

USING CLIMATE ECONOMIC MODELLING FOR SUSTAINABLE ECONOMIC DEVELOPMENT

A Practitioner's Guide

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On behalf of:



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for the Environment, Nature Conservation
and Nuclear Safety

IISD
International Institute for
Sustainable Development

of the Federal Republic of Germany

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On behalf of
German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU)

Germany, 2021

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EXECUTIVE SUMMARY

Climate change is not 'just' an environmental issue. It is also a socio-economic issue because it can affect the creation of employment, wealth, and people's living conditions with disproportional impacts on the most vulnerable groups of the population. The good news is that measures to develop our economies and to adapt to the impacts of climate change can mutually reinforce each other. But to ensure that economic development and climate adaptation efforts are mutually reinforcing, countries urgently need to stop treating climate change in isolation and bring it as an integral part of economic development. Climate adaptation mainstreaming in economic development planning and action can improve coordination among key actors and support alignment between different development goals for increased policy coherence. In turn, this can lead to more sustainable, effective, and efficient processes and improved development impacts. A consensus exists at the global level among scientists and policy makers on the need to address the links between economic development and climate change for sustainable development.

So, what does it look like practically to address the links between economic development and climate change? While the global economic impacts of climate change remain riddled with uncertainty, this can be partially offset by more local, country-based analyses. One tool in particular, climate economic modelling, can help to inform policy makers of the costs, benefits and potential trade-offs of climate risks and climate change adaptation on the economy. Such tool is generally asking three broad questions: (1) what are the economic impacts of climate change on the economy? (2) what are the impacts of climate change adaptation measures on the economy? and (3) what is the right set of economic instruments to support climate-resilient economic development? The results (as much as the process of developing economic models, if done in a participatory manner) can support the integration of climate adaptation in economic development. In particular, climate economic modelling can be most useful to support problem

framing, stakeholder engagement and awareness raising, and advocacy and communications related to climate change. Since uncertainties will remain inherent to simulating climate change impacts, results from climate economic modelling need to be interpreted with caution. Combining climate economic modelling with other tools and qualitative analysis (such as stakeholders' consultations) facilitates its use for decision-making.

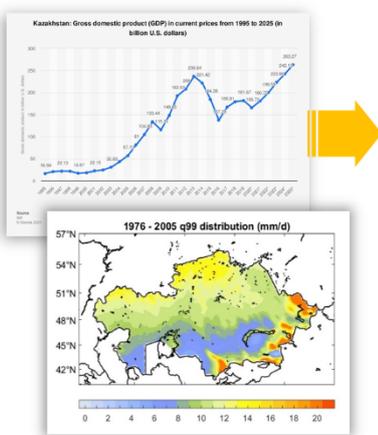
This guide offers a framework to help economic advisers in central and sectoral government ministries to integrate climate economic modelling results in economic development processes, with the ultimate objective to support climate-resilient economic development. Numerous opportunities exist to integrate climate modelling results along all steps of the economic development policy cycle, from planning to budgeting and financing, implementation, and monitoring, evaluation, and learning. The framework identifies nine indicative entry points. The selection of the most appropriate entry point(s) is very context specific and depends on the immediate opportunities and needs of the country. Four major factors should be considered for assessing the entry points: the modelling development process and results, the stage of the economic development policy cycle, the status of climate adaptation mainstreaming, and the overall enabling environment for climate adaptation mainstreaming. To address the later, the proposed framework lays out eight enabling factors, which together support (positively or negatively) the effective use and uptake of climate economic modelling results in economic development. The enablers are the conditions within which the entry points operate. As such, the entry points and the enablers reinforce each other; they are both important and closely linked. The document also offers guidance on how to use each entry point and enabler with examples to describe what it could look like in practice.

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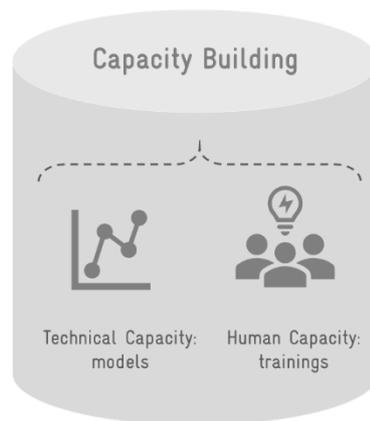
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economic impacts of climate change and climate change adaptation in three pilot countries (Georgia, Kazakhstan, and Vietnam) with the ultimate objective to support climate-resilient economic development. This guidance note will be applied in the three pilot countries and additional documents will be developed to capture the results and offer country specific recommendations.

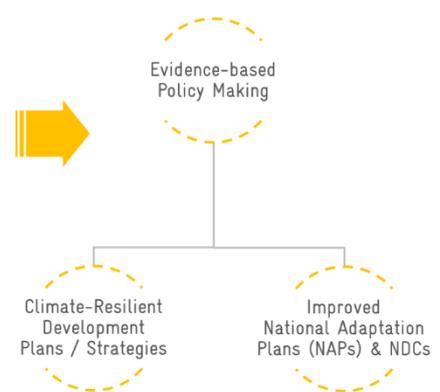
Climate and Economic Data



Macro-Economic Modelling



Policy Advice



CRED Approach Supports Climate-Resilient Economic Development

ACRONYMS

ADB	Asia Development Bank
AF	Adaptation Fund
AFD	Agence Française de Développement
CAPE	Climate Action Peer Exchange
CCFF	Climate Change Financing Frameworks
CEGIM	Climate Economic Growth Impact Model
CPEIR	Climate Public Expenditure and Institutional Review
CRED	Policy Advice for Climate-Resilient Economic Development
EACC	Economics of Adaptation to Climate Change
ECAL	Environment and Climate Adaptation Levy
EU	European Union
GCF	Green Climate Fund
GEMMES	General Monetary and Multisectoral Macrodynamics for the Ecological Shift
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GDP	Gross Domestic Product
IISD	International Institute for Sustainable Development
IVA	Integrated Vulnerability Assessment
LDC	Least Developed Countries
MEL	Monitoring, Evaluation and Learning
NAP	National Adaptation Plan
NDC	Nationally Determined Contributions
IKI	International Climate Initiative
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
OECD	Organization for Economic Co-operation and Development
SDG	Sustainable Development Goal
UNFCCC	United Nations Framework Convention on Climate Change
UNDP	United Nations Development Programme

I. INTRODUCTION

The purpose of this report is to provide a guide for integrating climate economic modelling results in sustainable economic development. Specifically, the objective is to offer an overview of relevant entry points and enabling activities countries can consider for integrating climate economic modelling results in sustainable economic development planning, implementation, and monitoring, evaluation, and learning (MEL).

This guide primarily targets mid-level, technical officers in central government ministries responsible for matters related to the economy (often within the ministry of economy, finance, planning, or alike) as well as economic advisers in sectoral ministries responsible for examining the economic implications of various sector development activities. In addition, this guide may also be useful to local government officers involved in development planning and budgeting, as well as development partners who support governments in economic development planning (implementing agencies, think tanks, academia, civil society organizations).

The approach used to develop this guide is based on a desk review of the latest academic and grey

literature on climate economics and climate-resilient development. The content of this guide also draws from IISD and the National Adaptation Plan (NAP) Global Network's experience in providing technical support to countries on climate adaptation planning and the development of related mainstreaming guides.

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II. BACKGROUND

Following a definition of the key terms and concepts used through the report, this section highlights the linkages between economic development and climate change, thereby offering a rationale for climate-resilient economic development, and discusses the role of climate economic modelling for climate adaptation mainstreaming.

Key terms and concepts

The following terms and concepts are used throughout the report.

Economic development policy cycle refers to the series of actions taken to encourage economic development. The process of undertaking an economic development intervention is usually described using the “policy cycle,” which involves four general steps: 1. planning, 2. budgeting and financing, 3. implementation, and 4. monitoring, evaluation, and learning. The cycle illustrates the iterative nature of the process with the results and lessons learned from the implementation of specific interventions feeding into the formulation of new interventions to continually improve.

Sustainable economic development focuses on promoting economic growth through the creation of jobs and wealth and the improvement of living conditions, in a way that is socially and environmentally sustainable. It acknowledges that sustainable development must include a focus on economic growth. In other words, ending poverty, reducing inequality, and protecting the environment cannot be achieved without economic growth. Promoting inclusive and environmentally sound economic growth should be considered across all key areas of economic development, including: private sector development, economic

policy, employment promotion and financial system development. The terms ‘shared prosperity’, ‘inclusive economic growth’, and ‘shared economic growth’ are used to emphasize the social equity aspects of sustainable economic development (i.e., who participates and benefits from economic growth in a country/region and the need to reduce economic inequalities).

Climate-resilient economic development explicitly acknowledges the need to account for, and address, climate risks in the pursuit of economic development. It is about integrating climate mitigation and adaptation (see ‘climate adaptation’ and ‘climate adaptation mainstreaming’) in economic development processes. Climate-resilient economic development is related to ‘green growth’, which aims to ensure that economic development also reduces greenhouse gas emissions that contribute to climate change.

Climate resilience refers to the ability of a system (e.g., a country, a sector, an enterprise, a household) to anticipate climate risks and hazards, absorb climate shocks and stresses, and reorganize development pathways. Looking at economic development from a resilience perspective acknowledges the need to promote ‘resilience’ instead of ‘stability’; it is about recognizing that uncertainty, change and complexity are the rule, not the exception (there is no simple cause-and-effect relationship, no single fixed equilibrium). And therefore, embracing these elements require taking a ‘systemic’, ‘integrated’ approach to solutions identification and implementation. This can be done for examples by combining climate change mitigation and adaptation actions (see ‘climate change adaptation’) and by engaging actors with different backgrounds and at different scale of governance.

Climate change adaptation, thereafter ‘climate adaptation’, is the continuous process of adjusting to the observed and anticipated impacts of climate change; this can mean putting in place measures to minimize such impacts or take advantage of any

opportunities they present. These adjustments are needed across the ecological, social, or economic systems. The ultimate objective is to reduce a country's vulnerability to climate change in the short-, medium- and long-term. Climate adaptation focuses on responding to the impacts of climate change while climate mitigation aims to address the causes of climate change by reducing greenhouse gas concentrations in the atmosphere. Climate adaptation is essential because the damages from greenhouse gas emissions already have irreversible consequences on our planet.

