health • Restore/improve/stabilize substrates • Dredge substrate • Plant/restore/maintain native vegetation • Manage/repopulate native fauna • Remove invasive (or aggressive indigenous) species • Undertake brush control • Undertake fire management • Avoid/limit habitat conversion • Reduce/avoid resource abstraction	Extent/coverage and condition of habitats	• Species habitat index • Biodiversity habitat index • Biodiversity intactness index • Proportion of land degraded over total land area • Coverage of protected areas
	Aquatic management	• Remove hard surfaces • Remove hard structures/barriers • Restore/improve soil health • Restore/improve/stabilize substrates • Dredge substrate • Plant/restore/maintain native vegetation • Manage/repopulate native fauna • Remove invasive (or aggressive indigenous) species • Undertake brush control • Undertake fire management • Avoid/limit habitat conversion • Reduce/avoid resource abstraction	Area of habitats under sustainable management	• Species habitat index • Biodiversity habitat index • STAR • GERI • Coverage of protected areas

Benefits	Habitat Intervention	Activity	Indicator	Calculation Method
Improved/ Maintained Aquatic Habitat Connectivity	Aquatic restoration, management, protection	• Remove hard structures/barriers • Restore/improve/stabilize substrates • Dredge substrate • Plant/restore/maintain native vegetation • Remove invasive (or aggressive indigenous) species • Avoid/limit habitat conversion • Reduce/avoid resource abstraction	Habitat connectivity/ fragmentation	• Species habitat index (proxy for habitat connectivity) • Biodiversity habitat index • Proportion of land degraded over total land area • GERI • Coverage of protected areas
Improved/ Maintained Support For Local Pollinators	Agricultural management	• Plant/restore/maintain native vegetation • Plant vegetation buffers • Undertake brush control	Number of plant species	Estimated count and/or number of species based on field counts before and after project
		• Plant/restore/maintain native vegetation • Plant vegetation buffers • Undertake brush control	Number of pollinators	Estimated or modelled number of pollinators
Increased/ Maintained Abundance and Diversity of Native Plant and Animal Species	Terrestrial and aquatic management, restoration and protection	Plant/restore/maintain native vegetation	Variety and number of native species	Estimated count and/or number of species based on field counts before and after project
		Manage/repopulate native fauna	Abundance and distribution of selected species	• Wildlife picture index • Species habitat index (proxy for abundance) • Biodiversity habitat index (proxy for abundance) • Biodiversity intactness index • Shannon and Simpson's diversity indices
			• Change in status of threatened and/or protected species • Change in status of priority or indicator species	• Wildlife picture index • Species habitat index • Biodiversity intactness index • Shannon and Simpson's diversity indices • Red List index • STAR
	Agricultural restoration, management, protection	• Plant/restore/maintain native vegetation • Manage/repopulate native fauna	Genetic diversity in native breeds of farm animals and cultivated varieties of agricultural and horticultural crops	• Biodiversity intactness index • Shannon and Simpson's diversity indices • Red List index

BOX 8: SOIL HEALTH INDICATORS

Soil health is fundamental to maintaining balanced ecosystems. Soil stability depends on a plethora of chemical, physical and biological processes, all of which must be considered when determining soil health and quality (Bouzouidja et al., 2021). The benefits of healthy soils include improvements to biotic and abiotic soil communities, avoided greenhouse gas emissions, increased carbon sequestration, and improved groundwater and surface water quality. NBS activities that contribute to healthy soils include removing hard surfaces, restoring/improving soil health, planting/restoring/maintaining native vegetation, undertaking fire management, avoiding habitat conversion, and mulching and fertilizing.

Bouzouidja et al. (2021) proposed a variety of indicators that can be used to measure soil health. These include:

- **Soil Crusting** – provides information on soil physical properties pertaining to water infiltration efficiency
- **Soil Macro-Porosity** – represents the capacity of the soil to provide air for root respiration
- **Soil Available Water** – represents the capacity of the soil to provide water for plant uptake
- **Soil Classification Factor** – overall characterization or type of soil, at the local scale
- **Soil Biological Activity** – provides information regarding organic matter decomposition
- **Soil Organic Matter** – a crucial parameter of soil biological, chemical and physical quality; relates to other soil parameters such as soil aggregation, soil nutrients, soil decomposers, etc.
- **Chemical Fertility of Soil** – relates to the mineral nutrient reservoir for plants, particularly nutrient bioavailability
- **Soil Water Infiltration** – shows the capacity of the soil to let water drain, corresponding to the soil hydraulic conductivity at saturation
- **Soil Contamination** – measures diffuse and point-source soil contaminants from inorganic contaminants, nutrients and pesticides, persistent organic pollutants, and soil acidifying
- **Ecotoxicology Factor** – based on (1) an evaluation of the concentration of pollutants for which an effect is measured in 50% of a population and (2) the time needed for 50% of a pollutant to disappear

Since public and private resources are limited, and preservation actions cannot be implemented everywhere at the same time, most near-term NBS efforts should be redirected to high-priority areas, where restoration/management for ecological functioning or protection of critical ecosystems and species will be most impactful. Sometimes, trade-offs between the different values that nature brings must be reconciled. For example, increasing floodplain habitat can be beneficial for fish and other aquatic species, but also brings mosquitoes, which may carry waterborne diseases, or could lead to flooding of landscapes and properties. Where trade-offs do occur, it is critical to mitigate these as quickly as possible and to consult those who are experiencing the trade-offs (Brill et al., 2022).

Abundance and Diversity of Native Species

The abundance and diversity of species is essential for the processes that support all life on Earth. Without a wide range of animals, plants and microorganisms, we cannot have the healthy ecosystems that we rely on to provide us with the goods and services we need to survive and thrive. Biodiversity may be particularly important for ecosystem multifunctionality because different native species with different traits can contribute to different functions (Lohbeck et al., 2016).

Globally, human activities are having significant negative impacts on the abundance and diversity of native species, as well as the habitats and ecosystems that house them. Many activities indispensable for human subsistence result in biodiversity loss, and this trend is likely to continue in the future. We clearly benefit from the diversity of organisms that we have learned to use for medicines, food, fibers and other renewable resources. Those who most directly utilize ecosystem goods and services, including subsistence farmers/fishers and Indigenous Peoples and local communities, face the most imminent risk from biodiversity loss, given that they rely on biodiversity for food security, protection from natural hazards, and access to medicines, fuel, construction materials, etc. (Díaz et al., 2006). Freshwater biodiversity is at greater threat of anthropogenic impacts, leading to higher levels of extinction, when compared to terrestrial and marine biodiversity (WWF, 2020). While efforts to identify priority areas for biodiversity have largely ignored freshwater, recent efforts have included freshwater along with terrestrial ecoregions (e.g. Abell et al., 2011; Tedesco et al., 2017). These efforts point to the importance of free-flowing rivers, allowing prioritization of riverine systems that remain highly functional and identification of altered systems that can be restored (Grill et al., 2019). All efforts to identify priorities for retaining important and threatened natural habitats are crucial in limiting extinctions and sustaining biodiversity. Many regional efforts have identified priorities for freshwater ecosystems and species (e.g. Heiner et al., 2010; Khoury et al., 2010). Several approaches to measure richness/diversity, composition and abundance of native plant and animal species are provided below.

Several frameworks and calculation methods can be used to measure or estimate indicators related to the abundance and diversity of species, habitat availability and quality and connectivity (Table 6). Appendix M provides these methods in detail.

Importance of Connectivity

Ecological connectivity refers to the unimpeded movement of species and the flow of natural processes that sustain life on Earth (Hilty et al., 2020). Connectivity is one of the essential enabling factors for successful preservation and restoration of terrestrial and aquatic biodiversity, and includes the concepts of dispersal, seasonal movements and migrations, fluvial processes and the connectivity that is inherent to naturally functioning areas. In terrestrial conservation, this concept describes linkages between habitats, such as corridors or nodes that allow wildlife to move freely, access resources and escape from external threats. In aquatic systems, connectivity happens in three dimensions: longitudinally, laterally and vertically. Aquatic connectivity is represented by free-flowing rivers and streams that spill naturally out onto floodplains and interact with the local groundwater system, as well as other aquatic habitats that have no barriers such as dams and constructed levees. Connected aquatic systems allow natural geomorphological and nutrient transport processes to occur and for aquatic species such as anadromous fish to migrate as part of their natural life cycle (Grill et al., 2019).

When designing investments in NBS, practitioners should consider the impact of the investment on ecological connectivity. NBS that increase connectivity, such as protecting or restoring corridors between two or more natural areas or removing barriers to free-flowing waterways, can have significant benefits to preserving or restoring local or regional terrestrial and/or aquatic biodiversity.

Importance of Pollinators

Pollinators are essential to healthy and functioning ecosystems and provide essential services that humans rely on. Pollination is vital for successful reproduction processes of most flowering plants and, therefore, is essential for animals dependent upon pollinated plants for food. Without pollinators, humans would lose the ability to grow most fruits, nuts and vegetables, as well as materials such as cotton. Plants that depend on pollination make up 35 per cent of global crop production volume with a value of as much as $577 billion a year (IPBES, 2016). Pollinators are essential to global agriculture, which employs about 26 per cent of the world's 7.8 billion people (World Bank, 2020). Beyond direct benefits to people, the health and abundance of native pollinators are foundational to the function of many natural systems, and to the plants and animals that rely on them.

Support for pollinators can take various forms: BMPs such as reducing chemical fertilizers and pesticides, as well as other agricultural NBS which increase the number of plants and plant species and protect this vegetation from human impacts. Invasive alien species (fauna and flora) also impact wild pollinators. Removal of invasive alien species could reduce pollination competition and ecosystem modification (IUCN, 2020). Protecting habitat, such as hibernating grounds or specific ecosystems, and planting native vegetation and plants that form part of pollinators' diets, can also support pollinators.

Species counts, as well as estimates or models of the number of pollinators, such as bees, moths, beetles, bats and butterflies, can measure the abundance of pollinators. Measuring the value, volume or percentage of crops that must be artificially pollinated in lieu of natural pollination is another method for evaluating pollinator health, or lack thereof. Lastly, pollination success rate (fruit- or seed-set) can measure pollinator health. Fruit- or seed-set is the ratio of ripe fruit or seeds relative to initial number of available flowers or ovules (Delaplane et al., 2013).

SOCIO-ECONOMIC BENEFITS

Many water, carbon and biodiversity benefits can provide secondary socio-economic benefits to a variety of beneficiaries. NBS can also be specifically designed to provide social and economic benefits to stakeholders during implementation (Indigenous Peoples and local communities, neighboring landowners, etc.). A full assessment of relevant stakeholders and beneficiaries should be undertaken at the start of any NBS project and reassessed periodically during other project phases (Brill et al., 2022).

A myriad of indicators and metrics are available for these benefits, from access to high-quality jobs and recreation opportunities to changes in poverty rates or reduced urban heat island effects. Table 9 offers examples of indicators and potential calculation methods that might be employed to measure socio-economic benefits of NBS. However, the specific indicators and calculation methods to be considered may depend on the ability to account for other factors that may influence the outcomes and the local biophysical, socio-economic and cultural context. Many socio-economic benefits are only realized if there is proactive engagement with local communities as potential beneficiaries (Diringer et al., 2020; Brill et al., 2022). This engagement should also consider the distribution of these benefits (see Section 1).

TABLE 9: BENEFITS AND INDICATORS FOR SOCIO-ECONOMIC BENEFITS

Benefit	Indicator	Calculation Methods
Improved/Maintained Climate Adaptation and Mitigation	Reduction in number or percentage of climate-related hazards/disaster risk reduction (heatwaves, flooding, drought)	• Reduction in Climate-Related Hazards • Compare records of climate-related hazards from pre- and post-project implementation • Risk Reduction • United Nations Office for Disaster Risk Reduction - National Disaster Risk Assessment • United Nations Office for Disaster Risk Reduction - Disaster Resilience Scorecard for Cities • World Bank Urban Risk Assessment
	Reduction in number or percentage of infrastructure/ property damage after extreme events	• Compare records of infrastructure/property damage from extreme events from pre- and post-project implementation • Use formal surveying processes to gauge levels of damage, such as FEMA Preliminary Damage Assessment
	Reduction in health impacts from climate-related conditions/ diseases	(See health benefits)
	Reduced loss of lives due to extreme weather events	Compare records of loss of life from extreme weather events from pre- and post-project implementation
	Reduced impacts on water quality and quantity	(See water benefits)
	Avoided greenhouse gas emissions	(See avoided carbon emissions)
	Reduced impacts of climate change on agricultural outputs	(See food security)
	Reduce urban heat island effects	(See microclimate regulation)
Improved/Maintained Livelihood Opportunities	Change in poverty rate	The Poverty Probability Index, typically used by organizations and companies, is a series of 10 questions regarding a household's characteristics and asset ownership, which are scored to compute the likelihood that the household is living below the poverty line. Through repeated use of this index, the project team can have a clearer picture of how an NBS project has impacted poverty rates.
	Total job availability by job type	US Bureau of Labor Statistics
	Job retention	Employee retention rates can be determined by dividing the number of employees who stayed during a given time by the number of employees that were at the start of the period; multiply this result by 100. The company Built In also provides an Employee Retention Rate Calculator (Heinz & Urwin, 2022).
	Change in property values	(See increased property/land value)
	Shadow wage benefits	Estimating Shadow Wage Rates for Economic Project Appraisal
	Reduce time burdens	• Reduced time spent collecting water, food, fuel and fiber in households and in unpaid care, particularly for women and girls • To calculate reduced time burdens, residents can be surveyed on how much time they spent doing certain activities (collecting water/food/fuel/fiber, unpaid care, etc.) before the NBS project was developed and for subsequent years after the project is completed

Benefit	Indicator	Calculation Methods
Improved/Maintained Human Health	Physical health metrics (e.g. blood pressure)	Physical health metrics can be assessed via questionnaires, such as: • PROMIS measures • RAND's Medical Outcomes Study 36-Item Short Form Health Survey • CDC's HRQOL–14 Healthy Days Measure • The YOUTHREX International Physical Activity Questionnaire specifically to track changes in physical activity for a population
	Perceived public safety	• Analyze changes to public crime rate data • Survey the public regarding their perceived sense of safety, via questionnaires such as the University of Sydney's Perceptions of Crime and Safety survey
	Mental and emotional health metrics (e.g. improvement in mood, workplace satisfaction, quality of life)	Mental health metrics can be assessed via questionnaires, such as: • Oxford Brookes University's Oxford Happiness Questionnaire • World Health Organization's Well-being Index (WHO-5) • Warwick Medical School's Warwick-Edinburgh Mental Wellbeing Scale • Ohio State University's Perceived Stress Scale
Improved/Maintained Agriculture/Agricultural Output	Increased crop yields and quality	Crop yield is typically expressed as kilograms of harvested crop per hectare of harvested area. There are a several ways to calculate or estimate crop yield, including whole plot harvest, the crop cut method, sampling of harvest units, farmer recall, farmer prediction, and crop modeling. Measuring crop yields can be complex, depending on the spatial scale that is being measured and whether multiple crops are planted within the same plot (FAO, 2017b).
Expanded/Maintained Religious/Spiritual Settings	Increased spiritual well-being	Spiritual well-being can be recorded via surveys and questionnaires. The types of questions that are asked should be reflective of the types of spiritual, religious and cultural traditions that exist within the population being surveyed.
Enhanced/Maintained Microclimate Regulation	Change in peak air temperatures	To confirm changes to the microclimate of an NBS project, the project team will want to routinely measure and record air temperature and humidity. Depending on the site, other parameters, such as wind, light intensity, rainfall, and slope can also be measured.
Improved/Maintained Opportunities for Education/Scientific Study	Adult or child eco-literacy	• Eco-literacy can be measured via surveys, which can contain questions that range from testing scientific knowledge about local ecosystems and general ecological concepts, through perceived beliefs and awareness regarding nature and environmental issues (Pitman and Daniels, 2016; Ha et al., 2022). • The Environmental Identity Scale (Clayton et al., 2021) is a reputable survey instrument when seeking to understand how a group of people feel connected to the environment (European Commission, 2021). • Other data to be collected may include counting the number of people that attend public environmental education programs (either in the NBS project location or within a determined spatial scale), or the number of people that engage with the NBS project site (European Commission, 2021).

Benefit	Indicator	Calculation Methods
Improved/Maintained Recreation/Tourism Opportunities	Distance to recreation	• One way to determine the distance to recreation can be to assess the per cent of a population that lives within a designated buffer (1 mile, 10 miles, etc.) of the project boundary (Merriam, 2016). • Alternatively, the project team can identify areas of high traffic/population (urban/community centers, public transportation stations) and measure the average distance to the project site from these locations (European Commission, 2021).
	Total recreation time	Residents can either be surveyed regarding the amount of time they spend at recreation sites, or project team members can perform observational studies to calculate the average time spent at recreation sites (Cohen and Han, 2018).
	New tourism	There are several ways to calculate whether an NBS project has led to the creation of new economic and tourism opportunities. Metrics to be tracked include the number of visitors to the NBS project, counting the number of new tourism-related activities or companies in the area, calculating the annual gross profit of companies working in nature-based tourism, and counting the number of new jobs in tourism-related activities (European Commission, 2021).
Increased/Maintained Food Security	Access to and availability of food	Local access to and availability of food is best measured through household surveys administered at the local, municipal and watershed levels. There are many reputable surveys that the project team can utilize, including: • UN Food and Agriculture Organization's Food Insecurity Experience Scale, which measures food-related behaviors and experiences associated food inaccessibility due to resource constraints • World Food Program's Food Consumption Score, which looks at the diversity and frequency of food groups that have been consumed over the previous seven days
Increased/Maintained Property/Land Value	Nominal value and price	Changes in mean and median land and property prices, including rental and market prices for homes and commercial spaces, can indicate changes in property/land value of the NBS itself. High-quality green spaces typically lead to increases in surrounding property values. For agricultural habitats, land productivity, or calculating the average economic return of the agricultural activity per hectare, can be a method for calculating property/land value (European Commission, 2021).

Note: Where possible, these socio-economic benefits should be disaggregated by sex, ethnicity and population group to understand the distribution of the benefits for excluded and vulnerable groups.

There are several standard approaches for assessing many of these socio-economic benefits, and potential trade-offs, quantitatively and qualitatively. Like other benefit themes, measuring the social impact of a project relies on developing a baseline of a benefit prior to implementation, and on monitoring the metric over time. For health benefits, for example, the impacts of NBS could be defined through a pre- and post-implementation epidemiological study measuring the prevalence of water-borne diseases throughout the study period or identifying the number of cases of people with asthma or hay fever, before and after NBS take effect. There are several existing tools for developing surveys to determine the desired social outcomes from the implementation of NBS, as well as tools for measuring these benefits over time. For example, the Social Indicator Planning & Evaluation Systems handbook provides practical guidance for developing surveys for social outcomes of non-point source pollution management projects. In addition, the related Social Indicator Data Management and Analysis is a web-based tool to help users create and administer surveys focused on social outcomes. These tools are primarily designed for water quality-related projects, but also provide practical guidance that can be applied to NBS projects more generally.

In addition to measuring socio-economic metrics directly, there are robust methods for economically valuing the social benefits, including willingness to pay or contingent valuation approaches. The NBS Benefits Explorer tool provides a means to estimate a social return on investment from any NBS project, and will help investors and practitioners quantify the potential value of their projects.

While quantitative approaches and economic valuations can provide the most direct measure of social outcomes, it is likely impractical to conduct these studies for each NBS application. For this reason, researchers often rely on more qualitative methods and/or data in the literature for similar case studies to predict a project's socio-economic outcomes. Qualitative methods, such as focus groups, can identify social and economic benefits of interest and help monitor social outcomes. For example, qualitative methods may include questions on personal health and well-being, individual and collective agency, time use and time burdens, whether respondents have access to recreational facilities, and how these change with the implementation of NBS. These engagements serve multiple purposes: identifying social challenges that may be addressed through NBS, identifying beneficiaries of NBS benefits (as well as those experiencing trade-offs), and providing an opportunity to monitor the efficacy of the NBS to provide these benefits over time. Engagements should be undertaken in an inclusive and equitable manner to ensure that the needs, values and voices of all stakeholders are included in NBS projects (Brill et al., 2022).

Additional information on socio-economic benefits of NBS can be found in Appendix N.

BOX 9: COMMUNITY ENGAGEMENT: BUILDING ADAPTIVE CAPACITY THROUGH NATURE-BASED SOLUTIONS

NBS can help improve long-term community resilience through management and governance reform, and through empowerment and access to resources. These ultimately support building biophysical and socio-economic adaptive capacity. Investment in NBS without community engagement can negatively impact socio-economic opportunities supporting local communities and other key groups. More meaningful participation by a broad range of stakeholders throughout the prefeasibility, design, implementation and M&E stages of the NBS project is essential, including representation from frontline and vulnerable communities, and Indigenous Peoples (Brill et al., 2022).

Companies will need to engage across government, academia and civil society groups. Developing these partnerships can help determine how the investments in NBS are likely to impact local communities (positively or negatively), identify options to mitigate any negative effects and maximize benefits. Successful, long-term NBS outcomes can depend on transparent articulation and negotiation of trade-offs and compensation among potentially affected parties for any impacts to local livelihoods. Asking questions around “who benefits?” and “what are the nature of benefits?” throughout the NBS project phases can maximize benefits for the most people.

Additional NBS Stakeholder Engagement Guidelines (Brill et al., 2022) have been developed to support equitable, inclusive engagement. This stakeholder engagement guide promotes the inclusion of frontline communities, Indigenous Peoples and local communities, and integrates a gender perspective throughout the analysis.

TRADE-OFFS

It is critical to consider trade-offs throughout all stages of an NBS project. These trade-offs should be mitigated wherever possible. For trade-offs that require balancing different benefits, there may be project or program design modifications that can provide for both (or more) benefits (Diringer et al., 2020). However, if this is a trade-off with financial, social or environmental impacts, decision makers will need to consider if and where compromises can be made to ensure that all stakeholders receive benefits appropriate to their needs.

Such trade-offs are often inherent features of NBS and arise when a particular ecosystem service or stakeholder preference (e.g. clean drinking water) is favored at the expense of another (e.g. water needed for recreational purposes). Other cases may relate to a particular habitat or activity. For example, by replanting indigenous tree species to restore a degraded forest, the newly planted trees will require sufficient water to grow. This may result in a decrease in groundwater or surface water resources in the immediate area. Some trade-offs result from deliberate decisions, while others occur without planning or awareness of the impacts. Trade-offs become a major problem when the same choice is replicated multiple times, causing suites of important ecosystem benefits to disappear or otherwise occur at sub-optimal levels across the entire landscape (IUCN, 2019). Trade-offs are also a major problem if certain communities or cohorts do not receive an equal share of the NBS benefits, based on where they are in the watershed (e.g. upstream or downstream).

Like benefits, trade-offs have spatial, temporal and reversibility dimensions. The spatial dimension refers to whether the effects of the trade-offs are felt locally, at a distant location or across a broader landscape level.

The temporal dimension refers to whether the effects take place relatively rapidly or over a longer period. Reversibility refers to the likelihood that the impacted ecosystem service(s) may return to its/their original state if the impact ceases (IUCN, 2019). These spatial, temporal and reversibility dimensions need to be considered fully when designing and implementing NBS, with modifications made as soon as possible during the M&E phase to mitigate any negative effects.

Multiple organizations recognize that trade-offs should be factored into any NBS project (see Attribute 4 in Appendix C). For example, criterion 6 of the IUCN NBS global standard deals exclusively with trade-offs. This criterion states that "NBS equitably balances trade-offs between achievement of its primary goal(s) and the continued provision of multiple benefits." (IUCN, 2019). The IUCN (2019) suggests establishing safeguards to prevent exceeding mutually agreed trade-off limits or trade-offs destabilizing the entire ecosystem or land/seascape. For example, a safeguard could include ensuring sustainable access to adequate quantities of acceptable water for downstream users, if there are large-scale agricultural users of water along a particular river. Many related policies, such as REDD+, have explicit safeguard policies (see for example the UNFCCC Cancun Agreement). World Bank investments have other safeguards. These safeguard systems are in place to anticipate and avoid adverse consequences of interventions and activities and can be used as a basis for NBS safeguards appropriate to local contexts. Furthermore, benefit-sharing arrangements that have been mutually agreed upon must be established to ensure equitable balancing of benefits and trade-offs from policies and investments (IUCN, 2019).

