CCICED

SPECIAL POLICY REPORT

Nature-Based Solutions (NbS)

2021

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contents

Introduction:

On March 15, 2021, in an address to the Ninth Meeting of the Central Committee for Financial and Economic Affairs, President XI Jinping reiterated China's goal of peaking carbon emissions and reaching carbon neutrality were part of the transition towards an ecological civilization that would "give full play to the ecological environment, including forests, wetlands and grasslands, in increasing carbon sinks."

In January 2021, the Ministry of Ecology and Environment (MEE) released Guiding Opinions on Integrating and Strengthening Efforts in Climate Actions and Ecological and Environmental Protection, which prioritizes holistic governance approaches to "integrating, coordinating and strengthening" climate and ecological and environmental conservation." Nature-based solutions (NbS) are identified in the guidance as a priority, as a means to

Mitigate and adapt to climate change, coordinating efforts to promote biodiversity protection and ecosystem restoration, taking the holistic approach to conserving mountains, rivers, forests, lakes and grasslands, enhancing the capability to adapt to climate change, and improving the quality and stability of ecosystems. In addition, urban-based solutions/urban green and blue infrastructure deliver multiple benefits for human health.

Interest in NbS at the international, national, and sub-national levels of government—among the business community and across conservation, climate mitigation, adaptation, freshwater management, agro-ecological regenerative food systems, and other communities—has increased in recent years. NbS are widely seen as supporting nature-positive and carbon-neutral pathways and as means to bridge the Kunming and Glasgow multilateral agendas. Accordingly, during the third quarter of 2020, CCICED convened a sub-committee on NbS to identify promising and urgent areas of forthcoming work. The sub-committee held meetings with Chinese and international experts, as well as two joint meetings (see Annex Two).

This report has benefited from these CCICED exchanges, as well as comments on various drafts. This final scoping report is organized thus: Part One examines some key concepts, scientific evidence, challenges, and research trends. Part Two provides examples of NbS at the economic sector or other levels. Part Three provides NbS case studies. Part Four examines ways to measure NbS. Part Five provides examples of NbS governance approaches. The report concludes with the following recommendations:

1.NbS should be a topic of future CCICED work, including through the creation of a new Special Policy Study. Such work should be coordinated with CCICED's ongoing work related to biodiversity, climate mitigation, climate adaptation, and integrated water resource, as well as international work including the green Belt and Road Initiative (BRI), green supply chains, and green/conservation finance.

2.Additional CCICED recommendations include:

a.Identify key sectors, regions, and objectives to advance NbS, as well as adopting a clear, coherent definition of NbS that includes appropriate safeguards. The 2021 Food Systems Summit is an opportunity for CCICED to identify eco-agriculture, regenerative and other approaches;

b.Identify opportunities for international NbS cooperation, including through South–South cooperation, innovative green BRI financing and other opportunities;

c.Establish a database and portal of NbS case studies, with clear criteria;

d.Apply innovative measurement of NbS outcomes, including through the use of inclusive wealth;

e.Identify policies and partnerships needed to implement NbS.

Part One: Background and Definitions

NbS at the project level have existed for decades, under different categories and definitions, such as the Ecosystem Approach and ecosystem-based approaches for climate change mitigation and adaptation and disaster risk reduction (endorsed by Parties to the UN Convention on Biological Diversity [CBD], in relation to different project features of integrated water resource management [IWRM]), to support natural disaster risk reduction measures and to support various aspects of agro-forestry, sustainable agriculture, urban green and blue infrastructure, and sustainable livelihoods.

As the 2021 MEE Guideline underscores, NbS play an important role in forest and other ecosystem conservation linked to climate mitigation. An important platform launched in 1997 in support of the UN Kyoto Protocol were project financing, related assessment tools, and methods intended to reduce emissions for deforestation and degradation (REDD). In 2008, at the United Nations Framework Convention on Climate Change (UNFCCC) 14th Conference of the Parties (COP 14), REDD was modified to REDD+ in order to support measures to enhance carbon stocks in forests. Since the inclusion of REDD+ in the 2015 Paris Climate Agreement, examples of project finance similarly related to carbon sinks include the World Bank Forest Carbon Partnership Facility, the African Forest Landscape Initiative, the Bonn Challenge, and the Architecture for REDD+ Transactions.

While carbon sequestration is one important reason for the increased attention to NbS, a critical assumption is a need for NbS to support multiple concurrent natural and human capital benefits and outcomes. The breadth of definitions linked with NbS underscores this key point. Examples include ecosystem-based adaptation, natural climate solutions, ecosystem-based disaster risk reduction, natural water retention measures, and other terms associated with climate adaptation; climate nature solutions, biological-based carbon capture and storage, biological engineering and others associated with climate mitigation; climate-smart agriculture, conservation agriculture, sustainable ecological restoration, regenerative food systems, nature-positive food production systems associated with sustainable food systems; and engineering with nature, green infrastructure, and others linked with green infrastructure. Many NbS concepts have strong links to ongoing work related to conserving, measuring, monitoring, and monetizing ecosystem services. For example, recent work by the World Economic Forum (WEF) identifies actions to advance a nature-positive food, land and oceans system, with multiple actions linked to NbS measures.

WWF defines NbS for climate as “Ecosystem conservation, management and/or restoration interventions intentionally planned to deliver measurable positive climate adaptation and/or mitigation benefits that have human development and biodiversity co-benefits managing anticipated climate risks to nature that can undermine their long-term effectiveness.”

Recent work by the Food and Agriculture Organization of the United Nations (FAO) and The Nature Conservancy (TNC) on NbS (January 2021) refers to the International Union for Conservation of

Nature's (IUCN's) 2016 definition. This IUCN definition and the more recent publication of its gold standard for NbS now serve as an important common definition of NbS:

Actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits. (IUCN, 2020).

In addition to global definitions, several governmental bodies have advanced their own NbS definitions. For example, the European Union defines NbS as:

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. Nature-based solutions must therefore benefit biodiversity and support the delivery of a range of ecosystem services.

Protect First: The IUCN definition establishes a useful sequence of NbS priorities, beginning with protecting existing ecosystems. Protecting forests, habitat, and ecosystems, as well as species, is of pressing importance in light of scientific reports of worsening trends in global ecosystem losses (IPBES, 2019), including the accelerating loss of tropical forests (Global Forest Watch, 2020; FAO 2020, Butler, 2020). The loss of forests has a double or dual-materiality negative climate effect, by reducing and degrading carbon sinks while contributing to net greenhouse gas (GHG) emissions arising from forest burning for land clearing as well as forest fires. The loss of tropical forests is among the most urgent global ecological and climate challenges due to their dual role in terrestrial biodiversity and carbon sequestration (see Table 2 below).

The IUCN definition further underscores the importance of ensuring human well-being in NbS. Since landscape-based NbS entail localized efforts like avoided fuelwood harvesting, agroforestry management, cropland nutrient management, avoided grassland conversion, improved rice and legume cultivation (TNC, 2020), or animal husbandry practices, people-centred NbS projects and policies are central to their success. Finally, IUCN underscores the importance of ecosystem restoration, either by allowing landscapes to be left undisturbed and recover (Mimgming et al., 2018) or via policy interventions like the Trillion Trees reforestation or similar initiatives.

Safeguards: While NbS can support multiple benefits, win–win outcomes are neither automatic nor easy. Problems with NbS projects that focus only on one outcome—for example, scaling up or expanding carbon sinks—risk detrimental ecosystem impacts. For example, introducing non-native monoculture species in large-scale afforestation or reforestation projects could yield carbon mitigation outcomes to the detriment of ecosystem integrity, biodiversity, and local communities. (IPBES, 2019). Similarly, NbS projects that support climate adaptation through the restoration of coastal mangroves

have been shown to have significant benefits in reducing flood risk and helping local communities (see Part Three examples). However, without due diligence, planning, consultation, and safeguards, mangroves could risk upstream and downstream freshwater availability (IUCN, 2018).

The IUCN Global Standard for Nature-Based Solutions sets out the principles and higher-level guidance on NbS safeguards. Eight criteria that elaborate these safeguards include governance and community-level engagement principles, the importance of NbS transparency and measurement, and quantitative safeguard criteria such as ensuring all NbS projects move beyond "do no harm" principles to achieve durable net positive outcomes (IUCN, 2020).

Recommendation: CCICED should support work by China in aligning its definition of NbS with IUCN and other international definitions while taking into account its own theories, practices, governance models, and international partnerships.

Part Two:Emerging Sectors, Systems and Places

NbS are being implemented in different economic sectors (such as agriculture), at different scales (for example, within urban clusters and wider freshwater basins), in different ecosystems (for example, forests or grasslands). Below are illustrative examples of how NbS are being applied. Future CCICED projects will align key sectors, systems, and places with criteria that will also guide case study selection.

