INTERNATIONAL GOOD PRACTICE PRINCIPLES FOR SUSTAINABLE INFRASTRUCTURE

INTEGRATED, SYSTEMS-LEVEL
APPROACHES FOR POLICYMAKERS

SECOND EDITION **(DRAFT)**

DISCLAIMER

SUGGESTED CITATION

ISBN No:

Job No:

[all to be added]

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FOREWORD

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ACKNOWLEDGEMENTS

[Logos and additional contributors to be added]

The *International Good Practice Principles for Sustainable Infrastructure* have been developed as part of the implementation of United Nations Environment Assembly (UNEA) Resolution 4/5 on sustainable infrastructure (UNEP/EA.4/Res.5). This draft was prepared by a team led by Rowan Palmer (UNEP) under the guidance of Fulai Sheng (UNEP). Members of the team include Motoko Aizawa (Observatory for Sustainable Infrastructure), Giulia Carbone (IUCN), Steven Crosskey (UNOPS), Douglas Herrick (OECD), Lori Kerr (GIF), Kate Kooka (OECD), Maikel Lieuw-Kie-Song (ILO), Geoffrey Morgan (UNOPS), Kate Newman (WWF), Daniel Taras (GIZ), Scott Thacker (UNOPS), Mito Tsukamoto (ILO), and Graham Watkins (IDB).

This draft has also benefitted greatly from the inputs of an Expert Working Group that helped to create the guidelines and develop the original outline, and provided comments on early drafts. In addition to the team members mentioned above, the Expert Working Group includes Graham Alabaster (UN-Habitat), Scott Chapelow (CIFF), Cristina Contreras Casado (Harvard University), Alison Davidian (UN Women), Achim Deuchert (GIZ), Alexandre Hedjazi (University of Geneva), Linda Krueger (TNC), Waleska Lemus (SIF), Oliver Lorenz (GIZ), Elizabeth Losos (Duke University), Katherine Lu (FoE), Virginie Marchal (OECD), Eva Mayerhoffer (EIB), Oshani Perera (IISD), Laura Platchkov (Swiss FOEN), Spiro Pollalis (Harvard University), Graham Pontin (FIDIC), Adina Relicovschi (EIB), Katharina Schneider-Roos (GIB), Veronica Ruiz (IUCN), Tim Scott (UNDP), Shang Shengping (CHINCA), and Laurin Waunnenberg (IISD).

The authors are also grateful for the review, comments, and additional contributions of Dorothée Allain-Dupré (OECD), Apoorva Bajpai (UNOPS), Timothy Bishop (OECD), Nicholas Bonvoisin (UNECE), Till-Niklas Braun (UNEP), Tihana Bule (OECD), Yaxuan Chen (UNEP), Sarwat Chowdhury (UNDP), Lorena Cruz Serrano (OECD), Anna-Sophia Elm (UNEP), Ana Fernández Vergara (UNEP), Sergio Forte (Banobras), Philippe Froissard (EC), Catherine

Gamper (OECD), Juan Garin (OECD), Colm Hastings (UNEP), Franziska Hirsch (UNECE), Jonathan Hobbs (UNEP-WCMC), Alice Jetin-Duceux (UNEP), Diego Juffe Bignoli (UNEP-WCMC),William Kelly (ASCE, ACECC), Renu Khosla (CURE), Jinseok Kim (UNEP), Arend Kolhoff (NCEA), Joanne Lee (WWF), Désirée Leon (UNEP), Max Linsen (UNECE), Dominic MacCormack (UNEP), Luca Marmo (EC), Beatriz Martins Carneiro (UNEP), Alexandre Martoussevitch (OECD), Isabella Neuweg (OECD),Stefano Paci (EC), Kristyna Pelikanova (EIB), Joseph Price (UNEP), Chengchen Qian (UNEP), Carme Rosell (IENE), Ana María Ruiz Rivadeneira (OECD), Dirk Röttgers (OECD), Sigita Strumskyte (OECD), Paolo Tibaldeschi (WWF), Anna Willingshofer (TNC), Helena Wright (WWF), and Maria Yeroyanni (EC).

The second edition of this publication was developed through an EMG Consultative Process on Sustainable Infrastructure, and benefitted from further inputs from Garo Batmanian (World Bank), Isabela De Paula Salgado (UNU-FLORES), Lorenzo Gavilli (ICAO), Edeltraud Günther (UNU-FLORES), Tobias Hatzfeld (UNU-FLORES), Jane Hupe (ICAO), Nele Kapp (UN-Habitat), Elena Mendoza Barajas (UNU-FLORES), Alicia Regodon (UN-Habitat), Maher Salman (FAO), Benjamin Schachter (OHCHR) Christian Schneider (UNU-FLORES), Björn Verse (UNU-FLORES) and Robin Zuercher (ITU). UNEP would also like to thank Marie Clerc, Hossein Fadaei, Carl Giardina, Sam Jeremy, Fatema Johara, Anna Kaplina, Jannica Pitkanen and Sam Sinclair at the UN EMG Secretariat for their strong support in coordinating the Consultative Process.

The report was edited by Frances Meadows (UNESCO) and designed by Katharine Mugridge.

UNEP gratefully acknowledges financial support from the Global Environment Facility (GEF) and the Swiss Federal Office for the Environment (FOEN).

ABBREVIATIONS

TERM	DEFINITION
ACECC	Asian Civil Engineering Coordinating Council
ADB	Asian Development Bank
AHP	Analytic Hierarchy Process
ASCE	American Society of Civil Engineers
CEA	Cumulative Effects Assessment
CHINCA	Chinese International Contractors Association
CIFF	Children’s Investment Fund Foundation
CURE	Centre for Urban and Regional Excellence
EC	European Commission
EIA	Environmental Impact Assessment
EIB	European Investment Bank
FAO	Food and Agriculture Organization of the United Nations
FIDIC	International Federation of Consulting Engineers
FoE	Friends of the Earth
FOEN	Swiss Federal Office for the Environment
GDP	Gross domestic product
GEF	Global Environment Facility
GHG	Greenhouse Gas
GIB	Global Infrastructure Basel
GIF	Global Infrastructure Facility
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GtCO2	Gigatons carbon dioxide
ICAO	International Civil Aviation Organization
ICE	Institution of Civil Engineers
IDB	Inter-American Development Bank
IFC	International Finance Corporation
IFRC	International Federation of Red Cross and Red Crescent Societies
IISD	International Institute for Sustainable Development
ILO	International Labour Organization
IMF	International Monetary Fund
IENE	Infra Eco Network Europe

InVEST	Integrated Valuation of Ecosystem Services and Tradeoffs
IPBES	Intergovernmental Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
MSMEs	Micro, small, and medium enterprises
NbS	Nature-based solutions
NCEA	Netherlands Commission for Environmental Assessment
OECD	Organisation for Economic Co-operation and Development
OHCHR	Office of the United Nations High Commissioner for Human Rights
PBS	Performance-based specifications
PPP	Public Private Partnership
R&D	Research and development
SCP	Sustainable Consumption and Production
SDGs	Sustainable Development Goals
SEA	Strategic Environmental Assessment
SEEA	System of Environmental-Economic Accounting
SIF	Sustainable Infrastructure Foundation
SLOCAT	Sustainable Low Carbon Transport
TEEB	The Economics of Ecosystems and Biodiversity
TNC	The Nature Conservancy
UNCTAD	United Nations Conference on Trade and Development
UNDESA	United Nations Department of Economic and Social Affairs
UNDP	United Nations Development Programme
UNEA	United Nations Environment Assembly
UNECE	United Nations Economic Commission for Europe
UN EMG	United Nations Environment Management Group
UNEP	United Nations Environment Programme
UNEP-WCMC	World Conservation Monitoring Centre
UNFCCC	United Nations Framework Convention of Climate Change
UN-Habitat	United Nations Human Settlement Programme
UNOPS	United Nations Office for Project Services
UNU-FLORES	United Nations University Institute for Integrated Management of Material Fluxes and of Resources
WAVES	Wealth Accounting and the Valuation of Ecosystem Services
WWF	World Wildlife Fund/Worldwide Fund for Nature

DEFINITIONS

There are a number of terms that are frequently used to describe various aspects of sustainable infrastructure, but have different usages among different people and groups[a]. The following definitions are intended to provide clarity on how these terms are used in this document.

Infrastructure systems comprise physical assets (also referred to as **hard infrastructure**) plus the knowledge, institutions and policy frameworks (also referred to as **soft infrastructure**) in which they exist and that enable them to function[b]. These include both built, or grey, infrastructure in all sectors, and natural, or green, infrastructure.

The term **social infrastructure** is generally used to refer to those systems that deliver services upon which the health and well-being of societies depend. The term can be used to describe infrastructure that delivers services related to healthcare, education, housing, water and sanitation, rule of law, culture and recreation, among others. **Economic infrastructure** generally refers to those systems that underpin the economy, including but not limited to energy, transport, and communication infrastructure. In many cases the lines between social and economic infrastructure are not well defined, since a given infrastructure system may serve both social and economic functions. For this reason, it is helpful to differentiate between social and economic infrastructures based on the needs they service, rather than on the type of service provided or the type of asset or system being used.

Sustainable infrastructure (sometimes also called green infrastructure) systems are those that are planned, designed, constructed, operated and decommissioned in a manner that ensures economic and financial, social, environmental (including climate resilience), and institutional sustainability over the entire infrastructure life cycle[c]. Sustainable infrastructure can include built infrastructure, natural infrastructure or hybrid infrastructure that contains elements of both (see below).

In this document, the concepts of inclusiveness, health and well-being, quality, service delivery, resilience and value for money are implicit in the term "sustainability".

a For example, the term "green infrastructure" is commonly used to describe environmentally sustainable infrastructure in general (renewable energy infrastructure, for example) and more specifically to describe elements of nature that are managed so that they provide infrastructure services, i.e., "natural infrastructure".

b Soft infrastructure can also deliver services independently of hard infrastructure — i.e. entirely soft infrastructure systems can exist.

c This definition is adapted from the Inter-American Development Bank's definition of sustainable infrastructure in its report *What is Sustainable Infrastructure? A Framework to Guide Sustainability Across the Project Cycle.*

Other terms commonly (but inconsistently) used when discussing sustainable infrastructure include ecological infrastructure, natural infrastructure, green infrastructure and nature-based solutions. While relevant, these terms are not synonymous with sustainable infrastructure; rather, they refer to specific aspects of it. **Natural infrastructure** (also sometimes called ecological **infrastructure, environmental infrastructure or green infrastructure**) refers to a "strategically planned and managed network[s] of natural lands, such as forests and wetlands, working landscapes, and other open spaces that conserves or enhances ecosystem values and functions and provides associated benefits to human populations"[1]. Natural infrastructure can be either naturally occurring or naturalized, but the defining feature is that it is actively managed; if it is not actively managed it is simply "nature"[2].

Natural infrastructure can function on its own or be used to complement built infrastructure, and elements of natural infrastructure can be incorporated into the design of built infrastructure (e.g., green roofs and walls), resulting in **hybrid infrastructure** (also referred to as **grey-green infrastructure**).

Nature-based solutions (NbS) are "actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits"[3]. NbS are not limited to infrastructure but are highly relevant. Nature-based solutions for infrastructure include the use of natural and hybrid infrastructure to meet infrastructure service needs (e.g. protecting a natural watershed to ensure drinking water quality).

EXECUTIVE SUMMARY

Infrastructure is central to sustainable development, underpins economic growth and delivers the services that are essential to improve livelihoods and well-being. At the same time, unsustainable, poorly planned and delivered infrastructure can have disastrous effects on the environment and societies.

The *International Good Practice Principles for Sustainable Infrastructure* are intended to provide guidance for global use on the integration of sustainability throughout the entire infrastructure life cycle, with the focus "upstream" of the project level. It aims to assist high-level policy- and decision-makers in governments in creating the enabling environment for sustainable infrastructure that is needed to achieve the Sustainable Development Goals (SDGs) and the objectives of the Paris Climate Agreement, while respecting existing international conventions and internationally agreed standards.

In general, this guidance emphasizes the importance of infrastructure approaches that respond to needs and demand for services, address sustainability as early in the planning process as possible and integrate not only all aspects of sustainability but also relevant governance frameworks and different infrastructure systems and sectors across time and space.

THE TEN GUIDING PRINCIPLES PRESENTED IN THIS PAPER OUTLINE HOW AND WHY INFRASTRUCTURE PLANNING AND DEVELOPMENT SHOULD FOCUS ON:

1. **STRATEGIC PLANNING to ensure the alignment of infrastructure policies and decisions with global sustainable development agendas and to strengthen the enabling environment.**

2. **RESPONSIVE, RESILIENT, AND FLEXIBLE SERVICE PROVISION to meet actual infrastructure needs, allow for changes and uncertainties over time, and promote synergies between infrastructure projects and systems.**

3. **COMPREHENSIVE LIFE CYCLE ASSESSMENT OF SUSTAINABILITY, including the cumulativeimpacts of multiple infrastructure systems on ecosystems and communities over their entirelifespans, to avoid "locking in" infrastructure projects and systems with various adverse effects.**

4. **AVOIDING ENVIRONMENTAL IMPACTS of infrastructure systems and investing in natural infrastructure to make use of nature's ability to provide essential, cost-effective infrastructure services and provide multiple co-benefits for people and the planet.**

5. **RESOURCE EFFICIENCY AND CIRCULARITY to minimize infrastructure's natural resource footprint, reduce emissions, waste and other pollutants, and increase the efficiency and affordability of services.**

6. **EQUITY, INCLUSIVENESS, AND EMPOWERMENT through a balance between social and economic infrastructure investment to respect, protect and fulfil human rights and promote well-being,particularly of more vulnerable or marginalized groups.**

7. **ENHANCING ECONOMIC BENEFITS through employment generation and support for the local economy.**

8. **FISCAL SUSTAINABILITY AND INNOVATIVE FINANCING to close the infrastructure investment gap within the context of increasingly constrained public budgets.**

9. **TRANSPARENT, INCLUSIVE, AND PARTICIPATORY DECISION-MAKING that includes stakeholder analysis, ongoing public participation, and grievance mechanisms for all stakeholders.**

10. **EVIDENCE-BASED DECISION-MAKING that includes regular monitoring of infrastructure performance and impacts based on key performance indicators and the promotion of data sharing with all stakeholders.**

These ten principles can be used to support integrated, systems-level approaches[d] that can increase governments' abilities to meet a given level of service needs with less infrastructure that is more resource efficient, pollutes less, is more resilient, more cost effective and has fewer risks than "business-as-usual" approaches.

d For a more detailed description of integrated approaches, see UNEP's report on Integrated Approaches to Sustainable Infrastructure.

