Country Climate and Development Report

Tools and Approaches

This Version: February 2022

This document – including the proposed outline – is provided for initial guidance. The outline can be customized for the country context and is not intended to define a rigid framework, but rather to allow the initial batch of CCDRs to generate some experiences on what resonates, what works, and what is tractable analytically. It is expected that the analyses listed in the outline might not be available in all countries, at least for the first generation of CCDRs, and the list of tools and approaches will be updated over time. As such, the outline and list of approaches should be considered as a menu of options, from which dedicated country teams will select the most important and relevant, based on their knowledge of the country development path and objectives.

The Tools & Approaches Note is intended to be a live document that will be revised periodically to incorporate additional inputs and tools, as information becomes available from teams.

February 2021 update includes:

- Annex 2 Global and National scenarios, and modeling tools - This annex no longer exists in this document - the stand-alone version named "Global scenarios for CCDR analyses" is available at the CCDR website
- Annex 3 Off-the-shelf data and resources – CCDR databank (CCDB) and Climate Change Knowledge Portal (CCKP)
- Annex 4.8 Water

Contents

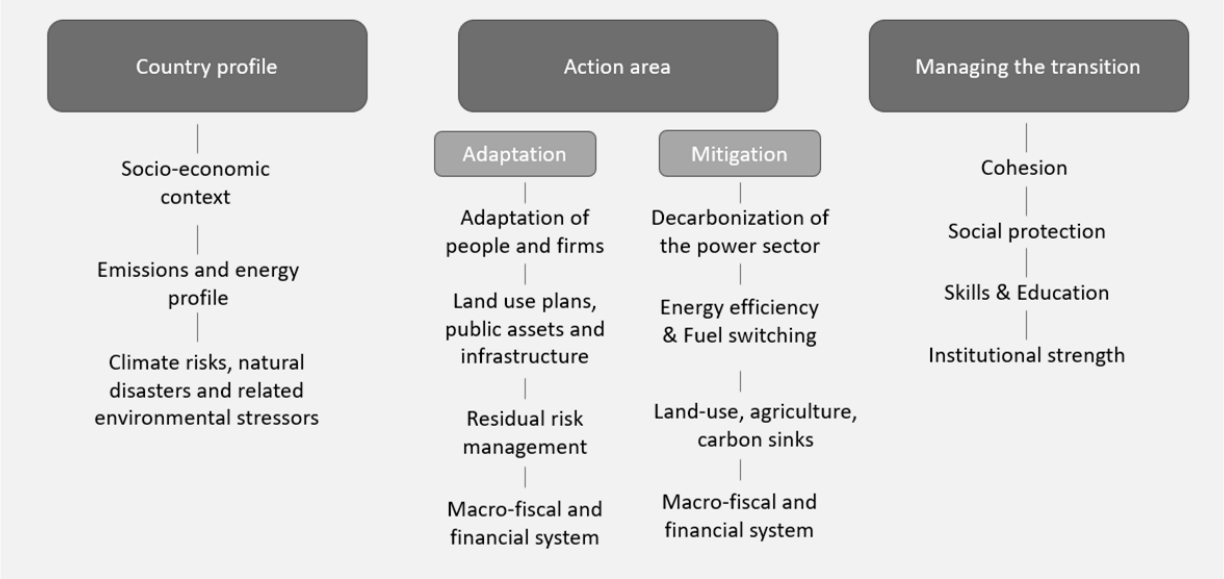
1. Climate-Related Risks and Opportunities for Development

This section reviews the current situation of the country and its development priorities, to ensure that climate change and policies are analyzed through the lens of the country's own objectives. To do so, this section covers the current development plans and objectives (Section 1.1), reviews the risks and opportunities from climate change and natural hazards (physical risks, Section 1.2), and the opportunities to reduce emissions, as well as risks from domestic and international decarbonization policies.

This section will rely heavily on widely available databases, benchmarking on the country context, as well as the large set of sectoral assessments produced by the World Bank and other domestic and international actors. The CCDR databank (or CCDB, see Figure 1) will provide a first set of relevant data, for all countries.

Where relevant, the team may select a few priority sectors or issues that appear particularly important from the perspective of the country's economic and development plan, but may have been overlooked or underexamined in the past (e.g., the impact of temperature on coffee production may be critical for a country and may not have been analyzed in the past).

Figure 1: The CCDR databank structure.



Context and development priorities and objectives

The goal of Section 1.1 is to anchor the Country Climate and Development Reports (CCDR) in the country's own objectives and development priorities.

- Current situation and growth path:
    - What is the basic structure of the economy? Is the country geographically heterogenous and does it require sub-national assessment for the climate change diagnostic and associated actions? What are the key tiers of subnational government? What is the level of urbanization?
    - Poverty and shared prosperity, rural/urban divide, demographics, regional inequalities (e.g., age distribution, gender, refugees, other vulnerable populations)
    - What is the country's performance across Sustainable Development Goals (SDG) indicators? What is the level of access/scarcity for basic resources (food, water, electricity, etc.)?
    - Adjusted net saving (ANS) including as a percentage of Gross National Income (GNI), and costs of environmental degradation (e.g., human and economic losses from local air pollution)

- Main development priorities and goals:
    - Review of national development plan
    - Review of previous diagnostics (such as Systematic Country Diagnostic – SCD, Country Private Sector Diagnostic – CPSD)
    - Existing growth analysis (e.g., from previous Country Economic Memorandum – CEM)
    - Country plans for infrastructure or sector-specific development (national, provincial, city, municipal)

Risks and opportunities from climate change and natural hazards[1] (physical risks)

Based on existing or new analytics, Section 1.2 summarizes the physical risks and opportunities from changes in climate conditions (e.g., reduction in crop yields or new diseases), **as well as risks from natural hazards** (e.g., hurricanes in small tropical islands).[2] This section will focus on sector vulnerabilities and include a discussion of adaptation interventions and their costs, and can draw on data on past disasters and known climate risks. Teams are encouraged to use the global climate scenarios described in Box 1.

Box 1. Global climate scenarios for physical risks

The nature and magnitude of physical risks depend on how climate conditions will change in the future, which is affected by policy and scientific uncertainties. It is recommended that teams use an optimistic and a pessimistic scenario with a consolidated set of assumptions related to global emission reduction ambition, the sensitivity of the climate systems, and various assumptions related to the magnitude of climate impacts (e.g., impact on crop yields). Rather than describing a single prediction of the future, which could lead to maladaptation, these scenarios are expected to provide boundary conditions for low and high threat levels and allow for further examination of the vulnerability of the country's development pathway. Country teams may choose to complement this analysis with country-specific issues (e.g., how coffee production increases its temperature range).

Optimistic case	Pessimistic case
• High global ambition in decarbonization • Low climate sensitivity. • Global temperature below 2C in 2100 (e.g., RCP2.6) • Sea level rise in 2100 is 30 cm. • CO2 fertilization translates into limited crop yield losses (and benefits in some regions). • Good resilience of major ecosystems (e.g., Amazon).	• Low global ambition in decarbonization • High climate sensitivity. • Global temperature close to 4 degree by 2100 • Sea level rise exceeds 100 cm in 2100. • Net increase in intensity of major storms. • CO2 fertilization is limited by other factors and crop yield losses are in the higher range. • If relevant, tipping points in major ecosystems (e.g., Amazon).

For more details, see Annex 2.1.

[1] In most instances, it may be simpler to explore all relevant natural risks, independent of whether their frequency or intensity is impacted by climate change. Even geophysical risks can be included in the analysis, to ensure that recommendations are efficient and applicable (e.g., construction norms need to consider both climate conditions and earthquake risks; assessment of contingent liabilities in budgetary processes are simpler if all hazards are included in the analysis).

[2] Modeling approaches for analyzing sudden shocks and extreme events are often different from those for estimating the impacts of long-term changes in average conditions.

Since all sectors and all regions are potentially exposed and vulnerable to climate change, the team cannot be expected to cover all issues in detail. Instead, the main vulnerabilities may be identified based on simple indicators (e.g., from the global databases listed in Annex 3, or the CCDR databank) and the country team's knowledge about the country context and priorities. Section 1.2 can provide a broad overview followed by deep dives into the main vulnerabilities of the country.

- What are the main risks from disasters and climate change in the country? What regions, cities, or sectors are most exposed? What are the poverty, distributional, employment, and exclusion impacts of existing climate risks on households and communities?
- What are the expected opportunities from climate change impacts or co-benefits from adaptation responses? Sector-specific risks – based on existing analytics – which could include, for example:
    - Food security, agriculture, food systems (including risks and opportunities related to shifts in agro-ecological zones, and import-related risks for food importers)
    - Current cost of infrastructure disruptions and climate exposure of infrastructure systems:
        - Water scarcity, water supply and sanitation
        - Risks to the energy and power sector (extreme weather events, changes in demand, water scarcity)
        - Transport and digital infrastructure
    - Forestry, wilderness areas, biodiversity
    - Environmental degradation, water pollution, air pollution
    - Emerging health risks
    - Risks to sectors that are major exporters, employers, or VA creators
    - What are the likely hotspots in terms of social and distributional impacts of physical risks?

Teams can start from the global scenarios discussed in Annex 2, the CCDR databank, and the available datasets listed in Annex 3, including various country profiles (from the Climate Change Knowledge Portal or CCKP, Global Facility for Disaster Reduction and Recovery or GFDRR, and the country climate profile dashboard under development). Opportunities arising from climate change can be assessed through tools such as Unbreakable (Annex 7.2), for benefits in terms of poverty reduction and increased welfare and the Lifelines report, which examines benefits such as reliability of infrastructure services. Furthermore, specific tools to identify sectoral risks are listed in Annex 4, including:

- Annex 4.1: Identifying critical assets to prioritize resilience investments in infrastructure systems
- Annex 4.2: Agriculture risk assessments
- Annex 4.4. Health and climate change
- Annex 4.5. Hazards and risk assessments tools
- Annex 4.6. City-level risk assessments

Opportunities for decarbonization and risks from domestic and international decarbonization

Based on existing or new analytics, Section 1.3 identifies the main risks and opportunities that may result from decarbonization of the global economy, either from domestic policies (e.g., a carbon intensive power system may be faced with stranded assets) or international policies (e.g., new trade rules may create barriers to accessing international markets). Like Section 1.2, this section will focus on sector vulnerabilities and include a discussion of interventions and their costs. Since these opportunities depend on the global context – What technologies are available? Is climate finance available? Are countries facing trade barriers for carbon-intensive exports? – the teams are encouraged to use the global scenarios discussed in Box 2.

Box 2. Global technology and policy scenarios for decarbonization analysis

Opportunities for decarbonization and transition risks do not only depend on domestic policies, but also on global evolutions, such as the improvement in zero-carbon technologies and the global trade and climate architecture. To explore these issues, therefore, teams are advised to assume **a global decarbonization process consistent with the Paris Agreement** (below 2 degrees), and to consider the main global uncertainties on how this decarbonization might take place: the **technological and lifestyle landscape** and the **global climate architecture**.

For the technological and lifestyle landscape, three main scenarios can be considered: (1) a "harder" landscape in which green technologies improve only slowly and global lifestyles remain very energy intensive (e.g., regarding diets); (2) an easier landscape, with specific progress around renewable energy sources and their integration (e.g., solar and wind, but also batteries and hydrogen) and more sustainable lifestyles; (3) another easier landscape, with specific progress around carbon capture and storage and direct air capture that allows a larger space for fossil fuels.

For the global architecture, the two contrasted scenarios include a collaborative one with larger ODA and climate finance flows, and a more adversarial one in which countries use trade policies to create an incentive for climate action.

As for physical risks, these scenarios are not predictions, but represent contrasted possible evolution of the world, in which countries' development pathways have to be designed. **Note that these scenarios are for the global evolution (e.g. for the global price of solar energy) and do not presume of the policies and evolutions in the CCDR country**.

Teams can select **two or three scenarios** among the 6 possible combinations, depending on the country context (e.g., fossil fuel exporters will need to explore the difference between the RE-focused and CCS-focus technology landscapes, since it affects global fossil fuel demand).

Table: Priority scenarios for decarbonization

Global Architecture/ Technologies	**Collaborative global architecture**	**Adversarial global architecture**
Harder technology and lifestyle landscape	Priority scenario	
RE-focused technology and lifestyle landscape		Priority scenario
CCS-focused technology and lifestyle landscape	Priority scenario	

For more details, including quantified estimates for technology costs and/or global demand, see Annex 2.2

The team is expected to provide a generic description of the challenges in the country, and then focus on what might be the main challenges (e.g., depending on the country, the challenge could be decarbonizing the power system, improving energy efficiency of buildings, reducing deforestation, etc.)

- What is the energy profile of the country and its carbon intensity? Tracking trends in decoupling between economic activity and carbon emissions:

    - Production-based CO2 productivity (GDP generated per unit of CO2 emitted)
    - Demand-based CO2 productivity (real national income per unit of CO2 emitted)
- What are the country's overall emissions (total, per GDP, and per capita) and main drivers of climate change in the country?[3] Which sectors contribute the most to GHG emissions? What is the share of land-use changes in emissions? Do sub-national or city-level emissions inventories or targets exist? What is the total primary energy (sources of supply, demand composition), domestic resources (renewable and non-renewable, and the share of fossil fuels in GDP and/or by sector), power and heat where relevant (share of total primary energy, current power generation mix, demand by sector, operating- and build-margin emissions)? What is the status of energy security and exports, heating supply, domestic industry and interests, substantial resource constraints, and energy pricing policy? What energy production and capacity expansion plans are in place?
- What are the decarbonization opportunities (and possible sectoral milestones)? It is possible to organize these opportunities using the decarbonization pillars that have been widely used, from the IPCC to World Bank reports (see Annex 1.1):
    - **Energy and power sector:** Decarbonization of the power sector
        - IEA diagnostic (and other standard databases)
        - If available, power sector modeling results
        - Non-power energy sector and upstream supply chain (including mining and extraction)
    - **End-use sectors:** Electrification, fuel shift, and efficiency in end-use sectors. Demand projections for the power sector
        - Transport (mobility, modal shares, fuels, performance standards)
        - Buildings (energy efficiency, construction standards, fuels)
        - Industries (cement, steel, chemicals)
        - Water (energy efficiency, energy source, and broader water management issues)
    - **Cities and Urban Infrastructure:**
        - Urban form (density, land use patterns)
        - Urban infrastructure (embodied carbon)
        - Waste management
    - **Food and land-use:** Agriculture, livestock, forestry, and carbon sinks
        - Agricultural production and emissions, including from livestock and aquaculture production
        - Forestry and natural sinks
        - Opportunities and threats from soil carbon
        - Tradeoffs in tackling food loss and waste along the value chain
        - Maximize GHG offsets from reservoirs (natural and manmade) and hydropower plants
- **What are the transition risks for the country?** What are the possible retrofit or early retirement risks for assets?[4]
    - How vulnerable is the country to domestic decarbonization?
        - What are the main long-lived emitting assets and their owners in the country? How will their effective economic lives be affected across fuel types (coal, oil, and gas)? How will the adoption of different future technologies affect these assets?
        - Which sectors, cities, or regions are the most vulnerable to decarbonization impacts?
        - What are likely to be the key poverty, social, employment, inclusion, and distributional impacts of decarbonization?
        - How vulnerable are water systems to decarbonization of the energy sector? How would the current fuels and energy needed for water extraction, treatment, and other processes on water system be affected? How might water demands change with decarbonization strategies, and is there adequate water availability to achieve these strategies?
    - How vulnerable is the country to international decarbonization? (Here, it is again recommended to use the global scenarios proposed in Box 2).
        - Trade related transition risks:

[3] In addition to available data for sector contributions to total GHG emissions in the country, teams may also consider long-term emissions under BAU conditions. However, teams would need to consider multiple scenarios to manage the uncertainty associated with projections.

[4] Physical and transition risks specific to the financial sector are expected to be covered in Section 3.2.

    - Highly carbon intensive and large exporting sectors?[5]
    - Comparison of carbon-content of exports vs. competitors
    - If available, CGE modeling to estimate risks to exports (see Annex 6.7)
- Co-benefits from decarbonization policies and interventions:
    - Air and water pollution, health, and labor productivity co-benefits
    - Reduced energy expenditures
    - Reduced energy imports
    - Reduced time lost in congestion
    - Reduced infrastructure costs (e.g., from denser cities)
    - Improved agricultural productivity
    - Additional income or reduced operating costs (e.g., from production of biogas and fertilizers from wastewater)

Like Section 1.2, teams can start from the scenarios discussed in Annex 2, as well as existing global databases and reports listed in Annex 3 and the CCDR databank. Furthermore, specific tools to identify transition risks and decarbonization opportunities are listed in Annex 4, including:
- Annex 4.2. Climate-smart agriculture tools and guidance
- Annex 4.3. Electricity planning model
- Annex 4.6 All city-level tools for decarbonization
- Annex 4.7. GHG assessments in the transport sector
- Annex 6.3 describes the CPAT1.0 tool, designed to assess the co-benefits of carbon pricing policies.

For the specific case of trade in case of Carbon Border Adjustment, various tools exist, including the ENVISAGE framework (Annex 6.7), or the EITE Country Comparison Tool (Annex 6.8).

2. Country climate commitments, policies, and capacities

Section 2 reviews the existing commitments of the country – either through international agreements (e.g., Nationally Determined Contribution or NDC; Long-Term Low GHG Emissions Strategies or LTS) or domestic legislation (e.g., net zero commitment – Section 2.1), the set of policies implemented to achieve these commitments, covering resilience and risk management (Section 2.2), and mitigation and decarbonization (Section 2.3). Above and beyond climate policies, Section 2.4 provides an assessment of the country's capacity to implement climate policies and manage economic transitions (regardless of whether they are driven by a change in climate or a change in policy).

Climate change commitments (resilience and decarbonization)

Section 2.1 reviews the country's commitments to the international community or to its populace.

- National-level commitments
    - What commitments did the country make in the past on resilience?
    - What commitments did the country make in the past on resilience decarbonization?
        - Note that commitments (especially in NDCs) can take many forms, including absolute commitment (in level of emissions) or relative commitment (% of reduction) that can be relative to an absolute level (e.g., 2005 level) or a baseline. The baseline is sometimes part of the NDC, which makes it possible to transform a relative commitment into an absolute one. When possible, the team is encouraged to report using the suggestions from Annex 2.3, with a peaking data and a target for net zero emissions (when relevant). Otherwise, absolute targets (e.g., in $MtCO_2$ in 2030) are preferred to relative targets.
    - What are the key national climate change-related plans, frameworks, and targets?

[5] Note: impacts from border carbon adjustments can be smaller than the direct effect of reduced demand for carbon-intensive products.

    - Are NDC commitments based on solid analytical processes, integrated in development planning and domestic policy, informed by public consultations, and backed by cost assessments?
    - Do NDC commitments clear assess tradeoffs and opportunities across sectors? Do NDCs identify synergies between mitigation and adaptation?
    - Are short- and medium-term commitments consistent with a path to net zero emissions?
    - Is there budgetary allocation and are there financing or resource mobilization targets?
- Private-sector commitments:
    - Has the private sector made commitments related to low carbon investments, carbon neutrality, or net zero goals?
- Subnational commitments:
    - Does the country have subnational commitments or plans, for example from states (in federal countries) or municipalities? For instance, see CDP database of subnational renewable energy commitments.
    - Are any cities signatories of the Covenant of Mayors? Have any cities prepared baseline emission inventories to track mitigation actions and a climate risks and vulnerability assessment. Have any cities prepared sustainable energy and climate action plans?

Existing policies for resilience and risk management

Section 2.2 focuses on the existing legal and institutional frameworks and on (sectoral or macro-fiscal-financial[6]) policies and regulations that aim to manage risks, boost resilience, and ensure the country's adaptation to a changing climate.

- Does the country have planning processes related to resilience and disaster risk management, with investment needs (and net costs) assessments and sectoral targets?
- Do cities have resilience or climate and disaster resilience or emergency plans? Do urban and land-use plans, as well as infrastructure and construction standards, have a mandate to take climate change and natural disasters into account? Do the country's environmental and social impact assessment regulations cover climate risk and climate resilience? How effective is the system overall?
- What are the technical and data capabilities of the country in terms of climate projections? Does the country have climatic databases/projections at the national or sub-national level? Does the country have data on past droughts and flood events and monitoring, forecasting, and early warning systems for climate risks?
- Does the country have the financing mechanisms in place for adaptation and resilience? Do people and firms have access to ex-post support after disasters and shocks, from insurance or social protection?
- Does the country have climate considerations included in monetary policy and financial system regulations (e.g., transparency requirements related to risk exposure, specific capital ratios, or financial stability monitoring and contingency management plans)?
- Other notable policies or actions
    - Private sector
    - Non-profit and civil society
    - Subnational actors, including province and municipalities

Teams can rely on the taxonomy in Annex 1 to identify these policies.

Existing policies for decarbonization

Section 2.3 focuses on the existing legal and institutional framework and on (sectoral or macro-fiscal-financial[7]) policies and regulations that aim to reduce carbon emissions and facilitate decarbonization of the economy.

[6] Considering the close interplay between sectoral and macro-fiscal policies (which often have sectoral coverage or exemptions, for instance), they are best described together in a single section.
[7] Considering the close interplay between sectoral and macro-fiscal policies (which often have sectoral coverage or exemptions, for instance), they are best described together in a single section.

- Does the country have the institutions and legal framework in place to implement its decarbonization policies? Does the country have planning processes for decarbonization, with investment needs (and net costs) assessments and sectoral targets?
- Does the country have a set of decarbonization policies in place, and can the impact of these policies be monitored? Do any regions or cities have decarbonization plans or green city action plans?
- Sectoral policies in energy, transport, building, industry, water, waste, agriculture and forestry sectors (and other relevant sectors). Does the country have sectoral medium-term milestones (e.g., share of renewable energy in 2030 or share of electric vehicles in 2040)? What are the sectoral policies implemented to achieve sectoral objectives (e.g., feed-in tariffs, vehicle feebate or performance standards, construction norms)?
- Does the tax system include environmental taxation? What is the total revenue and composition of energy, transport, pollution and resource taxation? Are there subsidies, tax expenditures and other incentives for brown activities? Are there taxes on durables (e.g. vehicle taxes, property taxes, taxes and tariffs on energy-intensive appliances)? Are there tax exemptions or tax breaks for appliances with energy efficiency improvements and to promote modal shifts? Are there subsidies, tax expenditures and support for R&D on low-carbon innovations? Are commodity taxes and subsidies as well as property taxes setting the right incentives for reducing deforestation and forest degradation?
- Other notable policies or actions
    - Private sector
    - Non-profit and civil society
    - Subnational actors, including province and municipalities

Teams can rely on the taxonomy in Annex 1 to identify these policies.

Institutions and financial markets for socio-economic transitions and impacts

Section 2.4 focuses on policies that may not explicitly be climate policies but play a key role in the successful implementation of climate policies and management of economic transitions. These include the ability to reallocate resources quickly and facilitate transitions (e.g., through a well-trained workforce and functioning capital market), but also the ability to collect data and manage engagement processes to identify and address unexpected difficulties and challenges.

- **Institutional strength and economic resilience**
    - Does the country have the institutional and regulatory foundations to manage an economy-wide transition?[8]
    - What is the resilience of the economy and its ability to reallocate resources and adapt to exogenous or domestic shocks?
    - Average level of education and ability to retrain/upskill/reskill workers?
    - Are there social and inclusion policies to address the impacts of climate change, build resilience, and benefit from opportunities for low carbon development?
- **Social protection/assistance.**
    - Does the country have the systems and instruments to identify, manage and correct for negative side-effects of policies, or other political economy concerns including mechanisms to compensate populations adversely affected?
    - Ability of the country to protect the poor and vulnerable against unintended effects of climate policies or climate impacts. Existence of any measures to support just transition planning in affected coal or carbon-intensive territories. Tool available:
        - Social Protection Stress Test tool (both under piloting), in some countries (Annex 5.2)
        - DRM-SP-Poverty modeling available, which can explore how existing social protection or poverty alleviation systems can help manage climate change or climate policy impacts (see Annex 7)

[8] This can include an examination of whether functional mandates for climate strategy, policy and implementation have been assigned among government entities and the existence of coordination mechanisms across ministries and with subnational governments.

- **Citizen engagement.** Does the country have mechanisms for citizen/public/stakeholder engagement on policy decision making and implementation? How often is information on climate emissions and risks made available publicly?
- **Land governance.** Does the country have a strong land governance system? What is the land tenure system and what fraction of the land-use is informal? How is the land use and land tenure data (e.g., cadaster)?
- **Public investment management.** What is the capacity of the public investment management system? Does the country have an inventory of public assets, including infrastructure assets, to monitor and plan maintenance and investments? Does the public financial management system account for climate risk? Does the procurement system consider environmental aspects? Tools available:
    - Climate Change Institutional Assessment (CCIA) (Annex 5.1)
- **Assessment of the financial sector**[9] (see Annex 6.5):
    - Standard diagnostics for capital markets
    - Standard diagnostics on financial inclusion
    - Infrastructure finance and Public Private Partnership (PPP) frameworks
    - Role of concessional finance
    - Green finance readiness (e.g., taxonomy, offset)

In addition to "off-the-shelf" tools and databases listed in Annex 3, specific tools and methodologies to assess institutional and financial capacity include:
- Annex 5.1. Climate Change Institutional Assessment (CCIA)
- Annex 5.2. Stress testing social protection
- Annex 5.3. Land Governance Assessment
- Annex 6.5. Financial sector risks and opportunities assessment
- Annex 7. Climate-Poverty modeling

3. Macroeconomic implications and policies for climate

The role of Section 3 is to integrate the opportunities and risks assessed through different tools and studies on various sectors to provide an integrated macroeconomic estimate of the opportunities and risks for three macro-level objectives: economic growth, poverty eradication and shared prosperity, and financial stability. This analysis will also reveal options available in terms of macro-level policies, such as fiscal reforms or regulations of the financial system.

When possible, this section should be written in collaboration with the IMF.

This section should benefit from and integrate the work at the sector level. For instance, this section will build on the information summarized in Section 1 on climate change risks at the sector level (e.g., estimate of the vulnerability of the agricultural sector to climate impacts) as well as on the risks and opportunities from decarbonization (e.g., estimate of investment needs to decarbonizing the power sector). It will also build on the policies and capacities assessed in Section 2. The value added of Section 3 is to integrate and consolidate insights from various sectoral studies and put them in the perspective of development macro objectives, such as economic growth, poverty reduction and inclusion, as well as financial stability and debt sustainability.

A thorough quantification of macroeconomic effects, taking into account all sectors and effects, is out of reach (even high-income countries do not have such estimates). Depending on the available data, models, and studies, teams may provide qualitative estimates (e.g., "In country X, long-term growth is threatened by the effect of water scarcity on major agricultural exports" or "financial stability is threatened by a potential drop in the value of fossil fuel reserves") or partial quantification (e.g. "In country X, the effect of droughts alone may reduce GDP by x percent and increase poverty by y million people"). In most instances, large uncertainty will make it unsuitable to provide a

[9] Note that this is an assessment of the strength and efficiency of the financial system, not of its vulnerability to physical and transition risks, as these questions are treated in chapter 3.

forecast or a single best guess, and teams are encouraged to use scenarios and provide results in the form of ranges or even stress tests.

Opportunities and threats to economic growth, poverty and inequality

Section 3.1 will summarize knowledge on sectoral risks and opportunities to assess the threat to economic growth, poverty and inequality, with approaches ranging from a simple enumerative approach to a full economic model. This section will cover both risks from shocks and disasters (focusing on the next 10 years) and longer-term risk, from changes in average climate conditions and changes in the frequency and intensity of natural hazards. For longer-term risks, teams are encouraged to use scenarios to explore possible impacts, including migrations triggered by climate impacts (e.g., due to lower water availability or rising sea level).

Short-term GDP, jobs, poverty and inequality impacts from natural disasters and shocks

- Estimate of possible short-term GDP shocks linked to natural disasters and shocks (translating asset risk estimates, if available, into GDP impacts). [e.g., Work in Argentina or the Philippines]
- Estimate of potential poverty, employment, and inequality impacts as well as exclusion risks of natural disasters and shocks (translating asset risk estimates into poverty and distributional impacts). Two possible approaches:
    - Bottom-up analysis, if household surveys and model available [Model available in approximately 15 countries, see Annex 7]
    - Top-down analysis, based on GDP impacts [Elasticity approach possible for all countries]

Specific tools and methodologies to explore short-term macro and poverty impacts of disasters include:
- Annex 6.1. Macro Fiscal Model (MFMod) Framework
- Annex 6.4. Climate and Disaster Risk Finance Diagnostics
- Annex 7.2. Poverty impacts of natural disasters (Unbreakable)
- Annex 7.3. Poverty and distributional models and tools (microsimulations with Global Income Distribution Dynamics or GIDD, vulnerability tools, and fiscal microsimulation tools)
- Additional tools and databases available “off-the-shelf” are listed in Annex 3

Potential impacts on GDP, jobs, poverty and inequality from climate change and decarbonization policies

- Estimate of the “GDP at risk” or GDP impacts over the long-term (2030 or 2050), from decarbonization policies and/or climate change impacts, combining information on exposed sectors (Section 1) and existing policy commitments (Section 2)
- Estimate of possible GDP gains from climate change physical impacts (e.g., higher crop yields in some regions; lower heating costs) as well as co-benefits of climate resilience and decarbonization actions (from Section 1 and 2, as well as the macro effects from, for e.g., tax reforms with positive multipliers). Two possible approaches:
    - If available based on sectoral risk assessment, aggregation into an expected GDP impact (enumeration approach, recommended to go up to 2030)
    - If macroeconomic modeling and sectoral risk assessment are available, macroeconomic simulations with appropriate scenario-based analysis (combining uncertainty on baseline development trends and on climate change impacts)
- Estimates of potential poverty and distributional impacts:
    - Longer-term risks linked to climate change impacts and decarbonization policies with appropriate scenario-based analysis (combining uncertainty on baseline development trends and on climate change impacts), including potential distributional and inclusion effects on human capital
    - Potential impacts in terms of human migration, displacements, conflicts, and political instability
- If possible, impacts from non-domestic effects, such as imported effect through supply-chain effect (e.g., change in price of major inputs, and change in demand from major clients), plus changes in trade policies (e.g., carbon border adjustment) and foreign regulations and behaviors (e.g., restricted sales or lower demand for high-carbon-content goods and services, reduction in international air travelers)
- If possible, include behavioral responses, such as impact on investment choices (e.g., avoidance of high-risk regions and sectors by domestic or foreign investments) and migration choices (e.g., accelerate out-migrations from the most affected areas)

- Overall discussion on distributional impacts (including horizontal effects with most affected regions and sectors), and political economy implications

Specific tools and methodologies to explore macro-fiscal and poverty implications of climate change and climate policies are listed in Annex 6 (for macro-fiscal) and Annex 7 (for poverty), and include:
- Annex 6.1. Macro Fiscal Model (MFMod) Framework
- Annex 6.2. The MANAGE (CGE) modelling framework
- Annex 6.3. The Carbon Pricing Assessment Tool (CPAT1.0) (including distributional impacts)
- Annex 6.6. The Multiregional Input-Output (MRIO) framework to estimate job and output effects of climate policies
- Annex 6.7. ENVISAGE-GIDD global model (especially for representing trade effects)
- Annex 7.1. Poverty impacts of climate change (Shock Waves)
- Annex 7.3. Poverty and distributional models and tools (microsimulations with GIDD, vulnerability tools, and fiscal microsimulation tools)
- Annex 7.4. Groundswell report series assesses slow-onset impacts into a model of future population distribution
- Additional tools and databases available "off-the-shelf" are listed in Annex 3

Potential impacts on the financial system

Section 3.2 will translate the sectoral and macroeconomic risk assessment into a financial risk assessment, considering both physical and transition risks, using multiple scenarios to cover uncertainty related to the pace and effectiveness of the transition and the magnitude of climate change impacts. Teams will be able to rely on work of the Network for Greening the Financial System – NGFS (and existing Financial Sector Assessment Programs – FSAPs with climate impacts). As is the case for macroeconomic impacts, it is likely that team will provide estimates for some risks without necessarily providing a comprehensive estimate.[10] Subject to availability of data, this section may also consider investment alternatives that would reduce climate risk.

