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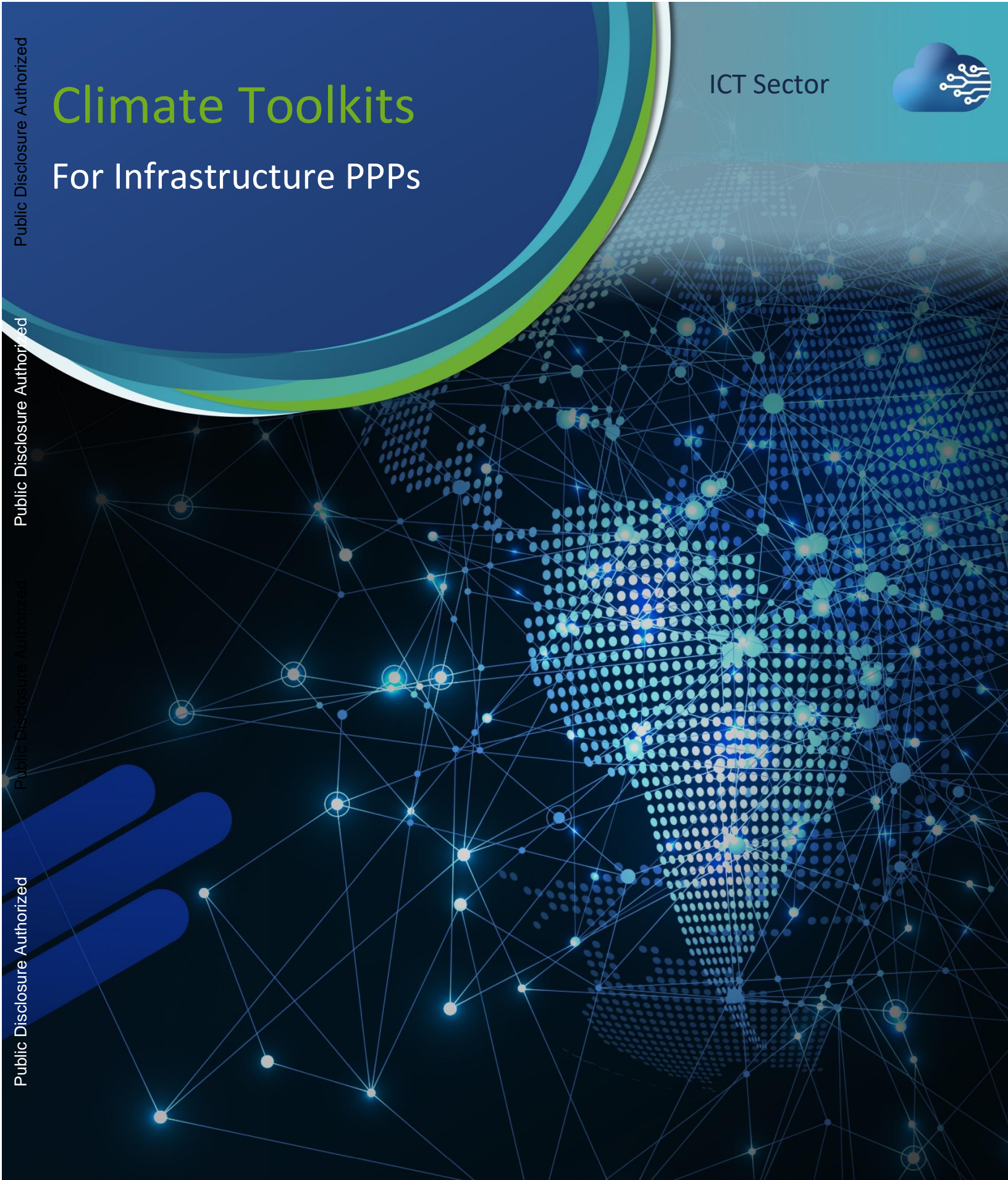
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Climate Toolkits For Infrastructure PPPs

ICT Sector



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PPIAF

Enabling Infrastructure Investment



Global
Infrastructure
Facility

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Telephone: 202-473-1000; Internet: www.worldbank.org

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About PPIAF

PPIAF helps developing-country governments strengthen policy, regulations, and institutions that enable sustainable infrastructure with private-sector participation. As part of these efforts, PPIAF promotes knowledge transfer by capturing lessons while funding research and tools; builds capacity to scale infrastructure delivery; and assists sub-national entities in accessing financing without sovereign guarantees. Donor-supported and housed within the World Bank, PPIAF's work helps generate hundreds of millions of dollars in infrastructure investment. While many initiatives focus on structuring and financing infrastructure projects with private participation, PPIAF sets the stage to make this possible.

About the GIF

The Global Infrastructure Facility, a G20 initiative, has the overarching goals of increasing private investment in sustainable infrastructure across emerging markets and developing economies, and improving services that contribute to poverty reduction and equitable growth aligned with the Sustainable Development Goals (SDGs). The GIF provides funding and hands-on technical support to client governments and multilateral development bank partners to build pipelines of bankable sustainable infrastructure. The GIF enables collective action among a wide range of partners—including donors, development finance institutions, and country governments, together with inputs of private sector investors and financiers—to leverage both resources and knowledge to find solutions to sustainable infrastructure financing challenges.

About CTA

IFC's PPP Transaction Advisory (CTA) advises governments on designing and implementing public-private partnership (PPP) projects that provide or expand much needed access to and/or improved delivery of high-quality infrastructure services—such as power, transportation, health, water and sanitation—to people while being affordable for governments. In doing so, CTA assists on the technical, financial, contractual, and procurement aspects of PPP transactions. To date, CTA has signed over 400 projects in 87 countries, mobilizing over \$30 billion of private investment in infrastructure, and demonstrating that well-structured PPPs can produce significant development gains even in challenging environments.

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List of Abbreviations and Acronyms

AI	artificial intelligence
BTS	base transceiver station
CAPEX	capital expenditures
CBA	cost-benefit analysis
CCKP	Climate Change Knowledge Portal
CMIP	Coupled Model Intercomparison Project
CO₂	carbon dioxide
CO₂e	carbon dioxide equivalent
CTIP3	Climate Toolkits for Infrastructure PPPs
DRC	Democratic Republic of Congo
EIRR	economic internal rate of return
EMDE	emerging market and developing economy
ESG	environmental, social, and governance
EU	European Union
GB	gigabyte
GeSI	Global Enabling Sustainability Initiative
GHG	greenhouse gas
GPP	green public procurement
GSMA	Global System for Mobile Communications Association
ICT	information and communication technology
IEA	International Energy Agency
IFC	International Finance Corporation
IoT	internet of things
IPCC	Intergovernmental Panel on Climate Change
IPCC AR6	Sixth Assessment Report of the Intergovernmental Panel on Climate Change
IPCC WGI	International Panel on Climate Change Working Group I
IT	information technology
ITU	International Telecommunication Union
ITU-T	ITU Telecommunication Standardization Sector
JRC	Joint Research Centre
KPI	key performance indicator
kWh	kilowatt-hour
LCA	life-cycle assessment
LTS	long-term strategy
MCDM	multi-criteria decision-making
MDB	multilateral development bank
MIGA	Multilateral Investment Guarantee Agency
MINPE	Ministry of Fishing and Livestock
NAP	national adaptation plan

NAPA	national adaptation program of action
NbS	nature-based solution
NDC	Nationally Determined Contribution
NPV	net present value
O&M	operation and maintenance
PE	project emissions
PPP	public-private partnership
PUE	power usage effectiveness
RCP	Representative Concentration Pathway
SBTi	Science Based Targets initiative
SDGs	Sustainable Development Goals
SMART	specific, measurable, attainable, relevant, and time-bound
SSPs	Shared Socioeconomic Pathways
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
UPS	uninterruptible power supply
USAID	United States Agency for International Development
USGS	United States Geological Survey
VfM	value for money
vs	versus
WBA	World Benchmarking Alliance
WESR	World Environment Situation Room

Foreword

The time for action to build a better future and green recovery has never been stronger as we navigate the uncertainty of a world dealing with multiple crisis on top of climate change. As governments across the globe face fiscal constraints, it has become imperative to crowd in private sector solutions, innovation, and finance to create new solutions and pathways to meet Paris Agreement goals on climate change and UN Sustainable Development Goal (SDG) commitments.

Participation of the private sector in Paris-Aligned infrastructure investments is critical and public-private partnerships (PPPs) are among the key solutions. PPPs are critical in supporting governments to bridge the infrastructure gap not only for the additional capital they bring but sector expertise and innovation as well. However, the PPP model is not without challenges, climate change creates uncertainty that can be difficult to account for in the framework of PPPs, which require a certain degree of predictability to attract investment and finance.

This sector-specific toolkit on the information and communications technology (ICT) sector aims to address this challenge by embedding a climate approach into upstream PPP structuring. If structured correctly, PPPs in Information & Communications Technology can increase climate resilience offering market-based solutions to address both mitigation and adaptation challenges. PPPs are able to provide well-informed and well-balanced risk allocation between partners— offering long-term visibility and stability for the duration of a contract (typically 20 to 30 years)- compensating climate change uncertainty through contractual predictability.

The toolkit attempts to address questions like:

- In what ways—in terms of likelihood and impact—does climate change affect ICT projects, both *directly* (e.g., in terms of construction, operation, and decommissioning of physical ICT infrastructure) and *indirectly* (e.g., in terms of ICT-enabled smart technologies across sectors), and what measures can be taken to alleviate these impacts through a PPP structure?
- How can you consider options to improve climate mitigation of GHG in ICT, including energy intensive data centers and other innovative options to decarbonization?
- How can we innovate to allow for optimal risk allocation and contractual predictability in an environment marked by uncertainty and the need for resilience to unpredictable scenarios?

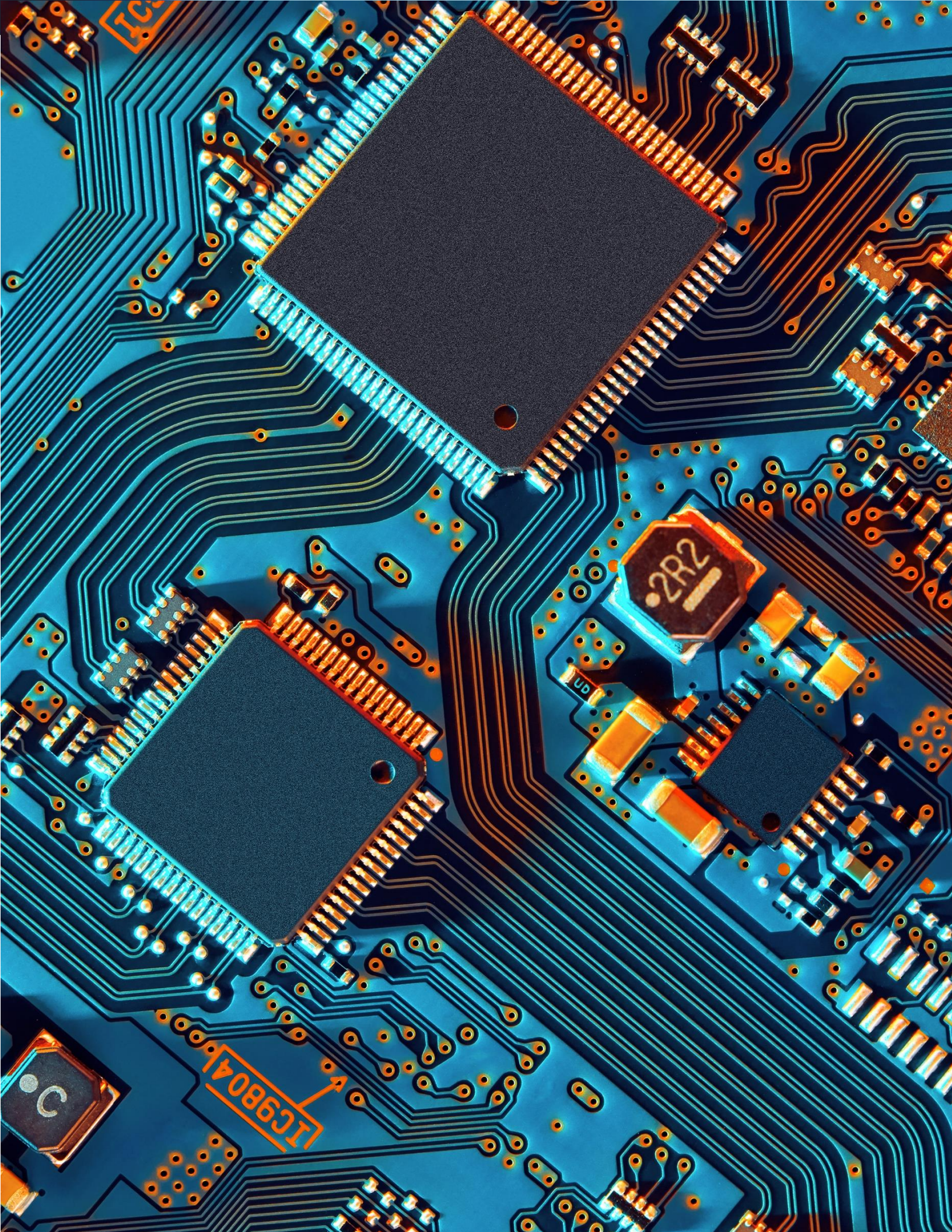
The Global Infrastructure Facility (GIF), The Public Private Infrastructure Advisory Facility (PPIAF) and International Finance Corporation, Transaction Advisory, Public-Private Partnership and Corporate Finance Advisory Services in collaboration with sector specialists across the World Bank Group (WBG)—have joined forces to build upon best practice on a topic at the cross-roads of climate change, infrastructure, and private sector participation. It is a field in evolution where there will be a great deal of innovation ahead of us.

Currently an insufficient focus is given to considering climate change in the framework of PPPs. For instance, the PPP tender selection criteria are currently ultimately based on the least cost approach, which may promote assets not resilient enough to withstand climate impacts. This may in turn result in total asset loss with devastating effects on the economy and society. This toolkit is indeed about providing solutions to public officials and their advisors on how to better align interests and incentives towards climate-smart investments and tap into private sector financing capacity.

This sector-specific toolkit on the information and communications technology (ICT) sector toolkit as part of the Climate Toolkits for Infrastructure PPPs (CTIP3) suite is ultimately a call for action for decision makers, to push for bold initiatives so that infrastructure investments become a critical and steady pathway to achieve Paris Agreement and SDG commitments.

Emmanuel B. Nyirinkindi Vice President, Cross-Cutting Solutions, International Finance Corporation

Imad Najib Ayed Fakhoury Global Director, Infrastructure Finance, PPPs and Guarantees Global Practice, World Bank



INTRODUCTION

Transition to a digital world

Around the world, the pace of digital transformation is accelerating. The COVID-19 pandemic has further increased the speed of digital technology adoption across almost all sectors of the economy, fueling the growth of the global information and communication technology (ICT) industry. Although governments are often seen mainly as providers of the legal, policy and regulatory frameworks and the public services that encourage the development of a healthy ICT sector, many governments have been taking a more active role, both by building digital skills vital for adoption, and by strengthening ICT infrastructure through innovative public-private partnerships (PPPs). Because sustainability and climate-change mitigation, adaptation, and resilience have become priorities for countries striving to meet their Paris Agreement (PA) commitments, it has become increasingly important to align these PPPs with global and national climate frameworks and policies.

ICT projects' climate impacts

Initially, digitalization's climate impact was widely perceived as unambiguously beneficial, because digital innovations enabled climate-friendly progress in various sectors, including transportation, the built environment, and waste management. As a result, much of the discussion in this area has focused on understanding the *indirect* climate impact of ICT projects (resulting from the application of ICT-enabled smart technologies in other sectors).

However, it is also important to consider—and mitigate—the *direct* climate impacts arising from the construction, operation, and decommissioning of ICT infrastructure.

Managing climate risks in ICT projects

Given the increasing digitalization of nearly all aspects of our society and economy, disruptions to digital services have serious ramifications beyond the ICT sector itself. It is therefore essential to foresee and, to the extent possible, mitigate climate-related risks related to the planned project. Due to the ICT infrastructure's networked nature, project-level risk management and adaptation plans need to include system-level considerations, building network-level resilience as well as strengthening the resilience of individual components.

Climate considerations affect project economics

Compared to traditional procurement, PPPs may unlock additional benefits by providing incentive mechanisms to align public and private sector interests, thereby enabling the use of private sector technology and innovation to address public needs (e.g., new materials and approaches to optimize energy efficiency and updated design of adaptation measures). On the other hand, climate-change-induced risks could reduce the appetite of private capital, especially when risk transfer options, such as insurance, are limited. Therefore, the implications of climate considerations on the costs and benefits as well as value for money (VfM) of an ICT project as a PPP should be considered at the

earlier stages of project selection, in order to identify any potential weaknesses and make the necessary adjustments.

Well-defined, measurable indicators are essential

Climate change may introduce new challenges in the delivery of ICT infrastructure projects. Meeting climate mitigation and adaptation goals will involve such considerations as proper site selection, design and construction; adequate monitoring; sustainable operations; and efficient maintenance.

To ensure that climate considerations are fully embedded in these processes, it is recommended that agencies provide specifications and output requirements in the form of specific, measurable, attainable, relevant, and time-bound (SMART) indicators.

The digital sector toolkit and its intended users

This toolkit is intended to help emerging market and developing economy (EMDE) government agencies incorporate climate-related risks and opportunities into the pre-structuring phase of ICT infrastructure projects procured through PPPs. The toolkit complements the World Bank Group's Climate Toolkits for Infrastructure PPPs¹ (CTIP3) (the "Umbrella Toolkit") by providing step-by-step instructions on how to apply its provisions to ICT infrastructure PPPs.

The toolkit is intended to familiarize non-experts with the potential effects of climate change on the project, as well as the resulting considerations for climate mitigation, adaptation and resilience, so that these can be properly incorporated when assessing the technical and commercial feasibility of ICT PPPs. As such, the toolkit focuses on preliminary steps (that could potentially be implemented with minimum external support) aiming to help users understand climate change's potential

consequences for the ICT infrastructure project and measures that can alleviate them. (Note that this toolkit it is not intended for the design to structuring and tendering phases, but should be consulted as a complementary tool to the Umbrella Toolkit.)



World Bank. Referred to as the [Umbrella Toolkit](#) in this document.

¹ World Bank, IFC (International Finance Corporation), and MIGA (Multilateral Investment Guarantee Agency). 2022. Climate Toolkits for Infrastructure PPPs. Washington, DC,

Typologies and definitions of ICT projects covered by this guide

Definition

In researching this toolkit, the Intergovernmental Panel on Climate Change's (IPCC's) broad definition² of the sector was used:

“Information and communication technology (ICT) comprises the integrated networks, systems and components enabling the transmission, receipt, capture, storage and manipulation of information by users on and across electronic devices.”

This is in line with the description proposed by the World Bank, which defines ICT³ as “hardware, software, networks, and media for the collection, storage, processing, transmission, and presentation of information (voice, data, text and images).”

Scope

This toolkit focuses on hard ICT infrastructure assets, including:

- **Data management infrastructure**—data centers and servers.
- **Data transmission infrastructure**/telecommunication networks—physical transmitters and receivers that send digital communications between end-users, including:
 - Wireless networks (especially mobile communication networks and satellite networks)
 - Fixed networks.

Other components (such as end-user devices, applications and services), although an integral part of the ICT infrastructure, remain outside the scope of the toolkit.

The toolkit covers sources of climate-related risks and possible adaptation measures for relevant asset categories within data management and transmission infrastructure. Given their growing importance for PPP purposes, throughout the toolkit additional, more detailed examples pertaining specifically to telecommunication networks and data centers are provided. However, the principles and approaches described in the toolkit apply broadly across all hard ICT infrastructure assets.

Besides projects that concern the design, building, operating and/or maintaining of hard ICT infrastructure, several types of PPPs may seek to develop and provide **digital/smart/e-public services**.

² Pörtner, H.-O., D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Lösckke, V. Möller, A. Okem, and B. Rama, eds. 2022. *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. IPCC (Intergovernmental Panel on Climate Change). doi:10.1017/9781009325844.

³ Khoury, Zaki Badie, Astrid Herdis Jacobsen, Elyse Jee Hyun Lee, and Jeongjin Oh. 2022. “Greening Digital in Korea: Korea Case Study for Greening the ICT Sector (English).” Innovation and Technology Note Series 6. World Bank, Washington, D.C.

These services⁴ are powered by (and are therefore dependent on) the hard infrastructure assets that this toolkit covers; as such, the toolkit’s emission reduction and climate risk considerations also apply to this category of PPPs. At the same time, it is important to acknowledge that there are certain adaptation and mitigation measures that are specific to the digital/smart services and not elaborated on in this toolkit.

Perspectives

There are four distinct climate-related perspectives from which an ICT infrastructure project may be approached:

- **Direct climate-change mitigation–Mitigation of:** how the ICT project can reduce its own carbon footprint (e.g., higher share of renewables in the energy mix of telecom towers, energy efficient components in data centers).
- **Indirect climate-change mitigation–Mitigation through:** how the ICT project can enable greenhouse gas (GHG) emission reduction in other projects or sectors (e.g., smart metering, digital abatements in transport).
- **Climate-change adaptation–Resilience of:**⁵ how the ICT project’s infrastructure and operations can be designed/implemented in a resilient way for the project to be able to face climate change’s challenges (e.g., extreme heat, floods).
- **Climate-change adaptation–Resilience through:** how the ICT project can help other sectors (e.g., transportation, agriculture) and society to adapt to climate change effects (e.g., through providing access to the digital world, building smart early warning systems or monitoring networks).

The “mitigation through” and “resilience through” perspectives tend to be prominent in policy discussions about ICT infrastructure development as other sectors explore digitally enabled solutions to reduce their climate impact and to increase their resilience to climate-induced hazards. These perspectives are therefore included in our policy assessment tools in Module 1. However, to ensure tractability and a clear scope, the rest of the toolkit takes a narrower focus and includes only the “mitigation of” and “resilience of” aspects of climate considerations in ICT infrastructure PPP projects.

⁴ Such as **national identification schemes:** GSMA and World Bank Group. 2016. “Digital Identity: Towards Shared Principles for Public and Private Sector Cooperation. Secure Identity Alliance Discussion Paper; **smart cities:** McKinsey & Company. 2018. *Leveraging PPPs for smart city infrastructure*; **digital health:** Ganapathy, K., S. Das, S. Reddy, V. Thaploo, A. Nazneen, A. Kosuru, and U. Shankar Nag. 2021. “Digital Health Care in Public Private Partnership Mode.” *Telemedicine Journal and E-Health* 27 (12): 1,363-1,371. doi: 10.1089/tmj.2020.0499; **telematics systems in public transport:** Greece Special Secretariat for Public-Private Partnerships (PPPs) website; **e-commerce opportunities:** Republic of the Philippines Public-Private Partnership Center website. “Improving Philpost’s Financial and Operational State Through ICT/E-Commerce Opportunities Project”; **e-education:** Munoz-Najar, A., and J. Osa Oviawe. 2020. “Nigeria: Edo-BEST@Home: Education continuity during the Coronavirus crisis.” OECD Publishing, Paris.

⁵ For the definitions of *resilience of* and *resilience through* terms see: World Bank Group. 2021. *Resilience Rating System: A Methodology for Building and Tracking Resilience to Climate Change*. Washington, DC: World Bank. <https://openknowledge.worldbank.org/handle/10986/35039>.

BOX 0.1 EXAMPLES OF ICT INFRASTRUCTURE PPP PROJECTS

There are several examples worldwide of public-private partnerships (PPPs) in ICT infrastructure projects. According to the Global System for Mobile Communications Association's (GSMA's) *Mobile Policy Handbook*,⁶ PPPs may be found across all telecoms network segments:

First mile: submarine cables, satellite hubs, internet exchange points

Medium mile: fiber backbone and backhaul

Last mile: radio access networks and wired local loops.

Notable examples of ICT infrastructure-related PPP projects (planned, ongoing or completed) include:

- Data centers (the Republic of Korea,⁷ The Gambia,⁸ Bhutan⁹)
- Submarine communication cables (Benin¹⁰)
- Cellular towers (the Philippines¹¹)
- Fiber-optic cable networks (Haiti¹²)
- Local broadband access (various examples¹³ from Brazil)
- Satellite (Indonesia¹⁴)
- Renewable power generation for telecommunication towers (Uganda¹⁵).

⁶ GSMA. 2022. *Mobile Policy Handbook: An Insider's Guide to the Issues*. GSM Association.

⁷ Khoury, Zaki Badie, Astrid Herdis Jacobsen, Elyse Jee Hyun Lee, and Jeongjin Oh. 2022. "Greening Digital in Korea: Korea Case Study for Greening the ICT Sector (English)." Innovation and Technology Note Series 6. World Bank, Washington, D.C.

⁸ The Gambia Ministry of Finance and Economic Affairs website: Public Private Partnerships/National Data Centre.

⁹ Dorji, Tshering Cigay. 2014. "PPP Experience in Bhutan: the Case of the Thimpu TechPark."

¹⁰ Krishnamani, Ranga Rajan. 2017. "Independent Evaluation Group (IEG) WARCIP APL 1C - Benin (P130184) Implementation Completion Report (ICR) Review." World Bank.

¹¹ Republic of the Philippines—Public-Private Partnership Center. "Department of Information and Communications Technology (DICT) eyes building cellular towers under PPP scheme." website.

¹² IFC (2013). Improving and expanding telecom - IFC Public-Private-Private Partnerships.

¹³ Migliorisi, Stefano et al. 2009. *Economic Development and Inclusion through Local Broadband Access Networks*.

Inter-American Development Bank. <https://publications.iadb.org/en/publication/economic-development-and-inclusion-through-local-broadband-access-networks>; Knight, Peter, and Flavio Feferman. 2014. *Private-Public Partnerships for Expanding Broadband Access: Lessons from the Cinturão Digital do Ceará Network in Brazil*.

¹⁴ Asian Infrastructure Investment Bank website. "Indonesia: Multifunctional Satellite PPP Project."

¹⁵ GSMA. 2020. *Renewable Energy for Mobile Towers: Opportunities for low- and middle-income countries*. GSM Association.

EXECUTIVE SUMMARY

This toolkit contains a set of tools covering the major climate entry points (identification of risks, incorporation of climate considerations in the project selection, and appraisal of climate effects in the project's economics), using as inputs the preliminary project data as well as readily available climate-related resources. This step-by-step process gradually builds up a project-specific collection of considerations that will need to be further evaluated and quantified in the subsequent phases, as well as an improved understanding of the potential needs for advisory services. The toolkit is divided into five modules:

Module 1 assists users with mapping climate policies and assessing projects against such policies in order to identify areas where a revision of plans may be required.

Module 2 provides a simplified methodology for the preliminary life-cycle assessment (LCA) of the project's greenhouse gas (GHG) emissions at a preliminary stage based on the project's typology and publicly available data.

Module 3 provides practical guidance to agencies to document—at a preliminary stage—which climate risks could affect a project, what their impact could be, and which adaptation measures might be applicable. Further guidance and more detailed instructions can be found in the [Umbrella Toolkit](#).