INTRODUCTION

This document aims to promote the adoption of integrated, systems-level approaches to sustainable infrastructure planning, delivery and management. Recognizing that every country has unique circumstances, it presents policymakers with guiding principles for integrating environmental, social and economic sustainability over the entire infrastructure life cycle, in such a way that they can be adapted and applied to any specific national context. In so doing, it aims to help governments at all levels move from "doing infrastructure right" to "doing the right infrastructure" that best meets service needs in a sustainable way.

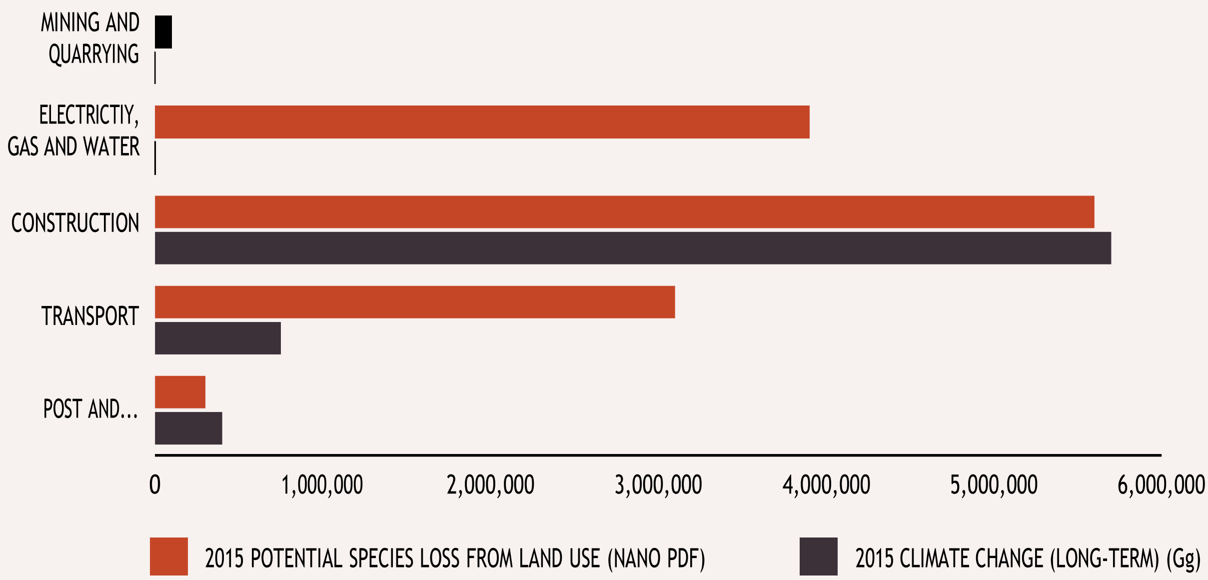
The principles outlined here can be broadly applied to all infrastructure systems, includingthose for transport, housing, energy, water and sanitation, waste management, food and telecommunications, among others.

INFRASTRUCTURE AND SUSTAINABLE DEVELOPMENT

Infrastructure underpins human and economic development and is linked to all 17 of the Sustainable Development Goals (SDGs), either directly or indirectly influencing the attainment of 92% of the 169 individual SDG targets[4]. Infrastructure systems are drivers of economic growth and enable access to the basic services and economic opportunities needed to improve livelihoods and well-being.

At the same time, infrastructure can have major negative impacts on people and the planet. The construction and operation of grey infrastructure (including buildings, transportation and power generation infrastructure) account for approximately 70% of global greenhouse gas (GHG) emissions[5], and can have direct and indirect impacts on biodiversity and ecosystem services[6] (see figure 1). Similarly, poorly planned infrastructure can exclude certain segments of society from access to services and benefits (for example employment), and large-scale infrastructure development can lead to displacement of entire communities. Financial sustainability is also a concern, as unaffordable infrastructure projects can burden national and subnational governments with unsustainable debt, and create unsustainable business models for private participation, investment and local communities. In addition, poorly designed infrastructure can lead to high long-term maintenance or replacement costs during operation and have implications for decommissioning.

FIGURE 1: POTENTIAL SPECIES LOSS AND CLIMATE CHANGE



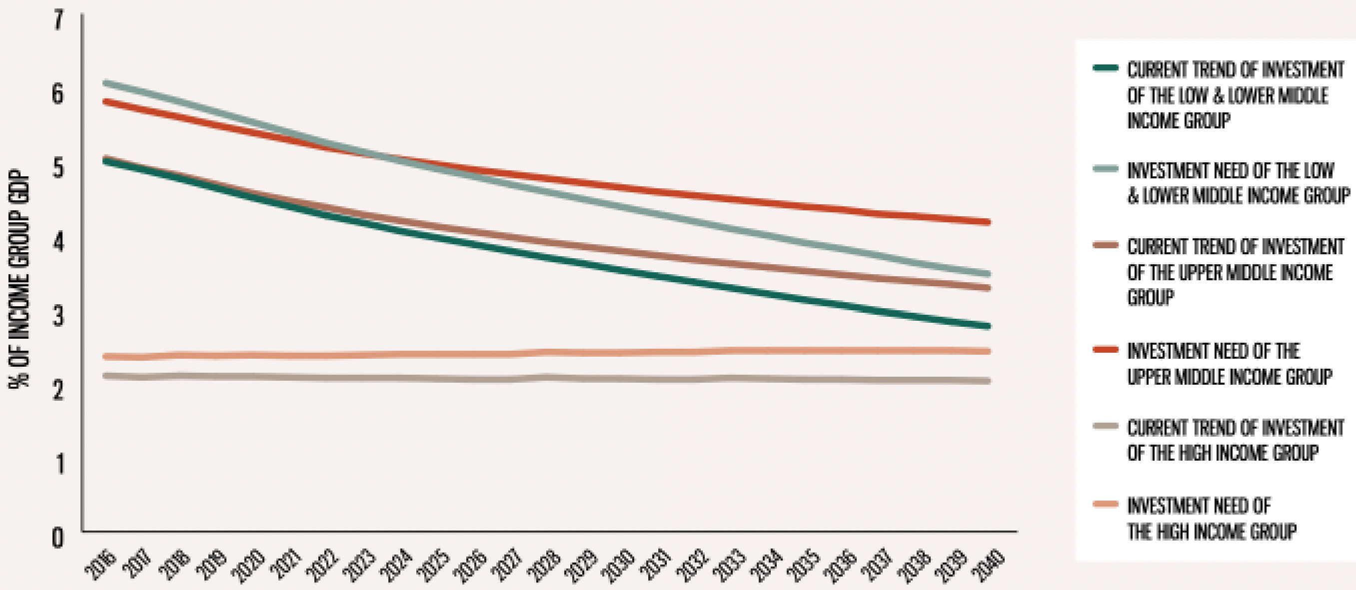
Source: SCP Hotspot Analysis

For infrastructure to serve a positive purpose, risks to people and the planet must be managed while societal, environmental and economic benefits are enhanced, and it should also be resilient and flexible under changing conditions. Making well-informed decisions is critical, because infrastructure systems typically last for decades, defining our collective future by locking in the consequences of decisions that are being made now.

This is particularly important because of the scale of infrastructure investment that is expected in the coming decades, and the short window of opportunity that we have before unsustainable investments cause irreparable damage to the planet. Increasing demand for infrastructure services means that trillions of dollars will need to be invested in new and existing infrastructure. The Organisation for Economic Co-operation and Development (OECD) has estimated that an annual average of 6.9 trillion USD in climate-compatible infrastructure investment is required over the next decade to meet global development needs[e,7]. According the Global Infrastructure Hub, there is a significant gap between these investmentneeds and current investment trends, particularly in low- and middle-income countries (see figure 2)[8].

e This figure includes only investments in four sectors: energy, transport, water, and telecoms. The amount of infrastructure investment needed for achieving the SDGs is likely to be significantly higher and includes additional sectors.

FIGURE 2: INFRASTRUCTURE INVESTMENT GAP



Source: Infrastructure Outlook

The COVID-19 pandemic has brought added urgency to the issue. Governments have already allocated trillions of dollars in economic recovery packages[9] that involve significant investments in infrastructure as a means of stimulating the economy[10]. These investments represent an unprecedented opportunity to reduce dependence on fossil fuels, protect and create natural capital[f], and increase resilience to future crises while simultaneously closing the global infrastructure gap and stimulating the economy[11]. Spending on renewables and energy efficiency, for example, creates five times more jobs per 1 million USD invested than spending on fossil fuels[12]. Similarly, investing in climate resilient infrastructure in developing countries can create 4.2 trillion USD in benefits, with a return of 4 USD for every 1 USD invested[13]. However, a large proportion of recovery spending is still being invested in unsustainable sectors[14,15].

In order to achieve the SDGs and the objectives of the Paris Climate Agreement, and safeguard our societies and economies against future crises, it is imperative that infrastructure investments do not follow the “business-as-usual” approaches that have proven unable to deliver sustainable infrastructure on the scale required. Norms must now shift towards improved infrastructure development that makes use of the best available evidence, knowledge and technologies to create infrastructure systems that can deliver services effectively, efficiently, inclusively and sustainably.

The time available to make these changes is quickly running out. Current negative trends in biodiversity and ecosystem health are undermining progress towards most of the SDGs[g,16], and keeping global temperature rises within the objectives of the Paris Climate Agreement requires rapid and radical reductions in carbon emissions[h,17]. Given that large infrastructure projects typically take years to plan and deliver, the transition to more sustainable infrastructure systems must begin immediately.

f The World Forum on Natural Capital defines natural capital as the “world’s stocks of natural assets which include geology, soil, air, water, and all living things”. Natural capital yields sustainable flows of valuable goods and services. For more information see Costanza and Daly. Natural Capital and Sustainable Development. *Conservation Biology*. 1992; 6(1): 37-46.

g The Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) reports that natural ecosystems have declined by 47 per cent on average relative to their earliest estimated states and 25 per cent of species are already threatened with extinction—a rate that is already at least tens to hundreds of times higher than the average rate over the past 10 million years and is quickly accelerating.

h The Intergovernmental Panel on Climate Change (IPCC) report Climate Change 2014: Mitigation of Climate Change estimates that the continued expansion of fossil fuel-based infrastructure would produce cumulative emissions of 2,986 – 7,402 GtCO2 during the remainder of the 21st century, which is substantially above the estimated upper limit (1,550 GtCO2) of cumulative CO2 emissions by 2100 that are allowed if temperature rise is to be kept below 2°C relative to pre-industrial levels. It is further estimated that having relatively high 2030 emission levels will pose an even greater challenge for the energy infrastructure during the period 2030 – 2050, when the low-carbon proportion would need to be rapidly scaled up almost by a factor of four in order to follow the 2°C pathway

INTERNATIONAL GOOD PRACTICE PRINCIPLES FOR INTEGRATED, SYSTEMS-LEVEL APPROACHES

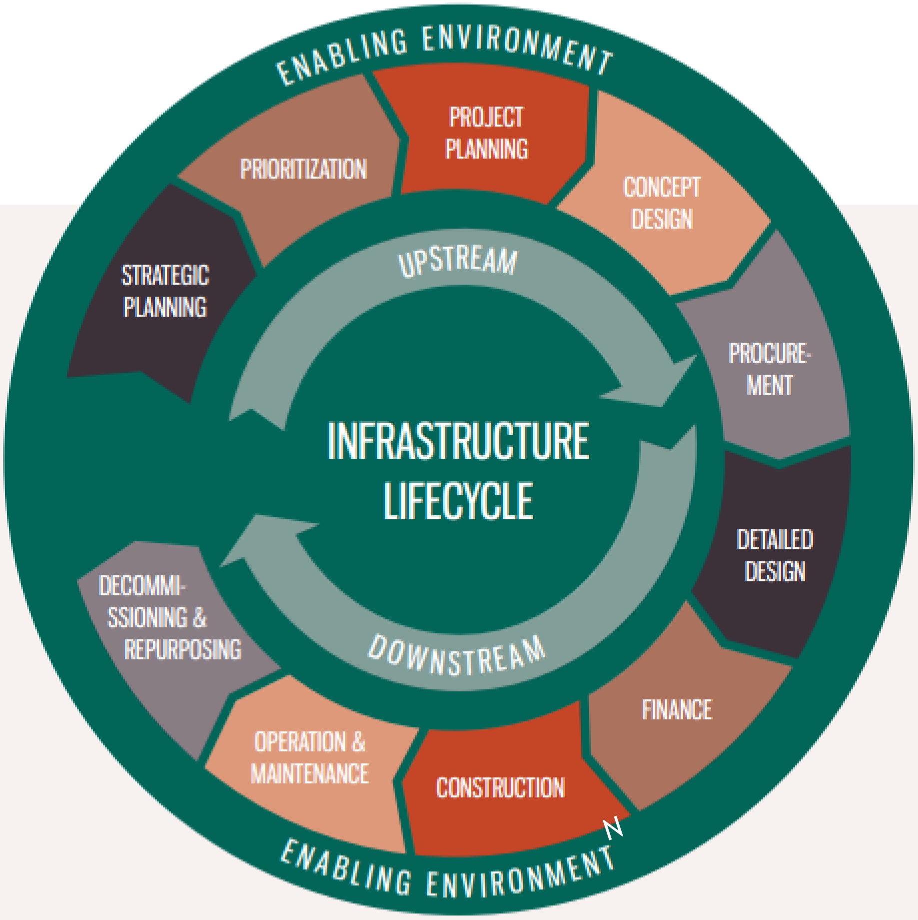
The relationship between different types of infrastructure systems and economies, societies and the environment are complex and multidimensional. For infrastructure investment to contribute to the SDGs, sustainability must be integrated into the earliest stages of infrastructure planning in a way that considers the interlinkages between different infrastructure systems and sectors, their locations, relevant governance frameworks, and the three pillars of sustainability (economic, social, and environmental) throughout the entire infrastructure life cycle. This type of integrated, systems-level approach[i] can increase governments' abilities to meet service needs with less infrastructure that is more resource efficient, pollutes less, is more resilient, more cost effective, and has fewer risks than "business-as-usual" approaches

FIGURE 3: THE INFRASTRUCTURE LIFECYCLE AND ENABLING ENVIRONMENT

The infrastructure lifecycle encompasses more than the single project lifecycle and includes decision-making phases that are "upstream" of planning for any specific project(s).