- Estimates of risks for the financial system, using either bottom up analysis or top-down stress tests:
    - Physical risks (natural disasters and longer-term changes in climate conditions)
    - Transition risks (including stranded assets in energy and high-carbon-intensity sectors)
    - For both categories of risks:
        - Impacts on non-performing loans and the banking system (and/or micro-finance institutions)
        - Impacts on the assets and liabilities of insurers
        - Risk to other investors (pension systems, institutional investors)

Specific tools and methodologies for possible impacts on the financial system are discussed in Annex 6.5 (Financial sector risks and opportunities assessment). A few FSAPs looking at climate risks are expected to be available in the following months.

Longer-term fiscal considerations and macro-fiscal sustainability

Section 3.3 explores the impact of climate change, natural disasters, and climate policies on long-term fiscal considerations and macro-fiscal sustainability, combining expected spending needs and impacts. It covers short-term issues and the management of contingent liabilities (Disaster Risk Financing and Insurance or DRFI) and longer-term issues and debt sustainability.

Short-term fiscal considerations and contingent liabilities

- Explicit contingent liabilities:
    - Public assets and infrastructure exposure and vulnerability to natural hazards
- Implicit contingent liabilities:

[10] Assessments of the physical and transition risks for the financial system are still in their infancy, with emerging research taking place, especially in the Europe.

    - Required post-disaster support for affected households (including adaptive social protection and ad hoc ex-post response)
    - Required post-disaster support to firms (including support to farmers after droughts)
- Impact of disasters and short-term climate change on tax revenues:
    - Exposure of the tax base

Longer-term fiscal challenges from climate change impacts

- Explicit and implicit liabilities linked to long-term risks from changes in average climate and shift in the frequency of extreme events:
    - Change in the frequency of extreme events and corresponding contingent liabilities
    - Longer-term risks from changes in average climate, and impact of sectors that are the largest contributors to tax revenues
- What are the additional spending needs implied by climate change, and by resilience commitments and plans (Based on Section 2)?
    - Investments and spending needs from resilience plans, with realistic mobilization of private finance
    - Spending to facilitate transition in highly exposed sectors (e.g., coffee production, winter tourism)
    - Availability of adaptation finance to cities or capacity of cities to attract and implement adaptation finance
- What are the expected savings in public expenditures that can be expected from higher resilience (e.g., such as reduced operational, maintenance, and repair costs for public infrastructure assets, or benefits from more reliable infrastructure services)?

Fiscal challenges and opportunities from decarbonization

- Transition risks and implications for tax revenues, with possible tax revenue reduction from:
    - Fossil fuel exports
    - Carbon-intensive industries
    - Carbon-intensive commodity and agriculture products
- What are the additional spending needs implied by decarbonization commitments and plans? Compilation from resilience and decarbonization plans (based on Section 2).
    - Investments and spending needs from decarbonization commitments and plans, with realistic mobilization of private finance
    - Spending to facilitate transition in carbon-intensive industries and regions (just transition)
    - Availability of climate finance to cities or capacity of cities (including municipal finance capacity) to attract and implement climate finance
- What are the expected savings in public expenditures that can be expected from climate action, such as reduced health expenditures due to improved air quality, or lower energy expenditures for heating and air conditioning in public buildings, livability of urban areas [Co-benefits potentially estimated using the Carbon Pricing Assessment Tool or CPAT]
- What are the opportunities for climate action to increase tax revenues, facilitate tax collection, and contribute to fiscal consolidation (e.g., through subsidy reforms or carbon or environmental taxes)?
    - Environmental and carbon taxes [Use of CPAT, unless other tools available]
    - Subsidy reform (energy, agriculture, water, construction)
    - Broadening of tax base (and more robust tax sources)

Implications for long-term macro-fiscal situation

Assessment of the impact on the long-term macro-fiscal situation [Can be done by adjusting a baseline scenario, or through full simulation with MFMod or other tools, if available], combining:

- Current contingent liabilities and their evolution over time
- Additional expenditure from resilience and decarbonization action, with realistic mobilization of private finance:
    - Percentage of spending expected from public budgets (social spending, some infrastructure)
    - PPPs and blended finance opportunities
    - Private sector financing
    - Climate finance and concessional resources (national and sub-national)

- Impact of climate change and decarbonization on tax revenues

Specific tools and methodologies to explore macro-fiscal implications of climate change and climate policies are listed in Annex 6 and include:
- Annex 6.1. Macro Fiscal Model (MFMod) Framework
- Annex 6.2. The MANAGE (CGE) modelling framework
- Annex 6.3. The Carbon Pricing Assessment Tool (CPAT1.0)
- Annex 6.4. Climate and Disaster Risk Finance Diagnostics
- Additional tools and databases available "off-the-shelf" are listed in Annex 3

Consistency, Feasibility, and Gap analysis

Section 3.4 is a (qualitative or quantitative) assessment of the adequacy of policies, in the context of existing risks and opportunities (Section 1), commitments (Section 2.1), actual policies (Section 2.2 – 2.4), and the macroeconomic context (Section 3). It focuses on whether sectoral and macroeconomic policies and actions are coordinated and consistent, and whether they are consistent with the magnitude of existing and expected challenges to development objectives.

Consistency and coordination across sectors

- Are sectoral commitments and policies part of a consistent strategy? (e.g., do power sector policies consider decarbonization and electrification in energy-use sectors?)
- Are there inconsistencies or trade-offs across resilience and decarbonization objectives?
- Recommendations for cross-sector analysis and development of consistent approaches

Feasibility

When all commitments (e.g., NDCs), policies, and recommended interventions are considered together, the total investment or policy needs may appear inconsistent with financing and implementation capacity:

- Section 3.3, in particular, will inform the feasibility analysis and guide the prioritization of the most important interventions
- Green finance opportunities:
    - Estimating the green finance investment gap (including portfolio alignment analysis)
    - Identifying barriers to close the green finance gap

Gap identification

- Comparison of identified physical risks (Section 1.2) with adaptation commitments and policies (Section 2.2)
- Comparison of identified decarbonization opportunities and transition risks (Section 1.3) with national and international decarbonization commitments and policies (Section 2.3). Identification of the sectors/regions where transition risks are growing if current policies are maintained
- Identification of gaps in policies and recommendations, where additional analysis should be prioritized (but are beyond the scope of the CCDR)

Box 3. Options to describe domestic scenarios explored in the CCDR.

Mitigation policy packages can be designed to achieve certain short- and long-term objectives, expressed either in terms of economy-wide emissions (e.g., reducing emissions by 50% by 2030, compared with 2005 levels) or sectoral-level milestones (e.g., a share of renewable energy in electricity generation of 50% in 2030, average energy consumption of buildings below 50 kWh/m^2 in 2040).

To be comparable, however, these objectives can be usefully incorporated into a long-term decarbonization pathway (e.g., the long-term low-carbon development strategies from Article 4 of the Paris Agreement). Such strategies help design short-term policies and identify priorities for actions and ensure consistency between policies and commitments.

In a simplified setting, the long-term pathways can be represented by two numbers that are widely used in country commitments and strategies: the peaking year (i.e., the year when economywide emissions start to decline) and the year when zero net emission is achieved. In between the peaking and the net zero years, a linear decline is often assumed. Beyond the year of net zero emissions, some countries may engage in negative net emissions.

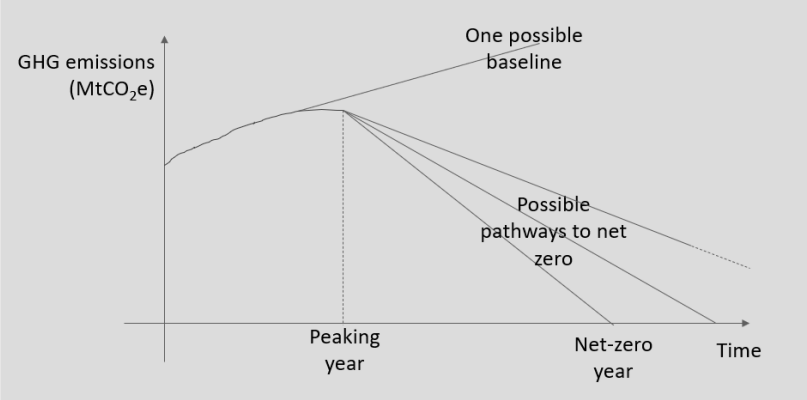


Table: Priority National Scenarios

Peaking Year	Linear decline of emissions
2030 2040	At least two scenarios, for each Peak Emissions year 2030, 2040 1. Net zero emissions by 2050 2. Net zero emissions by 2060 3. Any other target year for net zero in the context of national circumstances

More information and examples from countries are available in Annex 2.3.

4. Selected policies

The objective of this section is to identify climate-related interventions – either in terms of policies or investments (both public and private) – that should be prioritized over the next 5 years, based on their synergies with existing development goals and priorities, as well as their (economic and financial) costs and (economic and non-economic) benefits. Based on the consistency, feasibility, and gap analysis, the team can propose a set of policy packages of further actions and policies and assess their costs and benefits. Targeted climate change and development dialogues with key stakeholders (public sector, private sector, civil society) could be organized during the development of the CCDR to assess differential impacts and potential solutions.[11]

[11] A note on CCDR and stakeholder engagement is under development and will be made available through the CCDR website.

The policy packages are expected to put the country on a path toward green, resilience, and inclusive development, and teams are encouraged to link explicitly their proposed policy packages to possible paths toward resilient and low-carbon development. The decarbonization path can be described using the approach suggested in box 3. Objectives in terms of resilience and adaptation are notoriously difficult to quantify, and the best approach is left to the country team to determine (see the Annex 1 of the Adaptation Principles report for 111 indicators that can be used to set targets in terms of resilience and adaptation at the national level).

One important value added of the CCDR is to facilitate cross-sectoral discussion and the design of integrated policy packages covering multiple sectors. This section is organized in a few policy packages, which can be purely sectoral (e.g., decarbonizing power generation) or cross-sectoral (e.g., a combination of urban planning, urban infrastructure, and municipal finance; or combination of a tax reform, boost in social assistance, and infrastructure investments); cross cutting governance and institutional reforms affecting several sectors such as the adoption of green procurement or climate resilient investment standards; and climate-focused community, education, health, and social protection and jobs policies to ensure a people-centered approach. Since financing is often a critical challenge, it is particularly useful to have packages that balance spending and financing/funding.

To guide teams in the design of these packages, Annex 1 provides widely accepted framing for decarbonization and resilience:

- **For decarbonization**, there is consensus that feasible technological pathways rely on *parallel* actions across four pillars (i.e., decarbonization requires success in the four pillars):[12]
    - Decarbonization of the power sector (see Annex 4.3)
    - Energy efficiency in energy-use sectors (buildings, transportation, industry)
    - Fuel switching in energy-use sectors (buildings, transportation, industry)
    - Landscape management, food production, agriculture and forestry (see Annex 4.2)
- **For resilience and adaptation**, recent work has identified six pillars for action:
    - Ensure development is rapid, inclusive, and offers protection against shocks
    - Facilitate the adaptation of firms and people
    - Adapt land use and protect critical public assets and services
    - Help firms and people cope with and recover from disasters and shocks
    - Anticipate and manage macroeconomic and fiscal risks
    - Prioritize, implement, and monitor interventions

These changes can be implemented thanks to many different policies, which are also summarized in Annex 1 and include:

- Planning and information (both economywide and sectoral)
- Regulations and standards (both economywide and sectoral)
- Fiscal measures: taxes and revenues (including environmental taxes such as carbon taxes)
- Fiscal measures: expenditures and public investments
- Financing instruments, including green finance and financial sector regulations

In many cases, the precise definition of these recommendations will require further analysis and work, but the focus of this section is on the most promising interventions.

Teams can decide to provide individual economic assessments of each policy packages individually, or to consider all packages together. The assessment can be done over three different timelines: the immediate impacts of policy implementation (e.g., jobs created in the short-run, macroeconomic multipliers, poverty impacts); the medium-term effects for the achievement of the country's own development plan and growth potential (e.g., higher productivity, access to new markets); and the longer-term considerations regarding sustainability. Due to growing uncertainty

[12] The actions outlined in each of the pillars are not independent and need to be coordinated. For example, electrification of transport and buildings could affect the power sector; actions related to buildings may need to be better coordinated through low-carbon city planning, etc.

with a longer time horizon, these analyses tend to rely on different tools, and the long-term is often better approached as a set of stress tests with various scenarios.

The tools and data sources available for each time horizon are different. In particular, the very short-term estimates can disregard the structural changes that are essential for the longer time horizons. Technological and socioeconomic uncertainties can be disregarded in the assessment of immediate impacts, but they are essential to understand the long-term implications and design *robust* and *flexible* policies (which delivers benefit in spite of the uncertainty on some trends and technologies, and can be adapted to changing circumstances). The text below identifies a few tools and approaches for the three time horizons.

Immediate costs and benefits (including the post-COVID recovery context)

This subsection focuses on the immediate benefits that can be generated through climate policies (e.g., jobs created by an investment program in building energy efficiency or by a landscape restoration program), but it should also consider the associated costs and trade-offs. For the near future, the specific post-COVID context should play a key role in the analysis.

What resilience or decarbonization interventions through the energy, urban/transport and agriculture/ food transitions could generate immediate synergies with short-term needs in terms of, e.g., job creation, fiscal balance, trade, and other short-term objectives?

- Job content of direct investments, and adequacy of labor supply
- Contribution to macroeconomic growth and stability
- Impact on short-term poverty and inequality
- Contribution to fiscal consolidation and financing of emergency and urgent priorities
- Short-term growth benefits (multipliers from changes in tax structure or tax/spending changes)
- Support to vulnerable populations. Impacts on and opportunities for women, Indigenous Peoples, and persons with disabilities, who were particularly hard hit by the impacts of the pandemic
- Potential impacts on poverty and inequality

- The *sustainability checklist* provides a list of 32 different criteria, and has been applied to Fiji (for resilience) and Cyprus (for decarbonization)
- Various institutions are assessing the "greenness of recovery packages", including Vivid Economics, the Energy Policy Tracker, and the Global Recovery Observatory (UNEP/IMF)
- Annex 6 also includes tools that can be mobilized quickly to estimate job impacts, such as the MRIO framework. There are also employment multipliers available based on, e.g., the GTAP database.
- Additional tools and databases available "off-the-shelf" are listed in Annex 3

Synergies with medium-term growth potential (to 2030)

This subsection extends the analysis to 2030 and focuses on the synergies between the recommended climate actions and the country's medium-term development objectives (as identified in Section 1.1). Beyond the country's own objectives, this subsection also explores the potential benefits for poverty (including access to basic services such as electricity or health), shared prosperity, and economic growth.

- What are the resilience or decarbonization interventions through, for example, the energy, urban/transport, water and land/agriculture/food transitions, that could also increase medium-term growth potential? One option is to use the inclusive green growth framework:
    - Increasing physical, human, or natural capital:
        - Physical capital through reduced maintenance and repair costs
        - Human capital through better health and education
        - Natural capital based on nature-based solutions
    - Improving efficiency and productivity, such as:
        - Reduced congestion in cities
        - Cheaper infrastructure systems with denser development

        - Less distortive and contractionary tax system
        - Less distortive agricultural, water, or energy subsidies
    - Accelerating innovation or dissemination of the most productive technologies, creating new opportunities for exports
- What are the other synergies that can exist between climate actions and other political goals, such as regional balance, reduced inequality, resilience, or energy security?

Stress testing for long-term risks and opportunities (up to 2050 and beyond)

Since long-term risks cannot be ignored in the development of short-term policy packages, this subsection will focus on the long-term benefits and risks from the short-term package, stressing in particular how short-term action can mitigate long-term high-impact risks and threats to the country's development objectives.

- What are the long-term threats that require immediate action to be managed in a cost-efficient manner (e.g., risk of stranded assets in the energy sector or risk of collapse in important ecosystems)?
- What are the long-term opportunities that require short-term investments to be captured (e.g., export potential in some green technologies or other latent comparative advantage)?

Depending on the context, it is possible to use a combination of the global scenarios (see Box 1, 2 and Annex 2.1 and 2.2) and domestic scenarios (Annex 2.3). The NGFS scenario approach (see Annex 2.4) combines global and domestic scenarios to support stress tests of the financial system, but the same approach can be applied to various sectors, or macroeconomic systems.

Some countries may require an investigation of more specific scenarios focusing on identified vulnerabilities:

- Agricultural exports may require an examination of scenarios for ecological tipping points, such as large change in rainfall patterns that impacts water availability, as well as changed risk profiles, such as increased likelihood of floods or droughts
- Oil and gas exporters may want to consider different scenarios for oil and gas demand, depending on progress in renewable energy, electric transport, and the diffusion of carbon capture and sequestration
- Small islands may want to consider different scenarios for the magnitude and speed of sea level rise

Ideally, scenarios can be designed specifically based on the needs of the country and the vulnerability of its development pathway.

5. Conclusion and recommendations

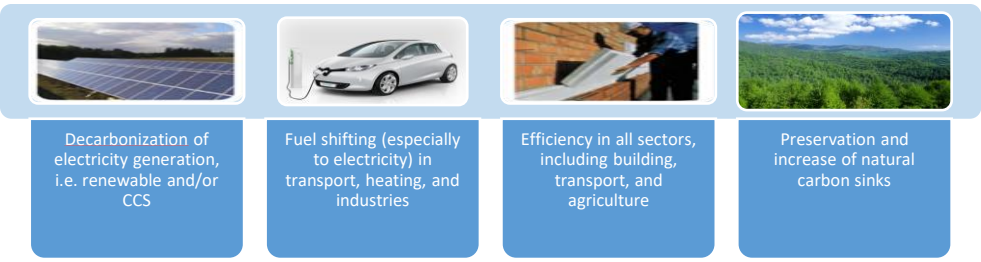
The CCDR will conclude with a summary of recommendations, appropriately prioritized within the macroeconomic framework discussed in Section 3 and with an assessment of consistency across sectors and consistency with climate commitments. In this section, it is particularly important to balance the consistency of the approach (i.e., that success requires many interventions in parallel) and prioritization (i.e., not everything can be done at once).

Annex 1. Typology of climate policies

Annex 1.1. Decarbonization strategies and policies

There is broad consensus on the technically feasible pathways to reach carbon neutrality, and they rely on four pillars. While there are different versions (e.g., from the Intergovernmental Panel on Climate Change, the Deep Decarbonization Pathway Project, the World Bank's Decarbonizing Development and 2050 Outlook reports), these pillars tend to include (see Figure 2). **One important dimension of the climate change mitigation problem is that countries can proceed at different rates across the four pillars, but stabilizing climate requires significant progress on all four.**

Figure 2: The Four Pillars of Decarbonization



Pillar 1: Decreasing carbon intensity of global electricity production to near zero around 2050. This objective implies that both high-income countries and emerging economies (such as China, India, and South Africa) would have to decarbonize electricity around mid-century. Low-income countries—which represent a small share of global electricity consumption—would have a few more decades, but they too would eventually need to converge to zero-emissions electricity. Carbon-neutral electricity can be produced from renewable sources (windmills, photovoltaic power, concentrated solar power, large dams and small hydropower, and biomass), nuclear power, and fossil-fuel resources with carbon capture and storage (CCS). In addition, bioenergy with CCS can produce electricity with negative emissions. Zero carbon electricity can be achieved using a subset of these technologies; for example, even if nuclear power is ruled out and CCS is unavailable.

Pillar 2: Switching from fossil fuel to low-carbon electricity in energy-intensive sectors, such as transportation, building, and industry. Technologies such as electric stoves and heat pumps, and electric furnaces are more energy efficient than fossil-fuel based alternatives and will reduce carbon emissions when powered by clean electricity.

Pillar 3: Boosting energy efficiency to reduce emissions, making electrification easier, and saving on energy bills. Boosting energy efficiency has high potential for the building, transport, and industry sectors. In agriculture and forestry, efficiency entails minimizing the food loss and food waste, increasing the supply of less emission-intensive products (including biofuels and wood materials), and changing food demand to shift consumption toward low-carbon food products and to free up land for other mitigation activities.

Pillar 4: Managing landscapes better to increase their ability to act as net carbon sinks. Mitigation policies can reduce emissions from land management and land use conversion and can increase the removal of carbon from the atmosphere. A detailed discussion can be found in the WRI report "Creating a sustainable food future".

Stabilizing the climate requires bringing *net* emissions of long-lived greenhouse gases to zero. This means that positive emissions from a sector or activity, can be offset by negative emissions elsewhere, through improved natural carbon sinks—for example, through reforestation or better soil management—or by combining bioenergy (renewable energy derived from biomass, such as wood, crops, or crop residues) with CCS.

To implement changes in these four pillars, many measures and policies can be implemented in parallel. The table below provides a typology of decarbonization policies.

Table 1: Typology of Decarbonization Policies

	Planning and Information	Regulation and Standards	Fiscal Measures
Economy wide	• Economic Planning: NDC, long-term decarbonization, green and blue growth strategies, plans and roadmaps • Just transition planning: managing social and distributional impacts • Land use planning: infrastructure networks and systems; green infrastructure management • GHG emissions monitoring and reporting • Consultation, communication, and stakeholder engagement	• Financial sector regulation for climate risk disclosures and reporting; risk assessment and stress-testing; ESG regulation and supervision; green taxonomies and green product regulation • SOE GHG emissions disclosures, reporting and targets • Emissions trading schemes: cap-and-trade; tradable emissions permits • Energy efficiency and emissions standards, certificates and product labelling	• Revenue: fuel excises and taxes; carbon taxes • Expenditure: elimination of fossil fuel subsidies; subsidies and tax expenditures for energy efficiency and GHG emissions reductions; green public procurement • Public Investment: climate-smart investment management practices; low/zero emissions research and technology development

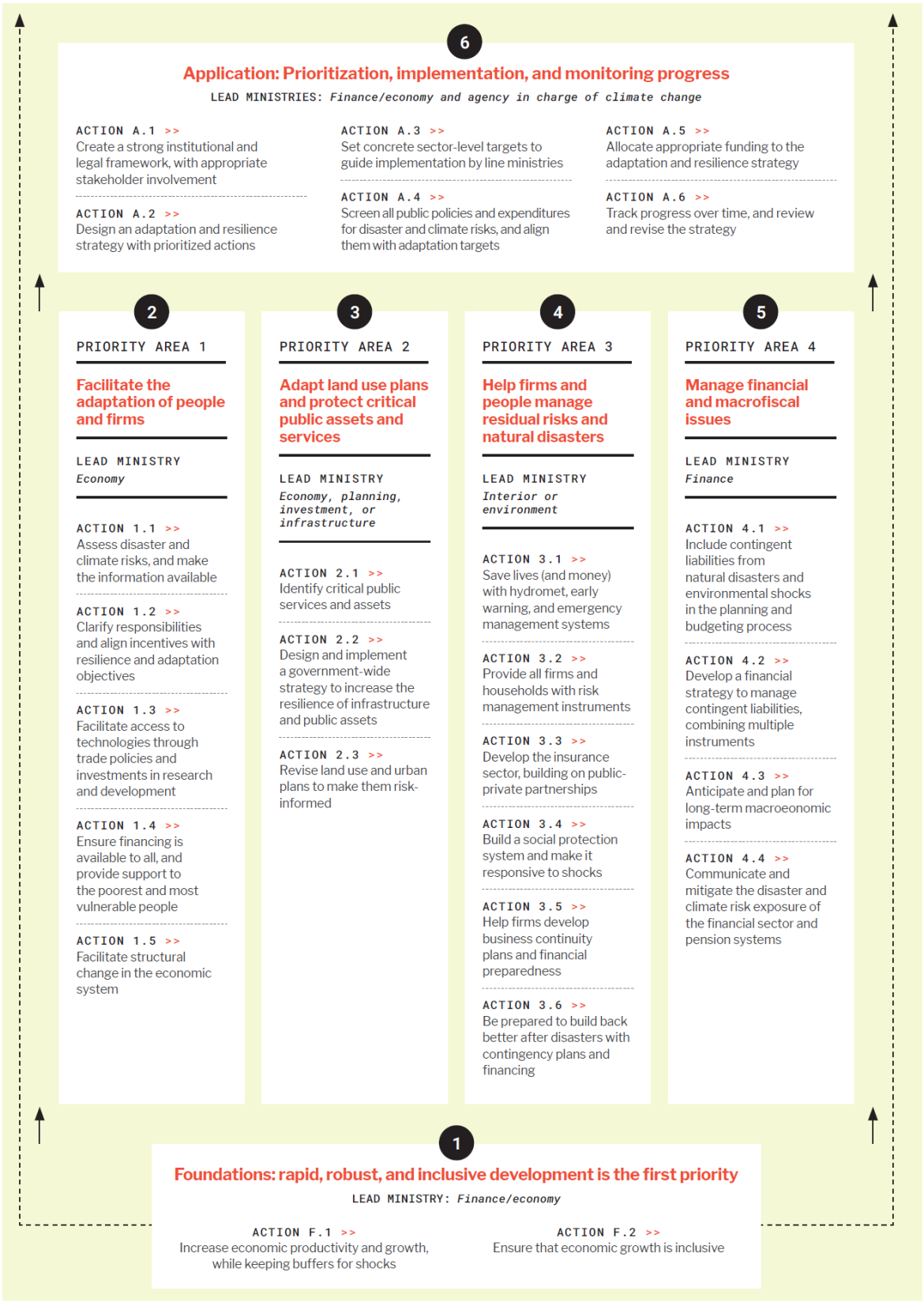
Energy	• Integrated energy and power system planning: cost optimal paths to scale-up zero-carbon power and fossil phase-out; sector coupling preparation • Improve system flexibility: expand power grid balancing zones, energy storage, digitalization and demand side management • Efficient RE integration: improved load and RE forecasting	• Renewable energy portfolio and energy efficiency standards • Emission standards (methane emissions, gas flaring, evaporative emissions, fuel economy) • Market regulation: competition policies; primary energy contracts; emissions certificates; time-of-use tariffs; demand-side management incentives; smart electricity pricing • Emissions trading: certificates and emissions permits • Disclosures: generation dispatch, primary energy contracts, emissions	• Revenue: pricing externalities (incl. carbon taxes), fuel excises and taxes, penalties for non-compliance • Expenditure: subsidies for renewables and energy efficiency • Public Investment: off-grid household and micro renewable energy; grid reinforcement and flexibility; renewables R&D; manufacturing incentives and guarantees for renewables, efficiency and storage
Transport	• Integrated and Multi-modal Transport and Green Logistics Planning: fossil fuel phase-out and electrification, reducing automobile use, promoting public and active transport; aviation and shipping decarbonization strategies; shift towards rail and inland waterways in freight • Active traffic management: ridesharing; eco-driving training; e-working campaigns	• Vehicle fuel economy and emissions standards, testing and enforcement (including for imported, second-hand vehicles) • Vehicle labelling and certificates • Biofuel blending standards • Vehicle scrapping and recycling regulations	• Revenue: vehicle and fuel taxes; parking and congestion charges, tolling • Expenditure: feebates and subsidies for electric vehicles; subsidies for public transport • Public Investment: integrated, intermodal, low carbon infrastructure; electric vehicle charging infrastructure; electrification of (high-speed) rail; low/zero emissions fuels and transport technology R&D
Urban and Buildings	• Urban Planning: densification, district heating, integrated urban and transport planning, building stock retrofitting and green infrastructure; wastewater treatment; waste management and recycling • Air quality monitoring, information, and warning	• Land-use regulations and zoning • Appliance energy efficiency standards, certification and labelling • Energy building standards and codes • Demand-side management • Waste management regulation (recycling, circular economy) • Payments for environmental services • Energy efficiency benchmarks for utilities (e.g. water supply/sanitation)	• Revenue: parking and congestion charges; land and property tax • Expenditure: subsidies and tax benefits for efficiency and property retrofitting; incentives for densification, greening urban services; payments for environmental services • Public Investment: urban infrastructure and green infrastructure
Industry	• Industrial Policy and Planning: decarbonizing industry; industry benchmarking • EnMS training and certification • Public education on recycling	• Energy efficiency, technology, and recycling standards • Product efficiency and emissions labelling • Leakage detection and repair regulation • Voluntary agreements for emissions reduction and efficiency • Tradable emissions permits	• Public Investment: guarantees and patent financing for R&D in hard to abate sectors, electrification, green innovation and recycling
Agriculture and Land Use	• Land use planning: integrated landscape management, sustainable agricultural and forestry, fertilizer use reduction, ecosystem and protected area management • Climate smart sustainable agriculture education, training, and awareness • Public education dietary choices • Crop and harvest loss reduction	• Land and forest use regulations, zoning, permitting and enforcement • Protected areas demarcation and enforcement • Regulation of agricultural inputs, practices and waste management • Pricing ecosystem services and tradable emissions reductions permits • Forestry and food product labelling	• Revenue: taxes on GHG emitting inputs • Expenditure: reduced subsidies for GHG emitting agricultural inputs: payments for ecosystem service. • Public Investment: climate smart agriculture and forestry R&D; restoration and protection natural resources
Human Development	• Climate education: school curriculum, public education campaigns, community programs • Training and Reskilling: retraining/reskilling, public engagement and education	• Environmental and public health regulations	• Expenditure: retraining programs; transition support for households.
Water	• Integrated planning of wastewater/sewage treatment plants with biogas generation facilities • Production of methane from sewage waste • Protecting the water table from human waste infiltration • Solar pumping • Centralized/energy-efficient water treatment and sanitation • Enhance water infrastructure capacity for mitigation	• Protected areas and demarcation for water-related ecosystems (Wetlands) • Energy efficiency standards for the water industry • Regulations promoting biogas capture at wastewater/sewage treatment plants • Co-benefits of water infrastructure (reduced flood risks downstream)	• Revenue: pricing externalities (penalties for groundwater depletion or degradation) • Expenditure: reduced subsidies for GHG emitting wastewater • Expenditure: Financial support for households to managed sanitation systems with high collection rates • Expenditure: Financial support for water-related renewable energy production • Expenditure: Financial support for energy audits for water supply and sanitation utilities

Annex 1.2. Adaptation and Resilience Strategies and Policies

The report Adaptation Principles offers a framework to design macro-level adaptation and resilience strategies, covering six key elements (see Figure 3):

- The foundations: ensure development is rapid and inclusive and offers protection against shocks
- Facilitate the adaptation of firms and people and support the private sector adaptation
- Adapt land use and urban planning, and protect critical public assets, infrastructure systems, and public services
- Help firms and people cope with and recover from disasters and shocks, with crisis management and disaster risk finance
- Anticipate and manage macroeconomic, financial, and fiscal risks, covering contingent liabilities from shocks and longer-term trends
- Prioritize, implement, and monitor interventions, with sectoral resilience milestones that can be integrated with line ministries' own objectives and mandates, and regular assessments and revisions of the adaptation and resilience strategy

Figure 3: Priority areas and concrete actions for climate change adaptation and resilience policy: an overview



To implement these changes, decision-makers have a large toolbox that is summarized in the table below.