Sustainable Food Systems

Many current agricultural production systems and related farm policies are unsustainable, including contributing to ecosystem, habitat, and biodiversity loss through land-use change, to freshwater scarcity, nonpoint pollution, and the depletion of aquifers for irrigation and on-farm uses, to organic soil degradation, as well as to climate change. Agriculture is also increasingly vulnerable to climate-related extreme events like prolonged drought, flooding, wildlife, and changing insect vectors.

A 2020 review by the European Commission concluded that current soil management practices associated with intensive agricultural practices led to significant losses of soil organic content, whereby most of Europe's agricultural soils were likely to be "net contributors to rather than sinks of atmospheric carbon" (Wild, 2020). Agriculture is also a major net source of GHGs, notably carbon dioxide, nitrous oxide, and methane. The Intergovernmental Panel on Climate Change (IPCC) recently concluded that the combined effects of agriculture, deforestation, and other land uses were responsible for approximately one third of GHGs, including 40 percent of methane emissions (IPCC, 2018). The 2020 European Commission analysis concludes that the sustainable management of agricultural landscapes offered greater carbon benefits compared to forestry/afforestation, urban sequestration, or blue NbS projects, including protecting and restoring seagrass and salt marshes. (Wild, 2020).

An extensive literature review showcases conservation/sustainable agriculture, including low-tillage or no-tillage practices, to reduce emissions and practices to increase physical organic soil properties leading to enhanced carbon storage (AgEvidence). Rewilding landscapes can help restore ecosystems, increase biodiversity, and support climate mitigation, including replacing ruminant livestock with native species to reduce methane emissions (Sandom, 2020).

Following decades of work (Nordstrom, 1999; OECD, 2002), reducing and eliminating environmentally harmful agricultural subsidies has gained new policy traction because of accelerating global threats to nature as well as the gap in conservation finance. The 2020 Financing Nature report recommends that an early step needed to close the global biodiversity conservation funding gap is to identify, reduce, eliminate, and reform the approximately US$540 billion governments spend annually on agricultural, forestry and fishery subsidies (Paulson, 2020). Other recent examples of work to reform agricultural subsidies include The Little Book of Investing in Nature of the French development agency (AFD, 2020) and ongoing work by the International Monetary Fund in the context of fiscal policy reform (IMF, 2020).

At the policy level, the European Union announced steps to align its Common Agricultural Policy with the EU Green Deal, including through its Farm to Fork program and other actions. China's Clean Plate initiative is an important national plan to reduce food waste; the FAO estimates that, globally, one third of all food is wasted annually, increasing to 45 percent for all fruit and vegetables (FAO Food Loss Index).

The 2021 UN Food Systems Summit, to be held in September 2021, will be an important opportunity to advance sustainable food systems, including via NbS. The Summit offers an opportunity to better align separate tracks of the multilateral system, including linking to the UN CBD agenda with sustainable food systems. Of the five Action Tracks of the Summit, WWF International is the co-lead of Action Track Three: Boosting Nature-positive production.

Table 1 UN Food Systems Summit: Action Track Three

Action Track Three aspires to
(a) Protect natural ecosystems against new conversions for food and feed production;
(b) Sustainably manage existing food production systems to benefit both nature and people; and
(c) restore and rehabilitate degraded ecosystems and soil functions for sustainable food production (UN Food Systems Summit).

Recommendation Two: The 2021 UN Global Food Summit provides an opportunity to advance agriculture-related NbS. CCICED should convene an informal meeting to examine opportunities for NbS to support the UN Food Systems Summit.

Terrestrial Ecosystems

Scientific estimates suggest between 33 (IPBES 2019; UN CBD SBSTTA, 2019) to as much as 37 percent (Griscom et al., 2017) of the global climate mitigation needed to meet the Paris Climate Agreement can be achieved through NbS in a cost-effective way. The IPCC concludes that NbS are "indispensable" to achieving carbon neutrality.

Annual deforestation accounts for approximately 10 percent of global GHG emissions, the second-largest single source after emissions from fossil fuels (UNFFF, 2018).

Table 2 Two functions of forest to absorb carbon

Carbon storage	Carbon sequestration
The absolute quantity of carbon held within a reservoir is referred to as a carbon stock. This reservoir is a component of the climate system, other than the atmosphere, which has the capacity to store, accumulate, or release carbon. Oceans, soils and forests are examples of reservoirs of carbon.	The process of increasing the carbon content of a carbon reservoir other than the atmosphere. Biological approaches to sequestration include the direct removal of carbon dioxide from the atmosphere. Vegetation removes carbon dioxide from the atmosphere through photosynthesis.

Source: Wild, 2020; European Commission

A widely cited Science (2019) article noted that planting trees on a massive scale and sustained period of time "is one of the most effective solutions at our disposal to mitigate climate change" (Bastin, 2019). For example, planting trees has the potential to sequester up to 20 percent of U.S. GHG emissions annually by fully stocking currently under-stocked productive forests (Domke, 2020).

Other research suggests leaving nature unperturbed to restore itself can contribute more in terms of carbon sequestration than previously estimated, underscoring the importance of ecosystem protection prior to reforestation or afforestation. The most extensive empirical evaluations of forest sequestration rates (based on some 13,000 geo-referenced studies) conclude that allowing natural regeneration may be preferable to afforestation. A Nature 2020 article concludes that the IPCC estimates of the carbon sequestration potential of standing forests may underestimate above-ground carbon accumulation by 32 percent, significant variance among different eco-regions, and overestimated natural forest regrowth by 11 percent (Cook-Patton, 2020).

The table below provides a higher-order comparative estimate of global carbon stocks by major ecosystems. The estimates are based on the geographic extent and average carbon content per hectare of different ecosystems, measuring above-ground, below-ground, and soil organic carbon up to 30 cm depths.

Table 3 Estimate of global carbon stocks by major ecosystems

Ecosystem	Typical carbon density (tonnes of carbon per ha)	Estimated global carbon content (Gt C)
Mangroves	502	7.3
Seagrass	111	5.0
Marshes	265	5.6
Boreal forests	264	283
Temperate broadleaf forests	268	133
Temperate conifer forests	272	66
Tropical dry forests	166	14
Tropical moist forests	252	295
Boreal peatlands	500	181
Temperate peatlands	500	9.3
Tropical peatlands	504	30
Temperate grasslands	77	39
Tropical grasslands	43	30
Montane grasslands	104	27

Source: Based on Goldstein et al., 2020.

The table below provides a snapshot of the different time frames for carbon sequestration by ecosystem, underscoring the sequence of the IUCN and other definitions to protect and sustainably manage first, and then look to restoration and remediation to realize climate benefits.

Table 4 Different time frames for carbon sequestration by ecosystems

Ecosystem	Average time to recover vulnerable carbon, if lost (years)
Tropical grasslands	19
Temperate grasslands	35
Montane grasslands	205
Tropical most forests	60
Tropical dry forests	77
Temperate broadleaf forests	78
Temperate conifer forests	78
Boreal forests	101
Marshes	64
Seagrass	93
Mangroves	153
Boreal/temperate peatlands	More than 100
Tropical peatlands	More than 200