The enabling environment is comprised of the institutions, policies, and rules and regulations that govern the planning, delivery, operation, and decommissioning of infrastructure systems. The enabling environment applies to the entire infrastructure lifecycle, although the creation of specific institutions, policies, and rules and regulations necessarily occurs upstream of the lifecycle phases to which they apply.

Source: GIZ and UNEP



i For a more detailed description of integrated approaches, see UNEP's report on Integrated Approaches to Sustainable Infrastructure.

In "business-as-usual" approaches, the environmental and social impacts of infrastructure are often considered only at the project level, and the synergies and interdependencies between different infrastructure systems and sectors – and their cumulative impacts on nature and societies — are not fully accounted for. When infrastructure is viewed as a "system of systems", trade-offs and synergies from different projects and sectors can be balanced against one another to achieve more efficient allocation of infrastructure investment in terms of delivering services and meeting national sustainable development objectives[18]. Potentialrisks can also be identified and addressed earlier in the planning process, resulting in more sustainable projects that are better aligned with users' needs and expectations.

Although there are many existing guidelines, standards and tools for integrating sustainability into infrastructure, there is an overreliance on project-level tools and safeguards that seek simply to "do noharm." These types of tools often lack ambition or areapplied too late in the planning process to influence key decisions about what project to build and where tobuild it, resulting in missed opportunities to minimize negative impacts and maximize positive ones.

SUSTAINABLE INFRASTRUCTURE TOOL NAVIGATOR:

The Sustainable Infrastructure Tool Navigator is an online platform that connects users with tools for integrating sustainability across the lifecycle of infrastructure projects. The platform is intended for public and private sector stakeholders involved in infrastructure development. The Navigator includes several categories of tools, including: high-level principles, impact assessments, computer modelling, project preparation & planning, financial and cost-benefit analyses, guidance, and rating systems. The tools contained can be used to help stakeholders implement the principles in this publication; many are relevant to multiple aspects of the different principles. The Sustainable Infrastructure Tool Navigator is free to use and can be accessed at https://sustainable-infrastructure-tools.org.

At the intergovernmental level, the G20 Principles for Quality Infrastructure Investment[19] provide a broad framework for infrastructure investment that supports the 2030 Agenda for Sustainable Development and recognizes the importance of governance, but they still approach infrastructure primarily from a project perspective and provide limited guidance on the environmental aspects of sustainability. The OECD Compendium of Policy Good Practices for Quality Infrastructure Investment[20] supplements the G20 Principles with more detailed and policy-oriented guidance on all aspects of sustainability.

The *International Good Practice Principles for Sustainable Infrastructure* are intended to complement existing materials by focusing upstream of the project level (see figure 3) and summarizing good practice for sustainable infrastructure policies, planning, preparation and delivery aimed at creating the enabling environment for sustainable infrastructure that supports the achievement of the SDGs.

The principles are focused on actions that can be taken by governments. The public sector plays the main role in creating the enabling environment for sustainable infrastructure, and identifying and overcoming barriers that impede implementation. Without the right institutions and policies in place, infrastructure investment will continue on an unsustainable pathway. This applies to all infrastructure development, regardless of the respective roles that the public and private sectors may play as sponsors or investors in any given project.

In addition to creating the enabling environment, governments are also the major drivers of infrastructure development. While private sector investment and technical expertise are increasingly needed to help close the infrastructure gap, especially in developing countries, it is government that civil society ultimately holds accountable for providing most infrastructure services. This is reflected in the fact that the public sector accounts for the majority of global infrastructure investment[21]. In 2017, for example, the public sector accounted for 83% of infrastructure investment in developing countries, and when the private sector does invest in infrastructure it is often in publicly sponsored infrastructure projects involving financing from public institutions[22]. Public policy and procurement of infrastructure, therefore, is a powerful force for channelling investment into sustainable infrastructure projects and creating positive impacts on the ground.

An accompanying publication, Integrated Approaches in Action: A Companion to the International Good Practice Principles for Sustainable Infrastructure, comprises ten case studies which illustrate specific aspects of the ten principles. Each principle in this document contains a hyperlink to its corresponding case study. Collectively, the case studies document real-world examples of government action across sectors in diverse contexts, including challenges faced. They demonstrate how governments can use the guiding principles to adopt sustainable infrastructure at scale.

GUIDING PRINCIPLES

1. STRATEGIC PLANNING

Infrastructure development decisions should be based on strategic planning that is aligned with global sustainable development agendas[j] and existing international conventions, and supported by enabling policies, regulations and institutions that facilitate coordination across departments and both national and sub-national levels of government and public administration.

LONG-TERM VISION

Decision-making on infrastructure investment should be informed by a long-term, needs-based strategic vision for sustainable development and a just transition that transcends national and sub-national political cycles. This vision must be supported by appropriate planning, including via national and sub-national infrastructure development and investment plans aligned with sequential planning cycles and global sustainable development agendas. It is crucial that environmental, social and economic sustainability is fully integrated into those plans in a coherent way. Pipelines of infrastructure projects should then be aligned with these plans and delivered in the context of multi-year public sector budgets[23]. Planning should include clear environmental, social and economic goals and targets, which can help guide decision-makers towards the selection of more sustainable infrastructure projects[k].

In addition to new sustainable infrastructure systems, these plans should include sustainability strategies for existing infrastructure. This can help to minimize environmental and social impacts, avoid stranded assets where possible, and mitigate the economic impacts where stranded assets are unavoidable.

STRATEGIC ENVIRONMENTAL ASSESSMENT:

Strategic Environmental Assessment(SEA) is a tool for integrating sustainability considerations into proposed policies, plans, and programmes. SEAs analyse the effects of proposed plans, programmes and policies, and synergies with existing infrastructure, helping planners to make decisions about trade-offs between environmental, social and economic outcomes. An SEA is applied much earlier in the planning process than a project- level Environmental Impact Assessment (EIA), at a time when more strategic options are available, and can be applied to programmes involving multiple projects. If used correctly, they can be an effective way to mainstream sustainability into strategic infrastructure planning and help create an enabling institutional and policy environment[24].

j The 2030 Agenda for Sustainable Development is considered to be the current overarching global sustainable development agenda.

k The 2030 Agenda and related material — which includes, inter alia, the SDGs, the Addis Ababa Action Agenda, the Paris Climate Agreement, the Sendai Framework and the New Urban Agenda — provide a comprehensive and broadly accepted framework on which to base national strategic visions and plans. Governments should select appropriate targets and indicators based on local objectives and conditions.

INSTITUTIONAL COORDINATION

To enable integrated and sustainable infrastructure planning, delivery and management, institutional coordination is required, both vertically (national to sub-national) and horizontally (e.g. between different ministries and administrative jurisdictions) at all levels of government. Across its life cycle, infrastructure touches upon the mandates of many different parts of government, and infrastructure systems and their impacts often cross geographical and administrative boundaries, including transnational boundaries. Optimization of physical and natural capital and the efficient use of resources mean that infrastructure must be planned and managed at the level of its geographic impact[25].

To enable this type of coordination, silos need to be broken down — both between and within institutions — to facilitate and incentivize more interdisciplinary collaboration. Data collection, generation andanalysis should be coordinated, and data shared. Visions, plans and policies need to be jointly developed. Policies and regulations at various levels must be harmonized so they do not contradict each other or give opposing incentives or market signals. Interdisciplinary and intersectoral coordination among and within institutions also ensures that all aspects of sustainability are duly considered from the earliest stages of infrastructure planning. Platforms for dialogue and cooperation, joint authorities, regional or municipal mergers and also contracts can all help to incentivize integrated governance[26].

> CASE STUDY: SAINT LUCIA'S NATIONAL INFRASTRUCTURE ASSESSMENT

ENABLING ENVIRONMENT

Implementation of the plans and strategies must be supported by a stable and predictable enabling regulatory and policy environment that mandates and incentivizes sustainability consistently over time and across domains. Barriers to successful planning and implementation should be identified and defined by policymakers, before collaborating with relevant stakeholders to overcome them and foster enabling conditions[l].

Stable and effective governance structures, legal frameworks and economic, social, and environmental policies that are aligned with long-term, needs-based planning help to provide certaintyand reduce risks for planners, businesses, investors and other key drivers of infrastructure development. The enabling framework for financing also includes regulatory certainty, appropriate economic incentives, fiscal policies, credit enhancement and risk mitigation mechanisms (including for social and environmental risks) as well as improving local capital market conditions for sustainable infrastructure (through green bonds, for example)[23]. Sanctions and penalties for non-compliance with laws and regulations need to be high enough, and well enough enforced, not to be considered as part of "the cost of doing business".

These measures are particularly important for attracting private sector investment, which will play an increasingly important role in infrastructure development as limited public budgets mean that governments are looking to the private sector to fill infrastructure investment gaps. A stable policy and regulatory environment must be supportedby appropriate institutions capable of designing, implementing and enforcing reforms to enable private investment.

l Policymakers can adopt formal barrier analysis frameworks, deploying mixed-method approaches with expert workshops, surveying and the Analytic Hierarchy Process (AHP).

2. RESPONSIVE, RESILIENT, AND FLEXIBLE SERVICE PROVISION

Infrastructure planning and development should be based on a good understanding of infrastructure service needs and informed by the diverse options available to meet those needs. This includes understanding and managing the changing demand, and meeting needs through renovating or rehabilitating existing infrastructure before investing in new infrastructure. Systems-level planning of infrastructure projects should promote synergies for improved integration, which can lead to improved productivity, efficiency, sustainability, and spillover benefits of investment. Flexibility and resilience should be built into infrastructure plans to allow for changes and uncertainties over time, and plans should be updated.

UNDERSTANDING AND MANAGING DEMAND

Infrastructure planning should be based on clearly identified service needs and be adaptable to a variety of future conditions. Planning sustainable infrastructure from a service-based understanding of needs also allows for more efficient allocation of resources and can result in lower-cost infrastructure that is better aligned with sustainable development objectives[27].

Central to service-needs-based approaches is a solid understanding of the diverse and changing drivers of demand for infrastructure — including demographics and population growth, urbanization and migration, climate change, lifestyles, health and economics, among others — as well as the performance[m] of existing systems in meeting current and projected demand. Because of the decades-long lifespan of many infrastructure systems, needs and demand are almost certain to change over time.

Taking account of the gender aspects of service provision is an important part of needs assessment. Men and women use infrastructure in very different ways that are often not factored into infrastructure planning and operation. Public transportation, for example, is often operated in ways that do not take account of women's scheduling or safety needs, which reduces women's participation in the job market and has negative effects on sustainable development[28].

m including integrated assessments of sustainability and resilience

BUILDING IN FLEXIBILITY AND RESILIENCE

It is also important to perform risk evaluations to understand potential risks to the viability of infrastructure, such as the projected impacts of climate change and land degradation, disasters, pandemics, conflicts, economic crises and other shocks. These include both direct risks to the physical integrity of infrastructure — suchas those posed by hurricanes or wildfires – and indirect risks, such as a drastic changes in demand due to an economic or public health crisis or natural disaster. Risks should be evaluated at different levels of analysis, e.g. beyond the project level, considering different networks of infrastructure at the systems-level.

> CASE STUDY: DIGITAL INFRASTRUCTURE IMPROVEMENTS FOR CONNECTIVITY AND RESILIENCE IN AFGHANISTAN

In addition, infrastructure should be planned and designed to accommodate technological changes and avoid locking in technology that may become obsolete or unaffordable. This includes carbon intensive and polluting technology that may increase future operating costs as environmental externalities are increasingly factored into pricing. Conversely, technology that increases future flexibility (e.g. digital technology and “smart” solutions) can helpto reduce the risks of uncertainty and increase resilience to shocks.

“SMART” SOLUTIONS FOR FLEXIBILITY AND RESPONSIVENESS:

“Smart” solutions enabled by digital technology generate data that can beused to help enable service provision that responds to demand in real time, thus improving flexibility and performance and optimizing the use of resources. These “smart” solutions can be integrated within and across several infrastructure sectors, from buildings, mobility, energy (see principle 5), water and waste management to health. For example, smart mobility systems make efficient use of data on mobility patterns and integrate multiple transport options, including both individual mobility and mass transit, thus improving network management, traffic congestion, accessibility and environmental performance. Smart water systems can analyse available flow and pressure data, provide real-time information to customers on the water situation and help conserve water[29].

