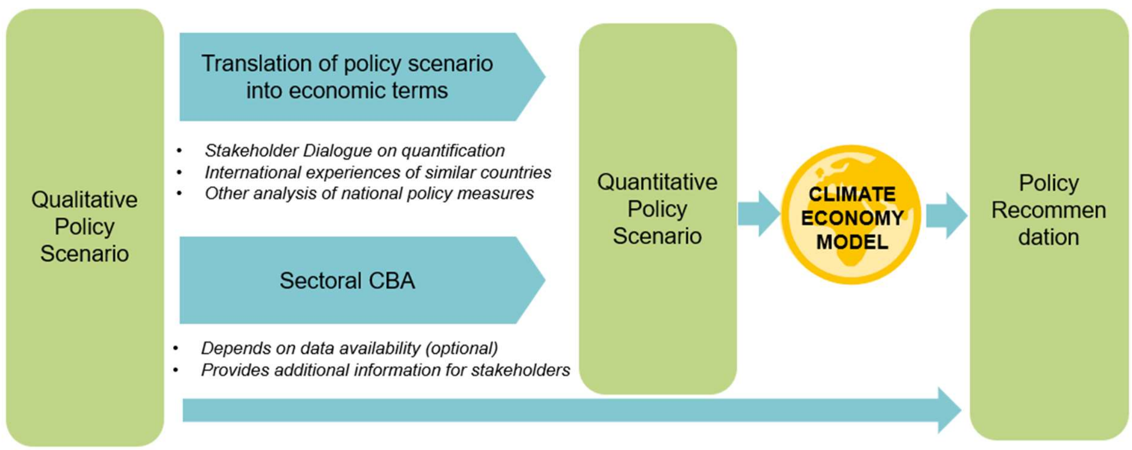
Guideline for Quantification of Sectoral Adaptation Policy Scenarios (QPS)

1 Introduction

The increasingly evident negative impact of climate change on socio-economic development affects various aspects of the economy and society, including employment, wealth, and living conditions across all sectors. Currently, climate adaptation analysis primarily targets the micro level – individual businesses, projects, or specific sectors – because the regional and local effects of climate change vary significantly, requiring adaptation efforts to be tailored to these specific contexts. However, there is a growing need for nation-wide macroeconomic analyses of sectoral adaptation measures to provide comprehensive insights for political decision makers. Understanding the broader impact of climate adaptation on socio-economic indicators is crucial for informing effective policy- and strategic decision-making that can address the wide-ranging effects of climate change on the national economy.
A potential starting point are planned adaptation measures in a country, that are described qualitatively. Yet, to gain insights about the macroeconomic implications, it is essential to have quantified effects of identified sectoral climate adaptation measures (policies). This can be achieved by directly calculating and translating aspects of an adaptation policy scenario into economic terms, such as changes in productivity, costs, and investment requirements, without conducting a full sectoral cost-benefit analysis (CBA). The results can be directly integrated into the macroeconomic model. If neither CBAs nor corresponding analyses are available, other national analyses including quantifications of policy measures or, international experiences of comparable countries can be used to inform the macro model.
As input, the macro models require *compatible* information. As a rule, this includes at least the costs of the measure, i.e., investments and other expenditures required for its implementation and operation (CAPEX and OPEX), reduced costs of climate change (damage reduction), and financing. An annual resolution of the information is advantageous, but not necessary. *Compatible* means that these effects can be quantified in model variables.
While this direct translation offers a streamlined approach, a CBA can be performed as an additional approach if the necessary data is available, to provide a more comprehensive comparison of socio-economic and environmental costs and benefits. If the benefits outweigh the costs, the adaptation measure can be deemed economically viable. CBAs are carried out on a project or sectoral, and subnational level and its findings form a crucial basis for macroeconomic assessments. The results of the CBA are then integrated into a macroeconomic model to assess the impact on the entire economy. In the following, it is assumed that the results of the CBA are aggregated at least to a sector level (sector CBA) to be relevant for the macroeconomic modelling. The guidelines describe how to translate adaptation policy scenarios into economic terms and prepare a sectoral Cost-Benefit Analysis (CBA) and a more general Quantification of a Policy Scenario (QPS) for macroeconomic modelling.
The method and implementation of a CBA is associated with advantages and some challenges. On the one hand, the costs and benefits of a project or measure are presented in detail over time providing valuable additional information for stakeholders and policy in general, i.e. there are various reasons for a CBA beyond the macro modelling. On the other hand, the time and cost efforts for CBA development are considerable due to the amount of data that has to be collected. The number of already existing feasible CBAs in a country will therefore remain limited.