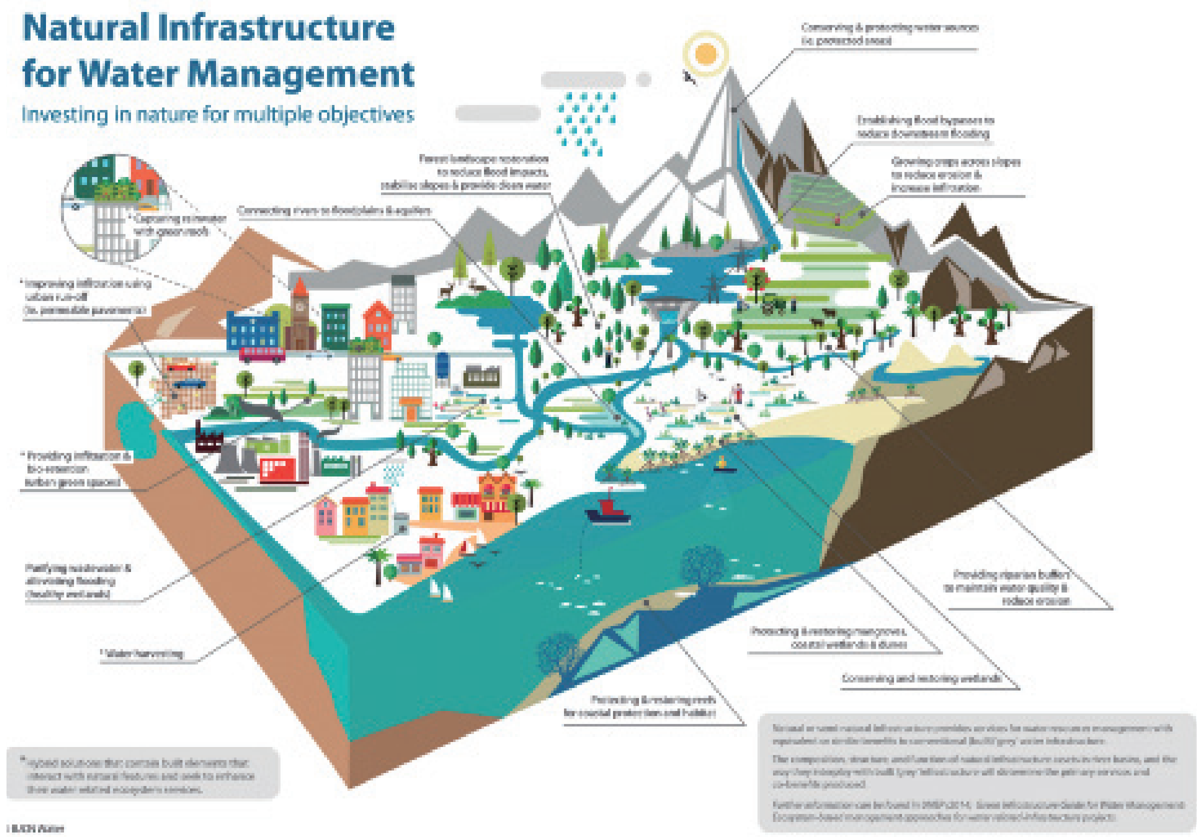
Source: Goldstein et al., 2020.

Recommendation: CCICED should identify best-in-class sequestration verification systems, including third-party certification, fit-for-purpose accounting systems, and other safeguards.

Water Management

Protecting and restoring ecological processes in a landscape can have important impacts on hydrology. Evidence also suggests that NbS closely associated with ecosystem services contribute to water quality. Examples include enabling wetlands to help purify wastewater, improving nutrient management to reduce nutrient runoff, and other nonpoint sources of water pollution (UN & World Water Development Report, 2018). China is a world leader in using NbS to reduce flood risk through some 30 Sponge City initiatives.

Examples of NbS contributions to freshwater management include:



Source: IUCN 2020

Sponge Cities: An important source of NbS innovation is China's advancement of sponge cities. In 2014, China launched its Sponge City strategy to mitigate urban water risks in urban areas. The objective of the strategy is to ensure that that urban areas are capable of absorbing and reusing a large proportion of stormwater linked to typhoons, coastal flooding and other events. Since different cities have different flood risk exposure, depending on location, hydrological and other characteristics, sponge city targets and indicators have been tailored based on science-based targets (Li, 2018). A number of pilot initiatives involving some 30 cities—including Beijing, Shanghai and Shenzhen—together comprise an estimated US$300 billion in green-blue infrastructure investments, including

urban wetlands, rain gardens and artificial ponds as catchment areas, and permeable pavements designed to decrease flooding risk (World Bank/OECD/UNEP, 2020). China has also been partnering with TNC in piloting buildings that contribute to sponge city objectives, as well as exploring the role of innovative green finance (for example, in the issuance of environmental impact bonds).

Recommendation Three: NbS should be one area of focus in CCICED's forthcoming work in the Yangtze and Yellow River basins, with proposed pilot projects to deploy NbS-related flood control grey infrastructure. Preliminary work should include project-level cost-benefit analysis.

Sustainable Cities

Many examples of urban NbS projects reduce climate-related hazards such as heat island effects, flooding, or landslide risk from deforested hillsides. Urban NbS projects vary from enhanced vegetation cover, expanding or creating new green spaces, building green roofs or vertical gardens, and using hybrid green and grey infrastructures like stormwater ponds, bioswales, or the restoration of riparian zones to restore natural hydrologic functions (Hobbie & Grimm, 2020). The European Union's Urban Nature Atlas classifies 12 categories of co-benefits from over 1,100 urban NbS projects, several of which are cross-referenced with the Sustainable Development Goals (SDGs).

Table 5 Urban NbS benefits linked to the SDGs:

Benefit	SDG
Climate adaptation, resilience, and mitigation	SDG 13
Coastal resilience and marine protection	SDG 14
Economic development and decent employment	SDG 8
Environmental quality, including air quality and waste management	
Green space, biodiversity, and habitats	SDG 15
Health and well-being	SDG 3
Inclusive and effective governance	SDG 16
Regeneration, land use, and urban development	
Social justice, cohesion, and equity	SDG 10
Sustainable production and consumption	SDG 12
Water management	SDG 6

Source: Naturvation

Oceans

Oceans play a role in mitigation and adaptation (WRI, 2021). Evidence, for example, suggests that marine benthic soft-sediment ecosystems provide important habitat, thereby playing an important role in regulating biogeochemical cycling, climate-active gases, ocean chemistry, and the removal of carbon from the ocean-atmosphere system. One example is the role of marine megafauna in enhancing vertical nutrient transfer through cetacean deep-feeding, surface defecation, and physical mixing, which in turn is estimated to affect carbon sequestration on a large scale (Solan, 2020).

Recommendation: In follow-up CCICED research, an analysis should identify a comprehensive list of eligible economic sectors, ecosystem services, and geographic regions with promising NbS opportunities, including agriculture, infrastructure, and resource extraction.

Part Three:Tools and Case Studies

Maps and Spatial Planning

The UN CBD's Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA, 2019) notes the importance of comprehensive spatial planning to integrate climate and biodiversity. Land use represents 13 percent of global carbon dioxide emissions, 44 percent of methane emissions, and 81 percent of nitrous oxide emissions. Land is also a net source of emissions, driven largely by deforestation and partially offset by afforestation and reforestation (IPCC, 2019).

Tools to understand the characteristics of different landscapes have long been deployed for conservation and protected area planning. By contrast, they have been used far less in planning for carbon sinks. However, this is changing with China as a global leader: the Ecological Redline is being used to delineate both areas for nature protection and carbon benefits. Other examples of maps and landscape-level planning tools linking biodiversity and carbon sequestration include:

- Nature Map provides beta data on terrestrial biodiversity, biomass carbon density, threatened species, human impacts on forests, and other indicators.
- The Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) tool identifies the location and estimated value of ecosystem services that sustain human capital.
- The United Nations Development Programme Essential Life Storage (ELS) Areas Map provides geospatial information on areas that conserve biodiversity and provide food, water, and carbon storage services. Two pilot maps under the ELS platform for Costa Rica and Uganda triangulate the location of opportunities to advance the SDGs, the UNFCCC, and the UN CBD.
- Other examples include the AgEvidence data portal, supported by TNC and agro-environmental integrated opportunities in the U.S. Midwest.

Experts recommend that maps are included in both Nationally Determined Contributions as well as the National Biodiversity Strategies and Actions Plans of the UN CBD (NBSAPs) to realize at the implementation-level synergies and integrated implementation (Khan & Schmidt-Traub, 2020).

Recommendation: CCICED should identify how China can effectively exchange experiences with international partners in the use of large-scale spatial planning and the Ecological Redline, including regions within countries with important biodiversity, carbon sequestration, human capital and other endowments. The 2021 China-Africa Summit, the green BRI, South–South cooperation, and other platforms provide opportunities to share such experiences.

Case Studies

There are thousands of NbS case studies. Several useful and accessible online NbS portals exist to share experiences about NbS features; examples include the United Nations Environment Programme (UNEP) NbS Contribution Platform, which lists almost 200 initiatives (including roughly 40 from China); the Compendium of Contributions of NbS prepared by New Zealand and China in support of the 2019 UN Climate Action Summit; the Urban Nature Atlas; the Panorama Solutions for a Healthy Planet portal; the Science for Nature and People Partnership; the U.S. Army Corps of Engineers Engineering With Nature atlas; EcoShape; and others.

The Urban Nature Atlas is accompanied by an interactive scenario planning tool to estimate individual and simultaneous NbS policy pathways, expected outcomes and budgets (https://www.urbannatureexplorer.com/#/ExploreSite).

Below are some examples of NbS case studies. Preliminary criteria guiding case study illustration focus on their primary objective (flood protection, urban heat islands, forestry conservation, watershed management, etc.). Experts of the sub-committee emphasized the need for criteria to highlight multiple non-linear ecosystem linkages, including co-benefits measured over long time periods (see Annex Two).