Trade-offs can be successfully managed if their likely consequences are accurately assessed, fully disclosed, and agreed upon by the most affected stakeholders. Fair and transparent negotiation of trade-offs and compensation among potentially affected parties for any damage or impacts to local opportunities and livelihoods provides the basis for successful long-term NBS outcomes. Finally, it is important to recognize that trade-offs have limits, which means that safeguards will be necessary to ensure that the long-term stabilizing properties of ecosystem regulating and supporting services are not exceeded (IUCN, 2019).

MONITORING AND EVALUATION OF NATURE-BASED SOLUTIONS

M&E are essential parts of any NBS project, as they allow companies and those investing in and implementing NBS to understand how projects are performing over time. This can help ensure the long-term sustainability and economic viability of NBS (see Attribute 3 in Appendix C). M&E also help decrease uncertainty about NBS and inform more effective NBS design and implementation (see Appendix C), which will help mainstream and upscale NBS globally.

It is important to note that the nature, scope and frequency of M&E will change over time. For example, different levels of monitoring should happen over time, potentially starting with one or two baseline assessments, then monitoring NBS implementation success, and finally measuring outputs and outcomes over the short, medium and long terms. Ensuring that the project is providing sufficient benefits and that any trade-offs are mitigated where possible may require more assessments over the short and medium term. Monitoring can be undertaken less frequently as the project becomes more established and provides greater benefits over the long term. It is vital that M&E happen *throughout* the project to ensure that any issues are addressed as soon as possible, and to adapt the project wherever necessary to maximize benefits and minimize trade-offs. The indicators and calculation methods presented in this section can support many of the stages of the M&E process.

Stakeholders are key participants in any M&E stage and can support reporting, risk reduction and project enhancements. Some stakeholders may also be involved in systematically collecting and analyzing data to track project progress towards goals and to measure outcomes and impacts. Providing a broad range of stakeholders with an opportunity to play an ongoing role in the success of an NBS project can lead to continuous buy-in and offer further co-creation opportunities, giving these stakeholder groups agency with project upkeep (Brill et al., 2022).

BOX 10: TIMING FOR AND LOCATION(S) OF DATA COLLECTION FOR MONITORING & EVALUATION

The following list summarizes the key points regarding timing and location of M&E data collection:

- Collect data prior to NBS project implementation to establish a baseline.
- Collect data at the location of expected impact. For example, if the project is aiming to impact water quality at a specific intake, measurements should take place at the intake.
- Continue monitoring on a regular basis to understand the impact of the NBS interventions and activities, but keep in mind that NBS may take several years to reach maturity and measurement of impacts will reflect this delay.
- The type of impact expected should dictate the timing of data collection. For example, if peak flows or turbidity are metrics of interest, collect data at appropriate intervals to capture peak flow events. If the metric of interest is change in biodiversity over time, annual or multi-survey intervals may suffice.
- There is often a delay in impacts seen for NBS interventions and activities, as it takes time to fully implement, and in part because interventions and activities may take time to mature. Therefore, it is often valuable to also measure impacts locally in early implementation. This can help confirm that the interventions and activities are having the expected local impact, inform adaptive management, and allow for detection of change earlier than full-scale implementation impacts can be seen.

Given the importance of M&E, project budgets should allocate a portion of total project funding to M&E from the start and continue through to impact assessment. This budget could cover costs related to travel or field visits, staff and resource time, sample testing, equipment, and stipends or salaries for external data collectors. In most cases, the implementation partner will lead on M&E, but companies should be aware of what to monitor, where to undertake assessments, and how to evaluate project success to ensure the outcomes of interest are being tracked. If several partners invest in NBS, the impacts can be attributed based on the level of investment.

For all NBS projects, it is critical that investors and practitioners only claim and communicate benefits once they have been validated or verified. All efforts should be made not to over-report, double count or claim benefits that were not realized. This may jeopardize the integrity of your NBS project and could influence future investments in NBS.

SECTION 5: Best Practices and Lessons Learned from Case Studies

This section includes best practices for NBS benefit identification, accounting and valuation. The best practices shared require consideration throughout the design and implementation phases of NBS projects. Additionally, this section reports on key learnings from a synthesis of NBS case studies from around the world. Practitioners can apply these lessons to current and future NBS projects.

BEST PRACTICES TO NATURE-BASED SOLUTIONS

The best practices described in Table 10 are elements or guidelines for companies and other stakeholders to consider when designing, implementing or monitoring NBS for watersheds. These approaches enhance the likelihood of project success and ensure long-term sustainability of the implemented solutions. Practitioners should consider these approaches throughout the project life cycle and revisit them through M&E to ensure that all elements are being considered and adopted. These best practices are based on a series of principles and attributes laid out by the IUCN and other experts working with NBS (see Appendix C).

TABLE 10: BEST PRACTICES FOR NATURE-BASED SOLUTIONS

Best Practice	Details
Engage Communities to Define Project Design, Implementation and Management	Possibly the most important best practice is to ensure inclusive and equitable stakeholder engagement across all stages of an NBS project. NBS are often implemented in regions where communities face a diverse range of challenges. To ensure that investments in NBS deliver broad environmental and community benefits, NBS investors and practitioners should actively engage with local communities, Indigenous Peoples, and vulnerable and frontline communities to identify the potential benefits of projects and mitigate trade-offs (see Box 8).
Ensure Equity and Inclusive Decision-Making	Benefits can accrue unevenly to different individuals or groups. Attempting to address access to excluded groups (including those based on gender) to ensure that they benefit equitably from the NBS investment and activities will be key to the acceptance and sustainability of NBS projects. The prefeasibility and design stages of NBS projects should begin with the inclusion of women, youth and Indigenous Peoples (where appropriate). Ensuring a focus on time use and time poverty (too many things to do and not enough time to do them) in project metrics will enable a more nuanced understanding of the potential health and well-being benefits and costs generated by NBS, revealing who is benefitting and enabling adaptive management of projects and investments. Brill et al. (2022) present a practical guide on stakeholder engagement for NBS projects. This guidance also presents additional principles and best practices for equitable and inclusive stakeholder engagement.
Account for Watershed Context	The selection, planning, implementation and impact measurement of NBS for watersheds must be informed by the local watershed context, as water is a localized resource. Any NBS project should begin and end with a clear understanding of the complexity of the biophysical, chemical, hydrological, hydrogeological, ecological and social conditions and challenges of the watershed in which the project is located (see Attribute 1 in Appendix C) (Matthews et al., 2019). Unlike carbon, for which the benefit or cost of any unit is equal to any other, changes to water quality and quantity are highly dependent on local context and most directly impact local water users. Companies are increasingly accounting for the watershed context in their water stewardship strategies and targets, which helps to drive action and create value for the watershed (UN Global Compact CEO Water Mandate et al., 2019).
Consider Spatial and Temporal Scales	The benefits from NBS accrue differently across spatial and temporal scales (see the Benefit Forecasting section). Practitioners should explore NBS holistically and consider their benefits (and trade-offs) in all their scalar dimensions to understand all the positive and negative impacts and potential benefits of specific NBS (see Attribute 2 in Appendix C). Ecosystem goods and services accrue across multiple spatial scales, ranging from local (e.g. within a property boundary) to landscape level (e.g. watershed scale). To effectively provide benefits, NBS activities must be strategically deployed across these multiple scales, with significant benefits accrued at the landscape scale (Somarakis et al., 2019) (see Attribute 3 in Appendix C). This makes landscapes the ideal unit for planning and decision-making, allowing the integration of diverse societal needs, sector plans, programs and policies, and use of suitable traditional or Indigenous practices for implementation into one single spatial context that has considered the trade-offs, options and scenarios (Somarakis et al., 2019). This approach also creates the opportunity to partner with other organizations working at the landscape level who may be supporting similar interventions to achieve similar or different objectives. The current literature contains little information regarding the time for individual NBS actions to become fully effective. Some benefits accrue almost immediately (e.g. improved aesthetics), while others take many years (e.g. increase in biodiversity). Some benefits may exist at some points in the year and not others. The impacts of NBS will vary according to habitat and intervention types, as well as the activities undertaken, and are not only dependent on spatial scale but also on time (Somarakis et al., 2019). Understanding the temporal categories (short, medium and long term) associated with the NBS of interest is critical for investors who have set time-based goals or commitments. Investors need to have realistic expectations of when NBS actions will become fully effective, and consequently, when benefits will accrue and can be claimed. Without careful thought to temporal scales, a company's sustainability claims (e.g. progress on water replenishment goals) may prompt critiques of the accounting method and the company's claims to driving positive change.

Consider Trade-Offs	NBS do not offer only benefits; some interventions and activities also have negative outcomes and may present trade-offs. Practitioners should consider two types of trade-offs when designing and/or implementing NBS: • The trade-off between two benefits that are achieved by different designs and may not be possible or optimized in the same design; and • Adverse impacts of a project. For trade-offs that require balancing different benefits, there may be project or program design modifications that can provide both (or more) benefits. However, if this is a true trade-off, decision makers will need to consider if and where compromises can be made to move forward with the project (Diringer et al, 2020). See Sections 2 and 4 for more information on trade-offs.
Implement Robust Monitoring and Evaluation Systems	Understanding the interconnectedness and impacts of different ecological, social and economic elements within ecosystems is crucial to ensuring that complexity across scales is considered (see Attributes 1 and 2 in Appendix C). Thus, the M&E of NBS outcomes over time and space is essential to understand and assess their benefits and adaptively manage for greater impact (Somarakis et al., 2019). M&E of NBS is also important to continue to build our scientific understanding of these elements, and to ensure their long-term sustainability (see Attribute 3 in Appendix C). M&E will help decrease uncertainty about NBS and inform more effective NBS design and implementation (see Appendix C). While it is important to note that the nature, scope and frequency of M&E will change over the various stages of the project, it is vital that M&E happen throughout the project to ensure that any issues are addressed as soon as possible and to adapt the project wherever necessary to maximize benefits and minimize trade-offs. The indicators and calculation methods presented in Section 4 can support many of the stages of the M&E process.
Avoid Leakage	Leakage is the "unintended displacement of impacts caused by an environmental policy intervention." (Bastos Lima et al, 2019). For example, projects that reduce deforestation in one area can shift deforestation to another area. While avoiding leakage is often difficult to achieve at a project level, those implementing NBS projects should consider broader landscapes and impacts at the program and watershed levels (GEF, 2020). Avoiding leakage ensures that initiatives contribute to reversing overall environmental degradation and that the benefits endure in the long term (GEF, 2020).
Focus On Durability, Scalability and Transformability	Stakeholders in NBS initiatives will be interested in ensuring that the outcomes and benefits are durable in the long term, can be scaled up to greater impact, and support transformational change. Practitioners should 1) apply systems thinking and a robust theory of change, 2) assess climate risk at the project development stage, 3) develop multi-stakeholder dialogue at all stages and build incentives for stakeholder involvement, 4) analyze the barriers to and enablers of scaling and transformation, 5) establish a monitoring, evaluation and learning process, and 6) incorporate adequate flexibility in project design and implementation (GEF, 2020).
Leverage Legal and Financial Transactions and Mechanisms	To reduce unsustainable resource extraction, the public and private sectors may need to develop a variety of legal and financial transactions and mechanisms (where needed). Legal mechanisms may include the consideration of NBS in procurement policies, planning or corporate strategies. These mechanisms are not strictly activities (see Section 2), as per the definition used in this guide, but lay a legal or economic foundation for the management or conservation of natural resources. In some countries, these legal and financial mechanisms are critical components of NBS and broader landscape management practices.

Lessons Learned from Nature-Based Solutions Case Studies

In addition to the best practices summarized above, this project explored NBS projects across the globe that received corporate support. We assessed 94 case studies (see Appendix O), which are documented on the Water Action Hub. By assessing how these case studies addressed project benefits (with a focus on water, carbon and biodiversity), we found that there is a large gap between benefits claimed and benefits measured or estimated. This may be due to the uncertainty around benefit accounting for NBS, a lack of sufficient funding for monitoring and measurement, or a combination of factors. We also found that some benefits, such as biodiversity, are less regularly claimed than others.

The review of NBS case studies revealed several learnings that can support the best practices, as well as inform the scaling up of investments in NBS for watersheds. From the case study review, high-level recommendations include:

- Earn buy-in from decision makers, local communities, environmental champions and other stakeholders at the project outset;
- Share project details and create networks with internal company representatives, the media, the public and governments;
- Show the data through feasibility studies, analyses, assessments and leveraging of mobile technology, big data analytics and citizen science;
- Educate companies, communities and farmers through activities including environmental education, peer-to-peer learning and training; and
- Improve policy and financing through small grants, loans, public sector/regulatory processes, public-private partnerships and market mechanisms.

SECTION 6: **Conclusions and Next Steps**

This guide highlights the imperative for private sector investments in NBS for watersheds, presents methods for identifying, forecasting and valuing the multiple benefits of NBS, provides indicators and calculation methods for benefit accounting, and outlines best practices and lessons learned from NBS projects around the world. Building on the landscape assessment (Shiao et al., 2020) and interviews with companies and other stakeholders, the guide aims to address the key gap mentioned in the uptake of NBS: a common method for NBS benefit accounting.

The project team developed a step-by-step benefit identification method which presents the interlinkages between challenges, habitats, interventions, activities and benefits/trade-offs. We categorized the identified benefits across the themes of water quality, water quantity, carbon, biodiversity and socio-economics, and discussed trade-offs and other negative or mitigating factors that may accompany NBS implementation. The benefit forecasts further clarify the types of benefits that will accrue over different spatial and temporal scales, and which benefits are most prominent under different habitats or through different interventions. Finally, the valuation methodology helps investors and practitioners estimate or measure the social return on investment of their NBS projects. This final component completes the NBS journey (Figure 1) and provides a complete picture of the kinds of benefits that could accrue, when and where these will accrue, and the value of this accrual.

All methods and indicators have been included in the NBS Benefits Explorer tool. This platform is a key starting point for potential and existing investors and practitioners to build the business case for NBS projects. The tool allows users to explore potential interventions and NBS activities by habitat, linking activities to processes and benefits. Benefit forecasts project how these benefits accrue over different habitat types and across multiple spatial and temporal scales. This provides users with a better indication of where and when benefits will accrue. Finally, users can explore the value of their potential or existing NBS project across the different benefit themes, providing well-defined and recognized indicators of benefits, with quantification methods.

The tool can help broaden support for NBS policies, programs and projects by providing a complete overview of benefit identification, accounting and valuation. This could help identify opportunities and trade-offs among different NBS project beneficiaries, and ultimately increase transparency associated with NBS decision-making leading to mainstreaming and upscaling NBS globally.

CONTINUING WORK

Future stages of the Benefits Accounting of Nature-Based Solutions for Watersheds project will look to incorporate geospatial and satellite elements as well as artificial intelligence into the NBS Benefits Explorer tool to build out more localized, context-specific outputs. This would help identify priority areas across key watersheds to ensure that investments in NBS are strategic and catalytic, and meet broader landscape objectives. Additionally, the project partners will collaborate with other organizations working on NBS to further drive this work and to mainstream NBS in policy and practice in the public and private sectors globally.

The functionality of the tool will be further enhanced through various deep-dive capabilities across the different thematic areas. This would allow users to assess, measure and model their benefit accrual at the site level. These additional tool-development elements may require partnering with other organizations.

Finally, an expert interface will be created to allow academics, researchers and habitat specialists to help improve the underlying data, models and algorithms according to new science-based research data that has been conducted and validated in specific locations around the globe.

CALL TO ACTION

We invite all interested stakeholders to join us in the effort to increase adoption of and investment in NBS for watersheds. Please contact the project team if you would like to:

- Provide feedback on the methods, guide or tool;
- Sponsor or conduct additional research on NBS for watersheds;
- Discuss opportunities for future partnerships; and/or
- Share case studies

Together, we can pursue untapped NBS opportunities for watersheds.

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Appendices

Appendix A: Members of the Project's Expert Advisory Groups

TABLE A1: NAMES AND COMPANY DETAILS OF THE MEMBERS OF THE PROJECT'S FORECASTING EXPERT ADVISORY GROUP

Forecasting Expert Advisory Group	
Name	**Company**
Adrian Vogl	Stanford University
Jan Cassin	Forest Trends
Niki Frantzeskaki	Utrecht University
Sarah Grammage	The Nature Conservancy
Yuta Masuda	The Nature Conservancy
Ed Pinero	Ecometrics LLC
Robert Costanza	University College London
Lizzie Marsters	World Resources Institute
Hamilton Hardman	TNC
Kate Brauman	University of Alabama
Daniela Rizzi	ICLEI
Kashif Shaad	Conservation International
Matthias Goerres	GIZ
Todd Bridges	US Army Corps of Engineers
Kevin Halsey	Ecometrix Solutions Group
Kenna Halsey	Ecometrix Solutions Group

TABLE A2: NAMES AND COMPANY DETAILS OF THE MEMBERS OF THE PROJECT'S VALUATION EXPERT ADVISORY GROUP

Valuation Expert Advisory Group	
Name	**Company**
France Guertin	Dow
Diego Rodriguez	World Bank
Alexander Nash	Asian Development Bank
Adrian Vogel	Stanford/World Bank
Ed Pinero	Ecometrics LLC
Janet Clements	Corona Environmental Consulting
Ivan Paspaldzhiev	Denkstatt
Martha Rogers	TNC
Paul Reig	BlueRisk
Samuel Vionnet	Valuing Impact
Nikolai Friberg	Norwegian Institute for Water Research
Kristian L. Dubrawski	Victoria University
Ken Cousins	Earth Economics
Robert Costanza	University College London
Bianca Nijhof	Netherlands Water Partnership / Capitals Coalition
Matthias Goerres	GIZ

Appendix B: Barriers and Opportunities to Developing and Implementing Nature-Based Solutions

As NBS is still a nascent concept, there are several barriers and opportunities to mainstreaming investment across different habitat and intervention types. This appendix highlights the barriers to entry for many companies, as well as the opportunities to mitigate or address these barriers.

BARRIERS TO INVESTING IN NATURE-BASED SOLUTIONS FOR WATERSHEDS

The implementation and up-scaling of NBS face a broad range of potential technical/operational, regulatory, legislative, economic, social and ecological barriers. Practitioners must understand these barriers, and the interconnected factors that reinforce them, in order to overcome them. Barriers fall into the following categories:

1. Knowledge Gaps, Uncertainty and Fear of the Unknown

NBS are often innovative and revolve around complex socio-ecological systems, which makes them difficult to monitor and evaluate. As a result, companies are uncertain if these solutions will provide results which address their specific priorities or challenges. Four main knowledge gaps emerge from both the academic literature and in practice, namely:

(1) The effectiveness of NBS
(2) The relationship between NBS and society
(3) The design of NBS
(4) NBS implementation aspects

In many cases, assessments of NBS effectiveness in dealing with societal challenges like water security, climate change mitigation/adaptation and biodiversity conservation have yet to be developed or, where these exist, have yet to be mainstreamed. These assessments often require experts to undertake scientific and technical studies on sites where the NBS were implemented. These studies can be costly and may not fully capture the true effectiveness of the project due to the multiple and interconnected benefits of NBS. Adding to the knowledge gap, case studies on NBS within the private sector are not always developed, and if they are, may not be widely disseminated. This lack of information sharing can limit future learning opportunities and can also limit awareness and acceptance of NBS more broadly. Case studies appear regularly in academic literature, but these may not always have applicability in private sector contexts.

The "fear of the unknown" considers both uncertainties and risks of designing and implementing NBS. NBS are inherently different from traditional engineered solutions and may require new protocols for implementation and maintenance. These factors are perceived as operational/technical unknowns (Kabisch et al., 2016). Developing, monitoring, evaluating and mainstreaming more NBS projects will increase operational and technical clarity.

Additionally, the frameworks and tools to quantify, value and monetize the benefits of NBS are limited. Some proponents of cost-benefit analyses have suggested that this valuation method is sufficient, while others suggest that such analyses are inadequate at evaluating NBS effectiveness given the potential for multiple forms of co-benefits spanning different elements of the socio-ecological system, and how these vary across spatial and temporal scales (Raymond et al., 2017). Reliable valuation of NBS requires new tools and models that consider different spatial and temporal distribution of benefits based on different land use scenarios and different socio-economic contexts.

2. Inadequate Regulations, Policies and Governance Incentives

There is still little representation of NBS in global policy, although some countries and companies have made considerable strides to include NBS (or similar terms). In cases where regulations and policies do consider NBS as options for addressing certain challenges, some public and private sector actors may still prefer to invest in conventional gray infrastructure options. Most regulations and policies across the public and private sectors have been developed to prioritize traditional gray infrastructure solutions based on historical practices (e.g. to enhance water security, dams have been built to store water, rather than investing in landscape management and alien plant removal to enhance surface and groundwater supplies which could support long-term water security). As the benefits of investing in NBS become more apparent, greater inclusion of NBS in policy will hopefully result in greater implementation of NBS on the ground.

Public sector policies/incentives for adopting NBS or prioritizing investments in green solutions are limited. It is critical that the public sector and funding agencies create conditions for new business and finance models by divesting from dominant gray solutions, and by leveraging private and public funding in strengthening NBS (European Commission 2015; Kabisch et al., 2016). These incentive schemes may take time to develop, but there has been a significant shift in this direction in recent years.

Additionally, land ownership and jurisdictional boundaries influence NBS uptake. For example, water utilities often cannot spend public money outside of their service area, which restricts them from investing in NBS in source watersheds if they are outside municipal boundaries, even if these investments are a cost-effective solution to secure their water supply. Further, companies may sometimes be legislatively restricted from owning or leasing land, which prevents them from having full discretion over how to manage these properties and implement NBS.

Policy options also need to be socially acceptable to citizens and diverse stakeholder groups, highlighting the importance of embedding NBS policy development in participatory processes that weave together multiple forms and systems of knowledge (Raymond et al., 2017). All sectors have called for collaborative governance, including considerations around provisioning of incentives and/or the removal of administrative barriers to allow for public-private partnerships to emerge between governments and companies, as well as other multi-stakeholder partnerships which include citizen organizations. Such partnerships can create resource and governance synergies, creating new opportunities for the efficient uptake of NBS (Kabisch et al., 2016).

3. Institutional Fragmentation and Sectoral Silos

The people or organizations responsible for funding and implementing NBS are distributed across multiple departments and agencies working within their own mandates. These mandates seldom consider external partners or collaborative opportunities. Multifaceted projects such as NBS often do not fit into existing decision-making functions and structures, even within the same organization. For example, in some cities, stormwater management falls under the mandate of the water department, whereas in others it is the responsibility of the roads department. If stormwater starts affecting properties, people or parks, then it becomes the responsibility of the public works, disaster management or parks and recreation teams. This makes it challenging to define NBS strategies and implement them in a coordinated manner. Challenges also stem from the absence of multi-stakeholder governance. For example, one company practicing water stewardship in isolation cannot achieve a sustainable water basin. Success requires that all water users simultaneously promote stewardship under an effective water governance structure, which aligns interests under an agreed-upon basin management plan. The involvement of various stakeholders in a truly participatory and multidisciplinary process is rare, particularly in government. There are even fewer examples of where multi-stakeholder initiatives have been systematically monitored and evaluated (Raymond et al., 2017), due, in part, to conflicting mandates or the inability of some departments or agencies to cross over into areas which fall outside of their siloes.

4. Inadequate Financial Resources

Historically, most financial resources for NBS projects have come from grants and government funding, which have been limited to certain NBS, geographic locations or to meet specific challenges. Some companies have been reluctant to invest in NBS due to the high levels of uncertainty regarding implementation processes and the effectiveness of solutions. Some companies may demand short-term returns on large investments, yet many of the benefits of NBS only become apparent over the longer term. This return-on-investment model may not be favorable when compared to other options which may yield similar benefits in the short term (e.g. a mangrove and a storm wall will both mitigate storm surges) yet fail to produce further benefits over the medium to long term (e.g. a mangrove will yield biodiversity, recreation and other economic opportunities that a storm wall may not).