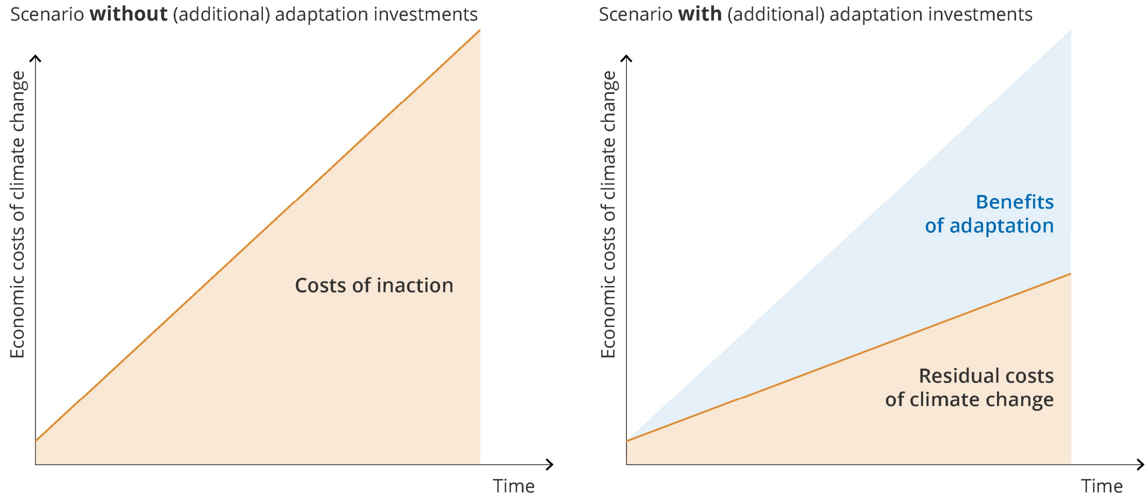
Macroeconomic modelling can help countries to effectively reduce the negative impact of climate risks on their economies. It is an efficient tool for calculating the impact of climate change on different aspects of the national economy (such as trade, prices, employment, and consumption) based on existing or newly collected data and assumptions. Drawing from this evidence, appropriate adaptation measures can be developed. Macroeconomic models can help policymakers to quantify the costs, benefits, and potential trade-offs of climate risks on the national economy and design specific adaptation interventions that contribute to climate resilience. The following figure describes the overall process explained above.

Figure 1: Process for quantification of policy scenarios



The results of climate-sensitive macroeconomic models may inform key planning documents, such as National Adaptation Plans (NAPs), Nationally Determined Contributions (NDCs), Long-Term Strategies (LTS), Low Emission Development Strategies (LEDS), and other national strategies. Measures have often already been quantified when these plans and strategies are drawn up, for example in the context of impact assessments, so that checking for usable quantifications in these key documents should be the starting point for the analyses. The quantification of sectoral adaptation measures requires the comparison of two scenarios: a scenario *with-the-measure* is compared with a counterfactual baseline scenario *without-the-measure* (Business As Usual (BAU)). First, the BAU scenario should be formulated, which describes, what would happen in absence of the climate adaptation measure. To facilitate the projection into the future, past years can be evaluated to identify a trend that is then assumed to continue over the selected timeframe. Subsequently, the scenario *with-the-measure* is defined. It considers all costs and benefits of the implemented climate adaptation measure. It is usually assumed that even with adaptation some residual damage persists. Eventually, the QPS/CBA reflects the difference between the cash flows of the two scenarios conditional to the selected climate change scenario in the country-specific context. This allows to compare a hypothetical scenario without investments in adaptation to a scenario with investments in adaptation (including the cost of adaptation and some residual damage). This difference can be described as the net adaptation benefit as depicted in Figure 2.