PROMOTING SYNERGIES FOR IMPROVED INTEGRATION

Accounting for the interactions between different infrastructure systems and sectors across the life cycle is critical to understanding all of these factors, as changes made to one can affect therisks to, demand for, and performance of others. For example, any infrastructure system is only as reliable,resilient or sustainable as its energy source. Failure to understand these interlinkages at the planning phase threatens the viability of infrastructure systems and can have broader social and environmental ramifications.

Following an assessment of current and anticipated service needs — and the performance and sustainability of existing infrastructure assets — planners should explore a range of options for meeting them. In meeting infrastructure service needs, planners should apply concepts like the mitigation hierarchy[30] or “avoid-shift-improve”that seek to avoid negative environmental and social impacts (those resulting from project siting, resource use, emissions, population displacement, etc.) and where these are unavoidable, first minimize and then compensate for them[n]. Reducing demand for infrastructure services (e.g. transport or energy) is an important part of avoiding and minimizing negative impacts.

Co-location and multi-purpose infrastructure should also be considered as a means of maximizing synergies in service delivery, improving resource efficiency, reducing the costs of construction and operations, minimizing adverse environmental and social impacts, and capturing the benefits of economies of scale. Over the last few decades, interest in development corridors has increased significantly[o]. By concentrating infrastructure development in already-disturbed areas and facilitating movement of capital, goods and services, and people, development corridors can enable regional integration and socio-economic development in previously remote areas while avoiding impacts to undisturbed habitat and ecosystems[31,32,33].

n While the mitigation hierarchy was devised with specific reference to biodiversity losses at the project level, the principle can also be applied at the strategic level and to other types of negative environmental and social impacts. The "avoid-shift-improve" strategy was developed by the Sustainable Low Carbon Transport Partnership (SLOCAT) to apply to transportation infrastructure but is applicable to other types of infrastructure as well.

o Development corridors are geographical target areas for economic growth and development that provide important connections between economic nodes or hubs through large-scale expansion of infrastructure.

BALANCING TRADE-OFFS

In some instances, new infrastructure assets will be the right choice. However, despite their political appeal, new assets are usually natural resource-, carbon- and capital-intensive and often take time to become operational. The tendency of plannersto focus on new assets can often mean that other more sustainable, less costly and lower-risk solutions for infrastructure service provision are overlooked. This can result in infrastructure that is unsustainable, inefficient and ultimately not fit for purpose. So-called "white elephant" infrastructure projects offer extreme examples of misalignment with demand, but even moderate cases represent missed opportunities and inefficient allocation of scarce resources.

While trade-offs between environmental, social and economic costs and benefits are inevitable,there are many options for meeting infrastructureservice needs in a way that balances outcomes vis- à-vis the three dimensions of sustainability. These include reducing demand for services where usageis inefficient or unsustainable (e.g. through financialincentives and taxation); retrofitting or upgrading existing infrastructure assets, selecting the best available technologies, improving efficiencies of distribution including reducing losses and policing illegal connections and usage, and substitutingnature-based solutions (NbS) for grey infrastructure where possible (see principle 4).

Tools such as strategic foresight, scenario analysis and computer-based modelling[p] can help planners understand the interactions between different infrastructure systems, potential synergies, trade-offs between different costs and benefits, potential risks and future uncertainties, and the viability and sustainability of different infrastructure solutions. When used as part of systems-level approaches, these tools can help create flexible, "no-regrets" approaches that allow for adaptation to changes and ensure continued and sustainable delivery of infrastructure services[34].

p Strategic foresight and scenario analysis are closely related processes that involve identifying and assessing the potential implications of different plausible but often highly uncertain imagined future scenarios. Computer-based modelling tools are generally more quantitative and can be used to simulate various social, economic, and environmental systems. They use mathematical formulas and algorithms to show what happens when different variables are introduced, helping planners to understand complex systems and optimize outcomes from different policy and investment decisions. Computer-based models can be used on their own or in support of more qualitative processes like strategic foresight and scenario analysis.

3. COMPREHENSIVE LIFE CYCLE ASSESSMENT OF SUSTAINABILITY

Infrastructure's environmental, social and economic sustainability should be assessed as early as possible in the planning and preparation cycle, covering both financial and non-financial factors across interdependent projects, systems and sectors over their lifecycles. Life cycle sustainability assessments should consider the cumulative impacts on ecosystems and communities as part of a broader landscape, beyond a project's immediate vicinity, and take account of transnational impacts.

ANALYSING FINANCIAL AND NON-FINANCIAL FACTORS

Analysis of infrastructure options should take account not only of financial costs and benefits based on market prices, but also social and environmental externalities with adjustments for risks and market imperfections. Where possible and appropriate (see principle 10), positive and negative impacts should be quantified and monetarized so that trade-offs can be assessed objectively, based on a common frame of reference. Where that is not possible or appropriate, as withthe value of biodiversity or human rights impacts,full account should be taken of measurements inphysical units or qualitative terms.

Environmental factors include the impacts of infrastructure on nature (including direct impacts like habitat degradation, biodiversity loss and pollution,as well as indirect impacts from climate change and unsustainable resource extraction, among many others); the impacts of nature on infrastructure and people (especially in terms of climate and disaster resilience); and the value that biodiversity and ecosystem services provide[q]. Social factors include human rights, inclusiveness, the creation of employment and livelihoods, gender impacts, andthe ways in which infrastructure affects the health and safety of users, workers and communities, among others.

Social and environmental impacts can be both immediate, as a result of construction (biodiversity loss from land clearance, displacement of people, etc.) and ongoing during operation (carbon emissions,disrupted ecosystem and habitat connectivity, changes in land use and economic activity, illegal wildlife trade, noise pollution, gender discrimination, etc.). Environmental, social, and economic costs and benefits should be considered across the entire infrastructure life cycle (see figure 3), and not just for certain phases. For example, the environmental and material footprint of each stage of the lifecycle must be assessed and the cumulative impacts considered. This includes both inputs (energy, construction materials like sand, minerals, etc.) and outputs (solid waste, water, emissions, etc.).

q There are several methodologies for quantifying the value of natural capital and ecosystem services so that they can be incorporated into decision-making (e.g. The Economics of Ecosystems and Biodiversity (TEEB), Wealth Accounting and the Valuation of Ecosystem Services (WAVES), System of Environmental-Economic Accounting (SEEA), Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST)). They all recognize the social and economic importance of biodiversity and ecosystem services and quantify their values in economic terms that can inform cost-benefit analysis and decision-making. These tools can help to demonstrate the benefits of investing in natural infrastructure, and facilitate accurate comparison of grey and green infrastructure as potential solutions for meeting infrastructure service needs.

CONSIDERING CUMULATIVE IMPACTS ON ECOSYSTEMS AND COMMUNITIES

Planners should also take account of the cumulative impacts of multiple interconnected infrastructure systems and projects, and evaluations should not be arbitrarily constrained by administrative boundaries. Environmental impacts should be considered on a landscape or ecosystem scale, across all relevant jurisdictions. This includes transnational impacts, which are particularly important for resources such as water, where upstream impacts in one country may have downstream effects in other countries, and impacts on migratory species whose ranges and habitats extend beyond national borders. In the latter case, ensuring habitat connectivity across borders is an important way of managing impacts. International coordination and cooperation among governments - including through dedicated bodies such as inter-governmental river basin organizations - is required to manage and monitor transboundary impacts and avoid conflict.

> CASE STUDY: LANDSCAPE-SCALE PLANNING TO SUPPORT CONSERVATION, NOMADIC LIVELIHOODS AND SUSTAINABLE DEVELOPMENT IN MONGOLIA

Rural-urban linkages are also important. Infrastructure built in rural areas to meet the service needs of urban populations may have negative local impacts that outweigh the benefits to distant end-users. With large amounts of infrastructure expected to be built in — or to provide services to — increasingly crowdedand expanding cities, planners must understand the spatial distribution of the impacts of urban infrastructure, beyond municipal boundaries.

Understanding the cumulative impacts — both positive and negative — and the synergies and trade-offs between environmental, social, andeconomic costs and benefits, can help determineif the overall mix of infrastructure systems provides the best solutions for meeting service needs (see principle 2) while achieving sustainability objectives. Risk assessment is often too heavily skewed towards financial risks, which can miss major environmental and social risks that can themselves ultimately have an impact on the financial bottom line (e.g. resettlement and land tenure risks that can expose the projects to legal action).

To fully understand all the costs and benefits of different infrastructure systems, tools such as SEA and Cumulative Effects Assessments (CEA)[r] should be systematically applied as early in the infrastructure life cycle as possible — ideally during strategic planning — when alternatives and opportunities for risk avoidance and synergies are still politically, economically and technically feasible.

r CEAs can be applied to single projects or to broader territorial land-use planning. Even when applied at the single project level, they differ from Environmental Impact Assessments (EIAs) primarily in that they explicitly consider the cumulative environmental and social effects of other projects on the study area. For more information see the Government of Canada's CEA Practitioners' Guide.

4. AVOIDING ENVIRONMENTAL IMPACTS AND INVESTING IN NATURE

Adverse environmental impacts from infrastructure should be minimized, and natural capital enhanced to the greatest degree possible. Construction should be avoided in areas important for the persistence of biodiversity or having high ecosystem service value. The development of physical infrastructure should seek to complement or strengthen, rather than replace, nature's ability to provide services such as water supply and purification, flood control and carbon sequestration. Nature-based solutions should be prioritized.

PROTECTING AND ENHANCING BIODIVERSITY

In order to minimize impacts on biodiversity from infrastructure development, brownfield development — i.e. choosing sites that have already been altered from their natural states — and co-location shouldbe prioritized to the extent possible. This applies to both above- and below-ground sites. The creation of development corridors in existing populationcentres, for example, can help to reduce impactson biodiversity. Where greenfield development — i.e. building in previously undisturbed areas —is absolutely necessary, areas important for the persistence of biodiversity or having high ecosystem service value should be avoided altogether. Such areas provide the most benefits at a larger scale, which makes it extremely difficult or impossibleto adequately compensate for impacts on them[35].These include, but are not limited to, protected areas and Key Biodiversity Areas[s].

In the project design phase, measures to avoid, minimize and restore negative impacts should be identified. Compensation measures for any estimated residual impact should be identified as early as possible and planned and budgeted for. The infrastructure project should aim for zero net loss of biodiversity, at a minimum, and preferably a net biodiversity gain[t]. For some infrastructure assets such as oil and gas infrastructure, the environmental impacts of an accident — however unlikely — may be so great that large buffers should be maintained between the assets and areas important for the persistence of biodiversity or high of ecosystem service value. Where construction and operation of infrastructure — or the use of potentially polluting or hazardous materials or technologies — is necessary,best practice measures to manage waste and mitigate environmental and safety impacts throughout the life cycle should be factored into the analyses of the various options being considered. Governments should coordinate with relevant stakeholders (including in neighbouring countries) to develop plans at the transnational, national and subnational levels for pollution management and biodiversity stewardship, and assess the impacts of infrastructure projects in terms of local, national and global sustainability targets[23].

s The Integrated Biodiversity Assessment Tool (IBAT) gives access to the IUCN Red List of Threatened Species (also known as the IUCN Red List), the World Database on Protected Areas (WDPA), and the World Database of Key Biodiversity Areas.

t For more information on Net Biodiversity Gain, see the International Union for Conservation of Nature (IUCN) Policy on Biodiversity Offset.

ECOSYSTEM SERVICES AND RESILIENCE

Ecosystem degradation can become a threat to built infrastructure systems themselves if nature loses its capacity to protect them from floods, landslides, wildfires, and other disasters and accidents. Potential impacts from accidents and disasters and the effects of climate change should also be taken into account when planning the location of infrastructure. This applies to the resilience of the infrastructure itself – exposure to landslides or flooding in a certain location, for example — and to the impacts that infrastructure can have on the natural environment in the event of a disaster, locally and across borders. Resilience and disaster and emergency response strategies should be prepared, for all phases of the infrastructure life cycle.

> CASE STUDY: WATER FUNDS TO INSTITUTIONALIZE NATURE-BASED SOLUTIONS IN ECUADOR

PRIORITIZING NATURE-BASED SOLUTIONS

The use of NbS as a means of delivering infrastructure services can play a major role in achieving the "triple wins" of increased environmental, social and economic sustainability. Nature-based solutions for infrastructure involve using the services that nature provides to replace or complement built infrastructure options. Examples of the former would include enhancing the water storage capacities of wetlands to provide flood protection, and preserving existing forests to prevent landslides and soil erosion. Examples of the latter include the incorporation of green spaces into urban environments, and the use of environmental design features such as green walls and roofs. NbS have the advantage of delivering infrastructure services while at the same time providing numerous co-benefits for nature, society (including the built environment) and human health and well-being[36].

NbS are a "no-regrets", cost-effective means of addressing societies' global challenges. Investing in the restoration and protection of mangrove ecosystems for flood protection purposes, for example, can save millions of dollars per year in the costs of dyke construction and maintenance, while also preserving the ecosystem functionalities and thus maintaining a diverse range of livelihoods[37]. Similarly, investing in watershed protection and restoration can save hundreds of millions of dollars a year in the cost of water quality management, while providing a host of co-benefits for biodiversity, carbon sequestration, human health and well-being, among others[38].

Preserving natural ecosystems is much less costly than restoring or replacing them, so decision- and policy-makers should prioritize their protection when planning infrastructure development and seek to maximize the synergies between natural and grey infrastructure. Investment in preserving and enhancing natural capital and ecosystem services should also be considered even when there are no immediate and direct social or economic benefits, since well-functioning natural systems and biodiversity also have intrinsic value[u].

u The IUCN Global Standard for Nature-based Solutions provides a user-friendly framework for the verification, design and scaling up of NbS.

5. RESOURCE EFFICIENCY AND CIRCULARITY

Circularity and the use of sustainable technologies[v] and construction materials should be planned and designed into infrastructure systems to minimize their footprints and reduce emissions, waste and other pollutants.