Table 2: Tools for Decision-makers

	Planning and Information	Regulation and Standards	Fiscal Measures
Economy wide	• Risk and Vulnerability Assessment: disaster and long-term environmental change • Economic Planning: national, subnational adaptation and resilience planning • Disaster risk management: critical infrastructure planning • Land use planning: adaptation and resilience infrastructure, land use and natural assets • Early warning systems • Information and education on climate change vulnerabilities and risks across sectors • Consultation, communication and stakeholder engagement	• Financial sector regulation for: climate risk disclosures and reporting; risk assessment and stress-testing; ESG regulation and supervision; green taxonomies and green product regulation; disaster risk assessment and financial layering; insurance market regulation • SOE risk reporting and resilience planning • Land use regulation and zoning	• Revenue: post-disaster revenue relief measures • Expenditure: disaster risk fiscal management and financial layering; guarantees, subsidies and tax expenditures for resilience investments, post-disaster build-back better and natural asset management; payments for environmental services • Public Investment: climate-smart investment management practices; climate proofing public infrastructure, critical infrastructure and services; environmental resource management; adaptation and resilience R&D
Energy	• Planning: energy asset and system-level disaster and long-term environmental change risk assessment and resilience planning • Metering and communication networks for outage detection/addressal • Improve forecasting capabilities for extreme weather	• Utility and system risk reporting and stress testing standards • Service standards for resilience to and recovery after extreme weather events • Standards and enforcement of asset level fortification (underground cabling, fuel reserves, no-build zones)	• Expenditure: guarantees, subsidies and tax expenditures for climate-proofing energy systems; building-back better post-disaster • Public Investment: climate proofing energy infrastructure; backup power systems with distributed RE and storage for critical infrastructure
Transport	• Planning: transport system modal and integrated disaster and long-term environmental change risk assessment and network resilience planning	• Construction, maintenance and service standards for resilience and extreme weather events • Emergency response and evacuation plans for public transport systems • Utility and system risk reporting and stress testing standards	• Expenditure: guarantees, subsidies and tax expenditures for climate-proofing transport systems and building-back better post-disaster • Public Investment: climate proofing public transport infrastructure
Urban and Buildings	• Urban Planning: disaster and long-term environmental change risk assessment and resilience planning • Air quality monitoring, information, and warning	• Land-use regulations and administration: land tenure regularization, updating cadastral surveys with climate risk data, zoning, permitting and enforcement • Building codes and standards for heating, cooling, and resilience to extreme weather events • Property insurance regulation • Payments for environmental services	• Revenue: integration of protection costs in land and property tax • Expenditure: guarantees, subsidies and tax expenditures for climate-proofing private assets and relocation from vulnerable sites • Public Investment: climate proofing urban infrastructure; public housing in safety zones; urban and building adaptation and resilience R&D
Industry	• Industrial Policy and Planning: disaster and long-term environmental change risk assessment and resilience planning • Information on industry specific climate change risks, impacts and opportunities for industry	• Land-use regulations, industrial zoning and enforcement • Building codes and standards for resilience to extreme weather events and climate change	• Expenditure: guarantees, subsidies and tax expenditures for climate-proofing industrial assets and relocation from vulnerable sites • Public Investment: industrial parks; urban and building adaptation and resilience R&D.
Agriculture and Land Use	• Food security planning • Land use planning: sustainable agricultural and forestry, ecosystem and protected area management • Climate smart sustainable agriculture education, training, and awareness	• Land and forest use regulations, zoning, permitting and enforcement • Land tenure and property rights • Protected areas demarcation and enforcement • Crop and parametric insurance • Payments for environmental services • Forestry and food product labelling	• Expenditure: payments for ecosystem services; retraining programs; guarantees, subsidies and tax expenditures for climate-proofing agricultural and forestry assets; relocation at vulnerable sites • Public Investment: climate smart agriculture/forestry R&D; restoration and protection natural resources
Human Development	• Risk and Vulnerability Assessment: health, employment and distributional impacts • Climate education: school curriculum, public education campaigns, community programs • Training and Reskilling, public engagement and education	• Environmental and public health regulations	• Expenditure: retraining programs; transition support for households; post-disaster social protection. • Public Investment: climate proofing critical health and social infrastructure; health, education and social protection adaptation and resilience R&D
Water	• Resilient water infrastructure planning and engineering design; including	• Room for the river floodplain management and land zoning	• Revenue: integrate flood protection costs in land and property tax

	expandable and modular water infrastructure • Utilize a range of water sources and storage options, including multipurpose reservoirs and groundwater recharge • Efficient and timely drought and flood monitoring and early warning systems	• Protection of aquifer recharge areas • Standards for weather-based insurance • Hydrological standards for flood protection (return period)	• Public investment: water use efficient technologies; dynamic water allocation • Drought risk financing mechanisms (and broader disaster risk financing for hydro-climatic risks)

Annex 2. Global and National scenarios, and modeling tools

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The first part of this annex (2.1-2.5) no longer exists in this document - the stand-alone version named "Global scenarios for CCDR analyses" is available at the CCDR website.

Annex 2.5. The Climate policy modelling and diagnostics toolbox

There is a set of tools available to incorporate climate change into economic and development planning and policies and create specific scenarios (either global or country-level scenarios).

For decarbonization policies, the available tools include:

- To explore long-term deep decarbonization or to anticipate the effects of high carbon prices that lead to deep emission cuts, it is necessary to consider more detailed representation of technological options (and the uncertainty regarding their progress over time). **Environmental-Energy-Land-use Models** such as those participating in the Energy Modeling Forum, the ongoing NAVIGATE project, or the IPCC AR5 Scenario data can provide global, regional, or country-level scenarios.
- **Sectoral engineering models**, such as the power sector planning model or models of the transport system, can provide assessments of robust strategies, together with corresponding investment and maintenance needs; see the Beyond the Gap report for an application to the energy, water, and transport sectors.
- When land-use emissions are particularly important (or to explore the potential for large negative emissions), **Integrated Assessment Models** with an appropriate representation of land-use, agricultural production, and natural vegetation can provide detailed scenarios.
- **The CPAT1.0** provides an easy way of exploring, in almost any country, the costs, benefits and co-benefits of various carbon pricing options and to test possible policy options around fossil fuel subsidy reforms or carbon taxes. It allows the user to enter a pricing scenario (including phase in, price levels, and recycling options) and provides information such as expected emission reductions, tax revenues, GDP impacts, as well as co-benefits such as air pollution, health benefits, and reduced congestion and car accidents.
- **Recursive dynamic multi-sector CGE models** (such as MANAGE for single countries and ENVISAGE for multi-regional modelling) can be used for exploring structural changes in response to climate policies, and cross-country impacts of trade and climate policies. Some of them also include an explicit representation of technologies in some sectors (especially energy).
- **Macrostructural models** – such as the version of MFMod for Pakistan or Argentina (forthcoming) –provide a more in-depth exploration of the future economic and debt pathways (although it limits sectoral disaggregation). These models also allow for a more precise description of tax revenues, spending, and fiscal rules, and for combining physical risks and transition risks.
- Financial stability issues can be explored with **financial sector models** that allow stress testing the portfolios of banks or other investors for various macroeconomic scenarios. They are based on introducing the results of CGEs or Environment-Economy models into a firm-per-firm risk analysis, that can then be aggregated for a portfolio. Other models focus on risks for banks, based on their portfolio and the risks from non-performing loans.

An entire set of models and tools are also available to estimate the physical risks from climate change. Most impact models are sector-specific (e.g., agriculture) or hazard-specific (e.g., hurricane). They include:

- Since climate change impacts on agriculture are often very important at the country level, impact assessments often use **crop or agriculture-economy models** (and sometimes include economic models, to estimate risks to agricultural income). Results are available through AgMIP and ISIMIP platforms, and some partners like IIASA can produce specific scenarios. These models can also carry out assessments that combine decarbonization policies and climate change impacts.
- **Hazard models**, such as hydrological model and global flood maps (to look into flood risks), and specialized hurricane models are available. Some of these models focus on the hazards (i.e., the change in intensity or frequency of the physical event), while others include estimates for economic damages. In some countries, catastrophe models (which are used by the insurance industry) are available; e.g., the AIR model was used for the FSAP (Philippines) and the Fiji CVA.
- **Epidemiologic models** can be used to examine the evolution of diseases like malaria or water-borne diseases, as well as changes in non-communicable diseases.
- **Energy demand models** are often mobilized to assess future energy demand for heating or AC, as well as some of the measures to minimize it (from urban planning and revegetation to changes in building construction norms).
- Climate change and disaster impacts affect infrastructure and supply chains. There are dedicated global and country-level models used to assess the economic costs of **infrastructure disruptions** and **network and supply chain** effects.
- The effect of climate change on labor productivity (for people working outdoors, indoor without air conditioning, and also possibly indoor with air conditioning) is a major channel for climate change impacts. **Temperature-productivity relationships** (often calibrated on empirical data or from experiments) can be used for these estimates.

These sectoral impacts can be introduced into macroeconomic models, including:

- **CGE models** such as MANAGE for single countries and ENVISAGE for multi-regional modelling, as well as the OECD ENV-Linkage model.
- **Macrostructural models**, as explored with MFMod (focusing on hurricanes in Jamaica, and floods, agricultural impacts, and labor productivity in Pakistan) and in the Philippines (for the FSAP, in collaboration with the IMF, using a DSGE modified to account for typhoon risks).
- Financial stability issues could potentially be explored with **financial sector models**, but the methodologies are not operational yet (given that it is much more difficult for climate change impacts than for decarbonization policies). Bank vulnerability models (based on empirical analyses of non-performing loans) have been used to assess risks from natural disasters and climate change.
- Since climate change impacts are highly heterogeneous, impacts on aggregated metrics (like GDP) can be highly misleading. **Microsimulations-based models** have been used to look into distributional, equality, or poverty impacts. Models are available for future climate change impacts by 2030 with the *Shock Waves* report model able to generate baselines for 2030 and include climate impacts across 5 channels. More detailed models at the country-level are also available (from the *Unbreakable* report and work program) to assess the impact of natural disasters (with a more detailed representation of the reconstruction period, insurance, and social protection), with applications in over 15 countries (e.g., see applications for the Philippines, Sri Lanka, and Fiji).
- Macro-financial models to assess compound risk impacts (e.g., pandemic and extreme weather events occurring at the same time) are under development in DFRI and MTI Trade.

Many of the global models have country coverage and can offer first-order estimates off-the-shelf for early diagnostics (this is the goal of CPAT1.0 and the Unbreakable work program). Other tools require dedicated work at the country level, which could take from a couple of months to over 12 months.

No single model can answer to all needs for all climate diagnostics. Each country, depending on its situation and characteristics, will require the mobilization of a set of tools and models to provide a comprehensive diagnostic of the country-specific risks from and opportunities for climate action.

Further research is underway to add additional dimensions of climate-policy analysis:

- Macro-financial models that capture endogenous feedback effects between the financial and real economic sectors. Such modeling approaches may incorporate the role of finance as a driver or barrier of climate-policy implementation.
- Macroeconomic methodologies such as Agent-based, Macro-econometric or Stock-Flow Consistent models offer a complementary perspective on climate policy assessment. Those models are based on different assumptions than CGE models, which could lead to different results. For example, green investments will boost real GDP in the demand driven framework of the E3ME model. In a standard CGE model, however, an increase in green investment distorts the economy from its optimal trajectory, thus having detrimental real GDP effects. Complementary perspectives could improve the understanding of drivers and transmission channels, providing added value for climate-policy diagnostics.

Annex 3. Off-the-shelf data and resources

Annex 3.1. For a first look: CCDR databank

The CCDR databank provides data points that are currently available from a variety of sources that provide country-level climate and sectoral metrics. This data provides a starting point for teams to define a country's current climate status and conduct an initial review of existing sectoral work, benchmarking exercises already undertaken, results from existing rapid diagnostic tools, and initial macro-economic analyses. In addition, the databank provides a useful source for analyzing comparative results across countries using common metrics from common sources.

The CCDR databank brings together 84 databases to present 333 core data series, which align to approximately 168 climate and development indicators. The data has been curated into key themes (i.e., country profile, mitigation, adaptation, and managing the transition) to support teams as they prepare their CCDR.

Annex 3.2. Basic information on the development context

Note: "*" indicates a global data that is available for most client countries.

- World Bank World Development Indicators*: Provides around 1,400 globally comparable time series indicators that measure development and poverty
- World Bank Atlas of Social Protection Indicators of Resilience and Equity (ASPIRE)*: Provides indicators for social assistance, social insurance and labor market programs
- World Bank Open Data*: Provides basic economic indicators, such as GDP, population, and poverty headcount as well as CO2 emissions (also provides labor and labor tax data relevant to macro-fiscal analysis)
- ADB Key Indicators Database*: Provides macroeconomic and social indicators across Asia and the Pacific relating to national accounts, prices, government finance, trade, balance of payments, money and banking, external debt, population, labor force, and social indicators
- IMF World Economic Outlook Database*: Provides data on current accounts and government finance (e.g. net lending and gross debt) as well as analysis of key economic challenges facing the country
- Observatory of Economic Complexity*: Provides data and data visualization of country's international trade, including key imports, exports, and trading partners
- UN Commtrade Database*: Provides global trade data, customizable by goods, services, type of commodity, and time period
- UN Statistics (country profiles)*: Provides data on GDP by type of expenditure, value added by economic activity, and other general economic indicators. (See also UN International Data Exchange database on National Accounts Statistics)

- UN Sustainable Development Goal (SDG) Country Profiles*: Provides key statistics related to a country's performance according to the 17 SDG goals (Country profile reports available here)
- World Income Inequality Database (WIID)*: Provides income inequality statistics (GINI coefficient, mean and medium income)
- International Centre for Tax and Development Government Revenue Dataset*: Provides data on policy-relevant indicators for analysis of revenue and tax trends over time at the regional or country level
- IMF Macroeconomic and Financial Data*: Provides data in international financial statistics, balance of payments, and trade, as well as central government statistics on revenue, expenditures, net lending/borrowing and financing
- FAOSTAT*: Provides a range of country specific data sets related to food and agriculture including emissions from the agriculture sector and land-use, as well as food security and agri-environmental indicators
- OECD tax database: Provides data on subsidies, tax expenditures and other incentives related to the tax system, including environmental taxation as well as labor statistics
- OECD Global Revenue Statistics: Provides indicators on tax structure (share of a tax category in total tax revenue) including energy, transport, pollution and resource-related taxation
- World Bank Open Data on labor force participation rate

Annex 3.3. The Climate Change Knowledge Portal

The Climate Change Knowledge Portal (CCKP) is an online platform which provides the World Bank Group (WBG), its operational teams, and the broader global development community with a comprehensive and transparent suite of climate change tools and resources. The primary objective of CCKP is to enable users to define, understand, and communicate future climate change scenarios and how they contrast with the present-day climate. In addition to a basic overview of climate, the site also supports country and project-oriented risk-screening efforts. Different tiers of the site enable the production of both high-level snapshots of broad trends for basic user needs, as well as more flexible exploration of climate in support of in-depth investigations on changing climate hazards, impacts and risks. CCKP also provides interactive, sector and sub-sector-centered tools tailored for enhanced Climate – Disaster Risk Screening, support project planning, and to inform adaptation actions.

CCKP adheres to best practices and science-driven standards in processing raw global climate and model-based projection data into climate information products. CCKP core data offerings include

- **Global observed, historical data** (CRU) including the most current climatology (1991-2020)[13]
- **Global projection data** (CMIP5) provided for climatological time periods up to 2100 and distinct climate scenarios (projected emission pathways) for over 40 distinct climate indicators.[14]

CMIPs are the most robust global climate model compilations currently available and are the foundational data used for the IPCC Assessment Reports. (i.e. CMIP5 for IPCC AR5; CMIP6 for AR6)

The WBG has invested in CCKP to ensure a systematic and coherent approach for using the best available climate change data, and to provide teams with an appropriate, robust, trusted source of information that allows them to undertake climate change assessments. It is recommended that the data and analysis used in understanding and presenting physical climate risks, such as precipitation, temperature, and extreme events, is sourced from CCKP.

CCKP recognizes the importance of providing guidance and supporting users in undertaking appropriate, contextualized analysis for specific countries and/or regions (i.e. climate risk and projection information used for Mongolia will be quite different than indicators used for Indonesia. Similarly, risk to the water sector are different

[13] Historical data is derived from the Climatic Research Unit (CRU), University of East Anglia. Historical data is presented at a 0.5ºx0.5º (50km x50km) resolution

[14] CMIP5 and CMIP6 (Coupled Model-Intercomparison Project Phase 5 And Phase 6) is the currently available global climate and earth system model compilations. CMIPs are overseen by the World Climate Research Program. Global climate model data is presented at 1ºx1º (100km x100km)..

than risks to a health sector). New data offerings include monthly, seasonal and annual data; expanded projection data calculations providing mean and anomaly for the full suite of indicators (~50+); all aggregated at national and sub-national scales. Improvements to data presentation and visuals to more readily communicate key takeaway messages and support appropriate interpretation. Access to multi-model ensembles or individual models is now available for all indicators. A General Resources Library holds country-specific climate documents and policies. Data collections are updated to include newly released CMIP6 data; CMIP5 data continues to be available. All data available for download as csv or NetCDF (spatial data).

Current CCKP Enhancements

CCKP offers a highly dynamic climate services environment and continues to be actively involved with WBG sectoral experts, regional teams, and global practices to ensure scientific content and climate indices are tailored to best meet unique sectoral, regional and project needs. CCKP is undergoing significant data and presentation enhancements based on expressed team needs.

The following enhancements are expected to be available by *January 2022:*

- **Improved insight into variability, trends and uncertainties** to explicitly identify significance of projected change. Helps users to recognize robustness of projected changes vis-à-vis inherent variability and to gain a better understanding of the uncertainties in climate change projections.
- **Expanded context for extremes** is important for users to better capture the guidance on potential changes in disaster-related events and to contrast the related indicators from overall mean changes. Tools to help estimate IDF curves (intensity-duration-frequency) will be provided.

The following enhancements are expected by *October 2021:*

- **Update projection data to CMIP6** will be undertaken upon full data release (summer 2021) to reflect latest projections from global models based on scenario simulations organized around Shared Socio-economic Pathways (SSPs).
- **Improved sector analysis and expanded sector coverage** dynamic tools tailored to specific sector and sub-sector needs. Extremes' information will also be tailored to needs in economic analyses. *New sector additions*: Transport and Blue Economy are underway.
- **Increase spatial granularity on climate projections,** downscaling at 0.25ºx0.25º (current 1ºx1º). *(Expected~April2022).*
- **New Sea Level Inundation Tool** understand impacts from projected sea level rise along coastal areas *(Expected~March2022).*

CCKP Knowledge Products

CCKP currently produces Climate Risk Country Profiles which summarize physical climate risks and national climate documents (~35 pages). The CCKP profiles follow a standardized format and are intended to provide "high-level" climate related information that would be useful for WBG Teams as a resource when carrying out Climate and Disaster Risk screening. They synthesize the current and future climate characteristics, projections across different scenarios and timelines, climate-related natural hazards, sectoral climate change impacts, and adaptation options for a targeted country. CCKP has published over 70 Profiles, with several more in Technical Reviews and as advanced drafts. 24 country profiles have been developed in partnership with Asian Development Bank.

Table 3: CCKP Climate Risk Country Profiles

Region	Published
EAP	Cambodia, China, Cook Islands, Fiji, Indonesia, Kiribati, Lao PDR, Malaysia, Marshall Islands, Micronesia, Mongolia, Nauru, Palau, Papua New Guinea, Philippines, Samoa, Solomon Islands, Thailand, Tonga, Tuvalu, Vanuatu, Vietnam; Myanmar(on hold) + Pacific Island Region.

ECA	Albania, Armenia, Azerbaijan, Bosnia and Herzegovina, Bulgaria, Croatia, Georgia, Kazakhstan, Kyrgyz Republic, Tajikistan, Turkmenistan, Uzbekistan
LAC	Argentina, Brazil, Chile, Colombia, Costa Rica, Ecuador, Paraguay
MENA	Djibouti, Egypt, Morocco, Tunisia
SAR	Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, Sri Lanka
AFR	Botswana, Central African Republic, DRC, Ethiopia, eSwatini, Gabon, Ghana, Kenya, Lesotho, Liberia, Namibia, Nigeria, Rwanda, South Africa, Togo, Uganda, Zimbabwe

Annex 3.4. Other climate-related sources

Note: "*" indicates a global data that is available for most client countries.

Primary sources

- Centre for Research on the Epidemiology of Disasters EM-DAT International Disaster Database: Provides records of past disasters and their human and economic consequences (curated by the Centre for Research on the Epidemiology of Disasters at Belgium's Université Catholique de Louvain). [Similar datasets include the UN-DRR's DesInventar, reinsurer MunichRe's NatCatSERVICE, and reinsurer SwissRe's Sigma]
- International Energy Agency (IEA) Energy Data, Country Profiles and Atlas of Energy Country Profiles, Energy Subsidies Database*: Provides energy data by categories (e.g. supply, consumption, imports/exports, type), customizable indicators (including energy efficiency), as well as estimates of subsidies to fossil fuels and analysis
- International Renewable Energy Agency (IRENA) country profiles*: Provides statistics on SDG energy indicators, energy supply, renewable energy consumption, electricity capacity, relevant energy targets, policies and measures, as well as renewable energy potential [Downloadable data set available here]
- National meteorological agencies*: Often provide more localized climate information. To access via the World Meteorological Organization's member resource page, search by country

Secondary sources

- Climate Analytics: Provides country profiles on decarbonization as well as tools and analysis on climate policy and finance
- Climate Change Knowledge Portal*: Provides historical and future climate information on key indicators, vulnerabilities, and impacts, at the country and sub-national level (Country profiles are available here)
- Climate Transparency: Provides country profiles that highlight country climate action, opportunities for enhancing climate ambition, and comprehensive sectoral information, mainly for G20 countries
- Climate Smart Agriculture (CSA) country profiles*: Overview of the agricultural challenges in countries around the world, and how CSA can help them adapt to and mitigate climate change. Developed by the International Center for Tropical Agriculture (CIAT) and CCAFS, in partnership with the World Bank, Costa Rica's Centro Agronómico Tropical de Investigación y Enseñanza, and USAID's Bureau for Food Security
- FM Global Flood and Earthquake Risk Map: Highlights areas of high and moderate risk
- German Watch Global Climate Risk Index*: Analyzes to what extent countries and regions have been affected by impacts of weather-related loss events such as storms, floods, and heat waves (2000 to 2019)
- IEA Policy Reviews*: Provides a broad analysis of recent trends in energy policy with summaries of individual country reports done during the period
- InfoRM (Joint Research Centre, European Commission)*: Measures the risk of humanitarian crisis and disasters and how the conditions that lead to them affect sustainable development. It calculates risk as the combination of three equally weighted components: hazard and exposure, vulnerability, and lack of coping capacity
- Notre Dame Global Adaptation Initiative (ND-GAIN)*: Provides a summary of a country's vulnerability to climate change, readiness to improve resilience, as well as country rankings
- OECD Environmental Country Review: Provides assessments of countries' progress towards their environmental policy objectives and recommendations based on broad set of economic and environmental data
- Regulatory Indicators for Sustainable Energy (RISE) scores*: Provides a policy scorecard for assessing the investment climate for sustainable energy with a focus on energy access, energy efficiency and renewable energy

- ThinkHazard database*: Provides ratings of key hazards – such as extreme heat, water scarcity, flooding, earthquakes, landslides, tsunamis, cyclones, and wildfires – for countries and sub-national units (Country profiles are available here)
- WRI ClimateWatch*: Provides information on country emissions, risks and vulnerabilities, climate progress, linkages between climate objectives and SDGs, readiness to climate impacts, information on NDCs, and models of emission pathways
- WHO and UNFCCC Health and Climate Country Profiles: Provides snapshots of the climate hazards and expected health impacts of climate change facing countries that highlight opportunities for health co-benefits from climate mitigation actions, track current policy responses and summarize key priorities for action
- The 2050 Outlook provides a framing for the transformations that are needed to achieve the objective of the Paris Agreement and the stabilization of climate change
- Future CO2 Emissions and Climate Change from Existing Energy Infrastructure estimates cumulative future emissions over 2010 – 2060 from combustion of fossil fuels through existing infrastructure
- Commitment accounting of CO2 emissions calculates total committed emissions from the power sector based on existing infrastructure in 2012 (assuming a 40-year operating life)
- Existing infrastructure and the 2°C target clarifies the link between existing infrastructure and climate change, including non-CO2 GHGs
- The Decarbonizing Development report provides a three-step approach to decarbonizing developing economies, covering (1) long-term and short-term planning and sectoral milestones and objective; (2) sectoral and macro-fiscal policies to achieve these milestones; and (3) managing the political economic and distributional consequences of the transition
- Diversification and Cooperation in a Decarbonizing World provides a roadmap and proactive strategies to incentivize fossil fuel-dependent countries' participation in low-carbon transition, and to examine impacts through trade
- The Lifelines report provides regional estimates of the economic costs of lack of reliability and resilience of infrastructure (for power, water, and transport), and the cost of making them more resilient. The CCG team has also broken down this information to the country level (dataset currently covers 140 countries)
- The Shock Waves model calculated the expected impact of climate change on poverty in 2030 in 92 countries, as well as the biggest threat among (1) ag income; (2) food prices; (3) malaria; (4) diarrhea; (5) stunting of children; (6) loss of labor productivity; (7) natural disasters. Country specific profiles are available from the CCG
- The Unbreakable model provides in 150 countries an estimate of the socioeconomic resilience and an estimate of the benefits from 11 possible interventions to reduce risks, with ready-to-use figures (from land-use planning and building norms to social protection or insurance). A data platform based on this model is forthcoming
- The Groundswell report provides estimates of expected internal migrants in 3 WB regions (AFR, LAC, SAR), to help plan for the possible scale, trend, and spatial patterns of internal migration due to climate change impacts. The second volume (will be published in a few months) will cover the last 3 WB regions (MNA, EAP, ECA)
- Diversification and Cooperation in a Decarbonizing World: Climate Strategies for Fossil Fuel-Dependent Countries provides an index of countries' preparedness to the low-carbon transition, including their exposure (how much they depend on carbon) and their resilience (how they are able to manage an economic transition) [Background data is available as an XLS file for easy use to tailor towards country-specific needs]
- Carbon Pricing Report, produced annually, provides the latest data on carbon pricing in countries around the world.
- Oxford Smith School Sustainable Finance Programme discussion on stranded assets and discussion paper on stranded assets and scenarios: Provides guidance on scenario analysis as a tool to help incorporate uncertainty in decision-making
- World Bank Regional Climate Change Action Plans (if available) as well as existing Systemic Country Diagnostics (SCDs), Country Partnership Frameworks (CPFs), and Country Economic Memorandums (CEMs) (For more information and approaches on embedding sustainability in SCDs see here)

Annex 3.5. Country climate commitments, policies, and capacities

Note: "*****" indicates a global data that is available for most client countries.

Data sources and off-the-shelf analytics

- UNFCCC NDC Registry*: Contains NDC submissions for all countries
- National and Sector Plans/Strategies/Programs (as available)
- Climate Action Tracker*: Provides independent assessments by technical experts and advocacy groups of the quality and ambition of country NDCs and other climate policies
- Climate Transparency: Provides a framework to assess whether an NDC contains all information now required to be included in each submission and a "transparency check" that can be used to assess compliance (in addition to climate country profiles). Among WB clients, reviews have already been completed for Argentina and Mexico's new 2020 updated NDC submissions
- GIZ Green Recovery for Practitioners: Setting the Course Towards a Sustainable, Inclusive and Resilient Transformation: Provides recommendations to policy makers for post-COVID recoveries that are sustainable, inclusive, and resilient – particularly in the medium to long-term
- WRI ClimateWatch NDC Portal*: Provides summaries of NDCs and indicators to compare NDCs across countries
- Various institutions conducting assessments of the "greenness of recovery packages", including Vivid Economics, the Energy Policy Tracker, and the Global Recovery Observatory (UNEP/IMF)

Annex 3.6. Energy sector indicators

- Regulatory Indicators for Sustainable Energy - RISE scores reflect a snapshot of a country's policies and regulations in the energy sector, organized by the three pillars of sustainable energy: Energy Access, Energy Efficiency, and Renewable Energy. Select the pillar from the drop-down menu on the right-hand side to view the pillar results.
- Multi-Tier Framework - The Multi-Tier Framework (MTF) initiative redefines the way energy access is measured, going beyond the traditional binary measure of "connected or not connected" for electricity access, and "solid vs nonsolid fuels" for cooking.
- Tracking SDG7 - aims to provide the international community with a global dashboard to register progress on energy access, energy efficiency, renewable energy and international cooperation to advance SDG7. It assesses the progress made by each country on these four pillars and provides a snapshot of how far we are from achieving the 2030 Sustainable Development Goals (SDG) targets.
- EnergyData.info - ENERGYDATA.INFO is an open data platform providing access to datasets and data analytics that are relevant to the energy sector. ENERGYDATA.INFO has been developed as a public good available to governments, development organizations, private sector, non-governmental organizations, academia, civil society and individuals to share data and analytics that can help achieving the United Nations' Sustainable Development Goal 7 of ensuring access to affordable, reliable, sustainable and modern energy for all. It includes tools like which has multiple relevant datasets like Global Solar Atlas, Global Wind Atlas, Solar PV Forecasting Tool and others.
- Energy Subsidy Reform Assessment Framework - Energy Subsidy Reform Assessment Framework (ESRAF) is a comprehensive analytical toolkit and assessment framework for helping countries to identify and quantify energy subsidies, understand their impact, and evaluate the enabling environment for reform.
- Global Electrification Platform – GEP allows users to explore least cost electrification strategies around the world, interacting with country contextual data and different investment scenarios.
- Database of satellite images for gas (methane) flaring volumes, and flaring emissions intensity, the amount flared per barrel of oil produced.[10]

Annex 3.7. Institutional and Macro-fiscal diagnostics

See other annexes for detailed descriptions of some of the available diagnostics. Other available tools include:

- Adaptation Principles: A Guide for Designing Strategies for Climate Change Adaptation and Resilience: Contains a set of 111 indicators for 26 actions in 6 priority areas, and is meant to provide a quick diagnosis of how countries are prepared to adapt

- Climate Responsive Public Financial Management Framework: Provides a framework for assessing and reporting on the strengths and weaknesses of public financial management (PFM) using quantitative indicators to measure performance
- Reference Guide to Climate Change Framework Legislation: Establishes a benchmark against which national climate policies can be compared
- Network for Greening the Financial System (NGFS): Provides publications on good practices for financial systems to manage risks and to mobilize capital for green and low-carbon investments in the broader context of environmentally sustainable development
- Brookings Accelerating the Low Carbon Transition Report: Provides an approach for identifying points of leverage for coordinated international action to accelerate low-carbon transition

Annex 4. Sector-level decarbonization and resilience tools

Annex 4.1. Identifying critical assets to prioritize resilience investments in infrastructure systems

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Sources of information : Lifelines report, with its companion reports on the power sector, the transport system, water and sanitation, and telecommunication systems.

