Nature-based Solutions and Natural Capital: An Introduction and Landscape Review

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Abstract

This paper examines Nature-based Solutions (NbS) and Natural Capital (NC), and assesses how the concepts are being used in practice. At present, experts and practitioners in the fields appear to lack consensus when defining the noted terms and when using them in the context of climate change mitigation or adaptation strategies. In view of this, the paper begins with a survey of the fields to understand how the noted terms are being defined, with attention to their historical contexts. We also identify different strategies that a range of stakeholders (i.e., government, private sector actors, and others) are mobilizing in alignment with various definitions. While NbS, NC, and Natural Capital Accounting (NCA) strategies present significant opportunities to drive positive place-based outcomes across a range of contexts, the lack of funding remains a significant barrier to the implementation and scale of NbS and adoption of NC more broadly. To that end, the paper includes a primer on how public finance strategies can be leveraged to fund NbS and NC, and presents areas for further inquiry.

Authors biographies

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I. Introduction

Nature-based Solutions (NbS) and Natural Capital (NC) are terms that encompass a range of strategies to address sustainability, biodiversity, environmental regeneration, and climate change adaptation and mitigation in ways that improve societal well-being. Each carries a unique historical context and wide-ranging application by global and U.S. stakeholders. Experts and scholars in the fields of Nature-based Solutions and Natural Capital lack consensus, however, in how the terms are defined, and there is no uniformity in the standards, guidelines, and criteria regarding what makes an effective NbS or NC strategy in practice.

This paper endeavors to survey the landscape of Nature-based Solutions and Natural Capital strategies including Natural Capital Accounting (NCA), with a lens on critical issues that are important to both approaches. Section II presents a comparative summary of different ways that Nature-based Solutions and Natural Capital are defined, coupled with examples of representative strategies and projects that are emerging in global and U.S. contexts across both terms. Although the differences between NbS and and NC definitions, strategies, and solutions are highly varied, a key challenge that often inhibits the implementation and scale of both is a lack of funding and financing. Section III presents a primer on how public finance and community investment can be leveraged to fund NbS and NC, with concrete examples of under-leveraged opportunities.

We conclude the paper in Section IV with an overview of critical issues, questions, and observations we surfaced in the course of surveying the NbS and NC landscape that can inform future study, as well as emerging efforts in the fields.

II. Defining Nature-based Solutions and Natural Capital

Defining Nature-based Solutions

NbS is a term that describes a range of ecological methods that in many cases target adapting to or mitigating the effects of climate change. As Table I demonstrates, most definitions state that NbS should benefit both nature and humans. Other common themes present in the definitions in Table I are the inclusion of biodiversity and societal well-being, a focus on addressing infrastructure needs, and hazard mitigation. There also exist supplemental guidelines for NbS such as the Recommendations for Action in the UNEP State of Finance for Nature Report (UNEP, 2023) and guidelines published by Seddon et al. (2021) from the NbS Initiative at Oxford University. These guidelines explicitly require engagement with Indigenous People and Local Communities (IPLCs) — those who are considered to both have the closest relationship with nature and most acutely experience the effects of intervention upon it.

Many international organizations have embraced the concept of NbS and claim credit for developing it. The International Union for Conservation of Nature (IUCN) World Conservation Congress claims to have developed the term NbS in the early 2000s (IUCN, 2024), while Seddon

et al. (2021) found that the first publication to focus on NbS was “a report by the World Bank in 2008 detailing the climate change mitigation and adaptation benefits of the Bank's investments in biodiversity conservation.” The United Nations (UN) adopted an official definition in 2022 (NbS Initiative, 2022). The term is still evolving, and the World Resources Institute (WRI) found that there remains no single, common definition (Swann et al. 2021).

Despite the lack of consensus around a definition, NbS have gained traction in both the U.S. and international discourse. NbS have been a centerpiece of both the UN’s and the Biden Administration’s respective efforts to combat climate change (UNEP, 2020; White House NbS Resource Guide, 2022). The chart from the UNEP (2021) in Appendix A shows the term’s adoption between 2012 and 2020.

The still-evolving nature of the terminology for NbS is evident in the numerous adjacent terms, apparent synonyms, and subcategories. An often-used subcategory is Nature-based Solutions for Adaptation (NbSA) which refers to NbS that specifically address adjusting to the effects of climate change. Ecosystem-based Adaptation (EbA) refers to “the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change” (Secretariat of the Convention on Biological Diversity, 2009). Another term often conflated with NbS is Natural Climate Solutions (NCS), defined by Ellis et al. (2024) as deliberate human actions that protect, restore, and improve management of forests, wetlands, grasslands, oceans, and agricultural lands to mitigate climate change. Ellis et al. note that NCS are distinct from NbS due to their narrower emphasis on carbon emissions reduction for climate change mitigation. Additionally, activities by other names[1] could fit NbS definitions, and “relevant research that does not use the specific term ‘NbS’ has a much longer history, with published articles going back to at least 1988” (Seddon et al., 2021).

Teasing out these subtle differences can prove difficult, especially as there is a lack of agreement in some areas. This is not just a contemporary phenomenon in the field. As a term, NbS could be considered a permutation or culmination of many others in a decades-long history of emerging and evolving environmental terms. There is evidence to demonstrate how many of those past terms[2] became more like “conservation fads” than effective solutions (Redford et al., 2013), and understanding this history gives context to the emergence of NbS. Often, proponents will frame NbS in a way that attempts to transcend conventional conservation. Seddon et al. (2021) describe how "Nature-based Solutions emerged from the major paradigm shift that took place in the late 2000s, that involved a move away from conserving nature for its own sake to conserving nature for people's sake, and from ‘regarding people as passive beneficiaries of nature to active protectors and restorers.’" Experts also observe that the concept of NbS can mirror what many Indigenous communities have already been doing for centuries — working

[1] "Ecosystem Restoration," "Agroecology," "Silviculture," "Permaculture," "Ecological Conservation / Preservation," "Natural Building," and "Green Infrastructure," to name a few.

[2] Examples include“... marketing of natural products from rainforests; biological diversity hotspots; integrated conservation and development projects (ICDPs); ecotourism; eco-certification; community-based conservation; payment for ecosystem or environmental services (PES); reduced emissions from deforestation and degradation (REDD); conservation concessions; and landscape approaches that integrate agriculture, sustainable uses, and conservation” (Redford et al., 2013)

with nature to achieve holistic benefits for the community and the environment (Cottrell, 2022). Despite the highly varied definitions, our survey of the approaches in the field suggests that NbS generally emphasize reacting to anthropogenic climate change.

Table I: Select Nature-based Solutions Definitions

Organization	Definition
United Nations (UN Environment Assembly - 5) (endorsed/adopted by IUCN and World Bank)	"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, resilience, and biodiversity benefits."
Oxford University's NbS Initiative	"[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."
World Resources Institute (WRI)	"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" (World Conservation Congress 2016)
American University	"[NbS] involves conserving, restoring, or better managing ecosystems to remove carbon dioxide (CO_2) from the atmosphere. Examples include allowing forests to regrow, restoring coastal wetlands, and switching to restorative agricultural practices, such as cover crop rotation, that support healthy soils."
The London School of Economics	"A collection of approaches that offer the potential to both reduce and remove emissions. They do this by enhancing the ability of ecosystems to sequester carbon dioxide, or reverse the degradation of an ecosystem so that it no longer emits harmful greenhouse gas emissions and once more becomes a 'net sink' of carbon (meaning it stores more carbon than it emits)."
Inspired by Nature-based Actions and Solutions (INAS)	"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. NbS encompasses ecosystem-based approaches and green infrastructure, which have been developed over the past few decades and are expected to be used as an integrated approach to deal with various issues." Specifies 4 types: (1) Disaster Risk Reduction, (2) Tradition, (3) Livelihood, (4) Socioeconomic Development.

Experts have found that unclear definitions of NbS can create confusion and decrease adoption and impact. The WRI suggested that the lack of a common definition likely inhibits the potential pipeline of NbSA investments, and that funding for NbS lacks clear data and valuation metrics (Swann et al., 2021). Finance Earth (2021) concurs, stating:

> NbS impact is challenging to measure due to complexity and lack of standards to accurately compare outcomes…across different locations, habitat types, and designs…There is currently significant ambiguity within the market around

assessment of the quality and impact (including negative impacts) of different NbS.