MINIMIZING RESOURCE USE

The construction of infrastructure uses vast amounts of natural resources and is the main driver of resource use in emerging economies[39]. Many infrastructure systems also require ongoing inputs of resourcessuch as energy and water throughout their life cycles. In addition, infrastructure assets contribute to other types of air, ground, and water pollution during construction, operation and decommissioning, andare also responsible for a large volume of solid waste. The construction, maintenance and demolition of buildings, for example, is responsible for 40% of the solid waste produced in developed countries[40].

Decoupling infrastructure from resource consumption, GHG emissions, pollution and waste generation can be most effectively achieved by using integrated, service-needs-based approaches (see principle 2) to minimize the amount of new infrastructure thatis constructed. With such approaches, reducing demand and investing in natural infrastructure should be the first options considered, followed by upgrading or repurposing existing infrastructure.

Where new infrastructure assets — or repair and upgrading of existing assets — are required, planners should understand the type and quantityof natural resources required across the whole life cycle and value chain. Planners should consider the use of alternative materials[w] and technologies that can help to reduce the material impact (including the whole carbon footprint, raw material consumption and emissions from materials, from a life cycle perspective). For example, finding alternatives to concrete, and ways to use less of it, will have a major positive impact on the resource efficiency (as well as the carbon footprint)of infrastructure[41,42], and major investments in theenergy efficiency of infrastructure will be essential for meeting the goals of the Paris Agreement[43]. Similarly, the prohibition or avoidance where possible of materials that are polluting, hazardous or difficultto dispose of safely can lead to significant savingson the costs of environmental mitigation and safety measures during construction and operation, and on disposal costs during decommissioning.

New technologies can also help decouple infrastructure development from resource use and pollution and waste by enabling “dematerialized” solutions, such as digital infrastructure that can reduce the need for built infrastructure. Digital infrastructure can also contribute to increased economic and social resilience to shocks, such as during the COVID-19 pandemic when access to internet and digital technology was a major factor in limiting the negative economic and social impacts of measures taken to stop the spread of the virus. In addition, technology like artificial intelligence and real-time data from remote sensors and “smart” meters can help to improve the efficiency of service delivery by better matching it to demand (see principle 2). In the case of energy infrastructure, for example, this

v The term “sustainable technology” is used here to refer to any technology — including building materials — that enables the shift towards increased sustainability. It is not limited to new technologies; existing technologies used in ways that result in increased sustainability can be considered sustainable technologies.

w New materials such as low carbon concrete, bio-based materials and certified wood can play a significant role (supported by research and development (R&D)).

can help reduce peak demand and the associated costs, enable the use of clean energy, and provide electricity more reliably[44]. Technological solutions may themselves, however, have environmental impacts (e.g. energy consumption and use of rare earth minerals) that must also be taken into account.

In meeting demands for sustainable infrastructure, many countries may require additional resources and expertise for adopting technological solutions. Peer learning and technology transfer from other countries are important enablers. Public policy also plays a critical role in enabling the use of new technologies and promoting alternative construction techniques and materials in infrastructure projects. Standards and specifications for design, construction and operationof infrastructure must be formulated to promote or enforce the use of sustainable and innovative materials, and laws and regulations should limit or prohibit the use of hazardous ones.

> CASE STUDY: SINGAPORE'S GREEN BUILDINGS

CLOSING MATERIAL LOOPS

Circularity and industrial symbiosis are also extremely important for improving resource efficiency and reducing pollution and waste. Reusing materials from existing infrastructure assets that are being replaced with new ones, for example, can reduce costs and increase the resource efficiency of the newassets. The potential savings are significant, since the cost of raw materials can account for 40-60% of the overall cost of construction of an infrastructure asset. Similarly, carefully designed interconnected and multifunctional infrastructure such as district energy systems enable greater energy efficiency and associated cost savings. District energy systems typically show efficiencies of 90%[45].

Principles of circularity, including resource recovery, reuse, remanufacturing and recycling, should be designed into the entire life cycle of infrastructure. Integrated planning across different sectors is essential for enabling this, as choices about the location of infrastructure and the technologies and materials used all impact the degree to which circularity can be incorporated. In this regard, urban areas are particularly important. Because of their relative population and infrastructure density, urban areas have huge potential for infrastructure system integration and circularity, which, when combined with other measures like strategic densification,can reduce resource intensity by more than half of current levels[46]. Such reductions would be globally significant, as cities currently consume three quarters of the world's resources[47].

SUSTAINABLE PUBLIC PROCUREMENT

When issuing contracts for infrastructure projects, governments can incentivize bidders to incorporate sustainability by embedding those criteria[x] into procurement processes. Governments can also identify and give more weight to sustainability factors and performance-based criteria when awarding contracts. Rather than basing procurement decisions on the lowest-cost bid, for example, governments should consider life cycle costing — including the costs of carbon emissions and other externalitiesover the entire infrastructure life cycle — as a means of incentivizing more sustainable infrastructure projects[48]. Performance-based specifications (PBS) are another way for the procurement authorityto incorporate sustainability into infrastructure procurement. PBS describe the desired performance level through output specifications with associated performance indicators, and they should include environmental and social performance criteria. By specifying only the desired outcomes and not the means of achieving them, well-formulated PBS can tap the power of the private sector to find innovative, sustainable infrastructure solutions[49].

x Sustainability criteria can include, inter alia, requirements for compliance with integrated spatial plans, the use of sustainable construction materials, incorporation of NbS and hybrid solutions, and sustainability certifications or labels.

6. EQUITY, INCLUSIVENESS, AND EMPOWERMENT

Infrastructure investment must be balanced between social and economic priorities. Infrastructure should provide accessible and affordable services equitably to all, with a view to promoting social inclusion and fostering economic empowerment and social mobility, and protecting human rights. It should avoid harm to communities and users (especially those who are vulnerable or marginalized), be safe and promote human health and well-being.

BALANCING SOCIAL AND ECONOMIC PRIORITIES

Infrastructure is the basis for the enhancement of human and social capital and is vital for improving the social inclusion of the world's poorest and most vulnerable. Underinvestment in, and lack of access to, infrastructure are among the main drivers of social exclusion.

However, unlike economic infrastructure that can often recover and generate revenue from end-users, many types of social infrastructure do not generate revenue and are therefore reliant on public funding[50]. As a result, more than twice as much investment goes into economic infrastructure than social infrastructure[51].

At the strategic level, infrastructure planning needs to allocate adequate resources to the development of social infrastructure as well as economic infrastructure. In many cases user revenues alone may not be enough to offset the cost of building and operating an infrastructure system, and other sources of revenue or cost optimization must be found. Projects that have primarily social or environmental benefits, for example, may never be "bankable" when considered as stand-alone projects. In such cases, other more bankable projects may be able to help cover the costs of providing important public goods. For example, taxes on cars or user fees from toll roads can be used to subsidize low-carbon public transportation. Innovative financing solutionssuch as green bonds and pooled or blended funds can also be used to finance the development of sustainable infrastructure projects that prioritize social and environmental over economic outcomes (see principle 8)[52].

> CASE STUDY: "SOLAR FOR HEALTH" IN ZIMBABWE

EQUITABLE ACCESS TO SERVICES

All infrastructure development should benefit communities, workers and employers, users, taxpayers and the population at large in an equitable manner. Critical services and benefits provided by infrastructure should be delivered with equal access, regardless of ability to pay. Strategic infrastructure planning should account for the varying levels of socio-economic development and service needs in different jurisdictions, and policies and investments should seek to address territorial disparities.

Particular attention should be paid to the needs of women and girls. The gaps in access to infrastructure affect men and women in different ways. Infrastructure development should thereforebe gender-responsive and provide men and women with equal access to jobs and services, as well asan equal voice in setting priorities for infrastructure design and operation[53]. The ability to do this requires a good understanding of the gender dimensions of demand (see principle 2) and access to gender-disaggregated data (see principle 9). Improving the lives of women and girls by mainstreaming gender into infrastructure development and service provision also has numerous macroeconomic benefits[54].

PROTECTING COMMUNITIES

Governments should ensure that measures are in place to protect workers on infrastructure projects, including legislation and standards on minimum wages, social security, leave, occupational safety and health, and public procurement processes. National legislation and standards should be in line with the International Labour Organization (ILO) Declaration on Fundamental Principles and Rights at Work[55] and the Safety and Health in Construction Convention[56].

Measures must be put in place to respect, protect and fulfil human rights and counteract the tendency of adverse impacts from infrastructure development to fall disproportionately on poor, more vulnerable, marginalized and disadvantaged groups. Infrastructure development should seek to avoid displacement, loss of housing, land, assets and livelihoods, and should avoid cultural heritage sites and other areas conservedby indigenous peoples and local communities[57]. In Indigenous Peoples' lands and territories developers must obtain free, prior and informed consent, in line with the United Nations Declaration on the Rights of Indigenous Peoples[58].

When displacement, loss of housing, land or livelihoods is unavoidable, affected communities and persons should be adequately compensated in an equitable, consistent, and transparent manner, offered improved or restored standards of living, and assisted and directly engaged during the resettlement process[59].

7. ENHANCING ECONOMIC BENEFITS

Infrastructure should create employment, support local businesses, and build amenities that benefit communities, thereby maximizing and safeguarding its economic benefits.

CREATING CO-BENEFITS

In many cases, economic stimulus is a driving factor in the decision to build new infrastructure. The provision of certain services from energy, water or transportation infrastructure, for example, can have far-reaching benefits for the economy, such as stimulating industrial development, trade, and workforce mobility, among others. However, these projected benefits can fail to materialize if infrastructure is planned based on an incomplete understanding of needs, in isolation from interconnected systems, and without the enabling policies in place to ensure the desired outcomes.

Infrastructure planners and developers should systematically seek opportunities to create environmental and social co-benefits from infrastructure development, which requires integrated, systems-level planning that considers sustainability and interlinkages across sectors from the outset.

EMPLOYMENT

The construction and operation of certain types of infrastructure has strong potential for job creation. Measures to optimize employment impacts (including incentivizing the use of labour-based and local-resource-based solutions, technologies and practices and enabling the participation of micro-, small and medium enterprises (MSMEs)) should be included in the design and procurement strategies and processes for infrastructure where possible. Policies to increase women's participation in the workforce have proven economic benefits and should also be included[60]. In the case of infrastructure development, increasing the involvement of women in infrastructure planning and design can also help to ensure that infrastructure is more gender-responsive, and may also contribute to the increased environmental sustainability of infrastructure, as studies show that women are more willing than men to adopt environmentally sustainable behaviours[28].

The deployment of NbS can also help to create jobs for local communities. For example, the use of native vegetation instead of concrete to prevent soil erosion around structures and as flood protection in coastal areas provides installation and maintenance jobs for local communities and reduces the amount of imported construction materials.

LOCAL ENTERPRISES

Involving MSMEs in infrastructure projects can have a multiplier effect on economic benefits in the local community. Linkages among large companies and MSMEs can be effective avenues for the transfer of technology, knowledge and managerial and technical skills, but this depends on the enabling environment and the capacity of domestic MSMEs to absorb them. Contractual incentives, streamlined business regulations and bidding procedures, targeted vocational training, business development services and access to mechanisms for dispute resolution can help to increase MSME involvement in infrastructure development.

Development around growth poles and corridors — which involves concentrating multi-sectoral investment and development in areas where certain infrastructure already exists — is another strategy for increasing the economic benefits of infrastructure development by driving the agglomeration of economic activity and the growth of industry. Beyond the simple economic benefits of co-location, growth pole development can stimulate growth by increasing competition, fostering innovation and exploiting synergies and linkages between different sectors and industries[60]. Co-location around growth poles and in development corridors can also have environmental benefits by enabling circularity and multipurpose infrastructure and limiting the need for greenfield development.

> CASE STUDY: THE COMMUNITY BENEFITS OF IRAN'S TRADITIONAL QANAT SYSTEMS

8. FISCAL SUSTAINABILITY AND INNOVATIVE FINANCING

Infrastructure development should be developed within frameworks of fiscal transparency, financial integrity and debt sustainability.

DEBT SUSTAINABILITY

The development, operation and maintenance of infrastructure requires large capital investments, with countries spending up to 8% of gross domestic product (GDP) on infrastructure[62]. These investments are expected to increase over the next 20 years to meet the infrastructure investment gap[8], so governments must be vigilant about ensuring financial and fiscal sustainability at the programme and project level as well as debt sustainability at the national level. This has become even more important as the economic impacts of the COVID-19 crisis have stretched public budgets and threaten debt sustainability, in developing countries in particular[63].

Debt sustainability assessments should take into account the cumulative commitments to infrastructure projects, whether projects are funded and financed publicly, privately, or both. The International Monetary Fund (IMF), for example, has developed debt sustainability assessment frameworks for countries of different income levels that can be used to identify vulnerabilities in national public debt structures and implement measures to address the issues. The results of debt sustainability assessments should help to inform the development of sustainable infrastructure investment plans.

Taking a long-term view of fiscal sustainability is particularly important for sustainable infrastructure projects where the more sustainable options may have higher up-front costs but deliver significant savings and benefits in the long run. Integrated, systems-level planning is essential for understanding fiscal sustainability across the lifespan of infrastructure, and how revenues from some infrastructure projects may help to offset the costs of others, preventing economic trade-offs in the short term while enabling enhanced environmental, social, and economic sustainability in the long-term. It is also important to understand how environmental and social factors may influence public budgets in the future, accounting for the impacts of climate change, among other phenomena[26].

Large infrastructure projects and programmes have a tendency to go over budget, in part because procurement processes place too much emphasis on costs, which incentivizes bidders to downplay estimated costs in order to win contracts. Procurement processes that place value on the full life cycle benefits of infrastructure can help to ensure more accurate cost estimates, which in turn contribute to the fiscal sustainability of infrastructure investments[64].