Natural hazards like floods not only affect people's assets and livelihoods directly, but also disrupt critical public infrastructure services, including roads. As a consequence, people's access to critical public services can be disrupted – e.g. healthcare facilities or cyclone shelters. Depending on the shape of networks, access for certain communities could be effectively cut off entirely. This can occur, for example, when their access relies on vulnerable network bottlenecks (such as bridges), or when the spatial distribution of services is sparse. Network tools and criticality analyses can help identify communities that are particularly at risk of losing access to critical facilities, and pinpoint network segments that should be prioritized for upgrades because many people rely on them.

A simple approach for prioritizing interventions is to assign a level of criticality to assets based on the quantity of services they provide— i.e., their capacity. For example, construction standards are often higher for primary roads such as highways and freeways than for tertiary roads that have a much lower volume of traffic. Power generation plants or water reservoirs can also be ranked as a function of their capacity. Although this is a useful first assessment for criticality, it is limited in that it does not include information on the type of service that the asset provides (for example, a freeway that provides access to a tourist area is less critical than one that leads to the main port or hospital) or the role that the asset plays in overall network functionality.

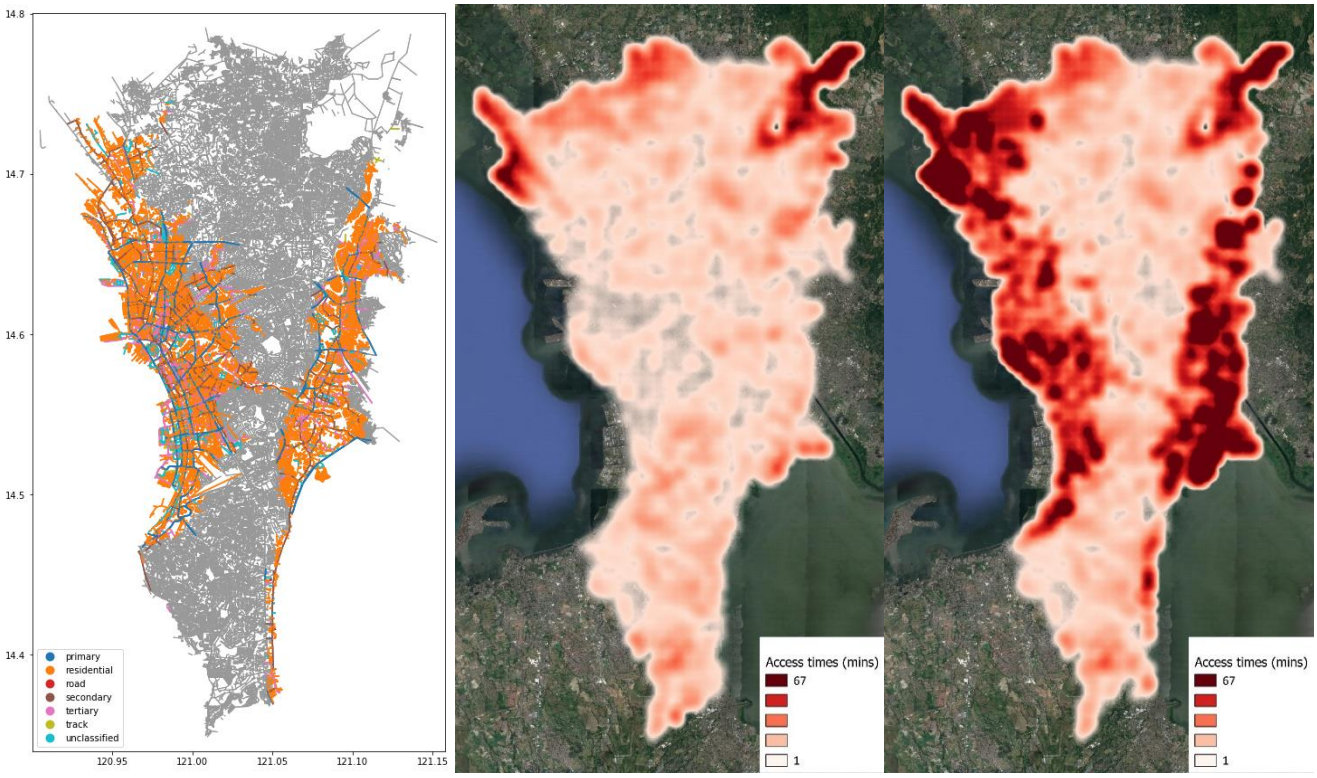
Sophisticated approaches to prioritizing infrastructure assets model infrastructure systems as a network of nodes and links. A network establishes and maintains connectivity between these nodes to facilitate a flow between them. A flow is the movement of people, goods, material, energy, and services through the system. The vulnerability of the system can therefore be linked to the network connectivity that guarantees an available and functional path between intended origin-destination (O-D) pairs.

This approach is well established for stress-testing transport systems. Criticality can be assessed by systematically simulating disruptions in a network and estimating the resulting loss of functionality. Links and nodes can be removed one by one—or several at a time—and the network functionality (e.g., for transport, travel time and cost) can be recalculated in the absence of these elements. Doing so enables identification of the most critical links as the ones that lead to the highest loss of functionality when they are removed. World Bank teams are using this approach to identify weak points in networks and prioritize resilience investments.

Figure 4: Case Study – Manila, Philippines

Map 1 Road sections at risk of liquefaction in the Metro Manila Area, by road type
(Data: HazardHunterPH, OSM)

Map 2 Access times to healthcare facilities in a baseline scenario (**left**) and a simulated post-earthquake scenario with liquefaction and ground deformation along the West Valley Fault (**right**).
(World Bank, based on data from HazardHunterPH and OSM)



Source: Jun Rentschler & Stephan Thies

Case study: Manila, Philippines

A recent analysis conducted for the Philippines Seismic Risk Reduction and Resilience Project (P171419) illustrates how. An overlay of hazard data (in this case seismic liquefaction) and the road network can identify vulnerable network segments (Map 1). This information is then used to estimate people's travel time to hospitals and education facilities (including schools and universities) using an origin-destination routing algorithm (similar to Google Maps trip directions) – first in a baseline scenario (Map 2: left) and then in a disaster scenario (Map 2: right). In certain neighborhoods access to critical public services to can be seen to be disrupted severely. Interventions should be prioritized in these neighborhoods, for instance by installing additional health care facilities (or shelters) in these locations.

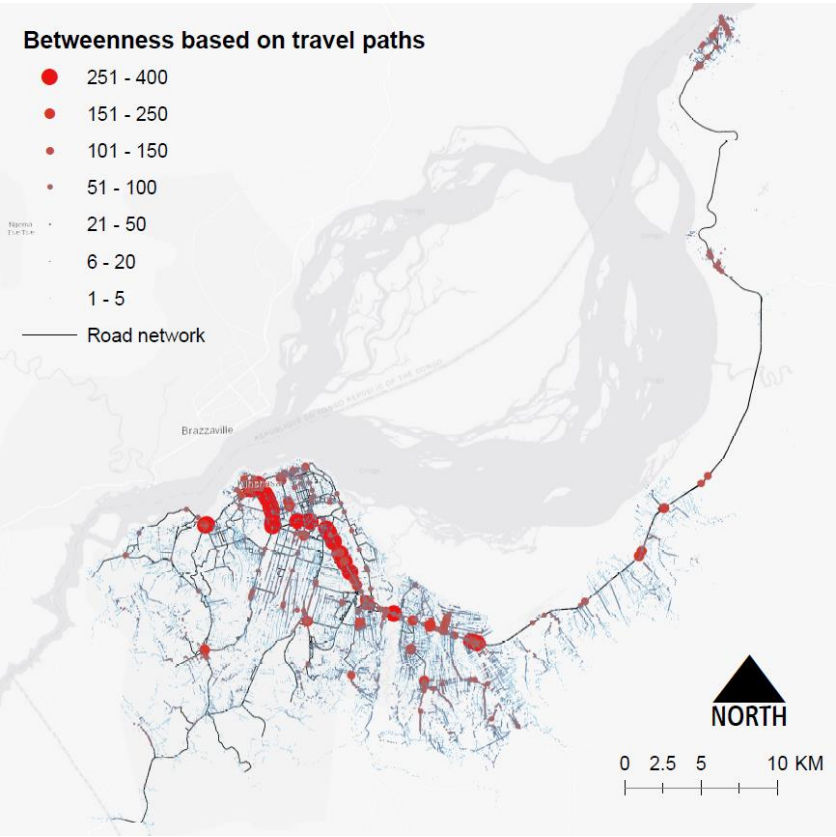
The network analysis can also identify which roads and network segments are most important to ensure access. For instance, if budget constraints mean that only 10 km of roads can be upgraded, this tool can identify the roads where upgrades would deliver the greatest benefit to residents. For example, see case study on Kinshasa below.

Such analysis can be tailored to a specific project context (e.g. different hazards, types of public services, spatial scales, etc.), and should be conducted in conjunction with an analysis of the underlying drivers of socio-economic vulnerability.

Case study: Kinshasa, DRC

The map below is based on a study by He et al (2020), and shows the results of a criticality analysis for the public This approach is able to reflect the actual travel patterns within the network and identify critical links/segments which are most commonly used by commuters and public transit users. Results show that Avenue Du 24 Novembre, east-west sections of the N1 expressway (including Boulevard Triomphal, Boulevard Sendwe, Boulevard Lumumba) have high betweenness centrality. This means that many people rely on these roads for daily commute to work. Disruptions along these road segments due to floods or traffic accidents are most likely to cause high levels of delay due to vehicle speed reduction, congestion, rerouting, etc., as well as associated economic losses. Investments in the resilience of the transport network should prioritize these road segments.

Figure 5: Case Study – Kinshasa, DRC



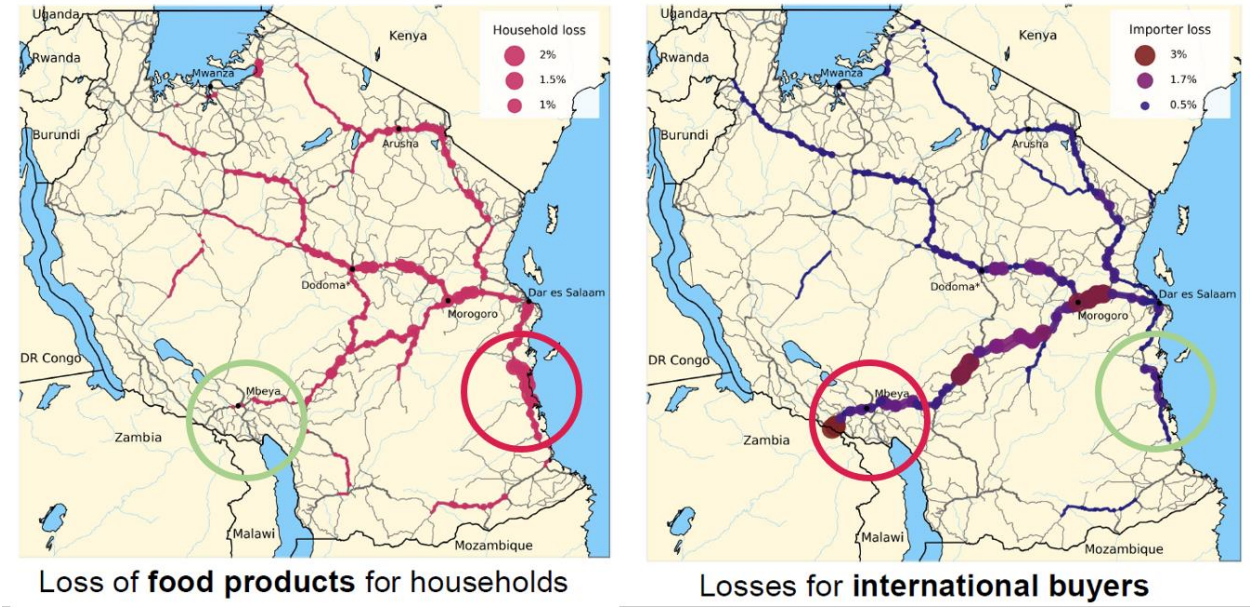
Source: *He, Yiyi; Thies, Stephan; Avner, Paolo; Rentschler, Jun. 2020. The Impact of Flooding on Urban Transit and Accessibility: A Case Study of Kinshasa. Policy Research Working Paper; No. 9504. World Bank, Washington, DC*

Case Study: Transportation and Supply Chain Resilience in the United Republic of Tanzania : Assessing the Supply-Chain Impacts of Disaster-Induced Transportation Disruptions

The economy of the United Republic of Tanzania is growing fast but remains vulnerable to disasters, which are likely to worsen with climate change. Its transportation system, which mainly consist of roads, often get disrupted by floods. How could the resilience of the transportation infrastructures be improved? A new type of model, called DisruptSCT brings together the strength of two different approaches: network criticality analyses and input–output models. Using a variety of data, it spatially disaggregates production, consumption, and input–output relationships and simulate the disruption of transportation infrastructures, their direct impacts on firms, and how these impacts propagate along supply chains and lead to losses to households. The outcome is the identification of potential bottlenecks in the transport network, for various supply chains (food supply, manufacturing, international trade), and assessment of the benefits from various resilience-enhancing strategies (improving the quality of targeted

infrastructure, developing alternative corridors, building capacity to accelerate post-disaster recovery, sourcing and inventory strategies).

Figure 6: Case Study – Tanzania



Annex 4.2. Agriculture & Food

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The following is a selection of pieces of analytical work, tools, and data sets with links developed by the Climate Smart Agriculture (CSA) Team of the World Bank Agriculture & Food Global Practice for the purpose of informing work by World Bank task teams CCDRs. The list is not exhaustive. It is considered a living document that will be updated as needed.

Climate-smart Agriculture country profiles

The Climate Smart Agriculture (CSA) Country Profile (CP) initiative is a series of publications containing a brief yet comprehensive overview of the status of CSA activities and enabling environment in a given country. The profiles provide an overview of the agricultural context and challenges in each country through a climate-smart agriculture lens and provide a snapshot of the key issues, challenges, constraints, opportunities, and enabling factors to scaling up the adoption of climate-smart agricultural practices.

- South Asia: Bangladesh; Bhutan; Kyrgyzstan; Nepal; Pakistan; Sri Lanka
- Europe & Central Asia: Moldova
- Africa: Senegal; Ethiopia; Kenya; Lesotho; Malawi; Mozambique; Rwanda; Tanzania, United Republic of; Uganda; Zambia; Zimbabwe
- Latin America & Caribbean: Argentina; Belize; Colombia; Costa Rica; El Salvador; Grenada; Mexico; Nicaragua; Peru; Uruguay
- East Asia & Pacific: Philippines; Vietnam

Available but not yet published:

- Indonesia and Chad

CSA investment plans:

The CSA Investment Plans (CSAIP) identify concrete actions governments can take to boost climate-smart agriculture, both in the form of investment opportunities and policy design and implementation. Countries can also use the CSAIPs to inform their NDC updates and National Agriculture Investment Plans. They also inform government, development partners and the private sector about promising climate-smart agriculture technologies, as well as associated costs.

- **Asia**
  - Bangladesh
- **Africa**
  - Côte d'Ivoire, Mali, Zambia, Zimbabwe, Lesotho, Morocco, Burkina Faso, Cameroon, Ghana, Republic of Congo
- **In preparation:**
  - Nepal, Greece, Jordan

Other key publications and guidance in CSA:

- CSA 101 Guide
- Future of food: shaping a climate-smart global food system
- Increasing Agricultural Production and Resilience Through Improved Agrometeorological Services
- Greenhouse Gas Accounting for Sustainable Land Management: Quick Guidance for Users
- Greenhouse gas mitigation opportunities in agricultural landscapes: a practitioner's guide to agricultural and land resources management
- Making Climate Finance Work in Agriculture
- Gender in Climate-Smart Agriculture: Module 18 for Gender in Agriculture Sourcebook
- Climate-Smart Agriculture Indicators
- Indicators for assessing policy and institutional frameworks for climate smart agriculture
- Carbon Accounting Tools for Sustainable Land Management

Country- or region-specific publications and guidance:

- Bringing the Concept of Climate-Smart Agriculture to Life: Insights from CSA Country Profiles Across Africa, Asia, and Latin America
- Cambodia: Striking a Balance: Managing El Niño and La Niña in Cambodia's Agriculture
- Lao PDR: Striking a Balance: Managing El Niño and La Niña in Lao PDR's Agriculture
- Myanmar: Striking a Balance: Managing El Niño and La Niña in Myanmar's Agriculture
- Philippines: Striking a Balance: Managing El Niño and La Niña in Philippines' Agriculture
- Vietnam: Striking a Balance: Managing El Niño and La Niña in Vietnam's Agriculture
- Early Warning Systems for Improving Food Security in East and Southern Africa
- Climate smart agriculture: successes in Africa
- Increasing agricultural resilience through better risk management in Zambia
- Scaling Up Climate-Smart Agriculture through the Africa Climate Business Plan
- Climate-Smart Agriculture Implementation Brief: As Summary of Insights and Upscaling Opportunities through the Africa Climate Business Plan
- Climate Information Services Providers in Kenya
- Looking Beyond the Horizon: How Climate Change Impacts and Adaptation Responses Will Reshape Agriculture in Eastern Europe and Central Asia
- Reducing the Vulnerability of Albania's Agricultural Systems to Climate Change: Impact Assessment and Adaptation Options
- Reducing the Vulnerability of the Former Yugoslav Republic of Macedonia's Agricultural Systems to Climate Change: Impact Assessment and Adaptation Options
- Reducing the Vulnerability of Moldova's Agricultural Systems to Climate Change: Impact Assessment and Adaptation Options

- Reducing the Vulnerability of Uzbekistan's Agricultural Systems to Climate Change: Impact Assessment and Adaptation Options
- Reducing the Vulnerability of Armenia's Agricultural Systems to Climate Change: Impact Assessment and Adaption Options
- Reducing the Vulnerability of Azerbaijan's Agricultural Systems to Climate Change: Impact Assessment and Adaptation Options
- Reducing the Vulnerability of Georgia's Agricultural Systems to Climate Change: Impact Assessment and Adaptation Options

Annex 4.3. Power sector decarbonization analysis

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Electricity Planning Model (EPM) is an in-house power system planning tool developed and applied by the World Bank since 2015 to more than 80 countries. It can be used for systematic assessments of the impacts on electricity systems' costs and supply of five different carbon reductions by 2040, compared to a stated policies scenario (-20%, -30%, -50%, -80%, -100%).

EPM uses a core Mixed Integer Programming (MIP) multi-zone model, implemented in the General Algebraic Modelling System (GAMS) to minimize the total discounted electricity system costs. The model optimizes the generation and transmission expansion over future years of the modelled time period as well as the underlying dispatch of generation and power flows on transmission lines for existing and new transmission assets. In addition to the core decision variables on generation and transmission capacity addition, dispatch and flow – the model also co-optimizes spinning reserve provision from the generators.

The planning analysis using the EPM may be structured in different ways. The path proposed below is aligned with the World Bank's internal priorities and has been conceived to develop meaningful dialogues with development partners and clients. It consists of the following steps:

1. Develop a baseline based on current national policies and targets (including under unconditional NDCs) for renewable energy, energy efficiency improvements, and electrification of transport and other sectors, GHG emissions, emissions of air pollutants, and any other policies that are amenable to modeling with relative ease.
2. Consider enhanced policy scenarios corresponding to deeper carbon emissions constraints including a 2030 pathway target from more comprehensive Earth Science and Integrated Assessment models (ESM/IAM) if available.
3. Explore alternative demand scenarios for each of the decarbonization scenarios in step 2 (e.g., aggressive electrification, COVID-19 recovery, economic growth, and harsher climate scenarios).
4. Develop additional scenarios by limiting available power sector investments. A ceiling on investments may force a change in the investment strategy. The ceiling may be benchmarked against the baseline scenario in step 1 and could help avoid an unrealistically costly investment strategy.

Figure 7: Use of EPM for Decarbonization Assessments

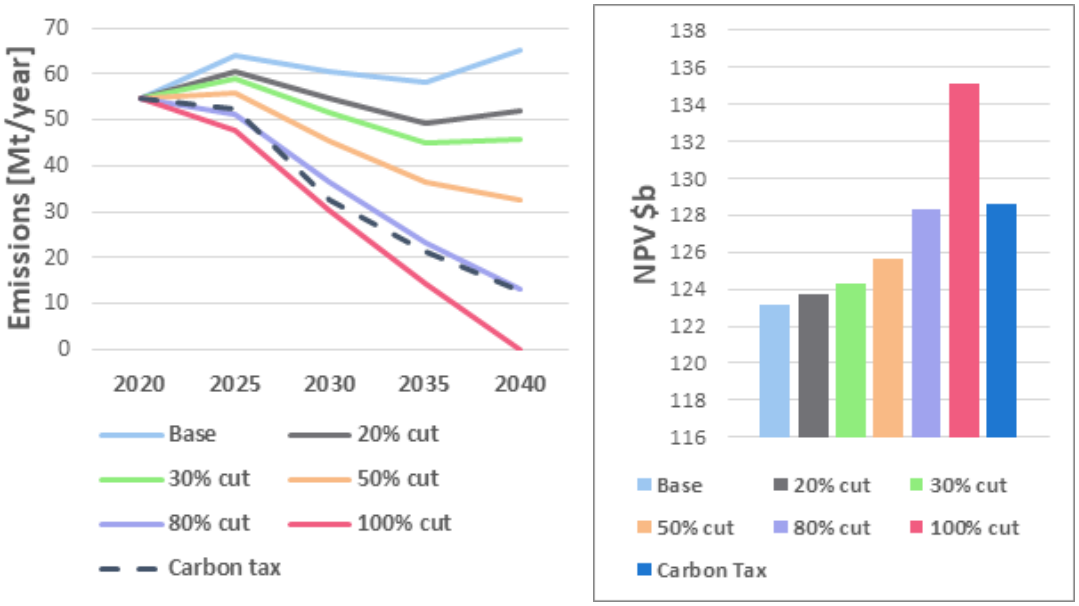


Figure 8: Model Output

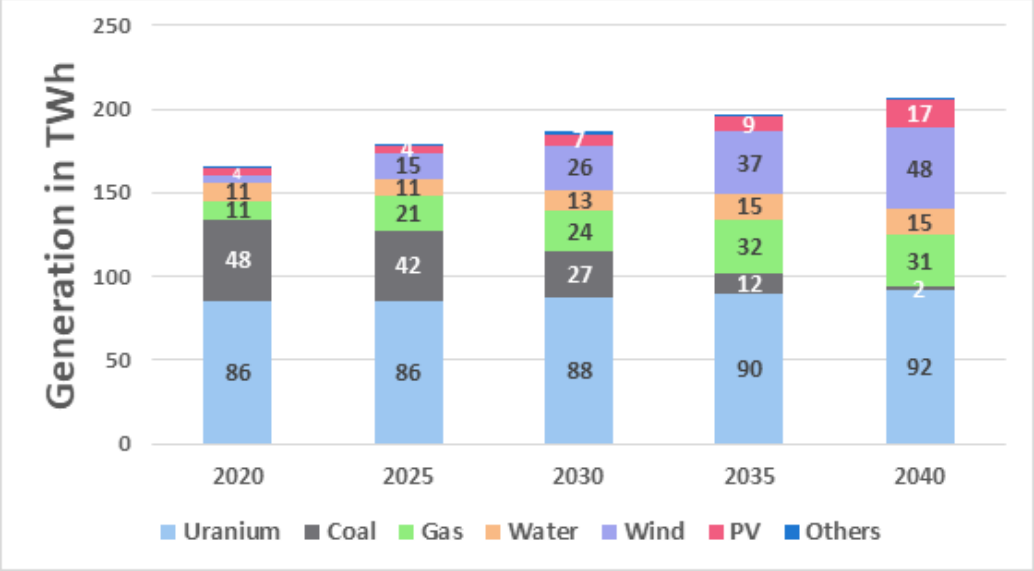


Figure 7 above illustrates typical use of EPM for the above described Decarbonization Assessments. Inputs to the model (emissions trajectories) are on the left, and outputs of the models (full system cost) are on the right. Figure 8 illustrates the output of the model in terms of energy mix, which can be translated into investment needs.

Efforts are now underway to better assess the implications of large-scale electrification of transport and industrial needs. Decarbonization studies are expected to take place in 20 countries over the next 18 months, in parallel with development of the model and its integration within economy-wide models. The time to prepare and run EPM depends on the country's power system size and complexity. Each decarbonization trajectory or scenario requires a separate model run.

Table 4: List of countries for which EPM models already exist (usually covering the period up to 2030)

Region/Country	Number of countries	Country names*

Central Asia + Pakistan	7	Uzbekistan, Kazakhstan, Kyrgyz Rep., Tajikistan, Afghanistan, Turkmenistan, Pakistan
Eastern Africa Power Pool Plus	14	Egypt, Sudan, Libya, Djibouti, DRC, Ethiopia, Tanzania, Kenya, Uganda, South Sudan, Zambia, Rwanda, Burundi, Eritrea
Southern Africa Power Pool	9	South Africa, Lesotho, Eswatini, Mozambique, Zimbabwe, Botswana, Namibia, Angola, Malawi, Zambia, DRC, Tanzania
Pan Arab Electricity Model	15	Algeria, Bahrain, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Palestine, Qatar, Saudi Arabia, Sudan, Syria, Tunisia, UAE, Yemen
South Asia (BBINS)	5	India, Bangladesh, Bhutan, Nepal, Sri Lanka
West Africa Power Pool	14	Benin, Burkina Faso, Cote d'Ivoire, Gambia, Guinea, Guinea Bissau, Ghana, Niger, Nigeria, Liberia, Mali, Togo, Senegal, Sierra Leone
Country Specific Models **	18	Albania, Bosnia & Herzegovina, Bulgaria, Cameroon, Central African Rep., Chad, Comoros, Kosovo, Lao PDR, Madagascar, Mongolia, Myanmar, Papua New Guinea, Poland, Solomon Islands, Turkey, Ukraine, Vietnam
TOTAL	82	

** Some countries appear in more than one regional model that are shown in light color (and are not double counted)*

*** Separate model for each country*

Using EPM and other models and scenarios available at the country level, decarbonization briefs will be prepared for a selection of proposed EEX operations in context of decarbonization pathways for the respective country or region and subsector. Planning is underway for broader adoption of such decarbonization assessments, material from which can be drawn on directly for the CCDR or highlighted in a dedicated section.

The intention is that briefs and analysis prepared as part of the decarbonization assessments would capture key issues and findings relevant for inclusion in Project Appraisal Documents (e.g. Strategic Context, Results Chain, Technical Analysis, Economic and Financial Analysis). However, the framework for the assessments (below) may serve as general reference, including for upstream country diagnostics like the CCDR, strategy development, and technical assistance including client capacity building and stakeholder consultations.

Annex 4.4. Health and climate change

- **Climate and health vulnerability assessments** (World Bank. Health, Nutrition and Population Global Practice): Provided by the Health-Climate and Environment Program (H-CEP) to help countries understand their climate-related exposures and provide recommendations to strengthen the capacity of their health systems to adapt to climate change. Energy efficiency audits are also available through H-CEP. Reductions in energy use present recipient countries with important financial as well as emissions related savings.
- **Building Resilience Against Climate Effects (BRACE) Framework** (Centers for Disease Control and Prevention): Allows health officials to develop strategies and programs to help communities prepare for the health effects of climate change. Part of this effort involves incorporating complex atmospheric data and both short and long-range climate projections into public health planning and response activities.
- **Guide for assessing health vulnerability to climate change for health departments**. Part of the BRACE Framework.
- **Methodological Guidance: Climate Change and Health Diagnostic. A Country-Based Approach for Assessing Risks and Investing in Climate-Smart Health Systems** (World Bank Group 2018): Provides steps to identify events and conditions where climate stresses and shocks undermine the effectiveness of health systems (at local or national scales), increasing morbidity and mortality. Uses these insights to prioritize interventions toward establishing climate-smart health systems that both increase resilience and reduce emissions.

- **Climate and Health Intervention Assessment: Evidence on Public Health Interventions to Prevent the Negative Health Effects of Climate Change** (Centers for Disease Control and Prevention (CDC) and the Building Resilience Against Climate Effects (BRACE) Midwest/Southeast Collaborative 2017): Outlines the findings of the BRACE Midwest/Southeast Collaborative on the evidence of effectiveness of various interventions for reducing the negative health impacts of climate change.
- **Tracking Progress on Health and Climate Change** (Lancet Countdown 2019): Tracks the relationship between health and climate change across five key domains and 41 indicators.
- **Geographic Hotspots for World Bank Action on Climate Change and Health** (World Bank Group 2017): A guide to countries that would most benefit from immediate efforts to ensure that health considerations are at the forefront of climate change adaptation responses and mitigation measures. Draws on vulnerability indices related to health outcomes, data outlining the disease burden linked to pollution, and proxies that measure country health systems' performance or readiness to cope with increased burden of disease.
- **Climate Smart Healthcare: Low Carbon and Resilience Strategies for the Health Sector** (World Bank Group 2017): A menu of tools for building low-carbon healthcare and addressing climate-related health impacts.
- **Reducing Climate-Sensitive Disease Risks** (World Bank 2014): Builds on scientific and operational knowledge of early action tools to help practitioners reduce the risks of key climate-sensitive infectious diseases by strengthening risk management systems for disease outbreaks. Includes an assessment of known interventions such as the establishment of surveillance systems, the development of region- and nation-specific disease outlooks, the creation of climate-sensitive disease risk maps, and the construction and implementation of early warning advisory systems.

Annex 4.5. Hazards and risk assessments tools

ThinkHazard!