Coastal Flood Protection

Coastal Protection, Tanzania: In order to reduce the risk of coastal flooding from sea-level rise, more extreme storms, and higher average wave height, a coastal defence system based on ecosystem-based adaptation combining grey and green infrastructure was implemented in Tanzania with the support of the Global Environment Facility. The coastal defence comprises 2,400 m of seawalls and dikes, the restoration of approximately 1,000 ha of mangroves, and 3,000 m2 of coral reefs. In addition, 2,300 m of drainage systems were created to reduce waterborne insect breeding spaces and lower public health risks; no-take zones were established in nearby forests; and enhanced rainwater collection services were created through boreholes and other collection devices. The project evolved from bottom-up community and household engagement. The project goal is to benefit 500,000 people (UNEP, 2019).

Coastal Flood Protection: Salt Marshes in Flood Protection, Wadden Region Delta Program, the Netherlands. The Netherlands is particularly vulnerable to climate-related coastal flooding from heightened sea levels, extreme surge levels, extreme wave heights, and more powerful wind conditions. The project focused on maintaining and enhancing coastal flood protection using green infrastructure by increasing barrier islands, salt marshes, and inter-tidal areas with a steady resupply of sediments. By bolstering natural barriers across approximately 9,000 ha, wave impacts were reduced while enlarged salt marches provide valuable new habitats to several plant and bird species. They also have new green spaces for tourism through walking paths, bird-watching, bicycle paths, mudflat hiking, and

other activities. An interpretation centre to support education about the functions of the marsh opened in 2016 (van Loon-Steensma, 2015).

Mangrove Forest Restoration, Costa Rica: Since the 1980s, Costa Rica has lost an estimated 25,000 ha of mangroves, more than 40 percent of the country's total. This local trend mirrors a grim global picture, in which 30 to 50 percent of the world's mangroves have been destroyed or depleted, making mangroves one of the world's most threatened tropical species. As mangroves cleared, they were replaced by aggressively growing ferns (Acrostichum aureum), which grow up to 3 metres and block the regrowth of new mangroves.

The goal of the NbS project is to clear 2,000 ha of invasive ferns, thereby allowing mangrove regrowth. The first phase of the project has led to the clearing of 30 ha and the planting of 28,000 mangrove saplings. The benefits of this project include local employment; community receiving payments of $1,500 per ha to restore mangroves, with the potential of 100 ha per year; harvesting of local mussels that grow in mangrove forests; and multiple climate benefits related to carbon storage in mangroves and increased coastal resilience (Whitworth, 2020).

Urban Green Infrastructure

Sponge City, Shenzhen: In 2016, Shenzhen became an early pilot city of China's Sponge City initiative by deploying green infrastructure to reduce the risk of urban flooding. Shenzhen has been prone to flooding, exacerbated by the widespread use of paved surfaces and storm pipes designed to remove as much water as quickly as possible, resulting in both capacity limits during extreme events and land-based pollution during runoff into the bay. Examples of green infrastructure to capture rainfall include green roofs, planted areas for catchment services, restoring urban forests and green spaces, and building water retention ponds and urban wetlands, which together help mimic the natural functions of catching and slowing filtering and releasing water. Green roofs in Shenzhen have also shown promising impacts in reduced urban heat islands (Bao-Jie et al., 2019).

Green Infrastructure, Tara River, Kenya: The Tara River is the source of 80 percent of Nairobi's drinking water supply, 70 percent of the region's hydroelectricity, and the source of 645 km2 of farmland irrigation. Decades of conversion of riverbeds and hillsides to farmland have increased soil erosion and sedimentation, decreased the integrity of the basin's reservoir, and increased water treatment costs. The NbS includes improving the river's riparian management, creating hillside terracing, and restoring degraded lands, including adding grass strips on farms adjacent to the river. The Nairobi City Water Supply and Sewage Co., a partner in the project with local conservation and other groups, has reported source water benefits that include avoided filtration and lower energy costs for treatment. The 10-year US$10 million project is projected to deliver $21.5 million in benefits over 30 years (World Water Development Report, 2018).

Greater Cape Town Water Fund, Cape Town, South Africa: Confronting an acute water supply crisis, in 2018 Cape Town, developed a new business plan informed by consultations, modelling, and other steps. The plan focused on investing US$25 million in the restoration of the city's upper watershed catchment area. By protecting the upper catchment area's natural systems, the project estimated that 100 billion litres of fresh water would be supplied within 30 years, of which half would be available within five years. The study concluded that, at one tenth of the cost of alternative options, catchment restoration was significantly more cost effective than other water supply augmentation solutions, including grey infrastructure solutions (Panorama).

Grey to Green Project, Sheffield, U.K.: Under the project's first phase, an old redundant concrete highway was replaced with a 1.2-km urban green space of wildflowers, trees, and shrubs that includes trails and benches. In addition to providing the local population with access to green spaces (and a local art installation), the greenbelt also functions as an urban drainage system, thereby reducing flood risk, including by creating natural rain gardens. The project won a number of awards in 2016, including the Eric Hughes Award for Outstanding Contribution to Improving Sustainability.

Green Infrastructure Plan, New York City, United States: Grey and green infrastructure are being used to capture urban stormwater runoff, including by using bioswales and green roofs to capture 90 percent of excess water during wet weather events while enhancing biodiversity and reducing daytime urban air temperatures. A 2.7 ha. green roof on the city's main convention centre retains more than half of storm event precipitation, thereby reducing storm runoff pollution and flooding (World Water Development Report, 2018)

Urban Tree Cover Reduces Extreme Heat: Upper Midwest, United States: Increasing urban tree cover helps regulate extremely hot temperatures. A pilot project in Madison, Wisconsin, was comprised of planting trees along roads and intersections and then measuring changes in average heat levels throughout the day, then comparing day and night. The results showed that air temperature decreased with increased tree cover: an increase in average tree cover by up to 100 percent led to a decrease in average daytime temperatures of 0.7°C over a 10-km range and up to 1.3°C over a 30-km range (Ziter et al., 2019).

Wetlands

Wetland Protection and Restoration, Bow River and South Saskatchewan River, Alberta, Canada: Following extreme flooding in 2013, interest in NbS to reduce flooding hazards focused on protecting existing wetlands and restoring others. The region had lost over 60 percent of its natural wetlands, which had been drained for farming, grazing, or construction. Project analysis, modelling, and consultations concluded that it was more cost effective to invest in wetland restoration than build additional grey infrastructure. NbS saved an estimated USD 257 million—saving $10,000 per ha in rural areas from averted flood damages and doubling that savings closer to the urban centre of Calgary.

Peat Land Restoration, Belarus: Belarus is leading European efforts in peatland restoration. In the past decade, an estimated 50,000 ha of degraded peatlands have been restored—primarily in the Białowieża Forest, one of Europe's last remaining primary forests. The forest, which is a UNESCO World Heritage Site and an Important Bird and Biodiversity Area, houses some 250 bird species (Bird Life International, 2016). The government announced plans to preserve 29 percent of its total peatland by 2030. The benefits include enhanced carbon sequestration, improved water quality, and improved biodiversity protection (University of Oxford, 2020).

Flood Management in China's Yangtze River Basin through River and Lake Connectivity: After the 1998 Flood, the WWF began to think about the protection of the Yangtze River at the basin level, especially in the areas of wetland protection, river and lake connectivity, ecological dispatch, and integrated watershed management policy advocacy. WWF hopes to work with the government, enterprises, and the public to reshape the Yangtze River as a "river of life". Since 2002, WWF has helped the Chinese government develop a river and lake connectivity plan to manage floods through economically viable nature-based solutions. By 2010, there were more than 30 lakes in the Yangtze River basin, about 2000 square kilometers of seasonal river and lake connectivity. Plus Poyang Lake and Dongting Lake as two natural lakes connected to the river, there are nearly 6000 square kilometers of lakes connected to the Yangtze River. There is flood control capacity of 1.5 billion square meters added. Among them, Dongting Lake and Poyang Lake Wetlands have the same flood control capacity as the $45 billion Three Gorges Dam. At the same time, the number of 39 threatened species has increased, and 30 million people has access to cleaner water resources.

Ecological Aquaculture Management of Ramsar Wetland in The Back Bay of Mai Po Nai, Hong Kong: Located in the Inner Back Bay at the mouth of the Pearl River, the Ramsar Wetland in Mai Po Nai are composed of tidal beaches, mangroves, marshes, traditional shrimp ponds (metapenaeus ensis) and fish ponds, providing wintering and transit habitats for more than 80,000 water birds each year. The area has recorded more than 400 species of birds, including 24 globally endangered birds that depend on wetlands. Their survival depends on the quality of the wetland. Mi po's aquaculture operation is a good example of how semi-artificial habitats can support high biodiversity with proper management. In the 1950s, most of Mipo's coastal mangroves were converted into tidal culture ponds, which also retained mangroves that feed shrimp, oysters and fish. After rotating drainage, the ponds attract water birds to prey on the remaining small fish or invertebrates. Currently, most shrimp ponds are managed as habitats and foraging habitats for migratory birds (Wikramanayake et al., 2020). In addition, there are innovative methods on Mai Po, such as grazing Buffalos in the freshwater wetland, which is more effective to attract water birds than artificial methods (WWF-HK, 2012). Except for bird watching and environmental education participants, human activities in the Ramsar Wetland are severely restricted, while in commercial fish ponds next to nature reserves, farmers are involved in the implementation of ecological farming methods appropriate to wetland conservation. As a result, this well-managed wetland area supports important carbon sinks and biodiversity hotspots.