Figure 2: Scenario Comparison of Adaptation Investments



Source: [EEA (2023)]

In both scenarios, the BAU and adaptation scenario, the climate change scenarios (e.g., SSP1-2.6, SSP2-4.5, SSP5-8.5) of the latest IPCC[1] might be included and adjusted to the national or regional climate change conditions within a parallel process. Climate change will continue to cause changes in temperatures and equally intensifying extreme weather events (EWE) which will also be accounted for in future projections. The magnitude of climate change is yet uncertain and depends on various factors, therefore different climate change scenarios can be used to allow for more robustness of the results.
To assess an economy-wide adaptation scenario it can be feasible to evaluate one adaptation measure on a regional/sectoral level with the goal of scaling up the results on other suitable regions or sectors by assuming analogue correlations of cost and benefits. In the context of limited resources this can be an efficient way to on the one hand conduct detailed bottom-up investigations and on the other hand allow for a top-down macroeconomic analysis. One key challenge in the economics of climate change adaptation is the fact that the costs and benefits of different adaptation measures often occur at different times and in different places. For example, the costs of implementing adaptation measures, such as building sea walls or improving irrigation systems, are often borne by governments or individuals in the present, while the benefits of these measures, such as reduced damage from natural disasters, may only be realized in the future. Putting such costs (investments) and benefits into perspective is the key value added.

For quantifying adaptation policy scenarios, the following steps should be taken:

1. Clarification of what minimum information the respective macro model requires (cf. Quantification of Policy Scenario (QPS) Template, sheet “QPS input” (Annex) and section 4 below)
2. Check for which adaptation measures relevant quantifications from sectoral CBAs, international experiences or other analyses of policy measures are already available (and collect the data)
3. Decision with modelers and stakeholders for which further adaptation measures QPS including sectoral CBAs will be conducted
4. Definition of the interfaces between QPS as sectoral CBA, quantifications from international experiences, or other quantitative analysis of national policy measures

[1] Chapter 4 | Climate Change 2021: The Physical Science Basis (ipcc.ch)

and climate economy model (CEM). Starting point is the sheet “QPS_input” of the QPS template
5. Implementation of the QPS including sectoral CBAs
6. Integration of QPS as sectoral CBA results or other quantifications into the CEM

Steps 1 to 4 should be conducted in coordination with modelers and GIZ. Step 2 may also be taken over by another institution. This document provides a guideline of how a sectoral policy scenario (an adaptation measures) translation of policy scenarios into economic terms, i.e. QPS including sectoral CBAs, can be conducted (step 5), to allow an integration into climate economy models (step 6) by touching on the underlying concept, methodologies of application, and technical coherence.

2 Translation of policy scenario into economic terms

As a starting point, qualitative policy scenarios for adaptation measures are selected in cooperation with national partners. The following steps may support this selection process, so that an iterative approach is taken if necessary.

1. Stakeholder dialogue on quantification of key aspects
2. Integration of international experiences of similar countries/ adaptation policies
3. Other analysis of policy measures

The translation of the qualitative adaptation policy scenario into a quantitative adaptation policy scenario can be based on different inputs. Dialogue with national stakeholders is an important step to collect available information, understand the importance of the policy and decide on additional quantification steps. Ideally, a quantification of aspects of the qualitative adaptation policy scenario is already available from another national context, such as a NAP process, which is then checked for usability and gaps in the quantification required for the CEM. Alternatively, or additionally, there may exist international quantifications of comparable measures. which may provide valuable insights and examples for the national quantification and can be transferred and adapted to the country if no specific national data is available. These steps provide the basis to jointly with national partners select the most suitable adaptation policies for quantification The decision is based on the availability assessment of data which may also provide additional information for stakeholders beyond the scope of economic modelling. The translation of qualitative adaptation policy scenarios into economic variables as the quantification of the policy scenario is a critical input for the macroeconomic evaluation.

3 Sectoral Cost Benefit Analysis

If only insufficient quantified data can be collected from other sources, sectoral CBAs can be developed to further enhance the quantification of the policy scenarios. A sectoral CBA can be calculated by aggregating project-specific CBAs while following the typical rules for creating a CBA. The results must meet the requirements in the QPS template.