- Type: Disaster risk indicator
- Output: National and sub-national level natural hazard risk indicators
- Format: API, web pages
- Link: https://thinkhazard.org/en/
- Focal points: Mattia Amadio mamadio@worldbank.org,
  Pierre Chrzanowski pchrzanowski@worldbank.org

ThinkHazard! provides a general view of the hazards that should be considered in project design and implementation for a given location to promote disaster and climate resilience. The tool highlights the likelihood of different natural hazards affecting project areas (very low, low, medium and high). It also provides guidance on how to reduce the impacts of these hazards and identifies sources of additional information. The hazard levels provided are based on published hazard data provided by a range of private, academic, and public organizations. The next version of ThinkHazard! will integrate projected changes in natural hazard risk indicators due to climate warming.

Risk Data Library

- Type: Disaster risk data
- Output: Exposure, hazard, vulnerability and loss data.
- Format: API, web pages
- Link: http://riskdatalibrary.org/
- Focal points: Stuart Fraser sfraser@worldbank.org,
  Pierre Chrzanowski, pchrzanowski@worldbank.org

The Risk Data Library is GFDRR's new digital platform for sharing disaster risk data at the national or sub-national level. It provides an open data standard to exchange and combine hazard, exposure, vulnerability and modeled loss

data. The Risk Data Library standard supports interoperability between risk models' data outputs and is particularly suited for climate disaster risks scenarios. The standard includes physical exposures at various scales and aims to include socio-economic exposure. In the next fiscal year, the Risk Data Library team will work to integrate existing disaster risk assessment data to the library. It will also provide support to Task Teams for integrating new risk data outputs, including data from Climate and Disaster Risk Finance Diagnostics.

GFDRR Risk Profiles

- Type: Disaster risk assessment
- Output: 46 risk country profiles in Africa, Europe and Central Asia
- Format: PDF
- Link: https://www.gfdrr.org/en/disaster-risk-country-profiles
- Focal points: Stuart Fraser sfraser@worldbank.org, Emma Phillips, ephillips@worldbank.org

The national risk profiles provide the estimated impact of disasters on the population, building stock, transport networks, critical facilities, and agriculture at the national and sub-national levels. These profiles can guide initial strategic dialogue on financial protection and/or risk reduction investment opportunities to manage disaster risk, and help identify priorities for more detailed risk assessments if specific interventions are to be made.

Global Flood Hazard (FATHOM) Data

The FATHOM flood hazard model (previously known as SSBN), is a global gridded dataset of flood hazard produced at the global scale. It provides flood water extent and depth for a range of pluvial and fluvial hazard scenarios, expressed as "return period", which indicates the probability of occurrence (i.e. once in 5, 10, 20, 50, 75, 100, 200, 250, 500, 750 and 1000 years). The Data is at 3 arc second (approximately 90m) resolution and have a global coverage between 56°S and 60°N.

The FATHOM Global Flood Hazard data ('the Data') has been licensed by the World Bank for internal use only. Teams can use the form to request access to one or more country data files and are requested to specify internal or external use. The data coordinators in GFDRR Labs will provide an access link. If external use is required, data coordinators can help in gaining written permission from Fathom.

Global Landslide Hazard Map

The Global Landslide hazard map is a gridded dataset of landslide hazard produced at the global scale. To better understand the spatial and temporal distribution of landslide hazard worldwide, the World Bank and the Global Facility for Disaster Reduction and Recovery (GFDRR) commissioned Arup to undertake a landslide hazard assessment at a global scale. Using a global landslide inventory, landslide susceptibility information provided by NASA, and an innovative machine learning model, the geohazard and risk management experts produced a state-of-the-art quantitative landslide hazard map for the whole world.

Other tools

- AQUEDUCT tool flood risk and impact of adaptation based on GLOFRID global flood model
- Coastal risk screening tools: Climate Central
- GEM global new EQ country risk profiles and global risk map
- Verisk Maplecroft have a series of risk viewing tools now (requires sign in)
- INFORM index
- JBA global flood maps

EAP Specific

In EAP, there are two sub-regional risk models and platforms developed for the purpose of CAT (catastrophe) risk insurance pools which might be a good starting point for section 1.2.

1. Pacific PCRAFI:
2. SEADRIF for Lao PDR, Cambodia, and Myanmar

There are also hazard-, location-, and asset-specific risk assessments for most countries in region. These have supported the development and implementation of DRM investments.

LAC Specific

A critical and comprehensive review of over 300 country disaster risk profiles was conducted in the LAC region, covering 43 countries for multiple hazards. For each profile over 100 key metrics were investigated relating to each component of the underlying risk analyses (i.e. the exposure, hazard and vulnerability). The underlying database of the analysis itself might also be valuable for further work under section 1.2. The team can also provide guidance on the suitability of different profiles for various use cases.

All LAC profiles can be accessed here. The analysis is being expanded to other regions as well.

For LAC, analysis for integrating future climate scenarios into the country disaster risk profiles (CDRPs) is in the final stages. This analysis aims to:

- Define future climate scenario typologies and describe their applicability to disaster risk assessments.
- Provide details on qualitative and quantitative approaches to incorporate socio-economic uncertainties within future climate scenarios and review common practices in use in disaster risk assessments.
- Provide an overview of current climate change scenarios and guidance on their use in disaster risk assessments from a top-down and bottom-up perspective.
- Provide guidance for TTLs on the use of future climate scenarios in disaster risk assessment at regional/country-scales in LAC.

Schools

The Roadmap for Safer and Resilient School could help to make a diagnostic (Steps 1 to 5) at country level. We have results from countries such as Peru, Kyrgyz, Dominican Republic, Uzbekistan, among others. This could provide a sector-view of tools to screen polices for resilience and risk management.

The Global Library of School Infrastructure has a catalog of over 40 representative school building types in several countries worldwide (Index Buildings) with information about structural characteristics, vulnerability, and lines of intervention. This is an example of a tool to facilitate risk assessment and mitigation at scale.

Buildings

The Building Regulatory Capacity Assessment covers building regulations and codes/standards and land use regulations and can be used to assess policies and regulations in this area.

- For floods and drought related policies teams could build on or use, the flood-drought policy framework developed by the Water GP and GPURL will be released soon.
- For emergency preparedness and response, the LLE and R2R can focus on legal and institutional frameworks as well as policies and regulations related to preparedness at the national and sub-national levels:
    - **The Lessons Learned Exercise (LLE)** is an entry point to advocate for Emergency Preparedness and Response (EP&R) systems enhancement and to gather initial data before a broader assessment. The LLE analyzes a recent emergency in the country and provides key government, private sector, and emergency relief entities an opportunity to discuss the systems, procedures and experiences related to emergency preparedness and response, and develop collaborative recommendations for EP&R capacity improvements.
    - **The Ready2Respond (R2R) Diagnostic** identifies both strengths and gaps of current EP&R systems using a robust and proven methodology. The assessment includes a thorough analysis of current capacities to inform investment plans and provide clear and actionable recommendations tailored to the country context.

Risk assessment can also benefit from our work on disaster recovery rapid assessment tools and use of disruptive technology. This could be particularly relevant to help with the quantification and impact assessment of the short-term GDP, poverty and inequality impacts from natural disasters and shocks. The likely impacts from future risk scenarios can also be estimated using rapid assessment tools and methodologies such as GRADE.

This may also be relevant for post COVID-19 recovery and how disaster recovery tools could be applied to develop multi-sectoral COVID-19 impact assessment and recovery plans. Similarly, tools for the country disaster recovery readiness assessments and diagnostics for determining the strengths and weaknesses of national recovery systems could also be relevant.

Annex 4.6. City-level risk assessments and decarbonization tools

Contact: Steven Rubinyi srubinyi@worldbank.org, Ross Eisenberg reisenberg1@worldbank.org

City-level risk assessments - CityScan

The City Scan is a package of maps, geospatial tools, and data visualizations that together provide a rapid assessment of the critical resilience challenges that cities face. It uses the best publicly available global geospatial datasets and open-source tools to build dialogue and generate shared insights related to a city's most pressing resilience challenges. It promotes spatial thinking about how urban forces affect the resilience of various local conditions, networks, and people, which can equip city officials to prioritize and coordinate future investments. Over 70 City Scans have been created to date.

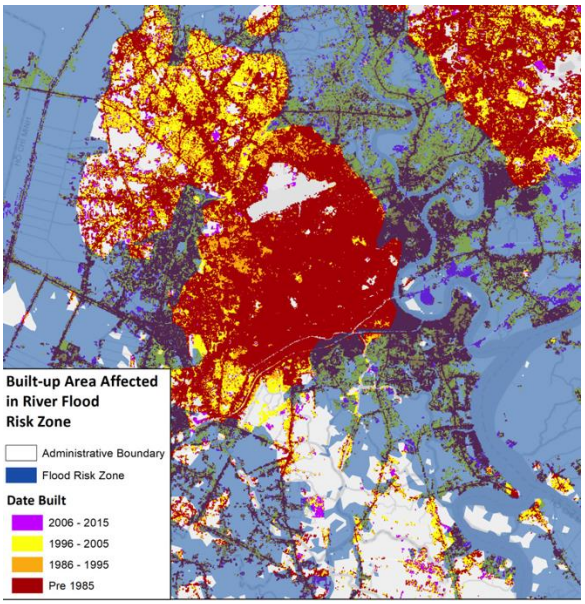
In addition to the standardized City Scan report product, the City Resilience Program can support the development of web-based City Scan tools for use in workshops or other engagements that provide greater data interactivity and cross-silo insights.

Themes that the City Scan covers include:

- **Setting the Context**: Describes the city's urbanization context, as well as its salient geographical features, principal economic activities, major access routes, and assets and constraints that favor or hinder urban expansion.
- **Population and Demographic Trends**: Presents some of the city's key population and demographic information, including growth trends, age distribution, and density.
- **City Competitiveness and Economic Growth**: Assesses the role of the city as a driver of economic growth and employment through growth trends, city-level GDP, and economic hotspots and ease of doing business.
- **Built Form**: Examines the city's state of built-up area and infrastructure by analyzing its expansion over time, land cover, slope and elevation, existing road network criticality, and intersection density.
- **Climate Conditions**: Explores climate change impacts and mitigation through photovoltaic power potential, air quality, and surface temperature and urban heat island effects.
- **Risk Identification**: Overlays various risk data, including urban flooding, landslides, earthquakes, and sea level rise with the city's built form and infrastructure assets.
- **COVID-19 Information**: Provides up-to-date country and city statistics on COVID-19 and shows information on access to hospitals for treatment and recent changes in economic activity.
- **Local Institutions & Planning**: Draws upon existing frameworks and policies to identify critical issues from financial, planning, and institutional perspectives for better city management.

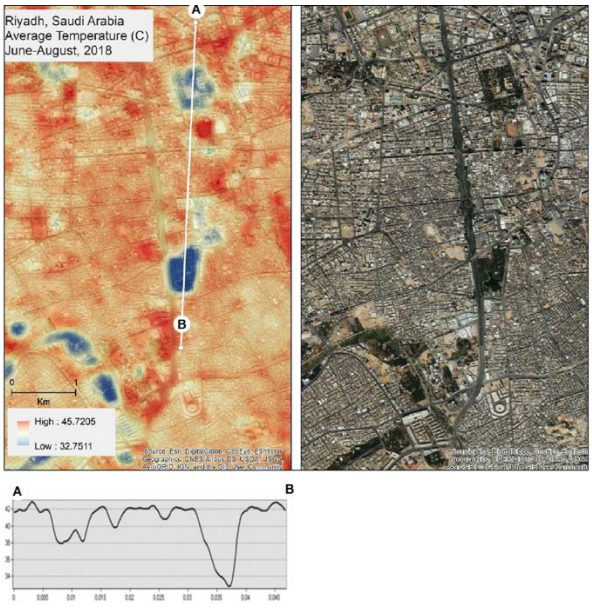
Examples of Spatial and Statistical Analysis in City Scans

Figure 9: Urban Built-Up Area Exposed to River Flooding Ho Chi Minh City, Vietnam



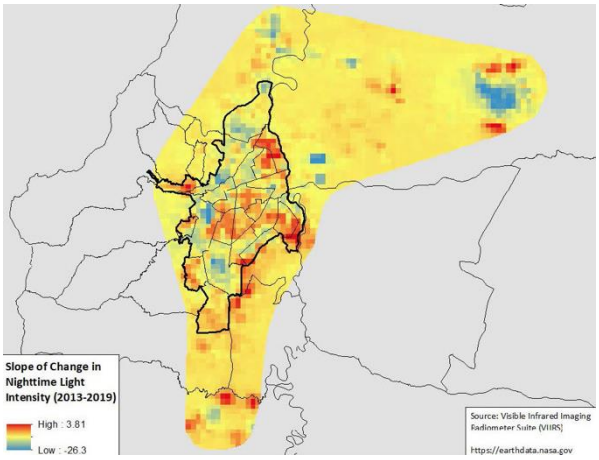
The built-up area in Ho Chi Minh City's urban districts exposed to river flooding grew from 71 sq in km 1985 to 159 sq km in 2015 – an average annual rate of increase of 4.13%.

Figure 10: Urban Temperature - Riyadh, Saudi Arabia



Variation in urban land cover imply variation in urban temperature. In a hot city like Riyadh, parks, other less built-up areas, and building material changes offer residents relief from heat and act as cooling centers.

Figure 11: Economic Hotspots – Cali, Colombia

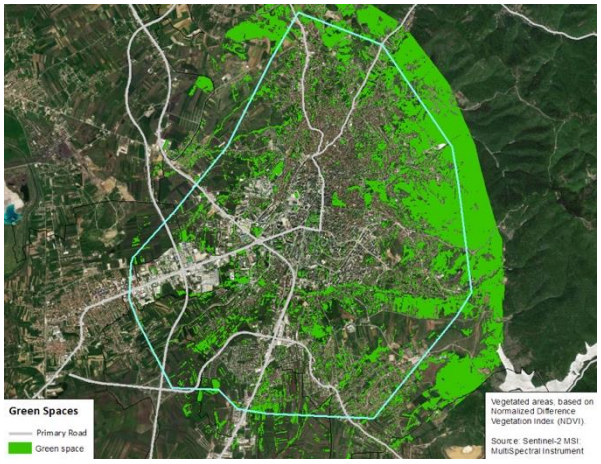


Diverse area's in Cali's center, at its western and eastern edges, and in places outside Jamundi and Palmira increased their nighttime light intensity from 2013-2019 indicating economic activity there outpaced neighboring areas.

Figure 12: City Share of National GDP, Employment and Population – Tashkent, Uzbekistan

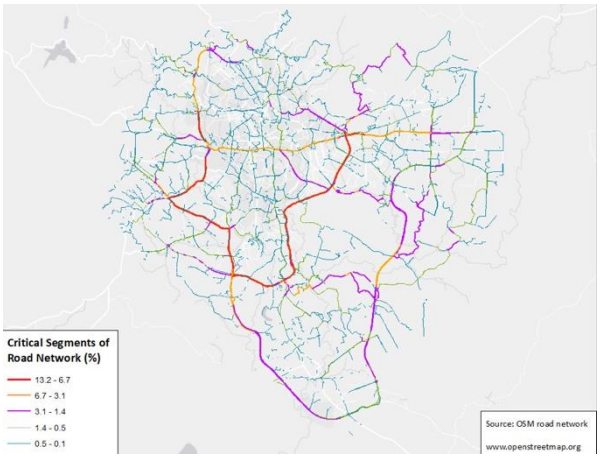
Tashkent's population represents almost 10% of the total country population. Additionally, the city contributes more than 10% of the national GDP and 8% of employment.

Figure 13: Urban Green Spaces – Pristina, Kosovo



Pristina exhibits a relatively high level of green space. Fewer and smaller green spaces are found in historical central city and along newer industrial zones to the southwest. Greenspaces are abundant to the forested east.

Figure 14: Road Network Criticality – Addis Ababa, Ethiopia



Road segments that are blocked by flooding would cause a high degree of disruption to travel across a city. Segments in red are the most critical for the overall connectivity of the city.

City Scan Details

- 2-week lead time
- Cost per city: $5,000 - $10,000

City Scan Data Sources

- Competitive Cities Database
- Climate Central, Surging Seas Risk Zone Map
- Dartmouth Flood Observatory, Global Active Archive of Large Flood Events
- European Space Agency Climate Change Initiative, Land Cover
- European Space Agency, Sentinel-2, Normalized Difference Vegetation Index (NDVI)
- European Space Agency, Sentinel-2, Normalized Difference Water Index (NDWI)
- FAO Africover
- Fathom-Global flood model
- German Aerospace Center, World Settlement Footprint Evolution
- German Aerospace Center, World Settlement Footprint Percent Impervious Surface
- Global Earthquake Model
- Global Solar Atlas
- IMF, Government Finance Statistics
- Johns Hopkins University of Medicine Coronavirus Research Center
- Luijendij et al., The State of the World's Beaches. Long-Term Shoreline Changes (1984-2016)
- NASA Earthdata, Visible Infrared Imaging Rediometer Suite (VIIRS)
- NASA Goddard, Global Landslide Model
- NASA Jet Propulsion Laboratory, Shuttle Radar Topography Mission
- NASA SEDAC, Columbia U CIESIN, Global Annual PM2.5 Grids from MODIS, MISR, and SeaWiFS Aerosol Optical Depth (AOD) with GWR
- NOAA, Significant Earthquake Database
- OpenStreetMap

- PreventionWeb, Disaster & Risk Profile
- U of Maryland, Hansen et al., Global Forest Change
- USGS Landsat Surface Temperature, Landsat 8
- Various local urban planning and local government sources
- World Bank Ease of Doing Business
- World Bank, Global Landslide Hazard Map
- WorldPop

City-level decarbonization tools

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Urban emissions inventories are necessary for a city to understand their *current* sources of emissions in a comprehensive and comparable manner. Urban GHG emissions modeling tools can help estimate the *future* impacts of various interventions for a particular city. By doing so, they can help planners and policymakers identify and prioritize investments and policy interventions and estimate their contribution to national and international emission reduction targets. The list below covers the tools available for use in cities in low- and middle-income countries but excludes those that produce emissions inventories without modeling future scenarios.

- **Advanced Practices for Environmental Excellence in Cities (APEX):** This tool builds on the World Bank's original **Climate Action for Urban Sustainability (CURB)** tool**.** APEX is an online tool that helps evaluate the emissions impacts of interventions related to the built environment, transportation, solid waste, and water/ wastewater. It is being used in Ahmedabad, Ho Chi Minh City, and Almaty.
- **Action Selection and Prioritization Tool (ASAP)** developed by C40, uses data from a city's existing GHG emissions inventory to prioritize interventions based on their mitigation and adaptation impacts, associated co-benefits, and feasibility.
- **Urban Performance**, developed by CAPSUS, evaluates the various impacts of spatial planning, transport, waste, and energy interventions. It has been used in Jordan, Indonesia, Vietnam, Cote d'Ivoire, Mexico etc. The Indonesia example can be found here**.**
- **RapidFire**, developed by Calthorpe Analytics, evaluates the impacts of spatial planning and transport interventions. It has been used in Chongqing and Mexico City amongst others.
- **City Performance Tool, CyPT**, developed by Siemens, evaluates the impacts of building, transportation, and energy interventions. It has been used in over 22 cities in Europe, Asia, and the Americas.

Other tools and frameworks that include emissions reductions approaches, plans, and policy tools:

- **Urban Sustainability Framework**, developed by the Global Platform for Sustainable Cities, which is funded by the Global Environment Facility, and managed by the World Bank.
- EBRD **Green City Policy tool**

Annex 4.7. Greenhouse gas emissions assessments in the transport sector

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This annex focuses on tools and data for understanding country-level pathways for decarbonizing the transport sector.[15] It includes 2 sections focused on diagnostics and a final section suggesting a scenario planning approach

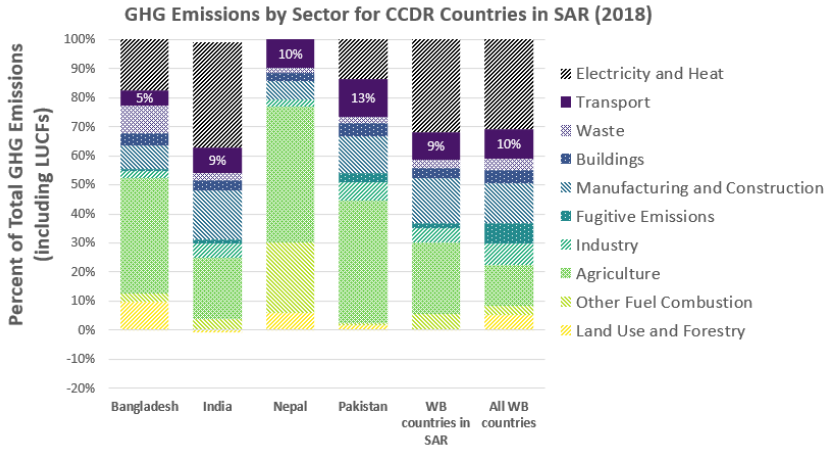
[15] Tools and data for understanding contextual climate risks faced by the country and the transport sector are summarized in other sections of this guidance note, including Annex 3.3, Annex 4.1, and Annex 4.5. In particular, Annex 4.1 presents tools for

that will help operationalize the Avoid-Shift-Improve-Resilience (ASIR) Framework in the parameters of the sector's emissions inventories. This note highlights key diagnostic results for India, but the work can be extended for the remaining 31 FY22 CCDRs.

4.7.1 Understanding the GHG Emissions of the Country and the Transport Sector

To ensure comparable and consistent data across sectors and countries, the transport team has compiled information on GHG emissions from the CAIT Database (maintained by WRI's ClimateWatch)[16] for 2018 for all 32 CCDR countries, accessible here. As illustrated in Figure 15, GHG emissions from transport can be compared with other economic sectors, and with other countries in the region.

Figure 15. Positioning India's transport emissions against emissions of other sectors and in the context of other countries in the SAR region.



The objective of this section is to determine the relative priority and urgency of decarbonizing the transport sector vis-à-vis other sectors. The transport team will add temporal analysis of historical trends (2008 – 18) in transport sector emissions to the excel sheet linked above to help demonstrate how "business as usual" pathways for transport sector development will not meet climate goals and the need for reversing current trajectories.

Positioning the transport sector and its emissions within broader macroeconomic, demographic, social trends, and national development goals requires contextualization of current and historical trends within the broader context of the country's energy mix, fuel and commodity flows, urbanization, economic growth, and other factors.

4.7.2 Understanding the GHG Emissions of Transport Sub-Sectors (Modes)

The diagnostic in this section builds on breaking down GHG emissions by sub-sector or mode. This will enable country teams to explore impacts of sub-sector-specific policy interventions, while maintaining a holistic view of transport systems that capture critical interactions among modes (see section 4.7.3).

Breaking down GHG emissions from the transport sector by mode requires the preparation of country-specific transportation emissions inventories that can inform air quality and climate change models. The IPCC provides guidance for completing transportation sector emissions inventories at different levels of granularity based on the intended application and availability of data.[17]

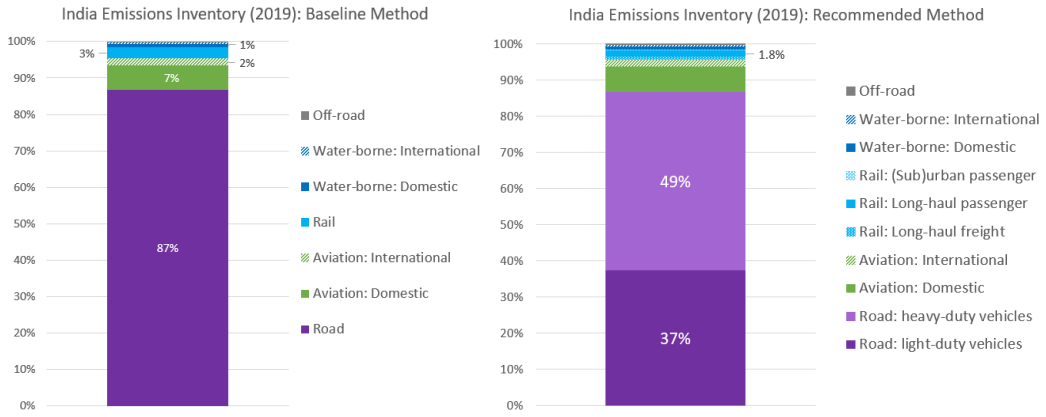
identifying critical assets to prioritize resilience investments in infrastructure systems, with specific guidance for transport systems.

[16] Data sourced from www.climatewatchdata.org/ghg-emissions. For detailed documentation of methods and data sources for the CAIT Database, see: http://cait.wri.org/docs/CAIT2.0_CountryGHG_Methods.pdf

[17] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf

Spreadsheets with the Baseline ("Tier 1") Method and Recommended ("Tier 2") Method have been developed. Given the need for mode specific GHG inventories for the CCDRs that allow teams to explore sub-sector specific interventions, the CCDR transport team recommends the IPCC's "Tier 2" method. Figure 16 presents preliminary results based on sample data and calculations for India.

Figure 16. Example greenhouse gas emissions inventory (in CO_2-equivalents) for India highlighting the level of granularity by mode (particularly road and rail) that can be achieved using the Baseline ("Tier 1") Method and the Recommended ("Tier 2") Method[18]



The CCDR transport team is available to guide country teams through a three-step process for generating (or updating) a transport emissions inventory:

0. Check existing modeling capabilities
1. Assess availability of input data
2. Input data into emissions calculator

Figure 17 provides a flowchart of the critical decisions involved in this three-step process.

Step 0. Check Existing Modeling Capabilities

The CCDR transport team can help country teams determine if existing transport and emissions models developed as part of previous analytical or advisory engagements may be suitable for the intended diagnostics and ways to update them to be comparable in approach to the method suggested here.

Step 1. Assess Availability of Input Data

Transportation sector emissions inventories rely on three main inputs:

i. *National fuel sales data by type of fuel*—The level of detail should be at least by Motor Spirit (Gasoline or Petrol), High Speed Diesel Oil, Furnace Oil, Aviation Turbine Fuel etc.[19]
   - While the sources and granularity of data will vary by country, national statistics agencies and/or data reported by refineries could provide good starting points. If unavailable, the transport team can provide values from the IEA, although these may not be granular enough to effectively differentiate across modes.
   - Units: All units will need to be converted to Tera Joules (TJ) for analysis using standard conversion factors by fuel.
     - *(Country-specific) emissions factors by type of fuel*—Emission factors convert TJ of fuel consumed to grams of CO_2e. Emission rates should also reflect country-specific emission standards (by fuel type), if available. Based on the fuel sales data, the transport team can provide guidance on the

[18] Figure notes: y-axis shows percentage of GHG emissions (including CO_2, CH_4, and N_2O expressed in CO_2-equivalents). Off-road consists of primarily of emissions from agricultural and construction vehicles. Light-duty vehicles include passenger cars, light trucks, motorcycles, etc.; Heavy-duty vehicles include trucks, buses, commercial vans, etc. These road transport splits were based on data from a single source and may be revised with improved background.

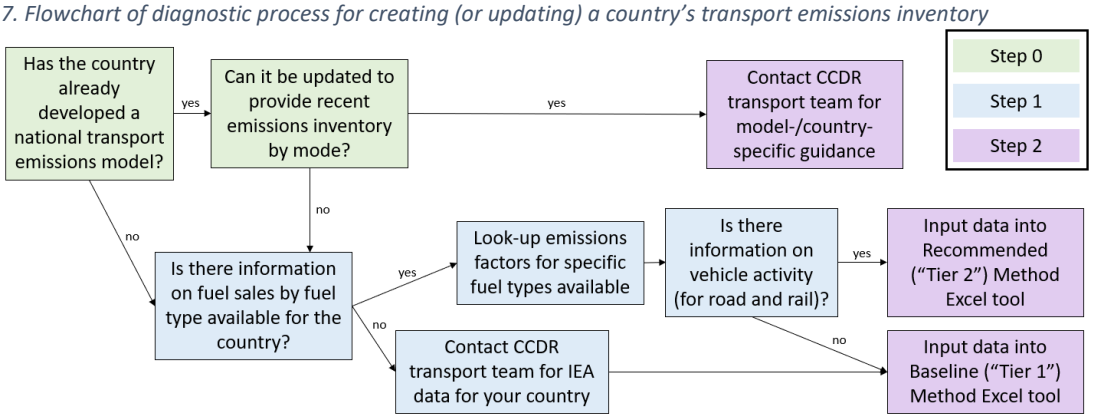
[19] Biofuels are traditionally accounted in the agriculture sector and can be omitted from transport sector analysis.

appropriate emissions factor for each fuel consumed (or closest comparator) based on existing databases of CO_2 emissions factors.

ii. *Aggregate activity data* (vehicle kilometers traveled) by vehicle type, particularly for road- and rail-based transport. National travel demand models are a great resource for this information, where available. Alternatively, national transport ministries or other agencies may have aggregate statistics.

A complete list of desired input data and suggested sources is provided here.

Figure 17. Flowchart of diagnostic process for creating (or updating) a country's transport emissions inventory



Step 3. Input Data into Emissions Calculator

The transport team is preparing an Excel spreadsheet-based tool for automating calculations for GHG emissions calculations by fuel and vehicle type. Depending on data availability, the tool will allow for a *Baseline* (Tier 1) analysis or a more advanced *Recommended* (Tier 2) method.

i. Calculate CO_2 emissions by fuel type:
   - Total emissions as the product of fuel sold (TJ) times emission factor (g CO_2/TJ)

ii. Calculate methane and nitrous oxide emissions:
   - Based on level of activity for different vehicle types, choose appropriate value for emissions factor. The transport team can provide guidance based on the type of activity.
   - For each type of fuel, calculate total emissions as the product of fuel sold times emission factor

iii. Attribute fuel types to sub-sectors or modes of transport (or sub-sectors), where applicable

iv. Aggregate across sub-sectors and calculate scaling factors so that overall transport emissions in the country match totals for the sector provided in the CAIT database

4.7.3 Identifying Policy Pathways for Climate Action in the Transport Sector

The quantitative diagnostics of the previous sections will feed *a scenario planning approach that will operationalize the Avoid-Shift-Improve-Resilience (ASIR) Framework in the parameters of the sector's emissions inventories.*[20,21] The objective of the policy analysis will be to construct potential climate action pathways for the transport sector; connect emissions diagnostics and climate action pathways to the emerging challenges, mobility needs, and policy priorities in each country; discuss consequential co-benefits from climate action pathways in transport; and identify opportunities for WB engagement in support of the country's climate action and suggest how the transport sector can best contribute to the country's Nationally Determined Contributions. Table 5 provides an indicative of ASIR policies that may be operationalized as part of transport sector climate action pathways.

[20] See, for example, section 8.10 "Sectoral Policies" of Chapter 8 "Transport" In *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_chapter8.pdf

[21] In the next iteration of the tools and approaches guidance note, the CCDR transport team will provide more detailed recommendations on how to construct climate action pathways for the transport sector.