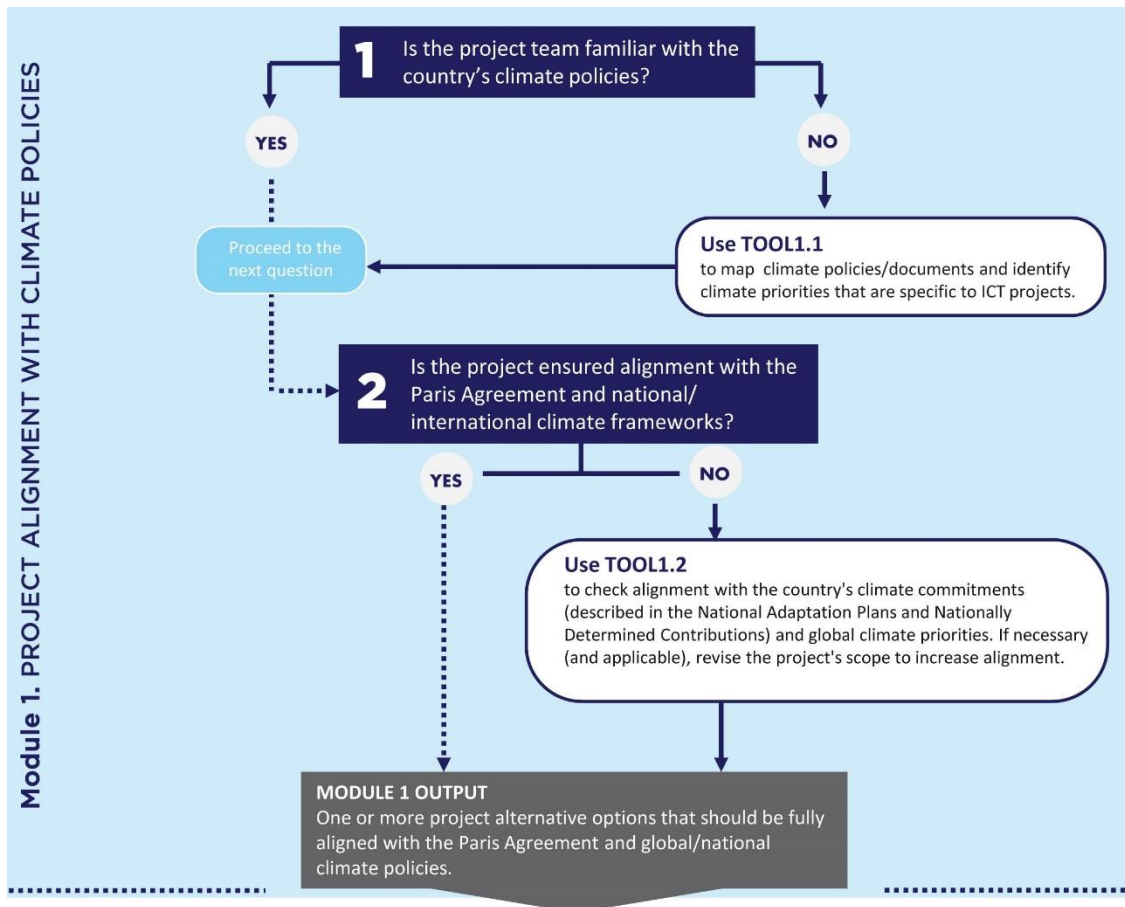
Module 4 provides tools to qualitatively estimate the impacts of climate considerations on the costs, benefits, and VfM of an ICT infrastructure project.

Module 5 proposes a set of output requirements in the form of key performance indicators (KPIs) that can be embedded in the PPP contracts to ensure compliance with the climate objectives that are specific to ICT projects.

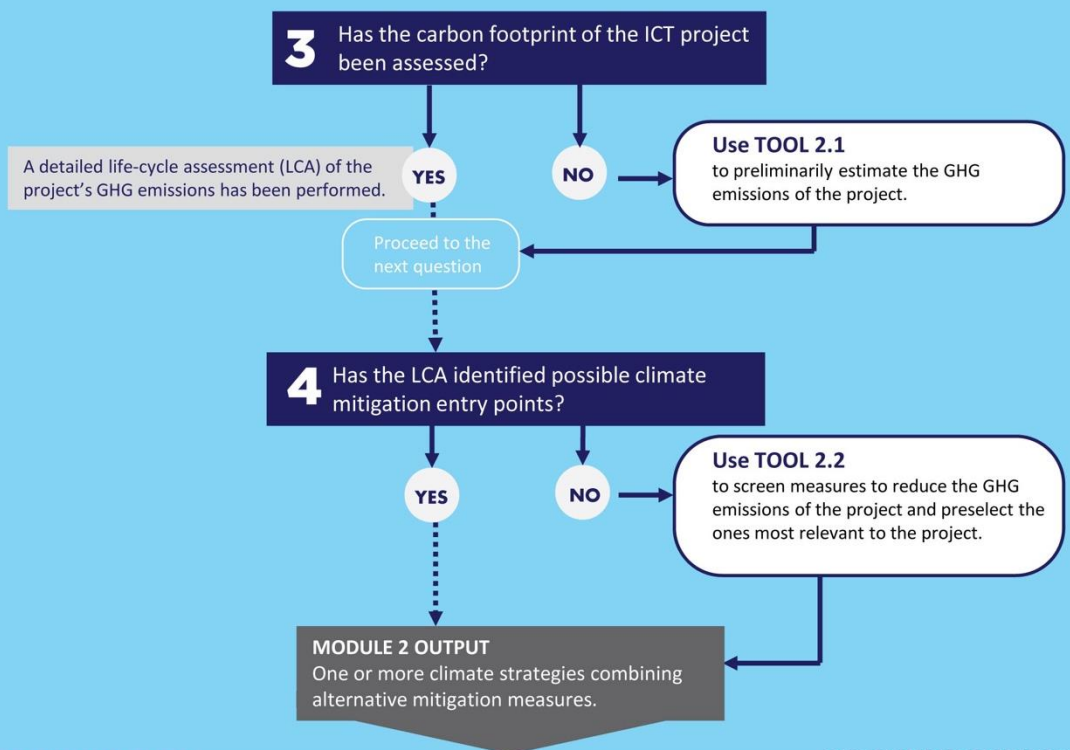
The interconnections between the modules and the tools contained within each module are explained schematically in the **Toolkit Navigator** provided on the next page.



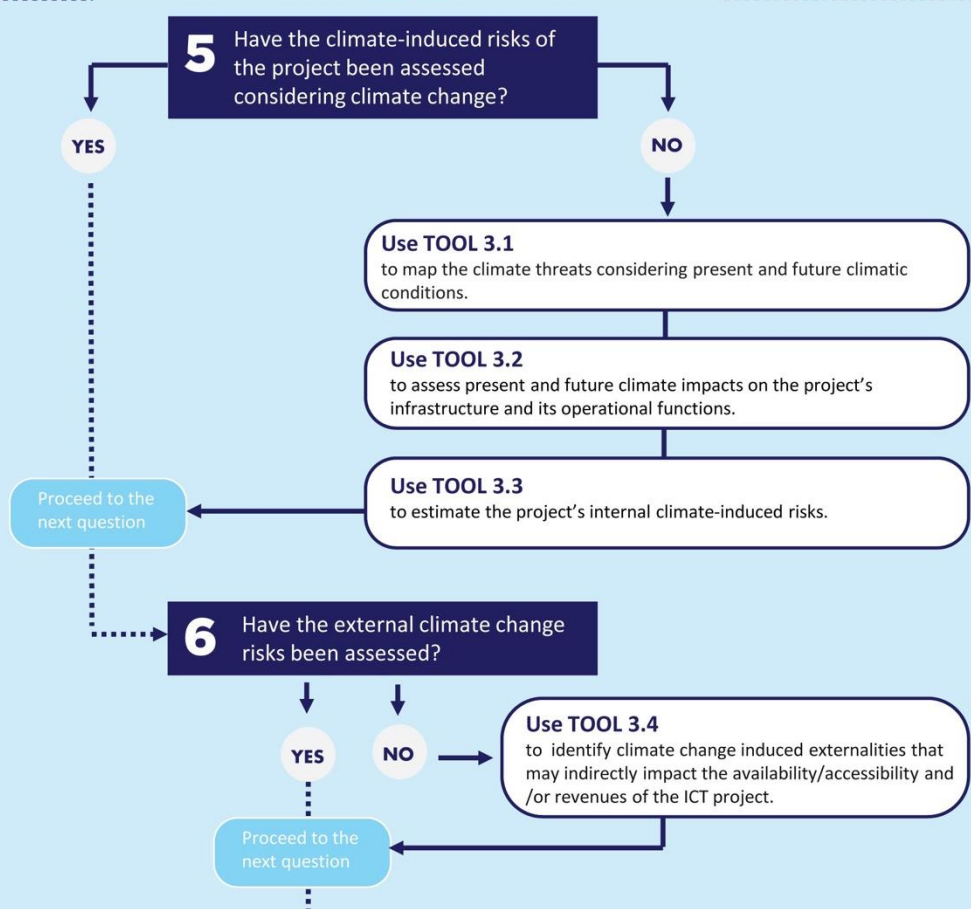
Toolkit Navigator

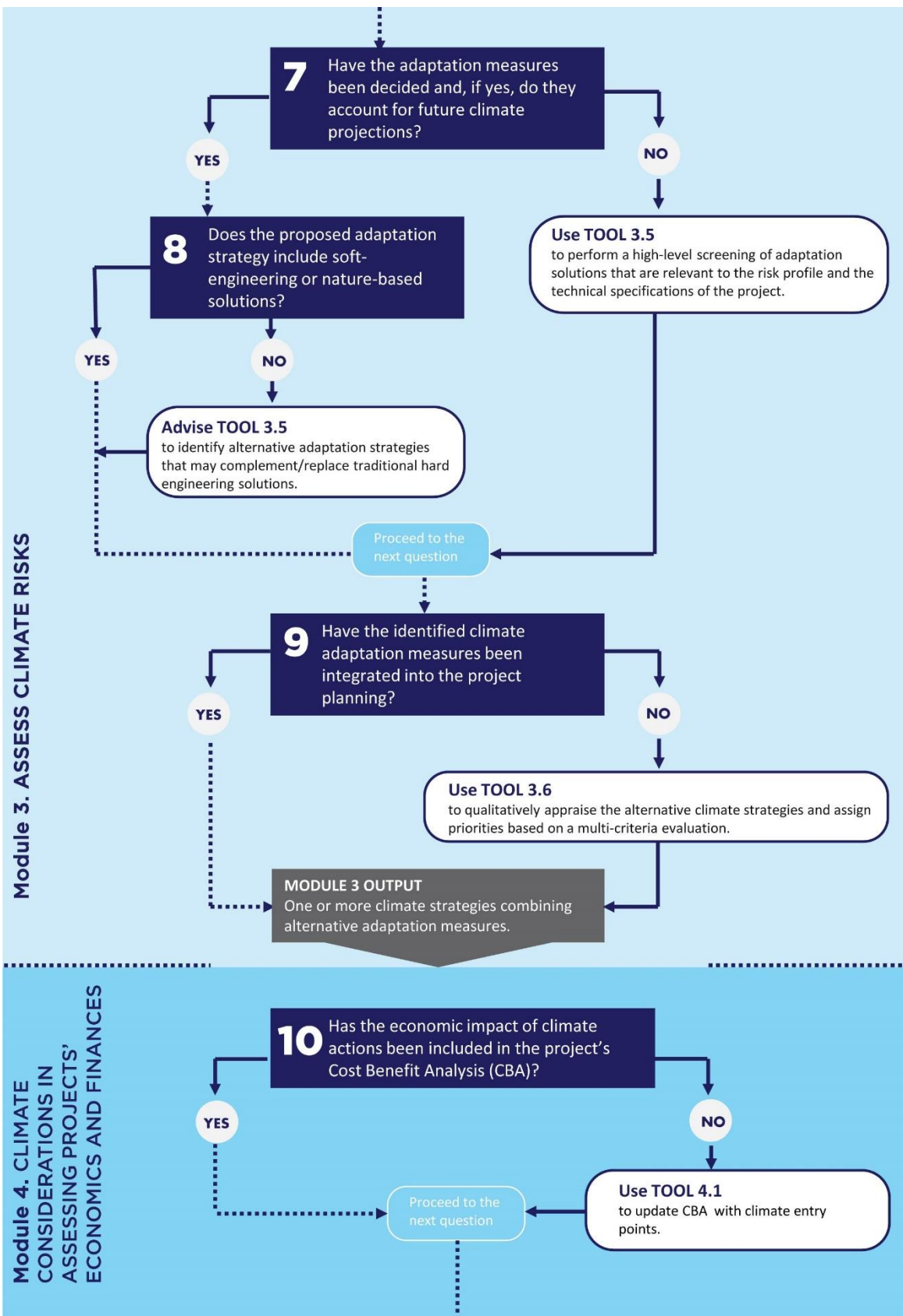


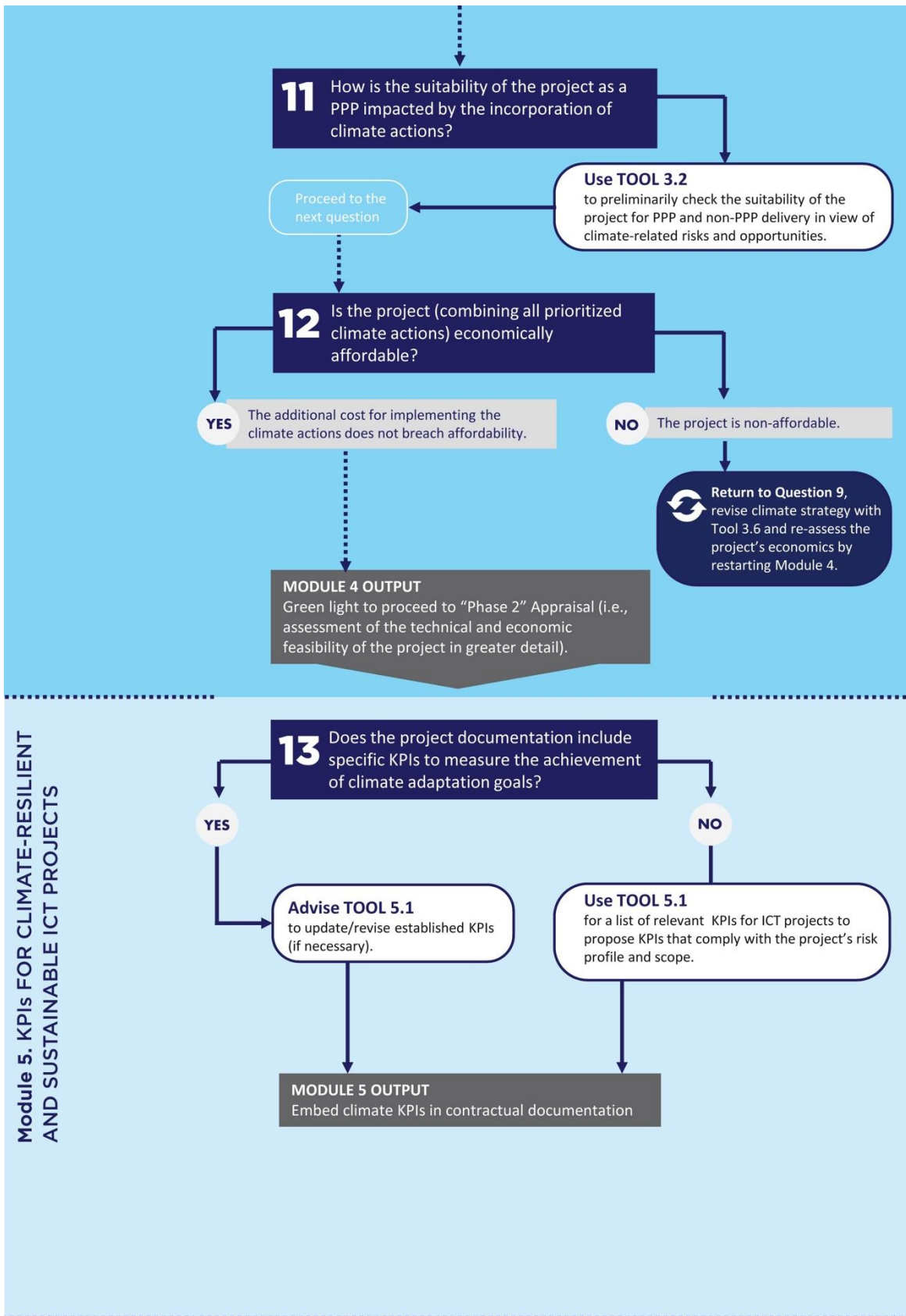
Module 2. PRELIMINARY EVALUATION OF THE CARBON FOOTPRINT OF THE PROJECT



Module 3. ASSESS CLIMATE RISKS







Module 5. KPIs FOR CLIMATE-RESILIENT AND SUSTAINABLE ICT PROJECTS

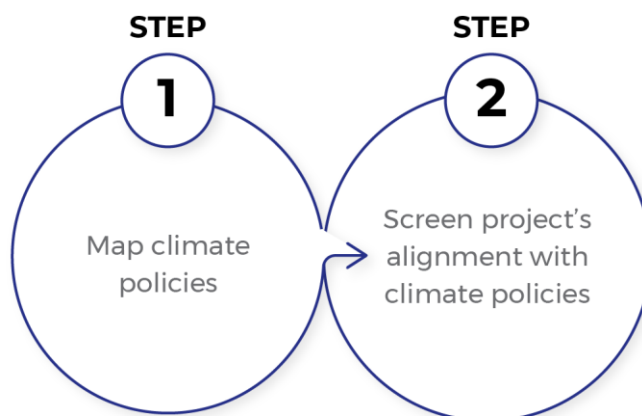
MODULE

1



Module 1

PROJECT ALIGNMENT WITH CLIMATE POLICIES



The module is broken down into two steps. **Step 1** identifies the relevant climate policies and maps climate goals into specific climate attributes for ICT projects. **Step 2** provides a methodology for assessing the alignment of the project's description with these attributes and considerations. This mapping exercise will define the scope of climate interventions that are meant to be specified, detailed, and appraised in **Modules 2** and **3**.

Step 1

Map Climate Policies

SCOPE	This step supports the systematic documentation of global and national climate strategies, policies, and plans that set the framework for developing and operating ICT infrastructure. By understanding the underlying principles, targets and commitments, the relevant agencies will be better prepared to design and deliver new sustainable ICT assets that align with the climate mitigation vision of the Paris Agreement (PA) and that strengthen the capacity of communities to adapt to the adverse effects of climate change.
PROCESS	The process starts with a quick scan of the country's Nationally Determined Contributions (NDCs), national adaptation plans (NAPs), and long-term strategies (LTS), which are the main national guidance documents for achieving the goals of the PA and for identifying climate opportunities for the ICT sector. The process continues with mapping relevant climate-change references in the country's digital development strategy and ICT-related targets at the national or subnational level. The process concludes with the compilation of the identified climate elements in these important documents that constitute the national climate policy landscape and the national ICT-related legislation—whether laws, policy or other official governance documents.
TOOLS	TOOL 1.1 Mapping climate policies and actors
OUTPUT	A country-specific inventory of the most important policy documents on climate change with specific references to the delivery of digital infrastructure and the ICT sector.



IMPORTANT NOTE

Effort and Resources

Note that as of the writing of this toolkit, it is still less common for climate-relevant policies and frameworks to include ICT-specific considerations compared

to those considerations of other sectors. Users are therefore encouraged to consult the climate policies, and to identify and select those that contain ICT-specific information in their project's context. To guide this process, **Tool 1.1** provides examples showcasing different countries' approaches to embedding ICT-related guidance in their legislation and regulations. In cases where references to ICT in official documents are limited, users may find it valuable to also include climate-related guidelines and peer country best practices in their review to fill gaps. The more detailed the answers to the prompt questions that are included in the following tools, the easier it will be to identify project-specific entry points in the next step, and eventually to achieve the highest alignment level with climate policies and targets. For further reading on the importance and benefits of alignment with climate policies, users are referred to the [Umbrella Toolkit \(Insight 1.5 and Phase 0\)](#).

TOOL 1.1

MAPPING CLIMATE POLICIES AND ACTORS

This tool is designed to facilitate a desk review of the landscape of climate policies and frameworks governing the planning and delivery of ICT infrastructure, based on the mapping methodology presented in the [Umbrella Toolkit \(Introductory Phase and Module 1.1\)](#).

For a more in-depth analysis of the country-specific policies and governance mechanisms, users are encouraged to seek support within the following agencies:

- The PPP unit (which is expected to have a general mapping exercise for the country's PPP portfolio already completed).
- Relevant ministries (e.g., Ministry of Climate Change, Ministry of Environment, Ministry of ICT, Ministry of Digital Governance, Ministry of Finance, Ministry of Infrastructure) and their corresponding departments (e.g., Department of Digital Development or E-governance, Department of ICT Innovation, ICT Infrastructure Development, Broadcasting and Telecommunications or Data Networks).
- National telecommunications/ICT regulatory authorities, which play a key role in implementing sectoral government policy by formulating and enforcing sectoral regulation. Though in many countries, there is a separate regulator responsible for the telecommunications sector specifically, in other countries, the same regulator is also responsible for adjacent markets (e.g., broadcasting), or a multi-sector regulator is responsible for telecommunications as well as other sectors with similar characteristics.
- Municipalities and other subnational agencies, which are better informed about the climate adaptation activities that happen locally and may not necessarily be reflected in national policy documents (outlined below).

INPUT

This mapping exercise requires users to consult the following climate policy documents to determine alignment with national and international goals. Each source is accompanied by a list of prompt questions meant to illuminate the respective focus areas.

1. National documents describing the country's strategic development vision

Focus areas:

- Is digital transformation recognized as a strategic vision?
- How does it relate to the Paris Agreement, NDCs, NAPs, and Sustainable Development Goals (SDGs)?
- Is there a national digital development or digital transformation plan available? What does it include with respect to climate change?
- Is the development of new ICT systems or the upgrade of existing ICT infrastructure part of the national strategic goals?
- Does the country support more holistic digital development policies and planning that take into consideration the environment and decarbonization?
- How is the country's strategic vision on sustainable development supported by the ICT sector?

2. Nationally Determined Contributions outlining short and mid-term climate action plans

According to the 2022 World Bank report *Catalyzing the Green Digital Transformation in Low and Middle Income Economies*,¹⁶ 45 percent of low- and middle-income countries mention digital technologies in the mitigation part of their NDCs, and 53 percent in the adaptation part.

Focus areas:

- What is the emission reduction target and which are the adaptation goals described in the NDCs?
- Do they mention the role of digital technologies as an enabler of climate adaptation/mitigation action? Typical examples in NDCs are digital technologies to enable data collection and monitoring, and to support disaster risk management.
- Do they mention digital development or the ICT sector? What are the exact priorities and measures covered in the NDCs for the sector?
- Do they mention technology more broadly with applications that span the digital sector?

3. Long-term strategy (if available) outlining a country's long-term vision on climate change

Focus areas:

- Does the LTS describe a long-term emission reduction goal or a climate change adaptation ambition? What is the horizon and what is the role of the ICT sector in this?
- Does it specify measures to achieve the goal? How do these measures relate to the ICT sector or digital development overall? For example, is a transition from overground ICT cables to an underground or submerged cabling network, or the development of fiber optics or 5G network mentioned? Is ICT infrastructure mentioned as a key component in the fight against climate change (e.g., through monitoring GHG emissions, raising awareness, analyzing short- and long-term climate trends)?

Example

In its Long-Term Strategy under the Paris Agreement¹⁷ (submitted in October 2021), Japan recognizes the leading role of the semiconductor and digital industries in building a sustainable society and promotes two ("Green by Digital") approaches: (i) enhancing efficiency and reducing carbon dioxide (CO₂) emissions in energy demand through digitization, and (ii) promoting energy conservation and the greening of the digital equipment and information and telecommunications industries themselves, thereby aiming to achieve carbon neutrality in the semiconductor/information and communication industries by 2040. Japan's LTS refers also to the "Semiconductor and Digital Industry Strategy" (compiled in June 2021), where specific directions that follow the two aforementioned approaches are provided in greater detail (for example, supporting post-5G/beyond-5G systems, promoting green investments in digital areas such as artificial intelligence (AI), progressively turning Japan's archipelago into smart islands, and encouraging large-scale data centers to be located in Japan).

¹⁶ World Bank. 2022. *Catalyzing the Green Digital Transformation in Low and Middle Income Economies*. <https://www.digitaldevelopmentpartnership.org/knowledge.html?ddp=kn-pb-22-t1-10>.

¹⁷ Japan. 2021. *The Long-Term Strategy under the Paris Agreement*. https://unfccc.int/sites/default/files/resource/Japan_LTS2021.pdf.

4. **National adaptation plans** (or National Adaptation Programmes of Action (NAPAs) or national adaptation strategies) providing a clear framework of how climate-change adaptation actions can be integrated into the development planning of all economy sectors.

Focus areas:

- Does the NAP address climate vulnerabilities that are specific to ICT assets? What are the most prominent climate risks identified?
- Does the NAP include an action plan to enhance climate adaptation and resilience? How is this related to ICT infrastructure?
- Has the NAP led to the development of subnational or regional adaptation plans? Is ICT recognized in these adaptation plans as a critical sector that requires actions for building the resilience of its infrastructure to the effects of climate change? Is the ICT sector recognized as an enabler to building adaptation and resilience in other sectors, and are specific ICT developments described or promoted?

Example

The NAP of the Democratic Republic of Congo (DRC)¹⁸ recognizes an increase in the inaccessibility of communication channels for local communities as a major potential negative impact of climate change. It identifies the improvement of access to communication (including ICT infrastructure) as a planned action/project with a dedicated budget of \$500 million within the Green Climate Fund's DRC Country Program. The NAP also sets the goal to strengthen the capacities of DRC staff to use new ICT technologies in the Ministry of Fishing and Livestock (MINPE) through a set of planned actions with an estimated cost of \$6 million: raise awareness among decision-makers on the need to digitalize procedures and train staff in the effective use of these tools; organize continuous training on the use of different information technology (IT) tools; train 15 MINPE agents (30 percent women) in the use of various IT tools; facilitate access by MINPE staff to software tools.

5. **Climate and environmental legislation or initiatives** (either enforced or announced at a national, sub-national or state level)

Focus areas:

- Which ministries are responsible for structuring the climate legislation and which ones for implementing the law? Is it the responsibility of a single ministry, or are several ministries involved? (Understanding how responsibilities are shared across the government helps ensure a comprehensive review that covers legislation and initiatives originating from all potential parties involved.)
- Does the legislation or announcement specify a “net zero” emissions target? Is this a cross-sectoral target or does it include specific provisions for the ICT sector?
- What policy measures does the legislation involve, and how are these translated into national action plans and programs? For example, are there regulations and initiatives that promote the development of digital infrastructure, and what are the action plans that have been developed in that respect?

¹⁸ Democratic Republic of the Congo Ministry of the Environment and Sustainable Development. 2021. *National Adaptation Plan to Climate Change (2022-2026)*. https://unfccc.int/sites/default/files/resource/DRC-NAP_EN.pdf.

- Is climate adaptation already incorporated into climate legislation or is it intended to be incorporated (e.g., when counting governmental or municipal announcements and initiatives)? What are the main areas of focus?
- Is there a national disaster risk management policy or disaster risk reduction plan? Does it prescribe ICT-enabled actions to enhance resilience against climate-induced impacts? Are there specific provisions for ICT assets and digital tools or targets for access to the digital world?

6. Digital development/transformation or e-governance strategies and plans (national or regional)

Focus areas:

- **Direct climate linkages**
 - Does the strategy or plan refer to climate or environmental issues?
 - Does the strategy target decarbonization of ICT infrastructure (e.g., data centers, servers, cable networks)? Does it offer any guidance on decarbonization priorities and objectives in ICT projects?
 - Does it target climate proofing of digital infrastructure to enhance resilience?
 - Does it prescribe specific use cases for ICT technologies focused on adaptation or mitigation with respect to climate change (e.g., an integrated database on climate change and environmental aspects)? How might these actions be integrated into the delivery of ICT assets? Are there specific requirements for improving the ICT system's resilience? How does it treat upgrade or rehabilitation programs for existing ICT systems?
- **Indirect climate linkages**
 - According to the strategic document, which are the recognized priorities for future digital development decisions, and how do they relate, directly or indirectly, to climate change? (For example, a priority investment that foresees the improvement of the condition and performance of the existing telecommunications cable network will, for one thing, reduce the exposure of the telecommunications network to extreme climate events that are exacerbated by climate change.)
 - Does the strategic document include a description of relevant investment plans or a project pipeline that enhances resilience (e.g., a network diversification strengthening resilience, dedicated budget to support an early transition to fiber optics or submarine cables)?
 - Does the strategy include standards, guidelines, or requirements around data governance (data management and data sharing) for public and private entities, including those concerning environmental data?