Melanidis and Hagerman (2022) stated that "ambiguity makes the NbS concept pliable." Some NbS proponents in turn argue that this very ambiguity is a benefit which makes it possible to facilitate engagement across sectors and increase funding, while critics frame it as a fundamental flaw that opens the concept up to greenwashing. This pliability is evident in the inconsistent definitions above, which appear to fall within a broad-to-narrow spectrum. The broadest definitions feature any ecological project, while narrow ones explicitly raise biodiversity and social equity considerations with regards to climate change mitigation and/or adaptation initiatives. Various organizations have created guiding principles governing the design of NbS in an effort to enhance their success, impact, and efficacy. For example, the NbS Initiative at Oxford University developed the following four guidelines, together with a consortium of 20 UK-based organizations (NbS Initiative, 2025):

1. NbS are not a substitute for the rapid phase-out of fossil fuels and must not delay urgent action to decarbonize our economies.

2. 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.

3. NbS are designed, implemented, managed, and monitored by or in partnership with Indigenous peoples and local communities (IPLC) through a process that fully respects and champions local rights and knowledge, and generates local benefits.

4. NbS support or enhance biodiversity, that is the diversity of life from the level of the gene to the level of the ecosystem.

Additionally, the IUCN Global Standard for NbS ("IUCN NbS Standard") published a framework that is intended to equip stakeholders that are designing or implementing Nature-based Solutions with a framework for designing and verifying that the solutions "yield the outcomes desired, in solving one or several societal challenge(s)." The IUCN Standard (IUCN, 2020) puts forward eight criteria and 28 indicators for NbS that include, but are not limited to, the following:

1. NbS must effectively address societal challenges.

2. The design of NbS should be informed by scale.

3. NbS should result in a net gain to biodiversity and ecosystem integrity.

4. NbS should be designed in ways that are economically viable.

5. NbS should reflect inclusive, transparent, and empowering governance processes, and be designed with attention to the jurisdictional context.

Defining Natural Capital

Natural Capital (NC) is often defined by experts as the global stock of natural resources — including air, soil, water, forests, and oceans, as further described in Table II, which provides some of the common definitions of the term (Damania et al., 2023). Some experts also include within their definition of Natural Capital an explicit reference to the potential economic value or economic contribution of environmental assets, or refer to their contribution to human enjoyment. According to Missemer (2018), the term Natural Capital has evolved in multiple languages across a couple of centuries, being first used to describe land and/or resources in a way that was similar to "natural resources." The term first shifted towards a more econometric definition due to the work of economist Alvin S. Johnson in 1909, who differentiated between artificial and natural capital. This definition focused on natural resources, but did not consider ecosystem services. "The Natural Capital concept therefore became progressively integrated into economic theory in the first third of the 20th century. However, despite this relative success, the concept apparently stopped developing, and remained nearly unused, from the 1930s to the 1980s" (Missemer, 2018). David Pearce used the term to refer to both natural resources and services in 1988, which pushed NC into economic literature and debate.

Table II. Select Definitions of Natural Capital

Organization	Definition
World Bank Group	"The world's stock of resources provided by nature…Clean air, abundant and clean water, fertile soils, productive fisheries, dense forests, and healthy oceans…"
Natural Capital Coalition	"The stock of renewable and nonrenewable natural resources (e.g., plants, animals, air, water, soils, minerals) that combine to yield a flow of benefits to people (adapted from Atkinson and Pearce 1995; Jansson et al. 1994)."
Oxford University's NbS Initiative	"Elements of nature that directly or indirectly produce value to people, including ecosystems, species, freshwater, land, minerals, the air and oceans, as well as natural processes and functions."
Oxford Languages	"The natural resources and environmental features in a given area, regarded as having economic value or providing a service to humankind."
White House	"Natural assets or Natural Capital stocks are durable physical or biological elements of nature that persist through time and contribute to current or future economic production, human enjoyment, or other services people value."

Natural Capital Accounting (NCA) emerged as a term that encompasses an economic valuation of Natural Capital, in some instances guided by a wide range of emerging financial or econometric frameworks (White House Office of Science and Technology Policy, 2023). Efforts to create NCA systems to utilize NC practically are relatively recent, and some approaches are summarized in Table III. The UN System of Environmental Economic Accounting (SEEA), for example, has put forward a guide to integrating economic, environmental, and social data into a single, coherent framework for holistic decision-making (UN SEEA, 2023). At present, the UN SEEA's framework remains one of the most widely adopted NCA approaches since its creation in 2012 (Scorzelli, 2023). Recently, the UN updated this framework and developed the SEEA Experimental Ecosystem Accounting framework (SEEA EEA), "an integrated statistical framework for organizing biophysical data, measuring ecosystem services, tracking changes in ecosystem assets, and linking this information to economic and other human activity" (UN, 2023). At present, it is unclear whether and how any jurisdictions have integrated the SEEA framework into their governance practices. Similarly, there are many approaches like the SEEA initiative that are emerging and there is no clear consensus establishing a single NCA strategy to perform an economic valuation of nature.

Table III. Approaches and Frameworks for Natural Capital Accounting

NCA Effort	Synopsis
United Nations System of Environmental Economic Accounting (SEEA)	The UN refers to this as the "accepted international standard for environmental-economic accounting." It follows a similar accounting structure as its System of National Accounts.
U.S. System of NC Accounting	The White House created this as part of its "National Strategy to Develop Statistics for Environmental-Economic Decisions." It has also released Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis.
Natural Capital Protocol	A decision-making framework for businesses created by a coalition of private-sector groups.
World Bank sustainable development framework	Makes use of a concept it calls "efficiency frontiers" to gauge the value and performance of natural assets.

When evaluating SEEA and other frameworks described in Table III, it is important to be attentive to several issues, including what "adoption" amounts to in practice. In addition, the valuation of nature can raise moral and ethical concerns. The UN (2023) has addressed this, stating:

> Attempts to place values on ecosystems in monetary terms may be considered inappropriate and the valuation of ecosystems and the estimated valuations

> themselves commonly generate the most contention among all measurement issues. Some argue that environmental valuation when market data is limited requires a number of assumptions and hence might be considered outside the domain of official statistics…care must be taken in interpreting and communicating valuation estimates to avoid overgeneralizing results.

Conducting an economic valuation is not sufficient to ensure that projects are achieving environmental goals, both because valuation cannot include non-economic values, and because valuations may not be tied to outcomes. Similarly, the Natural Capital Coalition (2016) noted that the valuation in its NC Protocol is "different from moral judgments, for example, people's environmental rights or the rights of a species to exist. These judgements require different approaches that are outside the scope of the Protocol." Though many experts, including UN SEEA (2023), explicitly state that NCA should *not* be considered "putting a price on nature," it does not eliminate the possibility that groups, businesses, or governments are adopting NCA to do just that.

Other experts elevate the importance of identifying actual co-benefits when NCA strategies are developed. Monbiot (2014), for example, cautions that the reduction of nature to a monetary valuation might obscure an analysis of the intangible value of co-benefits. If a focus on co-benefits is lacking, actors may have an economic rationale for activities that may appear sustainable on the Natural Capital balance sheet but are unsustainable when examined with a holistic view of co-benefits or place-based outcomes. Carbon credit markets and biodiversity credit markets are examples of fiscal and economic strategies that can yield mixed results if co-benefits are not elevated and properly considered. In some cases, for example, carbon offsets can be used in ways that result in outcomes that are susceptible to being characterized as greenwashing, where no tangible environmental co-benefits or additionality is achieved. This can happen, for example, when the initiatives being funded by credits are mismanaged or not subject to sufficient investigation or oversight (Baxter et al., 2021; Greenfield, 2023).

Practitioners of NCA may not be considering substitutability, additionality, or — importantly — the non-monetary benefits that natural assets provide both to humans and to the larger ecosystems in which they are embedded, and in such cases, NCA strategies may be weak or incomplete. Though there are potential drawbacks to an NCA approach, many organizations promoting NCA align to the approach put forward by the White House (2023) in its *U.S. System of NCA*, which states that it is better to attempt "...capturing the economic value of nature in a more comprehensive way...rather than effectively counting nature as zero on the balance sheet."

Biodiversity, NbS, and NC

The UN Convention on Biological Diversity (CBD) defines biodiversity as the variability of living organisms from all sources. This includes diversity within species, between species, and within ecosystems. Scientists generally assess three levels of diversity: species, genetic, and ecological (1999).

The anthropogenic systemic drivers of climate change are also responsible for a rapid global decrease in biodiversity, which some scientists consider a “biodiversity crisis” (2021), and many researchers now declare as either the beginning (2011) or middle of a sixth planetary mass extinction event, with current geologic record pattern trends of vertebrate animal extinctions comparable to the extinction of the dinosaurs (2017).