Table 5. Illustrative list of transport sector climate actions that may be packaged into pathways for CCDR countries

Avoid	• Coordinate land use and transport planning to encourage co-location of housing and activities and reduce the need for passenger kilometers traveled • Redesign supply chain networks to reduce freight kilometers traveled • Expand digital connectivity, allowing tele-activities to replace passenger kilometers traveled
Shift	• Shift X% of bulk freight from truck to rail (or waterways) • Shift X% of long-distance passenger travel from road (car or coach) to rail • Shift X% of urban passenger travel demand to walking, bicycling, and public transport rather than private car through travel demand management and pricing policies (including fuel and vehicle taxes, road use charges, parking and curb use pricing, etc)
Improve	• Improve fuel-efficiency of X% of light-duty vehicles (including 2-, 3-, and 4-wheelers) through fleet renewal (motorization management) and/or electrification • Improve fuel-efficiency of X% of trucks (or truck ton-kilometers) and/or public transit buses on the road through fleet renewal to cleaner diesel or natural gas vehicles or shift to alternative fuels and powertrains (e.g., electric, hydrogen, etc.) • Improve fuel-efficiency of X% of rail ton-kilometers through electrification or hydrogen • Improve fuel-efficiency of aviation or maritime through use of low-carbon alternative fuels • Improve efficiency of logistics systems (particularly vehicle load factors) through digitalization and collaborative platforms
Resilience	• Consider system redundancy and alternative routes and systems • Improve operations and maintenance strategies to reduce climate change impacts • Use new technologies, materials, and digitalization to build resilience • Enabling environment: institutional and capacity building, policy, regulations • Be prepared with post-disaster response and recovery plans • Develop multimodal networks • Improve construction standards • Strengthen supply chains and change inventory management

Annex 4.8. Water

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This annex provides links to some of the tools and reports related to water security, water services, and mitigation that may be relevant for teams developing CCDRs. **A more detailed version of this annex is expected to be developed for the next version of the Tools and Approaches note.**

Guidance to incorporate water in CCDRs

The main composition and proposed structure to include water within the CCDRs are shown below (a detailed description of this guidance is found here):

Several global databases have been assembled in Power BI reports[22] with basic information at the country level to enforce the water and climate narrative. In addition, key relevant information has been extracted from the Intergovernmental Panel on Climate Change (IPCC) 6th Assessment Report and included in the above-referenced Power BI reports.[23]

[22] Power BI reports are available at the Water & Climate GSG workspace: https://app.powerbi.com/groups/8d1182fe-ff1d-4509-b865-f00e049e6e23/list.

[23] Thus far it incorporates information from the IPCC 6th Assessment Report Working Group 1 (Physical Science). The reports from Working Group 2 (Impacts, Adaptation, and Vulnerability) and Working Group 3 (Mitigation) are anticipated to be released in early 2022, and when this happens, we will add data and information from these reports to the Power BI platform.

Teams are advised to structure the water narrative within three building blocks: i) Setting the stage, why does water matter for climate change?, ii) Setting the impacts of water on the emissions reduction agenda; and iii) Setting the impacts induced by climate change: How will climate risks impact on water?

Building Block	**Main topics and discussion points**
Setting the stage, why does water matter for climate change?	***General context***: water as a gateway to climate, water availability, use, management and storage, quality and sanitation ***Economic growth is thirsty:*** water as transectorial connector, the centrality of water for economic growth, role of water for energy security and green energy, water and the industry, commerce and exports, water and job creation, water for urban development **Role of water and human capital accumulation:** water as a risk to economic and social development, water related diseases and mortality, role and SDG achievement **The value of water:** role of water in sustaining the environment and ecosystem services, the role of water in cultural and religious practices
Setting the impacts of water on the emissions reduction agenda	**Water services and energy use:** water-related GHG emissions, water-energy-food nexus and virtual water, wetlands and water uses, water efficiency and water savings, fuel type for the water sector, circular economy, protection of watersheds, climate and water smart agriculture
Setting the impacts induced by climate change: How will climate risks impact on water?	**Managing climate risks is about adapting to a changing hydrological cycle:** Align to physical impacts, primary channels through which climate impact water, infrastructure disruptions, food and waterborne infections, impacts of water risks to climate mitigation agendas, costs of extreme events, change in water requirements for crops, bases for resilient strategies **Setting the opportunities:** Water as a connect to achieve mitigation and adaptation outcomes, support of water to a low-carbon transition, water and inclusive decision making, modernization of infrastructure, innovations and technologies, protection to societies and ecosystems, coastland protections, and others.

The following indicators are suggested to be used as a basis for the sectorial evaluation (these are preliminary, and a fully updated list will be shared in the next version):

Precipitation	Mean annual temperature (mm)
	Accumulated annual precipitation (mm)
Levels of Water Stress	Freshwater withdrawal as a proportion of available freshwater resources (%)

Variability of Water Supply	Level of interannual variability
	Seasonal water Variability
Water Withdrawals per source	Water withdrawals - surface water (%)
	Water withdrawals - groundwater (%)
	Water withdrawals - reuse (%)
Water Withdrawals per sector	Water withdrawals - Domestic (%)
	Water withdrawals - Industry (%)
	Water withdrawals - Irrigation (%)
Transboundary Aquifiers	Number of transboundary aquifiers (number)
Area under irrigation	Area under irrigation (ha)
Water Infrastructure	Number of dams (number)
	Total dam capacity (m3)
	Area equipped for irrigation (ha)
	Area equipped for irrigation potential (% irrigation potential)
	Electricity produced by hydropower (%)
Water supply access	Population access to safely managed water supply (%)
	Population access to basic water supply (%)
	Population access to limited water supply (%)
	Population access to unimproved water supply (%)
Sanitation access	Population access to safely managed sanitation (%)
	Population access to basic sanitation (%)
	Population access to limited sanitation (%)
	Population access to unimproved sanitation(%)

Additional sub-sectorial resources and detailed diagnostic and decision making tools include:

Water Security/Water Resources Management
Water Security Diagnostic
Confronting Climate Uncertainty in Water Resources Planning and Project Design: The Decision Tree Framework

Water Services
Building the Resilience of WSS Utilities to Climate Change and Other Threats: A Road Map
Resilient Water Infrastructure Design Brief
Resilience Guidelines for Hydropower
Utilities of the Future
City-Wide Inclusive Sanitation
Farmer-led Irrigation Development

Water and Mitigation
GHG Accounting Tool for Water Projects
Thirsty Energy (water and energy tradeoffs)
A Primer on Energy Efficiency for Municipal Water and Wastewater Utilities
Solar Pumping: The Basics

Annex 5. Institutional and Social protection assessments

Annex 5.1. Climate Change Institutional Assessment (CCIA)

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The Climate Change Institutional Assessment (CCIA) identifies the strengths and weaknesses of the institutional framework for addressing climate change. The CCIA can be used by countries at all income levels and stages of development in their climate change institutions. The CCIA complements diagnostics that focus on the private, financial, and real sectors. The audience for the assessment is officials of center-of-government agencies responsible for policy, planning, and finance, agencies with leading roles in climate change policy, and inter-ministerial climate change bodies.

The CCIA can be applied in whole or in part, depending on client interest. The first step is a desk review, which takes about a month. The desk review guides dialogue with the government to determine the scope of more in-depth analysis. The second step involves interviews with government and non-government actors. This can take between two and four months, depending on data availability and the scope of issues covered. The outcome is a prioritized list of recommendations for action. The CCIA does not score or rank countries. Governments may use CCIA findings to inform Nationally Determined Contribution updates and long-term climate strategies. The World Bank can use the CCIA to inform the design of budget support and investment operations, as well as ASA.

The CCIA is currently being applied in Argentina, Central Africa Republic, Dominican Republic, Ecuador, Mexico, Panama, Paraguay and Uruguay, with immediate plans for Ghana, Jordan and Uzbekistan. CCIAs are prepared by small teams of Bank staff and local Short-Term Consultants.

Table 6: Scope of the CCIA [24]

PILLAR 1. Organization	PILLAR 2. Planning	PILLAR 3. Public Finance	PILLAR 4. Subnational Governments & State-Owned Enterprises	PILLAR 5. Accountability
Regulatory framework	Long-term strategy	Public financial management	Functional assignment, coordination, & capacity	Access to climate information
Functional mandates	Medium-term strategy	Public investment & asset management	Strategic & land use planning	Stakeholder engagement
Government coordination	Risk and vulnerability	Public procurement	Subnational climate finance	Independent expert advice
Technical capacity	Development Planning	Climate finance	State-owned enterprises	Legislative body
	Monitoring, reporting, & verification			Audit
				Judicial review

Annex 5.2. Stress Testing Social Protection: A new tool to assess the adaptiveness of national social protection systems

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[24] The issues covered are summarized here with detailed assessment questions contained in an underlying questionnaire. Complementary diagnostic tools allow for in-depth analysis in specific areas.

Objective: The Social Protection System Stress Test is a tool to assess the adaptiveness of social protection systems in a simple, robust and systematic manner, focusing on their ability to respond to climate and other covariate shocks. Rather than 'ranking' a country's adaptive social protection (ASP) system, the tool is designed to identify gaps, areas for improvement, investments in key design and delivery dimensions, and to serve as a foundation for building policy dialogue. It will provide guidance to governments and other stakeholders on where and how to strengthen ASP systems. It can be applied by governments, World Bank staff, and development and humanitarian partners.

Rationale: There are large, untapped gains in conducting a systematic ex-ante stress test for social protection based on a country's climate and natural disaster risk profile. The stress test assesses a country's ASP system, relative to this risk profile, through an analytical process which provides quantifiable and measurable understanding of national capacities to scale up in anticipation of and in response to climate and other shocks. By identifying gaps, it can guide investment priorities in building capacity for crisis and risk management, while also enhancing accountability (i.e., a low stress test score may inform or activate a process of investing in better crisis preparedness). It uses a holistic approach that accounts for financing, disaster risk management, and social protection to emphasize the multidimensional nature of crisis and risk management and the need for strong national structures and coordination. It can help identify entry points for humanitarian interventions in national structures and compel greater convergence and coordination between government and humanitarian partners, thus limiting parallel mechanisms to only necessary cases.

Tool structure: The Stress Test tool comprises of two parts: The first part gives an empirically-based estimate of the number of people affected by varying intensities of climate and other shocks, while the second part assesses whether the system has sufficient capacity to adequately reach all those affected by these shocks. The second part reflects the four building blocks of an adaptive social protection system (institutional arrangements; data and information; finance; and delivery systems) and includes a limited and focused set of less than 50 questions with quantitative and descriptive responses. Responses to each question are ranked on a scale from 1 (nascent) to 5 (advanced). Each question would elicit an informed, evidence-based conversation and dialogue on where/why the country falls on the spectrum from 1 to 5 and how to make progress toward a more advanced system. The stress test results in a focused summary report and associated dissemination material.

Application: The tool can be deployed as stand-alone and/or as part of World Bank core diagnostics like the Country Climate and Development Report. Due to its focused nature, its application is straightforward and time efficient. The tool is intended to complement other tools available to governments to assess their social protection systems by providing a snapshot overview of the "scalability frontier" of a given country. The stress testing tool is: (i) relatively short and concise (e.g., part 2 features less than 50 questions); (ii) places an emphasis on shocks; and (iii) is dynamic in nature, including different risk and needs-generation scenarios.

The tool was developed by a World Bank team comprising of colleagues from several global practices (SPJ, FCI, POV) and regions (AFW, LAC, SAR) working collaboratively to bring together a variety of experiences. It is currently being tested in different country contexts (Sahel, Southern Africa, South Asia).

Annex 5.3. Considering National Environmental and Social Impact Assessment (ESIA) Systems in CCDRs

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National environmental and social impact assessment (ESIA) systems[25] are well-established mechanisms to assess and mitigate the environmental and social impacts of projects and policies. While the Paris Agreement, Nationally Determined Contributions (NDCs), and national laws provide the legal and policy framework for climate action, national ESIA systems are a proven, low-cost, and high-impact tool to test and assure the "climate readiness" of projects, such as those in the infrastructure, energy, agriculture, water, and health sectors. Applied at a policy level, such as through strategic or sectoral environmental assessments, ESIA systems can link a project's planning to the country's framework to promote climate-resilient and low-carbon economic development. It therefore comes as no surprise that now, more than ever, countries are turning to ESIA systems to integrate climate change considerations in project design, assessment, approval, and oversight.

In Ethiopia, the Bank is supporting the government's efforts to strengthen the national ESIA system to better account for proposed projects' climate resilience, and to align individual projects with national and international climate goals. The strengthening of the national ESIA system was a prior action for a $3 billion DPF series focused on macroeconomic development and PPPs. The strengthened ESIA system is expected to better account for proposed projects' climate impacts and resilience and their alignment with Ethiopia's Climate-Resilient Green Economy strategy. For IPF projects, the Bank's ESF also offers an entry point for country engagement on the climate proofing of projects, since it requires the consideration of climate risks and impacts in due diligence for Bank-financed investment projects. Examples of assessments under the ESF that could provide relevant analysis on ESIA systems and climate include an Overview Assessment that examines a Borrower country's existing ESIA system at a strategic level outside of Bank-supported projects, and an assessment of a Borrower country's ESIA system in relation to a Bank- supported project. CCDRs can also make use of data and analysis from Country Environmental Assessments.

Beyond Ethiopia, several other countries have also shown particular interest in the use of national ESIA systems as a tool to incorporate climate change in project design and screening. Some have included ESIAs as a tool to adapt to climate change in their National Adaptation Programmes of Action and National Communication on climate change to the United Nations Framework Convention on Climate Change secretariat.

Despite this critical link between climate goals and ESIA systems, there is relatively little practice and guidance, in both developed and developing nations, on how to integrate climate change into ESIAs. Canada is one of the few countries with over two decades of experience in utilizing their ESIA system to address climate change impacts at the project design and implementation phases. The country has documented several successful case studies in the energy, extractives, water, and urban development sectors. For example, a 150MW hydroelectric powerplant project in British Columbia explored potential impacts of climate change on aquatic ecosystems and transmission lines through the ESIA process. In doing so, the project design was altered to incorporate mitigation measures such as adjusting tensions in the transmission line to accommodate a temperature rise and protecting riparian zones from potential effects from faster runoff.

Strengthening national ESIA systems to account for climate impacts through the Country Climate & Development Report (CCDR) will have a multiplier effect beyond Bank-financed projects. National ESIA systems can be integrated as a core element of CCDRs, especially in the following sections of the CCDR outline:

- CCDR Section 2.2 on Existing policies for resilience and risk management which already points to the importance of ESIA systems with the questions: "Do the country's environmental and social impact assessment regulations cover climate risk and climate resilience? How effective is the system overall?", and

[25] A national system for ESIA includes the regulatory environment such as policies and legal and institutional frameworks, the capacity of actors and organizations, and the quality of a set of core functions necessary to effectively address environmental and social risks and impacts.

- CCDR Section 4 on Selected policies that "are expected to put the country on a path toward resilient and low-carbon development," and link their "proposed policy packages to possible paths toward resilient and low-carbon development."

The CCDR can assess the extent of integration of climate change considerations in national ESIA systems and recommend legal and policy reforms. The Bank already does this in an ad-hoc fashion, whether as part of DPFs like Ethiopia or as part of technical assistance focused on strengthening ESIA systems in Mauritania, Togo, Turkey, and Peru, to name a few recent examples. Considering ESIA systems as part of the analysis that underpins CCDRs would systematize and scale up a Bank service with tangible climate benefits. Following a diagnostic of the existing institutions and policy framework, CCDRs could identify possible reforms to, for example, require that proposed projects with significant climate change impacts assess, consult, report, and address such impacts through the ESIA process. Reforms might also entail developing sector-specific methodological requirements and guidance for project proponents to consider climate change impacts when preparing ESIA reports and developing environmental and social management plans. CCDRs can also help highlight the importance of tracking and reporting of relevant greenhouse gas information through national databases developed for monitoring and reporting of environmental and social impacts. Ultimately, these and similar reforms could take the form of legislative amendments (climate legislation or ESIA legislation), decrees, guidance, or implementation support, all of which could be supported through Bank-financed operations.

In sum, national ESIA systems are available in almost all countries and can support low-carbon, climate-resilient development; hence the need for identifying clear synergies with CCDRs. With carefully tailored adjustments, these existing ESIA systems can be turned into high-impact green growth planning tools. Proposing ESIAs to integrate climate considerations could also contribute to institutional strengthening, as many of them manage environment and climate change through a single ministry. Countries that do not have defined institutions for climate change impact assessments can therefore rely on their ESIA systems. In conclusion, incorporating national ESIA systems into the analysis that underpins CCDRs can foster opportunities for strengthening country efforts to minimize greenhouse gas emissions, account for climate impacts of new developments and promote a sustainable and just transition to a decarbonized economy.

The ESF ISU and LEGEN teams have assembled a sample of the literature to assist teams in incorporating climate considerations in ESIA systems as part of CCDRs.

- World Bank, Good Practices in National ESIA Systems: A Literature Review (2021) (forthcoming).
- Canadian Guidelines. Incorporating Climate Change Considerations in Environmental Assessment (National, Provincial–Ontario and Nova Scotia)
- Caribbean Community (CARICOM), Adapting to a Changing Climate in The Caribbean and South Pacific Regions: Guide to the Integration of Climate Change Adaptation into the Environmental Impact Assessment (EIA) Process (2004) (link).
- European Commission (EC), Guidance on Integrating Climate Change and Biodiversity into Environmental Impact Assessment, (2013) (Link)
- International Association for Impact Assessment (IAIA), Climate Change in Impact Assessment: International Best Practice Principles, P. Byer et al, Special Publication Series No. 8 (2012) (Link)
- Organisation for Economic Co-operation and Development (OECD), Incorporating climate change impacts and adaptation in Environmental Impact Assessments: Opportunities and Challenges. Agrawala S., A. Matus Kramer, G. Prudent-Richard and M. Sainsbury (2010) (Link).
- Columbia Law School, EIA Guidelines for Assessing the Impact of Climate Change on a Project, Sabin Center for Climate Change Law (website) (Link).
- London School of Economics and Political Science, Grantham Research Institute on Climate Change and the Environment (website) (Link)
- Institute of Environmental Management & Assessment (IEMA), Environmental Impact Assessment Guide to Climate Change & Adaptation (2020) (Link).

Annex 5.4. Land Governance Assessment Framework

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Principles

The Land Governance Assessment Framework (LGAF) is based on the key principle of a participatory process organized around a steering committee composed of local experts. The process is facilitated by a country coordinator who is a locally recognized and independent land expert with a broad network within and outside government.

The implementation of the LGAF starts with a country coordinator adapting the framework to the country context. The country coordinator then selects a team of technical experts for each of the framework's nine topic areas (see *Framework* section below). The coordinator also agrees with the ministry responsible for land matters on access to data and participation of government staff in panel meetings. The objective of the LGAF is to be constructive, rather than evaluative, and to be based on the evidence that already exists rather than on extensive new studies.

Technical experts prepare background reports that bring together available data and information and suggest ratings for each of a comprehensive set of 116 land governance dimensions. This report is then discussed thoroughly in daylong technical panels with knowledgeable stakeholders from the government, civil society, academia, and the private sector. The resulting policy recommendations are technical, rather than political, and are objective, replicable, and actionable.

The reports, panel documents, and agreed minutes are then synthesized in a country report that is publicly validated with results and recommendations presented to policy makers. The World Bank frequently organizes a high-level policy dialogue with the government to discuss key conclusions and policy recommendations.

Framework

The task of assigning a rating to each of the 116 dimensions is distributed among nine technical panels. Typically, these panels are comprised of between three and eight members who are subject matter specialists on different aspects of the relevant issues. The nine panels are organized around the following topics:

1. Land Tenure Recognition
2. Rights to Forest and Common Lands & Rural Land Use Regulations
3. Urban Land Use, Planning, and Development
4. Public Land Management
5. Transparent Process and Economic Benefit
6. Public Provision of Land Information: Registry and Cadastre
7. Land Valuation and Taxation
8. Dispute Resolution
9. Review of Institutional Arrangements and Policies

For a detailed explanation of the LGAF framework, see the LGAF framework overview and the LGAF country reports.

Structure and Scoring

Each of the 116 dimensions are rated on a 4-point scale (A to D, with A as good practice and D as weak practice). Expert panels rate these dimensions by selecting an appropriate answer among a list of pre-coded statements that draw on global experience. Depending on the country context, a few dimensions may not be eligible for scoring, or sub-dimensions can be added.

The LGAF scoring structure was developed on the basis of extensive interaction with land professionals and refined through pilot country case studies. The LGAF is not intended as a tool to rank countries; rather, the scoring is developed to guide discussion in-country and arrive at a consensus using objective criteria. Scores can be used to identify good practice in other countries.

For further details, see the LGAF Scorecard Template (English) (French). A compilation of scorecards for all LGAFs completed since 2013 is also available (XLSX).[26]

Process
The broad steps of the LGAF are:

1. Collection of qualitative and quantitative background information
2. Stakeholder panels to rate dimensions; invitation based on area of expertise
3. LGAF report with identification of priority policy areas for follow up
4. Validation of rankings and discussion of actionable policy priorities
5. Follow up with work plan

For an in-depth discussion of all aspects of the LGAF process and implementation, see Resources.

Annex 6. Macro-fiscal modeling

This section describes several of the macroeconomic and fiscal tools available to inform climate policy. The tools range from full-fledged economy-wide models with a global focus (ENVISAGE) and a country-level focus (MANAGE and MFMod) to excel-based tools that illuminate specific areas of interest (CPAT; MRIO; Financial Sector risk assessment models).

Determining which tool will work best for a country depends on the needs. The Carbon Tax Assessment Tool (CPAT) is a good starting point. It includes a wide range of data on carbon emissions, and associated pollutants. CPAT can be used to get a quick overview of the economic effects (including distributional effects) of carbon price interventions and subsidies. The Global CGE model (ENVISAGE) and the multi-regional input-output model (MRIO) are best suited to analyze the impacts, on a given developing country, of climate actions by other countries, notably for policies like the Carbon Border Adjustment Mechanism of the European Union, or the imposition of carbon taxes by major trade partners. The fiscal risk models can be used to evaluate the sensitivity of the domestic economy to transition shocks, such as sudden revaluations of firms' assets or revenue streams.

For a more detailed and whole of economy analysis, the macrostructural modelling framework (MFMod) and the dynamic computable general equilibrium frameworks (MANAGE) are the best suited tools. Models using the MFMod framework have the advantage of being relatively easy to use (especially for WBG country economists who are familiar with the standard MFMod). These models permit a coherent estimation of damages from climate change and allow an examination of policy alternatives considering economic and fiscal tradeoffs, with reasonable out-of-equilibrium behavior. Models derived from the MANAGE framework follow a similar whole of economy approach and allow for detailed analysis of tradeoffs. Typically, they have more sectoral details than the MFMod system. However, they are harder to work with and have weaker out-of-equilibrium dynamics.[27] Both macro models can be run in tandem with microsimulation models and the financial risk model to provide a fuller picture of economic and distributional impacts.

Annex 6.1. Macro Fiscal Model (MFMod) Framework

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The MFMod Framework comprises a standard online model used by country economists for their bi-annual MPO submissions, DPLs, CEM and Country Economic Updates; and a set of Country-specific models derived from it

[26] *The LGAF methodology underwent a revision in 2013 that expanded the number of dimensions from 80 to 116. A compilation of scorecards for LGAFs completed prior to 2013 is also available* (XLSX).
[27] Out-of-equilibrium dynamics is particularly critical to explore the impacts of shocks (like natural disasters or sudden implementation of policies).

(MFMod StandAlone (MFMod SA)). Country economists use either tool to (i) do projections; and (ii) run policy simulations: including fiscal and monetary policy simulations, exchange rate risks, and fiscal rules.

The MFMod SA models can be built as climate-aware models, supporting a full range of macroeconomic and climate scenarios and policy analysis.

Climate features

Climate features embedded in single-country standalone models include: a modelling of how economic activity affects climate, and how the climate affects the economy. They also include natural capital accounts and simulations regarding mitigation (including the impacts of border carbon adjustments), and adaptation policies.

- **Greenhouse Gas (GHG) emissions** tracked in the models include those from fossil fuels, agriculture activity and transportation as well as mechanisms by which policy (principally tax, and regulatory) can affect these.
- **Economic damages from climate change** such as increased incidence and/or severity of extreme weather events (droughts, floods, and hurricanes) and the impacts of higher temperatures and increased variability in precipitation on agricultural and labor productivity and human health are also included.
- **Adaptation to climate change** is modelled in a more rudimentary fashion. Adaptation reflects limited information on the benefits of specific interventions. Parametrization requires inputs from outside of the model typically coming from country- and sector-specific studies providing estimates of the expected damages averted from the specific measures being considered.

Scenario Analyses

The economy-wide nature of the models permits the exploration of a wide range of policy options, including the sensitivity of results to: alternative approaches to financing and revenue recycling, the sectoral make up of an economy; and the degree of informality observed.

An important strength of the MFMod SA system is its ability to track the out-of-equilibrium behavior of the economy. This makes it a preferred tool when the transition path from a climate or policy shock is of particular interest. As with the CGE model, its careful respect of budget and physical constraints in the economy allow for an evaluation of climate effects side-by-side with other policy priorities such as economic growth, inflation, unemployment, and current account and fiscal sustainability.

Models can be paired with a microsimulation model (Global Income Distribution Dynamics) to explore distributional impacts.

Four distinct types of scenario analysis can be performed:

a. **Climate scenarios**: In these scenarios, the sensitivity of the economy to alternative global climate scenarios (derived from ICCP RCP and SCP scenarios) can be generated, implicitly measuring the economic cost of policy inaction.
    a. Outputs focus on economic damages in the form of reduced labor and agricultural productivity.
    b. Health impacts (and health spending impacts) of increased incidence of extreme heat days as well as those associated with the pollution from GHG emissions.
    c. Impacts of extreme weather events (hurricanes and other wind events, droughts, wildfires) on productive capital and output.
b. **GHG mitigation scenarios:** Explore the aggregate economic effects (GDP; household welfare; fiscal and trade competitiveness impacts) of alternative strategies of decarbonization or non-carbonization (Carbon Taxes; Emissions Trading schemes, Regulatory approaches).
c. **External policy shocks:** The domestic impact of external climate policies like border carbon adjustments can also be explored.
d. Adaptation **scenarios:** These are the most challenging type of scenarios due to limited information about the degree of protection that specific investment provide against climate damages.

Risks

Data availability represents a challenge to building a robust climate model for a given country. For most countries adequate data on emissions and the sectoral composition of the economy exists. International data on the most important damages also exists. A good input-output table is needed to accurately model mitigation policy. Data on the cost effectiveness of adaptation is the most difficult to find, complicating the modelling of these interventions

Scaling up bandwidth within the modelling team to meet the expected demands in support of the CCDR and other climate related initiatives is the main risk to the implementation and deployment of this tool. Building all the channels into a single country model requires significant time and testing. Additional time constraints are placed on modelers regarding designing, analyzing, and reporting results. If MTI staff absorb the model and are able to run the model, then this risk can be mitigated.

Upcoming workplan and training of staff

The modelling group's workplan includes an extensive program to extend and increase the precision of the climate features included in the MFMod SA framework. Areas of focus include, improving the modeling of stranded assets, and the linkages between energy systems and pollution. Work is also underway to explore linkages between the macro model and the financial sector stress testing work of the FCI and disaster risk management teams in the Bank and IFC.

Given the familiarity with MFMod within the World Bank, MTI staff should be able to use the model with little training beyond that needed to cover the climate. The modeling unit may also assist country teams, but this will depend on the availability of staff members to react to requests.

Costs

Depending on the features and modelling team support required, costs can range between $15,000 (standard model with emissions and mitigation and damage functions for which data is readily available from international sources) and $80,000 for a more involved model with unusual data requirements and extensive simulation exercises. Training will escalate the costs beyond these estimates. Depending on availability, it typically takes between 2 and 4 months to build a standard model and produce results.

Annex 6.2. The MANAGE (single-country dynamic CGE) Modelling Framework

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The World Bank's Mitigation, Adaptation, and New Technologies Applied General Equilibrium (MANAGE) Model is a (recursive) dynamic single country CGE model designed to focus on energy, emissions, and climate change. The model covers all real sectors and agents in an economy as well as their interactions. The model relies on behavioral equations based on the economic theory that allows to capture a rich set of underlying dynamics. The MANAGE model is currently used in various countries for supporting regular bank products such as Flagship reports, PERs, PFRs, CEMs and economic updates as well as analytical support for operations.

NOTE: MANAGE and MFMod can explore the same type of scenarios, impacts, and policies. However, MANAGE can represent many sectors and their interactions, while MFMod has a simpler representation of the economic structure but a more sophisticated representation of the economic dynamics, as well as monetary and fiscal components.

Climate features

MANAGE is tailored to analyze macroeconomic impacts of mitigation and adaptation policies. Climate features embedded in single-country standalone models include: a modelling of how economic activity affects climate, and how the climate affects the economy.

- **Greenhouse Gas Emissions** due to economic activity are tracked via rich energy sector specification where fields of varying carbon intensity can be combined to produce energy. Other sectors including

transportation, household heating and industry consume energy and generate emissions. Agriculture and industry are also sources of GHG emissions tracked in the system.

- **Economic damages from climate change** due to rising temperatures and changing weather pattens are included in the model. Main channels comprise such as increased incidence and or severity of extreme weather events (droughts, floods, and hurricanes) and the impacts of higher temperatures and increased variability in precipitation on agricultural and labor productivity and human health are also included.
- **Adaptation to climate change** is modelled in a more rudimentary fashion. Adaptation reflects limited information on the benefits of specific interventions. Parametrization requires inputs from outside of the model typically coming from country- and sector-specific studies providing estimates of the expected damages averted from the specific measures being considered.

Scenario Analyses

As a general equilibrium system, the MANAGE system allows for climate scenarios and policies to be evaluated in a context where budget constraints, fiscal sustainability and other policy priorities can be taken into account. Distributional issues can be addressed by incorporating into the model different household types or regions. In addition the models can be paired with a microsimulation model (Global Income Distribution Dynamics).

Four distinct types of scenario analysis can be performed:

a. **Climate scenarios**: In these scenarios, the sensitivity of the economy to alternative global climate scenarios (derived from ICCP RCP and SCP scenarios) can be generated, implicitly measuring the economic cost of policy inaction. Outputs focus on:
    a. Economic damages in the form of reduced labor and agricultural productivity.
    b. Health impacts (and health spending impacts) of increased incidence of extreme heat days as well as those associated with the pollution from GHG emissions.
    c. Impacts of extreme weather events (hurricanes and other wind events, droughts, wildfires) on productive capital and output.
    d. impacts of rising sea levels on output and productivity
b. **GHG mitigation scenarios:** Explore the aggregate economic (GDP; household welfare; fiscal and trade competitiveness impacts) and distributional effects of alternative strategies of decarbonization or non-carbonization (Carbon Taxes; Emissions Trading schemes, Regulatory approaches). Associated improvements in labor productivity and lower healthcare costs due to reduced i pollution levels are also tracked.
c. **External policy shocks:** The domestic impact of external climate policies like border carbon adjustments can also be explored.
d. Adaptation **scenarios:** These are the most challenging type of scenarios due to limited information about the degree of protection that specific investment provide against climate damages.