Example

Denmark's National Strategy for Digitalisation¹⁹ describes its aims as follows: "Overall, the government's objective is that data and digitalisation to a much greater degree are used to ensure efficiency and coherence in Denmark's green transition while creating a breeding ground for Danish business adventures in the future." The strategy also outlines specific approaches, such as the use of artificial intelligence, sensors, satellites and other technologies to reduce the country's climate footprint and ensure adaptation to climate change.

¹⁹ Denmark. *National Strategy for Digitalisation Together in the Digital Development*.

<https://en.digst.dk/media/27861/national-strategy-for-digitalisation-together-in-the-digital-development.pdf>.

7. **National infrastructure strategy or plan**, outlining long-term goals for key national infrastructure development, with plans and funding commitments to support them

Focus areas:

- Does the strategy discuss the role that ICT may play in adaptation and mitigation plans in other infrastructure sectors, for example climate-smart mobility?
- Does it recognize key climate-related interdependencies between ICT infrastructure and other sectors, such as energy or transportation?
- Does the document set specific environmental targets? For example, is there a target to achieve no net loss of biodiversity or to reduce carbon emissions to a certain level? Are there initiatives for leveraging ecosystems and ecosystem services with the help of ICT infrastructure?

8. **National research and innovation strategy** (if available in the country-specific context)

Focus areas:

- Does the strategy recognize and promote digital technological innovation in order to achieve climate-related goals? For example, is the development of new smart city solutions promoted as a means towards climate-neutral urban ecosystems?
- Does the strategy highlight digital foundations such as connectivity, data infrastructure or digital skills as enablers for climate research and innovation?
- Does the strategy highlight green jobs and innovation, including digital entrepreneurship targeting climate applications?

Example

The Republic of Korea's Carbon Neutral Tech Innovation Strategy outlines the government's plan to leverage digital technologies to power its various carbon-neutral programs and projects. As explained in a recent Innovation and Technology Note from the World Bank Group Korea Office titled "Greening Digital in Korea—Korea Case Study for Greening the ICT Sector,"²⁰ the strategy focuses on building a low-carbon industry ecosystem in order to achieve carbon neutrality, economic growth, and improved quality of life.

9. **Public procurement policies**

Focus areas:

- Does the regulatory framework that governs public procurement authorize the voluntary or mandatory application of green public procurement (GPP) practices? Examples include minimum environmental criteria (such as an energy-efficiency standard or a share of recycled content) for all or specific procurement categories; a requirement that specific product categories be purchased from a pre-approved product and supplier list that meets the environmental criteria; and a requirement that environmental criteria are considered during the procurement process for specific procurement categories.

²⁰ Khoury, Zaki Badie, Astrid Herdis Jacobsen, Elyse Jee Hyun Lee, and Jeongjin Oh. 2022. "Greening Digital in Korea: Korea Case Study for Greening the ICT Sector (English)." Innovation and Technology Note Series 6. World Bank, Washington, D.C.

Example

The Slovak Republic's 2016–20 national action plan introduced mandatory green public procurement²¹ (GPP) requirements for three product categories, including ICT. By 2020, the goal was established to have 50 percent of public procurement at the central government level being “green” (defined as integrating at least one requirement from the European Commission's GPP criteria). For more details and other examples, it is recommended to consult the World Bank's 2021 report Green Public Procurement: An Overview of Green Reforms in Country Procurement Systems.²²

10. **Bilateral agreements** with neighboring or other countries outlining the regime for ICT infrastructure (e.g., satellites and antennas)

Focus areas:

- Are there any agreements/commitments that promote sustainable practices for providing connectivity (e.g., bilateral investment treaties for the protection of telecommunications networks or satellites, or other ICT services/activities)? This type of agreement would enhance infrastructure resilience.

Example

India has made a commitment in telecommunication services part of its overall services commitments in some of its Comprehensive Economic Cooperation Agreements and the Comprehensive Economic Partnership Agreements, which are publicly available.²³

11. **Good practices, and climate-related guidelines** describing opportunities and entry points for integrating green attributes/practices in ICT projects. Such documents may include applications of green practices in the reference country or neighboring ones as well as reference material at the international level.

Climate-related guides are gaining momentum around the world and contain insightful knowledge that should be reviewed for inspiration and applied in the project if possible. They can be particularly useful in cases where the national legislation does not provide clear guidance for integrating climate considerations specifically into ICT-related projects.

Details for major climate taxonomies and the definition of eligible activities may be found in the [Umbrella Toolkit \(Insights 1.3 and 1.4\)](#). Examples of green ICT standards and recommendations may be found in the L-Series Recommendations,²⁴ where an extensive list of ICT technology-specific recommendations related to climate-change mitigation are provided by the International Telecommunication Union (ITU), the United Nations specialized agency for information and communication technologies.

²¹ World Bank Group. 2021. *Green Public Procurement: An Overview of Green Reforms in Country Procurement Systems*. World Bank. <https://openknowledge.worldbank.org/handle/10986/36508>.

²² World Bank Group. 2021. *Green Public Procurement: An Overview of Green Reforms in Country Procurement Systems*. World Bank. <https://openknowledge.worldbank.org/handle/10986/36508>.

²³ Government of India Department of Telecommunications. “Bilateral/Multi-lateral Agreements.” <https://dot.gov.in/bilateral-multi-lateral-agreements>.

²⁴ ITU (International Telecommunication Union). L Series Recommendations: environment and ICTs, climate change, e-waste, energy efficiency, construction, installation and protection of cables and other elements of outside plants. <https://www.itu.int/rec/T-REC-L>.

To conclude the mapping exercise, it is worth reiterating the caveat raised in the Important Note at the start of **Tool 1.1**. The ICT sector has yet to receive extensive attention when it comes to the analysis of direct climate linkages. As a result, the ICT sector is not mentioned explicitly in climate policy documents to the same extent as other sectors such as energy or transportation. For this reason, an ICT-focused policy mapping exercise needs to take a broader view to encompass the cross-cutting and enabling role of the digital sector, which might more indirectly support a country's climate priorities.

OUTPUT

The results of the mapping need to be reported in a systematic and comprehensive way to assist the next steps. The **Reporting Template 1.1**²⁵ is provided to guide the reporting process.

Reporting Template 1.1 Climate entry points in climate-related and ICT-related policies

Policy Document	Document Type	Coverage	Entity in Charge	Climate Provisions/ICT References
Name (year)	Strategy, law, policy, action plan, taxonomy	National/subnational/regional	Intra-governmental entity (ministries or municipalities)	Summarize key points
Complete as appropriate				

²⁵ **Reporting Template 1.1** is an indicative template provided for guidance purposes only. The user is free to adopt any other structured format that best suits the project's characteristics and/or the identified policies/documents.

Step 2

Screen Project's Alignment with Climate Policies

SCOPE	<p>This step examines the project's scope and description vis-à-vis the mapped climate policies and the country's national development goals (outcome of Tool 1.1) and measures the project's alignment using a simple scoring system. In case of misalignment, specific actions are proposed to re-adjust the project scope towards a more sustainable and climate-resilient pathway.</p>
PROCESS	<p>The alignment process is performed in two stages that are implemented during different phases of the project preparation:</p> <p>The preliminary screening may be performed immediately after the project inception phase (when the only available information is the outline of the project scope and the need it addresses). This first-level screening is meant to confirm that the overall project's scope aligns with (or at least does not deviate from) the national vision for climate mitigation and adaptation.</p> <p>The second-level screening may be performed towards the end of the "project selection," and prior to the appraisal of the economic value of the project. At this stage, the project's risk profile has been qualitatively assessed, and a preliminary discussion on adaptation/mitigation measures is underway. This is the right time to re-evaluate the project's alignment with the national climate agenda (focusing now on specific project attributes) and re-adjust where necessary.</p>
TOOLS	<p>TOOL 1.2 Screening project's alignment with climate policies</p>
OUTPUT	<ul style="list-style-type: none"> ▪ Climate alignment score (pre-screening and final result). ▪ Actions to enhance the level of alignment (if deemed necessary).

TOOL 1.2

SCREENING PROJECT'S ALIGNMENT WITH CLIMATE POLICIES

The tool may be used to qualitatively assess the project's climate profile and its alignment with the vision, goals, and targets described in major climate policies. It is intended to complement the methodology described in the [Umbrella Toolkit \(Module 1.1\)](#). Therefore, it is structured in the form of a checklist comprising four pillars:

- Overall alignment of the project's scope with the country's Sustainable Development Goals and the Paris Agreement framework (**Pillar 1, or P1**)
- Overall alignment of the project's scope with the national climate agenda (primarily described in the NDCs, NAPs, LTS and other relevant documents) (**P2**)
- Specific interventions contributing to climate mitigation (**P3**)
- Specific interventions contributing to climate adaptation and resilience of the project and of the broader community (**P4**)

Its scope is to allow users to assign a qualitative score reflecting the performance of the project in each of the four pillars in order to identify areas where improvements may be possible.

INSTRUCTIONS

1**Define the type of screening**

For a **high-level screening** (performed during the very early stages of the project) users may focus on the first two pillars (P1 and P2) only. During the **second-level screening** (implemented towards the end of the project selection), it is recommended to use the entire checklist (P1 to P4).

2**Use the Input module of the tool to score the performance of the project according to each of the four pillars.****3****Use the tool's output module to calculate the project's alignment score.****4****Propose an action plan** for enhancing alignment and repeat scoring (ideally until a full alignment level is achieved).

The action plan should be targeted to those pillars that have received relatively low scores.

INPUT

The following checklist divides the criteria contributing to a project's alignment with the national and international climate policies into the relevant pillars (P1 to P4). Users are prompted to qualitatively assess the performance of the project in each of the four pillars, considering all the sub-criteria mentioned on the left columns. The goal is to be able to identify areas of poor alignment and to seek improvements at an early stage, acknowledging that poor alignment may bring into question the project's eligibility for funding by several sources, including multilateral development banks (MDBs).

To increase alignment in cases of an initial low score, users may consult the following resources:

- *ICT and climate change* report,²⁶ which provides a detailed list of ways in which ICT projects may be used to monitor climate change, reduce overall GHG emissions and adapt to climate change.
- The World Bank's 2022 report, *Catalyzing the Green Digital Transformation in Low and Middle Income Economies*,²⁷ which proposes a path toward low-emissions applications of digital technologies to help countries mitigate and adapt to climate change—and to achieve the goals of the 2015 Paris Agreement on Climate Change.
- Other resources with specific recommendations identified in the previous **Tool 1.1**, including the L Series Recommendations²⁸ and more specifically the Green ICT Standards and Supplements,²⁹ L. 1500 Framework for information and communication technologies and adaptation to the effects of climate change.³⁰

Four Pillars for Appraising Alignment

P1

PROJECT'S ALIGNMENT WITH THE SUSTAINABLE DEVELOPMENT GOALS AND THE PARIS AGREEMENT FRAMEWORK

Sub-criteria	Characteristics/actions enhancing project's alignment (non-exhaustive list of examples)
What is the project's primary purpose, and how does it support the country's Sustainable Development Goals (SDGs)?	<ul style="list-style-type: none"> • ICT technologies contribute to every single one of the 17 United Nations SDGs and especially to SDG9 (industry innovation and infrastructure). More details

²⁶ ITU-D (International Telecommunication Union Development Sector) Study Group 2. 2017. *Question 6/2: ICT and climate change*. ITU. https://www.itu.int/dms_pub/itu-d/opb/stg/D-STG-SG02.06.1-2017-PDF-E.pdf.

²⁷ World Bank. 2022. *Catalyzing the Green Digital Transformation in Low and Middle Income Economies*. <https://www.digitaldevelopmentpartnership.org/knowledge.html?ddp=kn-pb-22-t1-10>.

²⁸ L Series Recommendations by ITU: Environment and ICTs, climate change, e-waste, energy efficiency, construction, installation and protection of cables and other elements of outside plants: <https://www.itu.int/rec/T-REC-L>.

²⁹ ITU (International Telecommunication Union). L Series Recommendations: environment and ICTs; climate change, e-waste, energy efficiency, construction, installation and protection of cables, and other elements of outside plants. <https://www.itu.int/rec/T-REC-L>.

³⁰ ITU-T. 2014. L. 1500 (06/2014) Framework for information and communication technologies and adaptation to the effects of climate change. <https://www.itu.int/rec/T-REC-L.1500/en>.

Sub-criteria	Characteristics/actions enhancing project's alignment (non-exhaustive list of examples)
	for the SDGs and how ICT infrastructure supports them may be found on ITU's webpage. ³¹ For SDG5 (gender equality) more information is provided in WBG (2021a) ³² and WBG (2021b). ³³
Does the project support the country's effort to reduce CO ₂ emissions?	<ul style="list-style-type: none"> • Boosting green data centers³⁴ and green power feeding systems.³⁵ • Developing infrastructure that enables mitigation efforts, including monitoring of GHG emissions, digital-twin technologies that incorporate GHG attributes or other innovative ICT systems (e.g., internet of things (IoT)) linked to life-cycle GHG reduction).
Is climate adaptation an objective of the project?	<ul style="list-style-type: none"> • Performing a climate risk assessment prior to the technical design phase and adopting project-specific adaptation measures in the design (targeting “resilience of”). • Improving the population's access to the digital world through reliable and resilient ICT infrastructure that is at present hampered by frequent climate-related interruptions (targeting “resilience through”).
Does the project address greater overall inclusion and gender equality, and does it consider vulnerable groups?	<ul style="list-style-type: none"> • Increasing accessible ICT infrastructure, especially for people who are living in rural or remote areas, or people who cannot afford expensive ICT equipment (thus contributing towards social cohesion and gender inclusivity). • When possible, explicitly considering in the planning phase gendered barriers to access and use of ICT infrastructure, the potential lack of access to physical infrastructure, and broader issues around affordability, digital literacy, online safety, and social norms.

³¹ ITU. “Digital technologies to achieve the UN SDGs.”

<https://www.itu.int/en/mediacentre/backgrounders/Pages/icts-to-achieve-the-united-nations-sustainable-development-goals.aspx>.

³² WBG. 2021a. “Digital Development Note on Gender Equality.”

<https://thedocs.worldbank.org/en/doc/61714f214ed04bcd6e9623ad0e215897-0400012021/related/Digital-Development-Note-on-Gender-Equality-November2021-final.pdf>.

³³ WBG. 2021b. “Green, Resilient and Inclusive Development (GRID).”

<https://thedocs.worldbank.org/en/doc/9385bfef1c330ed6ed972dd9e70d0fb7-0200022021/green-resilient-and-inclusive-development-gri.d>.

³⁴ List of ITU-T Recommendations on Green Data Centres: <https://www.itu.int/en/action/environment-and-climate-change/Documents/ITU-TRecDataCentresList.pdf>.

³⁵ List of ITU-T Recommendations on Green ICT Power Feeding: <https://www.itu.int/en/action/environment-and-climate-change/Documents/ITU-TRecGreenICTPowerList.pdf>.

Sub-criteria	Characteristics/actions enhancing project's alignment (non-exhaustive list of examples)
Are there potential Paris Alignment trade-offs that emerge in the wider context of this project?	<ul style="list-style-type: none"> Identifying potential trade-offs between climate and development strategies, such as transition costs arising from potential negative impacts of domestic and international mitigation policies on equity, labor markets, or external competitiveness.³⁶ Reducing transition costs through a people-centered approach, effective fiscal and social policies, and policies supportive of attracting private sector investment.

P2

DOES THE PROJECT ALIGN WITH NATIONAL CLIMATE POLICIES?

Sub-criteria	Characteristics/actions enhancing project's alignment (non-exhaustive list of examples)
How does the project support the implementation of the country's NDCs, including GHG reduction targets described in the NDC?	<ul style="list-style-type: none"> Supporting the use of renewable energy sources for the power supply of the ICT operational functions. Reducing GHG emissions through green practices (optimizing data center energy management, re-use of waste heat). Setting and regularly monitoring specific GHG emission reduction targets. Considering the impact of increased cooling demand.
How does the project support the implementation of the country's sustainable digital transformation agenda?	<ul style="list-style-type: none"> Using the ICT infrastructure to enable the adoption of technologies to support broader mitigation and adaptation efforts, including platforms for quantifying the efficiency of innovative low carbon solutions (e.g., through performing advanced analytics based on measuring GHG emissions).
How does the project comply with the ICT-related climate mitigation and adaptation elements of the country's NDCs, NAPs, or other relevant national policies?	<ul style="list-style-type: none"> Supporting the strengthening of the resilience of the ICT infrastructure (e.g., submarine cabling, modular design of data centers, or through nature-based solutions (NbS) around the physical ICT infrastructure assets).

³⁶ WBG. 2021. *Climate Change Action Plan 2021-2025: Supporting Green, Resilient, and Inclusive Development*. <https://openknowledge.worldbank.org/bitstream/handle/10986/35799/CCAP-2021-25.pdf?sequence=2&isAllowed=y>.

Sub-criteria	Characteristics/actions enhancing project's alignment (non-exhaustive list of examples)
	<ul style="list-style-type: none"> Increasing the accessibility of basic ICT functions (including universal and affordable access to the internet), or to climate-related technologies such as early warning systems and automated weather monitoring.
Has the country's NDC or NAP diagnosed particular vulnerabilities for ICT assets? If yes, how is the project intended to address these vulnerabilities?	<ul style="list-style-type: none"> Incorporating climate change considerations (by performing climate change risk assessment, involving climate experts, implementing adaptation measures, allocating the climate change risk) into the planning, design, utilization, and management of the ICT infrastructure.

P3

PROJECT'S POTENTIAL TO REDUCE GHG EMISSIONS. DOES THE PROJECT INCORPORATE SMALL-SCALE MITIGATION?

Sub-criteria	Characteristics/actions enhancing project's alignment (non-exhaustive list of examples)
Will the project include small-scale (i.e., add-ons) climate mitigation components?	<ul style="list-style-type: none"> Provisions for power supply from renewable energy such as photovoltaic panels on data center facilities' roofs. Transportation of employees by electric buses or vehicle-sharing schemes. Charging stations and other infrastructure for electric vehicles, hydrogen-powered vehicles.
Will the project include activities to avoid/reduce GHG emissions, including energy-efficiency provisions during manufacturing, construction, and operation?	<ul style="list-style-type: none"> Monitoring and optimizing power consumption. Use of low-carbon materials and energy efficiency compliant hardware. Use of energy and temperature reporting hardware. External control of energy use equipment. Heat waste reuse for heating the air and water in project's own buildings or initiating discussions with public authorities for larger-scale repurposing of heat reuse. Green supply chain management of ICT manufacturing industry. Installation of energy-efficiency appliances and equipment. Use of electric vehicles/machinery during construction.

Sub-criteria	Characteristics/actions enhancing project's alignment (non-exhaustive list of examples)
Will ICT comply with the principles of a circular economy?	<ul style="list-style-type: none"> • Use of recycled components. • E-waste management.³⁷ • Heat waste reuse.
Does the project incorporate climate change aspects into its environmental impact assessment, and does it promote sustainable and climate-friendly solutions (such as NbS)?	<ul style="list-style-type: none"> • Mapping of pollution and air quality. • Monitoring the environmental impact of the project and acting in time when deviations from the specified climate-related targets are observed. • Replacing grey infrastructure components with NbS.

P4

INCORPORATION OF A SPECIFIC STRATEGY FOR ADAPTING TO CLIMATE CHANGE

Sub-criteria	Characteristics/actions enhancing project's alignment (non-exhaustive list of examples)
Does the project incorporate methods to assess its exposure/vulnerability to climatic risks and identify gaps in its current or future level of resilience?	<ul style="list-style-type: none"> • Perform risk studies for current and future climate conditions (e.g., temperature projections, current and future flood risk maps, geohazard mapping).
How will the project adapt to the adverse impact of climate change and enhance its resilience?	<ul style="list-style-type: none"> • Design and appraise adaptation strategies for different climate scenarios (e.g., robust cooling system, modular architecture).
Does the project promote/facilitate the integration of activities that support adaptive management in a changing climate through integrated observation/monitoring and use of decision support tools?	<ul style="list-style-type: none"> • Design adaptation measures based on the principles of adaptive/robust planning (e.g., provisions to replace/strengthen the cabling network and allow continuation of operations during weather-induced disasters through backup plans).
Does the project incorporate or support NbS or eco-friendly measures for climate adaptation?	<ul style="list-style-type: none"> • Assess potential environmental impacts and propose contingency NbS or eco-friendly measures by conducting a thorough scoping exercise prior to the construction of permanent structures.
Will the project include emergency procedures/equipment for climate risks?	<ul style="list-style-type: none"> • Install smart information systems for disaster risk management during extreme events. • Prepare/update disaster response plans.

³⁷ ITU. 2021. "Policy practices for e-waste management." https://www.itu.int/en/ITU-D/Environment/Documents/Publications/2021/Toolkit_Africa_final.pdf?csf=1&e=ivTock.

Sub-criteria	Characteristics/actions enhancing project's alignment (non-exhaustive list of examples)
Does the project design consider the impacts of climate change on women and vulnerable populations, and does it mainstream gender concerns in its programs and activities?	<ul style="list-style-type: none"> • Include gendered vulnerabilities in the climate risk analysis. • Ensure adaptation measures are gender-neutral or gender-inclusive. • Consult the WBG's Gender Data Portal³⁸ to identify and incorporate into the planning gender equality challenges that are specific to the project country.³⁹ • Have the project preparation run in parallel with a gender action plan to ensure that women have equal opportunities with men to participate and receive the project benefits. • Define sex-disaggregated indicators, outcomes, and/or output level results that will be relevant for proper monitoring to be carried out. • Include terms of reference (TORs) that stipulate gender expertise and concrete deliverables during preparation and implementation.

OUTPUT

Following the above process, users are expected to have identified the areas where the project is well aligned with Paris Agreement goals as well as the ones where further improvement is necessary.

³⁸ WBG. Gender Data Portal. <https://genderdata.worldbank.org/#countries>.

³⁹ Further guidance on gender aspects is also provided in: WBG. 2021. "Green, Resilient and Inclusive Development (GRID)." <https://thedocs.worldbank.org/en/doc/9385bfef1c330ed6ed972dd9e70d0fb7-0200022021/green-resilient-and-inclusive-development-grid>.

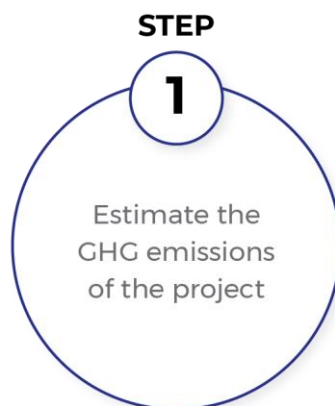
MODULE

2



Module 2

PRELIMINARY EVALUATION OF THE CARBON FOOTPRINT OF THE PROJECT



ICT projects can certainly contribute to mitigating climate change, but at the same time they are responsible for a considerable amount of GHG emissions. In total, the ICT sector is estimated to be responsible for about 1.5 percent to 4 percent⁴⁰ of global carbon emissions, an amount that may be compared to emissions produced by aviation (1.9 percent), shipping (1.7 percent), cement (3 percent), crop burning (3.5 percent), or deforestation (2.2 percent).⁴¹ With increasing digitalization, the overall ICT footprint is expected to grow in the future if no ICT-specific mitigation measures are put in place (**Box 2.1**). Currently, several efforts are underway to provide guidance towards the sector's decarbonization (**Box 2.2**).

In this context, understanding the necessity of investing in green ICT infrastructure, properly estimating a project's GHG emissions, and conceptualizing a mitigation strategy from the preparation and planning stages of the PPP can help raise awareness among the stakeholders and eventually minimize the project's environmental impact. The first step in this direction is to measure the carbon footprint of the project (**Tool 2.1**) before proposing actions to reduce it (**Tool 2.2**).

To properly quantify the GHG emissions and the effect of mitigation measures, it is essential that sufficient project data are available, which may not be the case at the very early stages of the project (which the present toolkit refers to). Hence, the tools presented in the ensuing aim (i) at a preliminary evaluation of the project's GHG emissions and their distribution among the project's infrastructural components and (ii) at a high-level identification of potential ways to decrease the ICT project's overall carbon footprint. After the application of this module, users will be better positioned to define the requirements of the analyses that will be carried out by experts in the subsequent project phases. The module includes a single step with two tools.

⁴⁰ World Bank. 2022. *Catalyzing the Green Digital Transformation in Low and Middle Income Economies*. <https://www.digitaldevelopmentpartnership.org/knowledge.html?ddp=kn-pb-22-t1-10>.

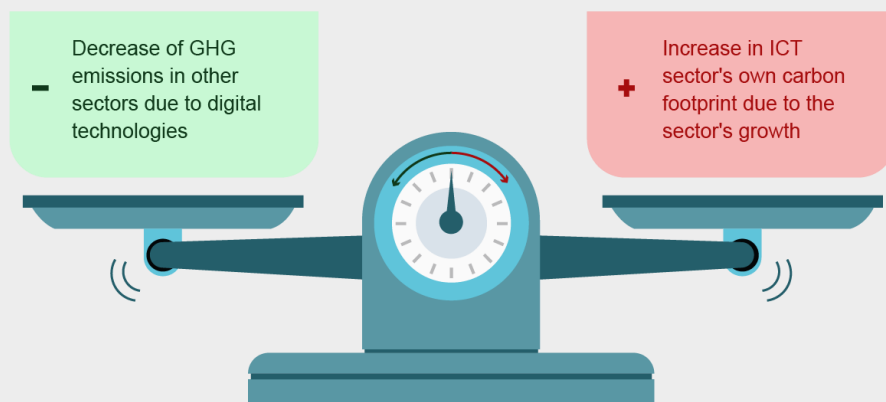
⁴¹ Ritchie, Hannah. 2020. "Sector by sector: where do global greenhouse gas emissions come from?" Our World in Data. <https://ourworldindata.org/ghg-emissions-by-sector>.

BOX 2.1 THE DUAL IMPACT OF ICT INFRASTRUCTURE PROJECTS

This module primarily focuses on assessing and reducing the GHG emissions directly resulting from the construction, use, and decommissioning of ICT infrastructure projects. However, it is also important to take a broader perspective and explore the indirect energy impact of ICT projects that materialize in other sectors, which may be both positive and negative. The development or improvement of ICT infrastructure enables the digitalization of sectors such as transportation, manufacturing, or the built environment; affects the efficiency of the energy supply; and may lead to system-wide transformation. Quantifying these indirect impacts is beyond the scope of this toolkit; however, users are advised to consult the International Energy Agency's 2017 report *Digitalization & Energy*,⁴² which provides a comprehensive picture of how digitalization is transforming the energy efficiency and needs of other sectors, and how it is reshaping the energy sector itself.

This enabling role of ICT in other sectors and the associated potential benefits for global GHG reduction come with the cost of increasing the ICT sector's own footprint at a very fast pace (**Figure B2.1.1**). The growth of the ICT sector is triggering, therefore, inquiries about the degree to which ICT developments are actually benefitting or harming the environment, and whether the net result is positive or negative for ICT-related GHG emissions. Implementing mitigation measures and promoting low-carbon solutions in ICT projects is the way forward for reducing the overall footprint of the ICT sector and boosting smart development in a sustainable manner.

FIGURE B2.1.1 Dual contribution of the ICT sector in global GHG emissions



⁴² IEA (International Energy Agency). 2017. *Digitalization & Energy*.
<https://iea.blob.core.windows.net/assets/b1e6600c-4e40-4d9c-809d-1d1724c763d5/DigitalizationandEnergy3.pdf>.