Cases exist that can serve as templates to convince private investors to invest in NBS. In “Conservation Finance: From Niche to Mainstream: The Building of an Institutional Asset Class,” Credit Suisse et al. (2016) discuss scalability as one of the main obstacles to greater investment in NBS. Most projects lack replicability beyond a $5 million threshold, which increases transaction costs. The lack of large-scale investment opportunities is another limiting factor for banks and other intermediaries, according to The Nature Conservancy’s “Investing in Nature” report (TNC, 2019). This especially discourages large, mainstream investors from considering NBS. Within the public sector, many municipalities lack the necessary human and financial resources to consider NBS investments at scale or are unable to invest in NBS due to policy constraints or social and economic priorities (e.g. social housing projects which limit public financing available for NBS).

5. The Disconnect and Discontinuity Between Short-Term Actions and Long-Term Plans and Goals

Many of the benefits which accrue from NBS projects are seen over the medium to long terms. This is contrary to the short-term priorities, actions and decision-making cycles common within companies. There is, however, a shortage of long-term projects, particularly regarding solutions about how to address implementation and maintenance after the project and related funding end. Researching the design and early-stage implementation of NBS must be paired with suitable funding to maintain the project and to monitor and evaluate the benefits and trade-offs over time.

In some cases, responsibility for project maintenance remains unspecified (throughout the project timeline), posing a risk to the continuity of delivering the desired social, economic and environmental benefits over the long term. Even in cities where long-term policy plans undergo adaptive monitoring for taking up new innovative solutions, scientifically validated options and knowledge are often not available at the time that the policy windows are receptive to new ideas. This may also be the case in the private sector, where investments made often require short-term return on investment. Decision makers may be less inclined to invest in NBS when some benefits only accrue over the long term (Kabisch et al., 2016).

6. Path Dependency of Organizational Decision Making

Stakeholders across both the public and private sectors are confident in making investments in gray infrastructure solutions based on demonstrated results over time. This has informed their decision making, as well as current and future behavior. Changing this behavior or mindset from gray to green (i.e. towards investment in NBS) can be a significant challenge. Some decision makers or practitioners within companies may be averse to the uncertainty posed by NBS and err on the side of tried and tested solutions (see category 1). Technical challenges also arise when companies lack internal hydrogeological expertise or capacity to understand watershed management and the implications of NBS projects (see category 1).

OPPORTUNITIES OF INVESTING IN NATURE-BASED SOLUTIONS FOR WATERSHEDS

NBS is a relatively new concept to science, policy and practice. As such, there are still plenty of opportunities for business, governments, academics, governance and management practitioners, civil society and citizens to address many of the barriers listed above. Some of these opportunities include:

1. Tapping Existing Knowledge

New NBS projects should draw from and build on the existing NBS knowledge of policymakers, planners, practitioners, researchers and civil society (Krasny et al., 2014). Experiences designing and implementing successful projects where NBS were restored, introduced or managed, as well as lessons learned from less successful or unsuccessful projects, are instrumental for effectively employing NBS more broadly. This knowledge, however, can only be put into practice when new actors or stakeholders engage with those new networks or acquire the experiences.

2. Creating and Fostering Communities of Practice

Knowledge sharing (as above) is critical to mainstreaming NBS. Multi-stakeholder projects, demonstration projects and broad engagements on NBS have created collaborative networks and communities of practice across institutional boundaries that legitimize new planning practices and concepts (Moore & Westley 2011; Boyd et al., 2015). Engaging and further extending those communities can accelerate NBS uptake and integration into existing knowledge areas and foster engagement with multiple knowledge-holders (Kabisch et al., 2016). It may also help overcome tensions between different stakeholders (see next two opportunities).

3. Aligning with Public Opinions, Perceptions, Attitudes and Behaviors

The opinions, perceptions, attitudes and behavior of governments, companies and communities toward the environment have improved significantly. By closely aligning NBS with the needs and perceptions of beneficiaries, practitioners and policymakers, practitioners can make the value case for NBS more easily to a wider audience and thus build greater public support (Lele et al., 2013). Specifically, a full understanding of NBS may support stakeholders in developing appropriate and effective strategies to elicit public support, inform policy and planning decisions, and mitigate environmental, social and economic impacts (Semenza et al., 2008; Toth & Hizsnyik, 2008). Understanding these opinions, perceptions, attitudes and behavior is a fundamental step in providing for management actions and collaborative governance opportunities (Brownlee, 2012).

4. Flexibility of Adaptive Management

NBS provide opportunities for decision makers to move from traditional management approaches (generally top-down decision making) to adaptive management[3]. Adaptive management is useful when there is substantial uncertainty regarding the most appropriate strategy for managing natural resources. Given that NBS is still emerging in both policy and practice, adaptive management provides the flexibility to try new natural resource management approaches and allows for broader inclusion of external actors in decision making and governance.

5. Establishing and Practicing Collaborative Governance Approaches

Management and governance of landscapes and ecosystems is no longer seen as the sole mandate of government agencies, NGOs or conservation agencies. Collaborative governance calls for government officials to collaborate with companies, civil society and citizens to connect demands for action with responsible actors or partnerships for action. These partnerships should strive for good governance practices adhering to transparency, legitimacy, equitability and honesty. Specifically, collaborative arrangements enable the distributed responsibilities that further foster a shift from risk aversion to sharing the risk of new solutions like NBS (Kabisch et al., 2016).

6. Shifting Path Dependencies in Policy, Practice and Funding

Risk aversion is one path dependency[4] present in many organizations, whether in business, government or civil society. Historical approaches to management and government have caused many companies and governments to not look beyond "tried and tested" methods they have designed and implemented before. Similarly, funding in both the public and private sectors has tended to flow to solutions which have a proven track record. Given the 200+ years of engineered solutions in many parts of the world, governments, companies and funding agencies may still prefer these options. But this is slowly changing, with policy, practice and funding focusing on scaling up NBS to meet key societal challenges.

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3 A structured approach that emphasizes accountability and explicitness in decision making.

4 Initial decisions or company positions that can increasingly restrain present and future choices.

7. Meeting Sustainability and Socio-Economic Objectives

From both a business and government perspective, NBS offers multiple benefits which align with ecological, social and economic objectives. Many organizations have key priority areas, namely water security, carbon sequestration, economic opportunities etc., and NBS provide the benefits to meet these priorities simultaneously. Within the public sector, governments need to address the complex task of meeting SDGs across local, regional and national scales, and in most cases, NBS can provide cost-effective and no-regret solutions (Matsler, 2019) to deal with meeting SDG commitments.

8. Combining Gray, Green and Blue Infrastructure

One of the greatest opportunities for NBS is the possibility of designing projects and programs to be solely or jointly based on natural solutions. NBS can operate efficiently and effectively without the need for engineered solutions, although a blend of ecological and engineered structures allows for some ecosystem functions mediated by technological solutions. The design of these systems can follow a continuum from majority engineered through to majority ecological, based on favoring flexibility, cost-effectiveness, feasibility, reliability, durability and long-term sustainability (Depietri & McPhearson, 2017).

9. Undertaking Robust Monitoring and Evaluation

Undertaking M&E throughout the project can ensure that any issues are addressed as soon as possible and that the project can be adapted to maximize benefits and minimize trade-offs. The nature, scope and frequency of M&E will change over time. For example, different levels of monitoring should happen over time, potentially starting with one or two baseline assessments, then monitoring NBS implementation success, and finally leading to measuring outputs and outcomes over the short, medium and long terms. There may be more assessments needed over the short and medium term to ensure that the project is providing sufficient benefits and that any trade-offs are mitigated where possible. Once the NBS becomes more established, monitoring can be undertaken less frequently as the system becomes more established and provides greater benefits over the long term. The indicators and calculation methods presented in Section 4 can support many of the stages of the M&E process.

The issue of monitoring the different scales of NBS impacts in both spatial and temporal dimensions is an important direction for future research. Most available monitoring technologies and methodologies focus on specific spatial scales and there are major limitations to bridge the monitoring results across different observation scales. The establishment of a common and holistic framework for the assessment of NBS impacts also demands further investigation (Somarakis et al., 2019).

Given the importance of M&E to project success, project budgets should incorporate a portion of total project funding towards M&E from the start and continue through to impact assessment (most frequently suggested at 5–10 percent of the project budget) (ITAD, 2014). In most cases the implementation partner will lead on M&E, but companies should be aware of the “who, what, where and how” components (e.g. who benefits or is impacted, what to monitor, where to undertake assessments, how to evaluate project success) of M&E to ensure the outcomes of interest are being tracked. If several partners invested in NBS, the impacts can be attributed based on the level of investment.

Appendix C: Definitions, Principles and Attributes of Nature-Based Solutions for Watersheds

DEFINITION OF NATURE-BASED SOLUTIONS

The concept of NBS arose out of an increasing recognition of the fundamental role ecosystems play in addressing some of society's biggest challenges, including enhancing water security, reducing risk of natural disasters, avoiding degradation of natural ecosystems, and mitigating or adapting to the impacts of climate change. The definition of NBS has evolved over time, with a greater emphasis on taking a proactive role in supporting NBS versus being a passive beneficiary of the societal benefits ecosystems provide.

There are multiple definitions of NBS. While they are very broad, which can lead to confusion, the definitions all allude to the need to consider the multiple benefits provided by NBS.

1. European Commission

Definition: Solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes, and seascapes, through locally adapted, resource-efficient and systemic interventions.

This definition for NBS focuses on "solutions that are inspired and supported by nature." This definition also considers environmental benefits beyond biodiversity, as well as including social and economic benefits. Furthermore, this definition addresses cost-effectiveness and broader resilience considerations.

2. European Parliament

Definition: Actions inspired by, supported by or copied from nature that aim to help societies address a variety of environmental, social and economic challenges in sustainable ways. Most nature-based solutions do not have a single objective but aim to bring multiple co-benefits.

This definition is like the European Union's definition, although it articulates that "actions inspired, supported by or copied from nature" should be considered. It does not state that purely natural solutions are relevant. This definition does not address cost-effectiveness or elements of resilience or sustainability .

3. International Union for Conservation of Nature

Definition: 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.

Currently, the NBS definition offered by the International Union for Conservation of Nature (IUCN) is the most widely accepted and used. It was developed from a global perspective considering all types of ecosystems, but it focuses primarily on the protection and management of natural ecosystems. The IUCN definition promotes "actions to protect, sustainably manage, and restore natural or modified ecosystems," as opposed to interventions that are inspired by nature and focuses on addressing societal challenges to meet human well-being and biodiversity priorities. A major criticism levelled at this definition is that it could include anything that provides a benefit to nature, whereas the other definitions explicitly mention solutions or actions that are inspired by and supported by nature. Other social, economic and environmental factors are not listed in this definition (Cohen-Shacham et al., 2019).

4. United Nations Environment Assembly

Definition: Actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems, which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services and resilience and biodiversity benefits.

This definition adopts similar language to the IUCN definition but elaborates on the types of habitats that should be included in NBS ("terrestrial, freshwater, coastal, and marine"), as well as stresses the importance of addressing "social, economic, and environmental challenges," rather than solely "societal challenges." This definition also highlights the importance of ecosystem services and resilience.

5. University of Oxford Nature-based Solutions Initiative

Definition: Nature-based solutions (NbS) involve working with nature to address societal challenges, providing benefits for both human well-being and biodiversity. Specifically, they are actions that involve the protection, restoration or management of natural and semi-natural ecosystems; the sustainable management of aquatic systems and working lands such as croplands or timberlands; or the creation of novel ecosystems in and around cities. They are actions that are underpinned by biodiversity and are designed and implemented with the full engagement and consent of local communities and Indigenous Peoples.

This definition is based on similar principles to those listed above, in that NBS address multiple challenges and provide benefits to both people and the environment. This definition includes all four of the intervention categories covered in this guidance and lists several habitat types too. Importantly, this definition suggests that NBS are underpinned on biodiversity and states that local communities and Indigenous Peoples should be engaged in an NBS project. The latter statement aligns perfectly with the NBS Stakeholder Engagement Guide (Brill et al., 2022).

PRINCIPLES AND ATTRIBUTES OF NBS

To implement NBS in a manner that results in intended positive impacts on people and nature, companies and those looking to invest in NBS need a set of clear and coordinated principles upon which to develop evidence-based guidelines and tools for practitioners and decision makers. The principles considered in this guide have been adapted from those provided by the IUCN (adapted text in **green** below). Many of the principles are linked and, in some circumstances, may be interdependent.

PRINCIPLE OVERVIEW

PRINCIPLE 1: NBS embrace nature conservation norms and principles.

PRINCIPLE 2: NBS can be implemented alone or in an integrated manner with other solutions to address societal challenges (i.e. NBS combined with technological and engineering solutions).

PRINCIPLE 3: NBS are determined by site-specific **ecological** and cultural contexts that include **meaningful engagements with multiple stakeholders holding Indigenous,** traditional, local and scientific knowledge.

PRINCIPLE 4: NBS produce **multiple** societal benefits in a fair and equitable way in a manner that promotes transparency and broad participation **among multiple stakeholders.**

PRINCIPLE 5: NBS maintain or improve **ecosystem processes,** cultural diversity and the ability of ecosystems to evolve over time.

PRINCIPLE 6: NBS **consider,** apply or **contribute to multiple benefits** at a landscape scale.

PRINCIPLE 7: NBS recognize and address the trade-offs between the production of a few immediate economic benefits for development, and future options to produce the full range of **benefits for a broad range of beneficiaries.**

PRINCIPLE 8: NBS are an integral part of the overall design of policies and measures or actions, to address **societal and environmental** challenges.

PRINCIPLE 9: NBS are assessed and designed using the best available science to optimize performance, identify the limits of benefits and acknowledge unknowns.

Given the complexity of the societal challenges that NBS aim to help address, we elaborate further on the principles below. The examples offer context for each of the principles. The “method considerations” column provides insight into how the principles will inform our method development.

Principle 1: NBS embrace nature conservation norms and principles

Explaining the principle
NBS are not an alternative to or a substitute for nature conservation. While NBS embrace elements and activities of nature conservation, not all conservation actions necessarily qualify as NBS. In some cases, NBS closely address nature conservation priorities, but not invariably or exclusively. Therefore, NBS is not wanting to replace existing conservation norms and principles, but rather align with them where possible.

Example
Protected areas are created to conserve a certain species or protect a landscape. NBS activities may occur in the protected area or nearby; for example, by conserving a forest and the species that live there, a protected area may also provide watershed protection while providing social and economic opportunities from tourism to the area. The protected area itself is not an NBS, as the area is a geographic location where landscapes and species are afforded varying degrees of protection rather than addressing key solutions to, for example, an improvement in water quality.

Method considerations
This method aligns with nature conservation norms and principles. This will include biodiversity as one part of the benefit suite as well as the multiple benefits that NBS provide to nature, including broader landscape processes, ecosystem health and ecosystem service provision.

Principle 2: NBS can be implemented alone or in an integrated manner with other solutions to address societal challenges (i.e. NBS combined with technological and engineering solutions)

Explaining the principle
NBS promotes the provision of a full range of ecosystem services and can complement other technological and engineering actions and interventions.

This principle requires consistency and alignment between policies and is linked to NBS Principle 8.

Example
To limit flooding in low lying coastal areas, activities, such as building seawalls and planting mangroves, can prove a successful combination of NBS and engineered solutions that meet societal needs.

It would not be considered NBS if a seawall was built with some vegetation planted on or around it for beautification, even if this vegetation assists partially with meeting societal needs like localized flooding.

Method considerations
The method focuses on the aim of NBS in addressing societal challenges, rather than the proportionality of green and gray infrastructure used. It will highlight the multiple benefits provided by NBS, and showcase the different benefits accrued over different time periods.

Principle 3: NBS are determined by site-specific ecological and cultural contexts that include meaningful engagements with multiple stakeholders holding traditional, local and scientific knowledge

Explaining the principle
NBS are evidence-based approaches built on understanding ecosystems and socio-economic/cultural contexts. Because all situations are different, NBS should consider ecological and cultural contexts that include traditional, local and scientific knowledge, through people living and having a stake in the ecosystem. Ensure that the voices of marginalized communities are included in NBS development and implementation. An effective system of local governance or integrating actions into existing governance structures will aid the process.

Example
Many communities in less developed areas have been incorporating NBS into their daily lives for hundreds of years. Examples include planting trees, shrubs or grasses in areas of high erosion or along coastal floodplains to limit flood risks. These communities often know what grows best in these areas and how these interventions and activities can support their societal challenges. By combining Indigenous, traditional or local knowledge with scientific data, NBS interventions and activities will be more sustainable and more culturally accepted than if solutions are imposed on landscapes without local input.

Method considerations
The method incorporates a variety of different data sources and multidisciplinary knowledge to produce outcomes and outputs that are relevant to local contexts. It is important to incorporate traditional, local and scientific knowledge in the method development to ensure that these insights are considered and valued. This will enhance understanding of the beneficiaries of NBS interventions and activities and the types of benefits accrued.

Principle 4: NBS produce multiple societal benefits in a fair and equitable way in a manner that promotes transparency and broad participation among multiple stakeholders

Explaining the principle
It is important to ensure that different categories of stakeholders are involved in NBS, and that the NBS in place provide multiple benefits to these stakeholders and avoid negative impacts. NBS activities for water security, carbon sequestration or disaster risk reduction frequently provide services for governments, companies and communities that can be outside of the immediate site but can entail loss of opportunities for those living in or near the services' source. NBS should therefore promote the sharing of costs and benefits for all beneficiaries in a fair and equitable way.

Example
When a community maintains a forested watershed to supply water downstream, it will need fair and transparent processes as well as an explicit understanding of the local politics of negotiations and implementations. This understanding should reflect the watershed's value to the forest community and help determine the nature of compensation-based mechanisms for the supply of ecosystem services. Where they exist, trade-offs should be mitigated wherever possible.

If a stakeholder unilaterally implements NBS without informing other stakeholders in the watershed or fails to consider the impacts the NBS may have on other communities, the process would not be considered fair, equitable or transparent (Brill et al., 2022).

Method considerations
The method provides an overview of any NBS project's benefits, beneficiaries and potential trade-off(s). It will attempt to incorporate a broader set of social and cultural values, and not focus explicitly on economic values. Ensuring that benefits accrue as equally as possible across stakeholders, and that some stakeholders are not disproportionately benefiting, are key considerations. M&E should be incorporated into NBS design to ensure that benefits are aligned to societal challenges over time.

Principle 5: NBS maintain or improve ecosystem processes, cultural diversity and the ability of ecosystems to evolve over time

Explaining the principle
To ensure that ecosystem services are sustainable and resilient to future environmental change, NBS need to be developed and implemented in a manner that is consistent with the temporal dynamics and complexity of ecosystems. Some benefits will accrue across the short, medium and long term and may change based on the dynamics and complexity of ecosystems.

Example
When designing NBS, practitioners should prioritize maintaining and improving natural landscape processes through the inclusion of social and cultural knowledge and actions. NBS can also add interventions and activities that incorporate culturally valuable materials, such as certain indigenous plant species that can be used for food, fuel, medicine or cultural practices. These indigenous materials will also support local ecosystem processes and create a more resilient ecosystem. NBS design and management should also consider how the NBS themselves may be impacted by a changing climate or other external changes.

Method considerations
The method promotes the maintenance and improvement of ecosystem processes, cultural diversity and the ability of ecosystems to evolve over time by highlighting how certain NBS can maintain and improve these processes. This will assist in reducing uncertainty and building long-term sustainability and resilience in these ecosystems.

Principle 6: NBS consider, apply or contribute to multiple benefits at a landscape scale

Explaining the principle

Many NBS are implemented over large spatial scales—such as watersheds or large forests—which usually combine several ecosystems (agricultural, inland waterways, coastal, forest, etc.), and that might, in some cases, be transboundary. Even when an NBS is implemented at a specific site level, it is important to consider the wider landscape-scale context and consequences, aiming to upscale where appropriate.

Example

When a business starts developing and implementing NBS, it should consider the broader scale benefits. Look beyond the boundaries of the business and design for benefits that accrue to the whole of society. An alien vegetation clearing project could be designed to create local jobs, and the area could be re-planted to provide native pollinator habitat. Consider these multiple benefits in advance to ensure the project is designed to optimize benefits. Think broad when thinking NBS.

Thinning or harvesting of commercial forest stands for replanting a new crop would not be considered NBS as this is a commercial venture with few benefits accruing to the environment or societies in or around the commercial plantation.

Method considerations

The method recognizes that scale matters and will account for the full suite of benefits across multiple scales. Scale is also important to improve levels of certainty. We have more certainty at more localized levels as actions and outputs can be easier to measure. Practitioners should ensure that any NBS contribute to benefits at the landscape scale by working through multi-stakeholder engagements to align with other projects and programs.

Principle 7: NBS recognize and address the trade-offs between the production of a few immediate economic benefits for development, and future options to produce the full range of benefits for a broad range of beneficiaries

Explaining the principle

A thorough understanding of trade-offs between current and future benefits is important when deciding among different NBS activities. Focus on thinking in longer time frames and considering a wide range of benefits. Most current project planning and funding processes only allow for a limited time frame in which to consider costs, benefits and the sustainability of solutions. By thinking further into the future and considering a wider range of benefits (not all of which can be captured in a traditional cost-benefit calculation), NBS can offer holistic and/or complementary solutions.

Example

Support for restoration, management and conservation efforts through mechanisms like payments for ecosystem services can provide economic and social benefits that outweigh the need to convert ecosystems.

NBS should avoid changing an ecosystem in favor of a particular service or resource, such as replacing natural mixed woodland with a monoculture crop plantation. Although the immediate benefit from crops seems enticing (e.g. food security, income from crop sales), the natural woodland contributes potentially more benefits over time.

Method considerations

The method considers the complexity of ecological and social systems and engages many stakeholder groups when accounting for interests, needs, benefits and trade-offs. The method also factors in how to mitigate trade-offs wherever possible and aims to decrease the level of uncertainty when designing and implementing NBS so that the balance of benefits and beneficiaries is more equal.

Principle 8: NBS are an integral part of the overall design of policies and measures or actions, to address societal and environmental challenges

Explaining the principle
For NBS interventions and activities to have broad influence, it is important to make sure that they are not only practically undertaken in the field, but are also incorporated into policy, funding criteria, project development protocols and related actions. The implementation of this principle will support large-scale interventions and activities, including the potential for adaptive management and collaborative governance, as the interventions' outcomes can inform and adapt natural resource management policy and governance strategies.

Example
Companies should align NBS design as much as possible with national legislative priorities, such as conservation objectives, social inclusivity, human health and economic opportunity creation. NBS can play a crucial role in solving many societal challenges but need to be formalized into policy to ensure implementation at scale. When there is a legislative requirement to consider NBS (with or without traditional systems), the opportunities for design and implementation of NBS will be significant.

When implementers only focus on the benefits to their business and ignore watershed priorities that address other societal challenges, NBS may fail to reach scale, as opportunities will appear less valuable.

Method considerations
The method acknowledges that multi-stakeholder engagement will be critical to ensure alignment between policy and practice. This will also require the public and private sectors, NGOs and civil society to collaborate on policies that promote NBS. These engagements will need to be ongoing and adapted to changing ecological and social systems in the local context.

Principle 9: NBS are assessed and designed using the best available science to optimize performance, identify the limits of benefits and acknowledge unknowns

Explaining the principle
NBS projects should leverage expertise and knowledge from NBS practitioners and academic partners. Applying the most relevant knowledge and incorporating new knowledge as it is developed to current and future NBS projects will establish a valuable "learning by doing" approach. There are always unknowns when designing projects involving NBS, but we can mitigate these uncertainties through adaptive management and multi-stakeholder engagement.

Example
An NBS project is developed by implementers who perform a thorough literature review, partner with an academic institution to understand the latest thinking and incorporate local communities in the design and decision-making process to understand traditional approaches to managing the land. This scientific and local knowledge informs the design, and the monitoring program tracks both the unknowns and intended project impacts to support learning and adaptive management.

When implementers do not apply contemporary science or use lessons learned from other NBS projects, NBS may fail to address the key societal challenges they were developed to address, limit the benefits accrued or compromise opportunities for reflective learning.

Method considerations
The developed method is based on contemporary literature and expert understanding of NBS and ecosystem processes and functions. The method will be dynamic and adaptable as our understanding of NBS benefits improves with experience and time. The method acknowledges gaps in our current knowledge and attempts to address these wherever possible to reduce the number of unknowns.