An important strength of the MANAGE system relative to the MFMod SA system is the level of disaggregation that it is able to incorporate. Standard versions include more than 50 different sectors and a similar level of commodity and service activities. This allows for a more granular identification of winners and losers in scenario analysis.

The framework is highly customizable so additional mitigation options, damages or adaptation measures can be introduced to the model depending on data availability and their importance at the macroeconomic level.

Risks

a. Data: MANAGE model relies on Social Accounting Matrix (SAM) as the main data source. Building a SAM is a complicated task that requires reconciling various data sources (e.g. Input-Output tables, the balance of payments, trade, government accounts, and microdata for households and labor).
b. The data required to calibrate the damage and adaptation functions follows from country specific studies when available. Otherwise they are taken from the global studies. In any case a careful analysis of these studies is needed to be able to use their findings in parametrization of damage and adaptation functions.

Upcoming workplan and training of staff

The work plan for the coming FY will focus on streamlining the SAM building process as well as improving the model's treatment of emissions, damages, and adaptation. Introducing air pollution, new damage channels and adaptation options other than investments, improving and standardizing the calibration of damage functions are among the most important development plans.

Costs

Depending on the data availability and policy options to be modelled costs can range from 40K for standard mitigation and adaptation policy analysis (e.g. simulations listed above) to 100K for a more detailed exercise with unusual policy components that would require changes in model structure. Time to build the SAM and the model for a standard analysis is around 6 weeks while analysis of complicated policies might take up to 15 weeks.

Annex 6.3. Carbon Pricing Assessment Tool (CPAT) v1.0

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The Carbon Pricing Assessment Tool (CPAT) is a spreadsheet-based tool to provide rapid estimation of effects of carbon pricing and fossil fuel subsidy reforms along several economic and non-economic dimensions. These include key macroeconomic variables, energy consumption, local and global pollutants, 'development co-benefits', distribution/equity and poverty. Its objectives are to:

- Help decision-makers and analysts do quick diagnostics on the potential benefits from explicit carbon pricing and fossil fuel subsidy reforms to inform SCDs and other country strategies; and
- Provide first estimates of benefits across different dimensions (from tax revenues to health) to start an engagement with country counterparts and identify areas where more in-depth analyses are needed or promising.

CPAT is being developed by the World Bank in partnership and with contributions from the IMF. Background research for the various channels modeled has been completed by the CPAT team, notably through the studies "Benefits beyond Climate" and "Getting Energy Prices Right".

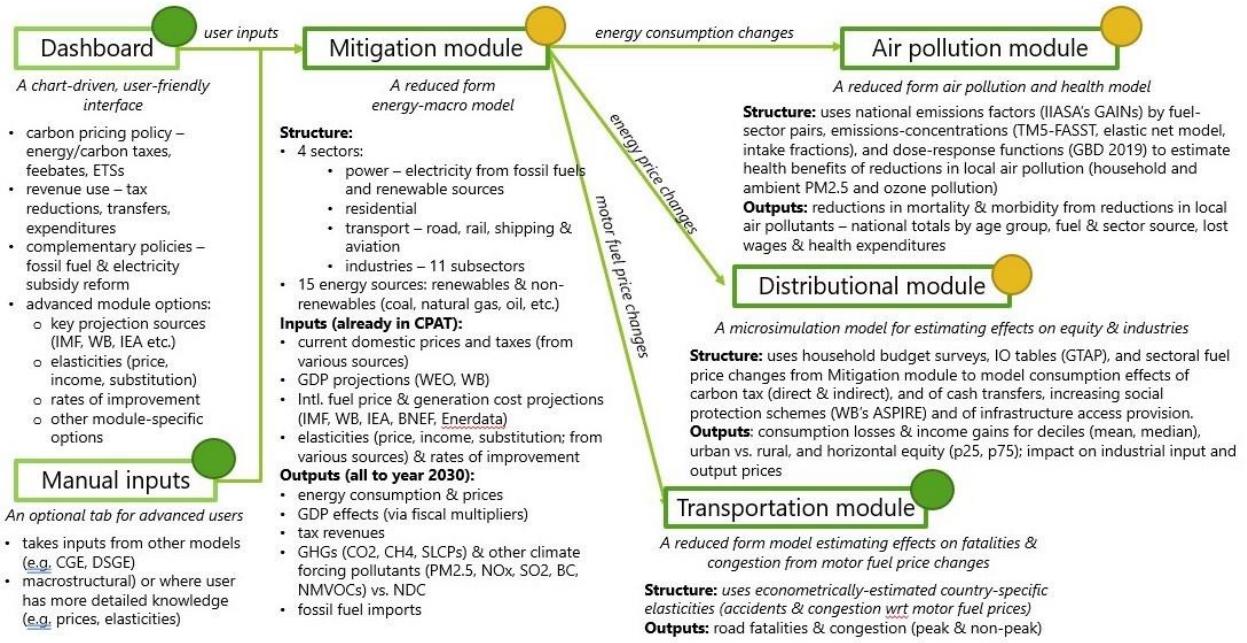
The CPAT tool is primarily a dashboard. It allows the user to input choices regarding the policy under investigation (such as a carbon tax trajectory, with different options for exemptions and recycling of the revenues) and modeling choices (e.g., choice between different data sources). The tool produces a series of assessments and visualizations of the impact of the policy scenarios on several dimensions including:

- Mitigation and energy efficiency (i.e., the reduction in GHG emissions, changes in energy consumption)
- Macroeconomic and fiscal aggregates (GDP, tax revenues)
- Air pollution and health (concentration, but also mortality and morbidity)
- Transport (road fatalities and congestion)
- Distributional impacts (per income decile, but also urban/rural, and industrial outputs)

A schematic view of the tool is provided in Figure 18 below. It is expected that the tool will be used to explore various policy options, either in an interactive way, or to create country-specific document (see the example on China below).

The tool is calibrated for 150 countries, but users are advised to remain cognizant of data issues, which can affect the quality of the assessment. The distributional module is more limited, as it depends on specific treatment of household surveys. This module is currently available in 33 countries, but additional countries will be continuously added over time.

Figure 18: Schematic view of CPAT



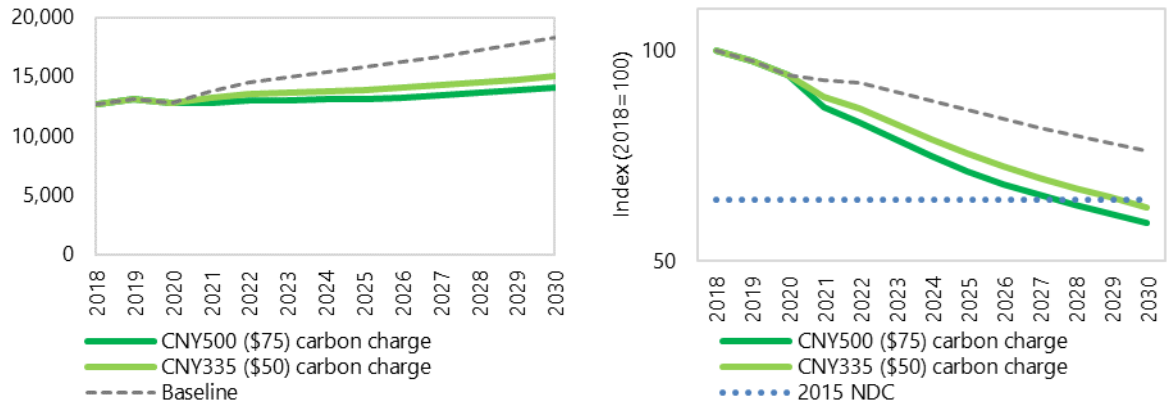
Illustrative use case – Carbon charges in China

For assessing the potential of carbon charging in China, two potential designs were considered. First, a 'moderate carbon charge' (RMB170/US$25 per tCO_2 in 2021, rising to MB340/US$50 by 2030, based on current exchange rates) and a 'strong carbon charge' (RMB340/US$50 per tCO2 in 2021, rising to RMB500/US$75 by 2030). The figures below illustrate the impact on emissions, tax revenues, distributional effects, and prevented deaths thanks to air quality co-benefits.

Limitations

CPAT is not meant to replace detailed analysis at the country level, but to support engagement and diagnostics by providing first estimates, and easy comparison across countries and scenarios. In its current version, the tool is expected to be used by the CPAT team, working with and for country teams, but checking results on a case-by-case basis. The tool offers the possibility of using different sub-models or assumptions (e.g., regarding air pollution or fiscal multipliers). After extensive testing in country studies, it will be possible to transfer the tool to country teams.

Figure 19: China's emissions: total GHGs excl. LULUCF (left) and indexed emissions vs. 2015 NDC (right)



Note: Excludes GHGs from land use, land use change, and forestry (LULUCF). NDC target (crossing the blue dotted line) is an intensity of GDP target of 62.5% reduction by 2030 compared with 2005.

Figure 20: Total fiscal revenues from fossil fuels for moderate (left) and strong (right) carbon charge regime

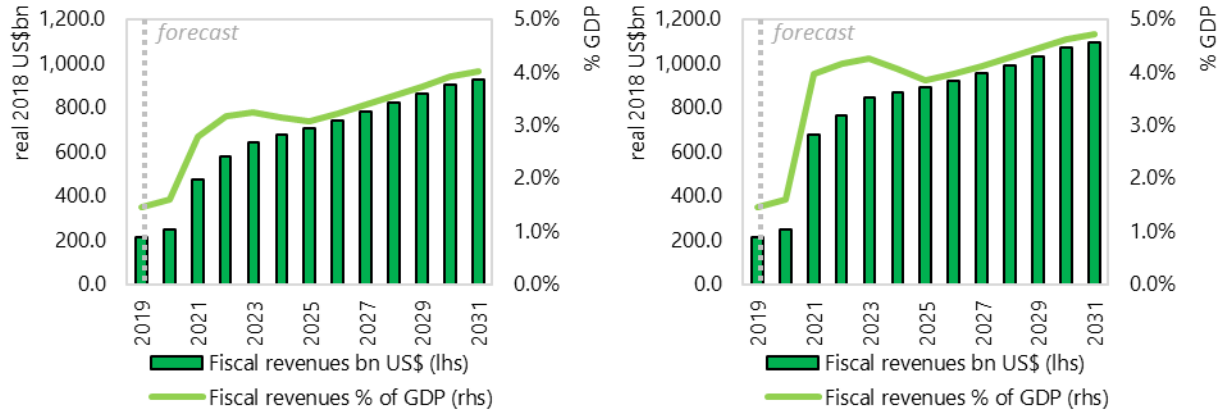
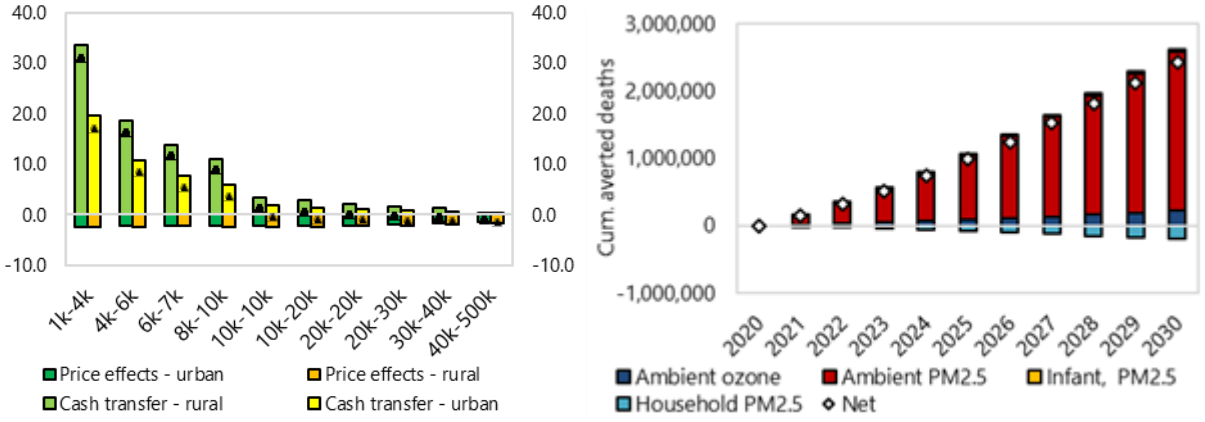


Figure 21: Larger relative gains for rural Chinese: relative loss in consumption by direct and indirect price increases on urban and rural deciles as % pre-policy consumption in 2022, and effects on averted deaths



Annex 6.4. Climate and Disaster Risk Finance Diagnostic

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Background: The World Bank's *Crisis and Disaster Risk Finance* team supports governments in strengthening their financial resilience against disasters and climate shocks. It offers a suite of analytical, advisory, convening and financial services to help vulnerable countries shift from being crisis responders to become proactive risk managers through developing or strengthening pre-arranged finance and (shock-responsive) systems to enable earlier action that can save lives, reduce costs and humanitarian needs, and protect development gains against disasters, climate shocks and crises.

Objective: The Climate and Disaster Risk Finance (CDRF) diagnostic is one of the analytical and diagnostic tools of the CDRF team. It aims to analyze current level of financial preparedness of a country and identify policy reforms and investments to strengthen pre-arranged finance for efficient disaster response:

- **Pre-arranged financial resources to respond to climate shocks, disasters, and crises**, embedding financial resilience to disasters and crises in the macroeconomic policy and fiscal planning efforts of countries

- **Financial markets for risk finance,** building stronger and more stable domestic financial markets so countries (government, businesses, and households) can reduce their protection gaps
- **Financial disbursement mechanisms across sectors,** identifying and establishing shock-responsive systems and measures that will enable timely and effective funding for post-disaster response

Steps to conduct the CDRF diagnostic: The diagnostic is structured to:

1. **Quantify the economic, financial and fiscal impact of disasters and climate (physical) shocks,** through *holistic risk assessment* of broad range of peril types (e.g. climate shocks and natural disasters, humanitarian crises, pandemics) and with a focus on: Government's contingent liability (e.g. emergency response costs); Financial exposure (e.g. public infrastructure, SMEs, residential, agriculture); Financial sector stability (e.g. for central banks); Populations including the most vulnerable (e.g., adaptative social protection)
2. **Review existing risk finance strategy and mechanisms** to finance these costs and analyze their legal, institutional, and operational underpinnings
3. **Review domestic insurance and capital markets** for climate resilient risk finance instruments
4. **Estimate potential funding gaps**. The funding gap is the difference between the available government budget and the probable loss for a given event size

These different steps are supported and informed by a suite of risk finance analytics tools and can be complemented by additional steps, such as:

- **Case studies of recent disasters** to help better understand the bottlenecks and inefficiencies of post-disaster financing, as well as value-for-money of DRF instruments
- **Climate physical risk assessment** combining climate scenario identification with macro-economic modelling of sectoral impact and loss transmission channels across the economy
- **Financial exposure mapping exercise** to qualitatively understand hot spots and critical sources of financial vulnerability
- **Compound risk assessments** to explore the potential interactions between different types of crises and disasters (and in close interaction with the Global Crisis Response Platform)

See Figure 22 on how instruments reviewed under Step 2 and 3 are combined into a risk layering strategy and results of analyzing these in Figure 23.

Figure 22: Risk layering of different sources of funding. Source: World Bank, CDRF

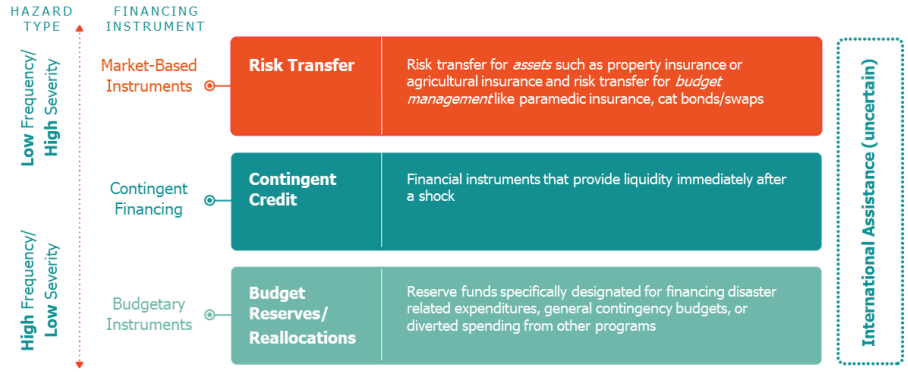
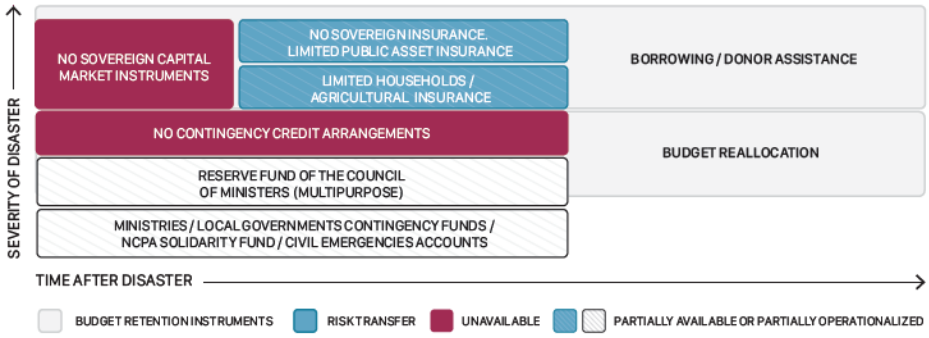


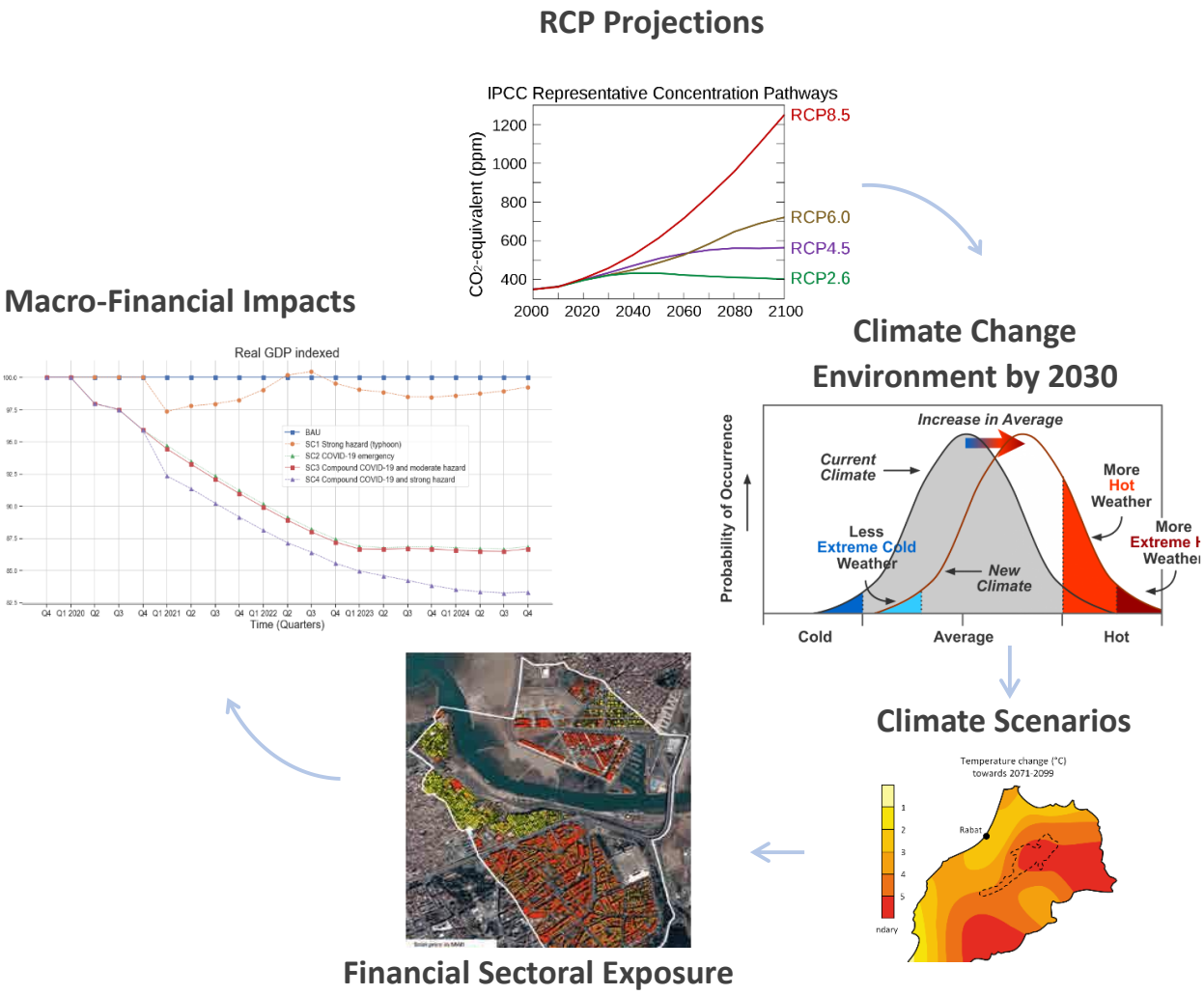
Figure 23: 2020 DRF diagnostic: Albania - results of reviewing the existing risk financing strategy



Practical considerations for development of the CDRF diagnostic:

- **Expertise:** It requires expertise in risk finance, combined with expertise in macroeconomics, public financial management, financial sector development, and governance.
- **Role of the government:** The diagnostic is developed for and jointly with Ministries of Finance, in coordination with disaster risk management agencies. Further consultations with the insurance regulator, Central Bank, budget department, fiscal department, and debt departments can help refine the diagnostics.
- **Coordination with other GPs:** This diagnostic is closely coordinated with other Global Practices (e.g., MTI, Governance, AG, PURL, SP&J) given the cross-cutting nature of this analysis.
- **Requirements:** This diagnostic is country and context-dependent and usually takes place over six months with a budget of $50-150k. It requires clients' involvement for most refined outputs. It is typically executed as a combination of a desk study, complemented with global and local expertise helping collect and interpret data.
- Analytics:
    - In case disaster data is unavailable (e.g., either historical loss or exposure information), specific procurements on risk modelling may be required.
    - There is a suite of analytics tools developed by the CDRF team openly available at:
        - http://149.28.228.221/apps/Tool1/
        - http://149.28.228.221/apps/Tool2/
    - The type of analytics required would depend on specific clients' needs, complexity of the peril types and data availability. For instance, climate physical risk assessments may imply identifying specific climate scenarios (e.g., defining the sequence of events from hazard occurrence to impact evaluation). This in-depth, peril-specific, sectoral evaluation would require multi-disciplinary risk assessment and contributions from various GPs.

Figure 24: Example: Climate Physical Risk Assessment in Morocco



Additional Resources: World Bank, Assessing Financial Protection against Disasters: A Guidance Note on Conducting a Disaster Risk Finance Diagnostic.

Annex 6.5. Financial Sector Risks and Opportunities Assessment

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Background: Financial sector authorities, such as central banks, financial regulators, and supervisors, play an important role in addressing climate change as (i) it can pose systemic risks to financial institutions, which need to be measured and addressed, and (ii) green objectives cannot be achieved without appropriate financial instruments and resources provided by the financial sector, as well as adequate incentives fostered by reporting and disclosure standards. The FCI *Financial Stability & Integrity and Long-Term Finance* teams support financial sector authorities in assessing risks and opportunities and in improving their regulatory and supervision practices. There is also close cooperation with the FCI *Crisis and Disaster Risk Finance* team on assessing physical risks.

Objective: The *Financial Sector Risks and Opportunities Assessment* covers both the resilience of the financial sector to climate-related risks (contributing inter alia to its ability to absorb and respond to disasters, see Annex 5.4 on the climate and disaster risk finance diagnostic), while at the same time better aligning capital allocation with the Paris

targets to limit global warming. It can be a stock-take of available analyses and regulatory requirements applicable to domestic financial sectors (with key gaps informing high-level priority recommendations), or go one step further and include for instance the conduct of analyses related to a financial system's exposure to physical and transition risks. These have different resource and time implications (see below).

Components:

- **Vulnerabilities to Climate-related Risks** identifies the relevant physical and transition risks the client country's financial sector faces. This can include qualitative descriptions and historical evidence of risks and scenarios, as well as quantitative elements, such as exposure mappings or results from sensitivity analyses and climate stress tests. It can also contain an overview of current financial sector practices with regard to climate-related risks.
- **Supervisory Response and Guidance** assesses actions that supervisory authorities have undertaken to address the identified climate issues in their supervisory frameworks and can provide guidance and recommendations on how to improve them.
- **Deepening Green Finance Markets** covers existing financial sector products and markets supporting climate objectives and identifies ways to stimulate green finance. It reviews the current financial sector regulatory framework, providing recommendations for green financial regulatory tools, incentives, and green financial instruments (green bonds, etc.)

Methodological approaches and resources:

In-depth assessments have been (or are being) conducted on a pilot basis in six countries[28], including four in the context of Financial Sector Assessment Programs, FSAPs (often jointly with the IMF). These exercises are highly resource intensive (especially stress testing exercises), require an intense mobilization of authorities, and could not realistically be conducted for a large number of countries over a year. Where such work has been conducted and is not covered by confidentiality requirements, it could provide the necessary input to the CCDR.

For other jurisdictions where such in-depth assessments will not be available (the most common case), a high-level analysis could be conducted based on a survey followed by focused interviews to shed light on the level of preparedness and maturity of a country's financial sector (and authorities) to approach its exposure to climate risks and its ability to provide solutions to contribute to the climate objective (in exceptional cases, conducting more thorough analyses could be considered). This would help frame high-level priorities and create momentum for authorities to take action in this important area.

Annex 6.6. Forward-looking MRIO Framework for sectoral labor demand, output & competitiveness effects of climate policies

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The price-dynamic Multi-Regional Input-Output (MRIO) tool is a user-friendly global model to rapidly analyze short- and medium-term sectoral output, labor demand and cross-border competitiveness effects of carbon fiscal reforms within and across countries. Quantifying the sectoral implications of induced low-carbon structural change is essential to inform climate change mitigation policies which are cognizant of both 'just transition' and competitiveness considerations. Introducing endogenous adjustments of production, consumption and trade into the input-output framework, the model predicts policy-induced shifts across a large number of sectors and across many countries. Based on the Global Trade Analysis Project (GTAP)-Power Data Base, the tool covers a total of 76 sectors across 141 countries and regions. Augmented with the Gender-Disaggregated Data Base (GDLD) as well as labor force microdata, the tool enables distributional employment analyses across income strata, skill levels, occupation types and subnational provinces, providing relevant information for active labor market and reskilling

[28] Philippines, Bangladesh, Trinidad and Tobago, South Africa, Colombia, and Morocco.

interventions, as well as sectoral or regional government support funds. The model has been used in country engagements such as the EU RER.

The model provides a tractable framework facilitating multi-country analyses and comparability of results. Its policy simulations allow the user to easily trace the relevant economic transmission channels determining results. Policy outcomes strongly depend on the sectoral composition of an economy, its integration along global value chains as well as on the specific design of the fiscal intervention. Estimates of sectoral output and employment multipliers of taxes and expenditures, therefore, consider price-induced adjustments, sectoral spillovers, bilateral trade flows and competitiveness effects. Carbon tax and green spending policies are often differentiated by energy fuel or agricultural commodity and by sectors, have unilateral or multilateral coverage and can include carbon border adjustments for trade-exposed sectors. The model's high sectoral resolution of energy inputs along domestic and global value chains facilitates a comprehensive, yet granular, representation of induced low-carbon macrostructural changes.

Granular green fiscal policy scenarios can be modelled simultaneously for all countries and all sectors:

a) **Carbon prices**: fossil fuel subsidy, energy, and agricultural tax reforms, differentiated by commodities, sectors and countries[29]
b) **Carbon Border Adjustments Mechanism (CBAM):** domestic carbon prices can be accompanied by border adjustments for user-defined energy-intensive trade-exposed sector, differentiated by sectors and countries for various global collaboration scenarios
c) **Labor tax reductions**: tax revenues can be used for labor tax cuts, differentiated by skill-level
d) Sectoral **public spending policies**

Model **outputs inform various metrics of interest** to support policy design choices:

- Sectoral **output multipliers** of tax and spending policies,
- Sectoral labor demand changes, or **employment multipliers** of tax and spending policies
- **Distributional effects**, differentiated by income, skill levels, occupation types and spatially, subnational provinces
- Sectoral **tax revenue collection**
- **Competitiveness** effects & changes in sectoral **imports & exports volumes**

The price-dynamic model relaxes the standard IO assumption of fixed technical coefficients as the model captures sectoral inter-fuel substitution, efficiency gains, final demand adjustments and trade adjustments. Considering price-induced adjustments, sectoral spillovers, bilateral trade flows and competitiveness effects, the model estimates advanced multipliers based on direct, indirect as well as induced effects. The MRIO framework is also well suited to represent trade dependencies. Trade flows are traced through the value added content of trade which conventional trade statistics are unable to quantify. Given that intermediate inputs account for about 2/3 of international trade, their MRIO representation may be more suitable.

Time and effort required

In its default parametrization, the model will facilitate ad-hoc global analyses without further data input needs.[30] These can be conducted by country economists or policymakers alike. For more in-depth country or regional analyses, informed country specialists are able to tailor various model parameters and data for their country through data template, such as the underlying sector-specific energy prices, and various price and labor elasticities. Augmenting the model with the latest available labor force microdata facilitates up-to-date estimations of distributional income, skill, occupation and subnational outcomes. Depending on the availability of data, the

[29] Carbon tax scenarios are in line with and informed by the Carbon Pricing Assessment Tool (CPAT).
[30] The tool will be available from mid-FY22.

complexity of scenarios (single or multi-country), and focus of the analysis, the overall project cycle can be flexibly adjusted to budgetary resources and project time. Analyses can take between one and five weeks. Interactions between the country team and the modeling team is required. Input and feedback from other GPs are welcome to calibrate the elasticities and design the scenarios.

Annex 6.7. The ENVISAGE global dynamic CGE Modelling Framework

The Environmental Impact and Sustainability Applied General Equilibrium (ENVISAGE) Model is a global recursive dynamic CGE model designed to assess the interactions between economies and the global environment. A set of non-linear behavioral equations is at the core of the ENVISAGE model, representing production and consumption choices of all key economic agents. The model relies on the Global Trade Analysis Project (GTAP) Data Base, covering 141 regions, of which 121 are individual countries. Global production is divided into 76 sectors with extensive details for agriculture, food and energy (coal mining, crude oil production, natural gas production and distribution, refined oil and various electricity generation technologies). Due to numerical and algorithmic constraints, a typical model is limited to some 20-25 sectors and 20-25 regions. The ENVISAGE model has been used in various World Bank reports and publications focusing on the Belt and Road Initiative, various free trade agreements (AfCFTA, CPTPP etc.), Reshaping of GVCs post COVID and others.

Climate features and policy scenarios

The Envisage Model is designed to analyze a variety of issues related to the economics of climate change:

- Assessment of the baseline emissions (CO2, non-CO2 GHG and air pollutant emissions)
- Impacts of climate change on the economy
- Adaptation by economic agents to climate change
- Greenhouse gas mitigation policies (taxes, caps and trade)
- The distributional consequences of climate change impacts, adaptation and mitigation at both the national and household level
- Assessment of the border carbon adjustment tax impacts

The **model provides a rich set of economic and environmental outputs**, including changes in welfare, GDP, output, producer and consumer prices, exports and imports, value-added by sectors, emissions/carbon prices, energy balances, etc. In order to study **the distributional impacts** of policy changes, we link the CGE simulations to micro-simulations based on household surveys under the Global Income Distribution Dynamics (GIDD) tool and using the Gender-Disaggregated Data Base (GDLD). This results in estimated impacts on poverty, income distribution by gender, skill level and employment (including at the sub-national level for selected countries).

Greenhouse Gas Emissions, including CO2 emissions from fossil-fuel combustion and industrial processes, as well as non-CO2 emissions from various economic activities are represented in the model. The model incorporates a flexible system for incorporating any combination of carbon taxes, emission caps and tradable permits.

Climate module that links greenhouse gas emissions to atmospheric concentrations combined with a carbon cycle that leads to radiative forcing and temperature changes. The model is set up to incorporate a feedback loop that links changes in temperature to impacts on economic variables such as agricultural yields or damages created by sea level rise (parametrization of the corresponding functions is required based on the regional or country-specific data).

Emissions of nine air pollutants are tracked in the model. Changes in air pollutant emissions can be further linked to the global atmospheric source–receptor model (TM5-FASST) for the assessment of a broad range of pollutant-related impacts on human health, agricultural crop production, and short-lived pollutant climate metrics.

Border carbon adjustment tax (BCAT) assessment module, which tracks CO2 emissions embedded into trade and allows for the country and commodity specific BCAT implementation.

Endogenous **coal, oil, and natural gas extraction module**, which mimics interactions between the fossil fuel supply curves and their depletion that ultimately drive the production of fossil fuel reserves and their market price.

A research and development (R&D) module incorporates R&D expenditures to the knowledge stock with a distributed lag structure. The knowledge stock influences an endogenous component of labor productivity growth.

The model allows for the **MRIO trade specification** with agent-based demand for imports by region of origin. In the standard model, a representative agent allocates import demand across regions of origin.

Scenario Analyses

1. NDC emission reduction targets following Chepeliev et al (2021) and Böhringer et al (2020). These targets are specified in the form of CO2 emission reductions in 2030 relative to the pre-COVID baseline scenario levels. It is assumed that countries implement carbon pricing policies to reach their NDC commitments and the model estimates the carbon price levels (for each region) consistent with these emission reduction targets. Longer-term climate mitigation options, e.g. for 2050 and beyond, can be also assessed by the model.
2. EU Green Deal mitigation plans to cut emissions by 55% in 2030 relative to the 1990 level (EC, 2019). This more ambitious emissions reduction policy in EU is achieved by further increase of carbon price in the model.
3. In addition to the EU Green Deal, the implementation of the Carbon Border Adjustment Mechanism (CBAM) is introduced. CBAM is implemented as an ad valorem equivalent tax imposed on region- and commodity-specific carbon content of imports to EU. The carbon price level that is used to determine the CBAM rate is estimated as the difference between carbon price in EU and the carbon price in the country/region of the imported commodity origin. Only imported commodities that correspond to the EU ETS sectors are assumed to be covered by the CBAM.
4. Various global collaboration scenarios such as regions achieving emission reduction requirements through regional action, i.e., regionally uniform CO2 prices, club trading with a number of countries linked through ETS etc. The ETS or sectoral focus of emission reductions can be adjusted as needed.

Risks

- Data: ENVISAGE relies on the GTAP data base, which covers 141 countries/regions. When available, the social accounting matrices for new countries can be added to the global data set.
- The data on emissions can be adjusted if country-specific information differs from that in the GTAP data base.

Upcoming workplan and training of staff

The workplan for the coming FY focuses on modeling country-specific implications of NDCs, the EU Green Deal and CBAM with an emphasis on trade and the resulting distributional impacts. In addition, at the global level the team plans to analyze various options for the design of CBAM to minimize the potential negative implications for developing countries. The team can train policymakers to become informed users of our analysis, but not to run the model themselves. However, GTAP Center could provide training to government counterparts or WB Colleagues.

Costs

Depending on the data availability and policy options to be modelled, costs can range from $25K (for the extension of an existing global application to cover a new set of countries) to $80K-100K to update the data set or cover new policy areas.

Annex 6.8. EITE Country Comparison Tool (under development) to identify sectors with potential exposure to international transition risk

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Context

Countries' exposure to international transition risks is increasing as the world takes action to decarbonize economies. If realized, international transition risks can reduce asset values and lower incomes. These risks are generally driven by action in other countries (e.g. mitigation policy) that impact on global markets through, for example, causing shifts in technology and fuel availability, as well as changes in trade dynamics from changing consumer preferences or tariffs on emissions-intensive goods. These shifts in international markets are further driven by countries' desire to reduce energy dependence and growing moves towards broader environmental sustainability throughout the supply chain e.g. circular economy efforts.

A tangible example of a transition risk is where a jurisdiction imposes a restriction or tariff on imported emissions-intensive products. This is the case in the EU where the European Commission is considering the use of a Carbon Border Adjustment Mechanism (CBAM), which would effectively put a carbon price on imports of certain emissions-intensive goods to the EU. The charge would reflect the emissions intensity of the exported good. Other jurisdictions, including Canada and the United States are also considering similar mechanisms.

Assessing Emissions Intensity and Trade Exposure

Two key determinants of the level of potential exposure to transition risks are: the level of exposure to international markets; and the emissions intensity of its trade-exposed sectors (relative to the emissions intensity in other countries). The Climate Change Group is developing an Emissions Intensity and Trade Exposure (EITE) Country Comparison Tool. It is a spreadsheet-based tool intended to provide a historical "snapshot" of the relative emissions intensity and trade exposure of key products. The results from this tool can be used to identify high risk areas and inform areas requiring more detailed analysis. A prototype has been developed, which provides a quick diagnostic, allowing users to identify:

1. Sectors that are large contributors to a country's exports (in trade value in USD).
2. The level of exposure of a sector's exports to a particular export market (e.g., the proportion of exports to the EU).
3. The emissions intensity of each sector, enabling a comparison of emissions intensities across sectors within a country (in tonnes CO2 per million USD)
4. The emissions intensities in other countries, enabling a comparison of emissions intensity for products/sectors across countries.

The tool provides a simple visual dashboard. Users can select the jurisdictions[31] and products/sectors for comparison.

Future Developments

It is anticipated that the scope of the tool will be expanded over time, as will the level of detail of the analysis and assessment. Priority updates include:

- An improved user experience, through additional automation and refining how countries/sectors are selected.
- Inclusion of additional data to enable the inclusion of additional metrics and visualizations, such as quantifying trade intensity $\left(\frac{Imports + Exports}{Imports + Production}\right)$ and identifying high risk sectors with large contributions to employment and tax revenue.

Limitations

The prototype of the EITE country comparison tool is based on 2014 GTAP emissions and production data and 2019 WITS trade data. The tool is not intended to be a substitute for detailed modelling and does not provide the level of detail required for an in-depth assessment of transition risks. For example, it does not provide an assessment of changes to trade flows (e.g., production/export declining in a certain region and how the shortfall might be met),

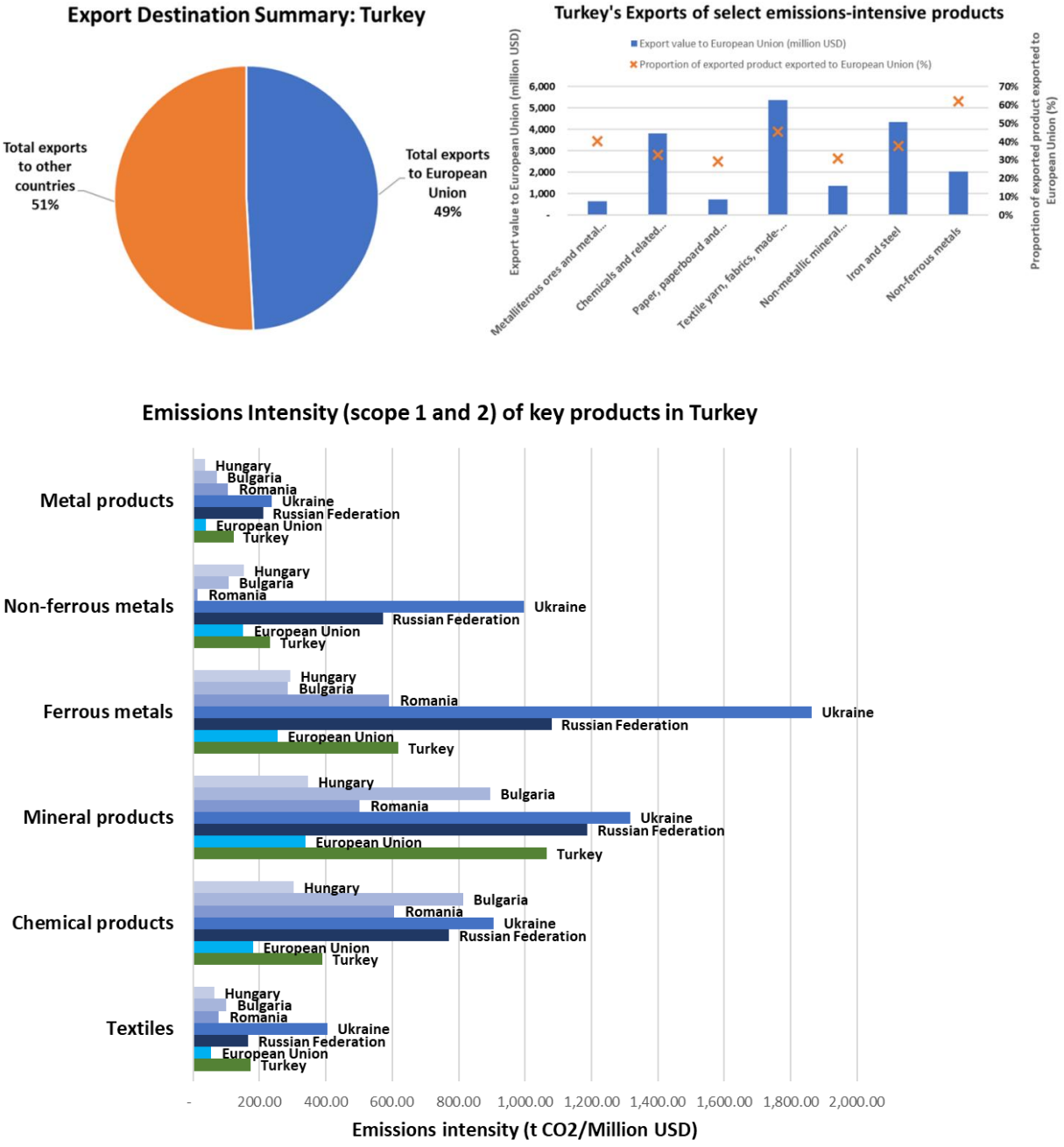
[31] The tool currently includes 140 countries and regional blocks

nor an assessment of broader domestic impacts (e.g., change in asset value, income/revenue impacts or the potential for stranded assets). Further, the limited nature of the data underpinning the tool highlights additional limitations, such as the relatively high level of product/sector aggregation (e.g. the emissions intensity of cement cannot be disaggregated from "non-metallic minerals"), and the need for simplified assumptions with regards to electricity consumption (particularly in relation to electricity imports). However, it provides a useful "light touch", initial assessment, which can be used to inform future areas of work.

Example

An example of the visualizations, based on Turkey as the primary country and the EU as the primary comparison, is provided in below.

Figure 25: Example – Turkey



Annex 7. Climate-Poverty modeling

Annex 7.1. Modeling the poverty impacts of climate change (Shock Waves model)

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This modeling exercise estimates the impacts of macroeconomic transformations and climate signals on household incomes, including poverty and inequality. Going beyond the "poor" and "near-poor" collectives, Shock Waves identifies (1) policy solutions for poverty relevant to mitigation agendas, and (2) the demographic groups most likely to be affected by climate change where it cannot be prevented.

Introduction:

Cost-benefit analytics of emissions pathways are commonly expressed in terms of national or global statistics such as GDP. These aggregate figures obscure heterogeneous impacts within countries, i.e. across classes and sectors, and therefore do not sufficiently capture the complex channels through which climate change and mitigation will impact people's well-being.

Using this microsimulation approach, the impacts of climate change on the poor and other vulnerable groups can be discerned. This tool has been used to estimate the impacts of climate change on poverty in 2030 in most countries in a 2016 report, and again for the 2020 Poverty & Shared Prosperity Report (background paper).

Model Description:

The *Shock Waves* approach combines household income & expenditures surveys (HIES) with development scenarios to project demographic, economic, and climactic trends into the future. By manipulating representative weights in the HIES, changes in population, education, sectoral productivity and growth, and redistribution are simulated. In terms of these parameters and their interactions, hundreds of development scenarios for each country are generated.

Future distributions of households and income are specified by the Shared Socioeconomic Pathways (SSPs). The SSPs are a set of five scenarios that describe plausible future scenarios. Each SSP is internally consistent in terms of changing demographics, human development, economies, institutions, technologies, and the environment, and collectively they are an exhaustive set of possible development trajectories relevant to the Twin Goals.

The SSP scenarios do not prescribe every dimension of future development. Most importantly, the SSPs do not specify the relative sizes of the agriculture, services, and manufacturing sectors within each country's economy, nor do they predict productivity gains in each of these sectors. By allowing unconstrained parameters to fluctuate randomly within a wide range of possible outcomes, we quantify their relevance to the Twin Goals, and identify the most important drivers of extreme poverty within each economy.

Finally, we model the impacts of climate change on the income and real consumption of households via five impact channels:

1. Impact on agricultural productivity and prices, with consequences for agricultural incomes. The impacts on incomes and poverty depend on the fraction of the population working in agriculture and agricultural productivity.
2. The impact of climate change on food prices (same as #1), and the consequences of this for consumers. The impact on poverty depends on the fraction the household expenditures dedicated to food consumption.
3. Intensification of exposure to and losses to natural disasters.
4. The impact of climate change on labor productivity, particularly outdoor workers.
5. The impact of climate change on child stunting, malaria, and diarrhea.

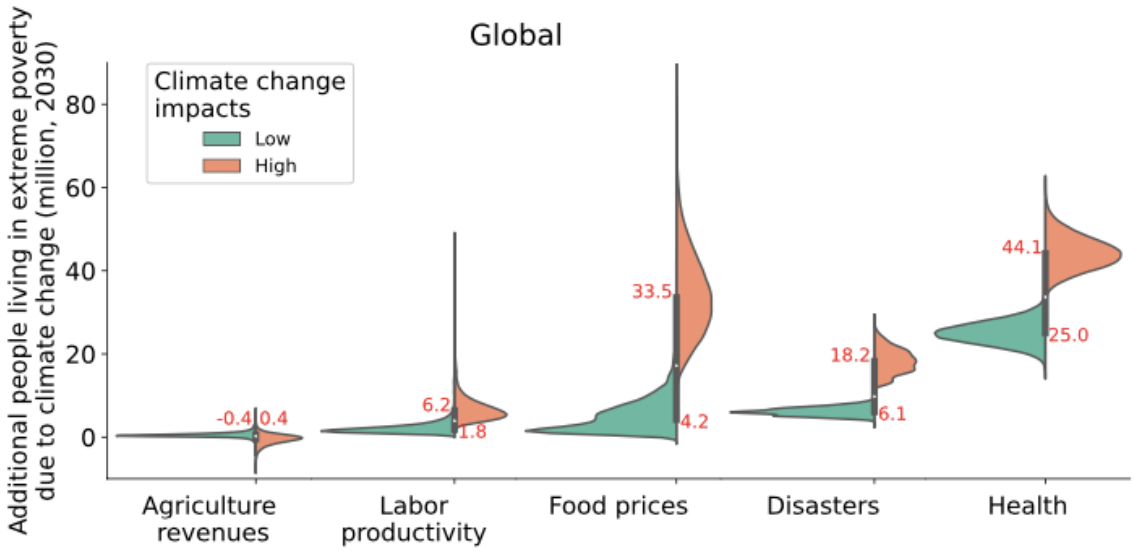
Data & time requirements:

Poverty estimates (downside risk via five climate impact channels) are available for most countries, based on 2020 vintage of Global Monitoring Database (harmonized HIES surveys)

Detailed country assessments range from 1 – 3 months, depending on the complexity of the national economy. Downside risk to poverty and inequality are relatively easier to measure, while integration of simulated development pathways with NDC/green growth dialogues can be more time intensive.

Please see the most recent Shock Waves publication for a list of countries included in the global analysis.

Figure 26: Sample output of the Shock Waves model



Global estimates of the number of people (millions) pushed into extreme poverty in 2030. Results are shown for high & low climate impact scenarios. Among the five impact channels, health shows the highest total impact, while food prices are subject to the widest range.

Annex 7.2. Modeling the poverty impacts of natural disasters, and identifying vulnerable population (the Unbreakable model)

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This modeling exercise estimates the impacts of acute covariate shocks, including natural disasters and layoffs, on household consumption and welfare. Unbreakable identifies ex-ante risk factors, tracks differential impacts, and assesses the long-term benefits of inclusive risk reduction and resilience strategies.

Introduction:

Disaster impacts, and the benefits of risk management, are commonly expressed in terms of total assets damaged or destroyed. These aggregate figures obscure heterogeneous impacts among households. Most importantly, asset losses do not capture the experiences of the poorest households; the value of assets and labor contained in sprawling slums is easily overshadowed by a single block in neighboring business districts.

When households struggle to rebuild or recover income, losses can accumulate over years and months, far in excess of direct damages. The Unbreakable model uses a Bayesian Monte Carlo approach to predict recovery dynamics and their costs. The results, especially total economic losses and differential risk of prolonged impoverishment or

deprivation, are useful for improving efficiency and effectiveness of disaster risk management and disaster responses.

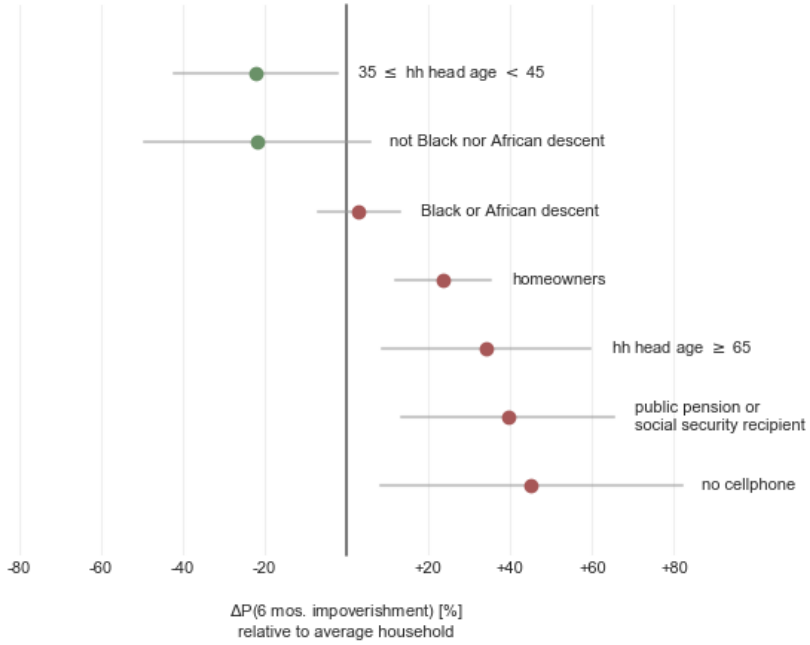
This tool was initially featured in a 2017 flagship report, and subsequently developed over successive country and regional applications.

Model Description:
The *Unbreakable* approach microsimulates covariate shocks among representative households in national income & expenditures surveys (HIES). Initially, the framework focused on an undifferentiated asset base, with vulnerability to physical hazards proxied by domicile construction and condition. More recent applications have focused on specific income and consumption streams, including shocks to housing assets and service, or labor income.

When households lose productive assets, such as their homes or livelihoods, their incomes are also reduced. During reconstruction, they must choose between consumption and reinvestment in these assets. For many, this choice entails difficult tradeoffs between food, education, healthcare, and housing. In the *Unbreakable* model, household-agents pace their individual reconstructions to optimize total welfare (CRRA welfare function) over the course of their recovery. We find that near-poor households are more likely to be pushed into poverty, and less likely to recover, when disasters occur. In extreme cases, natural disasters may be a significant source of chronic poverty.

To simulate labor income shocks, the model uses highly disaggregated labor force statistics, including total employment by sex, sector, occupation, education, and access to wifi, as available. Laborers in each segment are treated as homogeneous, so that collective shifts correspond to individual probability of job loss (i.e., a 10% decrease in employment among unskilled men in services implies that each unskilled man in services has 10% chance of job loss). Distributional uncertainties are addressed through a Monte Carlo approach, so that the income and poverty effects of extensive labor shocks are observed across the ensemble of simulations.

Figure 27: Risk of prolonged impoverishment in St. Lucia, given homes have been damaged by an earthquake. Probabilities are shown relative to the average household in the country



The *Unbreakable* approach has two primary benefits for risk management and resilience dialogues. First, it identifies the socioeconomic characteristics (e.g., economic and employment status, homeownership, race, education, or participation in public programs) correlated with the risk of severe or prolonged deprivation following a certain type

of shock. These characterizations are useful for targeting ex-ante and ex-post risk investments, including land use planning, retrofitting, water storage and waste management, and post-disaster support.

Second, the tool integrates micro- and macro-economic effects, tracing the consequences of stalled recoveries and unemployment into aggregate economic and productivity losses. This is useful for designing comprehensive risk management strategies that avoid disasters where possible, mitigate indirect losses when they cannot be prevented, and provide information on the spatial prioritization of interventions (Figure 27).

Data & time requirements

Data inputs:

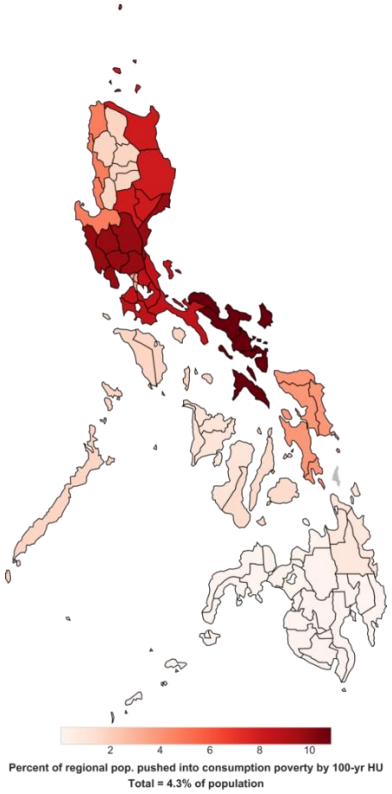
- Recent household income & expenditures survey with income and employment module
- Exceedance curve of asset losses or population affected (for natural hazard), usually from a previous risk assessment (possible to use global models if national data not available, but the results tend to be less precise)
- To measure the impact of historical shock (not the possible disasters), it is possible to use monthly or quarterly labor force statistics

Time inputs:

- Initial assessments can be produced within 3 – 6 weeks. Labor force and post-disaster support targeting analytics take longer, depending on the data available and state of client/country dialogue

Figure 28: Impact on poverty in Philippines

Poverty increase in the Philippines after a major tropical cyclone. Consequences are concentrated in the northern half of the country (Luzon and the Visayas), where storms are more frequent, and which have high asset and population densities. Events of this magnitude have at least a 1% chance of occurrence every year.



Existing country applications

Albania, Armenia, Argentina, Bolivia, Bulgaria, Croatia, Fiji, Georgia, Greece, Philippines, Romania, Sri Lanka, St Lucia, Turkey. Please see the Unbreakable reports for a list of countries included in global analyses.

Annex 7.3. Poverty and distributional analyses tools

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Macro- Microsimulation tools such as the Global Income Distribution Dynamics (GIDD) tool, use a CGE-microsimulation model to assess the distributional impact of structural changes brought on by large shocks. This model has been used at the country and regional level to assess a wide range of issues, including the impact of climate change, demographic changes, trade reforms, infectious disease outbreaks, and the expansion of biofuels, among others. The CGE-GIDD simulates the general equilibrium impact of shocks including the expected changes in the age and education structure of the population, worker migration from farming to non-farming activities and across sectors, changes in skilled-to-unskilled and farming-to-non-farming wage premiums, as well as different income growth rates. The microsimulation component takes the results of the CGE framework to generate ex-ante counterfactual income distributions and allows for projections of poverty and inequality and distributional impacts across household types, regions, and vulnerable categories. Microsimulation modeling can also be combined with other CGE models such as MANAGE for single countries and ENVISAGE for regional modeling. Going forward, the idea is that the POV GP, through the Equity Policy Lab, will work on the Microsim part along with the POV country economist, in collaboration with MTI and trade teams using the GIDD tool, to further develop the distributional analysis.

Vulnerability tool to analyze the prevalence, causes, and sources of **household vulnerability to poverty due to climate and disaster risk**. The tool can conduct analyses at the national or regional levels, and it can be customized to show results for population subgroups defined by gender, household type, and others. The vulnerability tool can estimate the share of those vulnerable due to low physical and human capital assets (poverty-induced), and the share due to high consumption volatility (risk-induced). The tool can also show how vulnerability due to community-level and household-level shocks varies across regions. The tool is flexible enough to be customized to country-specific contexts. This is the first version of the tool with plans to improve the tool as it is used in CCDRs/Poverty Assessments (PAs) over the coming year.

Fiscal microsimulation tools to analyze the **distributional impact of carbon tax and subsidy policies**. These provide detailed modeling of fiscal interventions, including fuel taxes and subsidies, as well as electricity subsidies. These models follow the CEQ approach and provide detailed modeling of all taxes and social assistance programs. Therefore, it is possible to simulate alternative policy scenarios, including alternative compensation schemes and mitigation policies. Each model is customized to country household data and reflects the details of current fiscal policies.

Analytical work in pilot phase

Using a more granular lens to assess the distributional impacts of climate risk and climate actions. This is a new effort to build a richer data infrastructure to allow for a more disaggregated look at climate risk impacts for different sub-groups. While this work is at an early stage, it is expected to be carried out for a couple of PA and CCDR countries the coming FY; particularly in Pakistan, where the Bank is piloting this approach, and in Vietnam, where there have been early discussions. The work in both Pakistan and Vietnam will focus first on the urban poor in large metro cities and consider three types of climate/environmental risks – heatwaves, air pollution and floods. The basic idea is to examine the welfare impacts of each, using a risk metric that is adjusted for both natural, locational and household socio-economic factors, that could dampen or accentuate exposure. The cities have been extensively mapped and small area estimates of poverty or other metrics of wellbeing are available at neighborhood levels. In Pakistan, the Bank is also piloting survey instruments to help assess this adjusted risk, as well as household perceptions of risk and welfare loss. This is expected to allow for variation in welfare impacts at both the area and the household level, which could be used to answer questions related to the costs of future shock scenarios, and potentially, going

forward, counterfactual adaptation or mitigation actions. The first part of the work will be completed over the coming FY and could inform both the PA and the CCDR. There is similar work planned for rural areas in Pakistan. This type of work is expected to be amenable to expansion in many other contexts and the new survey modules (in whole or part) could be included in more standard household surveys run by National Statistical Organizations (NSOs).

Annex 7.4. Groundswell Report Series

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The *Groundswell* report series use a robust and novel modeling approach to demonstrate the potency of climate change as a driver of migration within countries, across the six World Bank regions. Specifically, it examines how slow-onset climate change impacts, acting through changes in water availability, crop productivity, and sea-level rise augmented by storm surge, could affect future internal migration. Combined with subregional and country-level case studies, the model provides plausible scenarios to help understand the scale, trajectory, and spatial patterns of internal climate migration. The reports enable a better understanding of how projected climate change impacts, population dynamics, and development contexts will shape mobility trends. They also highlight the far-sighted planning needed to meet this challenge and ensure positive and sustainable development outcomes.

The first report was published in 2018 with a focus on three regions, and associated subregional and country-level case studies: Sub-Saharan Africa (East Africa, Ethiopia), South Asia (Bangladesh) and Latin America (Mexico and Central America, Mexico). The second report (forthcoming) completes the analysis for the three remaining regions, also with respective subregional and country case studies: Middle East and North Africa (North Africa, Morocco), East Asia and the Pacific (Lower Mekong, Vietnam), and Eastern Europe and Central Asia (Central Asia, Kyrgyz Republic). A qualitative analysis of climate-related mobility in the countries of the Mashreq and Small Island Developing States is also provided. Part 2 of the report is forthcoming.

The reports take a scenario-based approach and implement a modified form of a gravity model to isolate the projected portion of future changes in spatial population distribution that can be attributed to slow-onset climate factors up to 2050. The three internal climate migration scenarios combine alternative development (SSPs) and emissions (RCPs) pathways. They are:

- **Pessimistic:** high global greenhouse gas emissions (RCP 8.5) combined with unequal development pathways (SSP4)—the reference scenario for the report;
- **More inclusive development**: with similarly high emissions (RCP 8.5), but improved development pathways (SSP2); and
- **More climate-friendly:** with lower emissions (RCP 2.6), combined with unequal development pathways (SSP4).

Four types of results are presented for each subregion and country of focus:

1. The total number of climate change-induced internal migrants ("climate migrants") under the three scenarios.
2. The number of climate migrants as a share of the total number of internal migrants.
3. Maps of hotspots of climate in- and out-migration—that is, places where population distribution trends are projected to be amplified or dampened by climate change impacts, across all three scenarios modelled.
4. Net in- and out-migration in rural livelihood zones, coastal zones, and urban areas, under the different scenarios.

Expansion of the *Groundswell* model and applications for the Africa region: Since the first *Groundswell* report, the Africa region has expanded the model to include additional parameters including changes in net primary productivity as a slow-onset factor; flood risk as rapid-onset event; and non-climatic factors such as conflict data from ACLED and

demographic variables (median age and sex). The analysis was also conducted at more granular spatial level, shorter time steps, and includes a fourth optimistic scenario, which combines low global emissions trajectories (RCP2.6) and inclusive development pathways (SSP2). Regional reports have been completed for West African countries and Lake Victoria Basin countries, and stand-alone country reports have been produced for Senegal, Nigeria, Uganda and Tanzania.

The Climate-Smart Opportunities for Migration through Proactive and Sustainable Solutions (COMPASS) framework also sets out a response framework that builds on core policy directions buttressed with a set of action domains to avert and reduce the adverse consequence of climate induced migration within countries