Climate adaptation mainstreaming is a process that aims at integrating climate adaptation considerations in development efforts (policies, strategies, programs and projects) – and doing this as part of standard development practice rather than a separate, *ad hoc* exercise. Specifically, it is about developing an understanding of how climate change will affect societies, economies, and ecosystems, which measures are needed to manage these impacts, and then using this understanding to inform the identification and pursuit of development priorities, and to implement them. So far, limited consensus exists on what climate adaptation mainstreaming should look like in practice – in part because it will look differently in different contexts based on different needs, priorities, and resources. Broadly speaking, there are different 'levels' (or degrees) of mainstreaming: from climate adaptation simply being mentioned in strategic documents, to the identification of targets for specific adaptation measures, the establishment of institutional arrangements to coordinate the process, and the mobilization of additional financial and human resources to support its operationalization. Other terms commonly used: 'climate proofing', 'climate risk management', 'climate adaptation integration'. Terms used to refer to the expected outcome of adaptation mainstreaming: 'climate-resilient development', 'climate compatible development', 'climate-aligned development', 'climate risks informed development' and 'climate policy integration'.

Climate economic modelling is a tool used to represent in quantitative terms the links between climate change and the economy of a country (focusing on different variables, such as trade, employment, and consumption), based on existing data and assumptions. Broadly, climate economic modelling can help answer three key questions:

- (1) what are the economic impacts of climate change on the economy?
- (2) what are the impacts of climate change adaptation (policy and actions) on the economy?
- (3) what is the 'right' set of economic instruments and climate adaptation measures to support climate-resilient economic development?

The 'right' set of instruments must be identified by policymakers depending on the criteria they choose to prioritize (e.g., largest avoided damages, employment effects, urgency of action, contribution to mitigation goals, investment cost). Climate economic modelling can help to inform policy makers of the costs, benefits and potential trade-offs of climate risks and climate change adaptation on the economy. In the context of this report, the focus is on the impacts of climate change on the national economy (i.e., 'macroeconomic' modelling).

Rationale for climate-resilient economic development

Climate change is not 'just' an environmental issue; it is also a social and economic issue. This means that tackling climate change requires a whole-of-government approach, that involves all sectors, levels of governance, and all actors across the government and non-government spheres.

Figure 1. Three pillars structure of sustainability

Three Pillars of Sustainability

Climate change has an impact on marine, terrestrial and freshwater ecosystems and on biodiversity. Around 1 million species are at risk of extinction with an unprecedented rate of change due to climate change and other human drivers (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), 2019).

Climate change does not impact everyone the same way due to differences in roles and responsibilities at the household, community and societal levels as well as differences in access to, and benefit from, resources. Thus, some groups of the population will suffer disproportionately from the negative impacts of climate change because they have less resources (e.g., technologies and services, climate information, capacity building on climate risk management) and options they can mobilize for recovery and adaptation.



Climate change impacts can affect the creation of employment, wealth and people's living conditions; leading more than 100 million people in developing countries to move below the poverty line by 2030 (Global Commission on Adaptation, 2019). All sectors of the economy can be impacted. Some sectors will need to be phased out (e.g., ski tourism in region with too little snow) while new sectors may rise (e.g., coffee production in regions that were previously not suitable). The ability to produce certain products and services may also be impacted. Some countries may not be able to export some goods and may have to rely on imports. Besides the public and private assets reconstruction costs following climate hazards, the impacts on tax revenues can also be significant. For example, the World Bank (Hallegatte, S. et al., 2020) reports that in Argentina reduced exports due to a severe drought in 2017 led to an estimated USD 1.5 billion in tax revenue loss the following year.

Economic development and climate adaptation can mutually reinforce each other, but it does not always automatically happen. Broadly, an understanding of the economic development-climate nexus requires attention to the following:

- › **Impacts of climate change on economic development.** Climate change is a risk and an opportunity for sustainable economic development. Climate change can impact economic development in complex ways. For example, increased frequency and intensity of droughts resulting from a changing climate can lead to reduced quantity and quality of crop

production, which in turn will lead to reduced income for farmers among others. According to the Global Commission on Adaptation (2019), climate change could reduce global agriculture yields up to 30 percent by 2050, mostly affecting 500 million small farms. This will also affect other sectors of the economy indirectly as the reduced incomes of farmers and other actors along the agricultural value chains will reduce their consumption of other goods (e.g., foods, fertilizer, machinery). These economic risks can then generate financial risks (e.g., inability to repay loans). As well, climate change can also have direct impacts on

financial risks (e.g., decreased value of assets, such as real estates, following a climate hazard) with negative impacts on the economy. At the same time, climate change also presents new economic opportunities. For example, areas previously not suitable for wine cultivation could become suitable due to increased temperatures. Positive impacts on the economy may also be more indirect, for example, via the development and commercialization of new goods and services (e.g., drip irrigation, drought resistant crop varieties, climate database) to minimize the negative impacts of climate change.

- › **Impacts of economic development on people and assets' exposure and vulnerability to climate change.** Economic development can support climate adaptation. For example, economic development resulting in improved equitable access to key infrastructures and services for education and health has the potential to reduce vulnerability to climate change impacts. But such positive relationship does not automatically happen. Economic investments may be wasted, sometimes even causing detrimental impacts by increasing vulnerabilities or even by creating new vulnerabilities, if they do not consider and address the climate risk context. This is the case for example when investments in infrastructure are made in areas exposed to climate change risks, thereby increasing vulnerabilities of assets and people to climate change.
- › **Impacts of climate change adaptation measures on economic development.** Similarly, climate adaptation can generate economic benefits. Specifically, climate adaptation measures can help to save lives, avoid or minimize assets losses and the costs of reconstruction, reduce climate risks, increase productivity and generate new jobs and wealth. For example, adaptation strategies involving more efficient water use can also lead to improved income (for the technology users and the developers) (Chambwera et al. 2014). According to the Global Commission on Adaptation (2019), investments in early warning systems, climate-resilient infrastructure, improved dryland agriculture crop production, global mangrove protection, and resilient water resources totaling USD 1.8 trillion could generate USD 7.1 trillion of benefits. At the same time, a growing body of

evidence (Erikson et al., 2021) shows that climate adaptation can also reinforce or redistribute existing vulnerabilities (from one sector, group of the population, or region to another and from present to future generations) or even create new vulnerability. . This is called maladaptation. For example, infrastructure development such as embankments may increase people's vulnerability to flood risks as people may settle down near them without implementing traditional risk management strategies (see examples from Assam and Bihar in ICIMOD, 2009).

To ensure that economic development and climate adaptation efforts are mutually reinforcing, countries urgently need to stop treating climate change in isolation and bring it as an integral part of economic development. Climate adaptation mainstreaming acts as a risk management strategy and is a prerequisite for sustainable economic development. Adaptation mainstreaming has the potential to be 'transformational' with actors changing how decisions and investments are being made (Hammill and McGray, 2018). Strong arguments exist for integrating climate adaptation into economic development:

- › **Coordination.** Climate adaptation mainstreaming helps to improve coordination between and among all key actors because it requires to systematically review the existing systems in place to find the most relevant entry points and to reduce duplications of efforts and avoid creating parallel systems. For example, if a country has already developed a system to monitor and evaluate development progress, this system should be a good starting point for the measurement of climate adaptation progress to build on existing capacities, structures and lessons learned.
- › **Coherence/Alignment.** Climate adaptation efforts should not undermine economic and other social and environmental development gains. This can be done by combining different perspectives and needs (across different sectors and across different scales of governance) to assess the wider implications of proposed measures. Mainstreaming helps to assess trade-offs and increase synergies among different objectives, including mitigation. It supports alignment between different development

goals for increased policy coherence. The Covid-19 pandemic is revealing the interconnectedness of our economies, their fragility, and the importance of taking an integrated approach to development to deal with multiple (interconnected) crisis simultaneously (e.g., climate, biodiversity, pandemic).

- › **Effectiveness.** Improved coordination and policy coherence resulting from adaptation mainstreaming should lead to more sustainable, effective, and efficient processes (mobilization and use of resources) and improved development impacts.

Globally, scientists and policy makers recognize the need to address the economic development and climate change nexus for sustainable development ('the new climate economy'). Interest in the economics of climate change has steadily increased in the last 20 years both on the scientific and policy agendas.

- › **Scientific and economic development community.** The "Stern review on the economics of climate change" released by economist Nicholas Stern in 2006 for the UK government is a landmark study – though not the first report on the topic. In 2014, the world's leading climate scientists, under the Intergovernmental Panel on Climate Change (IPCC), the United Nations body for assessing the science related to climate change, concluded that globally climate change will impact on the supply and demand of economic goods and services across all sectors of the economy leading to reduced economic growth but that uncertainties remain on the magnitude of the effects (Arent et al. 2014). In parallel, over the past decades, several global initiatives, such as the [Global Commission on the Economy and Climate](#), have researched the economic impacts of climate change with support from development partners, in particular the World Bank, the International Monetary Fund (IMF), and the Organization for Economic Co-operation and Development (OECD). When it comes to climate adaptation, the attention has progressively evolved from calculating the economic costs of inaction, to costing climate adaptation actions and climate adaptation more broadly (co-benefits, co-costs,

barriers, etc.), and to looking at economic instruments to incentivize adaptation.

- › **Policy community.** In 2015, the economic development-climate change nexus was at the center of two important policy agendas: the 2030 Agenda for Sustainable Development (Sustainable Development Goals, SDGs) and the Paris Agreement. Countries agreed on a set of 17 global goals to achieve sustainable development by the year 2030. SDG8 focuses on decent work and economic growth and aims to promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work. It comprises of 12 targets with a focus on themes such as economic productivity, employment and decent work, labour rights, sustainable tourism, access to banking, insurance and financial services, and trade. SDG13 aims to take urgent action on climate change and its impacts. One of the five targets under SDG13 focuses on the need to "integrate climate change measures into national policies, strategies and planning". At the core of this framework for sustainable development is the recognition that the global goals, and related targets, are interconnected: success in achieving a specific goal is a means to achieving the other goals. In addition, Parties to the United Nations Framework Convention on Climate Change (UNFCCC), the primary international, intergovernmental forum for negotiating the global response to climate change, agreed on a global goal on adaptation under the Paris Agreement. This goal aims to enhance adaptive capacity and resilience and to reduce vulnerability, with a view to contributing to sustainable development. A part of the Paris Agreement, parties acknowledged the need to integrate adaptation into relevant socioeconomic and environmental policies and actions.