ATTRIBUTES OF SUCCESSFUL NATURE-BASED SOLUTIONS FOR WATERSHEDS

The project team developed a set of attributes for this guide based on principles and parameters proposed by the IUCN (2016a). These attributes represent the considerations that policymakers and practitioners should include in NBS project design and implementation to increase the likelihood of effectiveness and sustainability across a range of different contexts and localities. All NBS interventions, across all habitat types, should fully consider these attributes to increase the likelihood of NBS project success.

Ecological complexity
NBS should maintain or improve ecological complexity at different scales. Understanding the interconnectedness, influence and impacts of different elements (ecological, social and economic) within ecosystems is crucial to ensuring that complexity is considered. By undertaking a certain activity, there may be upstream and downstream consequences which should be planned for and mitigated where negative influences occur.

For example, by restoring a forest and planting new trees to increase available habitat, improve air quality, enhance carbon sequestration, etc., there may be a decline in the local surface water or groundwater resources as these new forest stands absorb more water as they grow. Less water in the system could affect aquatic ecosystems, local hydrology and soil and water chemistry. Practitioners, planners and policymakers need to be aware of the interconnectedness in ecological and social systems and mitigate any trade-offs wherever possible.

Scale of ecological organization
NBS should be implemented at a scale that helps mediate upstream and downstream relationships, beneficiaries and benefits. Ideally NBS should be implemented at the landscape (e.g. watershed) level and consider broad ecological, social and economic systems.

NBS practitioners should design projects at appropriate scales and align closely with other NBS or landscape management practices in the watershed. This offers the potential to maximize return on investments, reach project goals sooner, reap additional benefits, broaden beneficiary reach, pool resources and expedite project implementation. The smaller the scale (e.g. within the property boundary of a company) of the project, the less opportunity there may be to slot in with other projects, partner with other stakeholders in the watershed or reach a wider audience of beneficiaries.

Long-term sustainability
NBS interventions and activities should persist over many years and include M&E at every stage of the project. Long-term sustainability may require a suitable budget for maintenance, monitoring and further improvements. This approach will ensure that benefits are accrued across the short, medium and long term.

Practitioners may need to review public and private sector funding, policies and frameworks which oftentimes have short time frames attached to projects (under five years). Without adequate resources (finances, capacity, time, etc.), NBS projects may not reach their full potential or be able to provide the full suite of benefits they were designed to achieve. In a worst-case scenario, an NBS project may fail completely due to a lack of operational and maintenance support.

Direct societal benefits
NBS should support the delivery of multiple societal benefits (across ecological, social and economic systems) and attempt to mitigate trade-offs where these exist. It is important that those who seek to implement NBS articulate the nature, scope and scale of the benefits they wish to accrue.

By starting with the kinds of direct benefits wanted, either for the benefits of their organization (company, government agency, NGO, etc.) or for a broader community, practitioners can identify the kinds of interventions and activities across multiple habitat types that could help achieve these benefits. Some beneficiaries may accrue additional benefits depending on their needs (e.g. freshwater for drinking) or preferences (e.g. green urban space for recreation), while others may not benefit as much. It is critical that one cohort is not impacted by too many of the trade-offs (negative consequences of NBS actions) to create a more equitable share of NBS benefits.

Adaptive management and collaborative governance
NBS interventions and activities should be supported by institutional and decision-making arrangements that are flexible enough to adapt over time to meet changing landscape conditions and the needs of the people who manage and rely on these ecosystems. Inclusion of multiple stakeholders with different forms of knowledge throughout the project will be critical to the long-term effectiveness of NBS.

Some of the most successful NBS projects have had an extremely broad range of stakeholders, including project developers, investors, government officials, NGOs and local communities holding Indigenous knowledge. Multiple perspectives and approaches promote buy-in for the project from the outset and issues and opportunities can be addressed early on. A project has a greater chance of long-term sustainability when all groups have a vested interest in its success.

GUIDELINES FOR NBS INVESTMENTS

The Oxford NBS Initiative (2022) presents four evidence-based guidelines for delivering successful, sustainable NBS with long-term benefits for people and nature.

NBS are not a substitute for the rapid phase-out of fossil fuels and must not delay urgent action to decarbonize our economies
NBS play a vitally important role in helping to mitigate climate change this century, but their contribution is relatively small compared to what must be achieved by the rapid phase-out of fossil fuel use. Furthermore, unless we drastically reduce greenhouse gas emissions, global heating will adversely affect the carbon balance of many ecosystems, turning them from net sinks to net sources.

NBS involve the protection, restoration and/or management of a wide range of natural and semi-natural ecosystems on land and in the sea; the sustainable management of aquatic systems and working lands; or the creation of novel ecosystems in and around cities or across the wider landscape

All ecosystem types hold opportunities for NBS to enhance the provision of ecosystem services to people for supporting multiple societal challenges. It is critical that we avoid turning ecosystems from carbon sinks into carbon sources. The world's remaining intact ecosystems and biomes are hotspots for both biodiversity and carbon storage, while also protecting people from climate change impacts. Yet many of these areas lack effective protection or are poorly managed. Degradation of ecosystems significantly reduces carbon storage and sequestration and increases vulnerability to climate-related hazards such as fire.

It is also urgent to prevent inappropriate tree planting on naturally open ecosystems such as native grasslands, savannahs and peatlands, or replacement of native forests with plantations. NBS must be valued in terms of the multiple benefits to people and biodiversity, rather than overly simplistic metrics such as numbers of trees planted and short-term carbon gains. Management at the landscape scale, accounting for and utilizing interactions between ecosystems, as well as managing for climate risks to ecosystem services, can help secure and maximize long-term benefits.

NBS are designed, implemented, managed and monitored by or in partnership with Indigenous peoples and local communities through a process that fully respects and champions local rights and knowledge, and generates local benefits

NBS are explicitly designed and managed adaptively through just institutions to provide a range of benefits to local people, including supporting livelihoods and reducing vulnerability to climate change. They are designed to take the needs, values and knowledge of different sectors of society into account, and particularly of marginalized groups such as women. NBS are produced through partnerships between a diverse set of actors; local and Indigenous peoples should have control of the decision-making process, with financial, governance and/or in-kind support from researchers, and the private, public and charity sectors.

NBS support or enhance biodiversity, that is, the diversity of life from the level of the gene to the level of the ecosystem
Biodiversity underpins the societal benefits derived from NBS by supporting the delivery of many ecosystem services in the short term, reducing trade-offs among services (e.g. between carbon storage and water supply), and supporting the health and resilience of ecosystems in the face of environmental change, thus increasing their capacity to deliver benefits in the long term. To sustain ecosystem health, other location-specific ecological aspects must also be considered, such as ecosystem connectivity. Therefore, successful, sustainable NBS are explicitly designed and adaptively managed to provide measurable benefits for biodiversity and ecosystem health.

Appendix D: Agricultural Nature-Based Solutions Versus Best-Management Practices

There is no clear consensus among practitioners on which activities in agricultural landscapes fall under NBS and which should be considered BMPs. While both NBS and BMPs in agriculture are approaches which have proven to be effective in preventing or reducing negative impacts (e.g. reducing nitrogen pollution in waterways) and achieving benefits for water, carbon, biodiversity and soil health, the difference is that BMPs do not always fall strictly under the definition of NBS. Agricultural BMPs do not always aim to return ecosystems to their original state or manage or conserve healthy ecosystems. They often focus instead on increasing operational efficiency, such as through water-efficient irrigation technology or the use of heat-resistant crop seeds. These BMPs can reduce operational costs for farmers and improve agricultural yields. NBS can similarly provide multiple socio-economic benefits but are also focused on returning monocultured and degraded croplands to a more natural or pre-intervention state, for example, through planting diverse vegetation buffers and increasing organic matter in soils. The table below compares the list of agricultural BMPs versus NBS considered in this guide.

TABLE D1: EXAMPLES OF AGRICULTURAL NATURE-BASED SOLUTIONS AND BEST MANAGEMENT PRACTICES

Agricultural Nature-Based Solutions Activities	Agricultural Best Management Practices
• Terraced/contour planting (following natural gradients of landscape) • Vegetation buffers (cover crops, grass strips, hedge rows, trees in croplands, riparian buffers, filter strips, critical area planting) • Invasive species removal (flora and fauna (including reducing evapotranspiration by alien vegetation) • Grazing management systems (silvopasture, rotational grazing/reduce overgrazing) • Mulching and fertilizing (animal manure, compost pits, biochar, organic matter, crop residue, conservation tillage) • Barriers (fences, wire, etc. to reduce livestock/animal impacts, reduce unwanted herbivory) • Soil health improvement/restoration (increase organic matter, increase carbon content, earthworms, microbial activity, plant diversity) • Retention/detention ponds, swales, diversion/diversion channels	• Soil tillage (other than conservation tillage) • Irrigation practices including flood/drip/variable rate irrigation and advanced irrigation scheduling • Grow tunnels, shade netting or other evapotranspiration reducing technology • Crop diversification, intercropping, conversion or use of drought or heat resistant seeds, selecting livestock native to the region/adapted to certain conditions • Crop rotation • Pest management/limitation (pesticide and chemical fertilizer application including biological control) • Laser leveling

BOX D1: DIFFERENCES BETWEEN AGRICULTURAL INTERVENTIONS

Within agricultural habitats, there are several NBS interventions that can occur: restoration, management, protection and creation. The differences between these interventions are perhaps more nuanced in agricultural habitats than others, and are described below:

Restorative or regenerative agriculture aims to restore degraded landscapes into healthy agricultural ecosystems. This form of agriculture is a rehabilitation and conservation approach that focuses on topsoil regeneration, increasing biodiversity, improving the water cycle, enhancing ecosystem services, supporting biosequestration, increasing resilience to climate change and strengthening the health and vitality of farm soil.

Agricultural management refers to the optimal management and use of resources on a farm. This includes adopting both NBS and agricultural BMPs and may consider soil practices, farming techniques, irrigation technologies, etc. Agricultural management aims to keep farmlands in a sustainable condition for future generations.

Conservation agriculture is a farming system that promotes minimum soil disturbance (i.e. no tillage), maintenance of a permanent soil cover, and diversification of plant species. It enhances biodiversity and natural biological processes above and below the ground surface, which contribute to increased water and nutrient use efficiency and to improved and sustained crop production.

The creation of agricultural landscapes may include converting natural land into farms, converting urban space into food-production areas, or restoring degraded landscapes for farming activities. Depending on the nature of the original landscape, agricultural creation can play a positive or negative role in the landscape.

Appendix E: Private Sector Efforts that Evaluate Multiple Benefits of Nature-Based Solutions

TABLE E1: EXAMPLES OF COMPANIES AND TOOLS DEVELOPED TO MEASURE OR EVALUATE THE MULTIPLE BENEFITS OF NATURE-BASED SOLUTIONS.

Implementer	Project or Tool	Description
Electric Power Research Institute	Ohio River Basin Water Quality Trading Project	This is a market-based approach to achieve water quality goals by allowing permitted dischargers to generate or purchase pollution-reduction credits from another source, such as a farmer who has already adopted pollution-reduction agricultural practices and does not need credits to abate pollution. Nutrient reductions are quantified as credits (for example, one credit is equal to one pound of nutrient reduction). A regulatory agency then reviews the credits. Resulting benefits include water quantity and quality and co-benefits which include improved soils, carbon sequestration, improved wildlife habitat and additional income to farmers. A challenge with market-based approaches is that behavior may not change to a more desirable and sustainable state if the actor can simply pay off their current choices without additional punitive measures. This provided power companies in the watershed with a more cost-effective option to meet their water quality effluent limits, rather than investing in measures to reduce their effluent. One of the major challenges of the project was considering the uncertainty in measuring water quality benefits over time and place from on-the-ground practices. To overcome this, the project required careful documentation and incorporated science through monitoring and models. These models included estimating nutrient reductions at the field edge (point of credit generation) and a watershed analysis risk management framework for estimating nutrient reduction from field edge to point of use.
The Dow Chemical Company and The Nature Conservancy	ESII Tool	This tool helps companies such as Dow incorporate the value of nature into their business processes, strategies and decision making. The ESII Tool produces models and outputs with an engineering and design perspective to facilitate actionable land use and management decisions. For a given site, the ESII Tool helps non-ecologists make relative comparisons of the expected levels of ecosystem service performance, such as aesthetics, water filtration, nitrogen removal, water quantity control, etc. This tool requires data collection for inputs such as temperature, precipitation, type of habitats, types of vegetation, etc. It is not easy to compare outputs between different locations. However, this tool is especially useful for evaluating benefits and trade-offs from different NBS scenarios for a specific location. Robust models incorporated into the tool capture the physical and biological processes, and design and track different sources of uncertainty that arise during the measurement of benefits produced by a natural area.
The Coca-Cola Company	Natural Capital Projects	This initiative quantifies the stacked benefits of The Coca-Cola Company's natural capital projects (e.g. water ecosystem restoration, land restoration, water, sanitation and hygiene and on-farm projects). The Coca-Cola Company documented the ecosystem services of their natural capital projects (e.g. food, raw materials, water quantity, carbon sequestration) and identified calculations beyond common indicators to evaluating the value of those services (e.g. water pollution reduced vs cost of treatment saved). It is not clear how trade-offs or the temporal nature of benefits were included. However, focusing on valuation and economic cost will help the Coca-Cola Company continue to make the business case for natural capital projects. The Coca-Cola Company partnered with this work for Stage 2 of the project, specifically supporting the development of the valuation methodology and refinement of the NBS Benefits Explorer tool.

Microsoft	Planetary Computer	To minimize Microsoft's environmental impact, the Planetary Computer will help collect more data, increase computer power and advance machine learning to improve environmental decision making. For example, urban planners and farmers depend on forecasts of water availability and flood risks to make educated guesses about land management. The Planetary Computer will combine satellite data, local measurements of streams and groundwater and predictive algorithms, which will empower land planners and farmers to make data-driven decisions about water resources. This will improve our understanding of the interconnectedness of social-ecological systems, connect data, and provide solutions/actions to address environmental impacts. The Planetary Computer can also help determine areas of ecosystem degradation where NBS are needed and can monitor and evaluate the impacts of NBS through environmental data.

Appendix F: Details of Existing Approaches Complemented by this Guide

TABLE F1: EXISTING APPROACHES, WITH RELEVANT DETAILS, COMPLEMENTED BY THIS GUIDE (SEE TABLE 1)

Existing Approaches	Approach Details
Alliance for Water Stewardship Standard	Alliance for Water Stewardship Standard offers a credible, globally applicable framework for major water users to understand their own water use and impacts, and to work collaboratively and transparently with others for sustainable water management within the wider catchment context.
Gold Standard	Gold Standard sets the standard for climate and development measures to quantify, certify and maximize impact, creating value for people around the world and the planet we share.
Pacific Institute's Multi-Benefit Approach to Water Management	The Multi-Benefit Framework for Decision-Making is a framework to incorporate co-benefits into water investment decisions. Water managers can identify potential project partners and co-funding opportunities and modify project design to maximize the value of their investments.
Think Nature's NBS Handbook	This handbook gathers state-of-the-art knowledge regarding NBS into a guide relevant to all actors. It includes each aspect of NBS, from project development to financing and policymaking, and is presented in a concise and comprehensive way to be easily understandable.
Contextual Water Targets	This guide helping companies set effective site water targets informed by catchment context.
Dow's ESII Tool	This tool helps companies such as Dow incorporate the value of nature into their business processes, strategies and decisions.
EcoMetrics	EcoMetrics uses in-depth analytics to quantify and monetize the full value of each environmental, social and economic outcome produced by NBS.
EKLIPSE Impact Evaluation Framework	Through literature review, this framework explores the multiple dimensions of impact that NBS projects may have when implemented at different scales, from building to regional.
Forest Trend's CUBHIC Tool to Quantify Water Benefits	This tool supports the quantified estimates of the impacts of the most common NBS for water in Peru in terms of water quantity (e.g. increases in dry season flow) and water quality (reductions in sediments and nutrient pollution).
International Institute for Sustainable Development's Sustainable Asset Valuation Tool: Natural infrastructure	This tool integrates knowledge from various disciplines and sectors for sustainable asset valuation across gray and green infrastructure.
Natural Capital Protocol	The Natural Capital Protocol is a decision-making framework that enables organizations to identify, measure and value their direct and indirect impacts and dependencies on natural capital.
The Nature Conservancy's Water Proof tool	WaterProof provides a rapid and indicative NBS investment portfolio and associated ROI. The tool is intended to engage stakeholders interested in exploring solutions to local water challenges and prioritization of locations for possible NBS water security programs (such as Water Funds).
Volumetric Water Benefit Accounting	An approach for implementing and valuing water stewardship activities in a comparable way and ensuring they address current or projected water challenges, mainly relating to volumetric water benefits, and contribute to public policy objectives.

Appendix G: Steps for Method and Tol Development to Identify the Multiple Benefits of Nature-Based Solutions

This appendix details the various steps the project team followed along the method development process for this guide. This method forms the foundation for the practical tool which details the benefits and trade-offs accrued from NBS across different habitats.

OVERVIEW OF METHOD DEVELOPMENT PROCESS

The project team followed multiple steps in the development of the benefit-identification method (Figure G1). To start, the project team identified the environmental and societal challenges that can be addressed by NBS, based on the outcomes of Shiao et al. (2020). The second step was to determine the various habitats in which NBS can be deployed, and what kinds of interventions best suit the state of the landscape. Third, the team described the natural processes within different habitat types and categorized these across a series of functional domains (geomorphology, chemistry, etc.). Next, the team linked the benefits and trade-offs to natural processes across several themes (water quality, carbon sequestration, etc.). In Step 5, we identified the activities relevant to NBS that affected the natural processes. In Step 6, we created a series of method flows whereby we linked habitat and intervention types to activities, processes and benefits and trade-offs. These method flows informed the development of a practical tool for Step 7.

FIGURE G1: OVERVIEW OF METHOD DEVELOPMENT PROCESS

STEP 1: Identified environmental and societal challenges

STEP 2: Determined habitat and intervention types

STEP 3: Described and categorized natural processes across functional domains

STEP 4: Catgorized and linked beneits and trade-offs to processes

STEP 5: Identified activities that influence or impact natural processes

STEP 6: Linked habitats and interventions to activities, processes, benefits and trade-offs

STEP 7: Developed a practical NBS tool

To bridge these individual steps, the team created method flows for specific habitat-intervention categories (e.g. forest restoration). Each habitat type has at least three method flows based on possible NBS interventions and related activities. Processes and benefits/trade-offs for each of the habitat-interventions combinations were linked to these activities. Each step is detailed below.

1. Identified Environmental and Societal Challenges

Habitat-specific challenges may relate to physical impacts to a natural system. These can include water quantity issues (too much or too little), water quality concerns, anthropogenic or climate-induced hydrologic or ecosystem changes, or other impacts to ecosystem health. These challenges are highly localized and may vary by habitat, as do appropriate interventions. For example, healthy forests trap and retain soil and control erosion. Deforestation hinders these natural processes, as it contributes to erosion, sedimentation of waterways and degradation of surface water bodies. The challenges identified in this project informed the habitat and intervention types explored, as well as the other steps along the method flows. Shiao et al. (2020) provide an overview of these challenges across multiple habitat types. The challenges identified in this project informed the habitat and intervention types explored, as well as the other steps along the method flows.

2. Determined Habitat and Intervention Types

We developed a classification scheme based on the Nature-based Solutions Evidence Platform (University of Oxford, 2019) and the IUCN Habitats Classification Scheme (IUCN, 2012), to better understand the types of NBS for watersheds, including urban systems. The categories were based on two criteria:

1. They should be *mutually exclusive* to the extent possible (i.e. categories should not significantly overlap);
2. They should be c*omprehensive* to cover a broad range of NBS (i.e. categories should cover the majority of NBS types).

We then categorized NBS across two dimensions: *habitat and intervention.*

HABITAT TYPES

The IUCN designates 16 major habitat types using a combination of biogeography, latitudinal zonation and depth in marine systems. Each of the categories comprise multiple sub-categories. For this work, nine habitat types were selected (see Table G1), as these were considered relevant or appropriate to the primary and secondary audiences, based on the challenges listed above.

TABLE G1: HABITAT TYPES AND DEFINITIONS USED IN THIS PROJECT

Habitat Type	Definition
Agricultural lands	Land areas used by humans for food, fuel and fiber production.
Estuaries and deltas	A partially enclosed coastal body of brackish water with one or more rivers or streams flowing into it, and with a connection to the sea.
Forests	A continuous stand of trees dominating a landscape.
Grasslands	Areas characterized by a grass understory, and in some cases (shrubland and savanna) accompanied by a sparse herbaceous or woody overstory.
Lakes and ponds	An area filled with water, localized in a basin, surrounded by land, apart from any river or other outlet that serves to feed or drain the lake.
Mangroves	Distinct saline or brackish woodland or shrubland habitat characterized by depositional coastal environments, where fine sediments collect in areas protected from high-energy wave action.
Rivers and floodplains	Natural flowing watercourses, usually freshwater flowing towards an ocean, sea, lake or another river. Neighboring floodplains are areas of land adjacent to a stream or river which stretch from the banks of its channel to the base of the enclosing valley walls, and which experience flooding during periods of high flow. Riparian zones are included here.
Urban	Highly modified ecosystems or landscapes that have been altered by humans. Greenspace is dominated by cultivated or invasive species, such as gardens, parks, green roofs, etc., which are often actively managed.
Wetlands	Freshwater areas, either home to submerged vegetation (such as ponds) or areas with permanently or temporarily waterlogged soil and emergent vegetation (such as marshes, bogs, swamps, marshes and fens).

While agricultural landscapes were not considered a specific habitat category under the IUCN classification scheme, it has been allocated its own habitat category in this work due to the frequency with which NBS are implemented across agricultural landscapes, including rangelands. We also included urban landscapes, given the unique challenges and opportunities presented in these highly modified areas. While separated out for the purposes of this project, we acknowledge that the habitats listed above are often overlapping with, containing, and influencing one another.

Each habitat type is defined generally here. Practitioners should be aware of local habitat contexts and specificities. For example, forests are defined in this guide as a continuous stand of trees but given the wide spectrum of forests (e.g. tropical, temperate, boreal), local conditions, composition and characteristics should be observed. Additionally, many watersheds contain multiple habitat types to consider. In some cases, certain habitat types overlap (e.g. a river running through a forest, a wetland and lake).

INTERVENTION TYPES

An intervention is defined as "**Actions… involving management, restoration or protection of biodiversity, ecosystems, or ecosystem services, or involving the creation or management of artificial ecosystems.**" (University of Oxford, 2019). For this work, we use four types of intervention, defined below (Table G2):

TABLE G2: INTERVENTION TYPES, INCLUDING DEFINITIONS, USED IN THIS GUIDE

Intervention Type	Definition
Restoration	An intervention that involves returning degraded, damaged or destroyed ecosystems to a near pre-disturbance state. Considered synonymous with reforestation, rehabilitation, revegetation and reconstruction.
Management	An intervention that involves maintaining, improving or evolving actions and activities to drive positive structural or behavioral change within an ecosystem. These include natural resource management approaches other than restoration or protection.
Protection	An intervention that prevents or greatly limits human impact and use of resources within a clearly defined geographical area, through legal or other effective means and mechanisms, to achieve the long-term conservation of nature and social-ecological systems with associated provision of ecosystem services and cultural values.
Creation	An intervention involving the establishment, protection or management of artificial or urban ecosystems (i.e. a non-natural system), or if it cannot be determined if the intervention involves a natural habitat. This includes non-native tree stands created or managed to address climatic impacts, created mangroves or wetlands (not restored), all urban landscapes, etc.

These four intervention types are not mutually exclusive. Some interventions may require the inclusion of other intervention activities (e.g. protection of certain habitat types may require some degree of restoration and/or management activities). Where there is overlap, a combined intervention category (e.g. management-protection) may be preferred. However, for the purposes of this guide and the tool, the four intervention types are presented independently.

We allocated the restoration, management and protection intervention types to each of the nine habitat types listed above. The creation intervention type was assigned to five habitat types. This categorization resulted in 33 unique NBS habitat-intervention combinations (Table G3). The method flows which are explained below are based on these combinations.