BOX 2.2 GHG EMISSIONS TRAJECTORIES FOR THE ICT SECTOR COMPATIBLE WITH THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE (UNFCCC) PARIS AGREEMENT

The International Telecommunication Union (ITU), Science Based Targets initiative (SBTi), Global System for Mobile Communications Association (GSMA) and Global Enabling Sustainability Initiative (GeSI) collaborated to develop sectoral decarbonization pathways in order to help ICT companies set targets in line with climate science and to comply with the Paris Agreement's trajectory of 1.5°C (i.e., limiting the global temperature increase to 1.5°C above pre-industrial levels). ITU's Recommendation L. 1470, as part of this collaboration, provides the Paris Agreement's trajectory if GHG emissions from the ICT sector are cut in half by 2030, to less than 400 Metric tons carbon dioxide equivalent (CO₂e) (WBG 2022). This can only be achieved through continued efficiency measures and increased use of low-carbon electricity supplies.

Sources: ITU-T. 2020. L. 1470 "Greenhouse gas emissions trajectories for the information and communication technology sector compatible with the UNFCCC Paris Agreement." <https://www.itu.int/ITU-T/recommendations/rec.aspx?rec=14084>.

WBG. 2022. *Catalyzing the Green Digital Transformation in Low and Middle Income Economies*. <https://www.digitaldevelopmentpartnership.org/knowledge.html?ddp=kn-pb-22-t1-10>.

Step 1

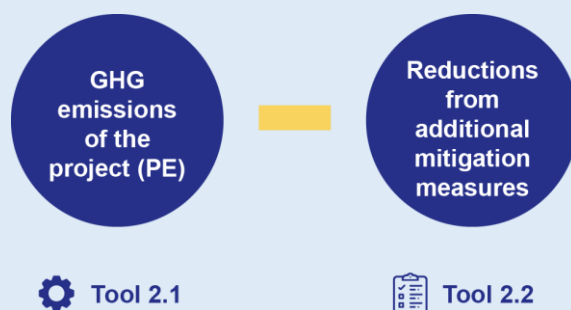
Estimate The GHG Emissions Of The Project

SCOPE

This step will assist users in assessing the project's carbon footprint and help them identify the most energy- and emissions-intensive stages and infrastructural components (i.e., the life-cycle environmental hotspots) of the project in order to identify potential GHG reduction measures and maximize the GHG reduction gain of the mitigation strategy to be adopted in the design.

PROCESS

The process starts with the estimation of the GHG emissions resulting from the project (project emissions, or PE) and continues with the identification of mitigation measures and actions that are appropriate for the specific ICT project. Next, it is shown how the project's emissions can be decreased when integrating the identified mitigation measures in the project planning.



TOOLS

TOOL 2.1 A simplified procedure for the preliminary estimation of GHG emissions

TOOL 2.2 A checklist of potential measures aiming to decrease the overall carbon footprint of the ICT project and its environmental impact

OUTPUT

GHG emissions calculations for the project and the project's components

TOOL 2.1

A SIMPLIFIED PROCEDURE FOR THE ASSESSMENT OF GHG EMISSIONS

The tool may be used to calculate emissions attributable to an ICT project in order to enable the identification of GHG reduction potential in the subsequent tool. **Figure 2.1** illustrates the three different types of emissions according to the Greenhouse Gas Protocol (GHG Protocol):⁴³

- Direct emissions, i.e., **Scope 1** emissions that are owned and controlled by the project.
- Indirect emissions, i.e., **Scope 2** emissions that are produced from the generation of the purchased energy and physically occur at the power plants, and **Scope 3** emissions that occur across the project's value chain—upstream, from products, materials or services acquired by the project, and downstream, from the use of products or services provided by the project to the end-users or beneficiaries.

The estimations to be performed at this stage are based on preliminary data and generic assumptions; therefore, they may focus only on Scope 1 and 2 emissions. The results from this high-level estimation of GHG emissions should not be considered final. In the subsequent phases of the project, this analysis should be repeated to include a full **life-cycle assessment (LCA)** of GHG emissions as described in the [Umbrella Toolkit](#), including a detailed calculation of the three scopes of emissions across the different stages: (i) the manufacturing process of the purchased equipment or materials; (ii) the transportation of equipment and materials at the project site; (iii) the installation of the equipment and the construction of the project facilities; (iv) the project operation and maintenance activities (including the energy consumption required for operations and for the project's vehicles movement, if applicable); (v) the power supply and the energy mix used; and (v) the dismantling and disposal of the equipment at the end of its lifetime.



IMPORTANT NOTE

Effort and Resources

A wide range of GHG-related standards and methodologies is available for assessing the carbon footprint and for reporting GHG emissions. Some of these (publicly) available methodologies are listed in the ensuing; however, because this is a rapidly evolving field, users are encouraged to review potentially updated calculation tools prior to performing their assessment. In addition, at the very early stages of the project, the necessary data for the GHG accounting may not be available at the required level of detail. The involvement of experts is recommended even at the assessment's early stages in order to assist the users in setting the baselines and potential assumptions, and to increase the accuracy of the estimation.

⁴³ The GHG Protocol establishes comprehensive global standardized frameworks to measure and manage greenhouse gas (GHG) emissions from private and public sector operations, value chains and mitigation actions. For information see <https://ghgprotocol.org/>.

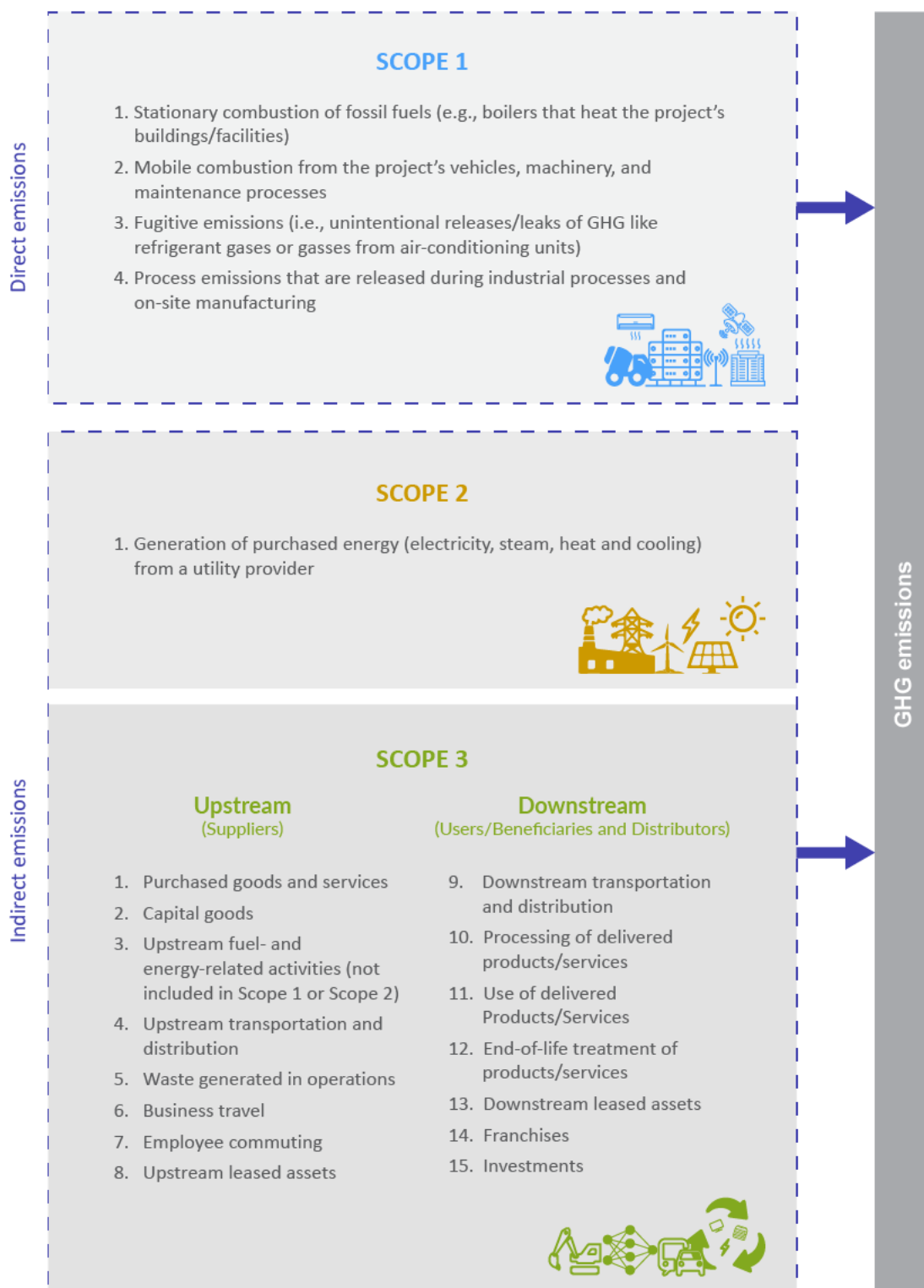


FIGURE 2.1 Direct (Scope 1) and indirect (Scope 2 and 3) emissions according to the GHG Protocol and sub-categories (adapted from GHG Protocol)

INPUT

1 Review available tools/methodologies for the estimation of GHG emissions in ICT projects. Tools and guidelines to be advised may include:

- The **GHG Protocol**,⁴⁴ which is widely accepted as the leading GHG accounting standard and provides **ICT-specific guidance**⁴⁵ for ICT infrastructure (including telecommunications network services, desktop managed services, cloud and data center services, hardware, software, and transport substitution⁴⁶).
- The **ITU Recommendations L. 1400 series**,⁴⁷ which provides methodology frameworks for the environmental impact, energy consumption, and GHG emissions assessment of ICT technologies and organizations.
- The **ICTFOOTPRINT.eu**,⁴⁸ which provides metrics, methodologies and best practices in measuring the energy and environmental efficiency of the ICT sector as well as an interactive map⁴⁹ showing relevant ICT standards.

2 Select and follow one of the most relevant-to-the-project online resources to estimate the carbon footprint of the project

Different tools may include different assumptions and limitations that need to be noted and documented. Users are advised to ensure that the resources used are indeed appropriate for the project's infrastructure typology and geographic location. The overall estimation process that is in principle common for all resources, consists of the following steps:

- Define the time horizon and geographic coverage of the ICT project that will be adopted to estimate GHG emissions.
- Define the reference unit, i.e., CO₂ or CO₂e, and the complementary references (per year, per data traffic, per user/beneficiary).

⁴⁴ GHG Protocol. <https://ghgprotocol.org/>.

⁴⁵ Carbon Trust. 2017. *ICT Sector Guidance built on the GHG Protocol Product Life Cycle Accounting and Reporting Standard*. <https://www.ghgprotocol.org/sites/default/files/ghgp/GHGP-ICTSG%20-%20ALL%20Chapters.pdf>.

⁴⁶ The application of ICT for remote collaboration and work (such as teleconferencing and telecommuting) can reduce GHG emissions in absolute terms by avoiding business travel and employee commuting. Guidance and methodologies for the calculation and reporting of the avoided emissions are provided in: Carbon Trust. 2017. *ICT Sector Guidance built on the GHG Protocol Product Life Cycle Accounting and Reporting Standard*.

⁴⁷ ITU-T. L. 1400 series (L.1400 – L.1499): Assessment methodologies of ICTs and CO₂ trajectories. <https://www.itu.int/ITU-T/recommendations/index.aspx?ser=L>.

⁴⁸ ICTFOOTPRINT.eu is the European Framework Initiative for Energy & Environmental Efficiency in the ICT Sector: <https://www.ictfootprint.eu/>. Applicable tools may be found here: <https://ictfootprint.eu/en/related-tools-services>.

⁴⁹ "ICTFOOTPRINT.eu Map of ICT Methodologies." <https://www.ictfootprint.eu/en/ict-standards/map-ict-standards>.

- Define whether to assess an absolute carbon footprint or one relative to a baseline scenario⁵⁰ (in the latter case the units and the methodological considerations, such as performance, system boundary, data quality, and allocation procedures should be defined in such a way that the two systems can be compared).
- Define the boundary details (which infrastructural components and which processes/stages—i.e., manufacturing, construction, operation and maintenance—will be considered).
- Identify and collect the necessary data for the calculation. Such data may include the full inventory of the existing ICT equipment for each stage, the measurement (for existing infrastructure) or estimation of the equipment’s power consumption and processing time, the project facilities including their energy requirements for cooling, the heating of the buildings, any diesel fuel used for generators or energy used in backup systems such as uninterruptible power supply (UPS), or any other data specified in the aforementioned resources that best match the project’s typology.
- Perform the calculation of the project’s footprint (absolute or relative to a baseline scenario).
- Report the results in a clear and transparent way, including a description of the starting points and adopted assumptions.

3

Repeat the calculation for alternative project options (if applicable), e.g., for different data center types,⁵¹ alternative geographic locations of the project, or alternative local electricity mix, in order to identify the ones with the least carbon-intense output at this preliminary stage.

OUTPUT

A shortlist of project options/alternatives documenting the carbon footprint of each one and the corresponding assumptions made for the calculations. It is recommended to include in such documentation the output file of the resource used, which can assist the experts involved in subsequent phases of the project.

⁵⁰ A baseline scenario (or “business as usual”) may either be a hypothetical reference case that best represents the conditions most likely to occur in the absence of the proposed ICT project, or a real reference case where emissions are being generated (e.g., from an existing older ICT system infrastructure).

⁵¹ Hyperscalers (0.15 ton CO₂e per workload) and co-located (0.25 ton CO₂e per workload) data centers are more efficient (when including accounting for water consumption), compared to internal data centers (0.75 ton CO₂e per workload). Siddik, Md Abu Bakar, Arman Shehabi, and Landon Marston. 2021. “The environmental footprint of data centers in the United States.” *Environmental Research Letters* 16 (6). <https://doi.org/10.1088/1748-9326/abfba1>.

BOX 2.3 ENERGY CONSUMPTION OF DATA CENTERS

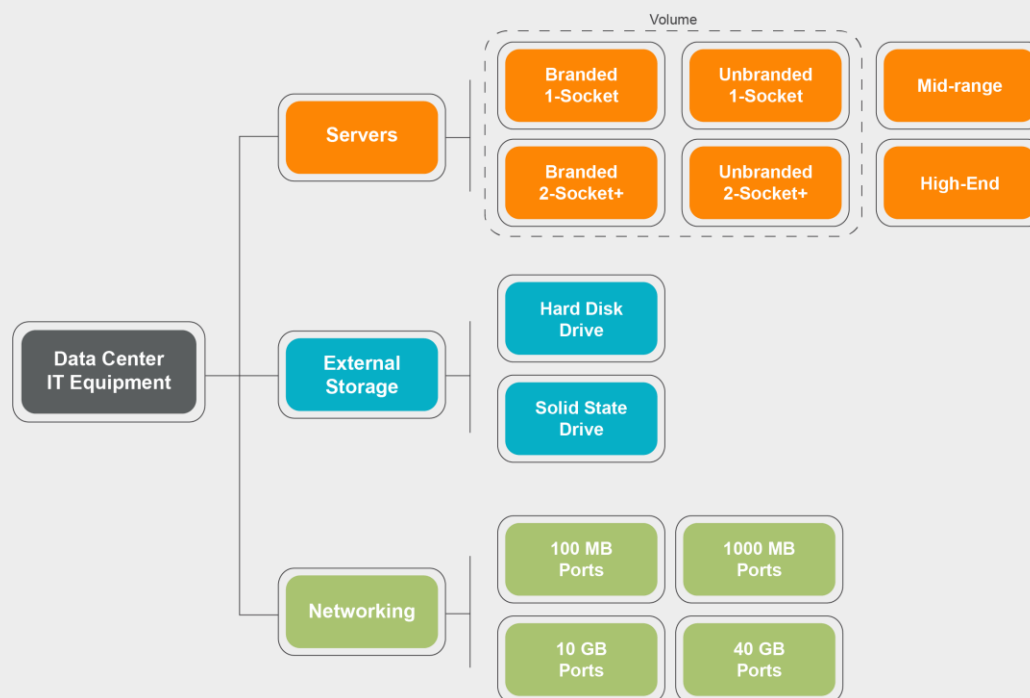
Part A - Estimating a data center's total energy consumption

The steps below may guide the energy use estimation for a data center. It is important to acknowledge though that, at early stages of a PPP project, preliminary data required for these calculations may not be available yet. Even in those cases, familiarity with the main determinants of data centers' energy consumption could provide helpful insights into the planning process and help users identify areas to focus on.

- Create inventory of IT equipment, disaggregated by type (servers, storage, networking) and classification (see [Figure B2.3.1](#) below).
- Apply power draw assumptions to the IT equipment base, considering equipment classification, network speed and data center space type, to arrive at the overall estimated IT equipment energy consumption.
- Consider the power usage effectiveness (PUE) associated with the relevant data center space type.
- Multiply the equipment energy consumption, calculated in step 2, with the data center's expected PUE to arrive at an estimate of the total energy needed to run the data center, including the data center infrastructure (i.e., cooling, lighting, controls).

It is noted that energy management systems and project design or business plans of existing data centers (preferably of similar type and scale) could be used to derive specific figures for the various IT equipment. For more details, consult Chapter 2 of [United States Data Center Energy Usage Report \(2016\)](#).

FIGURE B2.3.1 Schematization of infrastructural components of a data center's IT equipment



Source: Shehabi, A., S.J. Smith, N. Horner, I. Azevedo, R. Brown, J. Koomey, E. Masanet, D. Sartor, M. Herrlin, and W. Lintner. 2016. *United States Data Center Energy Usage Report*. Lawrence Berkeley National Laboratory, Berkeley, California. https://eta-publications.lbl.gov/sites/default/files/lbnl-1005775_v2.pdf.

BOX 2.4 ENERGY CONSUMPTION OF TELECOM TOWERS

Part A – Estimating a tower's energy consumption

In order to assess the energy demand of telecom towers, first it is helpful to recognize that base transceiver stations (BTS; the primary radio equipment) are the tower components with the largest consumption of energy. As such, a typical telecom tower's energy requirement is largely determined by the number and configuration of its base transceiver stations. BTS configurations, in turn, depend on the quantity of subscribers and the coverage area, as well as data traffic and teledensity values. **Table 2.1** provides approximate power requirement estimates of telecom tower sites for different BTS configurations.

TABLE 2.1 Power requirements of telecom tower sites for different BTS configurations

Configuration Type*	Load		Total power (kW)
	DC (kW)	AC (kW)	
2/2/2	1.24	1.80	3.04
4/4/4	2.04	2.40	4.44
6/6/6	2.82	3.60	6.42

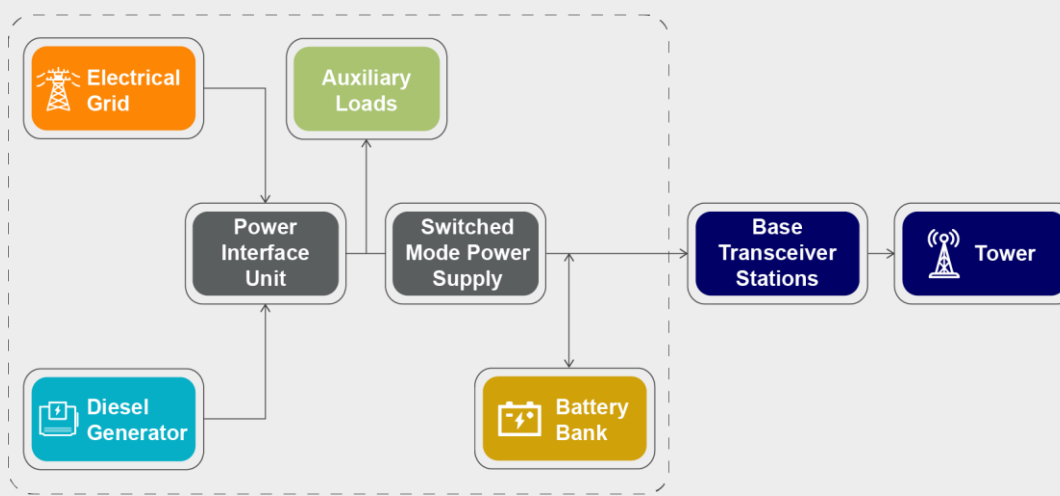
*Number of transceivers for the first/second/third sector of the cell. (kW : Kilowatts)

Source: Kaur, R., V. Krishnasamy, K. Muthusamy, and P. Chinnamuthan. 2017. "A novel proton exchange membrane fuel cell based power conversion system for telecom supply with genetic algorithm assisted intelligent interfacing converter." *Energy Conversion and Management* 136.

<https://doi.org/10.1016/j.enconman.2017.01.014>.

Second, it is important to recognize that active equipment at tower sites requires constant access to energy in order to function. To ensure 24/7 access to electricity, tower owners typically back up the electrical grid with battery banks and an on-site (diesel) generator (**Figure B2.4.1**), whose configurations take into account geographical location, grid reliability and capital expenditures (CAPEX) and operating expenses (OPEX) considerations.

FIGURE B2.4.1 Schematization of power supply at a telecom tower



Source: Intelligent Energy. 2012. *The True Cost of Providing Energy to Telecom Towers in India*. White paper. <https://www.gsma.com/membership/wp-content/uploads/2013/01/true-cost-providing-energy-telecom-towers-india.pdf>.

BOX 2.5 EXAMPLES OF CALCULATION OF GHG IMPACT FROM DIFFERENT IT ELEMENTS

According to the Carbon Trust's *ICT Sector Guidance*,⁵² the general approach for calculating GHG inventory is to multiply the activity data by the appropriate emission factors:

$$GHG \text{ Impact (kg CO}_2\text{e)} = \text{Activity Data (unit)} \times \text{Emission Factor (kg CO}_2\text{e/unit)}$$

Activity data refers to the quantified measure of an activity that gives rise to GHG emissions; it can mean either the quantity of physical material or substance, or the amount of activity. For example:

- A server casing weighs 700 grams (g) and is made of sheet steel. Using an emission factor for steel of 2.51 kilograms (kg) CO₂e per kg of steel, the GHG impact is calculated as follows:
 $GHG \text{ Impact} = 0.7 \text{ (kg)} \times 2.51 \text{ (kg CO}_2\text{e/kg)} = 1.76 \text{ (kg CO}_2\text{e)}$
- A router draws 800 watts (W) and is on for 24 hours, thus it uses $0.8 \times 24 = 19.2$ kilowatt-hours (kWh) per day. Using an emission factor for electricity of 0.60 kg CO₂e per kWh, the GHG impact is calculated as follows:
 $GHG \text{ Impact} = 19.2 \text{ (kWh per day)} \times 0.60^* \text{ (kg CO}_2\text{e/kWh)} = 11.5 \text{ (kg CO}_2\text{e per day)}$
- A base transceiver station requires approximately 3kW and 24/7 access to electricity, thus it uses $3 \times 24 = 72$ kWh per day. Using an emission factor for electricity of 0.60 kg CO₂e per kWh, the GHG impact is calculated as follows:
 $GHG \text{ Impact} = 72 \text{ (kWh per day)} \times 0.60^* \text{ (kg CO}_2\text{e/kWh)} = 43.2 \text{ (kg CO}_2\text{e per day)}$

Source: Carbon Trust. 2017. *ICT Sector Guidance Built on the GHG Protocol Product Life Cycle Accounting and Reporting Standard*. Note: kgCO₂e: Equivalent CO₂ kilograms

*The emission factor of 0.60 kg CO₂e per kWh is based on a global electricity mix. Pure renewable energy has a much lower carbon footprint of approximately 0.1 kg CO₂e/kWh.

TOOL 2.2

A CHECKLIST OF POTENTIAL MEASURES TO DECREASE THE CARBON FOOTPRINT OF ICT PROJECTS

This tool facilitates the process of forming an integrated mitigation strategy for promoting green sites, assets, networks, and operations in an ICT project's planning and design. This is achieved by identifying specific measures for reducing the project's emissions and its environmental impact through the

⁵² Carbon Trust. 2017. *ICT Sector Guidance Built on the GHG Protocol Product Life Cycle Accounting and Reporting Standard*. <https://www.ghgprotocol.org/sites/default/files/ghgp/GHGP-ICTSG%20-%20ALL%20Chapters.pdf>.

proper geographic selection of its site, adoption of low-carbon construction methods, purchase and use of energy-efficient ICT assets and materials with low carbon footprints, selection of green procurers, and implementation of circular economy concepts.

INPUT

1 **Analyze the results** of the previous tool by sorting the infrastructural components based on their energy demand and GHG intensity. Identifying the environmental hotspots, potential quick wins, and the unavoidable emissions—those that cannot be mitigated but can be compensated for (e.g., by buying carbon credits)—will guide the creation of a GHG mitigation strategy.

2 **Thoroughly review low-carbon technologies, green methods, and sustainable processes** applicable to the ICT project and its assets, including applications of circular economy concepts (in order to consider a second life for the physical components after decommissioning), and consult the checklist in **Table 2.2** to identify applicable mitigation measures.

- The **ITU L. 1300 series**⁵³ includes specific recommendations and best practices for energy efficiency and smart energy for data centers, telecommunication equipment, blockchain systems, cooling equipment, mobile networks, base stations, buildings, network architecture, functions, virtualization, and 5G radio access network equipment.
- The European Commission's Joint Research Centre (JRC) report ***Best Environmental Management Practice in the Telecommunications and ICT Services Sector***⁵⁴ provides guidance for improving the environmental performance of projects in the telecommunications and ICT services sectors.

It is highly recommended for cases of unavoidable emissions identified in (1) to adopt compensation measures through voluntary offsets recognized under the GHG Protocol. For more information on carbon credits see the [Umbrella Toolkit \(Module 3.2\)](#).

3 **Consult** with local experts and general contractors to understand the additional costs associated with the methods/products identified above, and make a preliminary decision on their cost-over-benefit ratio.

4

⁵³ ITU-T. "L. 1300 series (L.1300 – L.1399): Energy efficiency, smart energy and green data centers." <https://www.itu.int/ITU-T/recommendations/index.aspx?ser=L>.

⁵⁴ European Commission. 2020. *Best Environmental Management Practice in the Telecommunications and ICT Services Sector: Learning from Front Runners*. https://susproc.jrc.ec.europa.eu/product-bureau/sites/default/files/inline-files/jrc121781_final_bemp_report_telecom-ict_1.pdf.

Synthesize as many as possible mitigation strategies from the different options identified in (2) to achieve the maximum possible reduction in GHG emissions.

OUTPUT

Re-evaluated estimation of the project's emissions and cost effectiveness of the selected GHG emission reduction strategies.

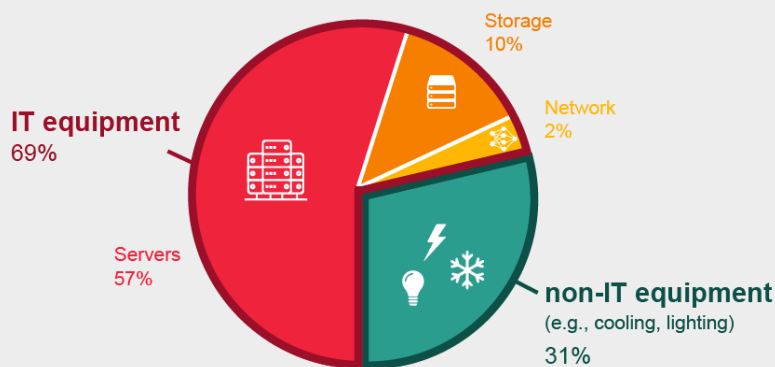
BOX 2.6 ENERGY CONSUMPTION OF DATA CENTERS

Part B - Reducing the energy consumption of data centers

A data center houses computers, servers, storage devices, and cooling and power equipment, and it combines them with the purpose of processing, exchanging and storing a significant amount of data. Government and state data centers play a crucial role in core public functions and services, and therefore they require an increased level of reliability and redundancy. Nowadays, data centers face several challenges: meeting an accelerating demand for information storage and processing power, adapting to technological advancements, and rehabilitating or replacing aging infrastructure. The need for modernization and expansion of public data center infrastructure sets the right conditions for investment opportunities through PPPs.

