Macroeconomic Models for Climate Resilience

An economic tool for adaptation and development planning

Summary

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Increased climate adaptation is a development priority and an economic imperative. But how can countries prioritise adaptation investments and ensure that their economic development pathway is climate resilient in the long term? An effective national response to climate risks requires not only an overview of the possible long-term impacts of climate change on the different economic sectors but also crucially depends on estimations of where economic effects are most pronounced and adaptation action most effective. Macroeconomic models that integrate economic impacts of climate change and adaptation measures are powerful tools to support national governments in this role.

Such models can be a valuable tool because:

- They provide a single coherent framework for integrating economy-wide impacts of climate hazards, economic development trends and effects of adaptation measures.
- They provide additional evaluations of adaptation measures e.g. in terms of GDP and employment effects for economic sectors and the whole economy. Thus, they help to orchestrate and guide adaptation actions i.e. as part of sectoral planning or a National Adaptation Plan (NAP).
- They foster inter-ministerial cooperation and discourse through the exchange of relevant policy issues, key assumptions, and model results.

If implemented well, macroeconomic models that include climate impacts have the power to inform adaptation strategies that unlock new opportunities, avoid economic losses and deliver additional social and environmental benefits. They provide crucial additional information for decision makers at the national level for prioritizing investments of particular adaptation measures, a critical part of climate risk management (see e.g. GIZ climate risk brief).

This report outlines what macroeconomic models are and highlights their power to support adaptation planning. It describes an idealised process, based on the experiences of the global programme for Climate Resilient Economic Development (CRED) that has piloted the approach in Georgia, Kazakhstan and Vietnam.

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Overview on Macroeconomic Models for Climate Resilience

The World Bank[1], the Organisation for Economic Co-operation and Development[2] as well as the European Commission[3] have developed principles, guides and precise studies on the effective integration of macroeconomic modelling of climate change into policy making. However, in practice developing and emerging countries planning and investing in adaptation measures rarely use macroeconomic assessments of climate change. One reason is that economic/planning ministries often do not yet carry out systematic economic analyses of climate change impacts. This is partly due to the limited technical and human capacities to conduct such assessments, as they are very complex and data-intensive. Furthermore, the political mandate for e.g. the development of National Adaptation Plans (NAP) is commonly with the ministry of environment and the linkages with national economic development are often unclear between the ministries of environment and economy/planning.

In order to promote economic analyses of climate adaptation, the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) initiated the Policy Advice for Climate Resilient Economic Development (CRED) programme to support three pilot countries Georgia, Kazakhstan and Vietnam in developing country-specific macroeconomic tools to model impacts of climate change on their national economy. The approach presented in this paper is based on experiences in this project – for more information see the CRED programme factsheet.

Types of macroeconomic models

Different kinds of macroeconomic models can be used to assess climate risks and plan climate resilient economic development. **E3 models** are macro-econometric (or dynamic) input-output models extended by environmental aspects that can be designed to evaluate the economic impacts of climate change. In their basic form E3 models contain three interlinked parts: the (1) economy module, the (2) energy module and the (3) emissions module (compare fig. 1). For the purpose of assessing climate risks a climate module can be integrated, which describes the economic impacts of projected, country-specific climate change scenarios, informed by damage data of past and current climate related impacts in the countries. Figure 1 shows a visualization of the E3 model used in the CRED program for Kazakhstan and Georgia.

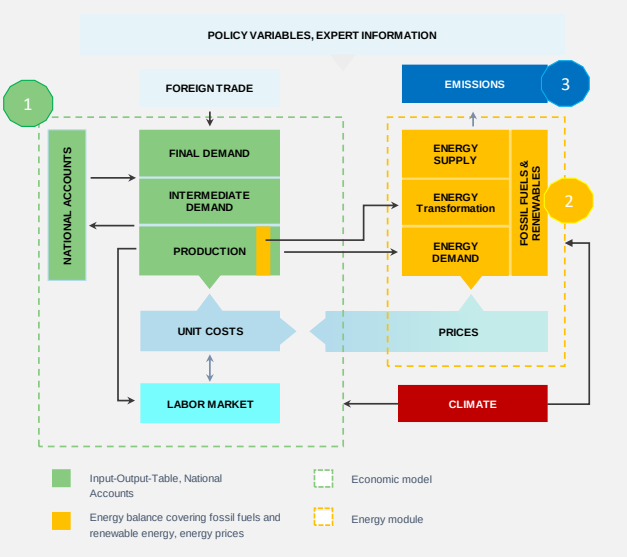

Figure 1: Example of E3 model with climate module (Source: Own figure based on GWS, 2022.)