TABLE G3: HABITAT-INTERVENTION COMBINATIONS

HABITAT TYPES	INTERVENTIONS: Restoration	Management	Protection	Creation
Agriculture	●	●	●	●
Estuaries and deltas	●	●	●	
Forests	●	●	●	●
Grasslands	●	●	●	
Lakes	●	●	●	●
Mangroves	●	●	●	●
Rivers and flood-plains	●	●	●	
Urban Greenspace	●	●	●	●
Wetlands	●	●	●	●

3. Described and Categorized Natural Processes Across Functional Domains

Determining a clear set of habitat and intervention types is foundational to defining the types of NBS that can be implemented, as interventions can be broken down into separate activities (e.g. removing a hard structure to allow migratory species to move freely) within a particular habitat-intervention combination (e.g. forest restoration). If successful, these activities will improve natural processes (e.g. production of clean air, filtering of water) in the landscape, which enhances the benefits a healthy habitat provides.

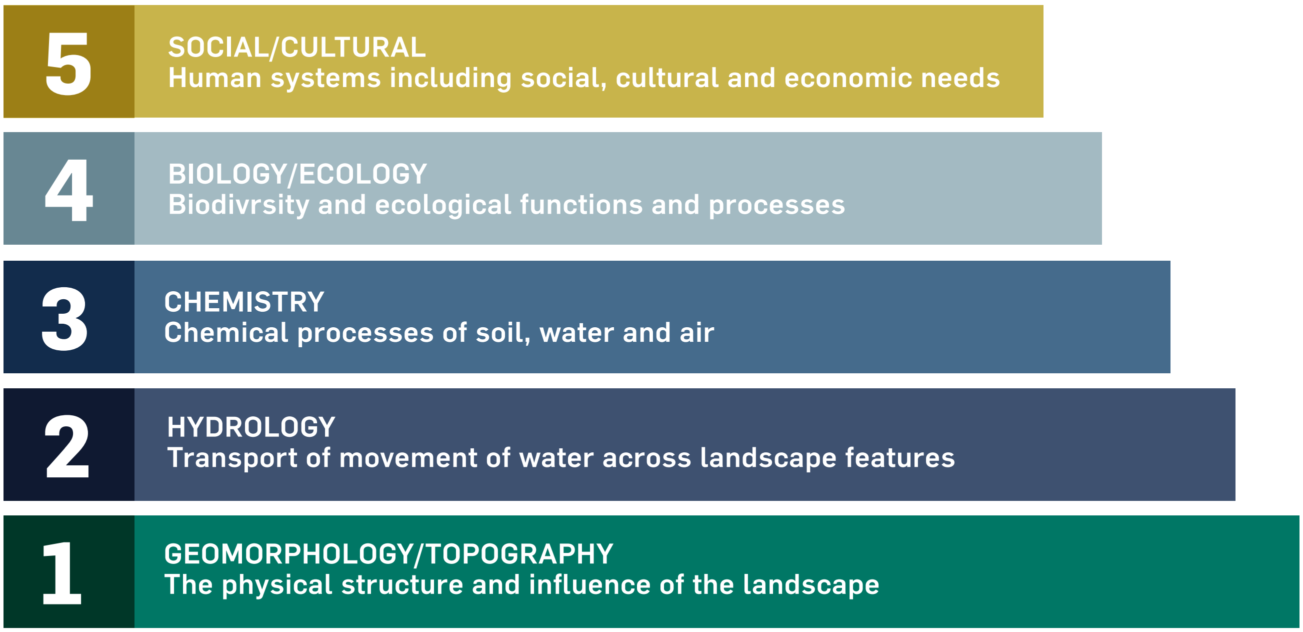
NBS influence natural systems or habitats, which are profoundly different but have a few things in common: they rest on fundamental physical, chemical and biological processes. These processes affect their environments by capturing and retaining water, carbon and nutrients; by diverting, storing and using energy; by enabling chemical transformations; and using all processes to establish complex ecological systems. In other words, processes relate to the underlying mechanisms controlling how ecosystems function.

Natural systems use these processes to create benefits for the immediate habitat, but they almost always serve the broader community of species and ecosystems as well, including social and economic systems. This web of natural functions is subjected to stress, often from human activity. NBS interventions can disrupt and mitigate these negative developments and other alterations of the natural environment.

Tracing the outcomes of a given activity requires an understanding of the processes in that system. These processes are closely related and interdependent, and to some degree hierarchical: the interactions of a broad range of biological species create a complex ecology; biology is supported by a healthy environmental chemistry, which in turn is built on hydrologic function and a geomorphologic base. Restoration ecologists, primarily in riparian restoration, have developed a nomenclature and structure for this “functional stack” of physical, chemical and biological functions that is helpful for structuring the assessment of natural functions in NBS. The project team identified processes and benefits and placed them into functional domains (Figure G2).

These functional domains included an additional category representing the social/cultural benefits of natural systems. We assigned a process to a particular domain (in some cases, processes operate across multiple domains) based on whether it is primarily related to one of the functional stack elements developed for this project.

FIGURE G2: FUNCTIONAL STACK DEVELOPED FOR THIS PROJECT



In all cases, the stacked tiers are dependent on the preceding elements, working from the bottom up in Figure G2 (e.g. hydrology is dependent on the geomorphology or topography of a landscape). This is most evident in the top tier, where it should be noted that humanity's needs are not superseding those of nature, but rather that social/cultural systems are highly dependent on nature. It is therefore critical that ecosystem needs are integrated into any decision-making process. The most resilient social-ecological systems and the most successful interventions are built on this full suite of functions.

An advantage of categorization by functional domain is that as we get beyond benefit identification, the tools and indicators used to characterize benefits tend to differ for each domain. For example, hydrologic benefits typically have a common set of indicators (volume of runoff, volume of infiltration into aquifer, etc.), while benefits accruing in the biological/ecological domain have a quite different set of indicators (e.g. number of species). Recommended indicators and methods for calculating the benefits of NBS are described in Section 4.

4. Categorized and Linked Benefits and Trade-offs to Processes

The activities and processes related to NBS in watersheds lead to outcomes that can be both positive and negative. Generally, the results become visible in the form of multiple benefits, with some trade-offs that are mostly unintended. To clarify the different effects that NBS can have, the project team categorized the benefits and trade-offs by functional domain, aligned with the processes above.

Benefits from Nature-Based Solutions

The project team identified benefits arising from the defined set of habitat-intervention combinations (Step 2) and then narrowed the list to a prioritized set of benefits across several themes. The benefit themes include water, carbon, biodiversity and environment, and socio-economic benefits. We prioritized benefits that are:

- Generally recognized by the scientific community;
- Observable, either qualitatively or quantitatively; and
- Linked to processes that can ultimately be traced back to actions.

The prioritized set of benefits (Table 4) is also most often documented in the technical literature, and amenable to monitoring and observation using generally recognized indicators or quantification methods.

As with the processes above, the project team assigned benefits according to the five-tiered functional domain structure (Figure G2), based on how their effects could be most directly measured. In some cases, effects are measurable across multiple domains. Method flow diagrams for each habitat (see below) document further benefits for each habitat, as well as trade-offs and other negative or mitigating factors that may accompany NBS implementation.

Considering Trade-offs from Nature-Based Solutions

When assessing the multiple benefits of NBS, it is essential to consider the trade-offs that may occur during the design, implementation and monitoring phases. When investors recognize that trade-offs are possible in all NBS, they are enabled to plan for their occurrence and define actions that minimize negative impacts as best as possible, through reconciling the different preferences of stakeholders. For more information on trade-offs, see sections 2 and 4.

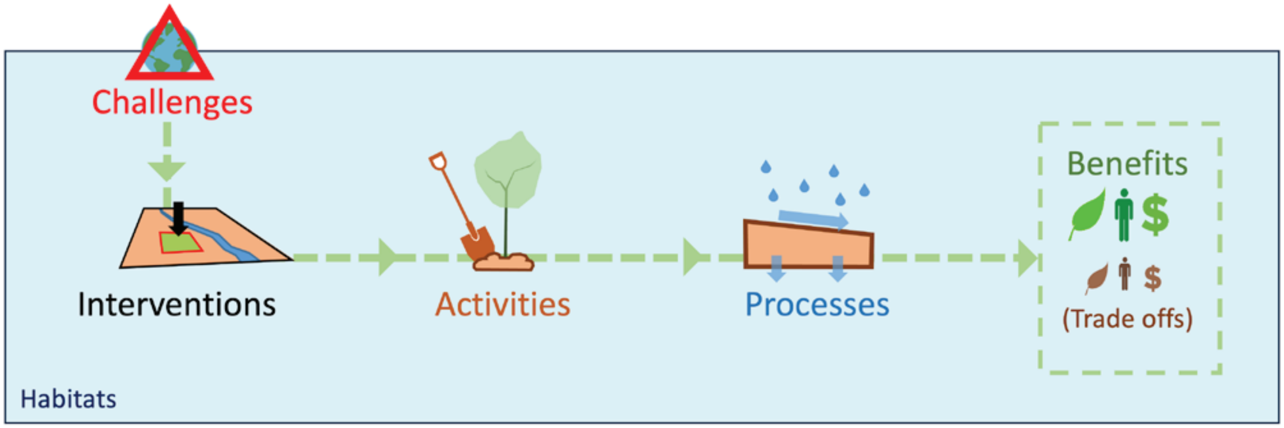
5. Identified Activities that Influence or Impact Natural Processes

The project team identified a series of activities based on literature and the project team's expertise on NBS (Table 3). Activities are defined here as "**human actions that improve landscape functions and processes which result in benefits and/or trade-offs.**" These activities physically change a landscape through restoration, management, protection or creation interventions, and have a direct influence on natural functions and processes.

6. Linked Habitats and Interventions to Activities, Processes, Benefits and Trade-Offs

The project team developed method flows to express and document how the above benefits are influenced by NBS activities. In response to habitat-specific challenges, and based on the intervention types, NBS activities such as planting native vegetation (including trees) can reduce erosion as the roots bind the soil (processes). Through reactivating these natural processes, these activities can lead to improved surface water quality and reduced water treatment costs (benefits). These flows and relationships are depicted in Figure G3.

FIGURE G3: RELATIONSHIP BETWEEN WATER CHALLENGES AND INTERVENTIONS THAT CONTRIBUTE TO BENEFITS OR TRADE-OFFS



The method flow diagram (Figure G4) identifies relevant processes supporting a given habitat, categorizes them by domain and captures linkages to benefits categorized into water quality, water quantity, carbon, biodiversity and socio-economic themes (a). Benefits are then linked to other co-benefits, and to the processes that influence them (b). In the example presented in Figure G4 for forest restoration, an activity (remove hard surfaces) undertaken in the landform/geomorphology domain influences processes that span the landform and hydraulics/hydrology domains. These processes in turn create benefits that cross multiple domains, including the biological and social/cultural. It is important to note that these effects may also change over time and vary over different spatial scales. These linkages exist for each of the activities across all the functional domains for each habitat-intervention combination.

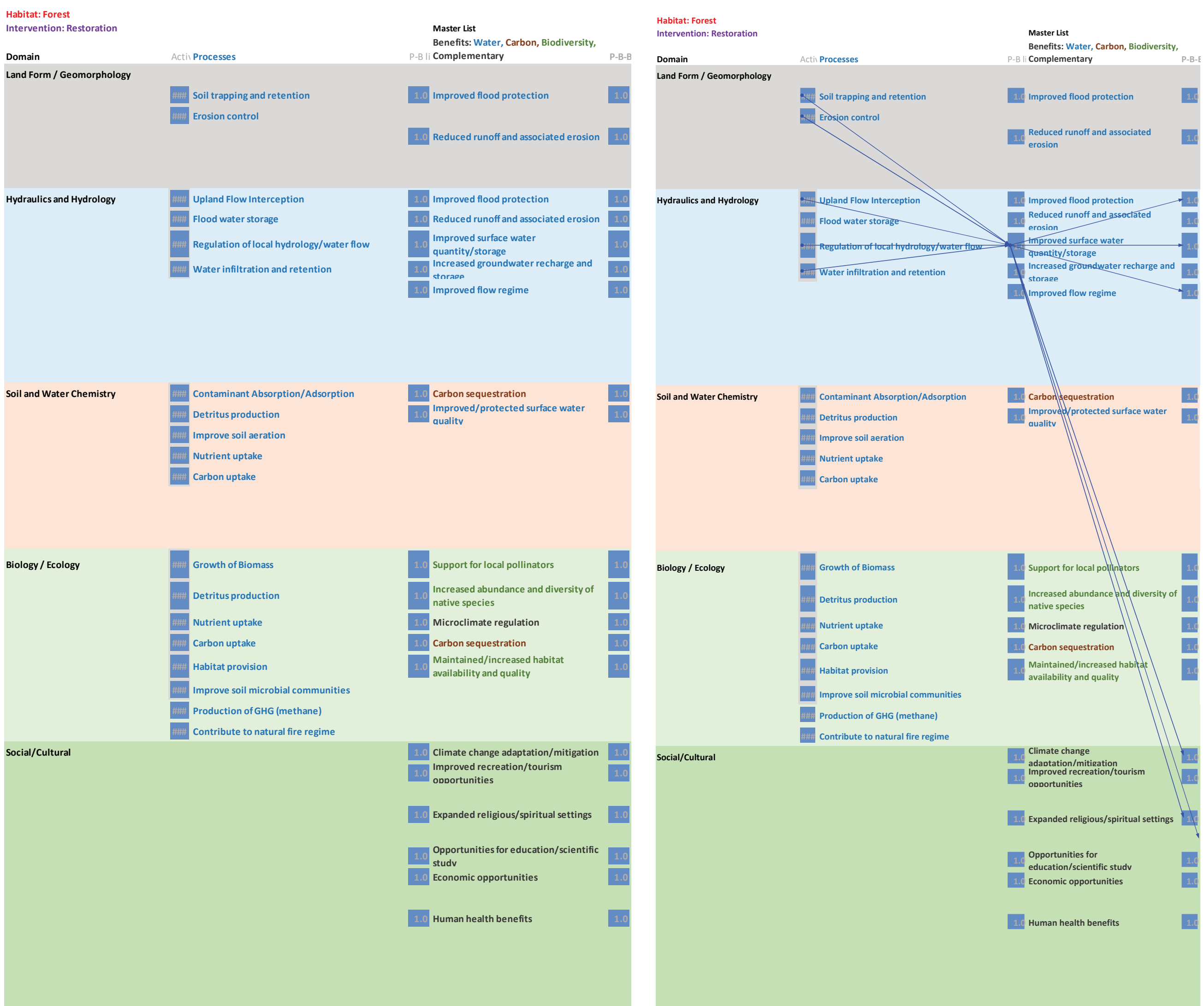
Method flow diagrams represent the general processes and benefits, as well as the interlinkages between them, for all habitats within a particular category (e.g. wetlands). The project team recognizes that there is a wide diversity of habitats within any category and that these flow diagrams may not capture all nuances of a particular habitat type based on localized conditions or contexts.

Like the natural systems they represent, these method flow diagrams demonstrate complex interconnections, but they also reflect what many restoration practitioners describe about the caretaking of natural systems: benefits from NBS activities rest on a hierarchy of natural processes that include diverse biology, high water quality, naturally varying hydrology and adapted, stable landforms.

Activity Overlays

A final step for the method flow diagrams is to demonstrate how activities relate to desired benefits. An activity overlay is an addition to the method flow diagram shown in Figure G4 that captures how a specific activity would affect the processes listed on the left side of the diagram, and in turn, would influence the benefits listed on the right side.

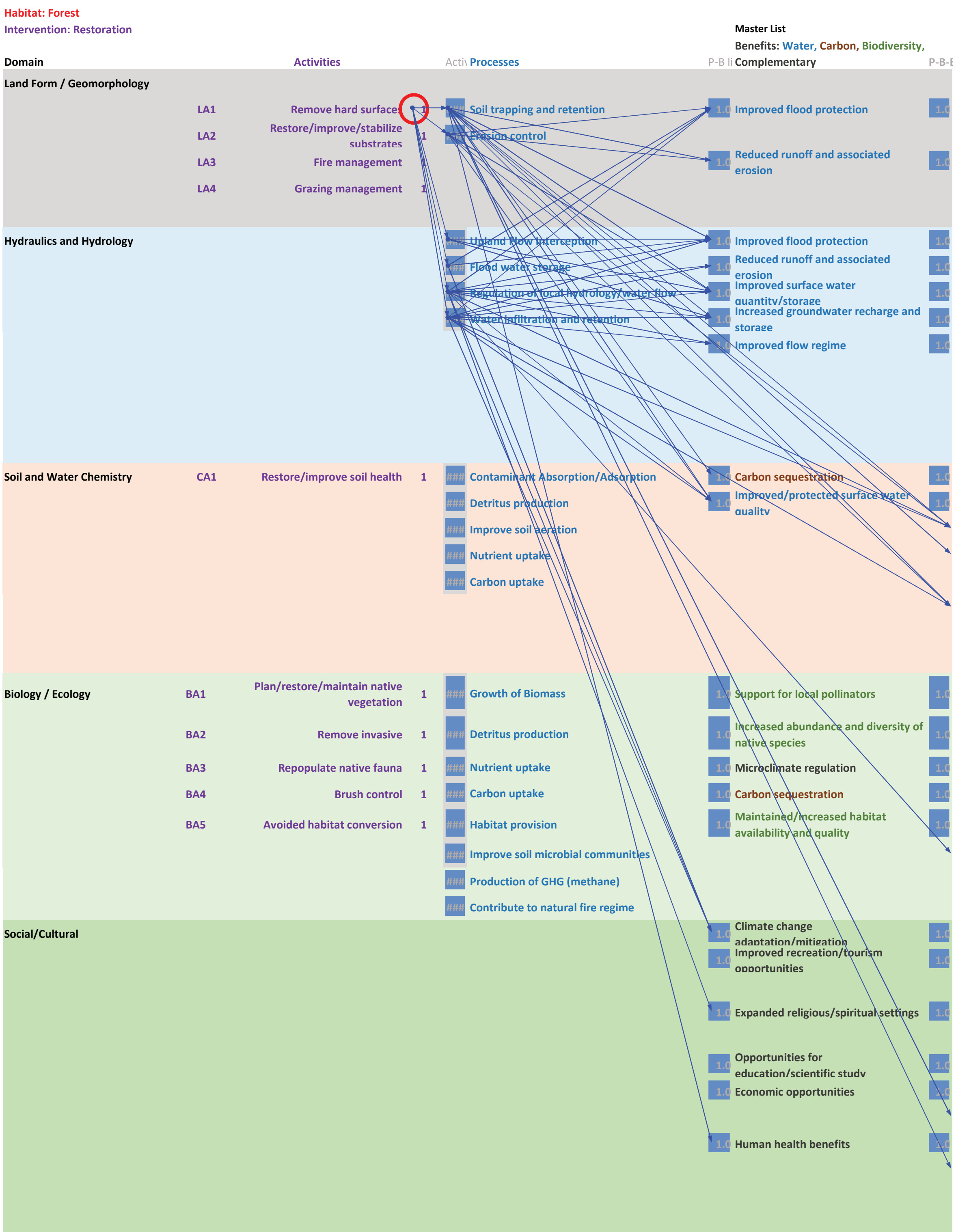
FIGURE G4: METHOD FLOW FOR FOREST RESTORATION.



In the example presented in Figure G5, an activity (remove hard surfaces) undertaken in the landform/geomorphology domain influences processes that span the landform and hydraulics/hydrology domains. These processes in turn create benefits that cross multiple domains, including the biological and social/cultural. It is important to note that these effects may also be time dependent (i.e. change over time) and vary over different spatial scales.

These linkages exist for each of the activities across all the functional domains for each habitat-intervention combination. The activity overlay can also help back track from desired benefits to identify actions that could play a role in creating those benefits. Activity overlays will be an important part of the development of an NBS tool, described below.

FIGURE G5: METHOD FLOW FOR FOREST RESTORATION WITH RESTORATION ACTIVITY OVERLAY



7. Developed a Practical NBS Tool

Based on these method flows, the project team developed the NBS Benefits Explorer tool to visualize the interconnectedness of these functions and relate them to benefits in a way that supports NBS planners. To be effective, an NBS tool needs to, at a minimum, assist NBS planners in exploring potential interventions and activities by habitat type, linking activities to processes and subsequent benefits, and providing well-defined and recognized indicators of benefits, with calculation methods to quantify them.

The tool has subsequently been refined to include the benefit forecasting (see Section 2) and valuation (see Section 3) elements. Additionally, the updated indicators and calculation methods presented in Section 4 are also incorporated.

The tool will continue to evolve as this work progresses. Future functionality will include spatial dimensions using geospatial data, satellite imagery and AI to present context-relevant outcomes. Additional functionality will be explored across the five benefit themes, allowing users to standardize their approaches to estimating and quantifying the outcomes of NBS investments.

Appendix H: NBS Benefit Forecasting Methodology

FORECASTING BENEFITS OVERVIEW

This appendix presents the NBS forecasting methodology developed in Stage 2 of the project. Forecasting predicts the magnitude of potential benefit accrual over multiple temporal and spatial scales, increasing transparency on what investors and practitioners can expect from an NBS project. These forecasts have been integrated into the NBS Benefits Explorer tool.

Objectives

The forecasting component of this project has several objectives:

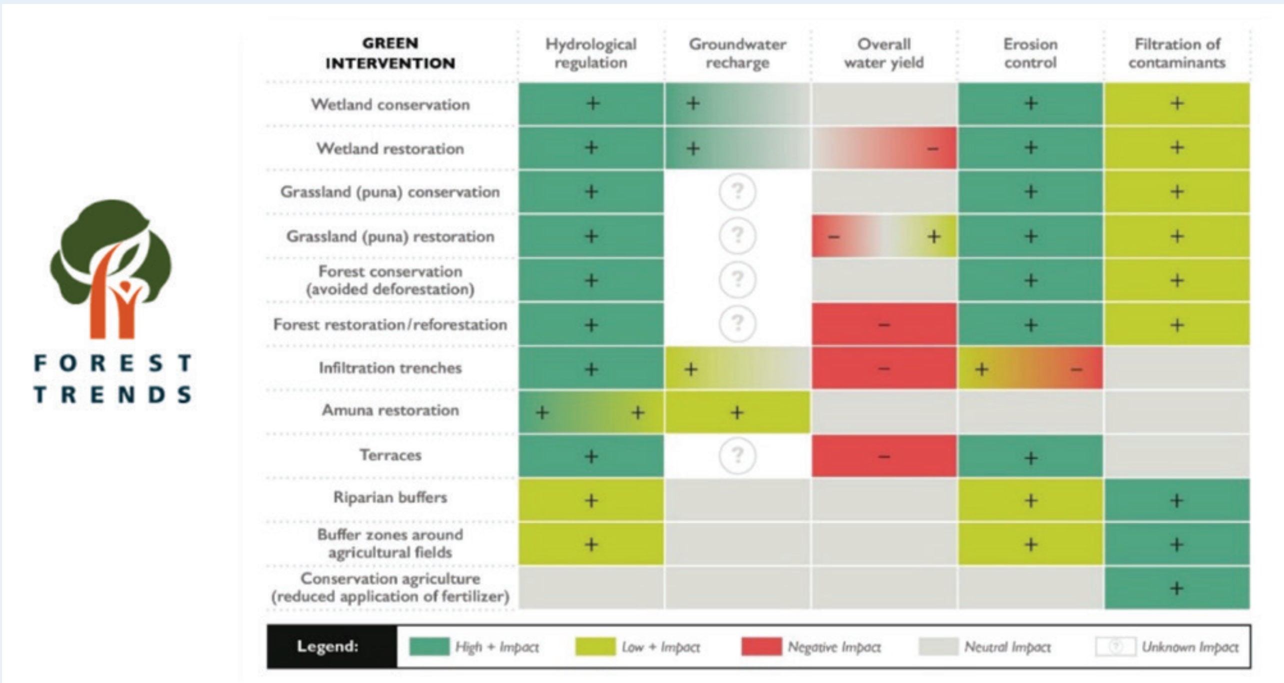
1. Bolster benefit identification outputs and provide clarity on when/where benefits accrue
   One of the key purposes of this work is to provide a clear roadmap for benefit accrual. Early versions of the guide and tool explicitly focus on identifying benefits/trade-offs from linking specific habitats, interventions, activities, and processes. The new forecasting method clarifies and improves upon this work, by indicating at what potential degree or magnitude benefits will accrue over different spatial and temporal scales. This expands the exercise from "what benefit will I accrue?" to "how much of that benefit will I accrue, when will it accrue, and where will it be experienced?"
2. Support the business case for investments in NBS
   Having approximate predictions for the magnitude of benefit accrual, across both temporal and spatial scales, ultimately aims to reduce uncertainty and increase understanding of when and where investors/practitioners can expect to see accrued benefits from projects. This enhanced understanding is crucial for mainstreaming and upscaling NBS projects, which may require much longer-term planning than gray infrastructure. The forecasting models will help to demystify what types of benefits can be expected and the length of time it may take to achieve those benefits.
3. Improve on past forecasting efforts
   Other organizations have initiated preliminary benefit forecasting techniques (see analysis below). This project expands on previous external efforts to provide more detailed benefit forecasts, ultimately adding to the growing body of evidence that supports the implementation of NBS.