Forests

China's Sloping Land Conversion Programme (or Grain for Green Programme) is one of the world's largest tree-planting projects. Established over two decades years ago, covering 25 provinces, and involving some 124 million people, the project has converted some 28 million ha of croplands on steep slopes to forests and grasslands. Farmers are supported through direct payments or grain supplies in exchange for conversions. The program's multiple objectives include reversing deforestation and land degradation, addressing climate change, supporting biodiversity, and alleviating rural poverty. A 2016 analysis suggested that soil erosion decreased, forest cover increased by 10 percent, and carbon storage increased. At the same time, progress can be made in tree mix away from monoculture species to support wider biodiversity outcomes (Hua et al., 2016).

Forest Conservation, Gabon: In 2019, Gabon and Norway finalized a USD 150 million agreement over 10 years by which payments would be made to leave standing forest intact as a means to finance habitat protection, avoid deforestation, maintain important forest carbon sinks, and avoid GHG emissions from deforestation and land degradation. The agreement is coordinated through the Central African Forest Initiative (CAFI). The agreement supports Gabon's ongoing efforts, including the creation of 13 national parks since 2000—of which one is a UNESCO Natural Heritage site—and support for sustainable forest management outside of parks. Through these measures, large tracts of Gabon's forests are intact and home to 60 percent of the threatened African forest elephants. The Norway-Gabon forest agreement is viewed as a model for other agreements in the West African and Central African forests in mitigating climate change (CAFI, 2019).

Ranch Systems and Viability Planning Network, U.S. Northern Great Plains: Led by the World Bank, this project provides support to ranchers in Montana, Nebraska, and South Dakota to improve cattle grazing practices over 1 million ha of land. Benefits include improved grasslands, increased carbon sequestration, and improved ecosystem protection. Support to ranchers includes individual knowledge sharing, training, financial support, and tools for monitoring to measure conservation and climate outcomes. The region supports 1,595 species of plants, 300 bird species, 95 mammal species, 28 reptile species, and many important pollinators. Launched in 2020, partners of the project that support sustainable sourcing include McDonald's, the Walmart Foundation, Cargill and WWF.

Integrated Farming, Forestry and Livestock Approach, Guatemala: Guatemala has taken ambitious actions to mainstream ecosystem-based adaptation measures into its national development plan, Plan K'atun 2032. The country continues to advance innovative governance systems, including enabling legislation, community-level consultations, financing, the development of a roadmap to upscale projects, and other measures. Today, the country has the largest number of climate adaptation projects of any Central American country. The project supports a shift from intensive, single-crop production to extensive inter-cropping that blends primary crops—maize and potatoes—with the addition of

secondary crops like beans and vegetables, as well as sheep grazing. In the past decade, there has been a significant increase in overall crop yields; communities have been involved in forest conservation and agroforestry practices that have built community resilience to climate-related crop failures, disease, and pests (International Climate Initiative/PAGE).

Mountain Ecosystem Restoration, Nor Yauyos, Peru: Changes in average temperatures coupled with extreme weather events like hailstorms adversely affect livestock and farm livelihoods. The project has involved restoring water channels and reservoirs to increase freshwater supply security; protecting grasslands to enhance pastoral livelihoods and increase resilience to drought and frost; enhancing the protection of a local species, the vicuña, used to produce animal fibre; and enlarging communal livestock management in natural grasslands. The benefits of the project include enhanced carbon storage in grasslands; a six-fold increase in the capacity per hectare of grasslands to support sheep grazing; reduced overall pressure on pastures, wetlands, and alpine ecosystems; improved indicators of biodiversity; and enhanced local governance and engagement (UNDP et al., 2016).

Recommendation: CCICED should develop criteria to share international case studies, including (a) case studies that demonstrate climate adaptation, climate mitigation, and nature-positive outcomes in a quantitative way; (b) that provide information on how safeguards were designed and implemented; and (c) quantitative analysis of costs and benefits. In order to support South–South cooperation, CCICED should synthesize data, maps, and other information from leading countries with high-value ecosystems, carbon sinks, and human capital estimates. Finally, CCICED should prepare and update an online portal of case studies.

Part Four: Measuring NbS Outcomes and Benefits

Measuring and quantifying NbS benefits is complex. Different NbS projects use different baselines, scales and time frames. Comparing NbS benefits with comparable engineering-based approaches is one way of estimating the relative NbS costs and benefits compared to grey infrastructure projects. Several case studies noted above compare these kinds of comparative savings. However, drawing wider measurement conclusions of NbS performance in its own right remains challenging.

Estimating Carbon Stocks

Methods to calculate carbon sequestration of land use, land-use change, and forestry (LULUCF) have been elaborated for 25 years; the IPCC's 2006 Revised Guidelines for National Greenhouse Gas Inventories set out good practices for national- and project-level GHG accounting, including accounting of LULUCF inventories. The 2019 IPCC refinement of those 2006 guidelines has standardized GHG inventory methodologies, including updated methods (Volume 4) regarding agriculture, forestry, and other land uses.

Table 6 The definition of carbon budget

Carbon budget: The balance of the exchanges of carbon between carbon pools or within one specific loop (e.g., atmosphere – biosphere) of the carbon cycle. This is a generic definition of "carbon budget" in the context of national GHG inventories. This term may be defined with other specific meanings in other contexts (IPCC, 2019).

The 2019 IPCC guidance marks an important step in standardizing GHG inventory methods. At the same time, methodological challenges remain. For example, many GHG inventories are based on statistical extrapolation drawn from limited field samples. Any extrapolation poses accuracy challenges at the micro level—for example, landscapes and ecosystems differ while inventories are less adept at estimating carbon fluxes such as annual changes in carbon stocks (for example, from wildfires). Given the growing interest in sequestration among private sector actors, there are many third-party carbon sequestration certification bodies, including Verified Carbon Standard, Carbon Trust, Climate, Community and Biodiversity Alliance and others.

The California Air Resource Board 2018 GHG inventory technical update provides a highly useful example of state-level GHG inventory methods based on the 2016 IPCC guidance, including the use of maps; the rationale for using the atmospheric flow approach to account for carbon fluxes to/from the atmosphere for lands and wood product pools, including from imported products; the use of land-fire data; and options to augment field-based monitoring with the application of remote-sensing tools to provide up-to-date estimates of changes in carbon stocks.

Examples of national-level GHG inventory systems and tools based on IPCC guidance related to LULUCF carbon sequestration include the Natural and Working Lands (NWL), in partnership with TNC, WRI and other groups under the US Climate Alliance and the US Environmental Protection Agency State Inventory and Projection Tool. The scope of NWL inventories comprises forests, wetlands, grasslands and shrubs, croplands and rangelands, wetlands, and urban areas, underscoring differences in carbon sink and sequestration characteristics between different biomass systems. As a further illustration, inventories differentiate the carbon attributes of wetlands into tidal wetland restoration, peatland restoration, avoided seagrass loss, and seagrass restoration.

Estimating Costs and Benefits

There are various estimates of global NbS benefits. The estimated global value of coastal flood protection provided by coral reefs is US$270 billion (Beck, 2018). A review of 52 coastal NbS flood mitigation and storm surge protection projects concluded that, on average, these were 2¬–5 times more cost effective than grey infrastructure and related engineering solutions (GIZ & UNEP, 2020). A 2020 WEF report concludes that investing in a nature-positive economy would generate an additional US$10 trillion in annual business revenues and cost savings by 2030 and an additional 395 million jobs.

Such aggregated global estimates are helpful in providing orders of magnitude of wider returns on NbS investments. Analysis at the project level similarly suggests that NbS investments have the potential for lower capital and operating costs compared to grey/engineering solutions and higher multi-year returns on investment. For example, green roofs, green spaces, and tree canopy urban projects have recorded localized temperature cooling effects of between 0.5 and 7°C, within a cost range of US$10–US$100 per GHG cost/tonne equivalent of avoided emissions (Bowler, 2010). In turn, reduced exposure to extreme heat has been measured in reduced public health hazards and lower energy demand from air conditioning and industrial cooling (Naumann, 2011; European Commission, 2012).