3.1 Definition and principles of a CBA

A CBA is a monetary assessment of negative and positive impacts associated with a given action. It allows the comparison of different interventions, investments or strategies and reveals how a given investment or policy effort pays off for a particular person, company, or country.

Hereby, the implementation of CBAs underlies several economic concepts, that illustrate the rationale[2]. To enable an economic analysis and comparison between costs and benefits, the relevant economic performance indicators need to be expressed in **monetary terms** which allows comparing and prioritizing between several alternatives and generally inform decision makes of the potential economic viability. Moreover, a CBA allows to investigate the **opportunity cost**, which is the potential gain of the best alternative missed of a good or service – in this case an adaptation measure. Thereby, the CBA approach is based on the idea that investment decisions made solely on profit and price mechanisms can result in negative social outcomes. Conversely, if the social opportunity costs of an investment project's input, output, and external effects are considered the resulting return is an accurate measure of the project's impact on social welfare. Additionally, a CBA is a **microeconomic approach** that assesses the impact of a single (climate adaptation) measure on mostly directly connected welfare implications instead of indirect and wider effects. To come to adequate conclusions, a **long-term perspective** of minimum 10 years needs to be presumed, as benefits may take time to materialize and amortize the costs. Therefore, a proper time horizon should be set over which the costs and benefits are forecasted while using appropriate discount rates to evaluate the monetary value while considering possible uncertainties.
Costs of climate adaptation measures can typically be two-fold; monetary in terms of initial investments and running costs and environmental/social, e.g. resettlement of people or animals. Whereas benefits can be threefold, by avoided losses, induced economic or development benefits by investing into adaptation, and additional social/environmental benefits[3]. This so-called "**triple dividends**" perspective highlights that there may be further advantages of climate adaptation beyond quantifiable indicators that can be considered qualitatively to further support implementation.
Generally, the CBA contributes to answer the following guiding questions that are crucial for investing parties[4]:

- **Viability**: Should resources be invested in this measure?
- **Feasibility**: Could it be afforded to adopt the proposed measure?
- **Uptake**: Would the risk be taken to change current practices?

By conducting a CBA, decision makers can be informed about relevant economic and social implications and are enabled to include those aspects into consideration to support the identification of a sustainable and just solution. This way, the chance of possible **maladaptation** can be decreased – meaning (unintended) actions that exacerbate negative climate, environmental, economic, and social impacts.

3.2 Sectoral CBA in the context of macroeconomic modelling

The CBA implementation needs to be specified for informing macroeconomic assessments, as macroeconomic models cannot assess project-based measures but rather policy scenarios for economic sectors at the national level. To do this, the originally microeconomic CBA must be scaled up to the sectoral or national level to a sectoral CBA as described. This aggregation is crucial for usability in the macroeconomic models. The results must be compatible with the CEM (see steps 1 and 4), which is provided by the QPS template.
Within a preceding process including all involved stakeholders such as political partners, national institutions, and consultants providing the services, climate adaptation measures are identified, prioritized, and selected according to different criteria that ensures the suitability for CBA and macroeconomic modelling.

[2] cba_guide.pdf (europa.eu)
[3] The Triple Dividend of Building Climate Resilience: Taking Stock, Moving Forward | World Resources Institute (wri.org)
[4] 1c6de3d5-787a-7c55-644c-6c2846d9be3a (ifad.org)

The measures may be based on strategies for instance NAPs or NDCs and are formulated as an economy- and nation-wide policy scenario. Within the CBA process then the selected sectoral adaptation scenarios are quantified, and associated economic costs and benefits are calculated. These results are fed into the CEM, which allows a macroeconomic evaluation of nation-wide and cross-sectoral impacts of the selected adaptation scenario. Subsequently, these findings are then interpreted and translated into concrete adaptation policy recommendations to support decision-making for underlying processes of political partners. This process may be iterative. Generally, the combination of sectoral CBA – or similarly QPS - and macroeconomic modelling gives insights on both sectoral and economy wide implications of climate adaptation action.