A large-scale data center, such as a typical government center, requires massive amounts of computational power that consumes energy. A common distribution of the energy consumption required for a data center is shown in **Figure B2.5.1**. When trying to reduce the carbon footprint of the project and identify GHG mitigation measures, it is important to know which components contribute the most to energy consumption. Green data centers include energy-efficient computing environments, with IT equipment and assets that utilize new software technologies, power usage optimization, and energy-efficient solutions that avoid wasting power (such as server consolidation and virtualization). Moreover, utilizing direct air-free cooling in place of traditional air conditioning, and applying green practices—such as using seawater or cooler temperatures of geothermal power; re-using wasted heat from servers (e.g., with absorption chillers); and optimizing the geographic location of the data center based on cooling criteria—are measures that can be considered when forming the cooling strategy and trying to decrease the project's total carbon footprint.

FIGURE B2.6.1 Global data energy demand distribution for data centers in 2021



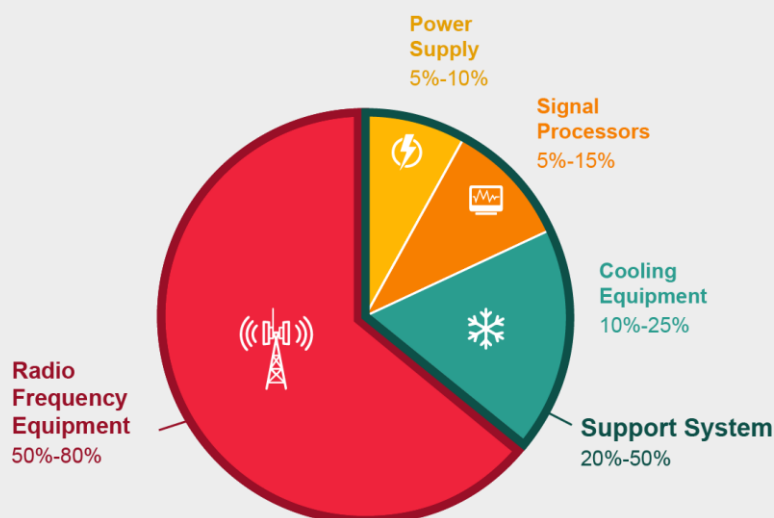
Source: IEA (International Energy Agency). 2021. "Global data centre energy demand by end-use." <https://www.iea.org/data-and-statistics/charts/global-data-centre-energy-demand-by-end-use>.

BOX 2.7 ENERGY CONSUMPTION OF TELECOM TOWERS

Part B - Reducing the energy consumption of telecom towers

Observing the distribution of the energy consumption of a typical telecom tower (shown in **Figure B2.7.1**), it is evident that the base transceiver station (BTS), the primary radio equipment at a tower site, is responsible for the majority of a tower's power demand, and consequently, of its use-phase GHG emissions. Many tower-specific mitigation options therefore focus on "greening" the BTS.

FIGURE B2.7.1 Breakdown of energy consumption at a tower site with an outdoor BTS requiring cooling



Source: GSMA. 2014. "Green Power for Mobile - The Global Telecom Tower ESCO Market - Overview of the Global Market for Energy to Telecom Towers in Off-Grid and Bad-Grid Areas." Draft report.

<https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2015/01/140617-GSMA-report-draft-vF-KR-v7.pdf>.

As an example, consider the Green Base Stations developed and installed by Japan's NTT DOCOMO. As described in the GSMA's "Case Study: NTT DOCOMO"⁵⁵ these Green Base Stations are equipped with photovoltaic (PV) panels, cycle-type lithium-ion (Li-ion) storage batteries, and DC power controllers, and they supply generated power to radio equipment with smart power control. These base stations are thus able to reduce their CO₂ emissions from the commercial electric grid use by drawing on renewable energy generated locally by the PV panels. PV power generation has the added advantage that in case of a power outage on the main electrical grid, it continues to supply clean energy, thereby reducing the tower operator's reliance on backup power alone.

For a broader perspective on the global trends and barriers currently influencing the deployment of renewable energy solutions for mobile towers in low- and middle-income countries, and a collection of proposed interventions for mobile network operators and other key ecosystem players, a 2020 GSMA report⁵⁶ can be used.

⁵⁵ GSMA. 2019. "Case Study: NTT DOCOMO." <https://www.gsma.com/futurenetworks/wiki/ntt-docomo-case-study/>.

⁵⁶ GSMA. 2020. *Renewable Energy for Mobile Towers: Opportunities for low- and middle-income countries.* https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2020/09/Clean_Tech_Report_R_WebSingles.2.pdf.

TABLE 2.2 Checklist of climate mitigation strategies to reduce GHG emissions in ICT projects

Construction/ Manufacture
<ul style="list-style-type: none"> • Favor primary and secondary suppliers of machinery/equipment with green/energy-efficient certifications • Select contractors possessing sustainability sourcing/procurement/management certification • Follow the relevant requirements and prepare the project's facilities/buildings to receive a green certification (e.g., EDGE or LEED) • Apply operational tools from green public procurement⁵⁷ (environmental criteria, ecolabels and environmental management systems, life-cycle costing)
Operation and Maintenance/ Use
<p>ENERGY EFFICIENCY</p> <p>Asset type:</p> <ul style="list-style-type: none"> • Select energy efficient asset types, e.g., for broadband access, mobile networks typically have higher electricity intensities (kWh/gigabyte) than fixed-line networks, but newer generation mobile networks (i.e., 4G or 5G) are closing the gap⁵⁸; for data centers, hyperscale servers are significantly more energy efficient than server closets and server rooms <p>Location/geography:</p> <ul style="list-style-type: none"> • Geographic optimization of the project's site based on energy and environmental criteria (e.g., the possibility of using free cooling, the reliability of the electric power and distribution system, the energy source for the electricity, the possibility of using the surplus heat) <p>System design:</p> <ul style="list-style-type: none"> • Right-sizing of the capacity, availability, and redundancy (e.g., for data centers by considering increasing IT utilization, consolidating IT equipment) • Improve the capacity utilization of data transmission networks • Consider infrastructure sharing (in-building whole or partial parts of infrastructure or the transmission lines) <p>Equipment and materials:</p> <ul style="list-style-type: none"> • Select IT equipment, materials and technologies with energy efficiency certifications, ratings or labels (e.g., Energy Star labeling, compliance with EU eco-design regulation, EPEAT graded ecolabel for servers)⁵⁹ • Invest in artificial intelligence (AI) to optimize energy use

⁵⁷ Green public procurement is defined as a process whereby public authorities seek to procure goods, services, and works with a reduced environmental impact throughout their life cycle when compared to goods, services, and works with the same primary function that would otherwise be procured. European Union. 2016. *Buying green! A handbook on green public procurement, 3rd Edition*. <https://ec.europa.eu/environment/gpp/pdf/Buying-Green-Handbook-3rd-Edition.pdf>.

⁵⁸ IEA. 2017. *Digitalization & Energy*. <https://iea.blob.core.windows.net/assets/b1e6600c-4e40-4d9c-809d-1d1724c763d5/DigitalizationandEnergy3.pdf>.

⁵⁹ Regulations, performance standards and certifications specifically for data centers are available in chapter 4 in Battelle Memorial Institute. 2022. *International review of energy efficiency in Data Centres for IEA EBC Building Energy Codes Working Group*. https://www.iea-ebc.org/Data/publications/EBC_WG_BECs_Data_Centers_March_2022.pdf.

- Require regular cleaning/maintenance of ICT equipment to increase cooling efficiency and performance overall
- Favor innovative, climate-friendly cooling systems and responsible use of water
- Reduce the physical servers by enhancing virtualization and follow a consolidation strategy for devices
- Consult the ITU-T Recommendations on green data centers⁶⁰

Facilities and buildings:

- Monitor energy consumption (including diesel fuel combustion where applicable) and apply rational management of electricity
- Host/locate server and data storage services in data centers with a low power usage effectiveness (PUE)⁶¹ quotient

Resource reuse:

- Exploit opportunities for using excess energy or waste energy (e.g., minimize waste heat from servers by reusing it in district heating)
- Consider water reuse for data centers' cooling

ENERGY MIX

Renewable energy

- Consider integrating local or remote renewable energy into the project's power system
- Purchase renewable energy by using procurement instruments such as green tariffs, energy attributes certificates, and power purchase agreements⁶²
- Promote the use of solar panels on the roof of the project's facilities
- Consider innovative energy storage technology for stationary use
- Consider renewable energy opportunities for mobile towers⁶³
- Consult the list of ITU-T Recommendations on Green ICT Power feeding⁶⁴

On-site generators:⁶⁵

⁶⁰ ITU-T. "Recommendations on Green Data Centres." <https://www.itu.int/en/action/environment-and-climate-change/Documents/ITU-TRecDataCentresList.pdf>.

⁶¹ Power usage effectiveness (PUE) is an index of the total power (including for the interdependent non-IT infrastructure, such as cooling, lighting, and control system) needed for a piece of IT equipment to run. A PUE of 1 would use no electricity other than the electricity consumed directly by the IT equipment. A PUE higher than 1 means that additional electricity is needed for the IT equipment to operate properly.

⁶² **green tariffs:** a share or all of the purchased electricity is matched by purchases of renewable electricity by the supplier on behalf of the contracting party. **energy attributes certificates:** contractual instruments certifying the origins of generated electricity. **power purchase agreement:** a long-term contract between a company and an independent power producer or utility in which the company agrees to purchase a set amount of renewable electricity or output from a specific asset. GSMA. *Setting Climate Targets: A step by step guide for mobile network operators to set science based targets.*

⁶³ GSMA. 2020. *Renewable Energy for Mobile Towers: Opportunities for low- and middle-income countries.* https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2020/09/Clean_Tech_Report_R_WebSingles.2.pdf.

⁶⁴ ITU-T. "Recommendations on Green ICT Power Feeding." <https://www.itu.int/en/action/environment-and-climate-change/Documents/ITU-TRecGreenICTPowerList.pdf>.

⁶⁵ SDIA (Sustainable Digital Infrastructure Alliance). "Support the removal of diesel generators by enabling signaling to the provisioning system or use alternative fuels." <https://knowledge.sdialliance.org/sustainable-it/rvo-best-practices-for-sustainable-it#b87f38a4577649dd87125fbc91cdc5c0>.

- Replace diesel fuel with less carbon-intensive and polluting alternatives (synthetic fuels or biofuels)
- Reduce test runs
- Consider whether possible to remove

End-of-life

TRADE-OFF BETWEEN EXTENDED LIFETIME AND ENERGY EFFICIENCY

- Estimate the environmental costs and benefits of investing in infrastructure/equipment with an extended lifetime compared with regular replacement of the infrastructure/equipment (modular approach) following the latest technological advancements; for more information check the [Umbrella Toolkit \(Box 2.9 and Box 2.10\)](#)
- Balance the GHG gain from improved technology versus embodied energy of manufacturing new ICT equipment

REUSE AND RECYCLING

- Eco-design of products and services
- Reuse/sell repairable equipment
- Optimize the life cycle and end-of-life of products and services
- Consider decommissioning stage when applying the concepts of the circular economy (reusing, repairing, refurbishing, recycling existing components and materials of the project)
- Consult the list of ITU-T Recommendations on e-waste and circular economy⁶⁶

⁶⁶ ITU-T. "Recommendations on e-waste and circular economy." <https://www.itu.int/en/action/environment-and-climate-change/Documents/ITU-TRecEWasteList.pdf>.

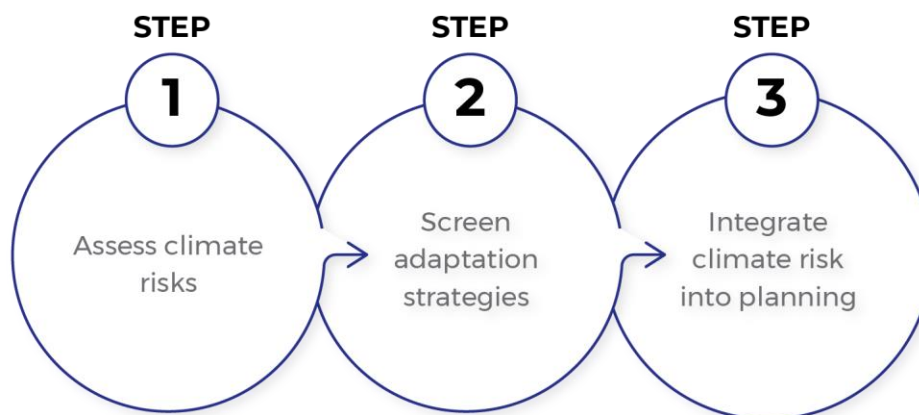
MODULE

3



Module 3

ASSESS CLIMATE RISKS AND PLAN ADAPTATION STRATEGIES



The module is divided into three consecutive steps:

Step 1: Users should assess the various ways an ICT project can be negatively impacted by changing climatic conditions.

Step 2: Users are guided to think of ways to alleviate these impacts and understand the cost implications of the various adaptation options.

Step 3: Climate considerations are introduced into a multi-criteria decision-making (MCDM) framework that aims to assist users in excluding risky or technically unfeasible projects and prioritizing those that receive the maximum consensus among stakeholders and that are less susceptible to changing climatic conditions.

When describing potential climate risks affecting distributed projects (e.g., projects involving a large number of telecom towers), the toolkit takes an asset-level approach to account for the fact that different components of a distributed project may have different exposures to various climate hazards. Meanwhile, when considering adaptation strategies, the toolkit includes a combination of system-level and asset-level responses for consideration.

Step 1

Assess Climate Risks

SCOPE	To identify and qualitatively assess (high, medium, low) the climate risks that may affect the infrastructure, revenues, and operations of an ICT project.
PROCESS	<p>The methodology for assessing climate risks is described in detail in the Umbrella Toolkit (Modules 1.2 and 2.1). The underlying assumption is that the risk depends on the intensity of the hazard, the likelihood of having a hazard of such intensity affecting the project, and the severity of the impact, according to the equation:</p> <p style="text-align: center;">RISK = [HAZARD x LIKELIHOOD] x IMPACT</p> <p>The process initiates with the identification of climate threats potentially affecting the ICT project. Then threats are characterized as high, medium, or low (taking into account their intensity and likelihood of occurrence). This is performed for different climatic futures (representing different climate projections). Next, the impacts of each hazard are assessed and combined with the (HAZARD x LIKELIHOOD) product to derive the climate risk matrix of the ICT project. The process is assisted by four tools as outlined below:</p>
	 <p>The diagram illustrates the process flow for assessing climate risks. It starts with 'Assess climate threats' (Tool 3.1), which is multiplied (indicated by a yellow 'X' symbol) by 'Assess impacts on project' (Tool 3.2). This product is then multiplied (indicated by a yellow '=' symbol) to produce 'Climate-induced risks' (Tools 3.3 and 3.4). Each step is represented by a circular icon with a corresponding tool icon below it: an eye for Tool 3.1, a clipboard for Tool 3.2, a gear for Tool 3.3, and a document for Tool 3.4.</p>
TOOLS	<p>TOOL 3.1 Mapping climate threats considering future projections</p> <p>TOOL 3.2 Assessment of climate impacts</p> <p>TOOL 3.3 Assessment of climate risks</p> <p>TOOL 3.4 Evaluation of climate-induced externalities and impacts</p>
OUTPUT	<ul style="list-style-type: none"> ▪ A qualitative risk matrix of the ICT project. ▪ A prioritization/ranking of the most significant risks that will be passed onto Step 2 to plan for adaptation measures.

TOOL 3.1

MAPPING CLIMATE THREATS CONSIDERING FUTURE PROJECTIONS

In the context of this toolkit, the **threat** is defined as any circumstance, action, or event that might exploit the potential vulnerabilities of the system (i.e., the susceptibility or inability of the system or the system's components to cope with climate variability and climate extremes) with the potential of adversely impacting the revenues, safety, or availability of the infrastructure. The threat can be:

- **An acute hazard** that may potentially damage or reduce the functionality of the infrastructure (or infrastructure component). For example, a cyclone damaging the cabling network or a severe storm damaging the pylons of antennas.
- **A chronic change in climate patterns** impacting the infrastructure or the operation of the project. For example, an increase in average temperatures will increase the demand for cooling and will negatively impact the wireless coverage (when the temperature rises, signal strength falls).
- **A multiplier of a climate stressor to an already recognized external threat** of the system (e.g., climate change affecting energy security and water availability or climate change increasing weather damages to interdependent infrastructure affecting, for example, fixed cables). This type of threat is separately covered in **Tool 1.4**.

INPUT

1 Decide on the timeframe of the assessment

The minimum timeframe for assessing climate threats will be the PPP life cycle. However, given that typical PPPs in the ICT sector have a short duration (e.g., five to 15 years), the public party is strongly advised to extend the timeframe of the study because the infrastructure life cycle may be longer than the duration of the PPP contract (e.g., infrastructure design life). **Figure 3.1** indicates the anticipated service life of ICT infrastructure and other interdependent infrastructure.

2 Screen chronic and acute climate hazards that may adversely impact the ICT project.

To retrieve country/region-specific hazards, users may refer to the resources in **Table 3.1**.

A generic list of hazards affecting ICT projects (applicable to a wide range of locations) is provided in **Table 3.2**. All hazards are classified by the variables of temperature, precipitation, sea-level rise, and wind, which can be directly retrieved from climate

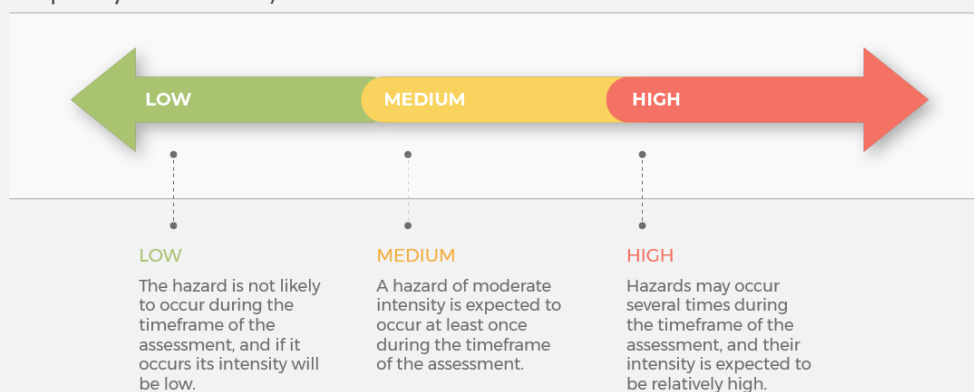
models. Due to climate change, these climate variables change at a global and regional scale, affecting chronic and acute weather patterns. For instance, a rise in the average air temperature will increase the number of very hot days, heat waves, and wildfires.

3 Exploit local knowledge and experience to confirm/revise findings

This may include already available regional impact maps and previous hazard studies. Past experience in the project area can also provide a foundation for identifying the most frequently encountered weather events or characterizing high-risk regions (e.g., flood plains, landslide/subsidence zones). Advice on regional risks may also be sought from local contractors or district engineers.

4 Assess the current threat level

Use the qualitative scoring scale provided below to characterize hazard severity as a function of the intensity of the hazard and its current likelihood of occurrence (or the frequency of the event).



5 Determine the future climate-change trend (i.e., increasing, decreasing or stable) for the identified climate hazards by screening climate predictions

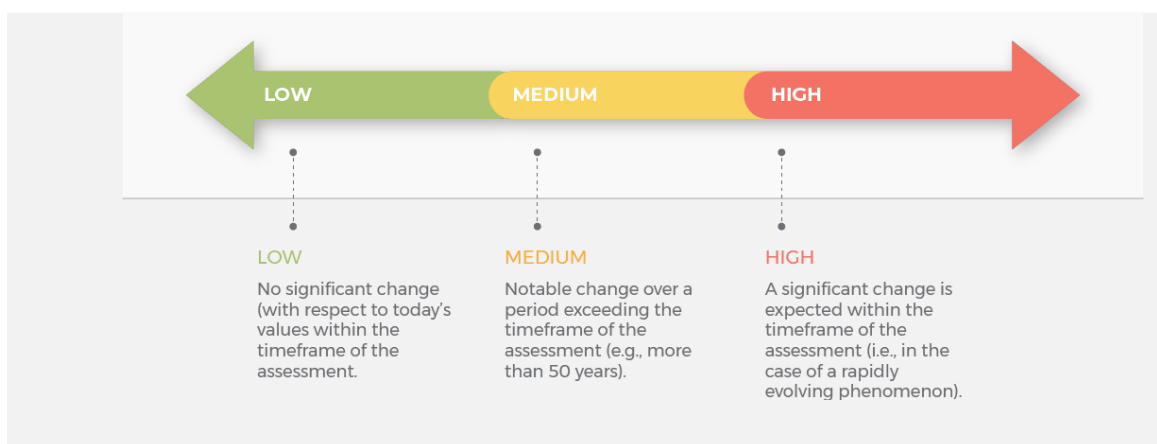
Observe the future projections of the corresponding controlling variable (second column of [Table 3.2](#)) to qualitatively estimate the future trend of the hazard under consideration. Where applicable, update the global or country-level data with regional predictions using any of the online resources in [Table 3.1](#).

For example, if the project region is showing an increasing trend in average precipitation (and if no other data are available), it is reasonable to anticipate an increase in extreme rainfall and flood events.

It is generally considered a good practice to use different climatic projections representing different Representative Concentration Pathway (RCP) scenarios.

6 Estimate the future threat level

Use the scoring system provided below to qualitatively assess climate stressor variability based on the rate of anticipated change of the primary stressor in the future. For example: for a “medium” current hazard level with an “increasing” trend, the future hazard level will be set to “high.”



OUTPUT

A preliminary characterization of the climate hazards potentially affecting the project for current and future climate conditions.



IMPORTANT NOTE

Future Climate Projections RCPs and SSPs

It is common practice to project future climate conditions based on the Representative Concentration Pathways (RCPs) to represent different trajectories of radiative forcing levels over time. Out of the four RCP scenarios, RCP 8.5 represents the highest emissions scenario, whereas RCP 2.6 represents the lowest emissions scenario. RCP 2.6 should generally be avoided when making projections because it is overly optimistic compared to recent emissions trends.

In 2016, the [Shared Socioeconomic Pathways](#) (SSPs) were introduced as an update and a substantial expansion over the RCPs. The SSP framework contains a total of eight different climate trajectories based on alternative/plausible scenarios of future emissions and land-use changes, according to which society and ecosystems will evolve in the 21st century. Global scale predictions of climate parameters for different SSPs are available in the [WorldClim database](#).

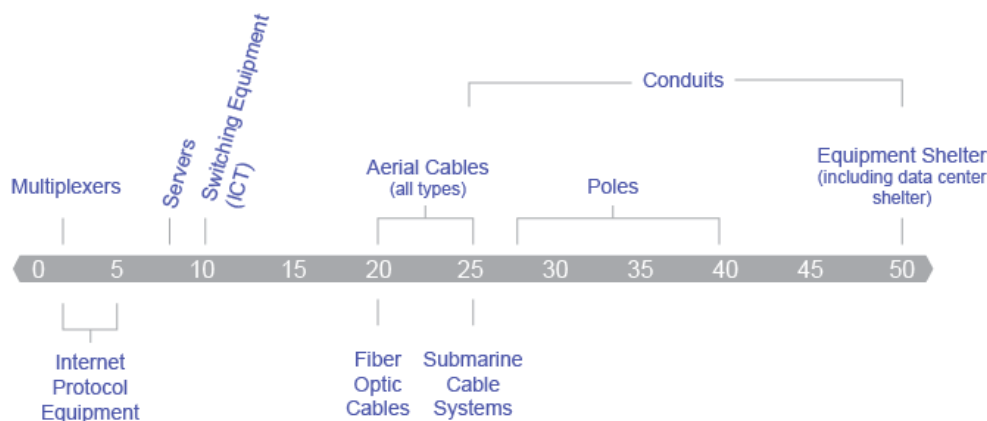






FIGURE 3.1 Anticipated service life in years of ICT infrastructure⁶⁷

BOX 3.1 MAPPING MAJOR CLIMATE-INDUCED HAZARDS FOR TELECOMS AND ICT IN THE UNITED KINGDOM

The latest United Kingdom (UK) Climate Risk technical report identifies five major climate-change induced hazards for telecommunications systems and ICT. The report provides future projections under two climate change scenarios, corresponding to approximately a 2°C and a 4°C rise in global temperature by 2100. The table below shows the weather-related events that may cause damage to ICT and telecommunications assets, power failures, poorer performance or outage incidents to the delivered services. Also, cascading failures (as will be explained in Tool 3.4) to interdependent infrastructure networks (water, energy, transport, ICT) are highlighted as a major threat to the telecommunications and ICT systems, with a high risk profile for current and future conditions.

Table 3.1.1. Projected climate impacts on the ICT infrastructure

CLIMATE THREAT	FUTURE PROJECTION
 <p>High and low temperatures, high winds, lightning</p>	<p>The UK’s annual average temperature has increased by 1°C above the pre-industrial period. The chance of extreme maximum daily temperatures is expected to increase, and the country is expected to experience warmer, wetter winters and hotter, drier summers as the climate changes.</p>
 <p>River, surface water, and groundwater flooding</p>	<p>Later this century more of the rain in summer will come from short-lived, high-intensity showers.</p>
 <p>Coastal flooding and erosion</p>	<p>Sea levels are currently rising, and the rate of rise is expected to accelerate in the future, including around the UK.</p>
 <p>Subsidence (applicable to subterranean and surface infrastructure)</p>	<p>The magnitude of the risk of damage due to subsidence is considered low currently, but it is expected to rise to the medium level across the UK by the 2050s.</p>

⁶⁷ Sandhu, Himmat Singh, and Siddhartha Raja. 2019. “No Broken Link: The Vulnerability of Telecommunication Infrastructure to Natural Hazards.” Background paper for Lifelines. World Bank, Washington, DC. <https://openknowledge.worldbank.org/handle/10986/31912>.

Source: UK Climate Risk. 2021. *Telecoms and ICT: Findings from the third UK Climate Change Risk Assessment (CCRA3) Evidence Report 2021*. <https://www.ukclimaterisk.org/wp-content/uploads/2021/06/CCRA3-Briefing-Telecoms-and-ICT.pdf>.