Since well-designed NbS projects deliver multiple benefits simultaneously, valuation techniques used for ecosystem services are also used to quantify NbS outcomes. These services can include less climate-related flooding, increased carbon storage and sequestration, improved water management and drainage, stronger ecological protection, and human and social capital benefits (Keniger, 2013). NbS work has included estimating the value of a hectare of the urban forest at US$1,500 (Brander, 2011); an estimated value related to green tourism and recreational values per hectare of coastal ecosystems at US$4,700 (Ghermandi, 2013); and an estimated value of one m2 of green roofs at US$290 and US$700 (Bianchini, 2012).

A long-standing challenge in ecosystem valuation is linking the bottom-up valuation of localized actions with top-down or highly aggregated observations. The Economics of Biodiversity: The Dasgupta Report (February 2021) is an important contribution: it sets out a robust methodological framework for valuation to inform both micro and macro-level estimates. Drawing on ongoing work over several decades with more robust data and new methods, Dasgutpa's work in inclusive wealth estimates based on valuing natural capital, human capital, social capital, and produced capital have influenced ongoing work by the World Bank, (UNEP, 2018) and, more recently, aspects of the UN System of Environmental-Ecological Accounting.

However, aggregating or scaling up project-level benefit valuation to wider observations remains a key challenge. For example, a recent study estimates the global values of wetlands contribute US$7,000/ha per annum in flood control, US$3,400/ha in freshwater supplies, and US$5,800/ha in water quality services (Brander, 2013), with an estimated global aggregate in wetlands services of $26.5 billion per year. However, given the uncertainties in aggregating local service values, the study cautions that such estimates have a variance of as much as US$20.2 billion per year. This margin of error of 80 percent underscores continued challenges to the economic valuation of ecosystem services in general, including NbS outcomes.

A central conclusion of a 2020 review of NbS projects by the Global Environment Facility underscores the ongoing challenges in NbS outcome measurement and calls for

much more attention on the costs and benefits of interventions, assessed comprehensively across outcomes for both society and nature; and the need to consolidate some sort of evidence base in this regard that is linked to monitoring and evaluation that might give investors (whether public or private) more confidence of ... more 'bankable' returns on investment. (GEF STAP 2020)

Fit for Purpose: Annex One examines how inclusive or comprehensive wealth is fit for the purpose of NbS measurement. Standard economic measurement tools like cost-benefit analysis, cost-effectiveness analysis recommended in the IUCN Global NbS Standard, and economic impact analysis face shortcomings and limitations in assessing the full value of NbS performance outcomes. Since these standard economic frameworks do not serve NbS well, a more holistic approach is needed. Both the Dasgupta report and updated UN System of Environmental Economic Accounting are welcome in measuring how natural capital assets contribute to overall national wealth. At the same time, more work will be needed to bridge these national or economy-wide systems with measuring the inclusive wealth of NbS at the project level, particularly in measuring long-term effects on ecosystems as well as families, farmers, foresters, and communities from human and social capital perspectives.

Recommendation: CCICED should apply pilot new approaches to NbS measurement based on more holistic ecological or natural capital accenting within a broader inclusive wealth framework at the micro or project levels.

Part Five: Policies, Pathways, and Practices

An important challenge for China and others that are on a carbon-neutral pathway is moving from individual NbS projects to systems to implement them in an ecologically and equitable way that is at scale. Options for further elaboration include:

Green Financing: 2020 saw a significant increase in climate ambition, both in countries, of which, China's September 2020 carbon neutrality pledge was the most important, as well as in some 1,500 leading companies. For example, Transform to Net Zero (launched in mid-2020) includes companies like Danone, Microsoft, Mercedes-Benz, Maersk, Nike, and Starbucks, supported by the Environmental Defense Fund, sharing lessons in decarbonization. The UNFCCC's Race to Zero initiative comprises over 2,000 businesses, 127 of the world's largest investors, and over 500 universities, to achieve net-zero carbon emissions by 2050 or earlier.

Reflecting this growing decarbonization push, private markets are poised to expand investments in carbon sequestration to help meet targets. For example, the first 2021 report of the Task Force on Scaling Voluntary Carbon Markets estimates that investments in NbS-related carbon sinks could expand to between US$50 billion and US$100 billion in the future. This compares with total spending on forest conservation of US$2.8 billion (Food and Land Use Coalition, 2019), of which only US$159 million comes from voluntary carbon markets. The scale with which forest-related carbon sequestration investments are expected to increase has led to an increased debate about the ecological integrity of forest carbon sinks.

In anticipation of a significant expansion in private sector financing, it will be critical to ensure the integrity and transparency of project design, adoption of comparable accounting systems, and the implementation of safeguards that protect and enhance ecosystem integrity while providing benefits to local communities, farmers, foresters and others. Existing financing models, including water fund models and conservation trust funds, provide existing governance models to leverage increased financing.

One opportunity to make use of existing financing initiatives is the Conservation Reserve Program, administered to remove ecologically important lands from agricultural production; restore native trees, grasslands and shrubs to protect water quality; decrease soil erosion; and increase habitat. Approximately US$2 billion has been provided to landowners under this voluntary program, which has led to over 100,000 km2 in land designated, with a contract duration of 10–15 years. Aggregate results include a reduction of nitrogen and phosphorus runoff by more than 80–90 percent in set-aside lands, increased topsoil protection from erosion, and the protection of 20 million ha.

A second example of using existing governance models to leverage NbS financing is China's eco-compensation to support the conservation of forests, grasslands, and wetlands. In 2014, the

Environmental Protection Law proposed that "the state will establish and improve an eco-compensation system, and strengthen the fiscal transfer payment for ecological protection region; the relevant local government shall implement eco-compensation funds and ensure it is used for eco- compensation; the state will guide relevant governments of the beneficiary areas and ecological protection areas to implement eco-compensation in accordance with the market rules through consultation" (ADB, 2016). Further elaboration of China's eco-compensation laws and practices related to public transfers include the February 2018 Guiding Opinion on Establishing Eco-Compensation and Long-Term Protection Mechanisms in the Yangtze River Economic Basin. In 2019, NDRC announced it would advance a national-level eco-compensation plan with pilot projects in some 50 counties, with a focus on forests and rivers.

Yangtze River Basin: The Yangtze River Economic Basin is an example of a large-scale region comprised of multiple jurisdictions. While most of the case studies discussed in this report involve projects within regimes, ecosystems cut across different jurisdictions. A basin-wide approach to piloting and scaling NbS offers an opportunity to coordinate solutions. Given the importance of the Yangtze and Yellow River basins in the 14th Five Year Plan, NbS projects can expand current work in sustainable ecological restoration and regenerative agricultural practices linked to rice, wheat, and other crops, as well as pilot projects for hydropower restoration. For example, with support from the TNC Center for Sustainable Hydropower linking NbS freshwater projects with underlying integrated water resource management approaches, including focusing NbS on both surface and groundwater issues and linking ecosystem restoration with organic soil carbon sink recovery.

National Laws and Regulations: An emerging approach to NbS governance involves laws and regulations. Peru is among the first countries with a national NbS law, consisting of provisions for green infrastructure investments to protect the sourcing of drinking water supplies and the elaboration of principles of a remuneration or compensation system. An Executive Order by the State of California sets out guiding principles in support of NbS.

NBS is still a relatively new concept in many jurisdictions, hence it doesn't yet appear in many legal systems. Attempts to integrate it are under way in some countries, such as the US and China. In some countries, NGOs, prosecutors and judges have attempted to bring the principles of NBS into court cases. After examining existing laws, policies, and cases, several recommendations for CCICED are made.

Recommendation:

(1) CCICED should emphasize the importance of integrating nature-based solutions in China's climate and biodiversity strategies, and strengthening China's legal framework, which include integrating NBS into the new EIA Law, establishing a strong legal framework for ECRL, and enhancing preventive public interest litigation.

(2) CCICED should continue to help mitigate risks to nature from overseas investments and trade, highlight the significance of implementing the traffic light system and green investment principles for BRI projects.

ANNEX 1: Evaluating Nature-based Solutions (Executive Summary)

In 2020, the IUCN released a global standard for nature-based solutions (IUCN, 2020) with eight criteria for "the verification, design and scaling up" of nature-based solutions (NbS). Criterion 4 states that NbS should be "economically viable" and that this viability should be evaluated by comparing the costs and benefits of implementing NbS with those of traditional solutions. In principle, such a comparison is valid for choosing between NbS and traditional solutions. In practice, however, the approach is fraught with shortcomings, many of which emanate from biases built into the standard cost-benefit analysis (CBA) frameworks. These biases pose particular problems for the evaluation of NbS.