3.3 Type of measures

Types of climate adaptation measures can be manifold and may vary in tangibility and design. They may differ from a more engineering focus of technical adaptation as the adaptation of economic agents can be supported with a broad set of economic policy measures. Table 1 shows different types of policy instruments that are options for governments to regulate, initiate or incentivize adaptation measures which aim at reducing the negative impacts from climate change. Adaptation measures with their costs and benefits can be translated or mapped into the economic model. Some policy instruments can only be implemented if additional assumptions are made (Table 1).

Table 1: Types of adaptation measures for macroeconomic modelling

Type of instrument	Assumptions for mapping into economic model
Command and control	Regulation is treated as binding
Price instrument	Prices are implemented
Direct subsidy	Subsidy is regarded as successful

For example, with regard to a command-and-control instrument, the assumption entered into the model would be to treat the regulation as binding, i.e., all people comply to the regulation. Different financing options could be considered by different assumptions. For the macroeconomic analysis, it is primarily important whether financial resources are additional (international) or whether they crowd out other investments domestically.

3.4 CBA implementation

Generally, a CBA should include a description of the context and objectives, an evaluation of technical and environmental feasibility, a financial and economic analysis, and a risk assessment. Therefore, several guidelines can be considered to allow a broad application of CBA output in macroeconomic models. A commonly used financial methodology is the Discounted Cash Flow (DCF) method[5] where only cashflows in constant prices without VAT are considered.

Technically, a CBA must include several indicators that are relevant for the monetary evaluation of selected adaptation measures. The **net present value (NPV)** is the difference between the discounted costs and benefits of a measure over its entire lifetime. By accounting for the fact that future costs and benefits are worth less today, the NPV provides a comprehensive assessment of the measure's value. Hereby, the **financial discount rate (FDR)** is a measure that reflects the decrease in the value of money over time, allowing for the comparison of future costs and benefits present value to calculate the NPV of future cash

[5] Commission Delegated Regulation (EU) No 480/2014

flows[6]. The FDR reflects the opportunity cost of capital. In addition, the **discount factor** represents the ratio of the net present value of a future cash flow to its value if the cash flow were occurring today. It decreases exponentially by the discount rate each year, with a discount factor of 1 for the current year and decreasing values for subsequent years. As an orientation for the FDR the European Commission suggests following reference period[7].

Table 2: Reference Period for various Sectors

Sector	Reference period (years)
Railways	30
Roads	25-30
Ports and airports	35
Water supply/sanitation	30
Waste management	25-30
Energy	15-25
Broadband	15-25
Research and Innovation	15-25
Business infrastructure	10-15
Other sectors	10-15

The **cost-benefit ratio (CBR)** is the share of discounted costs with discounted benefits for the entire lifetime of a measure. A CBR less than 1 indicates that the measure is cost-effective, meaning that the benefits outweigh the costs. Moreover, the **internal rate of return (IRR)** is the discount rate at which the NPV of a risk mitigation measure equals zero. It is used to compare different climate adaptation options as higher IRR values indicate greater returns on the investment. Additionally, the **return on investment (RoI)** measures the money saved with the investment as a percentage of the total investment. A higher RoI signifies higher returns of the project in relation to the invested sum. The **payback time (PT)** is the duration it takes for the undiscounted annual cash flows (benefits minus costs) to equal the initial investment costs. It indicates the time after which the organization will realize net benefits from the investment.

4. Quantitative Policy Scenario

As explained above, 6 steps are recommended to quantify policy scenarios for macroeconomic models. First, data requirements for the macro models are described in detail. Additionally, guidance is provided on the implementation of the QPS including CBAs (step 5). Furthermore, both climate impacts and the financing of the adaptation measure are taken into account in the QPS. Finally, the QPS (CBA) results will be integrated into climate-sensitive macroeconomic models by model builders or users (step 6).

4.1 Data requirements

The more detailed the quantification at sector level in the model categories, the better the results, that can be used in the macroeconomic models. Minimal data requirements are described in the Quantification of Policy Scenario template. Necessary quantifications for the CEM are collected as a row for each adaptation policy scenario. If data for different years is available, an additional row should be added for every year. The sheet QPS input contains basic information needed to implement the QPS in the CEM based on simple assumptions on

[6] For example, with a 3% discount rate, a cost or benefit of US$100 occurring next year would be equivalent to US$97 today, and a cash flow of US$100 occurring five years from now would be worth US$86 today.
[7] ANNEX I to Commission Delegated Regulation (EU) No 480/2014.

an industry/sector level and it also describes further details that facilitate the processing of QPS information in the CEM and make it more accurate. More information on the specific columns can be found in the QPS template. Costs in terms of investment and operation including source of funding, and benefits in terms of reduced impacts of climate change such as increased production, or reduced costs and prices, plus potential further advantages are required. The ideal case is to collect national data for the quantitative policy scenario, such as in the form of a sectoral CBA. The results of the data, i.e. also from a sectoral CBA must meet these data requirements.

If national data is not obtainable, searching for international data is possible with adequate assumptions on cost and benefits to be made (for example taking heat stress effects on labour productivity from the ILO). Since the quality of the model conclusions is strongly reliant on the quality of the data, it is essential to have enough validation including stakeholder discussions verifying the assumptions to ensure the robustness of the model results.

It should be assumed that if the ministries of economy themselves cannot provide this data, additional support and interaction with sectoral line ministries is needed to enable relevant institutes to deliver such data. If not existent, they can be created by national experts building on similar QPSs or CBAs from international reference cases and adapting them to local/national context. This might also involve additional interviews with stakeholder groups to have validated estimations on required investments (the adaptation costs), reduction in the climate damages they address and other associated economic co-benefits (the benefit of adaptation).

As mostly a long-term perspective is used in the context of CEM, a yearly resolution generally suffices. Naturally, choosing yearly data facilitates the data collection especially considering the required cross-sectional interplay of data sources within the overall macroeconomic approach which includes information such as climate hazard, damages, and economic indicators on regional and sectoral level.

Each selected adaptation measure or scenario might be evaluated against the three shared socioeconomic pathways SSP1-2.6, SSP2-4.5, and SSP5-8.5 to allow for a comprehensive analysis and robustness of the results. For the different scenarios, the climate change impact intensity and frequency vary which can be mapped in the QPS by choosing an appropriate intensity factor and annual probability that are estimated by a parallel process. As the pace of climate change is increasing a suitable factor needs to be determined and applied to both, intensity, and probability. To determine the lost revenue, past climate damage data is collected in a time series and projected to the future for each SSP.

Figure 3: Quantification of investment costs and adaptation benefits

Climate technology	Annual USD using economic prices (2017)			
	Additional agriculture production	Increased water availability	Increased energy availability	Total estimated USD/year
Conservation agriculture	USD 207 million (normal year) USD 237 million (drought year)	n/a	USD 44.05 million	USD 251.05 million
Drip irrigation	n/a	USD 1 million[a]	USD 2.4 million	USD 3.4 million
Field machinery	USD 41 million	n/a	USD 22 million	USD 63 million
Improved greenhouses	n/a	n/a	USD 1.04 million	USD 1.04 million
Precision agriculture	n/a	n/a	USD 10 million	USD 10 million
Improved pasture	USD 70 million	n/a	n/a	USD 70 million
Fattening units	USD 72 million	n/a	n/a	USD 72 million
Biogas	n/a	n/a	USD 3.5 million	USD 3.5 million
Wind water pumps	n/a	USD 0.11 million	USD 0.09 million	USD 0.2 million
Steam boilers	n/a	n/a	USD 1.9 million	USD 1.9 million
Dams	n/a	USD 0.4 million	n/a	n/a

Climate technology	Investment costs (USD)	NPV (USD)	IRR (%)	Payback period (years)
Conservation agriculture	USD 138 000	USD 138 000	22%	6
Drip irrigation	USD 125 000	USD 38 000	22%	3
Field machinery	USD 110 000	USD 8000	13%	6
Improved greenhouses	USD 100 000	USD 34 000	21%	4
Precision agriculture	USD 2000	USD 1000	27%	3
Pasture improvement	USD 50 000	USD 13 000	18%	5
Fattening units	USD 4 mio	USD 4 mio	34%	3
Steam boilers	USD 20 000	USD 7000	20%	4
Biogas	USD 2.8 mio	USD - 1.2 million	1%	15
Wind water pumps	USD 4000	USD 6000	44%	2
Dams	USD 4.6 mio	USD - 1.3 million	5%	12