Loss of biodiversity indicates a decrease in quantity, quality, and resilience of NC that supplies ecosystem goods and services (2021). Species are currently being eradicated at a rate 100 to 1,000 times higher than baseline, and the rates of extinction are only increasing (2014). This process degrades the resilience and adaptability of life on Earth, which has conventionally not been accounted for within financial systems.

Abundant biodiversity metrics, information platforms, and emergent best practices exist (2020), and there are also increasingly powerful and precise digital technologies for monitoring and synthesizing biodiversity data globally (2022). However, the inherent complexity and lack of standards across jurisdictions and markets present challenges for stakeholders to align on financial valuation of the various forms of biodiversity, NC, and NbS. This core challenge to valuing biodiversity is also preventing the adoption and scale of narrowly-defined NbS (which often are attempts to stem or reverse biodiversity loss in a specific place) by conventional financial markets.

The concept of biodiversity underpins narrow definitions of NbS, and has similarly recently received increased awareness, consideration, and attempts at econometric valuation as a form of NC, with UN, CBD, and private sector stakeholders introducing biodiversity credit markets (2023) in step with similar market-based initiatives valuing carbon sequestration and emissions, as well as water rights trading markets (2019).

As clarified in the previous section, broad NbS definitions do not reference biodiversity (e.g., The European Commission). Even when biodiversity appears among project objectives, it is often “not meaningfully integrated into project design” (Atteridge et al., 2022). However, narrower definitions frame biodiversity as a critical component of NbS, even when this can seem counterintuitive to market stakeholders:

> Diversity is not always associated with higher delivery of short-term benefits. For example, high-yielding monoculture crops or plantations can produce more food or wood per hectare for a few years compared to a mixed species system. However, [bio]diversity is essential for long-term sustainability, as functional resilience to stressors such as climate change, invasive species, and new pathogens is strongly determined by ecosystem connectivity and biodiversity at multiple trophic levels (Seddon et al., 2021).

NbS in Practice

The range of projects that encompass NbS strategies is highly varied, and includes sequestering carbon in soils to reduce urban heat island effects, reducing shoreline erosion, permeable pavements, bioswales, mitigating wildfires and drought, addressing crop failures, and other projects and strategies presented in Table IV.

Table IV. Select Examples of NbS Projects and Strategies

Project	Project Synopsis	NbS Method	Funding
Water Funds in Peru (Source: WRI)	The project consisted of three separate NbS interventions to improve watershed services in three regions in Peru, that included the engagement of local communities on improving water management techniques, appraising improved services including a new payment for ecosystem services by users, and the creation of a financial mechanism (Aquafondo) to generate public-private partnerships for investment in the three watersheds.	Nutrient and sediment retention techniques, flood attenuation.	• $1.7 million grants. • $300,000 public-private partnerships.
Equitable Green Infrastructure Project in Buffalo (Source: Quantified Ventures)	The project consisted of green stormwater infrastructure.	Tree planting, rain gardens, permeable pavements, underground filtration.	• $54 million environmental impact bonds.
Rhino Impact Investment Wildlife Conservation Bond in South Africa (Source: Finance Earth)	The project focused on increasing the channel resources to increase black rhino populations in target protected areas.	Protection of endangered rhino species.	• $100 million social impact bonds.
The DC Water and Sewer Authority in Washington Sewer Project (Source: Quantified Ventures)	The project focused on outdated pipes in the sewer system and addressing overflow pollution (bacteria/trash/heavy metals) into the Potomac and Chesapeake Bay.	Green infrastructure: planter boxes, rain gardens, permeable pavement, bioswales, green roofs, new urban green spaces.	• $25 million environmental impact bonds.
Insuring Natural Capital - Coral Reef Insurance in Mexico (Source: WRI Landscape Assessment)	The project created a Coastal Zone Management Trust by a state government and other stakeholders to purchase an insurance-for-nature policy. Allows trust to secure funding for ongoing maintenance and quickly repair damages following natural disasters.	Coral reef restoration, species habitat protection, biodiversity conservation.	• $3.8m insurance cover. Leverages an existing fee paid by beachfront property owners, among other funding sources.
Soil and Water Outcomes Fund in the U.S. Midwest (Source: Quantified Ventures)	The project created a fund using investor capital to provide financial incentives to farmers for implementing conservation practices. Corporations and governments purchase	Use of cover crops in farming for sustainable crop rotation, reduced or no tillage.	• Multi-payer outcomes — based fund capitalized with money from nonprofit, private, and public finance sources, including the USDA's

	"environmental outcomes."		Partnerships for Climate-Smart Commodities.
Wildfire Mitigation Environmental Impact Fund Study in Southwest Colorado (Source: Quantified Ventures)	The project studied the feasibility of an EIF capitalized by a combination of bond proceeds, grants, and appropriations. Disburses revolving loans each year to pay for forest health treatments. Hedges performance risk by tying payments to the success of projects.	Forest thinning, generation of woody biomass material.	• Multi-payer outcomes based fund capitalized by a combination of public finance sources (bond proceeds, grants, and appropriations).
Afforestation in Ghana and Sierra Leone (Source: Finance Earth)	The project sought to afforest plantations on degraded land.	Tree-planting, sustainable forest management.	• $56m in equity and quasi-equity from institutional investors and development banks.
Blue Bond in Seychelles (Source: Finance Earth)	The project is the world's first sovereign blue bond, a financial instrument designed to support sustainable marine and fisheries projects in the country.	Transition to sustainable, small-scale fisheries; rebuilding fish stocks; harvest control; complementary marine projects.	• $15m blue bonds issuance. • $5m partial guarantee by the World Bank.

Many NbS projects are implemented via multi-faceted place-based partnerships. They are not necessarily limited to a list of projects, nor can they be simply categorized as "nature projects" that only leverage natural assets. Chausson et al. (2023) embrace a narrow definition, stating that "NbS are not equivalent to Natural Capital and ensuing ecosystem services; they are place-based partnerships involving people working with nature, as a part of nature, to harness co-benefits and address societal challenges."

The DC Water and Sewer Authority project described in Table IV, for example, met many of the standards for NbS that are described earlier in this paper. It reflected a novel approach that combined a wide range of strategic water management projects, and capitalized on the opportunity to create new urban spaces and parks, all in lieu of standard "gray" infrastructure. The DC Water project could be considered a NbS because it holistically considered nature and human health across multiple dimensions of the project. Centering biodiversity and addressing societal challenges is what makes a NbS, per several global leading frameworks and narrower definitions described earlier in this paper, rather than just the engagement with nature.

III. Funding NbS and NC

Experts analyzing the climate finance landscape are consistent in expressing the dire need for substantially more funding for NbS and NC assets, particularly to address climate change (Boehm and Schumer, 2023). The WRI reports: "[A]ccording to the IPCC, developing countries alone will need $127 billion per year by 2030 and $295 billion per year by 2050 to adapt to climate change. But funds for adaptation reached just $23 billion to $46 billion from 2017 to

2018, accounting for only four to eight percent of tracked climate finance" (Boehm and Schumer, 2023; IPCC, 2023). Gomez et al. (2023) noted that "the total global financing gap towards protection of nature is more than $700 billion." The UNEP (2021) reported that "if the world is to meet the climate change, biodiversity, and land degradation targets, it needs to close a $4.1 trillion financing gap in nature by 2050."

The current state of NbS financing is small when compared to "nature-negative" financing, as revealed by the most recent UNEP State of Finance for Nature Report (SFN, 2023). Private finance flows that have a direct negative impact on nature are $5 trillion annually. Despite global government commitments, environmentally harmful subsidies have increased by 55 percent to $1.7 trillion over just the past two years, primarily driven by fiscal support for the fossil fuel industry, and by extension the agricultural and manufacturing industries that utilize petro-chemicals for herbicides, pesticides, synthetic fertilizers, and plastics, all of which increase carbon emissions, degrade ecosystems, and reduce biodiversity (UNEP, 2023).

Some experts have tried to quantify aggregate levels of public and private investment for NC or NbS at global scales, regions, or project types. For example, the WRI reports that in 2018, up to $8 billion of funding flowed globally to fund NbS (Swann et al., 2021). In contrast, in 2021 the UNEP (2021) estimated that "the United States and China dominated public sector spending [for NbS], followed by Japan, Germany, and Australia. The United States tops the list with approximately $36 billion per year in NbS spending, and is closely followed by China with $31 billion." The UNEP (2023) further estimated that "total annual finance flows to NbS in 2022 were roughly $200 billion," and observed that public finance remained the main source of funding for approximately 82 percent ($165 billion) of total funding for NbS. Swann et al. (2021) found that "overall, the amount of public international funding flowing to Nature-based Solutions (NbS) for adaptation, for example, is approximately $3.8–8.7 billion, or approximately 0.6–1.4 percent of total climate finance flows, and 1.5–3.4 percent of public climate finance flows, in 2018."