Comparative Analysis of Benefit Forecasting Efforts

Past Forecasting Work

Other organizations that have recognized the importance of benefit forecasting have made some attempts to predict NBS benefits. In 2017, Forest Trends developed a series of relationships between a variety of "green interventions" (such as wetland conservation, forest restoration, and riparian buffers) and benefits/trade-offs (such as groundwater recharge and erosion control) (Figure J1). Each relationship, or linkage, between green intervention and benefit/trade-off was given a color-coded rating: high positive impact (dark green), low positive impact (light green), negative impact (red), neutral impact (gray), and unknown impact (white). For example, the green intervention of wetland restoration was stated to have low positive (light green) impact on the benefit of filtration of contaminants. Some areas have a range of impacts – grassland restoration impact on overall water yield may be negative (red), neutral (gray), or low positive (light green).

FIGURE H1: FORECASTING BENEFITS OF "GREEN INTERVENTIONS" BY FOREST TRENDS (2017)

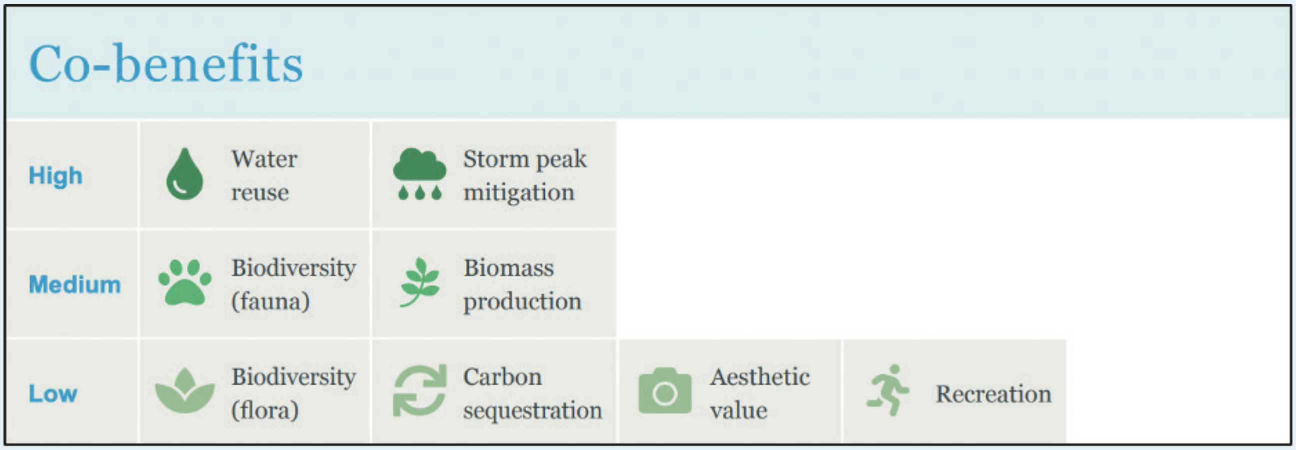


One advantage to this mode of forecasting is that Forest Trends does not just identify benefits, but rather they assign each benefit a certain level of accrued magnitude, which can aid practitioners in determining which interventions will experience the highest or lowest potential benefit. Additionally, the inclusion of negative impacts incorporates the concept of trade-offs (see Section 2) into forecasting. This chart, however, leaves room for clarifications, namely:

1. At what point in time will a benefit reach a certain level of magnitude?
2. At what spatial scale are these benefits being experienced?
3. Within the benefits that have gradations – how do practitioners determine which actions will push them towards the higher positive impact?

Another forecasting example can be seen in the 2021 report, "Nature-Based Solutions for Wastewater Treatment," published by the Science for Nature and People Partnership (SNAPP) (Cross et al., 2021). This report describes advantages, disadvantages, co-benefits (i.e. benefits), technical details, case studies and more, for specialized wastewater treatment options involving NBS, such as slow-rate soil infiltration systems, surface aerated ponds, and horizontal-flow treatment wetlands. To forecast the potential co-benefits of each wastewater treatment option, expert working groups classified a series of 13 co-benefits as either having high, medium, or low positive impact when compared to all other types of NBS. Figure J2 shows the forecasted co-benefits for Treatment Wetlands for Combined Sewer Overflow, noting that water reuse and storm peak mitigation will have high positive impacts, biodiversity (fauna) and biomass production will have medium positive impacts, and biodiversity (flora), carbon sequestration, aesthetic value, and recreation will have low positive impacts.

FIGURE H2: FORECASTED CO-BENEFITS FOR "TREATMENT WETLANDS FOR COMBINED SEWER OVERFLOW" BY SNAPP (CROSS ET AL., 2021, P. 145)



Co-benefits

High	Water reuse	Storm peak mitigation		
Medium	Biodiversity (fauna)	Biomass production		
Low	Biodiversity (flora)	Carbon sequestration	Aesthetic value	Recreation

This classification provides a way to improve transparency with stakeholders regarding exactly which co-benefits will result from certain projects, and to what magnitude that co-benefit will be experienced. However, like the Forest Trends example, there is no clarity on when benefits will occur or how widespread they will be. Unlike Forest Trends, this report does not include trade-offs or negative impacts.

Comparing Current and Past Work

In the comparison table below (Table J1), Pacific Institute's current project brings expanded functionality and clarity to existing benefit forecasting efforts. Like Forest Trends and SNAPP, the current project identifies the type of NBS that will be undertaken. Forest Trends identified "green interventions" and SNAPP identified specific wastewater treatment options, while the current project identifies distinct habitat-intervention categories. This project also goes a step further by identifying specific activities that may be performed within each habitat-intervention category.

All three projects also identify specific benefits (or co-benefits) of an NBS project, such as increasing biodiversity or preventing erosion. However, unlike the examples provided, the current project goes beyond linking benefits to NBS project types; rather, the project team has linked benefits to the specific activities that may take place within an NBS project, allowing for greater accuracy and specificity within the benefit forecast.

All three projects forecast a magnitude of potential benefit: the Forest Trends forecasts range from high impact to negative impact, which incorporates trade-offs, while the SNAPP forecasts range from high to low positive impact. The current project provides a potential percentage of benefit achieved, which is then converted into a ranking score that ranges from high (positive) benefit through trade-offs. This scoring method is used across varying temporal and spatial scales for each activity-benefit linkage, which the past examples do not account for.

TABLE H1: COMPARISONS OF FOREST TRENDS, SCIENCE FOR NATURE AND PEOPLE PARTNERSHIP (SNAPP) AND PACIFIC INSTITUTE FORECASTING METHODOLOGIES

	Forest Trends	SNAPP	Pacific Institute
Identifies baseline habitat-intervention type/project type	●	●	●
Identifies potential benefits	●	●	●
Identifies specific activities and links to specific benefits			●
Forecasts potential level of benefit accrual	●	●	●
Forecasts potential level of benefit accrual over time			●
Forecasts potential level of benefit accrual over space			●

BENEFIT FORECASTING METHODS

The following section outlines the benefit forecasting methodology, resulting in predictions of how benefits may accrue at specific temporal and spatial scales throughout the lifetime of an NBS project. These forecasting components are highly dependent on the habitat type, intervention type, and activities performed. Given that this forecasting work is intended for the pre-feasibility stage, it must be stressed that these forecasts are estimates, not guarantees. Actual benefit accruals are dependent on site-specific conditions and processes, the size of the NBS project, implementation methods for activities, and other factors. Below are several assumptions that the forecasting process adopts that users of the NBS Benefits Explorer tool should keep in mind:

- This process considers habitats in broad, simplified categories (i.e. forest, grassland, wetland, etc.) There are many different sub-habitats under these categories, each with unique properties and functions.
- This methodology does not indicate specific area sizes when discussing spatial accrual, but generally discusses the property, municipal, and watershed scale. The size of an actual project site will impact the magnitude of benefits that are accrued.
- This process does not account for variations within activity types. For example, the activity of "storing rainwater" could mean either creating a rain garden, bioswale or retention pond, or the use of rain barrels. It is unlikely that all these variations will result in the exact same benefit accruals.
- Forecasts do not factor in external impacts or influences, including climate change, fires, poaching, etc.

To account for these nuances, each forecast will come with a score gradient, showing the potential range of scores that can accrue (see Figure J3). Investors and practitioners should pursue more precise means of forecasting benefits as they move past the pre-feasibility phase of a project.

Allocating Scoring Ranks

Each activity-benefit linkage is scored nine times – across the three spatial and three temporal scales. Scores are based on expert knowledge of different habitats and are verified using academic literature when necessary. As shown in Table J2, the project team developed a scoring rubric to assign ranks for benefit accrual based on the percentage of potential benefit achieved. These potential benefits should be compared to the benefits experienced in pristine or near-natural habitats. For example, a High ranking means that the benefit accrued is between 85% -100% of what can be achieved in a near-natural example. The ranks include Trade-off, Low, Medium, and High, as well as intermediary ranks between each step (Trade-off-Low, Low-Medium, and Medium-High). Ranks from Low to High indicate levels of positive benefits, while Trade-off and Trade-off-Low indicate potential negative benefits.

In some cases, the maximum potential benefit that can be achieved within a near-natural state will always be Low, and not increase with time. For example, education benefits in an agricultural setting are likely to be scored lower than in an urban green space due to the overall nature of these habitat types. While a Low score may be the maximum benefit potential of one activity-benefit linkage for a certain habitat-intervention, the same activity in a different habitat-intervention may have a higher benefit potential.

TABLE H2: FORECAST SCORING RANKS REFLECTING PERCENTAGE OF POTENTIAL BENEFIT ACHIEVED

Scoring Rank	Percentage of Potential Benefit Achieved
High	80 - 100%
Medium - High	60 - 79%
Medium	40 - 59%
Low - Medium	20 - 39%
Low	0 - 19%
Trade-off - Low	-10 - 19%
Trade-off	< -10%

Temporal Scales

The forecasts consider benefit accrual over three time periods of an NBS project: 1 - 4 years, 5 – 9 years, and 10+ years. The magnitude of benefit accrual during the first few years of a project is likely to look very different than at the 10-year mark; both the initial level of accrual and the rate at which benefits accrue over time are identified through this project's forecasting methods. By estimating these aspects of potential benefit accrual, investors and practitioners will have greater clarity of when certain benefits are expected to peak, thus aiding with reporting of benefit accrual and long-term planning efforts. This also makes building the business case for investing in NBS more precise.

Benefit accrual will also fluctuate across different linkages of habitats, interventions, activities, processes and benefits. Box J1 details two scenarios of different interventions, but of the same habitat and activity-benefit linkage, to display how temporal accrual may be impacted specifically by intervention type.

BOX H1: TEMPORAL BENEFIT ACCRUAL SCENARIOS (CONSIDERED WITHIN THE PROJECT SITE BOUNDARIES)

Example 1: Forest Restoration

Activity: Plant/restore native vegetation
Benefit: Improved abundance/diversity of native plant species

Benefit Accrual Across Temporal Scales:

	TEMPORAL SCALE		
	1-4 YRS	5-9 YRS	10+ YRS
BENEFIT LEVEL	MEDIUM	HIGH	HIGH

Reasoning: In the first four years of a forest restoration project, accrual will not be at its maximum potential given that planted vegetation requires time to establish, grow, mature, and bear fruit or seeds. Particularly in a restoration project, certain areas may need to be completely re-planted. Benefits will increase over time as growth increases, and maximum benefit potential may be reached by the 5–9-year time scale.

Example 2: Forest Management

Activity: Plant/maintain native vegetation
Benefit: Improved abundance/diversity of native plant species

Benefit Accrual Across Temporal Scales:

	TEMPORAL SCALE		
	1-4 YRS	5-9 YRS	10+ YRS
BENEFIT LEVEL	HIGH	HIGH	HIGH

Reasoning: Assuming that a forest being managed already contains peak biodiversity, the maximum benefit potential will likely be maintained throughout the lifetime of the project.

Spatial Scales

The benefit forecasts also consider three spatial scales – the project site itself, the municipal/city scale, and the watershed scale. In considering these spatial scales, the forecasts are going beyond predicting benefit accrual and instead predicting benefit flows, or how a benefit generated at one point can flow outwards to larger scales. For example, water that is filtered in a treatment wetland will benefit spatial scales beyond the immediate property area as that water flows out of the site. When comparing the three spatial scales, there will almost always be a higher benefit potential at the project site than within the larger scales, despite the type of intervention or activity. This is because in most cases, benefits flow outwards from the project site, rather than being produced at broader scales.

It should be assumed that there will be higher certainty of benefit accrual at the property scale, given that it is easier to identify inputs/outputs and that there are more opportunities to measure data. Additionally, the spatial scale categories assigned in this methodology are quite generalized; actual benefit flows will be reliant on the size of the physical municipality or watershed in question, and therefore forecasted results will vary. Like Box J1, the scenarios in Box J2 outline how spatial benefit accrual/benefit flows may be impacted by different intervention types.

Combined Temporal & Spatial Scales

As shown in the temporal and spatial scenarios (Boxes J1 & J2), it is difficult to isolate these two scales from each other – temporal and spatial accruals must be forecasted simultaneously and collaboratively to have the most accurate snapshot of potential benefit accrual. The scenarios in Box J3 exemplify how each temporal scale is scored within each spatial scale, resulting in nine scores for each activity-benefit linkage.

BOX H2: SPATIAL BENEFIT ACCRUAL SCENARIOS (CONSIDERED WITHIN 1-4 YEARS OF A PROJECT)

Example 1: Forest Restoration

Activity: Plant/restore native vegetation
Benefit: Improved abundance/diversity of native plant species

Benefit Accrual Across Spatial Scales:

	SPATIAL SCALE		
	PROPERTY	MUNICIPALITY	WATERSHED
BENEFIT LEVEL	MEDIUM	LOW - MED.	LOW

Reasoning: In most cases, benefit accrual will decrease as the spatial scale increases. Therefore, if the property scale has a baseline Medium level benefit (see Box J1), then the wider spatial scales would not exceed Medium, and are likely to be less than Medium. For this particular activity-benefit linkage, seed dispersal and plant establishment is limited by varying factors, including the dispersal agent and ability for the seed to find suitable habitat outside of the property site (Bakker et al., 1996), etc. The likelihood of successful dispersal, establishment, growth, and subsequent increases in plant biodiversity, decreases at larger spatial scales.

Example 2: Forest Management

Activity: Plant/maintain native vegetation
Benefit: Improved abundance/diversity of native plant species

Benefit Accrual Across Spatial Scales:

	SPATIAL SCALE		
	PROPERTY	MUNICIPALITY	WATERSHED
BENEFIT LEVEL	HIGH	MEDIUM	LOW - MED.

Reasoning: Like Example 1, larger spatial scales will have lower potential benefits than the property site. Because managed forest sites may begin with high levels of biodiversity, there is more opportunity for varying seeds to disperse and establish at larger spatial scales, therefore improving biodiversity in those areas more quickly.

BOX H3: COMBINED TEMPORAL AND SPATIAL BENEFIT ACCRUAL SCENARIOS

Example 1: Forest Restoration

Activity: Plant/restore native vegetation
Benefit: Improved abundance/diversity of native plant species

Total Benefit Accrual:

	TEMPORAL AND SPATIAL SCALES								
	PROPERTY			MUNICIPALITY			WATERSHED		
	1-4 YRS	5-9 YRS	10+ YRS	1-4 YRS	5-9 YRS	10+ YRS	1-4 YRS	5-9 YRS	10+ YRS
BENEFIT LEVEL	MED.	HIGH	HIGH	LOW - MED.	MED.	MED.	LOW	LOW - MED.	LOW - MED.

Reasoning: As explained in Boxes J1 and J2, benefit accrual generally increases as the temporal scale increases, and decreases as the spatial scale increases.

Example 2: Forest Management

Activity: Plant/maintain native vegetation
Benefit: Improved abundance/diversity of native plant species

Total Benefit Accrual:

	TEMPORAL AND SPATIAL SCALES								
	PROPERTY			MUNICIPALITY			WATERSHED		
	1-4 YRS	5-9 YRS	10+ YRS	1-4 YRS	5-9 YRS	10+ YRS	1-4 YRS	5-9 YRS	10+ YRS
BENEFIT LEVEL	HIGH	HIGH	HIGH	MED.	MED.	MED.	LOW - MED.	LOW - MED.	LOW - MED.

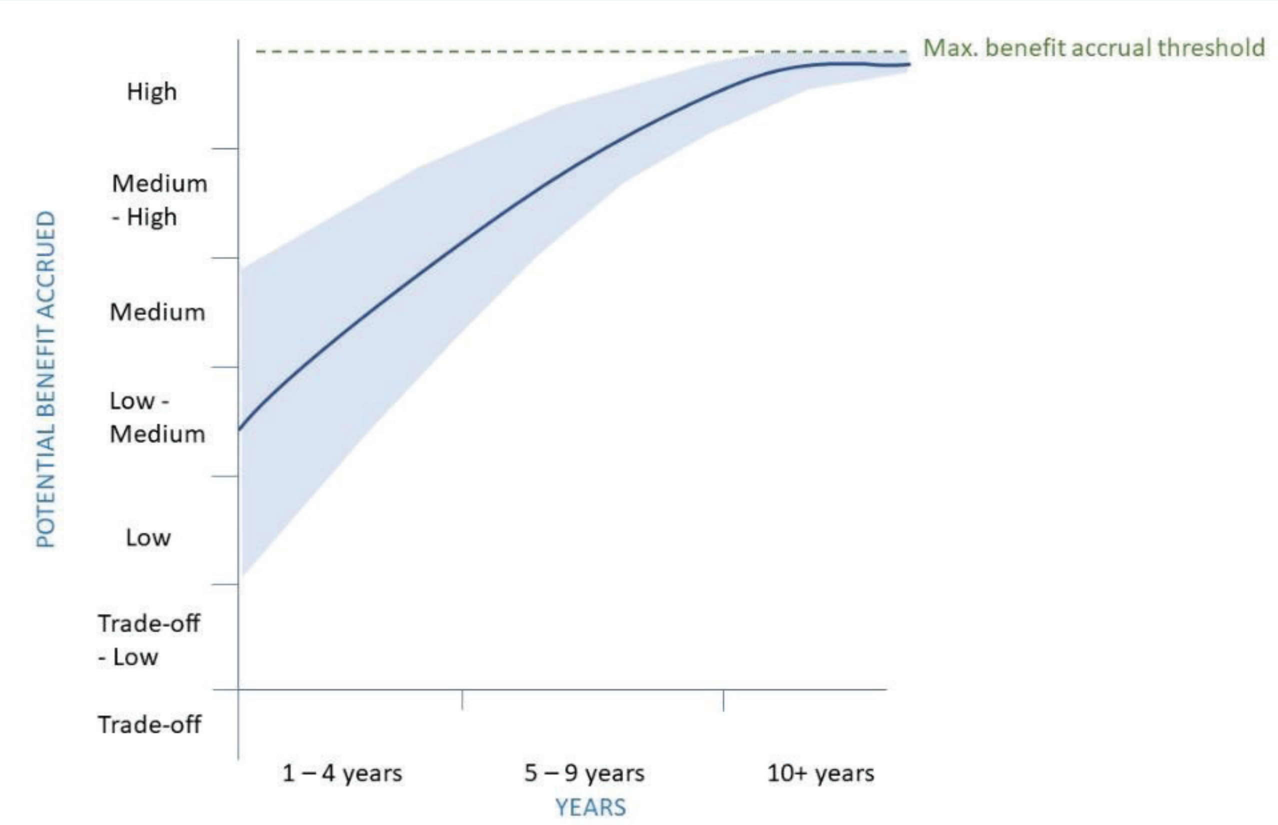
Reasoning: As explained in Boxes J1 and J2, benefit accrual increases as the temporal scale increases, and decreases as the spatial scale increases.

Overall, each habitat-intervention category has approximately 1,500 scoring data points, totaling close to 50,000 data points across the 33 habitat-intervention categories.

Outputs

Benefit forecasts are aggregated into graphs; each activity-benefit linkage will have one graph per spatial scale (three graphs in total), which shows the potential benefit accrued over time (Figure J3). This graph displays the link between Planting/restoring/maintaining native vegetation (activity) and support for local pollinators (benefit) for a forest restoration project. The dark line shows the projected median forecast score (indicating the potential benefit accrual), while the shaded blue area shows the score range that an actual project may fall between, given varying habitat and activity implementation parameters. Users of the tool may be interested to see how the benefit accrual of their NBS project compares to that of a near-natural ecosystem. To accommodate this, the graphs include a separate line that represents the expected maximum benefit accrual threshold at each temporal and spatial scale.

FIGURE H3: EXAMPLE BENEFIT FORECASTING OUTPUT GRAPH, SHOWING THE POTENTIAL BENEFIT ACCRUED OVER TIME BETWEEN A SPECIFIC ACTIVITY-BENEFIT LINKAGE



Appendix I: NBS Benefit Valuation Methodologies

Benefit	What is being valued?	Source
Water Quantity (Provisioning)	Reduced risk from lack of water for other users	GIZ/NCD/VfU Water Credit Risk Tool (Ridley and Boland, 2015)
	Contribution to achieving SDG6: Ensure availability and sustainable management of water and sanitation for all	Strong et al. (2020): Achieving Abundance: Understanding the Cost of a Sustainable Water Future
Water Quality	Avoided replacement costs for infrastructure treating in-stream diffuse pollution	La Notte et al. (2017)
		Strong et al. (2020): Achieving Abundance: Understanding the Cost of a Sustainable Water Future
Flood Protection (Climate Resilience)	Avoided costs of damages to man-made assets	Huizinga et al. (2017)
Carbon Sequestration	Costs to limit global warming to well-below 2°C	World Bank (2017)
	Costs to limit global warming to 1.5°C	Dietz et al. (2018)
	Social Cost of Carbon	US EPA (2022)
Recreation	Value of cultural ecosystem services (non-consumptive recreation, amenity and aesthetics)	Brander et al. (2008) Taye et al. (2021)
Biodiversity	Value of habitat services – the ability of nature to provide resources for the maintenance of species habitats and genetic diversity.	de Groot et al. (2012)

Appendix J: Water Quantity Benefits Calculation Methods

Curve Number Method:

This method, as implemented in the Soil and Water Assessment Tool (SWAT) model (Neitsch et al., 2011), is an empirical method for estimating runoff quantities based on land cover, land use, soil type and slope, and accounting for temporal changes in precipitation and soil water content. This method can be used to calculate the change in runoff due to land protection and land restoration activities, as well as agricultural NBS or BMPs. The method calculates the potential average annual VWB based on the project design, but in the case of restoration, there can be a time lag between the time the site is planted and the time it is fully restored. A detailed description of this method is provided in Appendix A-1 of the VWBA report (Reig et al., 2019).

Withdrawal and Consumption Methods:

The Withdrawal method calculates the long-term average annual reduced volume of water withdrawn for use. Withdrawal volume may be calculated as volume of water diverted from the source (i.e., surface water or groundwater) based on the duration of the diversion and the diversion flow rate over that time. Withdrawal volume may also be based on the volume leased or purchased through transactions involving water rights, where the reduced volume withdrawn is reassigned to keep the water in stream. The Consumption method applies to agricultural water demand reduction measures, although in some cases the Withdrawal method will be more appropriate. Detailed descriptions of the Withdrawal and Consumption methods are provided in Appendix A-2 of the VWBA report (Reig et al., 2019).