Source: Polo et al. 2022, Table 4, p. 20 and 26

The CEM requires information whether the financing sources for the identified climate adaptation scenarios are national or international because in the latter case there would be monetary funds added to the national account while for the first case money would merely be relocated within the domestic economy. In this case the financial means decrease for a different sector to finance the selected climate adaptation measure. In addition to the international vs. national dimension, the private vs. state investment should be considered to allow conclusions regarding the public budget. Both dimensions can be combined, so that there can be a mix between the different financing components. For instance, public funding can foster private investment and international money may be conditional to national financial commitments. While it may be challenging to exactly calculate the share of financing for selected climate adaptation scenarios, it should be considered from the beginning to enable the evaluation of economic feasibility of implementation.

The example in Figure 3 shows the results of CBA analyses from other sources that could be implemented in the macro model. In the case of Kazakhstan, crop farming and livestock technologies were already analysed regarding their adaptation costs and benefits[8].
The specified investments in the agriculture sector and the corresponding benefits in terms of additional agriculture production were then attributed to the suitable E3 model variables. Additional information on the import dependency of machinery and the high local content of construction works were also considered as it is important for economic growth[9].
As an adaptation measure is aiming at reducing the negative impacts of climate change, the benefits ideally are the reverse impacts of climate change (see document on climate impacts). For example, when a heat wave increases the demand for cooling, a suitable adaptation measure improves heat protection and thus lowers cooling demand.

4.2 Integration of results into macro models

To enable the integration of economic variables from the policy scenario (based on the QPS template and optional CBA template) results into the CEM the data structure of the QPS output needs to be suitable as data input for the model. There is generally no one-fits-it-all approach because the model configuration may differ. Therefore, the QPS/CBA implementing consultant should make sure to adapt to the structure of the model as indicated in the QPS template for an CEM. Currently, the GIZ is working with two different CEM types:
An **E3 model** (environment, economy, energy) is a model covering the demand-and-supply-relationships of an economy and its main connections to the environment. This integrated modelling approach of the 3Es in one model framework assures a consistent view of possible transition pathways. It enables to calculate macroeconomic and sector-specific impacts as well as conclusions to be drawn on social balance and environmental benefits. E3 models can capture the quantification of QPS/CBAs at the level of industries/sectors distinguished in the national input-output tables, energy balances or other central datasets. Thus, the allocation of both costs and benefits to distinct sectors is of major importance and accompanying qualitative explanatory notes crucial. In the case of drip irrigation systems, investments might for example go in a specific industrial sector (i.e. machinery) while also requiring associated construction services, an accurate split between these two is ideally drawn from the CBA. It is then transferred into the model, where the corresponding variables, in this case the demand from private enterprises or the public sector (depending on the type of financing), are increased. Information on prices as well as information on the use and production of energy may also be integrated through different channels.
(Additionally, **Computable General Equilibrium (CGE)** modelling …)

5 Conclusion and way forward

While a CBA provides insights on the financial feasibility of adaptation measures, the integration of upscaled results or more general of QPS into a macroeconomic model further enhances the informative capability by evaluating the effect on the whole economy, whereby direct, indirect and induced effects are considered. Direct effects in the respective sector are results of the QPS, while indirect effects in other sectors can either stem from the QPS or be result of the CEM. Induced effects are calculated by the CEM.
The results deliver quantitative arguments for implementation of climate adaptation measures and thereby may contribute to national strategies (e.g., NAPs) and international treaties (e.g., Paris Agreement, NDCs, SDGs). While QPS including CBAs and

[8] Adoption of Climate Technologies in the Agrifood System – Investment Opportunities in Kazakhstan (Polo et al. 2022)
[9] giz2021-en-kazakhstan-policy-brief-agriculture.pdf

macroeconomic conclusions support political decision making, they can in future additionally be used for international and national financial investment or funding considerations for both, public and private actors. Therefore, financing options should already be considered while implementing QPS and more specifically CBA for climate adaptation.