TABLE 3.1 List of resources that can be used for preliminary identification of climate hazards at the project location

Resource	Description	Climate Scenarios	Link
Climate Change Knowledge Portal (CCKP) developed by the World Bank Group	The CCKP contains climate, disaster risk, and socioeconomic datasets, as well as synthesis products, such as the Climate Risk Country Profiles, that include climate-related natural hazards and climate-change impacts. Temperature-related variables (e.g., number of hot/frost days, cold spell duration index) and precipitation-related variables (e.g., average largest five-day cumulative rainfall) are available for historic records and for future projections based on different climatic models.	Yes	https://climateknowledgeportal.worldbank.org
ThinkHazard! developed by the World Bank Group	ThinkHazard! provides a general view of the hazards (river flood, earthquake, drought, cyclone, coastal flood, tsunami, volcano, and landslide) for a given location. The tool highlights the likelihood of different natural hazards affecting project areas (very low, low, medium, and high), provides guidance on how to reduce the impact of these hazards, and suggests where to find more information. A brief statement is made to describe the potential impact of climate change on the hazard.	Yes	https://thinkhazard.org
ClimateLinks developed by the United States Agency for International Development (USAID)	ClimateLinks is a global knowledge portal that includes climate-related information and tools. Regional and country risk profiles are available, providing key climate stressors and risks for different regions or countries. Climate projections include temperature, precipitation variability, extreme weather events, sea level rise.	Yes	https://www.climatelinks.org/climate-risk-management/regional-country-risk-profiles
IPCC Working Group I (WGI) Interactive Atlas developed by the IPCC	The Interactive Atlas regional information supports the assessment done in the Sixth Assessment Report WGI (AR6-WGI) chapters, the Technical Summary and the Summary for Policymakers, allowing for flexible temporal and spatial analyses of trends and changes in key atmospheric and oceanic variables, extreme indexes, and climatic impact drivers related to temperature, sea level rise, sea ice concentration, drought, wind and storm, snow/ice and more.	Yes	https://interactive-atlas.ipcc.ch/
WorldClim developed by WordClim	Contains historical climate data (temperature, precipitation, wind speed, water vapor pressure) and a spectrum of future weather maps (temperature and precipitation) with a 30-second spatial resolution.	Yes	https://www.worldclim.org/

Resource	Description	Climate Scenarios	Link
The World Bank Maps developed by the World Bank Group	Provides a broad set of datasets, including relevant information for ICT projects (e.g., internet exchange points, submarine cables, subscriptions, electricity networks), as well as climate change risk for temperature and precipitation changes and other climatic variables (drought, fire, wind speed).	Yes	https://maps.worldbank.org/
The ITU Broadband Maps developed by ITU	The ITU maps illustrate existing ICT infrastructure around the world which in combination with hazard maps may be used to identify the exposure of the interdependent existing ICT facilities.	No	https://www.itu.int/en/ITU-D/Technology/Pages/InteractiveTransmissionMaps.aspx https://bbmaps.itu.int/bbmaps/
WESR-Risk developed by the UNEP/GRID-Geneva	This platform provides access to global datasets regarding hazards (floods, droughts, forest fires, tropical cyclones, earthquakes, tsunamis, landslides, volcanoes), the exposure (economic or population), as well as the risk of losses (mortality and economic risk).	No	https://wesr.unepgrid.ch/?project=MX-XVK-HPH-OGN-HVE-GGN&language=en
EarthExplorer developed by the United States Geological Survey (USGS)	A comprehensive collection of land remote-sensing data that spans more than 50 years of coverage for the world and provides digitized global maps of various data collections, including aerial photography, satellite imagery, elevation data, and land cover products.	No	https://earthexplorer.usgs.gov/

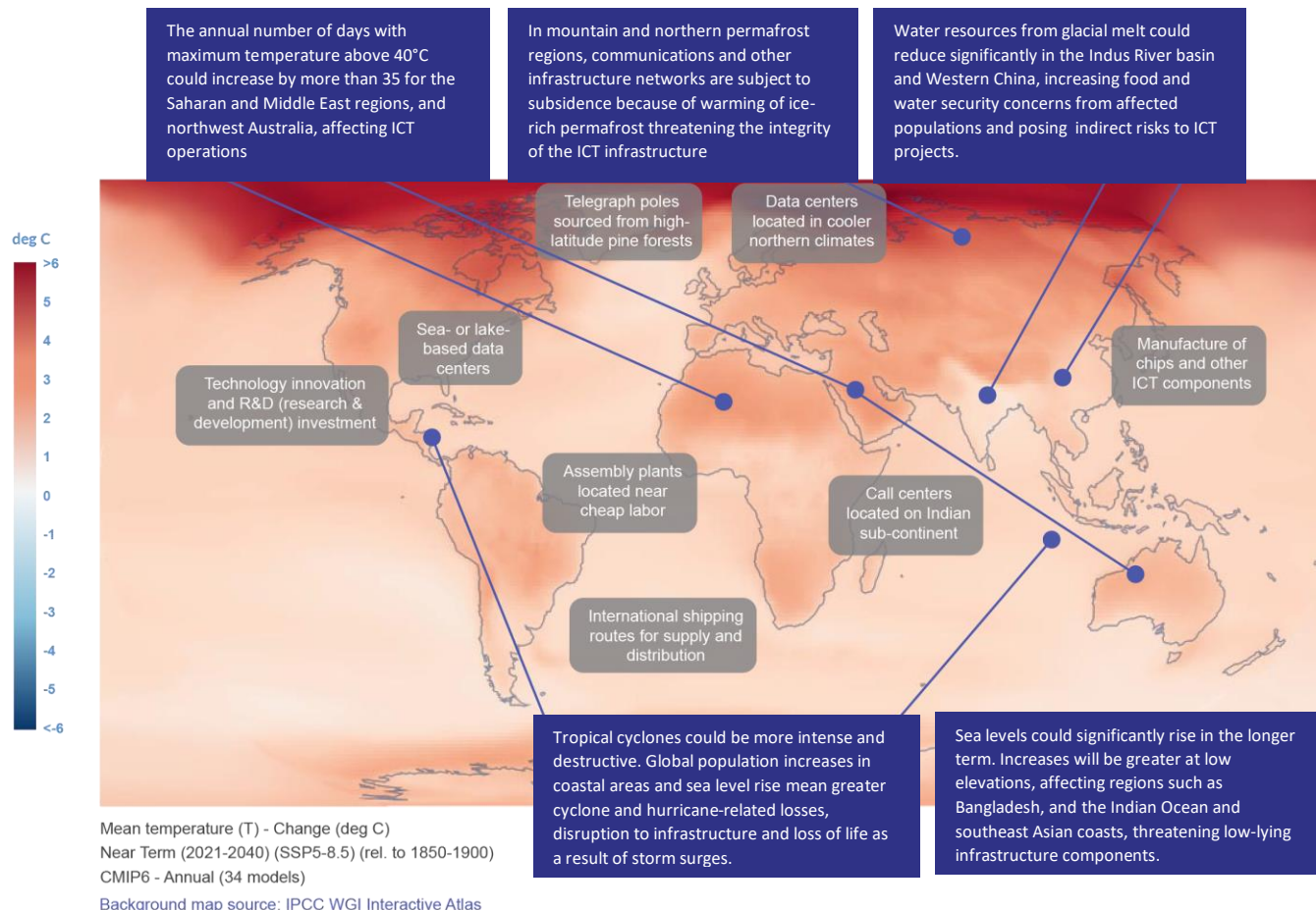


FIGURE 3.2 Examples of international climate-induced impacts on ICT infrastructure.⁶⁸ The background map illustrates the projection of the mean temperature change for the near term period (2021 – 2040) relative to 1850- 1900 levels.⁶⁹ Description of climate impacts and ICT infrastructure retrieved from: IPCC (2022)⁷⁰ and AEA (2010).

⁶⁸ AEA. 2010. *Adapting the ICT sector to the impacts of climate change*.

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/183486/infrastructure-aea-full.pdf.

⁶⁹ IPCC WGI Interactive Atlas. <https://interactive-atlas.ipcc.ch/>.

⁷⁰ Pörtner, H.-O., D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Lösschke, V. Möller, A. Okem, and B. Rama, eds. 2022. *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. IPCC (Intergovernmental Panel on Climate Change). doi:10.1017/9781009325844.

TOOL 3.2

ASSESSMENT OF CLIMATE IMPACTS

In ICT projects, climate impacts can materialize as:

- Physical damages that increase maintenance costs and capital expenses, and trigger business disruptions that could decrease revenues.
- Operational disruptions (e.g., reduced signal coverage due to increased temperatures or increased demand for cooling) that decrease revenues or increase operational expenses.

In all cases, impacts introduce losses reflected in increased expenditures or revenue losses. The higher the expected loss, the higher the severity of the impact is rated (from low to high). A schematic illustration of the potential climate impacts on ICT projects is displayed in **Figure 3.2**.

INPUT

The tool assists users in qualitatively assessing the impact⁷¹ of the climatic stressors identified above (input from **Tool 1.1**) on the ICT project (and the project components).

1 Think of the different ways the ICT project under consideration can be impacted by climate change

Table 3.2 contains a list of potential impacts typical for transmissions infrastructure, wireless signals, buildings, and IT equipment. Each impact is associated with a particular hazard. Shortlist the impacts that are the most relevant to the region under study by eliminating hazards that do not describe regional climate conditions/projections.

Whenever possible, highlight critically vulnerable elements (i.e., impacted components/processes that are essential for the operation of the ICT project). Having a clear understanding of the spectrum of climate-related impacts on the project will allow users to devise adaptation strategies that precisely address its critical vulnerabilities.

2 Assess the potential losses associated with negative impacts. Assessments should include:

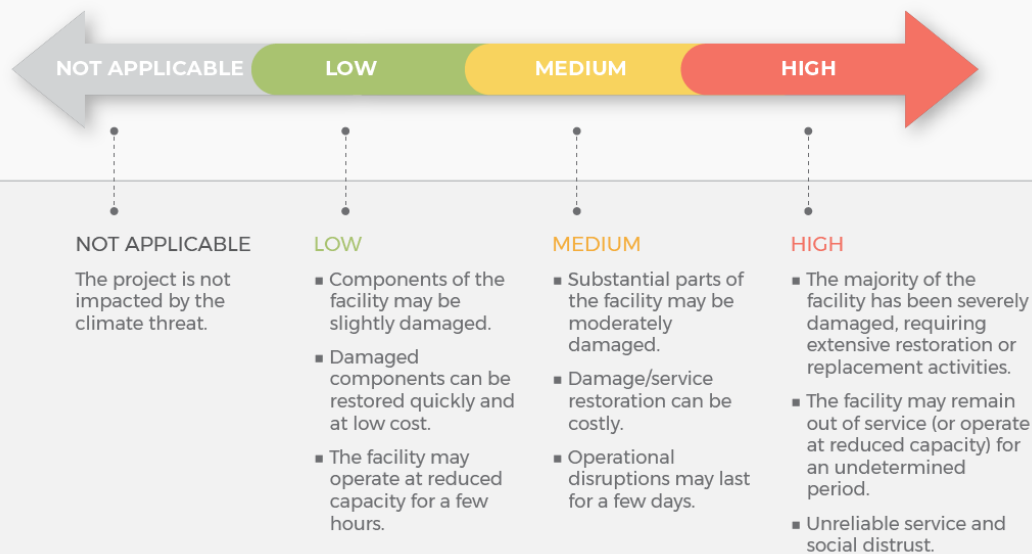
- Number of days per year that the facility is out of service or is underperforming (e.g., due to damage to critical asset components or operational disruption).

⁷¹ This tool focuses on potential negative impacts for which adaptation measures should be planned. However, it is sometimes the case that climate stressors can positively impact the facility (i.e., decreased temperatures may reduce the operational cost associated with the cooling of IT equipment). For the purpose of this preliminary assessment, positive impacts have been tacitly excluded from consideration.

- Indicative cost of repairs (e.g., cost of repairing the expected damages in telecommunication towers when specific weather thresholds, such as wind speed, are exceeded) and increases in operational/maintenance costs.

3

Appraise impact severity: Use the scoring system provided below to characterize the criticality of each potential impact on the operability and service quality of the ICT project.



4

Repeat the assessment for all the alternative project options and locations under investigation.

OUTPUT

A comprehensive listing of potential climate impacts on the project and the project's components, highlighting key system vulnerabilities.

BOX 3.2 SEVERITY OF CLIMATE IMPACTS ON ICT INFRASTRUCTURE COMPONENTS

ITU (2015) Recommendation L. 1502 “Adapting information and communication technology infrastructure to the effects of climate change” includes an overview in the form of a matrix of the of climate change effects and their impacts on ICT infrastructure components. The classification (L=Low, M=Moderate, H=High) of the impacts is based on their severity. This matrix may be used as a high-level guide when assessing the impacts of climatic hazards on the ICT infrastructural components if no other information is available.

Hazard	Temperature Rise	Humidity	Wind Loading	Sea Level Rise	Rainfall	Floods	Land-slides	Snow and Ice Fall	Lightning Strikes	Species Damage *
Infrastructure										
Tower	L	L	H	M	L	H	M	L	H	L
Antenna	M	M	H	L	H	M	M	H	H	L
Electronics	H	H	L	L	M	L	L	L	H	L
Equipment room	M	M	L	H	H	H	L	L	H	L
Terrestrial fiber optic**	L	L	L	L	L	L	H	L	L	M
Twisted pair and coaxial cables	L	L	H	M	M	H	H	M	H	H
Grid supply	L	L	L	M	M	H	M	M	H	M
Standby generators	L	L	L	M	M	H	H	H	M	L
Satellite earth stations	L	L	H	M	H/M	M	M	H	H	L
HVAC***	H	M	L	L	L	L	L	L	L	L

* Species damage refers to the damage caused by mammals, such as squirrels, mice, rats, moles, gophers and other rodents; birds, such as woodpeckers and cockatoos; insects, such as termites, ants, beetles, wasps and caterpillars; and micro-organisms, such as bacteria, fungus and/or mold. Climate change causes animal and plant species to migrate or increase their overall range, therefore areas that are not affected now may become exposed in the future due to the new climatic conditions.

** The impact of climate change on submarine fiber optics is considered very low in general. It is important to note though that near-shore submarine cables may be affected by coastal erosion, which may be exacerbated due to climate change through sea level rise and more frequent and intense coastal flooding events.

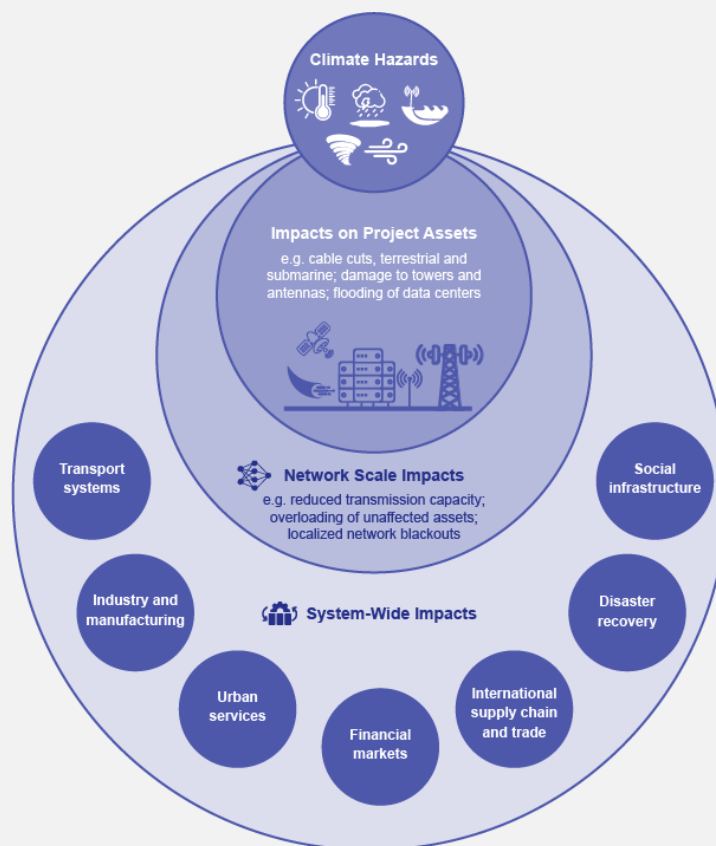
***HVAC : Heating, Ventilation and Air Conditioning

Source: ITU. 2015. “Recommendation L. 1502 Adapting information and communication technology infrastructure to the effects of climate change.” <https://www.itu.int/rec/T-REC-L.1502-201511-I/en>.

BOX 3.3 A SYSTEM-WIDE PERSPECTIVE ON IMPACTS

When assessing the climate impacts on the project's infrastructure, it is essential to recognize the interconnections among the project's components and the interdependency of its delivered service with other sectors. A climate event may directly impact one or multiple assets of the project, causing their failure (or disruption) and leading to network-scale impacts affecting the project overall, such as overloading other functional assets of the project or reducing the quality of the delivered service. These network-scale impacts may have tremendous consequences on any broader system in which ICT plays a fundamental role. For example, a failure in telecommunications systems would have severe implications for disaster response and recovery, as was the case in 2015 when the York and Leeds floods in the United Kingdom (UK) affected a Vodafone network site and BT exchange, leading to disruptions to 101 and 999 calls, while North Yorkshire Police's internal radio network was also under pressure. A malfunction in the ICT system of a busy airport would negatively impact aviation and, indirectly, the economy, or disruptions to international backhaul submarine cable systems would directly impact international financial transactions with immediate effects felt by the economy. A system-wide perspective is essential when assessing and scoring a project's different climate impacts and their consequences. Such a perspective is key as ICT infrastructure and services become more and more critical to a digital-era economy.

FIGURE B3.3.1 Schematization of system-wide perspective of climate impacts on ICT infrastructure



Source: Sandhu et al. 2019.

TABLE 3.2 Climate-change threats and their potential impacts⁷² on ICT projects

Climate Threats	Controlling Variable	Impacts on ICT Project
CHRONIC CLIMATE HAZARDS (affected by climate change)		
Changes in mean temperature	Temperature	<ul style="list-style-type: none"> Increased operating temperature of the network equipment causing malfunctions or permanent failures if exceeding design levels. Physical damage (sinking and tilting) to telecommunications towers, poles, underground infrastructure due to thawing permafrost. Increased need to cope with snow-melt water surge problems (i.e., flooding). Disruptions in wireless signals caused by changes in vegetation growth or type due to shifting ecosystems. Increased demands in cooling requirements. Faster material aging and possibly reduced life span due to long-term exposure to higher temperatures. Reduced signal coverage requiring increased density of wireless masts to compensate for the reduction in signal coverage.
Sea level rise	Global sea level	<ul style="list-style-type: none"> Inundation of coastal or low-lying facilities or limited access to them (if the surroundings are permanently or temporarily flooded) due to sea level rise. Threats to the structural/geotechnical integrity of coastal or low-lying infrastructure (e.g., submarine cable system landing stations) due to the additional loading imposed by sea-level increase and the corresponding influence of groundwater pore pressures. Flaws in telecommunication and satellite transmission calculations due to changes in reference datum. Increased saltwater corrosion to steel components at coastal or low-lying assets/facilities. Increased erosion threatening the stability of coastal or low-lying assets/facilities.

⁷² Impacts are based on information from: AEA. 2010. *Adapting the ICT sector to the impacts of climate change*. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/183486/infrastructure-aea-full.pdf; US General Services Administration. 2014. *Climate Risks Study for Telecommunications and Data Center Services*. <https://sftool.gov/Content/attachments/GSA%20Climate%20Risks%20Study%20for%20Telecommunications%20and%20Data%20Center%20Services%20-%20FINAL%20October%202014.pdf>; Tech UK. 2016. *The UK’s core digital infrastructure: data centres – Climate change adaptation and resilience*. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/620924/climate-adrep-tech-uk.pdf; Economic and Social Commission for Asia and the Pacific. 2022. “A Climate Resilient ICT Sector in the Mongolia - Action Plan and Policy Recommendations Framework.” Working Paper. <https://www.unescap.org/kp/2022/climate-resilient-ict-sector-mongolia-action-plan-and-policy-recommendations-framework>.

Climate Threats	Controlling Variable	Impacts on ICT Project
Humidity	Precipitation/temperature	<ul style="list-style-type: none"> • Changes in requirements to maintain internal environments (e.g., data centers) to acceptable humidity levels. • Faster deterioration of materials over the years (i.e., increased corrosion rates). • Weakening of the quality, strength and reliability of wireless transmission services (the radio spectrum on which wireless communications rely is affected by precipitation and humidity).
Droughts (increase in the number of dry days) and increase in water unavailability	Temperature/precipitation	<ul style="list-style-type: none"> • Increased seasonal water scarcity reduces the amount of available water for cooling purposes. • More intense or longer droughts and heatwaves can cause ground shrinkage and damage underground ICT infrastructure, or increased risk of subsidence, leading to reduced stability of foundations and tower structures.
Precipitation change	Precipitation	<ul style="list-style-type: none"> • Weakening of the quality, strength and reliability of wireless transmission service (rain and snow absorb signals at some frequencies, limiting the users supported in a given spectrum band). • Exposure of the underground cabling network due to increased erosion caused by rain. • Land subsidence and heave threatening the stability of both above and below ground infrastructure due to decreased precipitation.
ACUTE CLIMATE HAZARDS (affected by climate change)		
Extreme winds, rain, snow, hail, cyclones, and more frequent lightning	Wind/precipitation	<ul style="list-style-type: none"> • Physical damages to infrastructural components, especially for assets and facilities above ground (e.g., branches falling onto telecommunications lines). • Power outages due to increased lightning strikes causing damages to transmitters and cables.⁷³ • Potentially limited accessibility to the infrastructure or facilities by maintenance/operational staff during storms.
Extreme heat/temperatures	Temperature	<ul style="list-style-type: none"> • Power outages due to extreme heat generating extreme energy demands on very hot days. • Temporary or permanent damages due to overheating of data centers, base stations and mobile towers. • Health and safety issues for employees, especially maintenance staff. • Reduced lifetime of cables due to faster degradation of the rubber protection with extreme high temperatures. • Reduced signal coverage of wireless transmission due to high temperatures.

⁷³ ITU. 2019. "Recommendation K. 39 Risk assessment of damages to telecommunication sites due to lightning discharges." <https://www.itu.int/rec/T-REC-K.39-201911-I/en>.

Climate Threats	Controlling Variable	Impacts on ICT Project
		<ul style="list-style-type: none"> • Temperature-related electrical or mechanical failures. • Reduced efficiency of batteries. • Increased need to cope with snow-melt water surge problems (i.e., flooding). • Extreme low temperatures favor ice forming on aerial cables, increasing their weight, and antennas, affecting the radio systems.
Floods	Precipitation	<ul style="list-style-type: none"> • Damages to physical components (due to water or debris), especially for data centers that include multiple pieces of sensitive electrical equipment. • Transmission losses due to extreme wind and rain. • For fixed line telecoms, floods may lead to scour of cabling; flooding of ducting, underground cables, cabinets and access points; water damage to assets; and silt damage. • Disruption to fleet operations. Problems with staff safety and emergency access. • Delays and challenges (at least till flooding retreats) in restoration and repair work.
Landslides/subsidence (a cascading hazard caused by extreme rain that saturates soil and decreases stability)	Precipitation	<ul style="list-style-type: none"> • ICT assets (both over and underground), especially the cabling network and the foundation of masts or antennas, as well as the interdependent facilities (including the transmission lines and access roads) located in landslide-prone areas may experience increased (or unprecedented) risk when significant changes in precipitation extremes occur during the lifetime of the project.
Fires	Temperature ⁷⁴	<ul style="list-style-type: none"> • Physical damages to the overground assets (masts, antennas, wired network above ground), data center power facilities, and the equipment of transmission and distribution lines. • Impaired access to the facility.

⁷⁴ Although there is no direct relation between fires and climate change, there is evidence that as climate conditions have become hotter and drier, wildfires have grown more intense and destructive.

TOOL 3.3

ASSESSMENT OF CLIMATE RISKS

According to the definitions provided in the [Umbrella Toolkit \(Modules 1.2 and 2.1\)](#), internal climate risks originate from hazards that are posed directly on the project, describing the **likelihood of a project to experience an impact of a given severity**. In a preliminary climate assessment, the term likelihood is schematically used to encapsulate two factors:

- The *frequency of the climate event* (i.e., how often the project experiences such an impact), which is primarily a function of the intensity of the event. The stronger the event, the lower its frequency.
- The *uncertainty of the evolution of climatic factors*. In that respect, climate projections following an RCP 8.5 scenario (a very pessimistic one) may be considered less likely to materialize.

INPUT

The tool may be used for a qualitative assessment of internal climate-induced risks for ICT projects. **Tool 3.3** should be used in combination with **Tool 3.4** (employed to estimate external risks originating from hazards affecting not the project per se but its broader socioeconomic system) to estimate the total (internal and external) climate risk of the ICT project.

1 Assign likelihoods to hazards potentially affecting the ICT project.

For acute hazards: As a rule of thumb, set the likelihood to “low” for events that take place once or twice during the infrastructure’s life cycle (e.g., an extreme flood that has inundated the entire data center facility), or “high” for events that have a recurrence period of one to five years.

For chronic hazards: For conservative estimates, consider the likelihood to be “high” for all climate projections. Alternatively, set the likelihood to “low-medium” for climate projections made using RCP 8.5, and set the likelihood to “high” for RCP 4.5 and 6.0.

2 Calculate the climate risk level of each hazard according to the equation [HAZARD x LIKELIHOOD] x IMPACT using the two-dimensional color matrix provided below. First, combine HAZARD with LIKELIHOOD to estimate the THREAT severity. Then combine the THREAT severity with the IMPACT severity to calculate the RISK level (i.e., read hazard severity in the first column and combine it with the IMPACT score displayed in the first row).

Example calculation: [Low x Medium] x High = Low x High = Medium

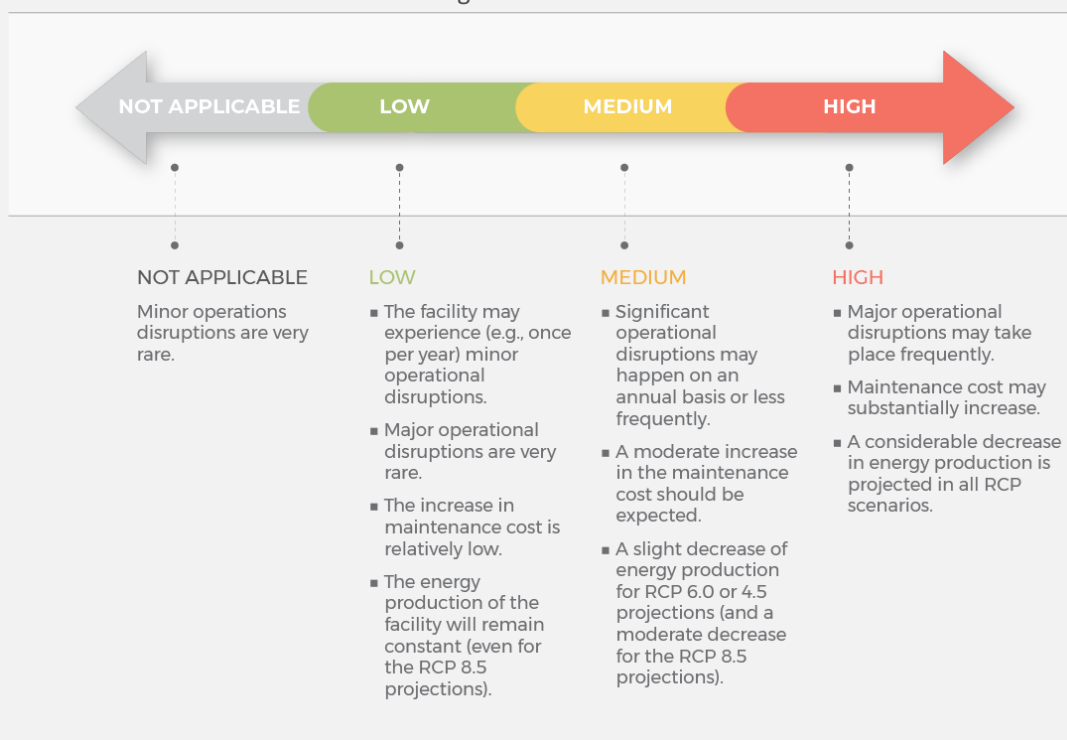
	Low	Medium	High
Low	LOW	LOW	MEDIUM
Medium	LOW	MEDIUM	HIGH
High	MEDIUM	HIGH	HIGH

3

Build the risk matrix of the project combining risks stemming from all potential threats. If available, repeat the process for alternative ICT locations or asset types.

4

Describe consequences and, where possible, provide cost estimates for the level of operational disruption. As displayed in the graphic below, low climate risks are associated with minimum disruptions to the facility and the broader community, whereas high climate risks may cause service unavailability for prolonged periods and significant revenue loss (that can be catastrophic for the investment), and in extreme cases social outrage and distrust.



OUTPUT

A systematic description of all potential climate risks affecting the ICT project and associated rough cost estimates.

TOOL 3.4

EVALUATION OF CLIMATE-INDUCED EXTERNALITIES AND IMPACTS

External risks originate from hazards affecting either the interlinked infrastructure of the ICT project or its broader socioeconomic system, thus indirectly impacting the project's operations and its service quality. Because external risks are beyond the control of the project, it is important to identify them early in the project selection process, estimate the severity of their impacts, and plan mitigations where possible. It may even be advisable to abandon or restructure projects that experience high external risks that cannot be mitigated.

INPUT

This tool may be used to perform a preliminary screening of the broader socioeconomic impacts of climate change and their interactions with the project underway.