> CASE STUDY: DEVELOPING WIND FARMS WITH FISCAL SUSTAINABILITY IN AUSTRIA

FINANCING INSTRUMENTS

There are different ways to pay for and finance infrastructure development, each with varyingdegrees of public and private sector involvement.The type of infrastructure that is being built and the services it is intended to provide will often determine the different funding and financing options available[y]; these in turn are factored into decisions on which infrastructure solutions to select to meet a given need.Selection of infrastructure projects and the choice between public and private provision (or a blend of both and other sources) should be guided by an impartial assessment of what best serves the public interest. This is best achieved through a full life cycle cost-benefit analysis of projects (see principle 3),all alternative modes of delivery, the full system of infrastructure provision, financing options and value for money. In the case of certain public goods, private provision may not be appropriate.

In the context of increasingly constrained government budgets, innovative financing mechanisms including Public Private Partnerships (PPPs) have become an important means of mobilizing private sector participation and long-term finance for infrastructure projects. PPPs can also improve the value for money of projects and create a contractual frameworkfor financing sustainable infrastructure outcomes. However, in some cases, the line between economic and social infrastructure may not be clear, and it is important that PPPs — which often involve increased cost recovery from users — do not prioritize private sector profits over provision of essential services that are affordable (particularly for MSMEs and more vulnerable groups). Similarly, a PPP project with low or marginal transfer of risk to the private sector will not show benefits from better risk management and therefore is probably best suited to conventional public procurement. Transferring too much risk to the private sector, on the other hand, increases project cost and may negatively impact the cost-benefit of private investment in the project.

Partnerships with international donors, development banks and other multilateral sources of financing (such as the Green Climate Fund) can help governments to attract private capital to fund high economic and social impact projects. To increase private investment even in less “bankable” infrastructure projects, investment vehicles such as blended funds and green bondscan bundle projects with varying degrees of financial attractiveness or allocate risk differently for different types of investors (with development banks takingon more risk than private investors, for example)[52]. Governments can also use various risk mitigants such as loan guarantees, and transaction enablers such as offtake agreements to increase private investment in sustainable infrastructure[65].

TRANSPARENCY

Regardless of the source of investment in infrastructure, fiscal and financial transparency are an essential part of sustainability, and institutional coordination is required to ensure accurate collection, analysis and sharing of financial information[66]. When the private sector is involved, guarantees and other financial incentives should be disclosed to the public so that stakeholders can understand the true risks associated with infrastructure development. Infrastructure projects are particularly vulnerableto bribery and corruption. OECD research shows that almost 60% of foreign bribery cases occurredin four sectors related to infrastructure[67]. Requiring due diligence on responsible business conduct for infrastructure projects can help governments ensure that the private sector participating in infrastructure delivery follows international standards and that the most severe environmental and social risks are prioritized. Responsible business expectations apply also to States as owners and economic actors, in State-owned enterprises, procurement practices, export credits and development finance[68].

y For example, the private sector is unlikely to invest alone in projects that cannot generate a financial return on investment (see principle 6).

8. TRANSPARENT, INCLUSIVE, AND PARTICIPATORY DECISION-MAKING

Infrastructure development should be underpinned by transparent planning, information sharing and decision-making processes that facilitate meaningful, inclusive and participatory stakeholder consultation, and in the case of indigenous peoples, their free, prior and informed consent. National, sub-national and project-level grievance mechanisms should be available for addressing stakeholder complaints and concerns.

STAKEHOLDER CONSULTATION

Inclusive and meaningful stakeholder consultation is essential to the successful implementation of every aspect of sustainable infrastructure. It facilitates a good understanding of service needs and preferences and helps ensure that infrastructure development is culturally appropriate[z] and well-aligned with demand (see principle 2). It is also an importanttool for accurately assessing the environmental, social, and economic costs and benefits of different infrastructure solutions and balancing trade-offs between them. Increased transparency helps to reduce corruption, thereby lowering the cost of infrastructure development and contributing to fiscal sustainability (see principle 8)[69]. Stakeholder consultation is also an important way of building trust and support for projects among local communities, and can help significantly reduce the likelihood of conflict related to infrastructure development, of which lack of transparency and consultation is a major driver[70].

To be effective, stakeholder consultation should be integrated throughout the infrastructure life cycle and be informed by comprehensive stakeholder analysis to identify all potential users, as well as non-user groups that are directly and indirectly affected. It is particularly important to include women, people with disabilities, older people, youth, indigenous peoples, minorities and other more vulnerable, marginalized or disadvantaged groups to ensure that infrastructure is responsive to their needs. It is also important for policymakers to engage the private sector, including projectdevelopers, sustainability standards setters, private financial institutions, construction and operating firms, and others that play a role in infrastructure atvarious points in the infrastructure life cycle[23].

> CASE STUDY: BALANCING NATIONAL PRIORITIES WITH LOCAL CONCERNS THROUGH TRANSPARENCY AND CONSULTATION IN CHILE

z The suitability of services and means of delivery may be perceived differently by groups with different cultural backgrounds.

INFORMATION SHARING

The quality of stakeholder consultation depends on the availability of appropriate information and the design of the processes themselves. Effective consultations involve early and ongoing public participation andfull disclosure of relevant information, including development objectives, spatial planning data, environmental baseline data, options considered, results of assessments, justifications for decisions, procurement processes and costs, among others.This information must be communicated in ways that the various stakeholders can access and understand. Consultation processes must also be designed with enough time to allow for stakeholders to provide feedback, and they must begin early enough in the decision-making process (ideally as part of strategic planning) to enable stakeholders to influence key decisions about what to build and where to build it, as well as overseeing implementation[26].

DISPUTE RESOLUTION

Judicial and non-judicial mechanisms should be available to help respond to stakeholders' grievances. This includes operational level grievance mechanisms. These mechanisms should use understandable and transparent processes that provide timely feedback to those concerned, without any retribution, and should not impede access toother judicial or administrative remedies that might be available under the law or through existing arbitration procedures. The existence of these mechanisms should be communicated to all stakeholders[71].

9. EVIDENCE-BASED DECISION-MAKING

The planning and management of infrastructure throughout the lifecycle should be informed by key performance indicators that should promote the collection of data, including data that is disaggregated by stakeholder groups. Regular monitoring of infrastructure performance and impacts is necessary to generate data, which should be made available to all stakeholders.

MEASUREMENT

The measurement of key performance indicators is an essential tool for managing the service delivery, value for money, and environmental, social, and economic sustainability of infrastructure. Monitoring the performance and impacts, both positive and negative, of infrastructure systems enables the use of adaptive management approaches that respond to changing conditions over the lifespan of an infrastructure system. This allows continuous improvement in the sustainability and service delivery of infrastructure systems across the different phases of the life cycle.

The use of common indicators allows for benchmarking against existing standards, and also allows government to assess performance against pre-defined targets and objectives and ensure alignment with strategic plans and global policy frameworks like the SDGs.

Relevant ex-ante and ex-post data on all stages of the infrastructure life cycle should be identified and defined, collected, managed, analysed and fed back to decision makers and stakeholders, so that fact-based decisions can be taken. This includes data on the performance of the existing stock of built and natural infrastructure (see principle 2).

Data is not only required by governments, but also by investors, who seek clear market signals, including on aspects of sustainability. To meet the needs of investors, it is important that sustainable infrastructure indicators are relevant, quantified and comprehensive (covering environmental, social, and economic/financial governance aspects), yet not overly complex or simply too numerous.

In addition to economic and financial data, adequate resources should be allocated to the collectionof data — including spatial data — relating to the environmental and social sustainability factors outlined in principle 3. The use of spatial data not only enables the identification of potential infrastructure sites and tracking of construction processes, but relevant environmental data collected and understood on a landscape scale can also ensure the health and functioning of entire ecosystems during the planning and operation of infrastructure. Social data should be disaggregated by the various population groups affected by infrastructure (e.g. gender-disaggregated data), particularly those that are more vulnerable or marginalized.

Data should be collected at the international, national, local and project levels when planning infrastructure. Blockchain and other emerging technological innovations may offer solutions to challenges in accessing data along the whole supply chain (e.g. from sub-contractors) and the use of “big data” can improve transparency and enable “smart” solutions, such as smart mobility or smart energy systems (see principles 2 and 5).