Although expert perspectives and estimates relating to the level of current and future NC and NbS investments vary, two themes are consistent and have garnered consensus. First, funding for NC and NbS is needed at scale, particularly for climate change mitigation and adaptation efforts and in view of growing levels of nature-negative finance flows. Channeling more public and private funding into NbS was one of three recommendations for action in the UNEP's State of Finance for Nature 2023. Second, public finance remains the predominant way that most NbS and NC assets are funded. Accordingly, approaching NC and NbS investment with awareness of the full scale of public finance resources that can be leveraged is vital.

As background, public finance commonly refers to the various ways that governments spend and raise money, in the U.S. or globally, as enabled by the laws governing the framework of fiscal governance in the particular jurisdiction (UN-Habitat, 2017). Revenues from public finance to fund NbS or NC can potentially arise from the following general sources:[3]

[3] The classification is based on the generally accepted/most widely used approach in public finance globally and for US jurisdictions (UN-Habitat, 2017, Urban Institute, 2024)

1. Own-source revenues from taxes (e.g.., property taxes, sales taxes, income taxes, corporate taxes.).

2. Non-tax own-source revenues (e.g., charges, fines, fees, payments-in-lieu of taxes, developer exactions).

3. Revenues raised from a higher level of government (e.g., federal, county, or state grants) as intergovernmental aid, grants, or shared revenues between multiple units of government.

4. Other funds raised from one-time transactions (e.g.., the sale of mineral rights.) or money that is raised as passive income (e.g., investment earnings).

Additionally, public finance borrowing instruments can potentially be leveraged to raise funding for NbS and NC from outside investors, including municipal bonds, notes, commercial paper, and revolving loan funds. Such instruments raise money for NbS and NC by creating a future liability that the government must repay. Public finance sources can be blended with funding raised from philanthropic sources, structured as grants or program-related investments, money raised from donor contributions, or funding raised via public-private partnerships (P3s). P3s are contractual arrangements that enable private and public sector actors to share the risks and responsibility for designing, building, operating, maintaining, and/or funding an NbS or NC asset, typically via a contractual arrangement. Pay-for-success instruments, like social impact bonds, are similar to P3s in bringing together public and private actors to engage in outcomes based financing and risk sharing to carry out NbS and fund NC.

The range of public and private finance vehicles that are actually being used to fund NbS and NC are, in many instances, hard to identify when projects are not specifically labeled or designated as NC or NbS projects, or when appropriations to fund projects are made on an annually recurring basis as part of the operating or capital budget process. For example, the U.S. state of Illinois is a contributing member and participant in a multi-state effort with the states of Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin known as the Great Lakes Protection Fund (Germán and Simmons, 2024). The Great Lakes Protection Fund is managed by an Illinois not-for-profit corporation and has served as the first multi-state environmental endowment in the United States since it was established in 1989. Member states of the Great Lakes Protection Fund make one-time contributions or appropriations of $81 million, as set forth in the articles of incorporation of the nonprofit that manages the fund, which when combined with investment earnings are used to finance projects compatible with objectives articulated in the articles of incorporation.

A number of NC or NbS projects are funded by intergovernmental revenues, including grants. In the U.S., for example, recent federal grant programs established by the Infrastructure and Jobs Act and Inflation Reduction Act earmarked billions of dollars for climate initiatives such as the restoration of natural ecosystems, climate resilience, and natural infrastructure (Perry, 2022).

Though it is unclear how much funding in either bill is earmarked specifically for NbS, or how effectively NbS is being utilized in the United States, the Biden Administration issued an executive order specifying that the Inflation Reduction Act would "harness nature-based solutions" (Federal Register, 2022). The Biden Administration also put forth a comprehensive NbS roadmap including a NCA strategy (White House, *Opportunities…*,2022; White House, *National Strategy…,* 2023). Internationally, NbS appears to be funded primarily by grants. Swann et al. (2023) noted for the WRI that approximately 80 percent of NbS funding is provided in the form of grants.

Loan instruments, particularly from pooled funds with interest rate subsidies, are emerging as an important source of funding for NC and NbS. In the U.S., for example, the Clean Water State Revolving Loan (CWSRF) and the Drinking Water State Revolving Loan (DWSRF) programs are capitalized with a combination of federal grant funds, state revenues, and proceeds raised from the issuance of municipal bonds (EPA, 2024). The DWSRF and CWSRFs programs are principal sources that U.S. state and local governments currently use to fund the acquisition, construction, improvement, expansion, extension, and repair of water and sewer systems because the loans often carry interest rate subsidies. Many U.S. governments are funding NbS implementation projects that leverage Green Stormwater Infrastructure (GSI) using CWSRF funds. According to Hansen et al. (2022), around $1 billion of CWSRF assistance from 2016 to 2020 went to fund GSI or Natural Infrastructure (NI). Examples of GSI and NI projects being funded by CWSRF loans are presented in Table V.

Table V. GSI and NI Infrastructure Project Examples

Green Stormwater Infrastructure Examples	Natural Infrastructure Examples
Permeable Pavers	Land Preservation
Perforated Pipes	Forest Restoration/Reforestation
Rain Gardens	Wetland Restoration
Green Roofs	Riparian Protection
Urban Trees	Groundwater Recharge
Pocket Wetland	Living Shorelines

Source: Hansen

Pooled loan models that are being leveraged for NbS and NC in international jurisdictions are often designed and administered by global development banks (Marsters et al., 2021). The Natural Capital Financing Facility created by the European Investment Bank serves as one example of a reduced-interest loan pool, run as part of the EU LIFE Programme since 2014 (Van Der Jagt et al., 2023). It offers loans of up to approximately €5 million to fund large-scale NbS for

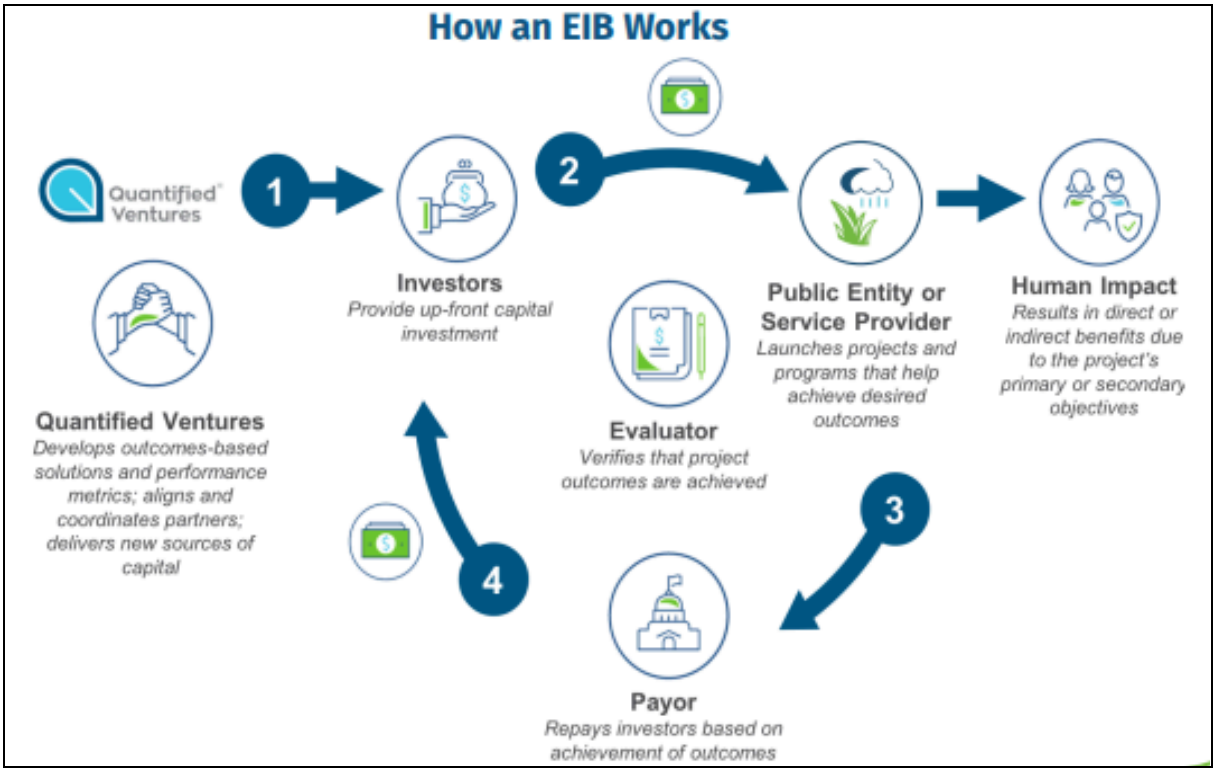
climate action. The city of Athens, Greece is using this fund to implement green-blue infrastructure measures across 400 sites (Van Der Jagt et al., 2023).