1 Identify external risks that are pertinent to the regional setting of the ICT project under consideration.

A list of commonly encountered external risks in ICT projects is provided in **Table 3.3**. The listing is indicative, describing conditions that may introduce positive or negative externalities to the project due to climate change. Users are requested to customize the list as appropriate to make it relevant to the project specifics.

2 Score the “external risk level” as “low,” “medium,” or “high” (specifying risk sources that are particular to the project under consideration) and add results to the climate risk matrix of the project (output of **Tool 3.3).**

3 For each externality, estimate potential losses (or gains) and think of ways to remediate their negative consequences. The external risks that cannot be mitigated by means of design/planning should be revisited and re-evaluated when assessing the bankability of the project and when the risk allocation matrix is structured (Phases 2 and 3 of the PPP project cycle). The users are hence advised to carefully evaluate them and document the results in detail.

TABLE 3.3 External climate-induced risks and consequences for ICT projects

External Factors that Can Be Impacted by Climate Change	Example Consequences for ICT Projects
Energy security	<p>Climate impacts (i.e., damages and disruptions) on power supply systems across all stages (generation, transmission and distribution) pose a significant risk for the ICT project due to its high reliance on energy for its operation.</p> <p>Climate change also causes an increased demand for energy to other sectors (e.g., increased electricity consumption for heating or cooling households), resulting in overloading of the power supply system and causing more frequent and more extended (spatially and in time) blackouts and power outages, unavoidably affecting the ICT project.</p> <p>Even though new generation technologies are more energy efficient, they usually have higher processing capacity and require more energy for their operation, resulting in the ICT infrastructure's greater dependence on the energy sector and further contributing to the energy insecurity that is intensified by climate change.</p>
Water scarcity	<p>Water is a fundamental element for the cooling process of data centers. Changes in water demand and conflicting uses resulting in policy-enforced limitations can affect the water management system of the data center and even threaten the viability of the ICT project.</p>
Transport vulnerability⁷⁵	<p>Usually the ICT infrastructure depends on existing or new transportation (road) networks; thus the inherent vulnerabilities of the road infrastructure are interlinked with the associated ICT assets.</p> <p>Accessibility of the project's facilities and assets may be limited by weather-related damage or disruption to the transport network.</p> <p>Supply chains associated with the project may be disrupted by climate events, resulting in significant challenges for the maintenance and repair activities associated with the ICT project.</p>

⁷⁵ A country-scale example of co-deployment and sharing of infrastructure organized among telecommunications operators and between operators of road and energy infrastructure networks may be found in the Asia-Pacific Information Superhighway Working Paper Series (2020): (i) *An In-Depth National Study on ICT Infrastructure Co-Deployment with Road Transport and Energy Infrastructure in Kazakhstan – Part I*. <https://repository.unescap.org/handle/20.500.12870/710> and (ii) *An In-Depth National Study on ICT Infrastructure Deployment along Road Transport and Energy Infrastructure in Kyrgyzstan*. <https://repository.unescap.org/handle/20.500.12870/4590>. The same Working Paper Series offers a capacity-building toolkit, Toolkit for ICT Infrastructure Co-Deployment with Road Transport and Energy Infrastructure (<https://repository.unescap.org/handle/20.500.12870/4572>), for assessing and planning the economic, organizational and technical aspects of ICT infrastructure co-deployment with road transport and energy infrastructure.

External Factors that Can Be Impacted by Climate Change	Example Consequences for ICT Projects
<p>Shared infrastructure</p> <p>both passive (non-electronic, such as towers, base transceiver station (BTS) shelters, and power) and active (electronic, including spectrum, switches, and antennas)</p>	<p>The risk of failure of the shared infrastructure poses a significant risk to the ICT project because the resilience standards may differ among the various parties that own and manage the shared infrastructure components.</p>
<p>Technological advancements</p>	<p>Increased demand for innovation (coming from ICT projects themselves or from other sectors that use ICT) pushes the ICT sector to develop and deliver new generation technologies, which may result in greater energy efficiency and create new markets. However, it may require the development of new ICT infrastructure, making current ICT infrastructure obsolete or requiring a need for duplicate infrastructure (and its maintenance) where new technologies are only rolled out in some areas.</p>
<p>Demographic changes in the characteristics of human population and population segments. These may refer to population distribution, age, marital status, occupation, income, education level, and other statistical measures that may influence the project.</p>	<p>Demographic changes may affect the project through:</p> <ul style="list-style-type: none"> • Changes in the demand for the delivered service (e.g., due to seasonal migration because of desertification exacerbated by climate change). Migration (especially urban to rural) may affect demand for ICT services by changing not just the size but also the composition of the population to be serviced, e.g., the gender balance and the share of young adults in a population, both important determinants of ICT demand. • Changes in energy demand and prices (see also energy security impacts). • Changes in water demand and competing uses (see also water scarcity impacts). • Changes in lifestyle (e.g., increased remote working increases the criticality of ICT infrastructure). • Gender and socioeconomic status are interlinked with infrastructure needs/use, and thus affect vulnerability to climate-driven risks. In many emerging economies, ICT literacy and device ownership is higher among men, so their direct exposure may be higher; on the other hand, women may be more vulnerable to the knock-on effects of ICT service disruptions on, for example, public transport services, of which they are majority users.⁷⁶
<p>Policy and regulation changes: evolution of national and worldwide</p>	<p>Government policy changes, national or regional action regulating the use of water, or the acceptable limits of energy</p>

⁷⁶ The Gender and Information and Communication Technology (ICT) Survey Toolkit developed by the FHI 3600 Mobile Solutions Technical Assistance and Research (mSTAR) project in partnership with USAID provides tools for agencies to assess current gender and ICT trends and collect sex-disaggregated data on gender and ICT access and use, especially mobile phones.

https://www.usaid.gov/sites/default/files/documents/15396/Gender_and_ICT_Toolkit.pdf. More information on gender aspects is provided in WBG. 2021. “Green, Resilient and Inclusive Development (GRID).”


External Factors that Can Be Impacted by Climate Change	Example Consequences for ICT Projects
guidelines and regulations on sustainability and climate change.	consumption (e.g., dictating specific PUE thresholds), or changes in land usage and biodiversity issues can have major implications for the project's viability.

OUTPUT

A ranked list of climate externalities for the project, including a description of consequences and possible remediation measures

Step 2

Screen Possible Adaptation Strategies To Reduce Climate Risks

SCOPE	To identify adaptation measures and compose alternative strategies that build climate resilience into the ICT project by reducing the project-specific climate risks while maximizing the positive socio-environmental impact of the project.
PROCESS	The process starts with a detailed mapping of possible adaptation solutions addressing the project's climate risks (derived from Tool 1.3). Users are then asked to build alternative adaptation strategies combining different adaptation measures. The alternative strategies may differ in terms of capital costs and may offer different protection within the multi-hazard environment of the project. Finally, a pre-selection of the preferred adaption strategy will be performed in Step 3 using a multi-criteria decision framework.
	 <p style="text-align: center;">Tool 3.5</p>
TOOLS	TOOL 3.5 Planning of climate adaptation strategies
OUTPUT	A list of possible adaptation strategies for further consideration (during Step 3)

TOOL 3.5

PLANNING CLIMATE ADAPTATION STRATEGIES

Adaptation measures for ICT infrastructure projects may be broadly categorized in the following three classes (for more details, see [Umbrella Toolkit \(Figure 1.4\)](#)):

- **Prevention** includes all measures that can lead to reducing the likelihood of the consequences of the risk once a hazard materializes.
- **Preparation** includes all measures that can lead to reducing the consequences of the risk once a hazard materializes.
- Finally, **recovery** includes measures that will allow the project to resume operations in a timely way following the occurrence of an event.

The adaptation strategies may then be further classified into three categories:

- ✓ **Changes in the planning of the project**, including changes in the location or changes in the asset type. For example, the agency may wish to change the location of the data center to avoid the projected higher temperatures of the initial site or to consider integrating the development of a renewable power generation on-site facility in the planning process that will satisfy the electricity needs of the IT equipment.
- ✓ **Changes in the design through hard-engineering solutions** (i.e., structural interventions) aimed at increasing the robustness of the design against identified climate risks (e.g., moving above-ground cables below the ground, increasing the elevation of coastal infrastructure to minimize the risk of inundation, increasing foundation dimensions of masts to increase stability in case of severe storms).
- ✓ **Soft-engineering solutions** that aim to protect the ICT project and safeguard its operational efficiency without building structural interventions. This category may include technological or operational approaches (e.g., AI energy management systems for increasing the energy efficiency of the ICT project and thus reducing the required capacity of the energy back-up system).

Nature-based solutions (NbS) that work with natural processes to reduce risks may provide alternatives to hard-engineering solutions. Examples include using vegetation for landslide protection, or adopting eco-friendly principles in the water management required for the cooling systems of IT equipment.

INPUT

This tool will guide users through the process of structuring climate adaptation strategies that are appropriate for the level of anticipated climate risk.

1 Select adaptation measures.

Identify threats that, based on the preceding analysis, introduce high risk to the ICT project. For each individual threat, look it up in **Table 3.4** and identify adaptation measures that can mitigate the respective climate impact.

2 Build an adaptation strategy by combining different adaptation measures.

Define a comfortable level of risk and combine adaptation options that can reduce the risk below the maximum acceptable level.

3 Conceptualize alternative adaptation strategies.

Review adaptation strategies and generate alternatives by replacing (where possible) hard engineering solutions with soft-engineering solutions. It is generally considered good practice to come up with more than one strategy to be further evaluated in **Step 3**.

4 Provide rough cost estimates for each adaptation strategy.**5 Repeat** the process for other climate hazards in order to define appropriate adaptation strategies for the project (or the project alternatives).

OUTPUT

A list of possible adaptation strategies for further consideration.

TABLE 3.4 List of potential climate adaptation measures for ICT projects

Stage	Category	Example Measure
PREVENTION	Planning/strategic	<ul style="list-style-type: none"> • Include long-term environmental and climate-change considerations into spatial planning; e.g., ensure that key buildings and facilities, such as data centers, are out of future storm paths and floodplains, including in coastal areas increasingly threatened by sea level rise and coastal storm surges. • Implement procurement processes that emphasize service continuity rather than compensation for disruption.
	Hard engineering/structural	<ul style="list-style-type: none"> • Place telecommunication cables underground where technically and economically feasible, and choose designs that are resilient to hotter temperatures and an increased risk of groundwater flooding and subsidence. • Raise equipment to higher floors in central offices and install flood barriers to reduce exposure to flooding; invest in improved lightning protection. • Reconsider the location of backup generators: raise them if necessary to prevent failure due to flooding, especially when located outside the main building at ground level.
	Soft engineering/technical and operational	<ul style="list-style-type: none"> • Use low-power wireless solutions to replace the most weather-susceptible segments of the wired network (e.g., customer drop wires). • Install devices and components (e.g., computer chips) with higher temperature operating ranges. • Choose climate-appropriate technology: in areas with high predicted wildfire risk, direct fresh air cooling might require extra filtration, whereas in an increasingly dry region, evaporative cooling may become unfeasible. • Avoid outages by trimming trees near power and communication lines. • Incorporate climate-change considerations into existing corporate risk assessment procedures and enterprise risk management systems.

Stage	Category	Example Measure
PREPARATION	Planning/strategic	<ul style="list-style-type: none"> • Build redundancies in the backbone network; collaborate through commercial negotiations with other telecommunications operators to establish redundant routes to be able to cope with faults and failures with minimal impact to subscribers by routing traffic through these alternative routes. • Explore opportunities for infrastructure sharing (e.g., mobile operators sharing towers) in order to reduce costs and increase resilience. • Introduce strategic or dynamic nodes for rural or more vulnerable locations to enable interconnectivity under disaster conditions.
	Hard engineering/structural	<ul style="list-style-type: none"> • Reduce dependence of communication infrastructure on electric grid infrastructure to the extent possible. This could, for example, involve the use of microgrids. • In anticipation of extended power grid outages, provide reliable backup power, such as generators, solar-powered battery banks, and “cells on wheels” that can replace disabled towers. Extend the fuel storage capacity for backup generators. • Invest in strategies to mitigate the impact of water shortages, such as greater on-site water storage or standby cooling.
	Soft engineering/technical and operational	<ul style="list-style-type: none"> • Improve resource efficiency by minimizing energy consumption and implementing energy-efficiency initiatives (e.g., AI energy management systems for increasing the energy efficiency of the ICT project and thus reducing the required capacity of the energy back-up systems). • Implement alternative telecommunication technologies that promise to increase redundancy and/or reliability, including free-space optics (which transmit data with light rather than physical connections) and power line communications (which transmit data over electric power lines). • Build the server network redundancy required for virtualization that enables computational load to be transferred from site to site around the globe if necessary, avoiding areas of increased weather risk. • Operate “warm standby” or “hot standby” for data centers and critical broadcast infrastructure. (Hot standby involves mirrored facilities⁷⁷ less than 30 kilometers (km) apart, which can be synchronized live and where functionality can be moved across seamlessly. Other mirrored facilities may be further apart.)

⁷⁷ “mirrored” means that activity is duplicated between two sites.

Stage	Category	Example Measure
		<ul style="list-style-type: none"> • Ensure access to disaster recovery facilities for data centers that are ready to receive an entire operation if it suffers partial or catastrophic failure. • Update organizational protocols: procedures for system back-up, business continuity standards.
RECOVERY	Planning/strategic	<ul style="list-style-type: none"> • Improve contingency planning across a full range of climate hazards, especially those which occur less frequently or of which providers have had little past experience: <ul style="list-style-type: none"> - Responses could be improved through the wider use of weather event early warning systems, linking infrastructure providers and operators directly with meteorological offices or environmental agencies (for flood, storm and heat warnings). - Close collaboration with local authorities may ensure a more efficient and effective recovery phase following weather disruption.
	Hard engineering/structural	<ul style="list-style-type: none"> • Maintain backup supplies of poles and wires to be able to avoid delays in replacing those that are damaged.
	Soft engineering/technical and operational	<ul style="list-style-type: none"> • Arrange emergency restoration crews ready to be deployed ahead of a storm's arrival. • Invest in novel technologies that provide coverage for disaster-hit areas, such as unmanned drones, transportable antennas, towers on wheels, and other modular transmission solutions. • Ensure site accessibility by understanding how workers' journeys to work will be affected by an extreme event, accounting for potential access and transport disruptions or personal challenges workers may face (e.g., homes are flooded).

Step 3

Integrate Climate Risks Into The Planning Of ICT Projects

To describe a multi-criteria analytical framework that will support users incorporating climate decisions into the planning of new ICT projects.

SCOPE

PROCESS

The completion of the previous steps of this guide should have produced a large amount of data that will need to be mainstreamed into strategic decisions about the new ICT facility. Comparing alternative options with respect to their service capacity, cost of operations, and energy efficiency is just one side of the coin. On the other side, there are climate-related risks and opportunities that can also influence planning decisions.

Balancing competing objectives (from technical, economic, social, environmental, political, and strategic standpoints) requires a multi-criteria approach that can best work within a participatory decision-making environment. The methodological framework of such an approach—termed herein multi-criteria decision-making framework (MCDM)—is described in **Tool 3.6**. The process starts with the definition of objectives, the engagement of a stakeholder council, and the selection of criteria. Following a scoring and weighting procedure, the preferred strategy is derived and is subsequently forwarded for a preliminary economic analysis (conducted in **Module 3**).



TOOLS

TOOL 3.6 A multi-criteria decision-making (MCDM) framework

OUTPUT

A climate-informed planning decision for a new ICT project.

TOOL 3.6

A MULTI-CRITERIA DECISION-MAKING (MCDM) FRAMEWORK

MCDM is a scientifically sound decision framework that can provide a comprehensive and transparent basis for any kind of assessment, including decisions on the planning of new ICT installations. In the context of this guide, the MCDM method aims to assist users in planning for ICT projects that, in addition to other traditional objectives, are:

- Climate resilient (i.e., can sustain extreme climate hazards with minimal disruption).
- Climate insensitive (i.e., are less affected by the variability of climate stressors).

Users are referred to the [Umbrella Toolkit \(Module 2.1\)](#) for insights on how climate decisions may benefit from empirically based multi-criteria analysis (and other equivalent approaches).

It must be acknowledged that MCDM-based methods rely on empirical correlations and expert judgment, and they do not model the actual physical or financial processes of the project. Although they can be very efficient in analyzing complex problems (especially at the early stages when very limited information is available for the technical and financial aspects of the project), they are prone to erroneous judgment. Therefore, it is recommended to carry out a validation of the MCDM analysis against a known problem (e.g., another ICT project in a similar environment, preferably in the same country).

INPUT

This tool describes the general framework for conducting an MCDM analysis to assist the preliminary planning decisions of an ICT project. Depending on the input parameters and the specific objectives of the assessment, the MCDM can support any other type of a decision, from risk assessments (where the objective is to minimize the climate-induced impacts) to operational decisions of ICT projects (see the example in **Box 3.4**). Instances of MCDM may also vary in complexity, from purely qualitative formulations to mathematical ones using fuzzy-logic theories for optimization.⁷⁸

- 1** Define the objective of the decision-making (assessed variable), e.g., identification of optimum project location, identification of optimum asset type, climate risk minimization.

⁷⁸ An overview for different MCDM techniques with varying levels of sophistication may be found in: Araújo, M., L. Ekenberg, M. Danielson, and J. Confraria. 2022. "A Multi-Criteria Approach to Decision Making in Broadband Technology Selection." *Group Decision and Negotiation* 31: 387–418. <https://doi.org/10.1007/s10726-021-09772-9>.

2 Engage a council of experts and stakeholders (digital development experts, environmental scientists, engineers, community engagement experts) that will participate in the decision-making process by proposing the criteria and their importance based on their own perspectives and empirical evidence.

3 Define/refine the criteria of the assessment that best reflect national priorities

Potential criteria to consider may include:

- The capital and life-cycle costs.
- The GHG emissions over the project life cycle.
- The risk level, i.e., the “resilience of” level of the project.
- The effectiveness in responding to the uncertainty of a changing climate (i.e., the adaptiveness of the solution).
- The potential of the project to enhance the overall resilience of the impacted community (or a certain disadvantaged population within the community), i.e., the “resilience to” level of the project.
- Other factors (e.g., technical feasibility, protection of biodiversity, social acceptance, the optionality of green financing/funding).

Users may update/modify the above list of criteria to best reflect the priorities of the ministry/authority in charge and the project specifics. It is generally not a good practice to enter the analysis with a very long list of criteria because this will increase the effort of the assessment and will further complicate the selection process. For a preliminary screening of key input parameters that describe the general project set-up, users are referred to in the ITU’s ICT Infrastructure Business Planning Toolkit.⁷⁹

4 Ranking, classification, and rating of criteria

Involve the council of experts and stakeholders to prioritize the criteria and rank them (i.e., apply weights) based on their importance or criticality. The scoring system of the criteria may be qualitative (e.g., high, medium, low) or arithmetic (e.g., 1 to 5). Users are prompted to use **Reporting Template 3.1**⁸⁰ (or any other similar structured format for reporting) to assess the envisioned project strategies and compare alternative climate measures⁸¹ in a structured and transparent way. As a general rule of thumb, the ranking of criteria and their rating should be compatible with national priorities.

⁷⁹ ITU. 2019. ICT Infrastructure Business Planning Toolkit. <https://www.itu.int/en/ITU-D/Technology/Documents/Publications/ICT%20Infrastructure-business-toolkit.pdf>.

⁸⁰ Reporting Template 3.1 is an indicative template provided only for guidance purposes. The user is free to adopt any other structured format that best suits the project’s characteristics and/or the identified climate strategies.

⁸¹ The term “climate measures” refers to both adaptation and mitigation measures.

BOX 3.4 A MCDM PROCESS FOR THE SELECTION OF BROADBAND TECHNOLOGY

In scarcely populated areas, operators usually do not have commercial incentives for deploying networks capable of high quality mass coverage. In such cases governments need to provide incentives to support private investments through public funds and public regulations or policies in order to make an attractive tender. During this process public decision-makers need to consider multiple criteria when selecting the preferred technology that will satisfy the local need for broadband service in a marketable way. Such criteria may include not only cost-related parameters such as the infrastructure costs and the regulated tariffs but also the technical quality of the solution, the public interest, the future-proofness of the solution—that is, avoiding the hypothetical necessity of replacing recently built networks in the near future—and the credibility of the candidates, i.e., the quality and track record of each candidate. Climate resiliency considerations may be included in the criteria related to the future-proofness of the proposal.

To enhance transparency and inclusivity, local interest groups, consumers, manufacturers, and service providers should be included in the negotiations and consultation mechanisms, and contribute to the decision-making process (e.g., the weight given to the position of a given industry might be proportional to its share of local employment).

An application example of such a situation (i.e., delivering a steady 100 megabits per second (Mbps) broadband connection in a rural area) is provided in Araújo et al. (2022) for a fictional case where the available information to be analyzed is limited and the evaluation needs to incorporate uncertainty. An integrated approach is followed by combining uncertain weights, probabilities, and values, and a step-by-step description is given for deciding the preferred technology among three solutions: (i) optical fiber directly to the end-user's home, (ii) optical fiber to a cabinet followed by DSL (copper telephone lines) from the cabinet to the end-user's home, and (iii) mobile 5G. Based on three main criteria—costs, quality, and delivery—and their sub-criteria, shown in the table below, the study concludes on a ranking of 24 synthetic contenders (bidders) with the second solution winning.

TABLE 3.5 The three main criteria of the selection process and their sub-criteria

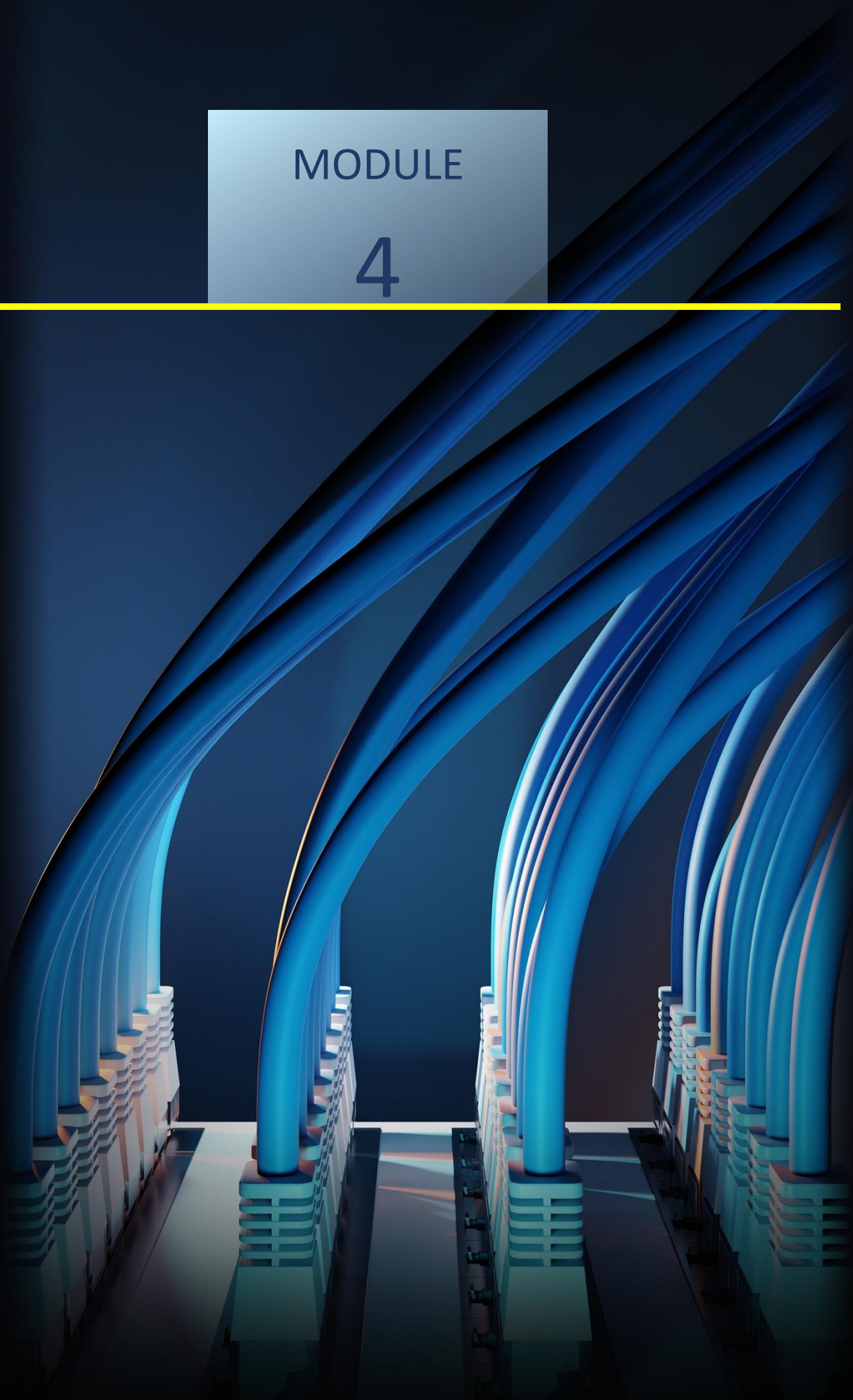
Main criteria	Sub-criteria
Costs related to the subsidies' costs	Infrastructure deployment costs
Quality of service related to how "future-proof" the proposed technology is	Data transmission speed: network latency, jitter, packet loss ⁸²
Delivery related to the candidate operators' skills	Time delivery: technical capacity, financial situation

Source: Araújo et al. 2022.

⁸² "Latency" refers to the delay of the transmission signal and "jitter" to the variation of that delay. "Packet loss" is the percentage of data transmission packets that do not reach their final destination.

MODULE

4



Module 4

CLIMATE CONSIDERATIONS IN ASSESSING PROJECT'S ECONOMICS AND FINANCE

STEP

1

Check economic soundness of alternative climate strategies

Module 4 is meant to assist entities in integrating the previous climate considerations into their traditional economic assessments of the PPP project cycle's Phase 1 "Project Identification and PPP Screening." This module consists of a single step that provides tools and examples for

Identifying all climate-related costs/benefits that should be integrated with an enhanced cost-benefit analysis (CBA) (**Tool 3.1**).

Performing a VfM assessment to determine whether the PPP should be preferred over traditional procurement after incorporation of climate considerations (**Tool 3.2**).

Adaptable to a wide range of broadband infrastructure deployment projects, the ICT Infrastructure Business Planning Toolkit⁸³ offers regulators and policy makers a clear and practical methodology for the accurate economic evaluation of broadband infrastructure installation and deployment plans. Integrating climate considerations (as recommended by this module) in an evaluation performed at the very early stages of the project cycle may reveal the undesired effect of climate change and its uncertainty in the project's economics and finances, and raise awareness among the stakeholders

⁸³ ITU. 2019. ICT Infrastructure Business Planning Toolkit. <https://www.itu.int/en/ITU-D/Technology/Documents/Publications/ICT%20Infrastructure-business-toolkit.pdf>.

Step 1

Check Economic Soundness Of Alternative Climate Strategies

SCOPE	To compare the climate strategies identified in the previous module in terms of cost-effectiveness, affordability, and suitability for a PPP. The output will be a project that has been successfully screened from an economic perspective and can therefore be considered suitable for proceeding to a full technical and economic appraisal.
PROCESS	Using the screening process presented in the Umbrella Toolkit , the economic analysis is performed in stages, starting with a preliminary CBA (Tool 3.1) to identify the project that maximizes the benefit over cost ratio. For best results, all important climate-related costs (e.g., additional climate CAPEX, cost of disruption caused by extreme weather events) and benefits (e.g., risk reduction benefits, protection of natural environment, and increasing resilience of interdependent systems) should be synthesized and compared after economic evaluation. Once the project has been identified, the project's affordability is tested in view of the public authority's budgetary limits, constraints, and other concurrent investment plans, employing the general considerations described in the Umbrella Toolkit . The final check is to assess how climate-induced risks, costs, and opportunities may affect the suitability of a project as a PPP (Tool 3.2). The project that successfully passes all tests receives the green light to proceed to the "Appraisal and Preparation Phase."
	<pre> graph LR A((Perform a (qualitative) CBA)) --> B((Check project's affordability)) B --> C((Check project's suitability for PPP)) A --- T1[Tool 4.1] C --- T2[Tool 4.2] </pre>
TOOLS	TOOL 4.1 Climate entry points for CBA (specific for ICT projects) TOOL 4.2 Climate value drivers for value for money (VfM) analysis
OUTPUT	A climate-informed project that can be moved forward for appraisal.