CBA emerges out of people's innate ability to compare short-term costs and benefits. Most of us are remarkably adept at assessing the costs and benefits of alternative pathways in our daily lives. This kind of simple CBA, which is largely informal and even unconscious, suits when the consequences of decisions are small. This is not the case with all decisions, however. Many of us are required to make decisions with consequences reaching far beyond the personal. As a result, a formal decision-making discipline has arisen, employing frameworks with carefully structured methods and data requirements. Unsurprisingly, given how instinctual the comparison of costs and benefits is for humans, the central framework for formalized decision-making has evolved around this very approach.

The rise of formalized CBA occurred largely in western countries during the middle of the 20th century. This was a time when continuous economic growth—as measured by GDP—was the unquestioned doctrine of governments and businesses alike. It was also a time when national statistical agencies were rapidly expanding and improving their collections of economic statistics, using the newly minted System of National Accounts as their guide. The combination of growth doctrine and increasingly robust data describing the market economy was a potent force. Those developing CBA as a discipline were inevitably drawn to focus their concepts, methods and data on the market economy. Costs and benefits not part of the market economy—including those related to the environment—were considered of secondary relevance, if at all. Clearly, this market bias disadvantages NBS when evaluated via CBA.

CBA in its purest form requires a comparison of costs and benefits in monetary terms. Any cost/benefit not already monetized must be converted into money for the purpose of the analysis. Of course, this is not always possible. Some costs/benefits are best (or only) expressed in "natural" units; for example, the benefit of building a hospital might best be expressed in terms of the number of lives saved rather than the purported "economic value" of those lives. For this reason, variants of pure CBA have been developed that allow benefits to be recorded in natural units. Cost-effectiveness analysis (CEA)—the framework recommended for NbS evaluation by the IUCN—is one such variant. In CEA, costs are expressed in monetary terms, but benefits remain in natural units. The choice between two projects depends on which of them offers its benefits at the lowest cost.

Comparing NbS and traditional solutions on the basis of CEA is problematic in a number of ways. First, it may be difficult to find an NbS that offers the same suite of benefits as a traditional solution. When benefits differ, how are the projects to be compared? Is, for example, the expansion of a mangrove forest that protects 200 ha of land, a school, and 100 homes from flooding better or worse than protecting 150 ha of land, 80 homes, and a hospital by building an artificial breakwater? There is no obvious answer to this question. Timing of benefits can also pose problems. Breakwaters can be built relatively quickly and begin offering full protection immediately. Mangroves take time to grow and offer only limited protection until fully grown. How are benefits today to be compared with benefits in the future?

Challenges exist on the cost side of CEA as well. For one, as already noted, not all costs may be easily expressed in monetary terms. For another, projected costs related to NbS are treated asymmetrically to costs for traditional solutions in corporate and government balance sheets. No balance sheet acknowledges mangrove forests as assets, whereas every balance sheet would admit an artificial breakwater as an asset. Thus, a government choosing to expand mangrove forests for flood protection would have to forego adding an asset to its balance sheet, something it may be reluctant to do. Governments—and the bond rating agencies that assess their credit-worthiness—like to see assets on balance sheets as evidence that public spending is "going somewhere." Artificial breakwaters have a clear advantage over mangrove forests due to this overly narrow definition of assets.

For the reasons above, CEA will often not provide clear guidance for choosing between NbS and traditional solutions. This is all the more so when NbS are proposed in the form of policies rather than projects. While projects may have reasonably well-defined costs and benefits, this is not always true for policies. Policies may cost practically nothing to implement but have major impacts on society and the economy. Reflecting this, another framework—economic impact analysis (EIA)—has emerged to support decision-making around policies. In it, complex and data-intensive models are used to measure policy outcomes (say, the change in spending on automobiles induced by an electric-vehicle subsidy policy) into impacts on GDP and other core macroeconomic variables. Policies are then judged by the size of their economic impacts.

For many of the same reasons that CBA and CEA are problematic when applied to NbS, so too is EIA. The models used in EIA focus on market impacts, and the fact is that many NbS have limited market impacts. Conserving a forest for its carbon sequestration function does little to stimulate the economy (indeed, it may stifle economic activity), so EIA is unlikely to recommend it over a traditional solution.

Overall, formalized decision-making frameworks cannot be expected to serve NbS well. The frameworks are excessively market-centred, tailored to the kinds of costs and benefits that traditional solutions offer and difficult to adapt to non-traditional solutions.

The last two decades have seen an emergence of an alternative framework for measuring economic progress that holds considerable promise for NbS evaluation. The central thesis of the framework—which is known by the name “comprehensive” or “inclusive” wealth—is that sustainability depends on wealth passing from one generation to another. Unlike traditional conceptions of wealth, however, comprehensive wealth is defined— as the name would imply—to include more than just buildings, machinery, stocks, and bonds. Comprehensive wealth adds natural capital (ecosystems and natural resources), human capital (skills and knowledge), and social capital (trust and norms) to the overall wealth portfolio.

Among many insights, comprehensive wealth offers a new way of thinking about economic evaluation. In a recent and thorough presentation of the framework titled The Economics of Biodiversity, Cambridge economist Sir Partha Dasgupta outlines why comprehensive wealth is, in fact, the proper basis for deciding among project options. More specifically, Dasgupta shows that the change in the size of a country’s (or a company’s) comprehensive wealth portfolio is the yardstick by which investment options should be compared. Choosing between flood protection using mangrove forests versus artificial breakwaters, for example, becomes a matter of assessing the contribution each makes to stocks of produced, human and natural capital. The project with the greatest contribution to wealth, other things equal, is that one that should be pursued.

There is much to recommend comprehensive wealth as the framework for evaluating economic viability. Many of the shortcomings of standard evaluation approaches would fall away if comprehensive wealth were routinely used for this purpose. Importantly, the asymmetry in the treatment of NbS and traditional solutions on balance sheets would disappear since comprehensive wealth explicitly recognizes nature as a form of capital. The excessive market focus of the standard approaches would also be dealt with since comprehensive wealth is built around the notion that “accounting” prices and not market prices should be the basis for valuation. Accounting prices are defined as those that reflect the social, rather than private, worth of a good or service. Concern over the timing of costs and benefits would also disappear since the asset values required to measure the change in comprehensive wealth are current-period measures.

Of course, no framework is perfect and comprehensive wealth, which remains relatively new as an area of inquiry, is not without challenges. Notably, the accounting prices it calls for cannot be observed. They may sometimes be proxied by market prices, but, especially in the case of natural capital, markets are often badly distorted from their social equilibria. Methods exist to model accounting prices, though these can be complex, data intensive, and not without controversy.

Standard economic evaluation frameworks do not serve NbS well. Comprehensive wealth, as Dasgupta and others show, offers an improved basis for assessing economic viability. Given this, it would be

CCICED Nature-Based Solutions (NbS) Special Policy Report

appropriate for researchers and institutions promoting NbS to engage in the effort to refine and apply comprehensive wealth thinking. A useful step in this direction would be to revise Criterion 4 in the IUCN global standard to call for comprehensive wealth, rather than cost-effectiveness analysis, as the basis for evaluating economic viability. Beyond this, support for research on, among other things, accounting prices would be helpful. Finally, and perhaps most importantly, governments must be persuaded to begin compiling and using measures of comprehensive wealth to drive decision-making. So long as governments remain fixated on growth in GDP, standard evaluation frameworks will remain their primary analytical tools, and NBS will remain disadvantaged in decision-making.

See Evaluating Nature-based Solutions FULL REPORT

ANNEX 2: CCICED Sub-Working Group Nature-Based Solutions Meeting Summary April 6, 2021

Opening Remarks

Professor LIU Shijin, CCICED Chinese Chief Advisor, kicked off the meeting by providing an overview of recent policy updates in China. He noted the growing interest in applying nature-based solutions (NbS) to climate actions, adding that NbS could also bring synergistic effects on solving many other challenges facing China today, namely biodiversity, ecological recovery, pollution prevention, and economic growth. He underscored the Chinese philosophy on following nature's laws and called for incorporating such traditional wisdom in the research, implementation, and communication about NbS. He also highlighted the importance of cultivating consensus, introducing international experiences, and identifying domestic case studies.

Mr. Scott Vaughan, CCICED International Chief Advisor, expressed gratitude to all participants' contribution to the sub-working group's scoping work, which set to identify future work priorities and solid solutions for China. He outlined four major aspects of the sub-working group's work to guide the discussion: 1) identifying the science foundation of NbS; 2) presenting and organising case studies; 3) measuring the cost and return; 4) policy pathways, focusing on scalability, bankability, and private sector engagement.

Session 1: Science, Definitions, Safeguards

Mr. Thomas Lovejoy, Senior Fellow, Biodiversity and Environmental Science, UN Foundation, shared the larger picture of NbS in linking the biological and physical system by reviewing the role the biological and geological process in bringing down the CO2 level twice in historical periods during which the CO2 level was higher than today. He also pointed out the CO2 in the atmosphere from destroyed terrestrial ecosystems is equivalent to what stays to an extent terrestrial ecosystem, which reflects the atmospheric consequences of climate change, as well as the opportunity for restoration (Woodwell Climate: Soil Carbon Debt). At last, he highlighted the dual benefits of ecosystem restoration on carbon sequence and the ecosystem (The Dasgupta Report).

Ms. LI Lin, Director of Global Policy and Advocacy at WWF International, recommended considering positioning NbS as a preferred solution to climate change, as well as to societal challenges. She highlighted the importance of coordinating different layers of land in spatial planning and pointed out that carbon sequestration, as one of the biggest ecological services, has not been considered in the ecological redlining and zoning at this moment. She also shared a few other remarks: 1) NbS provides an opportunity to mainstream nature and biodiversity; 2) financing NbS needs not only generating new funding but also removing harmful subsidies and realigning the financial flow to conservation; 3) China has carried out some experimental work on natural resource asset accounting. She suggested setting up a task force under the sub-working group to explore the synergies between NbS and other Special Policy Studies (SPS).

Dr. ZHANG Xiaoquan, Chief Scientific Officer, The Nature Conservancy, acknowledges the challenges in reaching a common definition for NbS. He suggested focusing on deepening the understanding on the key features and the science foundation of NbS. He provided insights on identifying the pathways, categorisation and the connotations. Dr. ZHANG recognised the necessity of raising awareness on NbS, while warning the risk of generalisation and misuse of the concept for greenwashing purposes. He concluded that NbS set to restore, conserve, and imitate nature under the inspiration of nature.

Session 2: Case Studies Comparable Criteria

Mr. Laszlo Pinter, Senior Fellow, IISD; Professor and Head of Department of Environmental Sciences and Policy, Central European, shared the progress of "Naturvation", an EU project aiming to understand the potential of NbS in the urban context. The project finds NbS as a new paradigm, standardizes the language and terminologies, and develops an Urban Nature Atlas. The project concludes that NBS addresses multiple SDGs and has the potential to contribute more, including green recovery. He outlined the challenge of identifying integrated business cases addressing societal challenges and the importance of tools (i.e. Nature Navigator and Urban Nature Explorer).

Dr. ZHU Chunquan, China Head, Tropical Forest Alliance, World Economic Forum Beijing, commented that the criteria should be based on the contribution of natural assets and ecosystem services to the economy and society. He emphasized three bottom lines: 1) preserving and adding value to natural and ecological assets; 2) enabling continuous ecological services to the wellbeing of human being; and 3) causing no harm to ecological assets nor to the self-restoration and resilience of ecosystems. He pointed out that any analysis on NbS should be made 1) within a limited time unit and spatial scale, taking into consideration the mutual diminishment and/or add-on effect among different ecological services; 2) based on the openness and fairness in the allocation of resources among different stakeholders; 3) at a moderate spatial and time scale in comparison to the short-/mid-/long-term impacts of engineer-based solutions.

Mr. SHI Lei, Researcher, International Centre for Bamboo and Rattan, addressed the importance of respecting the non-linear, complex ecological system; not following the internal rules of the natural system could lead to systemic collapse (Biosphere 2). Regarding criteria, he suggested considering the multi-outputs of NbS, respecting the differentiated rules under different scales, limiting the project assessment to a certain spatial and temporal, and promoting the integration of local species, community, culture, and policy, as well as existing projects. He stressed that NbS is multi-sectoral, multi-space, multi-stakeholder by nature, which requires comprehensive consideration in project design and implementation.

Session 3: Measurement, Cost-Benefit Analysis and Business Case

Mr. Robert Smith, Principal, Midsummer Analytics, Former Director of Environment Accounts and Statistics, argued the prevailing analytical frameworks such as cost-benefit analysis (CBA), cost-effectiveness analysis (CEA) and economic impact analysis (EIA) do not serve for NbS, for the following reasons: excessive market-orientation, tailored to the traditional solutions, and difficulties to adapt to NbS. He recommended exploring emerging alternatives such as the "inclusive wealth" model proposed in the Dasgupta Report, which measures the contribution to national wealth rather than contribution to GDP, income, and employment as a proper basis for evaluating investment options, as the framework for evaluating the economic viability of NBS.

Mr. REN Wenwei, Director for China Surface Water Program, World Wildlife Fund, pointed out WWF's many experiences on Yangtze River conservation can be now categorised as NbS. He shared two case studies carried out by WWF: 1) Since 2002, the initiative of re-establishing seasonal linkage of 60+ rivers and lakes increased the resilience of natural watershed and resulted in multiple outputs (i.e. restoration of threatened species, increasing access to clean drinking water, increased capacity on flood control); and 2) A bankable and scalable NbS case in Rhine estuary in Netherland where the ecological service resulted from wetland restoration is purchased by the government and paid off through public-private partnership (PPP) on affordable housing development. Dr. Ren added that two potential bankable NbS cases were already identified in the Yangtze River economic zone.

Session 4: Policy Pathways

Mr. Dimitri de Boer, Chief Representative of the China Office, ClientEarth, pointed out the inadequacy of regulations on NbS worldwide because of the difficulties for lawmakers to grapple with the complex concepts of NbS and to materialize the cross-cutting multi-benefits. He shared two exceptional cases: an executive order in California (Expanding nature-based solutions), and the MEE's Guiding opinions (2021). He recommended integrating NbS in China's legal system, policy frameworks and spatial planning, prioritising Yangtze River protection, climate adaptation, and disaster protection and prevention. He also suggested focusing on regulating supply chains as a first legislative pathway, in addition to prioritizing mitigating risks in the BRI and addressing harmful subsidies.

Professor LI Yu'E, Chinese Academy of Agricultural Sciences, provided a brief introduction on China's policy initiatives on promoting sustainable and green agriculture, grassland eco-compensation and the fishing ban in key areas of the Yangtze River Basin. She acknowledged the increasing notion in China on using carbon sequestration as a solution to climate mitigation. Prof. LI also shared the recent progress of the of the upcoming UN Food Summit: 1) 3 approaches are identified to "Boost nature-positive production" (namely, protection of the ecological system, sustainable management, and recovery and restoration); and 2), a list of 22 NbS are identified through questionnaires and submission, and it will be further narrowed down to a shorter list prior to the Summit.

Mr. QIU Jie, Research Center for Ecological Protection and Restoration, Nanjing Institute of Environmental Sciences, MEE, shared about China's policy initiative "Ecological Redline" which was first introduced in 2017 and matured in 2019. He highlighted the Ecological Redlines not only cover all areas of great ecological importance and fragility but also areas that cannot be identified now but are potential of ecological value. He addressed three bottom lines for the Ecological Redlines: 1) no arbitrary change of use; 2) no decrease but increase; and 3) prohibition in the principle of human activities in core protected zones, and strict prohibition of exploiting and productive construction activities in other areas within the Redlines.

Mr. Bob Tansey, Senior Advisor, The Nature Conservancy, shared how NbS can be used in solving the challenges in agriculture reform and nonpoint source pollution reduction: regenerative agriculture, urban environmental markets, and water fund for eco-compensation. He added that altogether, the three NbS approaches could achieve a great reduction in nonpoint source pollution while producing added benefits in line with the goals of the Yangtze River Protection Law.

Session 5: Recommendations on Next Steps

Professor WANG Yi, Team Lead, CCICED SPS Climate; Member of the Standing Committee of the 13th National People's Congress; Vice President, Science and Technology Strategy Consulting Institute, the Chinese Academy of Sciences, pointed out the crucial importance of finding an accurate and effective position of the NbS in China that is problem- and goal-oriented. He also outlined a few priorities for future work: 1) carrying out quantitative analysis on the cost and benefits; 2) enhancing the coordination across ministries; 3) strengthening international cooperation; 4) identifying comparable case studies of traditional projects; and 5) increasing the influence and acceptance of NbS in CBD COP15.

Concluding Comments

Professor LIU Shijin, CCICED Chinese Chief Advisor, noted that many past initiatives in China could be categorised as NbS. He addressed the people-centered principle in furthering NbS practices in China. Echoing the participants' speech, Professor Liu proposed three future work priorities: 1) exploring the application of "inclusive wealth" accounting in the Chinese context; 2) strengthening the recognition on the conviction of NbS to guide conscious implementation; 3) integrating good practices on NbS in China's upcoming provincial and sectoral specific 14th Five-Year Plans.

Mr. Scott Vaughan, CCICED International Chief Advisor, thanked all participants for sharing their insights and welcomed their continuous inputs to the sub-working group's draft report. He proposed two actions for the next step: 1) setting up a portal of case studies on both international and Chinese examples (i.e., sponge cities); 2) identifying 2-3 specific themes (i.e., sustainable agriculture, bridging COP15/COP26) for future collaboration.

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