Capture and Infiltration Method:

This method is applied to calculate the volume recharged to groundwater, based on available supply (i.e., volume draining from catchment), the volume captured by these activities and losses associated with evaporation (if any), and use (i.e., withdrawal). First, the method calculates the volume captured as the minimum of available supply and storage potential. Storage potential is based on the design storage capacity of the activity and the number of times it fills to capacity. Recharge volume is calculated by subtracting evaporation and usage losses. See Appendix A-4 of the VWBA report (Reig et al., 2019) for a detailed description of this method.

Volume Captured Method:

This method can be applied to stormwater management activities through a two-step approach. The first step is to calculate the volume of stormwater directed to a stormwater BMP using the Runoff Reduction method (Hirschman et al. 2018). This supply volume is calculated by considering annual average rainfall and runoff coefficients that correspond to the site land cover conditions. The proportional area of pervious (forest, turf, etc.) and impervious (concrete, metal, etc.) surfaces and their corresponding runoff coefficients are considered in the supply volume calculations. The next step is to calculate the volume captured by multiplying the supply volume estimated by a runoff reduction factor corresponding to the BMP. See Appendix A-5 of the VWBA report (Reig et al., 2019) for a detailed description of this method.

Volume Treated Method:

This method applies to constructed treatment wetland systems that improve water quality. In some cases, these projects benefit wildlife and birds, and/or increase recharge. While the focus is on water quality, a water quantity benefit reflects the volume of water that is purified and made available for other uses. The approach can be applied to constructed wetland treatment systems that are designed to capture and treat non-point source runoff. It can also be applied to wastewater treatment plants (point sources). This method involves:

- Selecting local water quality target(s) relevant to the pollutant(s) of concern and tied to the recognized uses of the receiving water (e.g. designated or actual uses);
- Confirming that the influent water does not meet the water quality target (before treatment);

- Confirming that the treated discharge meets the appropriate target(s); and
- Estimating the volume of water treated annually.

See Appendix A-6 of the VWBA report (Reig et al., 2019) for a detailed description of this method.

Recharge Method:
This method typically enables estimation of the volumetric benefit for wetland activities. Wetlands capture rainfall and runoff, and the water infiltrates the substrates, which may recharge an aquifer. Where recharge occurs, this method estimates the volume infiltrated based on ponded surface area and infiltration rate, accounting for time that water is retained in the wetlands. The volume recharged is equal to the product of the wetland surface area, the infiltration rate based on soil texture and the duration of time the wetland is inundated. This method is applicable for wetland types that provide recharge function. In addition to enhancing recharge, wetlands provide surface water benefits, including flow attenuation, hydroperiod regulation and aquatic habitat benefits. If recharge is not the objective or the primary hydrologic function provided by the project wetland, an alternative approach for quantifying the VWB may be warranted. Alternative approaches may include evaluation of inundation volume, increased storage volume or hydroperiod restoration, depending on the primary objective of the project. For example, the VWB of a floodplain reconnection project may be calculated as the increased inundation volume. Alternatively, the VWB of a side channel reconnection project may be calculated as the minimum flow providing habitat benefits to a key species and the duration over which that benefit is provided (e.g. spawning period for a migratory fish). See Appendix A-7 of the VWBA report (Reig et al., 2019) for a detailed description of this method.

Hydrograph Method:
This method evaluates the change in the hydrograph that results from removal of an in-stream barrier or due to dam reoperation. A hydrograph shows the rate of flow versus time past a specific point in a river. This method requires hydrographs for the time of ecological significance, from before and after the dam or barrier removal or dam reoperation. Hydrographs can be obtained from (a) a flow time series derived from stream flow monitoring; or (b) a hydraulic model that simulates the baseline (without-project conditions) and with-project conditions. Second, the with-project hydrograph is subtracted from the baseline daily. This will likely result in both positive and negative differences, both of which can represent a return to a more natural flow regime. The absolute value of the difference in the two hydrographs is calculated daily and then summed over the period of interest. The VWB is calculated as the volume difference between the two hydrographs. See Appendix A-8 of the VWBA report (Reig et al., 2019) for a detailed description of this method.

Evapotranspiration Method:
When invasive plants are removed and replaced with native vegetation, less water may be lost to evapotranspiration (ET). This can increase the volume of water storage in a wetland, increase water availability for native plants, increase infiltration, or have other beneficial impacts (Le Maitre et al., 2020). The Evapotranspiration method relies on published studies of ET for the invasive and native species. The ET value (in mm) is multiplied by the surface area (accounting for density) to estimate the volume lost to ET. The difference in ET between the pre-project condition (with invasive vegetation) and post-project condition (native plants) is equal to the volumetric benefit.

Inundation Method:
This method calculates the volumetric benefit of a floodplain reconnection project, which can be derived from the increased inundation volume: increased inundation area multiplied by average depth, multiplied by the average number of inundations per year. A similar approach is appropriate for a project that involves rewetting of a wetland, where the primary objective is to increase the storage volume for habitat improvement (rather than to increase recharge).

Appendix K: Water Quality Benefits Calculation Methods

Direct Monitoring

Many NBS activities that involve green infrastructure have a defined inlet and outlet where water quantity and quality may be measured. Monitoring at these locations enables a comparison of the pollutant load that enters the structure with the load being discharged after treatment.

It may not be possible to collect monitoring data for every NBS project, particularly when multiple small systems are constructed across a landscape. To meet this need, the water quality benefits calculated for stormwater capture/treatment systems with a proven track record based on monitoring conducted as part of demonstration projects may be scaled up as appropriate.

The key steps for monitoring are:

1. Identify parameters of concern;
2. Develop a monitoring program that includes baseline monitoring before the project is implemented;
3. Implement program;
4. Review and synthesize data; and
5. Calculate load reduction.

For more detailed information on M&E of NBS, see Appendix D.

Modeling

Models are often necessary to estimate water quality improvements associated with certain stormwater practices (green roofs, rain gardens, etc.), land conservation, land cover restoration and agricultural NBS and BMPs. This is because it is not possible to measure load avoided due to land conservation and certain stormwater practices, and it can be prohibitively expensive to measure reduced pollutant load that is distributed over broad landscapes.

Models can be used to calculate water quality benefits by conducting model simulations for "before" and "after" conditions, and then calculating the difference in loads. For restoration projects, the benefit is equal to the difference between pollutant loads for existing conditions and pollutant loads under a restored condition of intact forest or grassland. For green roofs and rain gardens, the benefit is the difference between the pollutant loading rate for the existing condition and the expected pollutant load with stormwater controls implemented. For protection projects, the benefit is equal to the difference between pollutant loads for a hypothetical developed condition (e.g. residential development, cropland) and pollutant loads for the existing intact condition. For agricultural NBS and BMPs, the benefit is the difference between the pollutant loading rate for existing conditions and the expected pollutant load with NBS and/or BMPs implemented.

We recommend separate modeling frameworks depending upon whether benefits are being developed for urban or agricultural watersheds, as described below.

Modified Simple Method:

The Modified Simple Method (Schueler, 1987) is a widely used tool developed to estimate pollutant loading for stormwater runoff from non-agricultural areas. The Simple Method multiplies an estimated annual average runoff volume by an average land use-specific runoff concentration to generate an annual load for each land use considered. The Modified Simple Method estimates a runoff coefficient based upon the percentage of impervious cover, which is combined with drainage area and annual precipitation to generate an annual runoff volume. The Modified Simple Method described here replaces the annual precipitation-based runoff calculation with the Curve number method described above for calculating quantity benefits and provides an alternative method for generating annual runoff volume. Typical concentration values for nutrients, solids and several heavy metals are provided based upon assessment of observed stormwater concentrations collected through municipal, state or national agencies. For example, the United States' National Urban Runoff Program provides such values (Smullen & Cave, 1998). This method can also be used to estimate pollutant loads associated with pre-development and/or restored conditions using curve numbers as described earlier and runoff concentrations associated with the pre-development/restored land use (described by the New Hampshire Department of Environmental Services, 2008).

Revised Universal Soil Loss Equation:

This Revised Universal Soil Loss Equation (RUSLE) calculates the long-term average annual rate of erosion based on climate, soil, topography and land use. The method was originally developed by Wischmeier and Smith (1978) but has been routinely updated over time and is now implemented in the modeling package RUSLE 2 supported by the U.S. Department of Agriculture's Agricultural Research Service. Based on information provided by users, RUSLE 2 calculates factors representing rainfall erosivity, soil erodibility, topography and land use/management practices to generate an annual average soil erosion rate. RUSLE generates estimates of erosion loss for soil only and does not calculate loads for other parameters such as nitrogen or phosphorus. Load estimates for these parameters can be calculated by multiplying predicted soil erosion load by the estimated soil nutrient concentrations, using guidance provided by the U.S. Environmental Protection Agency (EPA) (1982).

Pollutant Reduction Efficiency Method:

Functioning riparian buffers more than 100 feet wide can filter out significant amounts of the nutrient and sediment loads delivered to them from upland sources (Sweeney and Newbold, 2014). Arscott et al. (2020) assumed mean pollutant reduction efficiencies of 41 percent for total nitrogen, 40 percent for total phosphorus, and 54 percent for sediment for buffers of at least 100 feet in width, and those values are used here.

Models Under Development

Several modeling tools for estimating the water quality benefits of agricultural practices are in rapid development, driven in large part by ecosystem services markets. For example, the Ecosystem Services Market Consortium (ESMC) is working towards a launch of a "fully functioning national scale ecosystem services market conceived and designed to sell both carbon and water quality and quantity credits for the agriculture sector by 2022." The U.S. Department of Agriculture Nutrient Tracking Tool (NTT) estimates nutrient and sediment losses from crop and pasture lands at the field and/or watershed scales for selected agricultural management scenarios. NTT estimates are made using the Agricultural Policy/Extender (APEX) model (Version 0806) (Williams et al., 2000; Williams et al., 2015). A limitation of the NTT is that it does not address the full range of agricultural management scenarios, and it has only been tested in select regions of the United States so it cannot be widely applied globally.

Stream Bank Recession Rate:

NBS can reduce pollutant loading from eroding stream banks in multiple ways. Rapid and large increases in stream flow are a primary cause of bank erosion. NBS that reduce runoff rates consequently reduce the flashiness of stream flow5 and the resulting erosive capacity. In addition, restoration of rooted vegetation in riparian areas makes stream banks less susceptible to erosion.

The benefit of NBS can be calculated for those cases where solutions are implemented to eliminate bank erosion, based upon local knowledge of the current rate of bank recession (how many feet per year the bank is eroding) and the average depth of eroding banks. Recession rate can be determined via direct measurement or indirectly using historical remote sensing imagery. Pollutant loading under existing eroding conditions can be estimated by multiplying the existing rate of bank recession by the depth of eroding banks and an assumed soil density. Nutrient loads can be calculated using estimated soil nutrient concentrations, using EPA (1982) guidance discussed above. Because the expectation of streambank stabilization is to eliminate erosion in the area stabilized, the benefit of stabilization is equal to the pollutant loading rate calculated for the existing pre-stabilized condition.

5 The flashiness of a stream reflects how quickly flow in a river or stream increases and decreases during a storm.

Appendix L: Carbon Benefits Calculation Methods

Several established methods and tools, with varying levels of sophistication, can estimate the carbon-related benefits of NBS:

Winrock International's Forest Landscape Restoration Carbon Storage Calculator estimates tons of carbon dioxide (CO_2) stored for each acre of restored forest, sorted by forest type and by global region (Bernal et al., 2018). The calculator is based on an extensive literature review of biomass accumulation rates and accessed via a simple lookup table (IUCN, 2018).

The Natural Capital Project's InVEST (Integrated Valuation of Ecosystem Services and Trade-offs) open-source software uses a relatively simple terrestrial ecosystem biomass and soil carbon model to calculate net annual carbon balance (positive or negative) following a change from one land use/land cover (LULC) type to another and based on global datasets of LULC, soil carbon and other parameters. For tropical forests, InVEST includes a more sophisticated model that incorporates fragmentation effects in its estimates of carbon storage.

For the purposes of carbon credit trading, several organizations have developed greenhouse gas (GHG) benefit quantification methodologies based largely on the Intergovernmental Panel on Climate Change's (IPCC) 2006 Guidelines for National GHG Inventories. Notable examples include the United Nations' Verified Carbon Standard project and Gold Standard for the Global Goals.

The World Resources Institute's GHG Protocol for Project Accounting and Verra's Verified Carbon Unit methodologies.

Climate Watch offers open data, visualizations and analysis to help policymakers, researchers and other stakeholders gather insights on countries' climate commitments and progress. This platform can inform investors and practitioners to make informed decisions for where NBS could have the greatest impact.

These methods all recommend calculations based on field measurements, but most also offer alternatives for when field measurements are not available.

Stock-change or gain-loss methods to estimate avoided CO_2 emissions or CO_2 removals (Table 7) are based on information regarding activity data (i.e. hectares of protected area) and emission factors (i.e. tons of avoided CO_2 (t CO_2e)). IPCC (2006) presents a detailed description of the tiers used to estimate avoided CO_2 emissions and removals, based on the accuracy of available information. There are other methods for estimating CO_2 emissions and removals, such as using biogeochemical models like RothC, DNDC, COMET, and others. Estimates of removals can also be made through direct measurement of changes in soil stocks, such as outlined in the VM00021 soil carbon quantification methodology from Verra. All these approaches can also be used to calculate avoided atmospheric methane (CH_4) emissions and nitrous oxide (N_2O). Although CO_2 is the greenhouse gas most in focus globally, depending on the activity it can be equally or more important to consider sources and sinks for these other gases, given that CH_4 has 56 times the warming potential of CO_2, while N_2O warming potential is 280 times that of CO_2 in a 20-year span (IPCC, 2006).

Avoiding N_2O emissions from cropland is another important component of NBS for climate mitigation in agriculture. However, this guidance has focused on carbon and methane, given its prevalence as the greenhouse gas of most interest or concern across a variety of sectors.

The Land Cover and Climate Altering Land Cover Indicator measures changes to land cover, which can impact carbon sequestration. Land cover has important linkages to climate regulation and climate change and therefore can be used to construct climate change indicators. One simple way to present the influence land cover can have on the climate is by assigning each land cover class as either climate altering, climate regulating, or climate neutral:

1. Climate altering land cover: Artificial surfaces (including urban areas); herbaceous crops
2. Climate regulating land cover: Woody, multiple or layered crops; grasslands; tree-, mangrove-, shrub-covered areas; vegetated areas that are regularly flooded; permanent snow and glaciers; inland water bodies; coastal water bodies and intertidal areas
3. Climate neutral: Sparsely natural vegetated areas; terrestrial barren land.

An existing Climate Altering Land Cover Index (CALCI) reflects the changes in the share of climate altering land cover as compared to the base year (2015). Annual estimates of land cover and CALCI are presented at country and regional levels from 1992 through 2020. Estimates of land cover are presented in thousand hectares and the CALCI is unitless (IMF, 2022).

There are, however, limitations inherent to almost all Earth observation-derived information, such as sensitivity to the resolution and classification scheme used, and limits on what can be remotely observed and automatically classified in practice using the tools and techniques available (OECD, 2018).

Appendix M: Biodiversity Benefits Calculation Methods

Biodiversity Habitat Index:

Estimates how terrestrial biodiversity is impacted by habitat loss, degradation, and fragmentation. BHI links remote sensing data on forest and land-cover changes to a variety of biological and ecological analyses and models, resulting in an estimated change in the proportion of retained biodiversity within a specific spatial area (GEO BON, 2015).

Biodiversity Intactness Index:

Considers how land-use change and other human pressures have impacted the intactness of biodiversity. BII measures the abundance of a wide array of species, including plants, invertebrates, and vertebrates, within a particular area relative to their reference populations. Reference populations, populations that have not been impacted by human pressures, are typically measured in protected lands, given that such historical species data is not available. Biodiversity intactness index models combine total species abundance and compositional similarities to determine the average local abundance of species. These results can be averaged over regional, national, and global scales (GEO BON, 2015; De Palma et al., 2021).

Coverage of Protected Areas:

Protected areas are geographic spaces that are legally recognized and managed to fulfill long-term conservation goals. Through either statistical or spatial analysis, this indicator measures the extent to which components of marine and terrestrial biodiversity are formally protected. This can be used to track changes in the protection of crucial habitats, to inform the adequacy of existing protections for certain species; to help determine priority areas for conservation; and to measure political motivation for conservation objectives (Bubb et al., 2009).

Global Ecosystem Restoration Index:

The Global Ecosystem Restoration Index (GERI) is a composite index that aims to assess terrestrial restoration improvements or declines against a baseline for degraded ecosystems. Using remote sensing and ecosystem mapping, GERI integrates three major components of ecosystem restoration - changes in land productivity, changes in ecosystem energy balance, and changes in land cover. Land productivity is measured through primary productivity indicators; ecosystem energy balance is measured through latent and sensitive heat; and land cover is tracked via Landsat analysis of areas transitioning to and from forested land. This tool can be used at varying spatial scales, from local to global (GEO BON, 2015).

Proportion of Land Degraded Over Total Land Area:

Land degradation occurs when certain pressures, such as land use practices, result in the reduction or loss of ecological and economic productivity on croplands, rangelands, and forest/woodlands. The UN Global SDG Database recognizes Proportion of Land Degraded Over Total Land Area as an indicator for SDG Goal 15: "Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss" (United Nations Economic Commission for Europe, n.d.).

Red List Index:
The IUCN Red List Index is used by governments around the world to track progress in preventing biodiversity loss. The Index was created to provide more meaningful and accurate insights into extinction risk. Species often move between categories on the IUCN Red List due to improved knowledge or revised taxonomy; therefore, tracking the numbers of endangered and threatened species on the Red List is an inaccurate way to assess the status of biodiversity. To account for this, the Red List Index was created to show genuine trends in extinction risk for mammals, birds, amphibians, reef-forming corals, and cycads (IUCN Red List, 2022).

Shannon and Simpson's Diversity Indices:
Shannon's Diversity Index and Simpson's Diversity Index both use species richness and abundance as a means for measuring species diversity, however they are based on different foundational assumptions. Shannon's Diversity Index measures the uncertainty of knowing the identity of any individual and estimates the proportion of individuals of one species found as a proportion of all individuals found. Simpson's Diversity Index relies on the relative abundances of each species, measuring the probability that any two randomly selected individuals are of different species. For both indices, as richness and evenness increase, diversity also increases (Morris et al., 2014).

Species Habitat Index:
The Species Habitat Index measures changes in the approximate size and quality of ecologically intact areas supporting species populations, through local biodiversity observations and remotely sensed habitat characterizations. Ecosystems are made up of species, and as multi-species aggregate, the SHI provides a compound estimate of the ecological quality of natural ecosystems and the health and resilience of species populations. The indicator can be calculated annually on a near global scale and comprehensively for a large and growing set of species groups. It can be amended and optimized with regional or national data. SHI uses environmental and species data addressing all terrestrial areas of the world at 1 km spatial resolution (GEO BON, 2015).

The Species Threat Abatement Restoration (STAR) metric:
The STAR metric measures the potential of conservation actions in specific areas to aid in worldwide biodiversity goals. The STAR metric focuses on two key action categories, threat abatement and habitat restoration, and uses data on species distribution (either current or restorable habitat), threats to species (using the Threats Classification Scheme), and extinction risk (from the IUCN Red List). Using the STAR metric enables governments, companies, and other actors to identify beneficial conservation actions as well as create science-based objectives for biodiversity (IBAT, 2021).

Wildlife Picture Index:
The Wildlife Picture Index uses camera trap data to measure occupancy of upper-trophic level terrestrial mammals and birds; the data collected from the camera traps is inputted into occupancy analysis models and generalized additive models to determine current and future trends in abundance and diversity. Focus is put towards upper-trophic level mammals and birds because they are easier to study via camera traps due to their larger heat signatures, and because they can be crucial indicators for overall ecosystem health and are often targets of exploitation (O'Brien et al., 2010; O'Brien, 2010).

Appendix N: Additional Socio-Economic Benefits

Improved/Increased Climate Resilience

The potential for NBS to help improve resilience of communities and ecosystems is one of their most important socio-economic benefits. However, identifying a set of indicators for climate adaptation and mitigation can be complicated (Donatti et al., 2020). Focusing on a specific approach, such as NBS, and on indicators that can be used at the project level, may facilitate the identification of a set of indicators for tracking adaptation outcomes. The Inter-American Development Bank (2012), Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) (2015) and European Commission (2021) present comprehensive lists of climate adaptation and mitigation indicators which could be adapted to suit the contexts in which these will be used.

To quantify the potential climate adaptation and mitigation benefits of NBS to communities, consider how the project is likely to impact current community resilience, as well as future risk and resilience. Seddon et al. (2020) provide a framework for considering the climate adaptation and mitigation benefits of NBS, outlining how NBS can support human adaptation to climate change across three dimensions:

1. **Socio-economic exposure** includes benefits of NBS that can reduce exposure to disasters and climatic events, including flood or drought risk, exposure to landslides and fires;
2. **Socio-economic sensitivity** ensures that ecosystem services are maintained to help communities and individuals mitigate future shocks; and
3. **Socio-economic adaptive capacity** maintains species diversity and empowers local communities through environmental stewardship.

Improving climate adaptation and mitigation will have cross-cutting influences across multiple themes (e.g. carbon, water), activities and benefits. In fact, climate adaptation and mitigation will influence almost all the socio-economic benefits, ranging from potential impacts to economic opportunities (e.g. reduced job opportunities if tourism is affected due to extreme events), through to influencing property or land values (e.g. property along an area prone to extreme events may be worth less than other areas). Notably, climate adaptation and mitigation will have considerable influence over human health.

As noted in both the academic and gray literature (GIZ, 2015; Donatti et al., 2020), there are challenges in applying some indicators to climate adaptation and mitigation. These include issues of limited available data to assess the indicators in certain locations, that adaptation and mitigation outcomes take time to become identifiable and can be subject to evolving objectives and conditions (Noble et al., 2014), and the complexity of factors that may result in specific outcomes. However, when applied systematically and regularly, the suggested indicators (see below) could offer the opportunity to provide much-needed evidence on the success of the interventions and activities in achieving adaptation and mitigation outcomes:

- For reduction in number of climate-related hazards/disaster risk reduction (heatwaves, flooding, drought), use national or international climate data and statistics for monitoring and modelling.
- For reduction in number or percentage of infrastructure/property damage after extreme events (e.g. hospitals, schools, homes, roads, agricultural land), use satellite images to take stock of existing infrastructure, agricultural land and the extent of ecosystems. Information on damages collected during emergency response measures may also be valuable resources.
- For reduced impacts of climate change on agricultural outputs (see food security benefits), use qualitative instruments, such as questionnaires, to gather information on the percentage of the population that is food insecure. The Food Insecurity Experience Scale from the FAO provides a set of questions to ask communities (FAO, 2017a). Census data held by local, state or national governments may also provide these data, although they may be outdated or lack credibility depending on the areas being surveyed.
- For reduced impacts on water quality and quantity (see water benefits), consider the percentage population (local or broader scale) with access to enough clean drinking water under extreme events, or through time, comparing water quality or water quantity impacts with and without the NBS. Use census information to get data on the number of people in a location that have access to water year-round and during extreme events, and estimate how that might change with and without the NBS implementation.
- For reduced loss of lives due to extreme weather events, the percentage of deaths and missing persons after extreme events could be an appropriate indicator. Use local or national statistics to get the number of people that have died from extreme weather events and compare that with and without NBS. For example, hydraulic models can determine the extent of flooding under different biophysical conditions, including connection to the floodplain further upstream. By comparing the extent of flooding in a hydrologically connected system to one that is disconnected, practitioners can estimate damages to buildings and potential loss of life in each storm event.
- For the reduction in health impacts from climate-related conditions/diseases (see health benefits), practitioners can use national or regional statistics to calculate the disability-adjusted life year from the World Health Organization (a measure of overall disease burden) expressed as the number of years lost due to ill-health, disability or early death. Additionally, use local or national statistics to get the number of people that have died from extreme weather events. Parsing out human health impacts from a specific NBS is challenging, unless it is being applied at a sufficiently large scale (for example, large-scale tree planting efforts in an urban area impacting air quality and related health effects), or it is targeted at a specific and measurable health risk (such as a reconnecting a large floodplain to reduce flood risk in a populated area downstream).