In addition to approaching NbS and NC funding with awareness of the full range of public finance avenues that are potentially available, experts suggest that there is value in aggregating multiple bespoke NbS and NC projects together (where possible) to encourage expanded institutional investment at scale (Finance Earth, 2021). Creating a portfolio of NbS and NC projects guided by such principles could provide a pipeline of deals for investors to consider, allow the portfolio to attract funding with sustained continuity, and yield other potential benefits in alignment with capital absorption best practices (Center for Community Investment, 2023).

In both U.S. and international contexts where loan instruments and pooled vehicles are used, there are potential heightened risks associated with NbS or NC strategies if jurisdictions implementing the strategy have weak fiscal health, cannot meet debt service obligations, or face insolvency. Because the majority of NbS and NC projects often do not yield project-based revenues, jurisdictions leveraging pooled loans or other debt instruments (i.e., bonds, notes, etc.) may have to secure loans with a gross general obligation pledge and must be able to service the debt or rely on subsidies that provide debt affordability (UN-Habitat, 2017). As an example of subsidies that exist, certain U.S. federal programs governing the capitalization of CWSRF funds described earlier provide expanded subsidies for disadvantaged communities, or enable discretionary authority among states to help disadvantaged communities with grants, negative interest loans, or forgiveness of principal to support communities with a diminished and constrained resource base in funding and implementing vital projects (IIJA, 2021).

Jurisdictions with weak fiscal health that endeavor to use debt instruments to fund NbS and NC assets, particularly in offerings syndicated in municipal capital markets, may face high costs of capital, or a lack of liquidity if investor perceptions of risk are disproportionately high (MSRB, 2018). In addition to fiscal health, investor perceptions of risk might be informed by project-based risks arising in the context of nascent, novel, or untested NbS strategies. In such instances, mechanisms like guarantees, insurance, intercept programs, and other forms of credit enhancement can potentially help raise funds for the NbS or NC asset at a lower cost of capital (Fitch, 2024; Swann et al., 2021).

Some NbS and NC solutions are being funded via pay-for-success instruments and social impact bonds (“SIBs”), leveraging a mix of private, public, and philanthropic funding. Pay-for-success and SIBs are instruments that raise money to fund the project from outside investors with the promise to repay, in part or in whole, conditioned on the project’s ability to produce target outcomes, at predefined levels (Obama White House, 2016). Investors in SIBs and pay-for-success arrangements will bear significant risk, receiving no repayment if predefined outcomes are not met and verified by an external evaluator. A diagram of a representative Environmental Impact Bond (EIB) that is structured as a pay-for-success financing for the DC Water Authority referenced in Table IV earlier in this paper visualizes the stakeholders and traditional components of an EIB pay-for-success financings.



Source: Quantified Ventures

The DC Water EIB visualized in the diagram was structured to address the volume of stormwater flowing through sewer systems during peak storms. The proxy measure for the project's success and the core target outcome — "a cleaner Potomac River" — was the key criteria that would govern investor repayment.

Investors in the DC Water EIB financing faced three different scenarios that governed repayment guided by project performance. If the project performed as expected, investors would receive payments as promised in the investment terms. However, if the project did not meet outcomes or underperformed, investors would be required to pay back a sum to DC Water, and DC Water would reassess the viability of green infrastructure projects and revert to funding gray infrastructure to address stormwater flowing through its sewer systems during storms. If the project overperformed and exceeded target outcomes, investors would be repaid and DC Water would also realize cost-savings associated with the implementation of the green infrastructure, and could scale investments in the intervention to expanded levels (Quantified Ventures, 2019).

When NbS and NC assets and projects are seeded and launched with EIB proceeds, time-limited grant revenues, bond proceeds, pooled loan proceeds, or other one-time sources raised from discrete transactions, only the beginning phase of the life cycle of NC assets or NbS solutions is traditionally funded. However, projects referenced throughout this report, including the stormwater projects funded by the DC Water EIB, often have long useful lives that will require ongoing and continued investments in operations and maintenance. A vital part of positioning

NbS and NC strategies for success requires planning for a diverse array of public finance sources to be blended to fund ongoing needs while a project is placed in service (Gomez et al., 2023).

Some experts suggest that ongoing maintenance and operating expense needs should be met by creating new common asset trust vehicles that serve a dual purpose of growing the funds available for the recurring expenditure needs and earmarking them via the trust structure to the NbS and NC assets (Chausson et al., 2023). Jurisdictions with strong fiscal health and robust own-source revenue frameworks can potentially consider a simpler path and fund operations and maintenance expenses from annual appropriations by using own-source revenues from tax and non-tax sources. There may be particularly strong precedents for doing so in jurisdictions where NbS strategies leverage NC assets, and there is a legal expenditure mandate to fund environmental assets from general or governmental fund revenues.

In addition to the avenues of public finance described earlier, an emergent and growing source of funding for certain types of NbS and NC assets is arising from private investors in commodities markets. Practices like carbon sequestration and carbon credit trading serve as two examples. NbS projects with "strong links to existing commodities markets, such as agriculture, forestry, and freshwater projects, currently receive the largest share of investment globally" from commodities trading activities (Finance Earth, 2021). When leveraging commodities markets as a source of liquidity to fund NbS and NC it is important to be attentive to the potential for economic incentives to distort or detract from the focus on achieving place-based environmental outcomes. Consequently, it is vital to elevate the vital role of achieving environmental co-benefits in tandem with economic and financial results when leveraging the noted instruments to raise money from private investors (Swann et al., 2021).

It's also important, with all of the public finance and private finance mechanisms that rely on outside investors, to ensure that investors enter into the financings with aligned duration expectations. Financing methods may be less effective at funding long-term needs if money is raised from investors looking for a short-term return on investments.

Additionally, any public or private financing approach selected must also fit the jurisdictional context, enabling environment, and experience of stakeholders implementing the financing instrument. Emerging economies, least developed countries, and small jurisdictions often may have weak or narrow economies, low tax revenues, a smaller fiscal base, and other challenges that make certain public finance approaches cost-prohibitive or limited in their feasibility (Atteridge et al., 2022). Similarly, jurisdictions and actors seeking to fund NbS projects with inherent challenges (e.g.., the regeneration or restoration of degraded ecosystems) may have to cultivate mission-aligned institutional investors with a high tolerance for project-based risks.

IV. Conclusion

Nature-based Solutions and Natural Capital are environmental concepts gaining momentum, increased adoption, and implementation with and by worldwide organizations. However, both terms' definitions lack consensus among experts and scholars. There is also a lack of uniformity in the standards, guidelines, and criteria regarding what makes an effective NbS or NC strategy in practice, though some proposals to this effect have previously been published. Across the board, experts agree that in order for these fields to become effective climate change mitigation or adaptation strategies, there is a strong and present need for increased funding.

Though adoption and implementation of these concepts is growing, further research is needed to determine their efficacy in practice. NCA systems, for example, are being adopted by many countries, but it is unclear whether and how these have been effectively integrated into governance practices. If there are governments using NCA effectively, further inquiry would provide an example for other jurisdictions wishing to follow suit. Examples of NbS projects are numerous, but they vary widely due to the lack of consensus in the definitions for NbS, which may inhibit new funding as it presents a confusing narrative, or it may result in projects with adverse outcomes. The development of an agreed-upon definition and operational framework for NbS could make the field more effective by aligning stakeholders around goals and methods.

Consensus on definitions is particularly important in light of the context from which NbS is emerging. This includes a tangled history of environmental terms, some of which became more fads than effective climate solutions. Popular terms that demonstrate funding momentum and widespread adoption are at risk for greenwashing, and experts have already raised this concern regarding NbS. This results in climate negative outcomes, and contributes to the sort of vocabulary turnover evident in the past.

Another consistent critique found in the literature argues that NbS and NC strategies will not meaningfully address climate change while being used within an infinite economic growth paradigm. This argument points out that historical economic models are extractive and destructive of resources in pursuit of higher GDP, and suggest that it is the economic paradigm itself that needs to be reconsidered in order to adapt to or mitigate climate change. More research is needed to evaluate how and whether NbS and NCA can accelerate both climate change solutions and economic growth objectives.

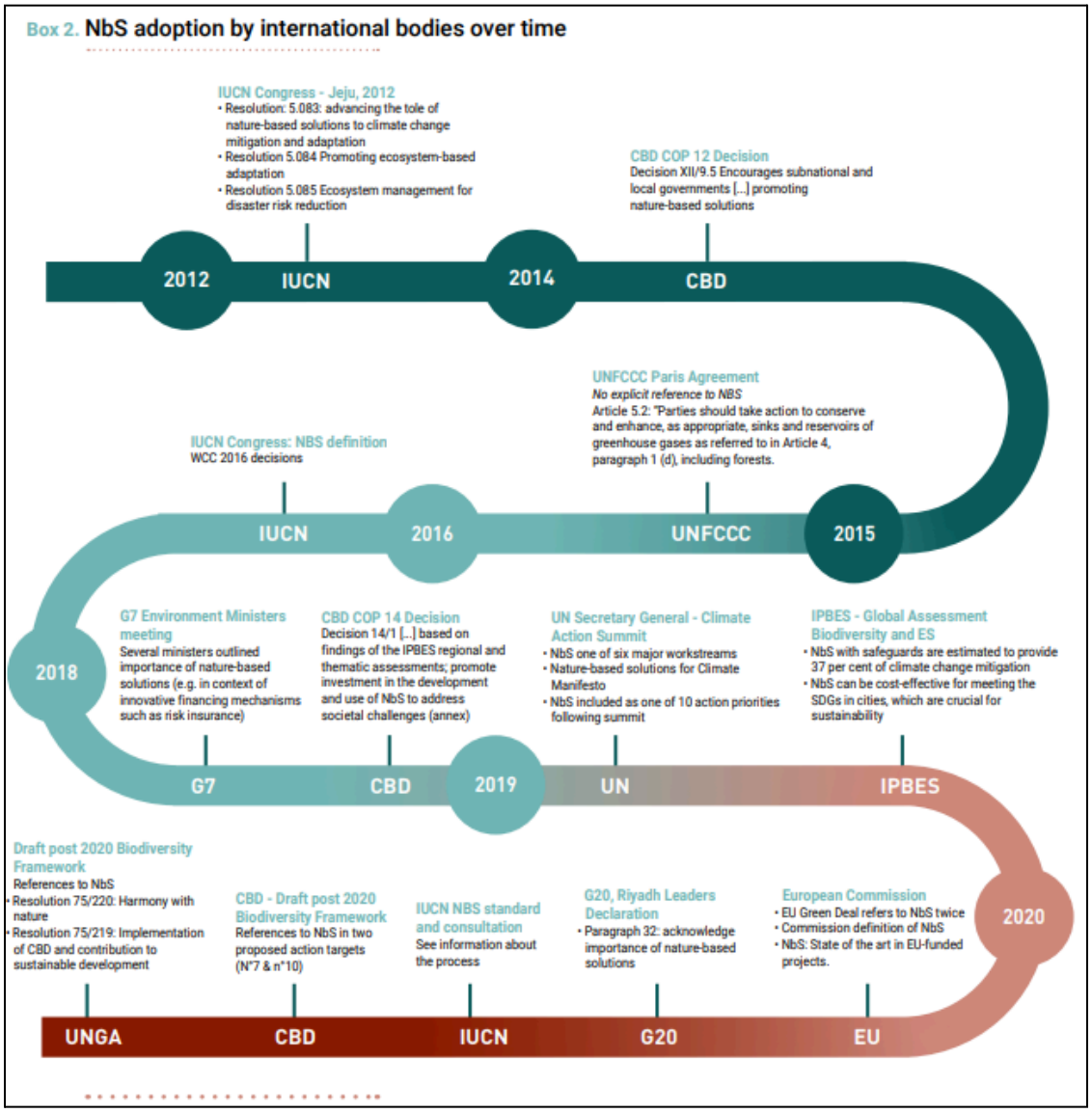
For potential practitioners of NbS and NC, these critiques elevate the need to assess the real impacts — both human and ecological — of these strategies. Importantly, the fields of NbS and NC lack consistency in whether and how equity is addressed. NbS and NC strategies can have origins in Indigenous cultures, and many stakeholders in the field also reflect equity values in frameworks that operationalize principles for implementing and measuring NbS projects. However, this area lacks consistency, and warrants attention and further research at two levels — centering equity in the uses of proceeds and in the plans of finance for NbS and NC.

In the absence of further alignment on definitions, there is opportunity to advance these fields by exploring ways to scale up funding. Currently there is a lot of research focused on innovative forms of finance for NbS (trading markets for carbon, biodiversity, and water rights; social

impact bonds; etc.), but less emphasis on how own-source revenue strategies are providing channels of resources to fund NbS and NC on a pay-as-you-go basis. This should be examined further, as it serves as a potentially promising way to seed projects and give sustained continuity to the operations and maintenance financing needed over the life of a NbS. Broadly speaking, rather than trying to reinvent funding, leveraging existing mechanisms for NbS could be a powerful way to scale up funding.

Appendices

Appendix A: NbS Adoption Over Time



Source: [2021 United Nations Environment Program]

Appendix B: Glossary of Terms

Additionality: The determination of whether or not an intervention's stated climate benefits would have occurred in the absence of the intervention. Used frequently in reference to carbon offset credits (Carbon Offset Guide).

Afforestation: The increase in the stock of forest and other wooded land either due to the establishment of new forest on land that was previously not classified as forest land, or as a result of silvicultural measures such as planting and seeding (United Nations).

Agroforestry: The practice of planting trees on farmland, including as rows between crops, or as shelter for livestock (Seddon et al., 2021).

Agro-ecology: Various approaches to sustainable agriculture that aim to protect soil health (Seddon et al., 2021).

Biodiversity: The variability among living organisms from all sources, including inter alia, terrestrial, marine, and other aquatic ecosystems, and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems (World Resources Institute).

Blended Finance: The strategic use of development finance for the mobilization of additional finance towards sustainable development in developing countries (Organisation for Economic Co-operation and Development).

Co-benefits: Beneficial outcomes from action that are not directly related to climate change mitigation. Such co-benefits include cleaner air, green job creation, public health benefits from active travel, and biodiversity improvement through expansion of green space (Carbon Disclosure Project).

Concessional Finance: Below market rate finance provided by major financial institutions, such as development banks and multilateral funds, to developing countries to accelerate development objectives. The term concessional finance does not represent a single mechanism or type of financial support but comprises a range of below market rate products used to accelerate a climate or development objective (The World Bank).

Deforestation: The decrease in the stock of forest and other wooded land due to the complete loss of tree cover and transfer of forest land to other uses (e.g., use as agricultural land, land under buildings, roads, etc.) or to no identifiable use (United Nations).

Ecosystem-based Adaptation: The use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people adapt to the adverse effects of climate change (Secretariat of the Convention on Biological Diversity, 2009).

Ecosystem Services: The contributions of ecosystems to economic and other human activity (United Nations).

> **Cultural Services**: Generated from the physical settings, locations, or situations that give rise to intellectual and symbolic benefits obtained by people from ecosystems through recreation, knowledge development, relaxation, and spiritual reflection (United Nations).

Provisioning Services: Representing the material and energy contributions generated by or in an ecosystem, e.g., fish or plants with pharmaceutical properties (United Nations).

Regulating Services: Resulting from the capacity of ecosystems to regulate climate, hydrologic and biochemical cycles, Earth surface processes, and a variety of biological processes. These services often have an important spatial aspect. For instance, the flood control service of an upper watershed forest is relevant only in the flood zone downstream of the forest (United Nations).

Pay-for-success: Strategy of procuring positive social or environmental outcomes by paying, in part or in whole, for an intervention only once it produces those outcomes (Obama White House, 2016).

Green/Blue Infrastructure: A strategically planned and managed, spatially-interconnected network of multi-functional natural, semi-natural, and man-made features including agricultural land, green corridors, urban parks, forest reserves, wetlands, rivers, and coastal and other aquatic ecosystems (Seddon et al., 2021).

Natural Infrastructure: Intentionally managed or restored natural landscapes or features that store, infiltrate, or evapotranspire water with no or relatively little engineering. NI is a relatively distinct subset of green infrastructure (Environmental Policy Innovation Center).
Green Stormwater Infrastructure: Systems or features that use or replicate the functions of the natural environment to store, infiltrate, or evapotranspire stormwater (Environmental Policy Innovation Center).

Greenhouse Gases: Gases that trap heat in the atmosphere, e.g., Carbon Dioxide, Methane, Nitrous Oxide, and Fluorinated Gases (Environmental Protection Agency).

Greenwashing: Misleading the public to believe that a company or other entity is doing more to protect the environment than it is (United Nations).

Gray Infrastructure: Human-built and human-engineered assets that provide one or multiple services required by society, such as dams, levees, reservoirs, treatment systems, and pipes (Not to be confused with a gray water system, which is a specific type of water recycling system.) (World Resources Institute).

Natural Assets / Environmental Assets / Ecosystem Assets / Biological Assets: The naturally occurring living and nonliving components of the Earth, together constituting the biophysical environment, which may provide benefits to humanity (United Nations).

Natural Climate Solutions: Deliberate human actions (NCS pathways) that protect, restore, and improve management of forests, wetlands, grasslands, oceans, and agricultural lands to mitigate climate change (Ellis, 2024).

Reduced Emissions from Deforestation and Degradation +: Fostering conservation, sustainable management of forests, and enhancement of forest carbon stocks in developing countries (Seddon et al., 2021).

Substitutability: The ability to replace one product, technology, or service which is insufficient with another. It has been widely used in economics to understand an elasticity of substitution between human and Natural Capitals. The concept has also been expanded to include other

situations: human-Natural Capital substitution, Natural Capital-energy substitution, import-export goods substitution, and information technology-labor substitution (Oh and Muneepeerakul, 2019).

Appendix C: Acronyms

CWSRFs: Clean Water State Revolving Funds
EbA: Ecosystem-based Adaptation
EIB: Environmental Impact Bond
EIF: Environmental Impact Fund
EPA: Environmental Protection Agency
GHG: Greenhouse Gas
GSI: Green Stormwater infrastructure
IPLC: Indigenous Peoples and Local Communities
IUCN: International Union for Conservation of Nature
NbS: Nature-based Solutions
NbSA: Nature-based Solutions for Adaptation
NC: Natural Capital
NCA: Natural Capital Accounting
NCS: Natural Climate Solutions
NI: Natural Infrastructure
O&M: Operations and Maintenance
PFI: Public Finance Initiative
REDD+: Reduced Emissions from Deforestation and Degradation +
SEEA: System of Environmental Economic Accounting
SEEA EA: SEEA Ecosystem Accounting
SEI: Stockholm Environment Institute
SFN: State of Finance for Nature (UNEP report)
UN: United Nations
UNEP: United Nations Environment Programme
WH: White House
WRI: World Resources Institute

References

Asiyanbi, A., Friis Lun, J. (2021). *Too big to fail? REDD+ and the promise of forest-based climate mitigation.* Undisciplined Environments. https://undisciplinedenvironments.org/2021/01/12/too-big-to-fail-redd-and-the-promise-of-forest-based-climate-mitigation/

Atteridge, A., Bhatpuria, D., Macura, B., Barquet, K., Green, J. (2022). *Assessing finance for nature-based solutions to climate change: SEI Working Paper*. Stockholm Environment Institute. https://doi.org/10.51414/sei2022.052

Baxter L.G. et al. (2021). *The Myth of Carbon Offsets.* Regenerative Crisis Response Committee. https://scholarship.law.duke.edu/cgi/viewcontent.cgi?article=1003&context=rcrc

Boehm, S. and Schumer, C. (2023, Mar 20). *10 Big Findings from the 2023 IPCC Report on Climate Change.* World Resources Institute. www.wri.org/insights/2023-ipcc-ar6-synthesis-report-climate-change-findings#:~:text=The%20IPCC%20finds%20that%20there,sooner%20%E2%80%94%20between%202018%20and%202037

Chausson, A., Welden, E.A., Melanidis, M.S., Gray, E., Hirons, M., Seddon, N. (2023). *Going beyond market-based mechanisms to finance nature-based solutions and foster sustainable futures.* PLOS Clim 2(4). https://doi.org/10.1371/journal.pclm.0000169

Center for Community Investment (2023). *Capital Absorption Framework*. Center for Community Investment. https://centerforcommunityinvestment.org/our-work/capital-absorption-framework/

Clarke, D., S. Sakata and S. Barahona (2023). "Public policy uses of the SEEA stocks and flows accounts." OECD Statistics Working Papers, No. 2023/02, OECD Publishing, Paris. https://doi.org/10.1787/116778b3-en.

Convention on Biological Diversity. (2023, Apr 10). *Kunming-Montreal Global Biodiversity Framework*. Convention on Biological Diversity. https://www.cbd.int/gbf/

Cottrell, Clifton (2022). *Avoiding a new era in biopiracy: Including indigenous and local knowledge in nature-based solutions to climate change*, Environmental Science & Policy, Volume 135, Pages 162-168, ISSN 1462-9011.https://doi.org/10.1016/j.envsci.2022.05.003

Damania, R., Polasky, S. Ruckelshaus, M., Russ, J., Amann, M., Chaplin-Kramer, R., Gerber, J., Hawthorne, P., Heger, M. P., Mamun, S., Ruta, G., Schmitt, R., Smith, J., Vogl, A., Wagner, F., & Zaveri, E., (2023). *Nature's Frontiers: Achieving Sustainability, Efficiency, and Prosperity with Natural Capital*. World Bank. doi:10.1596/978-1-4648-1923-0.

Ellis, P.W., Page, A.M., Wood, S. et al. (2024). *The principles of natural climate solutions*. Nat Commun 15, 547. https://doi.org/10.1038/s41467-023-44425-2

EPA (Environmental Protection Agency) (2024). *About the Clean Water State Revolving Fund (CWSRF)*. Environmental Protection Agency. https://www.epa.gov/cwsrf/about-clean-water-state-revolving-fund-cwsrf

European Commission, Directorate-General for Research and Innovation, (2015). *Towards an EU research and innovation policy agenda for nature-based solutions & re-naturing cities – Final report of the Horizon 2020 expert group on 'Nature-based solutions and re-naturing cities' – (full version).*" Publications Office. https://data.europa.eu/doi/10.2777/479582

Federal Register (2022). *Implementation of the Energy and Infrastructure Provisions of the Inflation Reduction Act of 2022: Executive Order 14082 of September 12, 2022*. Federal Register. https://www.federalregister.gov/documents/2022/09/16/2022-20210/implementation-of-the-energy-and-infrastructure-provisions-of-the-inflation-reduction-act-of-2022.

Finance Earth (2021). *A Market Review of Nature-Based Solutions: An Emerging Institutional Asset Class*. Finance Earth. https://finance.earth/wp-content/uploads/2021/05/Finance-Earth-GPC-Market-Review-of-NbS-Report-May-2021.pdf

Fitch (2024). *U.S. State Credit Enhancement Programs (How Fitch Approaches State Enhancement for Local Debt)*. Fitch Ratings. https://www.fitchratings.com/research/us-public-finance/us-state-credit-enhancement-programs-how-fitch-approaches-state-enhancement-for-local-debt-17-05-2024

Germán, L., Simmons, A. (2024). *U.S. State Investments in Water, Sewer, and Transportation Infrastructure: A Survey*. The Public Finance Initiative & The Pew Charitable Trusts. https://www.pewtrusts.org/-/media/assets/2024/10/us-state-investments-in-water-sewer-and-transportation-infrastructure.pdf

Gómez, S., Purata V.L.P., Rodríguez, S.E. (2023, Feb 23). *Pathways to Unblocking Private Financing for Nature-Based Solutions.* World Resources Institute. www.wri.org/update/pathways-unblocking-private-financing-nature-based-solutions.

Greenfield, P. (2023). *Revealed: more than 90% of rainforest carbon offsets by biggest certifier are worthless, analysis shows.* The Guardian. https://www.tritorch.com/degradation/CarbonCreditFraud90PercentOfRainforestOffestsAreWorthlessMay2023.pdf

Hansen, K., Thomas, T.,1 Vo, S., Berven, K., Moudgalya, P., Vedachalam, S. (2022). *Financing Green Stormwater and Natural Infrastructure with Clean Water State Revolving Funds.* Environmental Policy Innovation Center - EPIC. https://static1.squarespace.com/static/611cc20b78b5f677dad664ab/t/620a8241292cd8383cd43169/1644855885875/CWSRF_FinancedGSI_v3.pdf

IIJA (Infrastructure Investment and Jobs Act), H.R.3684 - Infrastructure Investment and Jobs Act, 117th Cong. (2021). https://www.congress.gov/bill/117th-congress/house-bill/3684

IPCC. (2023). *Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.* doi: 10.59327/IPCC/AR6-9789291691647

IUCN (2020). *Global Standard for Nature-based Solutions. A user-friendly framework for the verification, design and scaling up of NbS*. First edition. Gland, Switzerland: IUCN. 978-2-8317-2058-6 DOI. https://doi.org/10.2305/IUCN.CH.2020.08.en

IUCN (2024). *Our Work: Nature-based Solutions*. IUCN. https://iucn.org/our-work/nature-based-solutions

Jain, A. and Chhabra, S. (2022). *Redefining prosperity. Stockholm+50 background paper series.* Stockholm Environment Institute. https://www.sei.org/publications/redefining-prosperity/

Melanidis, M., Hagerman, S. (2022). *Competing narratives of nature-based solutions: Leveraging the power of nature or dangerous distraction?*, Environmental Science & Policy, Volume 132, Pages 273-281, ISSN 1462-9011. https://doi.org/10.1016/j.envsci.2022.02.028.