A second type of macroeconomic models are **dynamic general equilibrium** models with optimising agents. Such models allow to integrate climate change effects into the relevant productivity equations and can differentiate

[1] Hallegatte, Stephane; Rentschler, Jun; Rozenberg, Julie. (2020). Adaptation Principles: A Guide for Designing Strategies for Climate Change Adaptation and Resilience. World Bank.
[2] OECD (2021). Strengthening Climate Resilience: Guidance for Governments and Development Co-operation, OECD Publishing.
[3] Botzen, Wouter; Bacciu, Valentina Mereu, Valentina et al. (2021). Comprehensive desk review: climate adaptation models and tool. European Commission.

between regions to account for variations in climate vulnerability.

A more detailed description of the models supported by the CRED project can be found here.

Results only macroeconomic models can provide

Macroeconomic models can provide estimations on the **long-term economic** effects of specific adaptation measures **regarding key economic variables** (e.g. employment, GDP). For example, figure 2 shows the effects of investing in irrigation systems in the agriculture sector in Kazakhstan when assuming a climate scenario with more frequent and severe droughts: The economy-wide effects of this adaptation measure are positive for GDP and employment from the beginning in comparison to a drought scenario without adaptation. Construction activity to refurbish water canals boosts domestic production and creates additional jobs. Permanent jobs are created in agriculture by restored and additional irrigated land. Data was collected jointly with partners.

Macroeconomic models, like the CRED E3.kz/ge macro-econometric model used in Kazakhstan and Georgia and the dynamic general equilibrium model DGE-CRED used in Vietnam, allow to integrate climate hazards into economic analysis. They can provide information on the economic and social (so far mainly employment) effects of adaptation measures and consider relationships between the economic sectors. Their sector-specific information on e. g. GDP and employment (jobs) are an important input for further analysis (e.g. on non-economic effects) and can guide follow up policy processes and implementation of selected adaptation measures (for more in-depth information about the E3.ge, E3.kz and DGE-CRED model check our CRED project brief).

Macroeconomic models support adaptation planning

The role of macroeconomic models for adaptation planning is part of the broader question of how economic climate models can contribute to sustainable economic development. On this topic a comprehensive framework has been provided in the Practitioners Guide on Using Climate Economic Modelling for Sustainable Economic Development

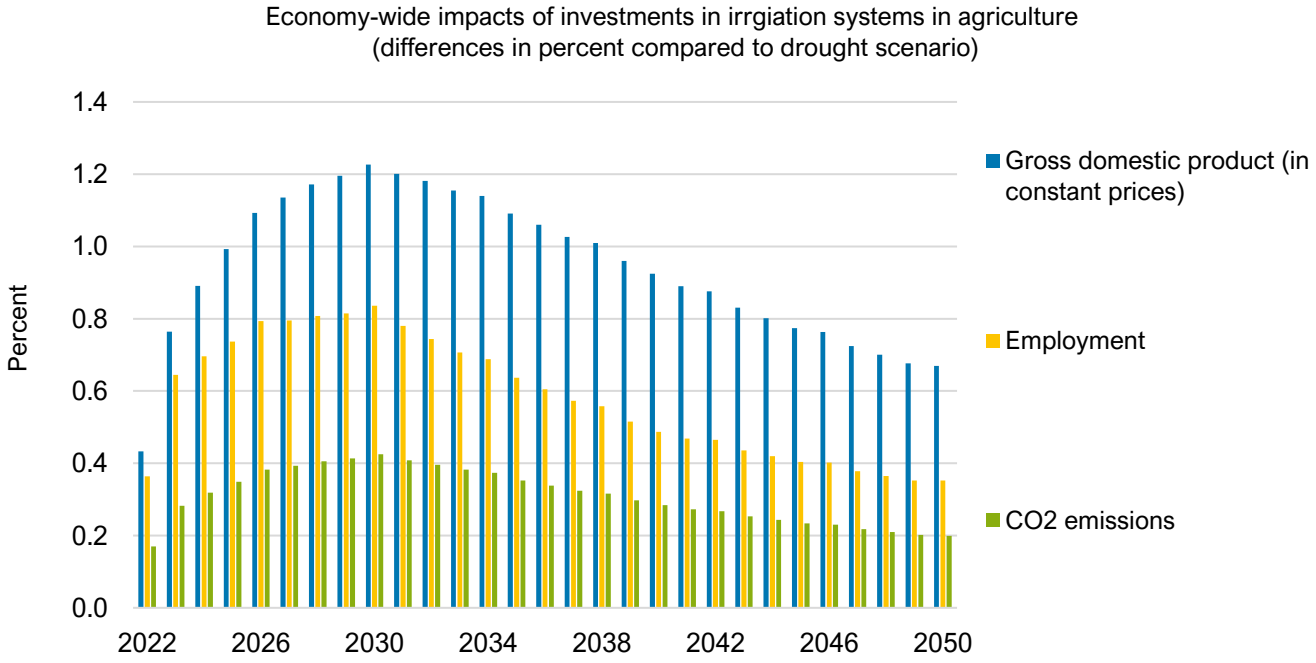

Figure 2: Example results for an adaptation measure (Source: own figure, Sectoral Policy Brief on Agriculture in Kazakhstan)

developed by IISD in cooperation with GIZ. 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 and outlines nine entry points that can be targeted. These entry points represent windows of opportunities that a wide range of stakeholders (i.e. governments but also development partners, private sector, civil society organizations) can leverage to integrate results in economic development efforts[4]. In order to understand the specific value added of macroeconomic models it is suggested to consider a **policy cycle explicitly oriented towards adaptation**. Such an adaptation cycle has been developed by the European Climate Adaptation Platform Climate-ADAPT[5].

The unique capacity of macroeconomic models is to integrate identified economic impacts of climate change and identified adaptation options in a coherent economic framework and analyse the economy-wide impacts of climate change and adaptation options. They provide additional insights by quantifying not only the direct impacts but also the indirect, induced and total socio-economic impacts of both climate hazards and adaptation. On its own, macroeconomic models are insufficient to fully evaluate adaptation options. For a comprehensive analysis, governments need to account for non-economic criteria (e.g. loss of biodiversity or cultural heritage sites) as well. However, macroeconomic models provide a specific value added (i.e. macro-economic impacts) to existing assessments of adaptation options. The following figure 3 is an adaptation of the EEA's adaptation policy cycle to illustrate how macroeconomic modelling supports the adaptation policy process. The framework distinguishes steps that are needed as preparation for the modelling (step 1-3), the analysis of adaptation options (step 4), and the subsequent translation into action (step 5-7).

On the next page a detailed description of the 7 steps is provided.

Figure 3: Macroeconomic modelling in the adaptation policy cycle (Source: figure based on Climate-ADAPT (n.d.))

[4] Dekens, Julie; Hammill, Anne (2021). Using Climate Economic Modelling for Sustainable Economic Development: A Practitioner's Guide. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ).
[5] Climate-ADAPT (n.d.): Adaptation Support Tool.

A 7-Step approach how macroeconomic models support adaptation policies

PHASE 1: CREATING THE BASIS FOR MACROECONOMIC MODELLING

Step 1: Preparing adaptation

As a starting point, a demand and political mandate for adaptation should be established in a particular ministry. Adaptation leadership is required for managing subsequent steps and the necessary inter-agency coordination.

Step 2: Assessing risks and vulnerabilities

The assessment of specific climate risks combines:

a) scenarios on possible future occurrence of climate hazards (extreme weather events/ slow onset hazards under key climate scenarios).

b) information on past and current economic damages of climate hazards to estimate how this could intensify under different climate scenarios.

Step 3: Identifying adaptation options

The macroeconomic analysis should only be conducted with a shortlist of the most relevant adaptation options, as the process is data intensive.

Identifying adaptation options can consider different criteria, including availability of data and cost benefit analysis (CBAs) and other multi-criteria analysis (e.g. CO2-intensity). These need to be provided and validated by sectoral experts.

PHASE 2: MODELLING / ASSESSMENT OF ADAPTATION OPTIONS

Step 4: Macroeconomic modelling of adaptation options

The macroeconomic analysis is based on long-term (30+ years[6]) economic models describing the expected development of the national economy (including GDP, sectoral productivity etc.). The macroeconomic model allows to identify the comparative economy-wide effects of adaptation measures through the comparison between different scenarios. The starting point for such a scenario analysis is a hypothetical reference scenario which assumes climate change is not occurring. Into this reference scenario the economic impacts from possible climate change scenarios are integrated (based on step 2) to understand the economy-wide impacts of climate change, including inter-sectoral relationships. Subsequently adaptation measures are included in this model as adaptation scenarios (based on step 3). The macroeconomic model can now provide insights into the broader economic effects of specific adaptation measures compared to a situation with climate change and no adaptation. Examples of this can be found in policy briefs developed by the CRED project (Agriculture Kazakhstan, Tourism and Infrastructure Georgia etc. – all available on the project website). A summary of the economic models applied in the CRED project is also provided in this CRED Project Brief on Managing Climate Risks.

PHASE 3: IMPLEMENTATION / USING THE RESULTS FROM MACROECONOMIC MODELLING

Step 5: Selecting adaptation measures

The results from macroeconomic analysis serve as additional information for the selection of adaptation measures by the authority with designated adaptation leadership (step 1). Macroeconomic modelling results need to be complemented with non-economic criteria.

Step 6: Implementation

Based on the selection (step 5), adaptation measures can finally be implemented. The necessary decisions on allocation of budget are supported by the economic evaluation of the macroeconomic assessment.

Step 7: Monitoring and evaluation

The results provided by the macroeconomic model can improve M&E activities by informing indicators (production, employment) against which the effectiveness of measures can be illustrated.

[6] Depending on the purpose, economic models do projections short (monthly, quarterly or a few years), medium (approx. a few to 10 years) - and long-term. In the context of climate change adaptation, long-term simulations are more appropriate.

Macroeconomic models facilitate inter-ministerial cooperation

Macroeconomic models provide a **single coherent framework** for integrating economic impacts of physical climate hazards, economic development trends and effects of adaptation measures. Such a comprehensive framework has great potential to foster inter-ministerial cooperation and discourse through the exchange of relevant policy issues, key assumptions, and model results. The models integrate information from a broad range of sectoral expertise (for validating damage functions and cost benefit assumptions of adaptation measures), often calling for inter-disciplinary exchange, i.e. describing crop losses in physical and monetary terms in mathematical form compatible to the economic model.

Macroeconomic models can **bridge traditional boundaries** of climate change being mainly a responsibility of ministries of the environment and economic development being the mandate for ministries of economy. However, this inter-ministerial cooperation is challenging, and sufficient time needs to be allocated to set-up the respective interfaces.

Macroeconomic models can **support the interface between adaptation and economic planning**. They provide a basis for exchange for sectoral ministries that plan adaptation in their field of responsibility (adaptation leadership) and the economic planning and financing mandates.

Figure 4 sketches **possible interactions between main institutional players**. Such an idealized process starts with a sectoral ministry having the mandate and need to improve adaptation in their sector or for a NAP. Based on a shortlist of relevant adaptation measures the ministry of economy (or subordinate institutes) analyse the measures with the macroeconomic model. This provides additional information on these measures as a basis for selection in the adaptation planning or programming process. Model results can also help to decide on budget allocation or leverage international climate finance, as the results provide additional information on the (economic) return of adaptation measures.

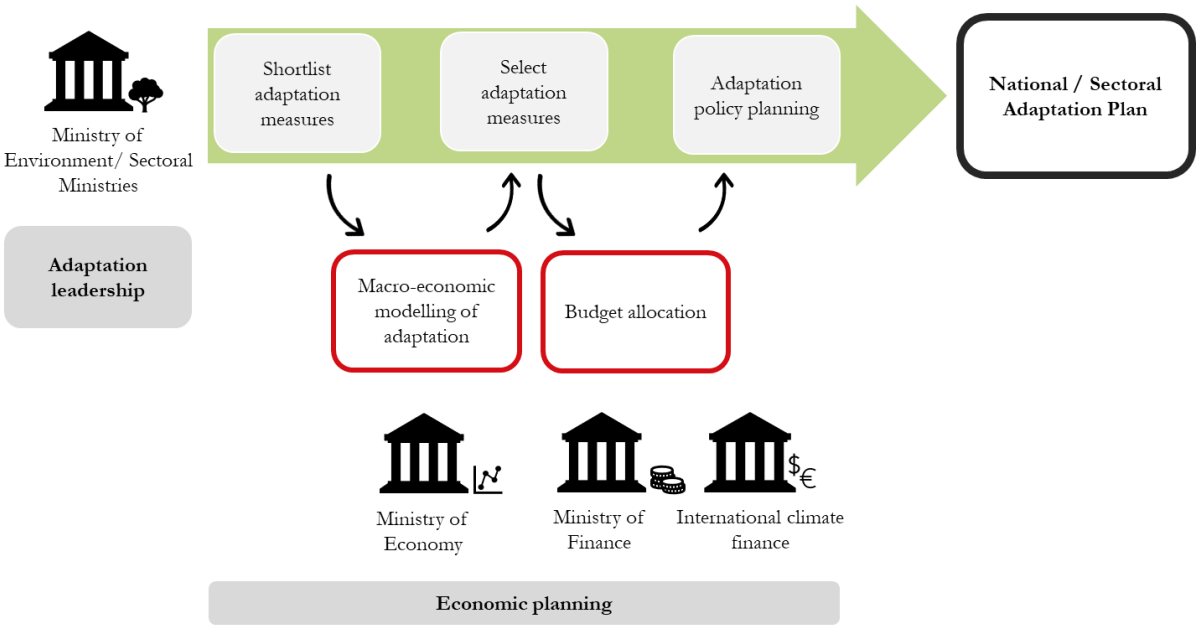

Figure 4: Inter-ministerial cooperation in the adaptation policy cycle (Source: own draft)

Benefits and challenges of using macroeconomic models

Benefits

Modelling the macroeconomic impacts of climate risks and climate change adaptation measures combined with effective policy advice support can pave the way to climate resilient economic development.

Integrating economic impacts of climate change and adaptation into macroeconomic modelling generates insights into broader and inter-sectoral economic impacts. If based on robust national data and climate impact forecasts, such models provide additional country-specific quantitative economic evidence to support and inform the development of policies and strategies that ensure sustainable and resilient economic development.

Key benefits are:

- Mainstreaming climate adaptation into economic development agenda: Macroeconomic models enable the integration of climate risks into economic development planning by providing insights on the contribution of adaptation measures to key development objectives (GDP, labor productivity, employment).
- Integration of sectoral impact and adaptation assessments: Macroeconomic models can integrate existing insights about climate risks for different economic sectors (e.g. agriculture or tourism). They provide a consistent framework for evaluating inter-sectoral relationships and generate results for the macroeconomy (e.g. on GDP).
- Comprehensive Risks Assessment: Macroeconomic models complement existing physical risk assessments by putting effects in economic and social context. Economic models consider future climate change scenarios including extreme weather events (e.g. droughts) and slow-onset events.

Challenges

A general assumption about economic modelling is: “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 – but is it the correct one?

Key challenges for models are:

- They approximate reality. Economic models often miss non-economic issues important to the question being considered, e.g. loss of biodiversity, heritage sites etc. Generally, any analysis of model results must consider the extent to which these are compromised by inaccuracies in input and quality of assumptions.
- They are data intensive: Macroeconomic models require comprehensive data sets on economic indicators, climate hazards and expected economic damages, and crucially cost-benefit analysis on planned adaptation measures. All data need to be of sufficient quality and regularly updated.
- They need time and experts’ know-how: A key challenge is to set up macroeconomic models and enable them to digest all relevant data, constrained by the time of national experts to gain the needed know-how and the challenge to coordinate with a broad spectrum of involved agencies.

Conclusion

It is the very process of constructing, testing, and revising models that forces economists and policymakers to develop their views about how an economy works and what could be the most effective adaptation approach. These dialogues are as important as the modelling results as such.

To learn more on the application of macroeconomic models for supporting climate resilient economic development, please visit the project website.

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