TOOL 4.1

CLIMATE ENTRY POINTS FOR ICT-SPECIFIC CBA

The tool describes entry points for climate-related CBA considerations that are relevant to ICT projects. Cost-benefit analyses are customarily conducted for different scenarios, including changes in the financing scheme and operational processes. Prior to applying the tool, users are advised to review methodologies for estimating the monetary value of social-environmental benefits and the CBA Primer (2017),⁸⁴ and consult the [Umbrella Toolkit](#), where climate-related considerations for CBA (applicable to all sectors) are described in greater detail

INPUT

TABLE 4.1 ICT-specific climate entry points for CBA

CBA Process Outline (per APMG PPP Certification guide)	CBA Sub-steps (per APMG PPP Certification guide)	Climate Entry Point
Projecting financial data with conversion/adjustment	Tax adjustment	<ul style="list-style-type: none"> If applicable in the country, include tax incentives or expedited permitting that promotes climate mitigation and adaptation actions (e.g., use of the rural masts and antennas for installation of weather monitoring equipment or equipment for monitoring/protecting biodiversity, support of ICT-enabled early warning systems). If applicable, include levies and environmental taxes in the “do nothing” option.
	Shadow prices and opportunity cost adjustments	<ul style="list-style-type: none"> Adjust costs and benefits as would otherwise be done following the 2017 WB Guidance Note on the shadow price of carbon.⁸⁵
	Construction of the model	<ul style="list-style-type: none"> Include the cost of implementing adaptation measures (e.g., cost of enhanced lightning protection, cost of higher capacity backup power systems, cost of increasing the design load thresholds of operational components—such as higher operating temperatures for IT equipment) or of structural components (e.g., design of facilities based on lower probabilities of floods), cost of anti-erosion measures. Consider the cost of adopting sustainable/green construction principles (e.g., cost of recycling, reuse/resell opportunities of IT equipment, investment in electrical construction machinery, cost

Guzman, A., and F. Estrázulas. 2012. “Full Speed Ahead: Economic Cost-Benefit Analyses Pave the Way for Decision-Making.” *Handshake* (IFC quarterly journal of public-private partnership) 7 (October).

⁸⁵ World Bank. 2017. “Shadow Price of Carbon in Economic Analysis.” Guidance Note, November 12, 2017.

<https://thedocs.worldbank.org/en/doc/911381516303509498-0020022018/original/2017ShadowPriceofCarbonGuidanceNoteFINALCLEARED.pdf>.

CBA Process Outline (per APMG PPP Certification guide)	CBA Sub-steps (per APMG PPP Certification guide)	Climate Entry Point
	Operational and maintenance cost	<p>of constructing a sustainable water management system for the ICT project, i.e., integration with local water resources).</p> <ul style="list-style-type: none"> • Consider the increase in the cost of operation (e.g., due to the possible need to install and maintain additional energy backup systems for operation during potential weather-related power outages, the need to reserve additional water resources for cooling, cost of possibly necessary repairs after intense storms and flood events). • Consider an increase in maintenance costs (e.g., more frequent cleaning of IT equipment to decrease the need for cooling, anti-icing of the cabled network, maintenance of vegetated slopes, cost of monitoring). • Include provisions for increased costs for decommissioning of the equipment after completion of the project's productive life. Consider the possibility of stricter reuse/recycle requirements in the future, resulting in increased expenses towards the end of the project's life.
	Term and residual value	<ul style="list-style-type: none"> • Residual value estimates should be adjusted to include climate-change impacts, for example: • Reductions related to frequent weather-related damages • Reductions caused by reduced service demand triggered by climate change (e.g., migration due to desertification) • Reductions caused by increased costs related to energy pricing and/or power availability.
Adding externalities	List of externalities	<ul style="list-style-type: none"> • The cost of externalities may include: • Cost of indirect loss caused by service disruption/loss due to damage to transmission lines; broken supply chains due to damage in the transportation network, leading to limited accessibility of the ICT facilities/assets; increased travel times for employees. • Cost of emergency services (e.g., use of aerial means to extinguish fires or evacuate on-site personnel, or availability of additional backup supplies). • Permanent or temporary changes in demographics (see Table 3.3). • Disruption during construction (introduced by unfavorable weather conditions, e.g., extreme heat, frequent and intense rainfalls, cyclones, extreme waves). • External benefits arising from the installation of monitoring systems and weather stations at the ICT assets, useful for early warning and protection of the surrounding environment and communities.
Adding (other) socioeconomic benefits	Monetizing/infering value for relevant benefits	<ul style="list-style-type: none"> • Include an increase in private investment confidence (business, entrepreneurship, property). • Include the effect of encouraging investments in enhancing climate resilience in the region (e.g., through providing access to ICT services to vulnerable or rural communities).
	Considering/qualifying other unvalued benefits	<ul style="list-style-type: none"> • Include resilience benefits such as:

CBA Process Outline (per APMG PPP Certification guide)	CBA Sub-steps (per APMG PPP Certification guide)	Climate Entry Point
		<ul style="list-style-type: none"> - Avoided loss (e.g., service downtime) to the network adjusted over the probability of the climate event.⁸⁶ - Monitoring of the broader ecosystem (e.g., stormwater management at data centers and integration with water used for cooling, slope stability monitoring at ground-mounted assets). - Providing a reliable source of ICT services to nearby businesses and to vulnerable beneficiaries. • Environmental benefits of nature-based or eco-friendly solutions (e.g., vegetated slopes, on-site renewable energy generation, integration of project's water management with the broader water supply system). • Alignment with strategic climate objectives.
Relative price adjustments and bias/ risk adjustments	Market imperfection	<ul style="list-style-type: none"> • Apply as would otherwise have been done.
	Other opportunity cost adjustments	<ul style="list-style-type: none"> • Consider alternative uses of the land and space that need to be covered due to climate-change-related works, if any, and apply such costs (e.g., master plans that integrate future intervention plans for building climate resilience).
	Taxes	<ul style="list-style-type: none"> • Same as above, apply only to the extent that tax advantages are applicable when a project exceeds its purpose in social benefits; and/or • Consider the tax income gained from steady uninterrupted operations.
Defining base case, defining and calculating economic internal rate of return (EIRR)	Discount rate definition and calculation of net present value (NPV) and EIRR	<ul style="list-style-type: none"> • Consider adjusting discount rate for valuation depending on levels of certainty of cash flows (applies to projects that include climate adaptation measures) and uncertainty of cash flows (applies to alternatives with no adaptation measures). This needs to be aligned with the probabilistic analysis of events occurring to avoid "hurting" a project with uncertainty twice (once with a high probability of costs occurring, and a second time with a high discount rate because of the uncertainty of cashflows).
Incorporating uncertainty: sensitivities	Test the strength of the proposed business plan and present the effect of variations	<ul style="list-style-type: none"> • As would otherwise be conducted.

OUTPUT

⁸⁶ The annual probability, p , of an event is equal to the reverse of its return period, T : $p = 1/T$. Exceedance probability of an event over a period of n years for an event with an annual probability of p is: $1 - (1-p)^n$. For example, a storm with a 100-year return period has only a 1 percent probability of occurring in any given year. When assuming a 20-year period for the ICT project life cycle, this probability corresponds to an 18 percent likelihood of occurring within the period of 20 years. When assuming a five-year period, the likelihood of occurrence reduces to 5 percent.

The results of the analysis of climate entry points in the project's CBA may be summarized in a screening report highlighting which climate mitigation and adaptation aspects have been considered and ensuring these have been adequately evaluated.



IMPORTANT NOTE

Choosing Discount Rate

The discount rate used in the economic analysis is particularly important when evaluating and comparing adaptation options because the associated benefits (or avoided costs) are likely not to realize for many decades. There is no consensus on the appropriate discount rate to use for resilience strategies. As a good practice, study teams may choose to explore the sensitivity of economic analysis findings to different discount rates or the possibility of applying a non-constant discount rate over the horizon of the assessment.

TOOL 4.2

CLIMATE VALUE DRIVERS FOR VFM ANALYSIS

A VfM analysis is performed to identify whether (and to what extent) climate-related risks, opportunities, and uncertainties may affect the suitability of a project for PPP and non-PPP delivery. The tool describes entry points for climate-related considerations for VfM analysis that are relevant to ICT projects. It explains the rationale of these considerations; identifies conditions of positive, negative, or conditional performance; and, where applicable, provides specific references and examples.

INPUT

TABLE 4.2 Impacts of climate change on PPP suitability for ICT projects

VfM Driver	PPP Suitability: Climate Considerations	Conditions	Impact on PPP Suitability
Project size	Is the project too big for the market? Or is the project too complex to be delivered as a PPP?	In cases where climate risks are increased, the use of larger, more efficient equipment may be necessary. This may lead to the introduction of untested (for the region/country) technologies and infrastructure assets of high unit cost, which could hinder the market's appetite or the project's financing.	Negative

VfM Driver	PPP Suitability: Climate Considerations	Conditions	Impact on PPP Suitability
Market appetite	Would there be private investor appetite?	The identification of previously unknown climate risks (e.g., the increased frequency of cyclones that may result in increased damages to the above-ground infrastructure) could hamper the investor appetite to invest in the ICT project.	Negative
		A thorough CBA of climate adaptation/mitigation works would provide visibility and hence increase private sector appetite.	Positive
		Engagement with local communities and other stakeholders, and the establishment of an inclusive, participatory method for decision-making regarding the provided type of service (e.g., 5G or optic fibers), will provide confidence that future master plans and developments, or possible water scarcity periods, will not impact the project disproportionately.	Positive
Precedent projects	Are precedent transactions already developed as PPPs for this type of project in the country/region/similar countries?	Climate risks are better understood in countries with a legacy of ICT infrastructure development under a PPP scheme. The involved stakeholders are better informed, and the local communities are familiar with the services and benefits provided.	Positive
Risk allocation⁸⁷	Are there any significant climate risks within the project that are not manageable by a private partner?	Gradual changes in weather patterns or extreme climate events may under certain circumstances cause extended losses to ICT projects. The risk of sustaining such losses may be reduced by the proper design of climate adaptation works. Insurance should also be sought to cover excess climate risks. In case costs for climate adaptation works are high, or insurance is unavailable, the risk may not be manageable by the private partner (e.g., risk of backbone network damages due to extreme loading during storms implies high restoration/replacement costs, or the necessity of including high-capacity backup energy systems to reduce the exposure to energy security issues implies higher initial CAPEX).	Negative

⁸⁷ An indicative list of ICT-related risks allocated to the party that is more capable of controlling the risk and is less risk averse is presented in: Nel, Danielle. 2020. "Allocation of Risk in Public Private Partnerships in Information and Communications Technology." *International Journal of eBusiness and eGovernment Studies* 12 (1): 17-32. DOI: 10.34111/ijepeg.202012102. Additionally, the Global Infrastructure Hub's PPP Risk Allocation Tool 2019 (<https://ppp-risk.github.org/>) contains a matrix of risks typically found in a submarine power cable PPP transaction, together with guidance on how those risks are typically allocated between the contracting authority and the private partner, the rationale for such risk allocation, mitigation measures and possible government support arrangements.

VfM Driver	PPP Suitability: Climate Considerations	Conditions	Impact on PPP Suitability
		Uncertainty in estimating climate risks (i.e., CAPEX and/or operation and maintenance costs) impacts the PPP suitability of ICT projects.	Mostly negative (unless specific measures to increase certainty are taken)
	Are there circumstances where climate risks can be better assumed by the private party?	The private sector's capital and innovation bring higher efficiency in disaster preparedness, response, and recovery. Also, insurance coverage increases the capability of the private party to assume a certain level of climate risks.	Positive
	Is there a risk of non-availability of the land/right of way and land acquisition cost overrun?	Geophysical hazards (e.g., landslide, subsidence, flooding, icing conditions) may be intensified by climate change; hence ICT infrastructure near landslide-prone areas, floodplains, thawing permafrost zones, or areas impacted by coastal erosion could experience higher risks.	Mostly negative (unless recognized and proper measures are structured)
Certainty of offtake/ supply	Is it possible that the project will experience a change in demand due to climate change?	Interdependencies between climate, land use, population, water usage, energy supply, or innovative ICT technologies render ICT services vulnerable to external factors that may not be under the control of the PPP and may have a negative impact on the demand for the ICT service and hence the tariffs, thus, compromising investment certainty.	Mostly negative (unless climate uncertainty and inter-dependencies have been properly addressed during planning)
		Increased growth of a region (partially affected by milder climate conditions) may positively impact the ICT service demand.	Mostly positive
Project quality	Will the project quality increase if the project is developed through a PPP scheme?	In several cases, the private party may bring innovation and high standards. Examples of such innovations applicable to ICT projects could indicatively include contractors with experience in the development of integrated energy monitoring systems for adaptive management of the ICT service, flood risk management, and early warning systems.	Mostly positive (provided that the methods used are tested)
		As commercial lenders become more informed on the climate-change risk, they will demand higher climate-resilience standards in order to ensure repayment/returns.	Positive
Output-based contracting	Is it possible to define clear output requirements for the project's	The service's availability and quality could be linked with financial incentives or penalties to encourage	Mostly positive

VfM Driver	PPP Suitability: Climate Considerations	Conditions	Impact on PPP Suitability
	performance with respect to weather events?	faster and better responses to climate-related disruptions.	
Finance availability	Are there any significant climate risks that may harm the availability of financing?	Unmitigated risks (such as the increased probability of high-impact weather events, water demand changes, geomorphological changes) will test the willingness of financiers to participate or could raise requests for higher guarantees.	Negative (unless recognized and proper adaptation measures are structured)
Legal or regulatory framework	Has the country adopted national legislation on climate change?	Prior existence of a national framework promoting green investments (defining subsidies and incentives for private sector participation) would definitely boost the project. For example, subsidies to invest in on-site renewable energy generation, or tax incentives would positively impact the development of the ICT project.	Mostly positive

OUTPUT

The results of the VfM may be summarized in a screening report highlighting which climate mitigation and resilience aspects have been considered and how they impact the suitability of the project for a PPP.



MODULE
5



Module 5

KPIs FOR CLIMATE-RESILIENT AND SUSTAINABLE ICT PROJECTS

Key performance indicators (KPIs) are customarily used in ICT projects to assess and evaluate the project's performance during design, construction, and operation. KPIs are developed around specific government objectives, and the private partner will either be entitled to additional payments for good performance or will receive reduced payments for poor performance. Expanding this general notion to PPPs containing climate actions, the relevant KPIs can be used to measure the ICT project's resilience to climate change, i.e., the ability to prepare for, respond to and quickly recover from climatic hazards, and the project's ability to contribute to climate-change mitigation, i.e., reduce its own carbon footprint.

The tool described below provides indicative high-level examples of climate KPIs soliciting the inclusion of forward-looking information in performance-based contracts.

Based on the understanding that there is no one-size-fits-all for KPIs, the tool describes climate indicators that may be applicable to a broad range of ICT projects. It is then the obligation of the entity in charge, with the assistance of experienced consultants, to design project-specific KPIs that best describe the technical/operational challenges of the project and take advantage of the expertise and innovation skills of the private sector.

TOOL 5.1

KPIs MEASURING CLIMATE RESILIENCE AND SUSTAINABILITY OBJECTIVES

This tool is designed to assist public authorities and their advisors when structuring and preparing performance-based contracts for ICT projects. The relevant KPIs included in this section have a dual purpose: (i) to facilitate assessments of a project's resilience to climate change and (ii) to track the effectiveness of the project in contributing to the sustainability and socio-environmental objectives of the country/region.

KPIs are typically described by a performance objective, a measurement indicator, and a threshold to gauge compliance with the objective. It should be noted that the tool does not provide threshold values for the suggested KPIs. This is country- and project-specific information that the public authority should provide based on good-practice examples, applicable norms/rules, and in consultation with the technical advisor, in due consideration of the project's risk profile, the frequency of the event, and the importance of the project for the management of climate-induced risks. Overall, it is considered good practice to define two levels of achievement: a *conserving level* as having no negative impacts, and an *improved level* that will overall benefit the project's performance. Performance below the conserving level signifies the application of penalties, whereas performance above the improved level may be tied to specific rewards/incentives for the private partner.

INPUT

Tables 5.1 and **5.2** provide a non-exhaustive list of climate KPIs that can be widely adaptable to ICT projects and that have been recommended by international literature and frameworks.⁸⁸ The KPIs describe the project's performance according to resilience and sustainability goals covering its entire life cycle, from design and construction to operation and maintenance. Users are advised to revise/complete the list of KPIs to better reflect the project-specific goals.

⁸⁸ Brocklehurst, Fiona. 2022. *International review of energy efficiency in Data Centres for IEA EBC Building Energy Codes Working Group*. Battelle Memorial Institute. https://www.iea-ebc.org/Data/publications/EBC_WG_BECs_Data_Centers_March_2022.pdf; GSMA and EY. 2022. *ESG Metrics for Mobile: Realising value for society through common industry KPIs*. GSM Association. <https://www.gsma.com/betterfuture/wp-content/uploads/2022/06/ESG-Metrics-for-Mobile-June-2022.pdf>; ITU. 2012. *Toolkit on Environmental Sustainability for the ICT Sector*. ITU. https://www.itu.int/dms_pub/itu-t/oth/4B/01/T4B010000060001PDFE.pdf; ENISA (European Network and Information Security Agency). 2011. *Measurement Frameworks and Metrics for Resilient Networks and Services: Technical Report*. <https://www.enisa.europa.eu/publications/metrics-tech-report>.

TABLE 5.1 Indicative climate KPIs measuring the **climate resilience of the project**

Project Phase	Example Indicators
DESIGN/ CONSTRUCTION	<p>Climate-related design documents:</p> <ul style="list-style-type: none"> • Existence of climate and/or disaster risk assessments • Existence of climate adaptation/resilience studies and plans • Existence of an emergency response plan addressing climate events • Amount of excess climate risks, i.e., the portion of climate risk that exceeds the respective provisions which the design of adaptation/resilience plans would have adhered to and efficiently addressed (<i>local currency</i>) • Percentage of excess climate risks that are covered by available insurance mechanisms (%)
	<p>Adaptation/resilience implementation metrics:</p> <ul style="list-style-type: none"> • Ratio of construction works (related to adaptation/resilience measures) completed/planned (%) including auxiliary infrastructure (e.g., infrastructure to access/maintain/monitor the main ICT infrastructure) • Existence of early warning systems • Existence of redundancies
OPERATIONS/ MAINTENANCE	<p>Impact metrics for climate-related disruptions:</p> <ul style="list-style-type: none"> • Number of climate-related incidents causing disruptions or requiring significant capital mobilization (<i>number/year</i>) • Number of users/customers affected by the network service disruption (<i>number of users/year or number of users/event</i>) • Number of critical facilities (e.g., hospitals, schools, power plants) impacted by the network service disruption (<i>number/year or number/event</i>) • Number of network elements affected by the network service disruption (<i>number/year or number/event</i>) • Geographical area impacted by the network service disruption (<i>square meters / event</i>) • Financial impact of the climate-related disruption, i.e., financial liabilities such as number of contractual fines (<i>cost/revenues</i>)
	<p>Duration metrics for climate-related disruptions:</p> <ul style="list-style-type: none"> • Total downtime, i.e., time during which the ICT facility (or a specific element/unit) is out of service (<i>time unit, e.g., hours</i>) • Time to repair physical damages (<i>time unit</i>) • Time to receive spare parts for damaged equipment (<i>time unit</i>) • Time to restore operations and service continuity, i.e., the time required to restore a network or service to a specific level of functionality (<i>time unit as a function of % restoration, e.g., 3 hours for 75% restoration; 1 day for 100% restoration</i>)

Project Phase	Example Indicators
	<p>Disruption tolerance:⁸⁹ e.g., the number of ICT systems in a network that are protected against power outages (for example: by having a battery backup) versus the total number of ICT systems in that network</p>
	<p>Monitoring system: installation/operation of a robust/reliable monitoring system that includes weather forecasting modules. Example KPIs for the monitoring system:</p> <ul style="list-style-type: none"> • Number of installed sensors (e.g., for identifying hotspots overcooling, and extreme humidity levels in data centers) and accuracy of sensors • Data availability index (time that the monitoring system delivers data) • Data quality index (existence of quality control system)

TABLE 5.2 Indicative climate KPIs measuring **sustainability, environmental and social goals**

Goal	Example Indicators
SUSTAINABLE/ ENVIRONMENTAL	<p>Carbon footprint metrics:</p> <ul style="list-style-type: none"> • Existence of a life-cycle analysis demonstrating the project's GHG emissions (projected CO_2e) and numerical targets for GHG emissions ($CO_2e/year$) • Emission intensities related to operations and maintenance activities (measured CO_2e) • Primary and secondary suppliers of construction machinery/equipment that have sustainability or green sourcing/procurement/management certification (% or <i>number</i>)
	<p>Energy efficiency:</p> <ul style="list-style-type: none"> • Total energy consumption (<i>MWh</i> or <i>MWh per 1 gigabyte (GB) of data</i>) • Network energy consumption (<i>megawatt-hour (MWh)</i> or <i>MWh per 1 GB of data</i>) • Network energy mix (<i>% renewables</i>) • On-site power generation (<i>%</i> or <i>kWh</i>)
	<p>Waste management:</p> <ul style="list-style-type: none"> • Network equipment repaired or reused (<i>% by units</i>) • Waste generated, total and network, (<i>tonnes per 1 GB of data</i>) • Waste recycled, total and network (<i>% by units</i>)
	<p>Specific to wireless networks:</p> <ul style="list-style-type: none"> • Mobile network energy consumption (<i>MWh per mobile connection, per mobile traffic, per cell site</i>) • Network level efficiency based on coverage (for rural cases)

⁸⁹ The ability of an ICT system to tolerate disruptions in connectivity among its components. Disruption tolerance is a superset of tolerance of the environmental challenges: weak and episodic channel connectivity, mobility, delay tolerance, as well as tolerance of power and energy constraints.

Goal	Example Indicators
	<ul style="list-style-type: none"> • Network level performance indicator based on data traffic (for urban cases) <p>Specific to towers:</p> <ul style="list-style-type: none"> • Tenancy ratio (<i>average number of tenants or operators sharing tower infrastructure</i>) • Energy mix (<i>% renewables</i>) <p>Specific to data centers:</p> <ul style="list-style-type: none"> • PUE (power usage effectiveness; total energy usage of the data center, divided by the IT energy consumption) • Water usage effectiveness (WUE) (annual water usage divided by IT equipment energy, and expressed in liters/kilowatt-hour) <p>Broader environmental metrics:</p> <ul style="list-style-type: none"> • Existence of environmental impact assessment • Part of the revenues (<i>% or local currency</i>) that can be used for environmental services
SOCIAL	<p>Existence of a sustainable procurement policy covering the following elements: organizational governance, human rights, labor practices, environment, fair operating practices, consumer issues, community involvement and development</p> <p>Percentage of suppliers screened against the sustainable procurement policy (%)</p> <hr/> <p>Network coverage: percentage of the population covered by telecom network after a climate-related event (%)</p> <hr/> <ul style="list-style-type: none"> • Job opportunities <ul style="list-style-type: none"> • Number of new jobs created by the project (<i>number</i>) • Number of new jobs covered by locals and/or women, including positions related to climate change issues and adaptation/mitigation measures (%) • Ratio of women's and men's salaries for the same position

OUTPUT

Project-specific climate KPIs for consideration in the project documentation/contract

Summary and Conclusions

CLIMATE ENTRY POINTS IN THE EARLY STAGES OF AN ICT PROJECT'S PREPARATION

After completion of all the steps in this toolkit, users are expected to have shaped a clear view of how to incorporate climate considerations into the early stages of an ICT PPP project's preparation, using a set of practical tools that allow:

- **Identification and mapping of the national and international climate-related frameworks** and commitments relevant to the project under consideration. To this end, the tool navigates users through the main documents defining such policies while guiding them as to the specific focus areas that are important for ICT PPP projects.
- **Screening of the alignment of the ICT PPP project with the Paris Agreement** and the regulations stemming from it. Screening is performed by means of four sets of questionnaires—each one referring to one pillar of the relevant considerations—through which users are able to identify areas where improvements may be necessary, recalling that all World Bank Group-supported projects must be fully aligned with the Paris Agreement by 2025.
- **Estimation of the carbon footprint of the project**, by performing a preliminary assessment of the GHG emissions associated with the construction and operation of the ICT project. The relevant tools provide guidance on how to provide a preliminary life-cycle assessment (LCA) of such emissions and are supported by a list of international resources for assessing emissions associated with the various project components (e.g., IT equipment) and stages (e.g., construction and operation).
- **Identification of applicable mitigation measures** that can be applied to reduce the emissions of various project components. To this end, the toolkit analyzes opportunities for GHG reduction and energy savings in several stages of ICT projects, including construction/manufacturing; operation and maintenance/use; and end-of-life.
- **Appraisal of the climate-related risks that the specific project is exposed to**, which are defined as the potential losses that could be either internal to the project (in the form of physical damage and loss of revenues due to a climate event immediately impacting the operability of the infrastructure) or external (in the form of economic losses due to an acute event or chronic hazard impacting the operation of the ICT infrastructure, which may remain physically intact). To this end, a set of readily available online resources are provided that allow users to understand which hazards may affect the project, given its location and components. Based on such data, the potential effects of each hazard on specific project assets may be assessed. Hence, users will be able to form a preliminary opinion as to the vulnerability of the project as a whole, its appropriateness for the project/region, and the associated needs for risk reduction measures.
- **Preliminary exploration of climate adaptation and resilience strategies** aimed at reducing the risks identified previously and enhancing the project's bankability. Users are guided through the relevant tools enabling identification of adaptation measures for their ICT project, while at the same time providing a high-level indication as to the costs and benefits of each alternative option through a multi-criteria decision-making framework, so that users are able to design different resilience strategies—each with distinct costs and benefits.

- **Preliminary identification of climate entry points in the cost-benefit analysis of the project**, using a step-by-step approach that supports users in understanding how climate risks, as well as adaptation and resilience plans, may be reflected in the project economics, by presenting the tradeoffs between climate-related risks and investments.
- **Preliminary appraisal of the project's VfM and suitability as a PPP**, using a set of tabulated instructions explaining the effects of the various potential climate actions previously identified on parameters such as project bankability, investor appetite, and project risk profile. It is also shown how failure to act—or invest—may result in a negative impact on the project in cases where investor risks remain unmitigated, or if insufficient measures hamper the eligibility of the project to receive funding from multiple sources.
- **Preliminary identification of climate (mitigation- or adaptation-related) KPIs** that could be used to trigger climate-related clauses of the payment mechanism in PPP contracts. It is shown that climate considerations are meant to be present in all phases of the PPP project—from project selection, design, and construction through project implementation. To this end, a non-exhaustive set of essential climate-related KPIs is presented as part of the relevant tools that describe ICT-specific actions and quantifiers to allow them to be monitored.

The present ICT-specific toolkit, when used in conjunction with the WBG's [Umbrella Toolkit](#), is meant to support PPP agencies operating in EMDE countries in incorporating climate risks and opportunities in ICT PPP projects, by providing detailed guidance applicable to the early stages of such projects' preparation. Given the importance and complexity of incorporating climate change in PPP projects, all appraisals performed during the preliminary stages with the help of this toolkit will need to be reassessed in detail with the help of expert consultants on the basis of project-specific data that will become available in subsequent stages of the project.



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