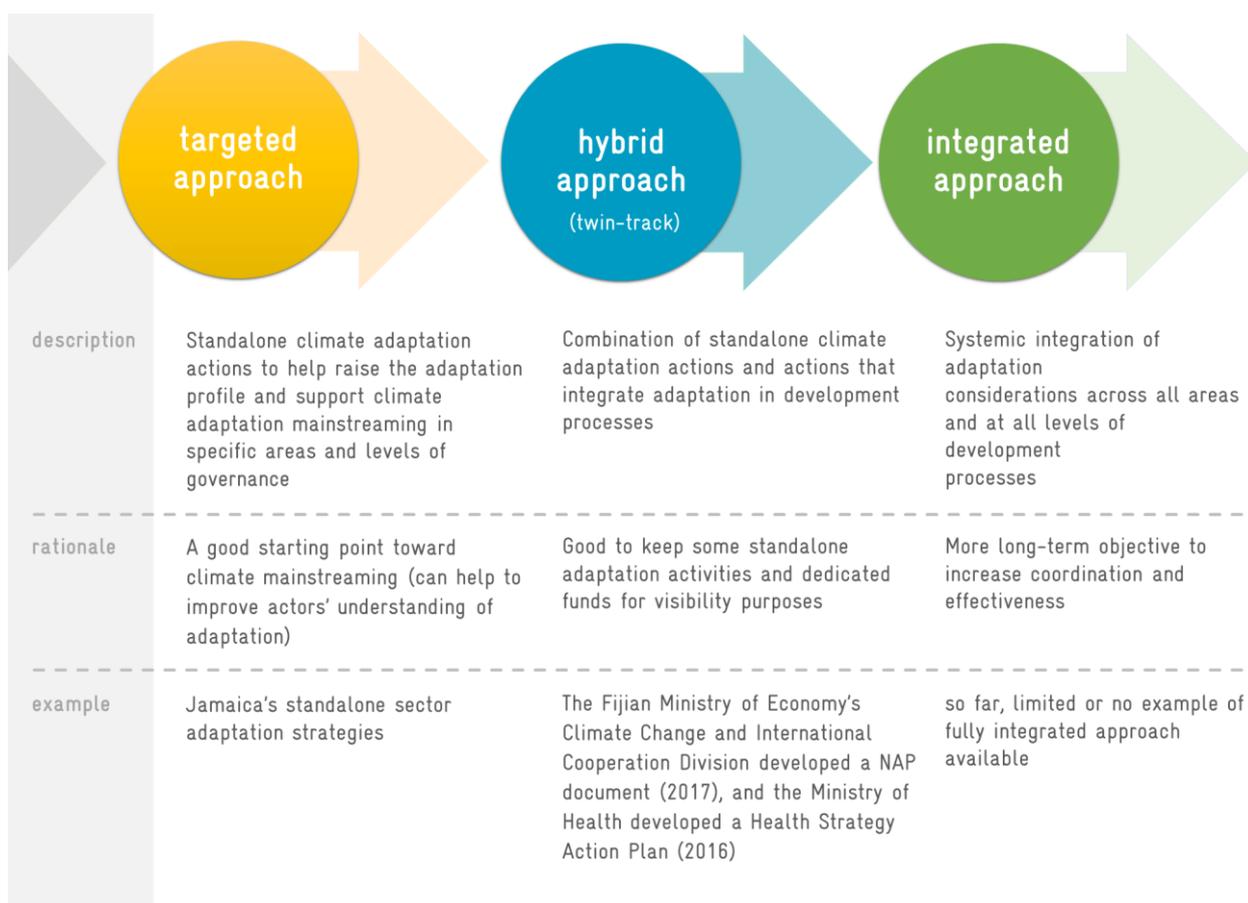
National climate adaptation planning processes provide an opening for integrating climate risk into economic development policy and decision-making. The Paris Agreement requires all Parties to submit, and regularly update, their Nationally Determined Contributions (NDCs). NDCs are pledges countries make to limit global temperature increase and, as appropriate, adapt to climate change (Hammill, et al. 2019). As mentioned previously, the Paris Agreement also requires Parties on a voluntary basis to integrate adaptation

into relevant socioeconomic and environmental policies and actions, where appropriate, including through their National Adaptation Plans (NAPs). NAPs aim to support a different way of doing climate adaptation by putting in place the systems and capacities needed to make adaptation a standard, ongoing practice as part of a country's development decision making. Therefore, mainstreaming adaptation into development planning and budgeting is a key objective of the NAP process. The ultimate objective is to identify and address a country's medium and long-term priorities for adapting to climate change (Hammill, et al. 2019). NAPs and NDCs can be mutually reinforcing: the priorities identified through a country's NAP process can be included in its NDC,

and the NAP process itself can be a means of operationalizing the adaptation commitments of its NDC. (Hammill, et al. 2019)

Importantly, climate adaptation mainstreaming in economic development efforts needs to be considered as a spectrum of approaches/activities (see Figure 2), from the development of separate, standalone climate adaptation policies, strategies, programs and projects ('targeted approach'), to the systemic integration of adaptation considerations across all areas and at all levels of development processes ('integrated approach').

Figure 2: Mainstreaming climate adaptation in development efforts



The role of climate economic modelling for adaptation mainstreaming

While the global economic impacts of climate change remain riddled with uncertainty, this can be partially offset by more local, country-based analyses. Predicting the impacts of climate change on economic growth (with and without adaptation) is associated with numerous methodological challenges. Estimates show significant variations. This is due to, among others, the diversity of approaches used focusing on different sectors and using different assumptions (e.g., assumptions on levels and causes of economic growth, on demographics, on future climate hazards and impacts), uncertainties associated with both future climate change and economic growth in the long-term, and the diversity of (economic) development contexts with important differences within and among countries. (For further information, see for e.g., OECD, 2021; Defries et al., 2019; Kousky, 2014). As such, there is an important need for more local, country-based evidence to support decision making and investments. Climate economic modelling can help countries to quantify the future impacts of climate change on their economy. Specifically, it can help explore questions such as: How does climate change affect the demand and supply for goods and services? What are the effects on producers and consumers? What is the effect on the overall economy? How do specific climate adaptation measures affect the demand and supply of goods and services? How do they affect the financing conditions of economic agents? What is the effect on the overall economy? (Arent et al. 2014)

Climate economic modelling (both in terms of results and process) can support the integration of climate adaptation in economic development. An adage about modelling in general is that: “All models are wrong, but some are useful”. The main added value of (economic) modelling is the translation of complex relationships in numbers and figures to give an indication of the general direction of impacts (e.g., related to climate change, the COVID-19

pandemic) on the economy of a country. This is often measured in terms of GDP losses or gains. There are few documented examples of climate economic modelling results that have directly influenced decision-making at national and subnational levels. One such example is the new [EU Strategy on Adaptation to Climate Change](#) released in 2021, which explicitly refers to the results of the project ‘[Projection of Economic impacts of climate change in Sectors of the EU based on bottom-up Analysis](#)’ (PESETA). Reasons for the lack of documented examples may include, among others, the complexity and high-level of uncertainties associated with change in climate and non-climate variables and related impacts as well as the general tendency to focus on short-term priorities. Generally speaking, climate **economic modelling is most relevant to support three main purposes**, which are important for integrating climate adaptation into economic development: **(1)** problem framing/orientation, **(2)** stakeholder engagement and awareness raising, and **(3)** advocacy and communications (see below).

1. Problem framing/orientation

- › Illustrating that climate change can impact directly and indirectly all sectors of the economy, meaning that it should be framed as an economic and social development issue (versus solely as an environmental issue) that concerns all actors across all sectors and levels
- › Building consensus among key actors (e.g., starting with model developers) on the need to prioritize certain sectors/groups of the population/regions for further investigations.
- › Providing evidence on the overall direction of changes and the interactions among different variables in the economic system; providing a basis for further discussions and analysis

2. Stakeholder engagement and awareness raising

- › Providing a space for dialogue between and among policy and decision-makers and scientific experts. The resulting network building and stakeholder engagement can help increase interest and understanding of the topic. The process of developing the model and interpreting results, if done using participatory approaches, can support awareness raising. Importantly, this means that

the process of developing the economic model is as important as (if not more important than) the results (for more information, see for e.g., IISD, 2019 and Weaver et al., 2013).

- › Raising the awareness of model users and developers on the importance of taking a long-term, forward-looking perspective
- › Discussing intersectoral and economy-wide impacts beyond their own sector and/or scale of governance as well as the potential trade-offs between different objectives or strategies.
- › Testing some assumptions and beliefs, building trust between policy makers and scientists and generating data that is trusted by policymakers. Feedback provided by policy and decision-makers can also help scientists to improve models.

3. Advocacy and communications

- › Assigning numbers to climate change impacts and climate adaptation can raise the profile of adaptation and provide more impetus towards ambitious action on adaptation. It can serve as a basis to advocate on the urgency of acting on/prioritizing climate adaptation. This is important because given the limited resources available, adaptation mainstreaming may appear to ‘compete’ with various other development priorities (e.g., poverty reduction, social inclusion, mitigation, disaster risks reduction, biodiversity conservation).
- › Communicating results in relatively easy to grasp and ‘actionable’ messages such as “if you take action in sector x, the GDP will increase by x% by 2050 compare to the scenario without adaptation”, “if you take the following adaptation action “xxx”, you can avoid the estimated damage of floods by x% of the GDP by 2050”. Such messages can help inform key actors about the aggregate implications of climate change and the role of climate adaptation measures in minimizing or avoiding climate change damages. This is particularly

useful, because to gain some traction, climate adaptation needs to speak to the ministries with budgetary power (often the ministries of finance, planning and economy). These ministries tend to have strong convening and decision-making powers. Results from climate economic models help translate the impacts of changes in climate on the various economic activities of a country and the benefits of adaptation measures in quantitative terms in such a way that they are tailored to the specific needs of these ministries.

Combining climate economic modelling with other tools and qualitative analysis facilitates its use for decision-making. A mix of quantitative (monetary valuation) and qualitative information is important to obtain a more nuanced picture of climate change impacts. In fact, qualitative information may sometimes influence decision making more than figures only (OECD, 2021). It is also important to recognise that economic impacts cannot be isolated from other impacts from climate change (e.g., physical, social, environmental, fiscal) which interact in complex ways. The IPCC (Chambwera et al. 2014) warns that a narrow economic approach could fail to account for these other dimensions. Decision-making relies on many more considerations than just economic or monetary factors, and these cannot be ignored in the final analysis. For example, in the World Bank’s Economics of Adaptation to Climate Change (EACC) study (World Bank, 2010), the country case studies included an evaluation of economy-wide impacts of climate change using economic modelling combined with social vulnerability assessment conducted at the community level. This allowed for the exploration of holistic solutions that address the drivers of vulnerability to climate change instead of focusing solely on addressing the impacts of climate change – i.e., longer-term, more transformative solutions.

III. FRAMEWORK FOR INTEGRATING THE CLIMATE ECONOMIC MODELLING RESULTS IN DEVELOPMENT PROCESSES

Integrating the climate economic modelling results in economic development processes requires considering two main elements: (1) the entry points along the development policy cycle and (2) the enabling conditions or enablers. This section gives a high-level overview of the main entry points and enablers. More information about these categories, including some examples, is provided in the next chapters.

Entry points

Entry points are windows of opportunities that a wide range of stakeholders (governments but also development partners, private sector, civil society organisations) can leverage to integrate the climate economic modelling results in economic development efforts. As summarized in Figure 2 below, entry points exist across all steps of the policy cycle, from planning to budgeting and financing, implementation, and monitoring, evaluation, and learning.

Figure 2. Entry points steps in policy cycle



The indicative entry points for integrating climate economic modelling results in the economic development policy cycle are adapted from NAP Global Network & UNFCCC 2019.

1. Planning (incl. agenda setting, problem framing, preparation)

- 1.1 [Development or update of legal and policy frameworks that provide a mandate for climate-resilient development](#)
- 1.2 [Diagnoses or assessments of risk and vulnerability](#)
- 1.3 [Development or update of strategies and plans \(incl. identification and prioritization of measures\)](#)

2. Budgeting and financing

- 2.1. [Formulation of government budgets, investment plans, resource allocation frameworks in line with government strategies and policies](#)
- 2.2. [Review and approval of government budget \(national and sector levels\)](#)

3. Implementation

- 3.1. [Mobilization and allocation of resources \(incl. public procurement\)](#)
- 3.2. [Management of programmes and projects \(delivery of goods and services as per budget\)](#)

4. Monitoring, evaluation and learning (incl. learning from modelling results and climate adaptation mainstreaming)

- 4.1. [Management of data and information \(from data collection to data analysis and dissemination\)](#)
- 4.2. [Reporting \(verifying\)](#)

These entry points can relate to different timeframes and exist at all levels of governance (national, sectoral and subnational level). Although climate adaptation typically must consider a long term perspective, it must also focus on immediate priorities. In addition, entry points can be found (simultaneously or not) at the national, sectoral, and subnational levels. For example, at the planning stage, climate adaptation can be integrated in national poverty reduction strategies, in sector development strategies and in district or city development strategies. Ideally, countries need to advance both the integration of climate adaptation across sectors ('horizontal integration') and to foster strategic linkages between the national and the subnational level ('vertical integration').

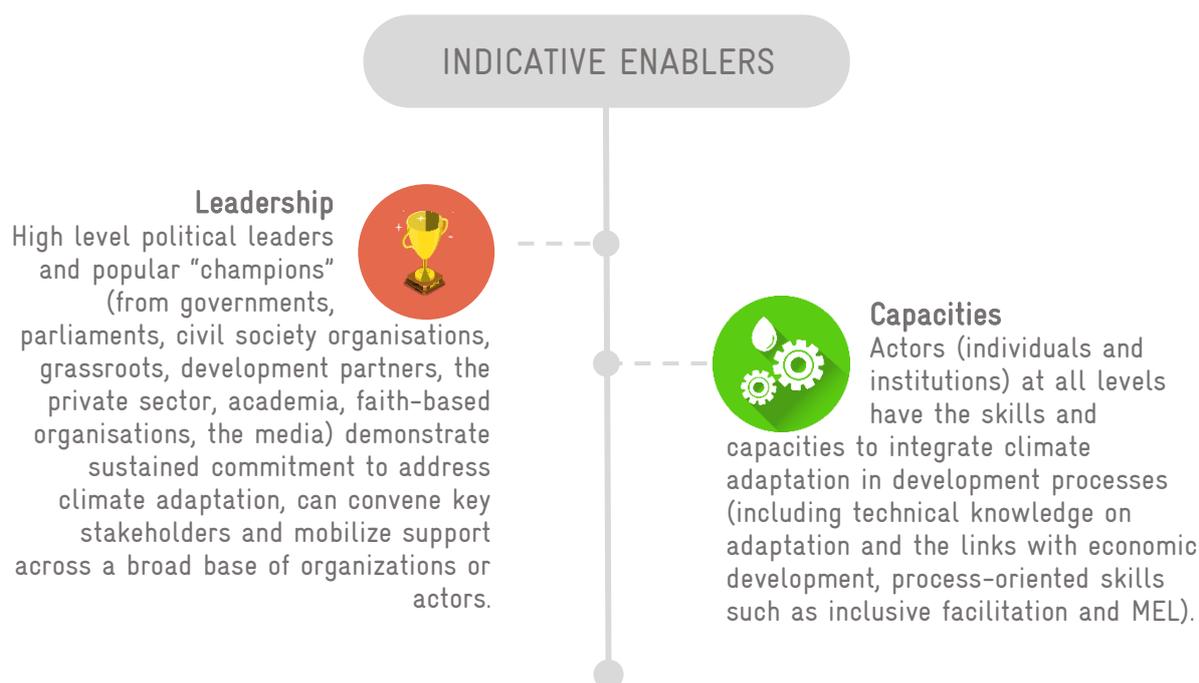
Entry points should not work in isolation. Integrating climate adaptation via a particular entry point should propel integration of climate adaptation in other parts of development planning cycles. This requires coordination across actors, sectors, levels of governance and across the development planning cycle. For example, the integration of climate adaptation in policies and strategies should be then reflected in budgets

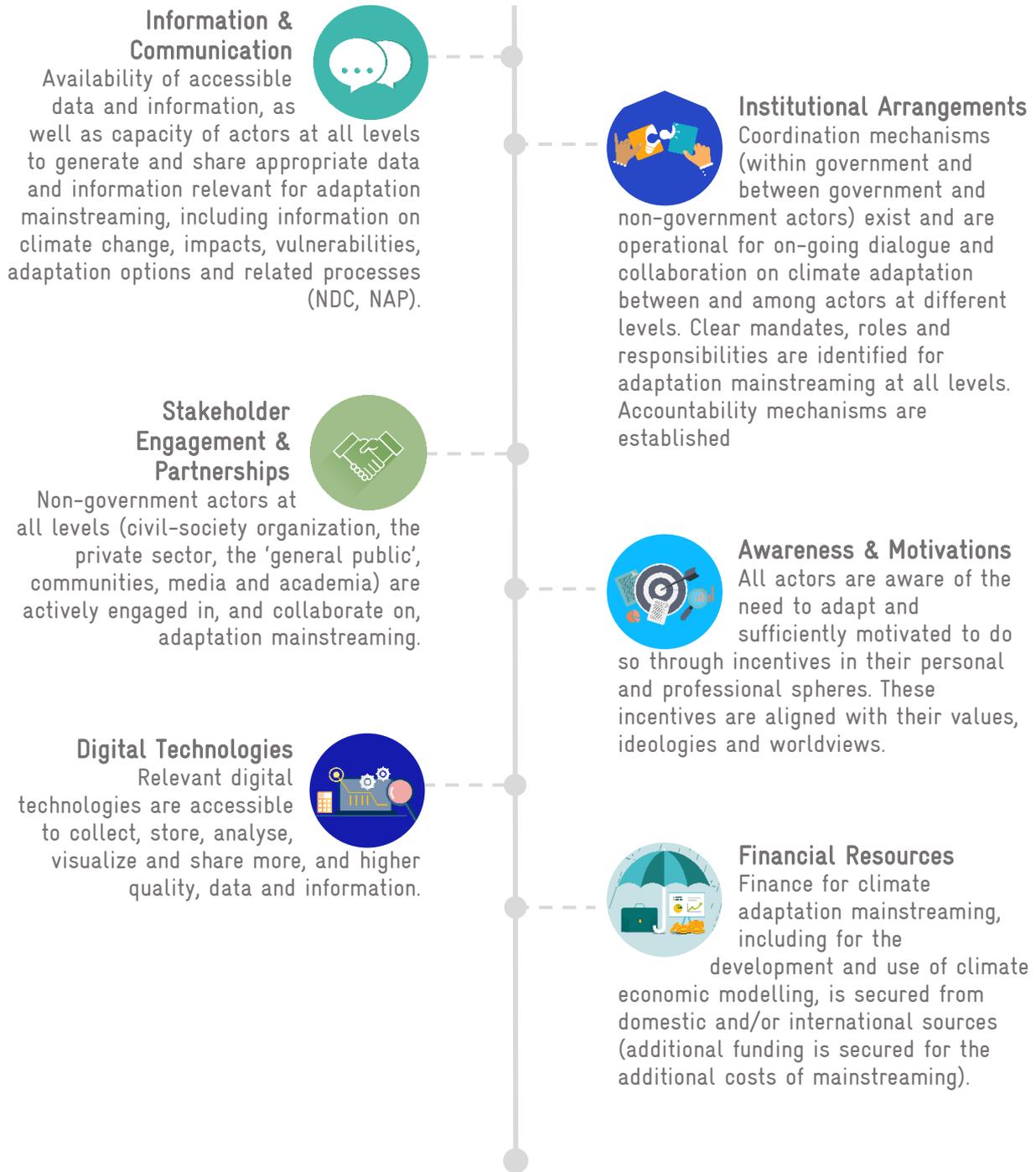
leading to concrete projects and programs. Similarly, the integration of climate adaptation in sector policies and programs can trigger greater integration of climate adaptation in another sector. Global factors (e.g., socio-economic, political, environmental) can also accelerate, or inhibit, climate adaptation mainstreaming in national development efforts. For example, the impacts of the Covid-19 pandemic on the economy could accelerate (or hinder) the integration of climate adaptation in economic development.

Enabling factors

A combination of key factors, or enablers, (see Figure 3) is required to support the effective use and uptake of climate economic modelling results in economic development. Together, these factors can influence the successful use of climate economic modelling results to support the integration of climate adaptation in development processes.

Figure 3. Indicative enablers of the effective use and uptake of climate economic modelling results in development efforts (adapted from NAP Global Network & UNFCCC, 2019)





How to use the enablers. Like the entry points, these enabling factors do not work in isolation. In other words, these factors work as a set of interrelated conditions that can affect the use and uptake of climate economic modelling results. For examples, leadership often requires *access to relevant information and capacities*; institutional arrangements and stakeholder engagement often requires *access to financial resources*; and securing financial resources for climate adaptation mainstreaming on its own will

not be sufficient; actors need to have *access to the relevant information* and be equip with the necessary *skills and capacities* to be able to use these resources appropriately. Since these enabling activities are mutually reinforcing, coordination is required across all of them to facilitate climate adaptation mainstreaming.

An effective enabling environment means that progress is being made across all enabling conditions on a sustained basis. Of course, in

reality, progress rarely happens simultaneously across all enablers; in some cases, some enabling conditions may be well established while other may be inexistent or at the early stage of development. It is an ongoing, iterative, and long-term process to develop, maintain and strengthen these conditions. Indeed, it takes time and resources to build trust, dialogues, common understanding, and capacities, among other things, between and among a wide range of actors. As such creating an enabling environment for adaptation mainstreaming does not happen automatically. It requires constant investments and efforts. It must be thought for, crafted, designed, and re-evaluated on a regular basis.

The priority enabling conditions depends on the country context. In a given context and at a given time, each enabler may be at a different “stage of development”. For example, leadership to address climate adaptation may exist outside the government without high-level political support for it yet. Or some capacities to understand climate economic models exist but are limited to few individuals within the same institution. This means that an assessment of each enabler is required to understand their status as well as the gaps that need to be filled. This evaluation can be done by answering a set a few key questions based on a review of existing documents together with consultations with relevant actors if possible (see examples of questions in figure 4 below). Once an understanding of the status of each enabling

condition has been developed, results can then be consolidated to provide an evaluation of the overall enabling environment including an identification of the leverage points and gaps that need to be filled. Results from such assessment will help identify which enabler, or set of enablers, should be prioritized at a specific point in time. It will be important to prioritize the enablers where progress can most easily be achieved in the short- and medium-term with minimum resources and high potential impacts.

Linking the entry points with the enabling factors

Four major factors should be considered for assessing the entry points:

1. The climate economic modelling development process and results,
2. The stage of the economic development policy cycle,
3. The status of climate adaptation planning and mainstreaming, and
4. The overall enabling environment for adaptation mainstreaming.

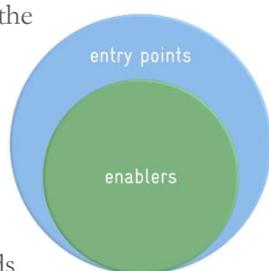
Table below provides an overview of these factors with some guiding questions and examples.

Table 1: Factors for assessing the entry points

Factors	Guiding questions	Examples/explanations
Modelling development process and results	Is there an economic model available that is regularly used? What are the results of the model currently available? What are the implications for economic development? Who has mostly been engaged in the development and use of the model? Do the results confirm existing knowledge and information and/or bring new knowledge and information?	If a specific ministry has been actively engaged in the development and use of the model, then identifying an entry point that is under the responsibility of that ministry is a good starting point. If the model has been used in specific sectors, then it would make sense to explore entry points that are related to these sectors, or if the model shows that the impact may be particularly important on a specific sector (e.g., trade, tourism) or on a specific element of economic development (e.g., private

Factors	Guiding questions	Examples/explanations
Stage of the economic development policy cycle	At what stage is the economic development policy cycle at the national, sectoral and subnational levels? What are the current and planned activities? Do activities tend to focus primarily on a specific stage of the development cycle?	sector development, employment, trade), then it is worth exploring entry points that specifically relate to it. If most on-going or planned activities tend to focus on the planning stage of the economic development policy cycle (e.g., review and update of various policies, strategies and plans), then it is worth exploring entry points at the level of the policy cycle first.
Status of the climate adaptation planning and mainstreaming	What is the status of the climate adaptation planning and action? To what extent is climate adaptation integrated in the economic development cycle and vice versa, to what extent climate adaptation planning and action integrate economic considerations?	It is worth exploring if and how economic considerations have already been integrated in a country's NDC or NAP process and if and how economic actors have been part of the development and implementation of these processes.
Enabling environment for climate adaptation mainstreaming	Does leadership on climate adaptation exist? If yes, where? What is the level of leadership? Do capacities on the economic development-climate adaptation nexus exist? Where? What types of capacities are available? Has the link between climate adaptation and economic development been established? Do coordination mechanisms exist? Are these mechanisms operational? Who is part of these mechanisms?	It is likely that more than one entry point exists. The assessment of the enabling environment can help you zoom in on the most strategic entry points, the 'low hanging fruits' – i.e., the entry points with high potential for impact and requiring limited or relatively low investment in resources.

The entry points and the enablers reinforce each other. They are both important and closely linked. The enablers are the conditions within which the entry points operate. In other words, the enabling conditions “help” to integrate economic modelling results. Without an effective enabling environment, it is hard to ‘activate’ the entry points and to support and sustain in the long run the use and uptake of climate economic



modelling results and ultimately the integration of climate adaptation in economic development efforts. While it would be ideal, not all the enabling conditions need to be in place to be able to use the entry points. For example, if one wants to integrate climate economic modelling results in “the development or update of legal and policy frameworks” (one of the nine entry points identified in this framework), such as the development of a national economic development policy, then some minimum level of awareness, capacity and leadership within the Ministry in charge of developing this policy will be needed.

IV. GUIDANCE ON UTILIZING THE ENTRY POINTS FOR INTEGRATING CLIMATE ECONOMIC MODELLING RESULTS

This section provides guidance on applying the climate economic modelling results at each of the key entry points in the economic development policy cycle. While it makes sense to start using the results of economic modelling at the planning stage, there is no one-fit-all strategy on how to use these entry points. The selection of the 'best' entry point(s) is very context specific and depends on the immediate opportunities and needs of the country. In other words, climate economic modelling results can be used at any point in the development policy cycle. For each entry point, a description of the following is provided:

- › **“why it is important”** provides an explanation of why it is important to integrate climate economic modelling results during this phase of the policy cycle;
- › **“what it looks like in practice”** offers a set of potential actions you can take to integrate climate economic modelling results into this step;
- › **“example”** describes what it could look like in practice at the global or country level.

1. Planning

1.1 Development or update of legal and policy frameworks that provide a mandate for climate-resilient development.

Why this is important

This is the visioning step of the planning process, where governments develop and update their legal and policy frameworks ranging from development visions, climate change bills/laws, economic policies (employment, budgetary, fiscal, monetary, trade policies), and sector policies (e.g., agriculture,

tourism) among others. Economic modelling results provide a narrative justification for proposing/revising legal and policy frameworks that account for the impacts of climate change on the economy. Integration of modelling results into this step is an opportunity to establish a commitment to address the economic impacts of climate change and to maximize potential benefits. Legal and policy frameworks can provide a mandate to incentivize all key actors (not just the Ministry responsible for coordinating climate change) to account for, and address, the negative impacts of climate change on the economy and maximize the potential benefits; it can help address the issue in a more systematic way rather than on an *ad hoc* basis.

What does it look like in practice

Establish more ambitious **vision and high-level targets and goals** for climate-resilient economic development.

Frame the issues of economic development and adaptation and the links between the two in a way that is more nuanced, context specific, and forward-looking. (e.g., Climate change is not only an environmental and a social issue, it's also an economic issue.)

Assign **role and responsibilities**/obligations to all key actors in addressing the economic-climate change nexus, including the Ministries of Economy, Finance and Planning.

Define which economic activities support climate adaptation using taxonomies and standards

Examples

Fiji's draft Climate Change Bill (2020) recognizes among other things that “economic development is essential for adopting measures to address climate change” and that “the Minister responsible for the economy must provide information on the economic implications of climate change in the supplement to the budget address”.

The [EU taxonomy regulation for sustainable economic activities](#) establishes six environmental objectives including one on climate adaptation.

1.2 Diagnoses or assessments of risk and vulnerability

Why this is important

This is the evidence step in the planning process, where the analysis presented will determine the course of policy/strategy development, investment, and implementation. This is the step where actors ask themselves, what is the current socio-economic situation, what are the trends (population growth, ageing population, urbanization, ascendance of some sectors, etc.), what are the key issues that need to be addressed and main drivers? This is likely the biggest and most important entry point for economic modelling. Risk and vulnerability assessments for a country/a sector/a social group provide a basis for identifying solutions and to review/update existing policies and strategies.

What does it look like in practice

Identify sectors or elements of the economy (e.g., public infrastructures, trade) that require **more in-depth assessments/economic analyses** to get a more detailed understanding of the macroeconomic (and related fiscal and financial) implications of climate change and capacity of the economy to adapt. (e.g., focus on a specific sector/region/group of the population)

Promote the development of **standardized vulnerability assessment framework** that includes a focus on climate-resilient economic

development, to develop robust baselines for replication for times/geographies

Examples

Austria: 2015 [project COIN \(Cost of Inaction: Assessing the costs of climate change for Austria\)](#)

Germany: 2020 analysis on [In-depth economic analysis of individual policy instruments and measures for adapting to climate change](#) and the project “[Economics of Climate Change Adaptation](#)” during the period 2011-2015.

EU: The PESETA project (“[Projection of Economic impacts of climate change in Sectors of the EU based on bottom-up Analysis](#)”) has been exploring the economic impacts of climate change on key sectors of the EU and how these effects could be avoided with mitigation and adaptation policies.

Organisation for Economic Co-operation and Development (OECD): 2015 [Economic consequences of climate change](#); 2021 [project on Losses and damages from climate change](#)

International Monetary Fund (IMF): [2017 Climate Change Policy Assessment for Small States, with the World Bank](#)

World Bank: The [Economics of Adaptation to Climate Change \(EACC\)](#) study was a multiyear study managed by World Bank and initiated in 2008 and released in 2010. Seven country case studies —Bangladesh, Bolivia, Ethiopia, Ghana, Mozambique, Samoa, and Vietnam were conducted to help decision-makers in these developing countries assess the risks posed by climate change and design national strategies for adaptation. The country case studies include an evaluation of economywide impacts of climate change using a CGE model. Also: 2016 study [Climate Change, Water and the Economy](#).

Asian Development Bank (ADB): 2013 [The economics of climate change in the Pacific](#)

Inter-American Development Bank (IADB): [2014 Understanding the economics of climate adaptation in Trinidad and Tobago](#)

1.3 Development or update of strategies and plans (incl. identification and prioritization of measures)

Why this is important

This is the step in the planning process, where strategies and plans (e.g., green growth strategies, climate adaptation plan, agricultural development strategies, land-use, and urban plans) are developed or updated to clarify where to go and how to get there. In this step, economic modelling results provide a narrative justification for proposing or revising strategies and plans that account for the impacts of climate change/climate change adaptation on the economy. It is an opportunity for clarifying how the climate change-economy nexus will be addressed including which options, priorities and approaches will be pursued and who should be involved to advance climate-resilient economic development in the country. This is likely an important entry point for economic modelling.

What does it look like in practice

Establish climate-resilient economic development as an overall **guiding principle** in the strategies/plans.

Account for climate change impacts in the **identification and prioritization of economic measures** for e.g., during cost-benefit analyses, multicriteria analysis, participatory scenario development workshops

(more robust economic measures).

Use “contribution to sustainable economic development” as a **guiding principle or criterion for prioritization** of adaptation measures, linking to the results of the economic modelling and assessing the extent to which adaptation options address identified issues (more robust adaptation measures that account for maladaptation, and the trade-offs and synergies among different objectives such as between adaptation and mitigation).

Frame the issues of economic development and adaptation and the links between the two in a way that is more nuanced, context specific, and forward-looking. (e.g., Climate change is not only

an environmental and a social issue, it's also an economic issue.)

Establish more ambitious **targets and goals** for climate-resilient economic development (e.g., justifications to support the integration of an adaptation component in the NDC or to strengthen an existing NDC's adaptation component.)

Incorporate **specific sections** summarizing the economic impacts of climate change and the opportunities (and trade-offs) of climate adaptation for economic growth (e.g., competitiveness of particular sectors, green jobs creation, development and marketing of new technologies).

Include **specific goals/objectives/expected outcomes, target groups for the actions and timelines** to address the economic impacts of climate change/climate change adaptation (not just in the introductory sections or guiding principles).

Conduct **more detailed analysis/assessments** in certain sectors/regions/groups of the population that may have been overlooked to support the identification and prioritization of measures.

Examples

Process for measure selection -- The [application of Climate Economic Growth Impact Model \(CEGIM\) in Cambodia](#) helped the Ministry of Economy and Finance and the Ministry of Environment and the National Council for Sustainable Development to identify that the existing climate adaptation measures were overlooking the importance of heat stress on labour productivity. According to model, by 2050 reduced labor productivity would account for 57% of all losses and damage. One of the recommendations from the application of the CEGIM indicates: “More attention should be paid to activities such as: mechanisation; more labour efficient farming systems with flexible farm work scheduling; improved working practices on construction sites; better working conditions in factories (...); improved understanding of risks amongst workers and employers; improved forecasting and measurement of heatwaves; and planning to protect supply chains from heat stress.” (MEF and MENCSD, 2019: 15)

Criteria for measure selection -- One of the criteria used for prioritizing the adaptation measures selected in **Fiji's NAP document** includes: "Support better management environmental, societal, and economic trade-offs".

Strategy informed by modelling results - According to [Manda and Chevillard \(2019\)](#), the application of the Climate Economic Growth Impact Model (CEGIM) in Cambodia in 2018 contributed to support the integration of climate change in the country's Rectangular Strategy for Growth, Employment, Equity and Efficiency Phase IV for the period 2019–2023. The model predicted that climate change could reduce average GDP growth to 6.6% and absolute GDP by 0.4% in 2020, 2.5% in 2030 and 9.8% in 2050.

The 2021 [EU Strategy on Adaptation to Climate Change](#) explicitly refers to the results of the project '[Projection of Economic impacts of climate change in Sectors of the EU based on bottom-up Analysis](#)' (PESETA). The new strategy is also accompanied by a staff working document '[impact assessment report](#)', which presents the results of the PESETA project.

Germany's third Adaptation Action Plan (APA III), published in 2020 as part of the [Second progress report of the 2008 German Adaptation Strategy](#), was informed by the results of a study on [In-depth economic analysis of individual policy instruments and measures for adapting to climate change](#)

2. Budgeting and financing¹

2.1 Formulation of government budgets, investment plans, resource allocation frameworks in line with government strategies and policies

Why this is important

This is the planning step in the budgeting process, where government formulate budgets, investments plans, and resource allocation frameworks in line with their policies and strategies. Government budgets include central budgets, sector budgets, the services provided by the government, and budgets allocated for subnational authorities and implementing partners. In this step, government must prioritize where and how resources will be allocated. Economic modelling results provide a justification for channeling resources for climate-resilient economic development to address the economic (and related fiscal and financial) losses due to climate change (and the associated adaptation finance gap). It makes the case for preventive (climate adaptation, risk management strategies) rather than reactive (disaster response) public investments. It justifies the need for initiating or deepening and widening climate budgeting reforms to optimise public investment in adaptation, ensuring that public expenditure overall is more resilient to climate change. By demonstrating domestic financing commitment for adaptation, government are better placed to leverage additional financing from international and private sources to support climate resilient economic development.

What does it look like in practice

Integrate climate adaptation into macroeconomic forecasts, ministries' annual budgeting frameworks,

¹ This section draws part of its content from : [The Role of Domestic Budgets in Financing Climate Change Adaptation - Global Center on Adaptation \(gca.org\)](#)

medium-term expenditure frameworks, and budgeting guidelines.

Request line ministries to explicitly consider the adaptation impacts of their **proposed budgets** and to provide costs of their proposed adaptation proposals to help prioritize spending items and projects.

Establish climate-resilient economic development as a **criterion for the budget preparation guidelines**.

Example

Fiji's Ministry of Economy is responsible for the development of the **Supplement to the Budget Address** which provides the annual macroeconomic and fiscal position of the country and forward projections for the next three years. Under the draft climate change bill (GoF, 2020), the Ministry of Economy "must provide information on the economic implications of climate change in the supplement to the budget address". The draft bill also states that "all State entities must include, in their submissions of **actual and estimated details of expenditure** for the purposes of the national budget and budget estimates document, the contribution of the State entity to mitigation and adaptation and the financial impacts of climate change on the State entity".

UNDP developed and piloted an approach called **Climate Change Financing Frameworks (CCFFs)** to engage all relevant stakeholders toward the mobilization, management, and targeting of climate change finance. For more information: "[Hard Choices - Integrated Approaches. A guidance note on climate change financing frameworks](#)" (Nicholson, et al. 2017); examples of applications are available [here](#).

UNDP developed and piloted an approach called the Climate Public Expenditure and Institutional Review (CPEIR) to analysis a country's public expenditures and how they relate to climate change. For more information, check the CPEIR methodological guidebook (2015), the countries CPEIR reports and the CPEIR online database [here](#).

2.2 Review and approval of government budget (national and sector levels)

Why this is important

This is the negotiation step in the budgeting process, where governments present, discuss, and approve budgets in line with their policies and strategies. During the budget review and approval process, it is important to have some checks and balances in place for accountability purpose. In this step, economic modelling results provide a justification for prioritizing resources allocation towards climate-resilient economic development.

What does it look like in practice

Establish climate-resilient economic development as an appraisal criterium during the **budget hearings process conducted by the Ministry of Finance**.

Include references to climate adaptation/climate-resilient economic development in **budget statements / speeches made by the Minister of Finance** (presentation of the resource allocation priorities of the government with their overall rationale and political context).

Establish climate-resilient economic development as an appraisal criterium during the **parliament's budget review / approval**

Example

In the UK, each year the Chancellor of the Exchequer, the head of the Her Majesty's Treasury, makes a Budget statement on the state of the country's economy. The [2021 budget speech](#) and the 2021 budget report made explicit reference to 'green growth' and climate change respectively. ("It's not enough to have some general desire to grow the economy. We need a real commitment to green growth. (...) Our future economy needs investment in green industries across the United Kingdom. So I can announce today the first ever UK Infrastructure Bank.", Chancellor Rishi Sunak, 3rd of March 2021)

For the next EU long-term budget, the Commission has proposed that at least 25% of EU expenditure will contribute to climate action during 2021-27. This commitment to further strengthen climate mainstreaming, reiterated in the [European Green Deal communication](#) of 11 December 2019, reflects the long-term ambition of the EU to achieve climate neutrality by 2050.

3. Implementation

3.1 Mobilization and allocation of resources (incl. public procurement)

Why this is important

This is the step in the implementation process, where governments collect taxes and other revenues, manage budget shortfalls or surpluses, and mobilize additional (off-budget) resources (financial but also technical support) for program and project implementation. In this step, economic modelling results provide a justification for ensuring that revenue collection supports climate-resilient economic development, for protecting adaptation spending from budget cuts (in the context of budget shortfalls), and for mobilizing and allocating additional resources for climate-resilient economic development. This step is likely a relatively minor entry point for economic modelling.

What does it look like in practice

Align the **taxation system** to climate adaptation/climate-resilient economic development objectives.

Integrate climate adaptation in **sustainable public procurement systems and related guidelines and contracts** (for e.g., integration of climate adaptation as a procurement criterium) by providing evidence that procurement sources may need to shift as a results of climate change.

Use **climate budget tagging or scoring system**, as a tool for the monitoring and tracking of climate-related expenditures in the national budget system.

Inform program and project **funding proposals/resources mobilization strategies** (for e.g., by incorporating information about the modelling results in the context analysis and framing of the project; by ensuring that the objectives and activities address the impacts identified; by incorporating specific actions that promote climate-resilient economic development in the project design).

Examples

[Fiji's Environment and Climate Adaptation Levy \(ECAL\)](#) is a tax on prescribed services, items and income. "ECAL helps fund critical work across Fiji to protect our natural environment, reduce our carbon footprint, and adapt our economy, our communities and our infrastructure to the worsening impacts of climate change." ECAL is collected by the Fiji Revenue & Customs Services and administered by the Ministry of Economy in accordance with the Finance Management Act 2004 and Finance Instructions 2010. So far, a vast majority of ECAL funds have been utilised for climate adaptation initiatives.

World Bank (2021) report on "[Climate Change Budget Tagging: A Review of International Experience](#)".

UNDP (2019) developed a guide, "[Knowing what you spend: a guidance note for governments to track climate change finance](#)", to help governments to set up or strengthen climate budget tagging system.

The Institute for Climate Economics (I4CE) and its [work program in green budgeting](#) supported the publication of the French government's first green budget by releasing in 2019 a 360-degree climate assessment France's State budget. I4CE is now working on identifying historical trends in climate-compatible expenditure, and on assessing what the national budget should look like in order to align with the national low-carbon strategy.

3.2 Management of programmes and projects (delivery of goods and services as per budget)

Why this is important

This is the step in the implementation process, where governments focus on managing programmes and projects to deliver the prioritized public goods and services as per budget. In this step, economic modelling results provide a justification for ensuring that programs and projects support, or at a minimum not to undermine, climate-resilient economic development (programs and projects are 'climate proofed').

What does it look like in practice

Inform program and project management systems and protocols (e.g., risk management frameworks, updates/revisions of risk management frameworks, mid-point reviews, evaluations, standards)

Examples

GIZ (2011) developed a guide, "[Climate Proofing for Development. Adapting to Climate Change, Reducing Risk](#)", to support climate change mainstreaming at project level.

ADB (2020) [Principles of Climate Risk Management for Climate Proofing Projects \(adb.org\)](#)

4. Monitoring, evaluation, and learning (MEL)

4.1. Management of data and information (from data collection to data analysis and dissemination)

Why this is important

This is the step in the MEL process, where governments focus on collecting, analyzing and sharing relevant data and information for tracking development progress. In this step, economic modelling results provide a justification for tracking the economic impacts of climate risks and for evaluating the measures taken to mitigate them.

What does it look like in practice

Develop or revise **data management protocols** and **database management plans** to improve the collection, analysis and sharing of data and information needed to inform climate-resilient economic development (e.g., trends in climate variables, climate change impacts, vulnerabilities, impacts of adaptation measures, impacts of economic instruments).

Develop national adaptation **M&E system** or revise existing M&E systems to integrate considerations related to climate-resilient economic development.

Develop or update **M&E frameworks** including the **tools used for data and information collection** (e.g., indicators, theory of change, case studies, key experts assessments) to include a focus on climate-resilient economic development (e.g. tracking the impacts of climate change and/or climate change adaptation on the economy, tracking the impacts of economic instruments to support climate-resilient economic development).

Develop or update **standardized vulnerability assessment framework** with a focus on economic impacts, to develop robust baselines and allow comparison across times/geographies/sectors.

Examples

A growing number of countries are developing M&E systems to measure progress on national adaptation. The UNFCCC's Adaptation Committee provided a review of approaches (e.g. scorecards, indicators, informal knowledge exchange, questionnaires) taken by various countries in the Annex "Considering approaches to reviewing the overall progress made in achieving the global goal on adaptation" in its 2021 report on "[Approaches to reviewing the overall progress made in achieving the global goal on adaptation](#)".

The Integrated Vulnerability Assessment (IVA) is a government-led, standardized approach to conducting community-level vulnerability assessment to climate change, which is being used and adapted in different countries in the Pacific region (Kiribati, Tuvalu, Solomon Islands, Vanuatu) based on their specific needs and priorities. The approach explores on the one hand the impacts of climate change on a community's livelihood assets (e.g., natural resources, infrastructure, finance) and on the other hand, how these impacts affect a community's ability to meet its human security objectives (in terms of for e.g., security of place, community health, ecosystem health, water security, food security, income security and energy security) at a particular point in time. The results offer a list of climate change issues identified by community members. The economic dimension of climate change is therefore integrated as a cross-cutting theme in the IVA approach (e.g., focus on 'income security', 'finance'). For more information about the IVA, check this [briefing note](#) (NAP Global Network, 2019).

The 2014 [LDCE/SCCF Adaptation Monitoring and Assessment Tool \(AMAT\)](#) measures progress toward achieving the outputs and outcomes established at the portfolio level under the Least Developed Countries Fund (LDCF) and the Special Climate Change Fund (SCCF) as part of the Global Environment Facility (GEF).

4.2. Reporting (verifying)

Why this is important

This is the step in the MEL process, where governments focus on verifying and reporting progress against commitments to promote transparency and accountability (incl. in terms of aligning policy frameworks with budgets) both nationally and internationally. In this step, economic modelling results provide a justification for reporting on progress made to achieve climate-resilient economic development and lessons learned to improve future actions (e.g., Which economic instruments support climate-resilient economic development? How investments in adaptation support economic growth (and vice versa)? where, for whom, why?)

What does it look like in practice

Model can be used to request ministries to provide regular updated information on the current and future impacts of climate change on the economy and on the measures for addressing these impacts.

Include a section on contribution towards climate-resilient economic development in national, sectoral and local government reporting systems (e.g., progress reports, program evaluation).

Example

[Evaluation of Climate Change Adaptation Measures: Portfolio and Allocation Analysis \(Deval, 2019\)](#). This report analyses the portfolio of the German federal government's allocation for climate-related development finance over 2011-17. It includes overarching evaluation questions that can be considered when conducting such portfolio and allocation analysis at the national level.

V. GUIDANCE ON UTILIZING THE ENABLING FACTORS FOR INTEGRATING ECONOMIC MODELLING RESULTS

This section provides guidance on utilizing the enabling factors for supporting the application and uptake of climate economic modelling results in development processes. For each enabler, a description of the following is provided:

- › **“why it is important”** provides an explanation of why the enabler is important to support the use and uptake of climate economic modelling results in development;
- › **“what it looks like in practice”** offers a set of potential actions you can take to activate the enabler;
- › **“example”** illustrates what it could look like in practice at the global or country level.



1. Leadership

Why this is important

Provide a strong and sustained signal to all actors that the government, and ideally other non-government actors, recognize the impacts of climate change on the economy of the country and are committed to address the negative impacts and to take advantage of the opportunities.

What does it look like in practice

Deliver officials statements on the economic costs of climate change and the benefits of adaptation.

Participate in events related to the topic.

Become a member of relevant networks and alliances – at the national, subnational, and international levels.

Example

International level - [The Coalition of Finance Ministers for Climate Action](#): A Ministerial-level group launched in 2019 to support the use of fiscal policy, public financial management and climate finance to promote domestic and global action on climate change, through mitigation and adaptation measures. The members of the Coalition have signed on to a set of 6 principles (the 'Helsinki Principles') to promote national climate action. Principle 4 ‘mainstream’ focuses on taking climate change into account in macroeconomic policy, fiscal planning, budgeting, public investment management, and procurement practices.



2. Capacities

Why this is important

On-going capacity development on what is climate adaptation and its link with economic development is essential for all actors to enable their meaningful engagement in the development, use and revision/update of climate economic models. This is also likely to increase trust in the modelling results.

Quantifying the macroeconomic impacts of climate change and the economic returns to investment in adaptation requires technical capacities and expertise, which may not be readily available in country or which may be limited. People with a different background or with no experience in modelling often find it difficult to evaluate the model results. The development and use of the model also requires the engagement of actors who have climate adaptation expertise but may be less familiar with economic development.

What does it look like in practice

Undertake a stakeholder mapping exercise (regional, national, subnational levels) to understand where capacities and experiences are located (within and outside the government) and look for opportunities to involve these actors in the development and use of the model.

Undertake a capacity assessment of key actors on economic development, economic modelling, climate adaptation, climate-resilient economic development.

Develop a capacity development plan/strategy targeting both economic and adaptation actors.

Secure additional resources for on-going capacity development on the links between climate adaptation and economic development.

Promote learning processes that bring climate adaptation and economic actors together in dialogue (for example, through joint training workshops).

Invest in education and training systems to increase the national pool of expertise on the economics of climate adaptation (e.g., climate adaptation is often reduced to technical measures focused on infrastructures; modelling often depends on support provided by external experts).

Invest in mentoring /deploying advisors on the economics of adaptation in Finance and Planning Ministries responsible for climate proofing investments and planning decisions and for supporting the development of pipelines of bankable projects.

Participate in peer learning exchanges on the topic to share, exchange, and learn from best practices among different countries.

Example

Development agencies are supporting the development and applications of climate economic models in various countries. These applications often involve dialogues between international and national modelers and trainings sessions of model developers and users.

- › The GIZ International Climate Initiative (IKI) global program Policy Advice for Climate Resilient Economic Development (CRED) financed by BMU is working on applying and adapting macro-economic models to assess the impact of climate risk on national economies in Georgia, Kazakhstan and Vietnam. The program and their national partners are implementing two input-output model in Georgia and Kazakhstan (E3.ge and E3.kz) and a dynamic general equilibrium model (DGE CRED) in Vietnam (for more information check the [CRED project Brief](#))
- › AFD: development of the model, “[General Monetary and Multisectoral Macrodynamics for the Ecological Shift](#)”, (GEMMES). Current applications: Brazil (focus on the energy sector), Colombia (transition risks), Côte d'Ivoire (raw materials and the informal economy), Vietnam (impact of climate change on coastal areas), Tunisia and Morocco (impact of climate change on agriculture)
- › UNDP/EU: application of [Climate Economic Growth Impact Model \(CEGIM\)](#) in Cambodia

[Climate Action Peer Exchange \(CAPE\)](#) is a World Bank led-initiative that provides capacity-building for peer-to-peer knowledge sharing and advisory support for finance ministries to design climate-smart macroeconomic policies, discuss fiscal-policy measures for mitigating the impact of climate change, and develop financing strategies for implementing NDCs. The initiative is supported by the government of Germany and the World Bank Group's South-South Experience Exchange Facility



3. Information and communications

Why this is important

Access to country-specific and quality data and information is a key input to the development of climate economic models. It can support more robust model outputs by reducing uncertainties and increasing confidence in assumptions. Access to information such as climate information on past, current and future climate change impacts, is also essential for the on-going improvement/refinement and revision of climate economic models. Broadly, climate-resilient economic development requires data and information that is accessible and tailored to the needs and roles of different actors involved.

What does it look like in practice

Invest in collecting data on climate change damages and on the benefits of climate adaptation measures to support the development/refinement and revision of climate economic models.

Invest in strategic communications and climate services as essential elements to support the use of climate economic modelling results.

Develop a communication strategy around the climate economic model that consider different target groups.

Ensure that climate adaptation actors have access to information related to economic development trends and processes (e.g., SDGs, economic development strategy) tailored to their needs and roles.

Ensure that economic actors have access to information related to climate adaptation trends and processes (NDC, NAPs) tailored to their needs and roles.

Communicate information about the modelling results with a clear indication of the assumptions, gaps and limitations associated with the methodology (including in terms of uncertainties).

Examples

Global databases:

- › Global databases with records of past disasters and their human and economic consequences, such as the [Emergency Events Database \(EM-DAT\)](#) developed by the Centre for Research on the Epidemiology of Disasters (CRED) at the Université catholique de Louvain, Belgium.
- › The [Shared Socioeconomic Pathways \(SSP\) database](#) includes scenarios of future global socioeconomic changes up to 2100.

Communicating information about the modelling results:

- › The EU project [‘Projection of Economic impacts of climate change in Sectors of the EU based on bottom-up Analysis’ \(PESETA\)](#) developed ‘summary cards’ on the impacts of climate change in key sectors and various associated infographics.

AFD in collaboration with the Government of Vietnam is planning to development different products to disseminate the results of the GEMMES model. [Finding Climate Solutions in Vietnam with Etienne Espagne | AFD - Agence Française de Développement](#)



4. Institutional arrangements

Why this is important

Institutional arrangements influence how decisions are made including what actions are prioritized, how they are implemented and who is represented. Climate adaptation mainstreaming requires huge coordination efforts –across different actors, sectors, levels of governance, and timeframe. It is hard because governments need to address an issue that is ‘cross-sectoral’ when they are still traditionally organized in silos. Economic experts and the government institutions responsible for economic development, must be part of the institutional arrangements for climate change (incl.

adaptation) to support the use of climate economic modelling results in economic development. The Ministries of economy, finance and planning are also the government bodies with strong convening and decision-making powers, which can help give more visibility and traction for climate adaptation/climate-resilient economic development.

What does it look like in practice

Include the Ministry of economy and other agencies responsible for economic development in institutional mechanisms for coordination and implementation of adaptation at the national, sectoral and subnational levels.

Involve economic actors as advisors to institutional structures established for climate change /climate adaptation planning.

Appoint and/or reinforce the role of climate change focal points and economic experts in relevant ministries to promote climate-resilient economic development.

Ensure that functional institutional mechanisms are in place to strengthen coordination and collaboration between economic and climate change actors (for example, through technical working groups or inter-ministerial committees).

Clarify the **role and responsibilities** of all key actors in addressing the linkage between economic growth and climate adaptation including the Ministries of Economy, Finance and Planning (or alike).

Example

Coordination of NAP processes including:

- › Establishment of cross-sectoral committees led by (or including) the Ministry of economy, the Ministry of Environment and the Ministry of Planning– e.g., Togo;

Climate change adaptation coordinated by the Ministry of Economy (instead of the Ministry of Environment) – e.g., Fiji



5. Stakeholder engagement and partnership

Why this is important

Participation of relevant/diverse actors (incl. civil society organizations, the private sector, the media) in the development of the climate economic modelling will contribute to build trust / legitimacy, and accountability in the process and associated results (more robust process and results). Stakeholder should be engaged on an on-going basis – including for the interpretation of the results; the validation of key assumptions, etc. Ongoing stakeholder engagement, including between model developers and users, is essential to facilitate the uptake of the results/to ensure that climate economic modelling results are communicated, used, and regularly updated.

What does it look like in practice

Secure additional resources of inclusive participation with a focus on gender equity and the involvement of gender and social inclusion experts

Integrate economists and Ministry of Finance/Economy (i.e., the economic model developers in general) in the development and application of integrated approaches to vulnerability assessments.

Engage economic experts and climate change actors in the development of plans and strategies.

Integrate economists and Ministry of Finance/Economy (i.e., the economic model developers in general) in the identification and prioritization of adaptation measures (at the national level, within sectors, in different regions or at the local level).

Integrate climate adaptation experts in the identification and prioritization of economic development measures.

Engage economists in the development of criteria for prioritization of adaptation measures at different levels.

Engage economic and climate adaptation actors in the budget preparation process, budget review and approval process (negotiation process).

Involve adaptation and economic actors in proposal development and project implementation.

Involve economic and climate adaptation actors in the coordination mechanisms for program and projects implementation.

Engage economic (incl. statisticians) and climate adaptation actors in data and information management systems (for robust data collection and analysis).

Engage economic and climate adaptation actors in the development of M&E frameworks, building on existing systems and data.

Example

The [GIZ International Climate Initiative \(IKI\)'s global programme on Policy Advice for Climate Resilient Economic Development \(CRED\)](#) financed by BMU has been working on applying and adapting macro-economic models to assess the impact of climate change on national economies in Georgia, Kazakhstan and Vietnam. In 2020, the program included in-country training courses on the economic models developed by the Institute of Economic Structures Research (GWS) and the Halle Institute for Economic Research (IWH). Trainings covered topics such as finding data on climate change and adaptation; data management; translation of the data into model parameters; creation of different climate change and climate adaptation scenarios; running the model; comparison of scenarios and the preparation of results in graphs and tables. To strengthen the country ownership of the model, a 3-month coaching program delivered by GWS and IWH will complement these trainings in 2021. The coaching activities will comprise of sector-focused meetings to gather further data and information with country experts, and to apply and further refine the models.



6. Awareness and motivations

Why this is important

All actors must be aware of the need to adapt and adequately incentivized in their personal and professional spheres to integrate climate adaptation in development in line with their values, ideologies and worldviews. This is critical because evidence from behavioral sciences indicate that scientific, technical information (incl. information from modelling results) matter but is often not sufficient to influence what people do, which is largely determined by their values, ideologies and worldviews (USAID, 2019).

What does it look like in practice

Engage with behavioral scientists and experts to develop appropriate incentives (e.g., salary, visibility, international recognition) and communication strategies.

Conduct behavioral analysis to inform awareness strategies and develop appropriate incentives.

Example

Rare, an NGO working on behavior change in conservation, has developed a framework that identifies 6 levers of behavioral change:

1. Information - Providing information about what the target behavior is, why it matters, and how to do it
2. Rules and regulations - Enacting rules that promote or restrict a behavior
3. Material incentives - Increasing or decreasing real or perceived costs, time, or effort for doing a behavior
4. Emotional appeals - Using emotional messages to drive behavior
5. Social influences - Leveraging the behavior, beliefs, and expectations of others
6. Choices architecture - Changing the context in which choices are made

It highlights that so far, the focus has mostly been on the first three levers with no to limited attention paid to the last three. For more information: Rare. (2020). Levers of behavior change. Behavior change for the environment. <https://behavior.rare.org/wp-content/uploads/2020/11/Understanding-Behavior-Change-Levers-and-Strategies-scroll-Nov-2020-.pdf>



7. Digital technologies

Why this is important

Digital technologies can improve the development and use of climate economic models. They can help use more and higher quality data and information on climate risks, climate impacts and responses and therefore increase confidence in the assumptions used for developing the model and improve the models results. They can also support the monitoring and evaluation of adaptation measures and facilitate stakeholder engagements, exchange of information, and communications around the model results. Digital technologies can help account for complexities, interactions among various variables and develop integrated solutions (across sectors and scale of governance).

What does it look like in practice

- › Engage with the Ministry responsible for Information, Technologies and Communications (ITCs) through regular communications
- › Collaborate on the use of digital technologies with experts at the regional and international levels
- › Digitalize climate data
- › Use machine learning to improve climate models and extreme weather forecasts
- › Use remote sensing technologies to monitor observed climate impacts

- › Monitor changes in legislations, policies, plans and strategies using language processing methods/political texts and legislation analysis

Examples

The GIZ programme “[Enhancing climate services for infrastructure investment \(CSI\)](#)” supports the use of climate products and advisory services for infrastructure planning. This is done, for example, through the development of knowledge management platforms for the observation and monitoring of climate impacts and the presentation of possible adaptation measures.

The GIZ programme “[Technology based Adaptation to Climate Change in Rural Areas of Tajikistan and Kyrgyzstan](#)” aims to establish national geodata infrastructures in both countries with the ultimate objective to inform climate-resilient development planning



8. Financial resources

Why this is important

Globally, financial resources allocated towards climate adaptation are increasing but remain limited. Governments need to finance the additional costs of adaptation mainstreaming. Financial resources are needed to ensure that all the systems and capacities (i.e., all the enabling factors described in this section) are in place to support the meaningful development and use of climate economic modelling.

What does it look like in practice

Incorporate climate-resilient economic development issues in the context analysis and framing of programs and projects.

Ensure that resources are allocated within program and projects for climate-resilient economic development.

Example

Mechanisms such as the Green Climate Fund (GCF), the Adaptation Fund (AF) and the Least Developed Country (LDC) Fund have been established to provide financial support to countries in addressing climate change.

[Supporting Access to Finance for Climate Action \(Sida, 2017\)](#). This guide provides an overview of the different sources of finance for climate action.

VI. CONCLUSION AND OUTLOOK

Climate macroeconomic modelling translates complex relationships among many different climatic and economic variables in numbers. The results give an indication of *the general direction* of climate change impacts on the economy of a country under different scenarios (with and without investments in climate adaptation). These results, as much as the progress of developing such models, can be especially helpful in framing the problem, engaging (new) stakeholders and raising their awareness, and improving communications on the linkages between climate change (adaptation) and economic development. For policy and decision makers, these are essential elements in support of advancing climate-resilient economic development. And these benefits are most likely when climate economic modelling is developed using participatory approaches and when results are combined with other tools and qualitative analysis.

But to realize this potential, and therefore facilitate the integration of climate economic modelling results in economic development efforts, an understanding of the modelling development process and results must be combined with considerations for the following:

- › the stage of the economic development policy cycle,

- › the status of climate adaptation mainstreaming, and
- › the overall enabling environment for adaptation mainstreaming in the country of focus.

Such understanding can help to identify which entry point(s) along the economic development policy cycle should be activated to facilitate the integration of modelling results in economic development efforts.

The proposed framework identifies different entry points for consideration. The selection of the most appropriate entry point(s) is very context specific and depends on the immediate opportunities and needs of the country. The framework also identifies the key enabling factors, which are the conditions within which the entry points operate. An assessment of the enabling factors will help identify which entry point(s) may be most strategic – i.e., those entry points with high potential for impact while at the same time requiring relatively limited or low investment in resources -- in a particular context.

As a next step, this framework will be applied in the three pilot countries (Georgia, Kazakhstan, and Vietnam) and then further revised to capture the results and lessons learned.

References

1. Arent et al. (2014). *Key economic sectors and services. Chapter 10*. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 659-708
2. Chambwera et al. (2014). *Economics of adaptation. Chapter 17*. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 945-977.
3. DeFries, R. et al. (2019). *The missing economic risks in assessments of climate change impacts. Policy insights*. The Grantham Research Institute on Climate Change and the Environment, The Earth Institute at Columbia University, and The Potsdam Institute for Climate Impact Research (PIK).
4. Erikson, S. et al. (2021). *Adaptation interventions and their effect on vulnerability in developing countries: Help, hindrance or irrelevance?* in World Development 141: 105383.
5. Global Commission on Adaptation (GCA) (2019). *Adapt Now: A Global Call for Leadership on Climate Resilience*. Rotterdam and Washington, D.C.: Global Center on Adaptation and World Resources Institute.
6. Hallegatte et al. (2020). *Adaptation Principles—A Guide for Designing Strategies for Climate Change Adaptation and Resilience*. Overview booklet. Washington, DC: World Bank.
7. Hammill, A. et al. (2019). *The National Adaptation Plan (NAP) process: Frequently asked questions*. NAP Global Network. The National Adaptation Plan (NAP) Process: Frequently Asked Questions | NAP Global Network
8. Hammill, A. and McGray, H. (2018). *Is it adaptation or development? Revisiting the continuum 10 years later*. Winnipeg: International Institute for Sustainable Development (IISD).
9. IPBES (2019): Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. S. Díaz, et al. (eds.). IPBES secretariat, Bonn, Germany.
10. ICIMOD. (2009). *Local responses to too much and too little water in the Greater Himalayan region*. International Centre for Integrated Mountain Development (ICIMOD)
11. IISD. (2019). *Modelling for Sustainable Development. Modelling for a new age*. Winnipeg: International Institute for Sustainable Development (IISD).
12. International Bank for Reconstruction and Development and World Bank. (2010). *Economics of adaptation to climate change. Synthesis report*. The International Bank for Reconstruction and Development and the World Bank.
13. Kousky, C. (2014). Informing climate adaptation: A review of the economic costs of natural disasters in Energy Economics, 46: 576–592.
14. NAP Global Network & UNFCCC. (2019). *Toolkit for a gender-responsive process to formulate and implement National Adaptation Plans (NAPs)*. Dazé, A., and Church, C. (lead authors). Winnipeg: International Institute for Sustainable Development.
15. OECD. (2021). *Losses and damages from climate change. Workshop on Assessing socio-economic losses and damages*. 13 January 2021 – Virtual Zoom Meeting. Key Insights. OECD.
16. USAID. (2019). *Applying social and behavior change to climate change adaptation. A literature review*. Chemonics International Inc. and USAID.
17. Weaver, C.P. et al. (2013). Improving the contribution of climate model information to decision making: the value and demands of robust decision frameworks in WIREs Climate Change, 4: 39–60.