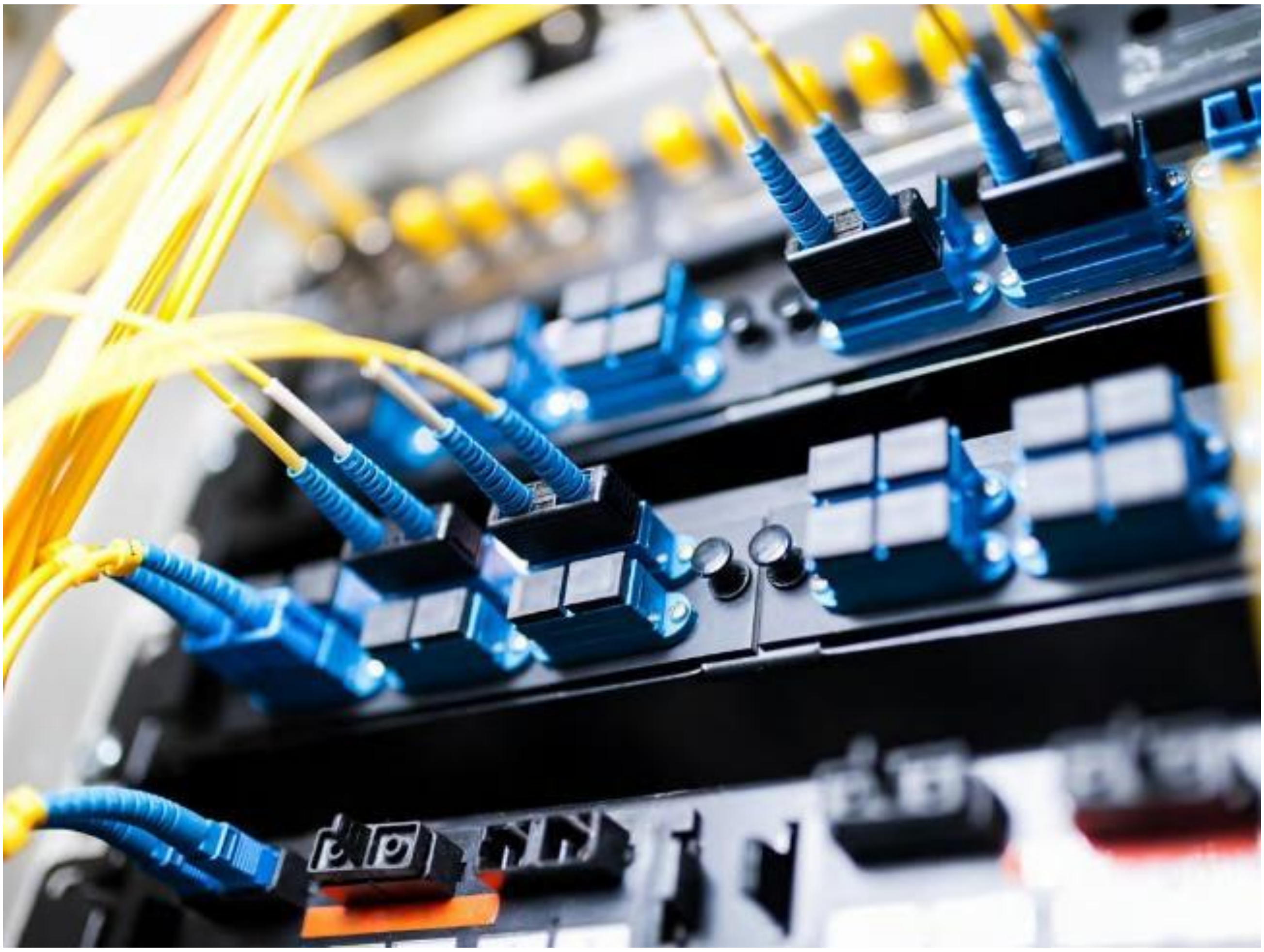
DATA SHARING

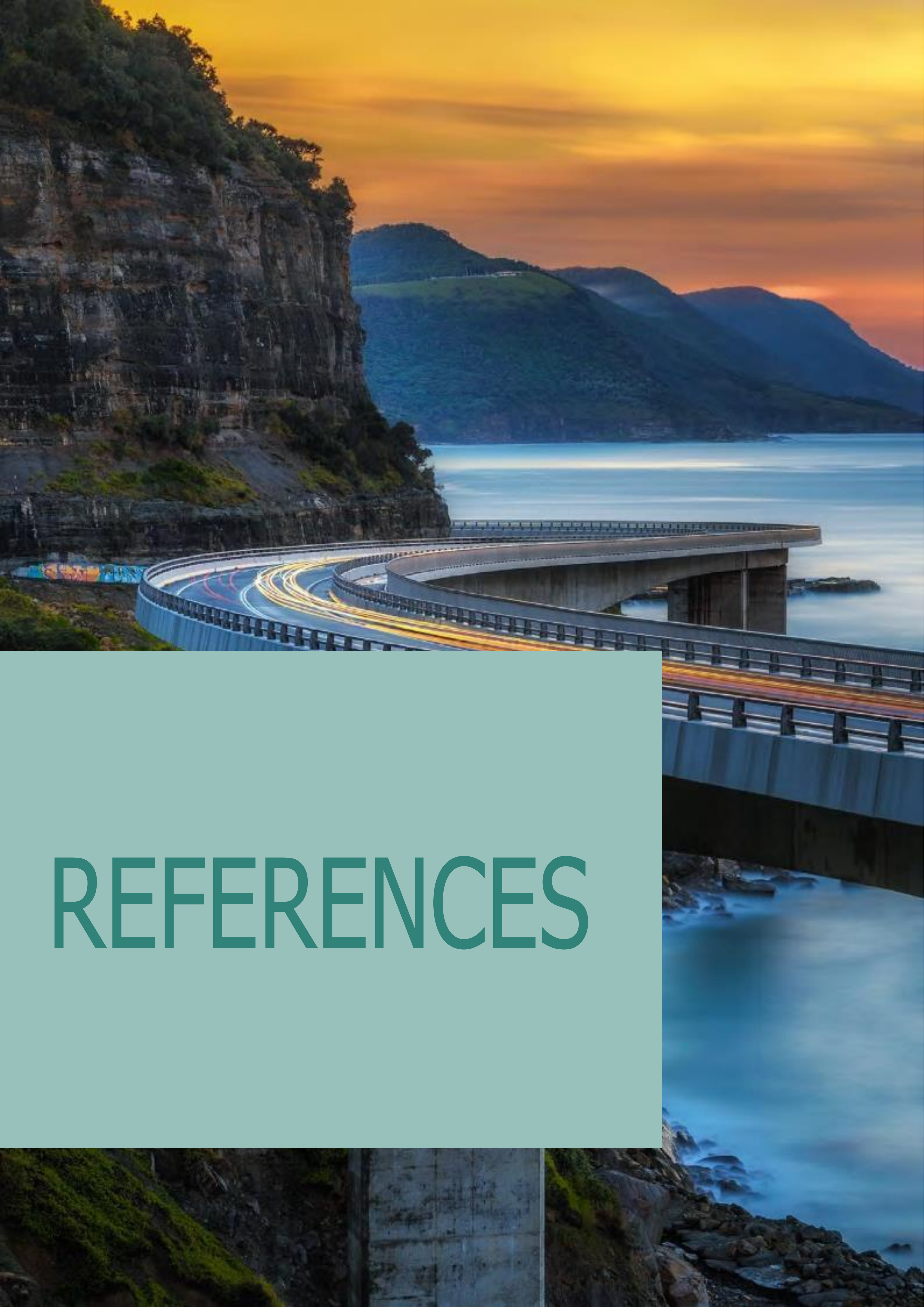
Effective monitoring requires data management and storage capacity that allows for continuity of data and information gathering, storage and sharing across different project and life cycle phases and with different stakeholder groups. The economicbenefits of public sector data transparency have been estimated at USD 3 trillion to USD 5 trillion per year globally[72].

> CASE STUDY: INFRASTRUCTURE DATA INNOVATIONS IN MALAWI

Governments should therefore engage in partnerships with the private sector, academia and civil society to ensure that relevant data are defined, measured, collected, analysed and synthesized in ways that are useful for decision makers and the public. As broad expertise in collecting, connecting and interpreting quality data might not exist across all sectors and countries, capacity building is a key enabler of data-driven approaches to sustainable infrastructure planning and operating.

The establishment of “digital ecosystems” of data can help to address many existing data challenges, exploit synergies between different data initiatives, and offer various opportunities to better align infrastructure development with the SDGs. Such a digital ecosystem connects individual data with algorithms and analysis to create trustworthy insights about the state of the environment and the interconnections between the economy, society and the environment. It could improve the ability to make informed decisions and evaluate policy interventions[73].





REFERENCES

END NOTES

1. Benedict, M. A. and McMahon, E. T. *Green Infrastructure: Linking Landscapes and Communities*. 2nd ed. Washington, DC, USA: Island Press; 2006.
2. Roy, D. "The Multiple Benefits of Natural Infrastructure". International Institute for Sustainable Development Blog; 27 August 2018. Available from: https://www.iisd.org/articles/multiple-benefits-natural-infrastructure. [Accessed 4 January 2021].
3. International Union for Conservation of Nature. "Defining Nature-based Solutions." IUCN Resolution WCC-2016-Res-069-EN; 2016. Available from: https://portals.iucn.org/library/sites/library/files/resrecfiles/WCC_2016_RES_069_EN.pdf.
4. Thacker, S., Adshead, D., Morgan, G., Crosskey, S., Bajpai, A., Ceppi, P. et al. *Infrastructure: Underpinning Sustainable Development*. Copenhagen, Denmark: UNOPS; 2018. Available from: https://content.unops.org/publications/Infrastructure_underpining_sustainable_development_EN.pdf?mtime=20200416084541
5. Saha, D. "Low Carbon Infrastructure: an essential solution to climate change?". World Bank Blogs; 18 April 2018. Available from: https://blogs.worldbank.org/ppps/low-carbon-infrastructure-essential-solution-climate-change [Accessed 4 January 2021].
6. Brondízio, E.S., Settele, J., Díaz, S. and Ngo, H.T. (eds.). *Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services - Chapters 2 and 4*. Bonn, Germany: IPBES secretariat; 2019. Available from: https://www.ipbes.net/global-assessment.
7. Organisation for Economic Co-operation and Development. *Investing in Climate, Investing in Growth: A Synthesis*. Paris, France: OECD; 2017. Available from: https://www.oecd.org/environment/cc/g20-climate/synthesis-investing-in-climate-investing-in-growth.pdf.
8. Global Infrastructure Hub and Oxford Economics. *Global Infrastructure Outlook.* Sydney, Australia: Global Infrastructure Hub; 2017. Available from: https://cdn.gihub.org/outlook/live/methodology/Global+Infrastructure+Outlook+-+July+2017.pdf.
9. Vivid Economics. "Greenness of Stimulus Index". Available from: https://www.vivideconomics.com/wp-content/uploads/2021/01/201214-GSI-report_December-release.pdf [Accessed 12 January 2021].
10. Davisson, K. and Losavio, J. "How Sustainable Infrastructure Can Aid the Post-COVID Recovery", World Economic Forum website; 28 April 2020. Available from: https://www.weforum.org/agenda/2020/04/coronavirus-covid-19-sustainable-infrastructure-investments-aid-recovery/ [Accessed 4 January 2021].
11. International Monetary Fund. "How a Collective Infrastructure Push Will Boost Global Growth", IMFBlog; 24 November 2020. Available from: https://blogs.imf.org/2020/11/24/how-a-collective-infrastructure-push-will-boost-global-growth/?utm_medium=email&utm_source=govdelivery [Accessed 4 January 2021].
12. Garrett-Peltier, H. Green versus brown: Comparing the employment impacts of energy efficiency, renewable energy, and fossil fuels using an input-output model. *Economic Modelling.* 2017; 61: 439-447.
13. Hallegatte, S., Rentschler, J. and Rozenberg. J. *Lifelines: The Resilient Infrastructure Opportunity.* Washington, DC, USA: World Bank; 2019. Available from: https://openknowledge.worldbank.org/handle/10986/31805.
14. International Institute for Sustainable Development. "Energy Policy Tracker". Available from: https://www.energypolicytracker.org/about/ [Accessed 17 November 2020].
15. Organisation for Economic Co-operation and Development. "Biodiversity and the economic response to COVID-19: Ensuring a green and resilient recovery." OECD Policy Brief; 28 September 2020. Available from: https://www.oecd.org/coronavirus/policy-responses/biodiversity-and-the-economic-response-to-covid-19-ensuring-a-green-and-resilient-recovery-d98b5a09/ [Accessed 4 January 2021].

16. Díaz, S., Settele, J., Brondízio, E.S., Ngo, H.T., Guèze, M., Agard, J. et al. (eds.). *Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*. Bonn, Germany: IPBES secretariat; 2019. Available from: https://www.ipbes.net/sites/default/files/2020-02/ipbes_global_assessment_report_summary_for_policymakers_en.pdf.

17. Edenhofer, O., Pichs-Madruga, R., Sokona, Y., Farahani, E., Kadner, S., Seyboth, K. et al. (eds.). *AR5 Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press; 2014. Available from: https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_full.pdf.

18. Hall, J.W., Tran, M., Hickford, A.J. and Nicholls, R.J. (eds.). *The Future of National Infrastructure: A System of Systems Approach.* Cambridge, UK: Cambridge University Press; 2016.

19. G20. *G20 Principles for Quality Infrastructure Investment.* Japan: G20; 2019. Available from: https://www.mof.go.jp/english/international_policy/convention/g20/annex6_1.pdf

20. Organisation for Economic Co-operation and Development. *OECD Compendium of Policy Good Practices for Quality Infrastructure Investment.* Paris, France: OECD; 2020. Available from: www.oecd.org/finance/oecd-compendium-of-policy-good-practices-for-quality-infrastructure-investment.htm.

21. The Global Commission on Economy and Climate. *The Sustainable Infrastructure Imperative: Financing for Better Growth and Development.* Washington, DC: World Resources Institute; 2016. Available from: https://greengrowthknowledge.org/research/sustainable-infrastructure-imperative-financing-better-growth-and-development.

22. World Bank. *Who Sponsors Infrastructure Projects? Disentangling public and private contributions, 2017.* Washington, DC, USA: World Bank; 2019. Available from: https://ppi.worldbank.org/content/dam/PPI/documents/SPIReport_2017_small_interactive.pdf.

23. Inter-American Development Bank. *What is Sustainable Infrastructure? A Framework to Guide Sustainability Across the Project Cycle.* Washington, DC, USA: IDB; 2018. Available from: https://publications.iadb.org/en/what-sustainable-infrastructure-framework-guide-sustainability-across-project-cycle.

24. Organisation for Economic Co-operation and Development. *Applying Strategic Environmental Assessment: Good Practice Guidance for Development Cooperation*. Paris, France: OECD; 2006. Available from: https://www.oecd.org/dac/environment-development/applying-sea-good-practice-guidance.htm.

25. Battacharya, A., Nofal, B., Krueger, L., Jeong, M. and Gallagher, K. "Policy and Institutional Framework for Delivering on Sustainable Infrastructure", T20 Policy Brief; 9 May 2019. Available from: https://t20japan.org/wp-content/uploads/2019/05/t20-japan-tf4-10-policy-institutional-framework-delivering-sustainable-infrastructure.pdf.

26 Organisation for Economic Co-operation and Development. *Recommendations of the Council of the Governance of Infrastructure*. Paris, France: OECD; 2020. Available from: https://legalinstruments.oecd.org/en/instruments/OECD-LEGAL-0460.

27. Rozenberg, J., and Fay, M. *Beyond the Gap: How Countries Can Afford the Infrastructure They Need while Protecting the Planet.* Washington, DC, USA: World Bank; 2019. Available from: https://openknowledge.worldbank.org/handle/10986/31291.

28. Organisation for Economic Co-operation and Development. "Sustainable Connectivity: Closing the Gender Gap in Infrastructure", OECD Environment Policy Paper No. 15; 2019. Available from: https://www.oecd-ilibrary.org/docserver/6350ba66-en.pdf?expires=1610284970&id=id&accname=guest&checksum=6907E3C6DFFCCCAC06FDEA2F6BB0F318

29. United Nations Economic and Social Council. “Smart cities and infrastructure”. Report of the Secretary-General: E/CN.16/2016/2; 26 February 2016. Available from: https://unctad.org/system/files/official-document/ecn162016d2_en.pdf.

30. Stevenson, M. and Weber, C. “Mitigation Hierarchies First Things First: Avoid, Reduce…and Only After that—Compensate.” WWF Discussion Paper; April 2020. Available from: https://wwfint.awsassets.panda.org/downloads/wwf_discussion_paper_mitigation_hierarchies_april_2020.pdf

31. Development Corridors Partnership. *“What is a Development Corridor?”*. Available from: https://developmentcorridors.org/development-corridors/ [Accessed 4 January 2021].

32. Brunner, H.-P. *What is Economic Corridor Development and What Can It Achieve in Asia’s Subregions?* Manila, Philippines: Asian Development Bank; 2013. Available from: https://www.adb.org/sites/default/files/publication/100110/reiwp-117-economic-corridor-development.pdf.

33. Development Corridors Partnership. *Development Corridors in Tanzania - A scoping study*. Cambridge, UK: UNEP-WCMC; 2019. Available from: https://developmentcorridors.org/wp-content/uploads/2019/07/Tanzania-Scoping-Study.pdf

34. United Nations Development Programme Global Centre for Public Service Excellence. *Foresight as a strategic long-term planning tool for developing countries*. Singapore: UNDP; 2014. Available from: https://www.undp.org/content/undp/en/home/librarypage/capacity-building/global-centre-for-public-service-excellence/Foresight.html.

35. Bartlett, R. *Visioning Futures: Improving infrastructure planning to harness nature’s benefits in a warming world.* Washington, DC, USA: WWF; 2019. Available from: https://www.worldwildlife.org/publications/visioning-futures-improving-infrastructure-planning-to-harness-nature-s-benefits-in-a-warming-world-lo-res.

36. Cohen-Shacham, E., Walters, G., Janzen, C. and Maginnis, S. (eds.). *Nature-based Solutions to address global societal challenges*. Gland, Switzerland: IUCN; 2016. Available from: https://portals.iucn.org/library/sites/library/files/documents/2016-036.pdf.

37. International Federation of Red Cross and Red Crescent Societies. *World Disasters Report: Focus on Reducing Risk.* Geneva, Switzerland: IFRC; 2002. Available from: https://www.ifrc.org/Global/Publications/disasters/WDR/32600-WDR2002.pdf.

38. Gartner, T., Mulligan, J., Schmidt, R. and Gunn, J. *Natural Infrastructure: Investing in Forested Landscapes for Source Water Protection in the United States*. Washington, DC, USA: World Resources Institute; 2013. Available from: https://www.wri.org/publication/natural-infrastructure?downloaded=true.