Improved/Increased Economic Opportunities

NBS can contribute to new green economies through creating green jobs that restore, manage and protect nature, as well as, in some cases, indirect job creation through increased tourism. These direct green jobs are typically low-skill, labor intensive and fast to implement, with on average 7–40 jobs created per $1 million invested in NBS (BenDor et al., 2014). Jobs may include laborers, foresters, botanists, technicians, etc.

In addition, NBS strengthen ecosystem services, which support industries that employ large numbers of people (1.2 billion worldwide) in farming, fishing and forestry. Therefore, NBS bring significant opportunities for improved incomes and livelihoods, as so many people worldwide are economically dependent on healthy ecosystems. For example:

- Around 500 million people worldwide make their living in the fishing industry, the productivity of which can be negatively impacted by water quality and quantity changes (WWF, 2016).
- Some NBS can improve agricultural productivity and rural incomes, as shown in the Upper Tana-Nairobi Water Fund Business Case (TNC, 2015).
- Reforestation and other NBS restoration activities are suitable for public employment programs, mostly reaching workers in the primary sectors or informal economy.
- NBS can also contribute to long-term economic growth through socio-economic benefits such as greater food security and tourism.
- At the company level, NBS can help to reduce or avoid costs, such as water treatment costs through enhancing water-related ecosystem services. In addition, companies can avoid losses through preventing damage to infrastructure from floods, heatwaves or other extreme weather events.

Measurement indicators include the change in poverty rate or changes in job opportunities in each area, before and after NBS implementation. Total job availability by job type could be investigated to see if, for example, the number of farming jobs increased. In addition, looking at whether there are increases to the shadow wage rates, and overall economic spending in an area, would demonstrate economic benefits of NBS. As NBS can improve the quality of ecosystems for both humans and nature, as well as improve aesthetics, implementation can increase local property values, as specified further below.

Improved/Increased Human Health Benefits

Besides positive effects on mental and physical health through recreation access, NBS deliver various additional health benefits, including improvements in air quality through the filtering of pollutants by restored or protected forested ecosystems, a more reliable supply of clean drinking water or the provision of food, fuel and fiber for health purposes (medicinal plants, wood to make a fire to keep warm or boil water, etc.). Natural ecosystems are also an important source of traditional medicines, such as natural and synthetic medical drugs derived from natural products and species. Herbs and medical plants provide health-care benefits to local communities, cultural benefits through traditional plant ceremonies, and a potential source of revenue, particularly for indigenous communities and women (Mackinnon et al., 2019). NBS-enhanced ecosystem services can contribute to reducing multiple ailments, including infectious diseases, skin conditions and respiratory disorders.

Increased access to nature includes greater opportunities for physical activity, which results in improved physical and mental health. Related benefits include a reduction of stress levels through community cohesion and engagement, lower rates of obesity and weight-related problems, and greater social well-being from natural habitats and their therapeutic effects. Like recreational benefits, there are quantitative physical health indicators and (primarily) qualitative mental health indicators. Through greater access to nature and physical activities, NBS have huge cost-saving potential for health services, especially in urban settings (Mackinnon et al., 2019. It is critical to set up partnerships with conservationists, city planners and health professionals when implementing NBS, especially in urban settings.

Integrating Gender and Equity Concerns

Benefits can accrue unevenly to different groups. Attempting to ensure that women and excluded groups benefit equitably from NBS investment and activities will be key to their acceptance and sustainability. How different groups are engaged in stakeholder consultations and how they are drawn into governance mechanisms and into the definition of which projects to pursue will greatly affect the distribution of the socio-economic benefits. An intersectional approach that addresses exclusion from economic opportunity and unequal access to productive assets, information, technology and markets can improve the distribution of these benefits. We suggest that the design of projects begin with an inclusion diagnostic to promote the inclusion of women, youth and indigenous peoples across NBS investments.

A broad body of literature on the inclusion of women, girls and other vulnerable groups in development projects and activities is available. There are also a number of toolkits and frameworks that foster more consistent gender integration in projects and planning processes (for example, toolkits from Swedish International Development Cooperation Agency, KIT Royal Tropical Institute, and Civicus). Work by KIT Royal Tropical Institute and the FAO on gender in key supply chains, as well as the International Food Policy Research Institute (IFPRI) on gender, agriculture and resilience to economic and environmental shocks are particularly relevant (Meinzen-Dick et al., 2013; FAO, 2018a; KIT, 2020). These frameworks highlight how agricultural systems, gender roles and climate change interact: as climate change reduces ecosystem resilience, incomes fall, livelihoods shift, and time-use patterns change. Ensuring that NBS restore resilience and do not contribute to time poverty by increasing time burdens, particularly those of women and children, will be key to protecting household well-being (Burchardt, 2008; Bardasi & Wodon, 2010; Gammage, 2010; Zacharias, 2011).

Ensuring a focus on time use and time poverty in the metrics will enable a more nuanced understanding of the potential health and well-being benefits and costs generated by NBS. Health and well-being benefits flowing from improved water availability and quality can also reduce time burdens and time poverty. If water sources are more consistent, less time will be spent provisioning water; if the water is of higher quality with fewer parasites and lower levels of contamination, reduced health impacts will translate into less labor time lost, fewer school absences and less time spent on caring for the sick. Many countries collect time use data and practitioners can draw on national, state and local studies and instruments to develop simple and rapid appraisal methods to capture some of these benefits either quantitatively or qualitatively (see for example the Women's Empowerment in Agriculture Index from the International Food Policy Research Institute; American Time Use Survey (ATUS); the Harmonized European Time Use Survey (HETUS); and the Gender Equality Observatory for Latin America and the Caribbean for more refined indicators).

It is highly likely that in undertaking NBS investments, proponents will need to integrate capacity building—ensuring access to technical knowledge and assistance that does not reinforce gender, age or ethnic inequality. Many NBS projects will also strengthen local governance mechanisms; ensuring that women, Indigenous

People and local communities and other marginalized or previously excluded groups are part of these governance mechanisms will enhance their voice and agency in processes determining the benefits received from NBS (Akhmouch, 2012; Brill et al., 2022). Asking who is engaged in these groups and how they participate will yield information about the participatory and inclusive nature of these governance mechanisms (Solava & Alkire, 2007).

M&E systems offer another means of ensuring greater integration of excluded groups. M&E systems can collect data and disaggregate all beneficiaries by different variables (e.g. gender, ethnicity, etc.). Applying qualitative and quantitative data collection methodologies and conducting rapid appraisals of household well-being and time use, in concert with key indicators of ecosystem resilience and economic benefits, will reveal who is benefitting and enable adaptive management of projects and investments.

Improved Agricultural Output (Yield and Quality)

Besides benefits of NBS actions in agricultural habitats for soil health (see Box 4), water, carbon and biodiversity, there are clear gains for farmers and stakeholders involved in the agricultural value chain. Healthier soils can improve both crop quality and yield, which results in greater economic gains for farmers, as they can charge premium prices and sell higher quantities. Healthier soils are also less vulnerable to drought and other natural disasters, which improves overall food security and reduces harvest volatility, enabling a more stable and long-term income for farmers. This also brings the potential to integrate vulnerable groups, young people and the unemployed into the farming business. Farming is often the main driver of development in rural areas. Improved agricultural yield and quality through NBS can deliver substantial direct economic benefits, as calculated through farmers' and farming companies' financial statements. In addition, indirect economic benefits accrue to local communities through more economic transactions, as well as social benefits from greater job security, as measured by retention and unemployment rates (GIZ, 2020).

Expanded Religious/Spiritual Settings

Spirituality is a common feature of experiences in nature, and some religious or spiritual practices depend on access to nature and calm, non-urban spaces to encounter them. As nature is seen as an embodiment of spirituality, it is essential to have healthy ecosystems to practice spirituality. There is also a therapeutic value to experiencing spirituality in nature (Naor & Mayseless, 2020). NBS can therefore be said to expand religious and spiritual settings, which can be measured through a survey-type approach around time spent in nature for religious activities, and changes to spiritual well-being of the beneficiaries of NBS-enhanced systems.

Enhanced Microclimate Regulation

NBS that are implemented in primarily urban settings can mitigate urban heat island effect, a phenomenon in which air temperatures in cities are substantially higher than in adjacent rural areas (Imhoff et al., 2010). By incorporating natural vegetation through NBS into urban centers, some of the benefits that accrue will include reduced ambient temperatures, shade provision, aesthetic improvements and possible health benefits, particularly for vulnerable populations (Poumadere et al., 2006).

A variety of tools can model the potential impacts of NBS projects on urban heat islands, depending on the type of projects implemented. The selected urban heat island model should match the project in affected processes, spatial scale and computational ability. For example, projects that make large changes in surface cover types (e.g. converting impervious surfaces to a green space) can be modeled using several of the easier-to-use models (e.g. FRAISE, LUMPS, UWG). If the project is making smaller surface alterations such as a transition from grass to trees or an increase in irrigation, a more detailed model can capture the effects, such as ENVI-met and Surface Urban Energy and Water Balance Scheme.

Improved Opportunities for Education and Scientific Studies

NBS are usually implemented after conducting socio-economic and environmental feasibility studies, and the impacts of activities are monitored throughout the project (i.e. from the start to the finish and beyond). Data gathered on both environmental and socio-economic information can be used for wider scientific and economic studies to understand general trends and natural phenomena. Findings can be extrapolated to other contexts and hence improve understanding and decision-making regarding nature, ecosystem services and their impacts. The effects of NBS on all benefit categories listed in this guide present research opportunities. In addition, NBS bring opportunities for general education. Through more green jobs and enhanced ecosystems, people will spend more time in nature improving their ecological literacy. Specific educational efforts in ecosystem settings can strengthen this impact. As environmental education requires outdoor activities, NBS can improve the quality of education through increased opportunities for real-world, in situ teachings, in better functioning ecosystems, and can be measured through actual time spent outside. Through interviews and tests, ecological literacy measures a person's knowledge of ecological systems, their care for the environment and correlated action impacting the environment.

Improved Recreation/Tourism Opportunities

Creating, protecting or restoring green spaces in cities and rural areas through NBS can increase tourism revenues, as these public spaces become more attractive to locals and visitors. Methods to investigate NBS improvements to tourism opportunities include the total number of tourists/visitors within a given time frame in NBS-enhanced spaces. Tourism opportunities have direct economic benefits for local communities. They create restoration, management or conservation jobs, provide employment opportunities for guiding, fishing, hunting, etc., as well as for the hospitality industry. Tourism increases local economic transactions, such as through charging fees for access to green spaces.

NBS can also increase opportunities for physical activity, such as walking, hiking or cycling infrastructure, and other outdoor leisure activities, improving mental and physical health (see health benefits above). Traditional gray infrastructure may not offer these additional recreation or tourism benefits. These NBS-enhanced green spaces can motivate people to spend more time in natural habitats. Increased access to recreation is essential to human biology and psychology. Practitioners can quantitatively measure the benefits of improved recreation/tourism opportunities through the distance to recreational spaces and total recreational time spent there. Another option is to measure health benefits from time spent in nature. Qualitative indicators are also available, whereby visitors and tourists to NBS-enhanced areas share the emotional, mental, spiritual or physical benefits they receive from nature.

Improved Food Security

Through protecting and restoring natural resources and ecosystem services, NBS can improve agricultural performance and provide a mechanism for greater food security. This is because implementing NBS can make agriculture more sustainable, improve outputs and secure access to resources over the long term. NBS may also increase the resilience of food production to unpredictable climate change and extreme weather. For example, NBS activities that improve soil health will reduce the impact of future water shortages, as water retention rates are higher in healthier soils. This will result in more reliable yields (FAO, 2018b). In addition, NBS strengthen ecosystem services essential for fisheries. Many people depend socially, culturally and economically on fish and other marine resources. Productive fisheries are also essential for global food security, providing over 3 billion people with at least 20 percent of their animal protein. Even small quantities of fish can have a significant positive nutritional impact, which is important for fighting hunger and malnutrition in poorer countries (WWF, 2016).

Even NBS in non-agricultural/natural habitats contribute to feeding the current and future world population. This is because NBS can enhance the overall availability and quality of water in the region, and support biological functions and processes which neighboring farming systems are heavily reliant upon. For example, healthier forests will protect catchments and deliver cleaner water to agricultural lands. As farmers can also improve food security by retaining trees on agricultural lands, forests and agroforestry are an essential component of long-term food production (FAO, 2017c).

The WRI found that restoring 160 million hectares of degraded agricultural land can generate $84 billion annually for local and national economies, which not only increases smallholder farmer's income, but could provide additional food for almost 200 million people globally (Wu, 2017). Changes in access to high quality, affordable food, pre- and post NBS implementation, are a way to study food security.

Increased Property/Land Values

The price of property or land represents a net market value for a variety of factors, including size and shape of the property or lot, access to jobs, type of street, commute, schools, crime rate, weather, neighborhood, amenities, etc. (AEI, 2020). The state and functioning of local landscape features (such as surrounding vegetation, aquatic systems, etc.) also influence the value of properties and land. NBS can greatly enhance landscapes, with property/landowners and surrounding communities benefitting from additional or enhanced ecosystem services. NBS also offer opportunities to mitigate impacts from climate change (e.g. sea level rise) or other extreme events (e.g. flooding or fires). This additional protection service could greatly increase land or property values. Additionally, by providing ongoing protection against certain disasters, NBS can decrease insurance premiums. Several indices offer ways to quantify the additional value to property or land provided by NBS, including the property price index or home price appreciation index. Practitioners are urged to use an index which considers local contexts and data sets. Qualitative indicators are also available, such as surveys, to test the market and determine whether NBS have influenced property/land values.

Appendix O: Synthesis of Corporate Nature-Based Solutions Projects

This appendix provides an overview of the corporate NBS project examples that were used to inform the focus of this work, including the criteria applied for inclusion and the types of information that were analyzed.

To improve the understanding of current corporate investment in NBS for watersheds, this guide catalogued a sample of global corporate NBS projects that were available online. To understand what is driving corporations to invest in NBS projects, see the Drivers & Decision Making section below, as well as our blog post "Why Should Your Business Be Interested in Nature-Based Solutions for Watersheds?" for a deeper dive. The aim was to collect a range of corporate NBS projects focused on private investments in NBS for watersheds across differing NBS classifications, geographies, industry sectors and outcomes. For inclusion in this project, the projects had to meet five criteria:

1. Be publicly available via an internet search;
2. Adhere to the IUCN definition of NBS (see Section 1 and Appendix C);
3. Have private sector investment and/or ties to a corporate water stewardship goal;
4. Clearly state water benefits (quantity or quality) and/or be implemented in a freshwater habitat; and
5. State at least one co-benefit (carbon, biodiversity, etc.)

From each project example, we sought the following information:

1. Project title and overview
2. Geography
3. Organizations (company and implementing partners)
4. NBS habitat-intervention classification (see Appendix G)
5. Drivers for investing in NBS for watersheds
6. Benefits stated and measured
7. Methods used to measure the benefits
8. Lessons learned and insights on how to scale NBS for watersheds

In total, we assessed 94 project examples encompassing multiple habitat-intervention categories. Most of the projects were classified as wetland restoration (37), agricultural management practices (34), or forest restoration (21) (Table I1).

TABLE I1: NUMBER OF PROJECTS REVIEWED ACROSS DIFFERENT HABITAT AND INTERVENTION TYPES

HABITAT TYPE	INTERVENTION TYPE: Restoration	Protection	Management	Creation
Forest	21	12	4	
Savanna, Shrubland, Grassland and Desert	14	4	1	
Marine, Estuaries and Intertidal	4		1	
Wetland	37	3	1	
Artificial and Introduced			4	15
Terrestrial Agriculture	5		34	1

Many projects incorporated multiple NBS categories (across different intervention and habitat types), such as a combination of forest and grassland restoration, or agricultural management practices combined with wetland protection. All project examples were documented on the Water Action Hub. The geographic distribution of projects skewed towards the Americas. African and Asian project examples were similar in number, while fewer examples from Europe and Australia (Figure I1).

FIGURE I1: GEOGRAPHIC DISTRIBUTION OF NBS CASE STUDIES REVIEWED

BENEFITS OF NATURE-BASED SOLUTIONS IN PROJECTS

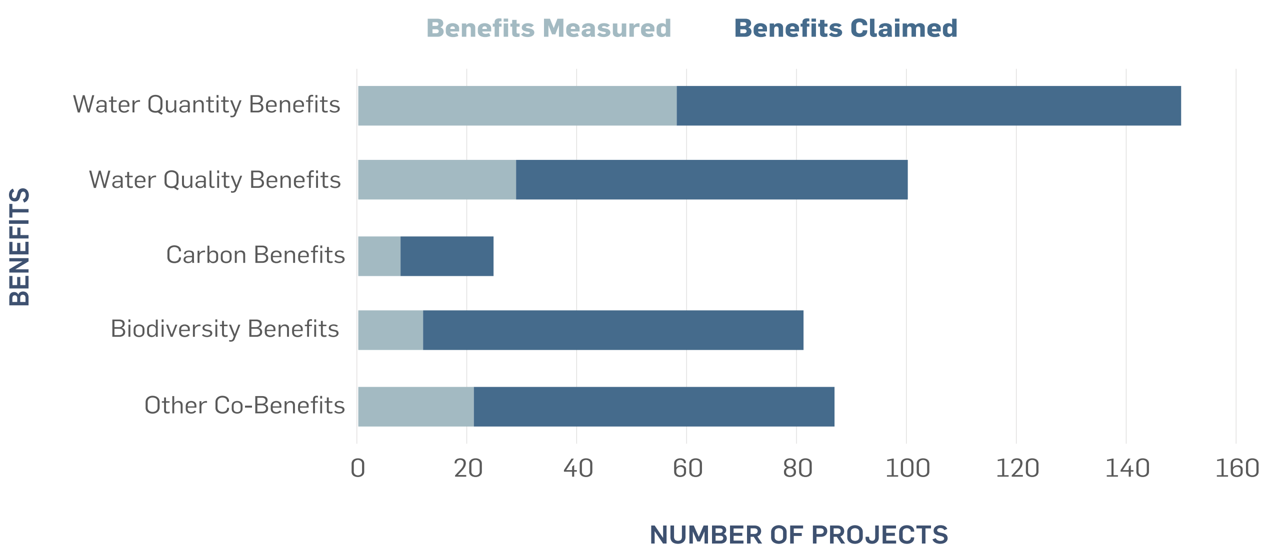
The documentation and measurement of benefits within the project examples was particularly important to this project. Information was gathered on benefits *claimed as outcomes of the* NBS, *and how benefits were measured or estimated.*

Which Benefits were Claimed?

Water quantity and quality were the majority benefits claimed, followed closely by biodiversity and other co-benefits. Fewer projects mentioned carbon benefits. The "Other Co-Benefits" category included outcomes such as community resilience, local job creation, poverty alleviation, increased crop yields, education, reduced urban heat island impacts, improved air quality and more. These co-benefits have all been listed under the socio-economic benefits in this guide.

The data for these project examples showed a large gap between the benefits claimed and the benefits measured or estimated either through modeling or monitoring (Figure I2). Lack of quantitative data on the benefits of NBS is often cited as a barrier to building the business case for, and thus scaling investment in, these kinds of NBS projects (Somarakis et al., 2019) (see Section 1 and Appendix B). Across the set of examples, only about 40 percent of the benefits claimed were supported by measurements or estimations. The occurrence of benefit measurements or estimations varied widely depending on the benefit in question. For example, 63 percent of water quantity benefit claims were measured or estimated, while only 17 percent of biodiversity claims were measured or estimated. An important caveat here is that these data are only based on what was reported in the publicly available project examples; it is possible that these NBS projects provided additional benefits, and that they were measured or estimated, but the information was excluded from the project.

FIGURE I2: BREAKDOWN OF BENEFITS CLAIMED AND MEASURED IN REVIEWED PROJECTS



HOW WERE BENEFITS MEASURED OR ESTIMATED?

The project team sought to understand how benefits were measured or estimated. Was it more common for the benefits to be monitored onsite, or to be estimated using a mathematical model? Of the 94 corporate NBS project examples, 68 had distinguishing information about whether monitoring or modeling was used. This leaves a gap between benefits claimed and benefits measured. Of those, 42 companies utilized modeling while 24 utilized monitoring to measure or estimate benefits. Some cases cited specific tools or resources used to measure or estimate benefits, including the Verified Carbon Standard, Restore the Earth EcoMetrics model, the ESII Tool and the Sustainable Rice Platform Standard (see Section 1 and Appendix E).

DRIVERS AND DECISION MAKING

The project examples revealed a diversity of factors driving companies' decisions to invest in NBS. Common drivers included:

- Corporate sustainability goals, such as a water replenishment target;
- Ethos and mindset of corporate responsibility;
- Regulatory compliance; and
- Financial return on investment.

Lessons Learned

Some of the projects shared insights, lessons learned or recommendations based on the experience of investing in and/or implementing an NBS project. Below is a list of some of those insights on scaling investments in NBS for watersheds.

1. **Earn Buy-In at the Outset**
    - Engage with decision makers early in the process to ensure that NBS are being considered as an option.
    - Allow local communities and other key stakeholders to participate and take ownership of the project from the planning phases through to maintenance and adaptive management.
    - Find a persistent internal champion. They will be critical in propelling NBS projects forward or maintaining momentum for existing projects.
    - Get uptake and acceptance by the local community by informing them of or demonstrating positive socio-economic benefits in the short term. This will make communities more open to making changes with long-term ecological benefits.

2. **Share the Story**
    - Share projects (internally and externally) that demonstrate NBS success with a broad range of interested and affected parties.
    - Showcase how it is possible to create healthy, productive landscapes where nature and people thrive.
    - Emphasize corporate investment in NBS to showcase community leadership and encourage employee recruitment and retention. Consumers and employees like companies who "do good" for nature.

- Educate the media, public and government on the value of natural or green engineering in building resilience into the environment, as well as the role of public-private collaborations in advancing these types of projects.
- Establish a network for sharing knowledge, skills, examples and insights regarding NBS.

3. **Show the Data**
    - Leverage mobile technology, big data analytics and citizen science to help generate data that demonstrate benefits.
    - Demonstrate cost savings over time.
    - Undertake detailed feasibility studies, which are key to successful execution.
    - Develop tools for the proper assessment of the "full value" of NBS (include multiple benefits and cost savings covering capital, operational and maintenance costs).
    - Develop more comprehensive environmental foot-printing and economic analysis to compare green and gray infrastructure costs and benefits.

4. **Educate Companies and Communities**
    - Promote efforts in environmental education.
    - Foster peer-to-peer learning within companies and communities.
    - Share experiences among farmers for further adoption of NBS in agriculture.
    - Provide community training on NBS, including for local companies.
    - Create a decision-making framework for companies to compare NBS to other alternatives.
    - Promote NBS pilot sites as a means for expanding NBS projects within a single company.
    - Encourage the shift to a more environmentally conscious mindset, emphasizing the need for long-term sustainability and a more holistic approach to management.
    - Develop educational resources to help companies identify NBS opportunities and advise where challenges or trade-offs are likely to occur.

5. **Improve Policy and Financing**
    - Leverage small grants and loans from financial institutions for companies and farmers to implement NBS.
    - Share positive results from NBS projects with the public sector to help advocate for and advance policies that support NBS.
    - Revise land-use permitting and regulatory processes to make NBS easier.
    - Advance long-term, sustained public-private partnerships.
    - Utilize market mechanisms such as a water quality trading program.

The CEO Water Mandate's six core elements:

DIRECT OPERATIONS

Mandate endorsers measure and reduce their water use and wastewater discharge and develop strategies for eliminating their impacts on communities and ecosystems.

SUPPLY CHAIN AND WATERSHED MANAGEMENT

Mandate endorsers seek avenues through which to encourage improved water management among their suppliers and public water managers alike.

COLLECTIVE ACTION

Mandate endorsers look to participate in collective efforts with civil society, intergovernmental organizations, affected communities, and other businesses to advance water sustainability.

PUBLIC POLICY

Mandate endorsers seek ways to facilitate the development and implementation of sustainable, equitable, and coherent water policy and regulatory frameworks.

COMMUNITY ENGAGEMENT

Mandate endorsers seek ways to improve community water efficiency, protect watersheds, and increase access to water services as a way of promoting sustainable water management and reducing risks.

TRANSPARENCY

Mandate endorsers are committed to transparency and disclosure in order to hold themselves accountable and meet the expectations of their stakeholders.