Marsters, L., Morales, G., Ozment, S., Silva Zuniga, M.C., Watson, G, Netto, M., & Frisari, G.L. (2021 Oct). *Nature-based Solutions in Latin America and the Caribbean: Financing Mechanisms for Regional Replication.* Inter-American Development Bank. https://publications.iadb.org/en/nature-based-solutions-latin-america-and-caribbean-financing-mechanisms-regional-replication

Missemer, A. (2018). *Natural Capital as an Economic Concept, History and Contemporary Issues*. Ecological Economics, Volume 143, pg. 90-96. https://doi.org/10.1016/j.ecolecon.2017.07.011.

Monbiot, George. (2014). *Put a price on nature? We must stop this neoliberal road to ruin.* The Guardian. https://www.theguardian.com/environment/georgemonbiot/2014/jul/24/price-nature-neoliberal-capital-road-ruin

MSRB (Municipal Securities Rulemaking Board) (2018). *What to Expect When Selling Municipal Bonds Before Maturity*. Municipal Securities Rulemaking Board. https://www.msrb.org/sites/default/files/Selling-Before-Maturity.pdf

Nature-Based Solutions Initiative. (2022, Mar 3). *United Nations Environment Assembly Agrees Nature-Based Solutions Definition*. Nature-Based Solutions Initiative. www.naturebasedsolutionsinitiative.org/news/united-nations-environment-assembly-nature-based-solutions-definition.

NbS Initiative. (2025). *Nature-based Solutions Guidelines*. Nature-based Solutions Initiative. https://www.naturebasedsolutionsinitiative.org/nbs-guidelines/

Natural Capital Coalition. (2016). *Natural Capital Protocol.* Natural Capital Coalition. www.naturalcapitalcoalition.org/protocol

Obama White House (2016). *Pay for Success: An Opportunity to Find and Scale What Works*. Obama White House. https://obamawhitehouse.archives.gov/administration/eop/sicp/initiatives/pay-for-success#:~:text=Pay%20for%20Success%20(PFS)%3A,once%20it%20produces%20those%20outcomes

Perry, J. (2022). *Opportunities for Nature-Based Solutions in the Inflation Reduction Act*. Environmental Law Institute. https://www.eli.org/vibrant-environment-blog/opportunities-nature-based-solutions-inflation-reduction-act

Quantified Ventures (2019). *DC Water Case Study*. Quantified Ventures. https://static1.squarespace.com/static/5d5b210885b4ce0001663c25/t/5e136b61f2afef61e95e7472/1578331001269/DC+Water+Case+Study_Quantified+Ventures

Redford, K., Padoch, C., Sunderland, T.. (2013). *Fads, Funding, and Forgetting in Three Decades of Conservation*. Society for Conservation Biology, Conservation Biology, Volume 27, No. 3, 437–438, DOI: 10.1111/cobi.12071

Scorzelli, R., Murgante, B., Manganelli, B., Scorza, F. (2023). *The Evolution of Natural Capital Accounting: From Origins to System of Environmental-Economic Accounting*. In: Gervasi, O., et al. Computational Science and Its Applications – ICCSA 2023 Workshops. ICCSA 2023. Lecture Notes in Computer Science, vol 14106. Springer, Cham. https://doi.org/10.1007/978-3-031-37111-0_43

Secretariat of the Convention on Biological Diversity (2009). *Connecting Biodiversity and Climate Change Mitigation and Adaptation: Report of the Second Ad Hoc Technical Expert Group on Biodiversity and Climate Change*. Montreal, Technical Series No. 41, 126 pages. https://www.cbd.int/doc/publications/cbd-ts-41-en.pdf

Seddon, N., Smith, A., Smith, P., Key, I., Chausson, A., Girardin, C., House, J., Srivastava, S. and Turner, B. (2021). *Getting the message right on nature-based solutions to climate change*. Glob. Change Biol., 27: 1518-1546. https://doi.org/10.1111/gcb.15513

Swann, S., L. Blandford, S. Cheng, J. Cook, A. Miller, and R. Barr. (2021). *Public International Funding of Nature-based Solutions for Adaptation: A Landscape Assessment.* Working Paper. World Resources Institute. https://doi.org/10.46830/ wriwp.20.00065.

United Nations, European Union, Food and Agriculture Organization of the United Nations, International Monetary Fund, Organisation for Economic Co-operation and Development,

The World Bank (2014). “System of Environmental-Economic Accounting 2012: Central Framework.” United Nations. https://seea.un.org/sites/seea.un.org/files/seea_cf_final_en.pdf

United Nations Environment Programme (2020). *The Economics of Nature-based Solutions: Current Status and Future Priorities*. United Nations Environment Programme. https://www.un.org/sites/un2.un.org/files/2021/04/nature-based-solutions-20110426.pdf

United Nations Environment Programme (2021). *State of Finance for Nature 2021*. United Nations. https://www.unep.org/resources/state-finance-nature-2021

United Nations Environment Programme (2023). *State of Finance for Nature: The Big Nature Turnaround – Repurposing $7 trillion to combat nature loss*. United Nations. https://doi.org/10.59117/20.500.11822/44278

UN-Habitat (UN Habitat for a Better Urban Future) (2017). *Finance for City Leaders Handbook Source*, 2nd ed., 1-352. https://unhabitat.org/sites/default/files/2021/01/fcl_2017_2nd_ed_lowres_2.pdf

UN SEEA (United Nations System of Environmental Economic Accounting) (2023). *Natural Capital and Ecosystem Services FAQ.*” United Nations. (https://seea.un.org/content/natural-capital-and-ecosystem-services-faq

Urban Institute (2024). *What are the sources of revenue for state and local governments?* Tax Policy Center, Urban Institute & Brookings Institution. www.urban.org/policy-centers/cross-center-initiatives/state-and-local-finance-initiative/state-and-local-backgrounders/state-and-local-revenues

Van Der Jagt, A., Tozer, L., Toxopeus, H., & Runhaar, H. (2023). *Policy mixes for mainstreaming urban nature-based solutions: An analysis of six European countries and the European Union*. Environmental Science & Policy. Volume 139, Pages 51-61. ISSN 1462-9011. https://www.sciencedirect.com/science/article/pii/S1462901122003239

White House Council on Environmental Quality, White House Office of Science and Technology Policy, White House Office of Domestic Climate Policy, (2022). *Nature-Based Solutions Resource Guide.* White House. https://bidenwhitehouse.archives.gov/wp-content/uploads/2022/11/Nature-Based-Solutions-Resource-Guide-2022.pdf

White House Council on Environmental Quality, White House Office of Science and Technology Policy, White House Domestic Climate Policy Office, (2022). *Opportunities for Accelerating Nature-Based Solutions: A Roadmap for Climate Progress, Thriving Nature, Equity, and Prosperity*. Report to the National Climate Task Force. White House. https://bidenwhitehouse.archives.gov/wp-content/uploads/2022/11/Nature-Based-Solutions-Roadmap.pdf

White House Office of Science and Technology Policy, White House Office of Management and Budget, Department of Commerce, (2023). *National Strategy to Develop Statistics for Environmental-Economic Decisions: A U.S. System of Natural Capital Accounting and Associated Environmental-Economic Statistics*. White House. https://bidenwhitehouse.archives.gov/wp-content/uploads/2023/01/Natural-Capital-Accounting-Strategy-final.pdf

White House Office of Information and Regulatory Affairs, White House Office of Management and Budget, Department of Commerce, (2023). *Guidance For Assessing Changes In Environmental And Ecosystem Services In Benefit-Cost Analysis DRAFT FOR PUBLIC REVIEW*." White House. https://bidenwhitehouse.archives.gov/wp-content/uploads/2023/08/DraftESGuidance.pdf