39. Oberle, B.,Bringezu, S., Hatfield-Dodds, S., Hellweg, S., Schandl, H., Clement, J. et al. *Global Resources Outlook 2019: Natural Resources for the Future We Want.* Nairobi, Kenya: International Resource Panel and United Nations Environment Programme; 2019. Available from: https://www.resourcepanel.org/reports/global-resources-outlook

40. Bringezu, S., Ramaswami, A., Schandl, H., O’Brien, M., Pelton, R., Acquatella, J. et al. *Assessing global resource use: A systems approach to resource efficiency and pollution reduction.* Nairobi, Kenya: International Resource Panel and United Nations Environment Programme; 2017. Available from: https://www.resourcepanel.org/reports/assessing-global-resource-use.

41. Peduzzi, P. Sand, rarer than one thinks. *Environmental Development*. 2014; 11: 208-218.

42. Lehne, J. and Preston, F. *Making Concrete Change: Innovation in Low-carbon Cement and Concrete.* London, UK: Chatham House; 2018. Available from: https://www.chathamhouse.org/sites/default/files/publications/2018-06-13-making-concrete-change-cement-lehne-preston-final.pdf.

43. Amon, A., and Holmes, I. *Energy Efficiency as Infrastructure: Leaping the Investment Gap*. London, UK: E3G; 2016. Available from: https://www.e3g.org/wp-content/uploads/E3G_Energy_Efficiency_as_Infra structure.pdf.

44. Atkinson, R. D., Castro, D., and Ezell, S. J. *The Digital Road to Recovery: A Stimulus Plan to Create Jobs, Boost Productivity and Revitalize America*. Washington, DC, USA: Information, Technology, and Innovation Foundation; 2009. Available from: https://itif.org/files/roadtorecovery.pdf.

45. United Nations Environment Programme. *District Energy in Cities: Unlocking the Potential of Energy Efficiency and Renewable Energy*. Nairobi, Kenya: UNEP; 2015. Available from: https://greengrowthknowledge.org/research/district-energy-cities-unlocking-potential-energy-efficiency-and-renewable-energy.

46. Swilling, M., Hajer, M., Baynes, T., Bergesen, J., Labbé, F., Musango, J.K. et al. *The Weight of Cities: Resource Requirements of Future Urbanization*. Nairobi, Kenya: International Resource Panel and United Nations Environment Programme; 2018. Available from: https://www.resourcepanel.org/reports/weight-cities.

47. Swilling, M., Robinson, B., Marvin, S. and Hodson, M. *City-Level Decoupling: urban resource flows and the governance of infrastructure transitions*. Nairobi, Kenya: International Resource Panel and United Nations Environment Programme; 2013. Available from: https://www.resourcepanel.org/reports/city-level-decoupling.

48. Organisation for Economic Co-operation and Development/World Bank/United Nations Environment Programme. *Financing Climate Futures: Rethinking Infrastructure*. Paris, France: OECD; 2018. Available from: https://www.oecd.org/environment/financing-climate-futures-9789264308114-en.htm.

49. Turley, L., Hug Silva, M., Benson, S., and Dominguez, C. *Performance-Based Specifications: Exploring when they work and why.* Winnipeg, Manitoba, Canada: IISD; 2014. Available from: https://www.iisd.org/system/files/publications/performance-based-speculations-exploring-when-they-work-and-why.pdf.

50. Fransen, L., del Bufalo, G., and Reviglio, E. “Boosting Investment in Social Infrastructure in Europe: Report of the High-Level Task Force on Investing in Social Infrastructure in Europe”. European Economy Discussion Paper 074; January 2018. Available from: https://ec.europa.eu/info/sites/info/files/economy-finance/dp074_en.pdf.

51. Woetzel, J., Garemo, N., Mischke, J., Kamra, P., and Palter, R. *Bridging Infrastructure Gaps: Has the World made Progress?*. McKinsey Global Institute; 2017. Available from: https://www.mckinsey.com/business-functions/operations/our-insights/bridging-infrastructure-gaps-has-the-world-made-progress.

52. The Ecological Sequestration Trust. *Smart ways to mobilise more efficient and effective long-term investment in city regions*. London, UK: The Ecological Sequestration Trust; 2014. Available from: https://ecosequestrust.org/financeforSDGs.pdf.

53. Wellenstein, A. and Gill, M. “Making Infrastructure Work for Both Women and Men”. World Bank Blogs; 28 August 2019. Available from: https://blogs.worldbank.org/voices/making-infrastructure-work-both-wom- en-and-men [Accessed 4 January 2021].

54. Morgan G, Bajpai A, Ceppi P, Al-Hinai A, Christensen T, Kumar S, Crosskey S and O’Regan N. *Infrastructure for gender equality and the empowerment of women*. Copenhagen, Denmark: UNOPS; 2020. Available from : https://content.unops.org/publications/UNOPS-Infrastructure-for-Gender-Equality-and-the-Empowerment-of-women.pdf?mtime=20200914194443.

55. International Labour Organization. *Declaration on Fundamental Principles and Rights at Work.* Geneva, Switzerland: ILO; 18 June 1998. Available from: https://www.ilo.org/declaration/thedeclaration/textdeclaration/lang--en/index.htm.

56. International Labour Organization. *Safety and Health in Construction Convention*. Geneva, Switzerland: ILO, 1988 (No. 167). Available from: https://www.ilo.org/dyn/normlex/en/f?p=NORMLEXPUB:12100:0::NO::P12100_INSTRUMENT_ID:312312.

57. International Union for the Conservation of Nature. “Protected areas and other areas important for biodiversity in relation to environmentally damaging industrial activities and infrastructure development”. IUCN Recommendation WCC-2016-Rec-102-EN ; 2016. Available from: https://portals.iucn.org/library/sites/library/files/resrecfiles/WCC_2016_REC_102_EN.pdf.

58. United Nations. “United Nations Declaration on the Rights of Indigenous Peoples”. Resolution A/RES/61/295; 2007. Available from: https://www.un.org/development/desa/indigenouspeoples/declaration-on-the-rights-of-indigenous-peoples.html.

59. International Finance Corporation. *Performance Standard 5 – Land Acquisition and Involuntary Resettlement.* Washington, DC, USA: IFC; 2012. Available from: https://www.ifc.org/wps/wcm/connect/75de96d4-ed36-4bdb-8050-400be02bf2d9/PS5_English_2012.pdf?MOD=AJPERES&CVID=jqex59b.

60. International Labour Organization. *World Employment and Social Outlook: Trends for Women 2017*. Geneva, Switzerland: ILO; 2017. Available from: https://www.ilo.org/wcmsp5/groups/public/---dgreports/---

inst/documents/publication/wcms_557245.pdf.

61. Speakman, J. and Koivisto, M. “Growth Poles: Raising Competitiveness and Deepening Integration”, in *The Africa Competitiveness Report 2013*. Geneva, Switzerland: World Economic Forum; 2013. Available from: http://www3.weforum.org/docs/ACR/2013/ACR_Chapter2.3_2013.pdf.
62. Fay, M., Lee, H.I., Mastruzzi, M., Han, S., and Cho, M. “Hitting the Trillion Mark; A Look at How Much Countries are Spending on Infrastructure”. World Bank Policy Research Working Paper 8730; 2019. Available from: https://openknowledge.worldbank.org/handle/10986/31234.
63. United Nations Conference on Trade and Development. “The Covid-19 Shock to Developing Countries: towards a ‘whatever it takes’ programme for two thirds of the world’s population being left behind”. Trade and Development Report Update, March 2020. Available from: https://unctad.org/system/files/official-document/gds_tdr2019_covid2_en.pdf.
64. Institution of Civil Engineers. *Reducing the gap between cost estimates and outturns for major infrastructure projects and programmes.* London, UK: ICE; 2019. Available from: https://www.ice.org.uk/news-and-insight/policy/gap-between-estimates-and-outturns.
65. Röttgers, D., Tandon, A. and Kaminker, C. “OECD Progress Update on Approaches to Mobilising Institutional Investment for Sustainable Infrastructure”. OECD Environment Working Papers No. 138; 2018. Available from: https://www.oecd-ilibrary.org/docserver/45426991-en.pdf?expires=1609765223&id=id&accname=guest&checksum=F2D80B68030B9FBFD7ABE7C99D57FB79.
66. International Monetary Fund and World Bank. “G20 Note: Improving Public Debt Recording, Monitoring, and Reporting Capacity in Low and Lower Middle-Income Countries”. G20 Notes on Strengthening Public Debt Transparency; 14 June 2018. Available from: https://www.imf.org/external/np/g20/pdf/2018/072718.pdf.
67. Organisation for Economic Co-operation and Development. *OECD Foreign Bribery Report: An Analysis of the Crime of Bribery of Foreign Public Officials*. Paris, France: OECD; 2014. Available from: https://www.oecd.org/corruption/oecd-foreign-bribery-report-9789264226616-en.htm.
68. Organisation for Economic Co-operation and Development. *OECD Due Diligence Guidance for Responsible Business Conduct*. Paris, France: OECD; 2018. Available from: http://mneguidelines.oecd.org/OECD-Due-Diligence-Guidance-for-Responsible-Business-Conduct.pdf.
69. G20. *G20 Compendium of Good Practices for Promoting Integrity and Transparency in Infrastructure Development*. Japan: G20; 2019. Available from: https://www.oecd.org/g20/summits/osaka/G20-Compendium-of-Good-Practices-in-Infrastructure-Development.pdf.
70. Watkins, G., Mueller, S., Meller, H., Ramirez, M.C., Serebrisky, T., and Georgoulias, A. *Lessons from Four Decades of Infrastructure Project-Related Conflicts in Latin America and the Caribbean*. Washington, DC, USA: IDB; 2017. Available from: https://publications.iadb.org/en/lessons-four-decades-infrastructure-project-related-conflicts-latin-america-and-caribbean.
71. International Finance Corporation. *IFC Performance Standards on Environmental and Social Sustainability.* Washington, DC, USA: IFC; 2012. Available from: https://www.ifc.org/wps/wcm/connect/24e6bfc3-5de3-444d-be9b-226188c95454/PS_English_2012_Full-Document.pdf?MOD=AJPERES&CVID=jkV-X6h.
72. United Nations Department of Economic and Social Affairs. *United Nations E-Government Survey 2016: E-Government in Support of Sustainable Development*. New York, USA: United Nations; 2016. Available from: https://publicadministration.un.org/egovkb/Portals/egovkb/Documents/un/2016-Survey/E-Government%20Survey%202016.pdf.
73. United Nations Environment Programme and Science Policy Business Forum. “The Case for a Digital Ecosystem for the Environment: Bringing together data, algorithms and insights for sustainable development.” Discussion Paper; 5 March 2019. Available from: https://un-spbf.org/wp-content/uploads/2019/03/Digital-Ecosystem-final-2.pdf.

ADDITIONAL RESOURCES

Browder, G., Ozment, S., Rehberger Bescos, I., Gartner, T. and Lange, G.-M. *Integrating Green and Gray – Creating Next Generation Infrastructure*. Washington, DC, USA: World Bank and World Resources Institute; 2019. Available from: https://www.wri.org/publication/integrating-green-gray.

Costanza and Daly. Natural Capital and Sustainable Development. *Conservation Biology.* 1992; 6(1): 37-46.

Foresight4Food. "A Framework for Understanding Foresight & Scenario Analysis". Available from: https://www.foresight4food.net/a-framework-for-understanding-foresight-scenario-analysis/ [Accessed 13 January 2021].

Hegmann, G., Cocklin, C., Creasey, R., Dupuis, S., Kennedy, A., Kingsley, L. et al. *Cumulative Effects Assessment Practitioners Guide.* Hull, Quebec, Canada: Canadian Environmental Assessment Agency; 1999. Available from: https://www.canada.ca/en/impact-assessment-agency/services/policy-guidance/cumulative-effects-assessment-practitioners-guide.html.

Integrated Biodiversity Assessment Tool. Available from: https://www.ibat-alliance.org/about-us

International Union for Conservation of Nature. *Global Standard for Nature-based Solutions. A user-friendly framework for the verification, design and scaling up of NbS.* First edition. Gland, Switzerland: IUCN; 2020. Available from: https://portals.iucn.org/library/node/49070

International Union for Conservation of Nature. "IUCN Policy on Biodiversity Offsets". IUCN Resolution WCC-2016-Res-059-EN; 2016. Available from: https://portals.iucn.org/library/sites/library/files/resrecfiles/WCC_2016_RES_059_EN.pdf.

Stanford University. "Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST)". Available from: https://naturalcapitalproject.stanford.edu/software/invest [Accessed 13 January 2021].

Sterman, J. D. A Skeptic's Guide to Computer Models. In: *Managing a Nation: The Microcomputer Software Catalog Barney.* Barney, G. O. et al. (eds.). Boulder, CO: Westview Press; 1991. 209-229. Available from: https://web.mit.edu/jsterman/www/Skeptic%27s_Guide.pdf.

Sustainable Low Carbon Transport Partnership. Available from: https://slocat.net/about-us/who-we-are/ [Accessed 13 January 2021].

The Economics of Ecosystems and Biodiversity initiative. Available from: http://teebweb.org/ [Accessed 13 January 2021].

United Nations. "System of Environmental Economic Accounting (SEEA)". Available from: https://seea.un.org/ecosystem-accounting [Accessed 13 January 2021].

United Nations Environment Programme. *Integrated Approaches to Sustainable Infrastructure*. Geneva, Switzerland: UNEP; 2019. Available from: https://www.greengrowthknowledge.org/sites/default/files/downloads/resource/Integrated_Approaches_To_Sustainable_Infrastructure_UNEP.pdf.

United Nations Environment Programme. *Integrated Approaches in Action: A Companion to the International Good Practice Principles for Sustainable Infrastructure.* Nairobi, Kenya: UNEP, 2021.

Wealth Accounting and the Valuation of Ecosystem Services (WAVES) Partnership. Available from: https://www.wavespartnership.org/ [Accessed 13 January 2021].

World Forum on Natural Capital. "What is Natural Capital?". Available from: https://naturalcapitalforum.com/about/ [Accessed 13 January 2021].

ISBN NO:

JOB NO: