# Economics of climate change adaptation in a resource-based economy

## – The case of Kazakhstan –

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**Abstract**

Economic growth and the wealth of Kazakhstan is dependent on resources which are at risk. The country exports fossil fuels especially to the European market as well as agricultural products. While agriculture is highly vulnerable to climate change (CC), oil and gas demand are more affected by mitigation strategies of EU countries and their aim to be climate-neutral in 2050. Recently, the president of Kazakhstan has emphasized that the country is very vulnerable to various effects of CC. Thus, suitable CC adaptation strategies must be identified to reduce the economic damage. Based on experiences in previous projects, E3 (economy-energy-emissions) models are considered appropriate tools to analyze the impacts of CC and adaptation. Scenario analysis is used to implement CC effects and adaptation strategies into the E3 model. Scenario results help to identify adaptation options with high effectiveness and positive impacts on the economy and environment.

**Keywords**: economic modelling, climate change adaptation, economic sector analysis, evidence-based policy advice

**JEL**: C54, C67, O11, Q54, Q58

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## Long Abstract

Climate change (CC) is of increasing importance to Kazakhstan especially in the agricultural, energy and the water sector. In climate projections, increased temperatures, droughts, heat waves and heavy precipitation events are expected by 2050. As climate risks affect key economic processes, policy makers need to manage adaptation measures for a climate resilient economic development.

E3 (economy-energy-emissions) models are considered appropriate tools to analyze the impacts of CC and adaptation (Lehr et al. 2016, 2018, 2020, Aaheim et al. 2015). For an economic model to be CC aware, it needs to capture the structural economic changes that are directly affected by CC and must consider supply chains. Additionally, such an economic model must quantify long-term macroeconomic developments. The enhancement by energy and environmental aspects enables to identify synergies and trade-offs of adaptation and mitigation strategies as well as Nationally Determined Contribution goals.

The e3.kz model has been developed for Kazakhstan to quantify the impacts of CC as well as adaptation strategies and to actively support policy makers in their CC adaptation management. Figure 1 briefly shows the e3.kz model. The core of the economic model is a macro-econometric input-output (IO) model which is based on the INFORUM approach (Almon 1991, 2014). Such models exist in different forms and degrees of complexity (see e. g. Eurostat 2008, pp. 527, Stocker et al. 2011, Lehr et al. 2016, Lewney et al. 2019). IO tables and national accounts are depicting the key and supporting industries, their interlinkages as well as the domestic and foreign drivers for economic growth. Employment and income trends are part of the model to monitor the impacts on jobs and wealth. Energy balances, which include energy supply, transformation and demand for various fossil fuels and renewable energy sources, are at the center of the energy module. Energy demand is determined by the economic activity but is also influenced by energy costs and prices which, in turn, affects energy supply provided either domestically or imported. The emissions module contains the energy-related countries $CO_2$ emissions caused by the combustion of fossil fuels.

Integrating CC into economic models is challenging. Usually, economists derive future developments from past observations. Unfortunately, economic impacts from CC are not directly visible in time series data of economic models. Either CC did not cause any observable damage to the economy, was not relevant for the economic performance or could not even be detected as an impact from CC since repairing CC damages result in positive GDP effects.

Furthermore, economic and climate models are operating on different temporal and spatial scales. While climate models have a high spatial resolution and a long-term horizon, e3.kz models the Kazakh economy at the national level and has a mid-to long-term perspective (annual calculation until 2050). Additionally, climate models are very computing intensive while the e3.kz model computes in less than a minute on an average desktop computer / laptop.

Thus, climate models are not integrated into e3.kz, instead scenario analysis is applied to model CC and adaptation which follows a four-step approach:

1. Identification of extreme weather events (EWE) and their effects,
2. Translation of EWE into model parameters,
3. Identification of adaptation measures (their costs and benefits) and
4. Comparative scenario analysis

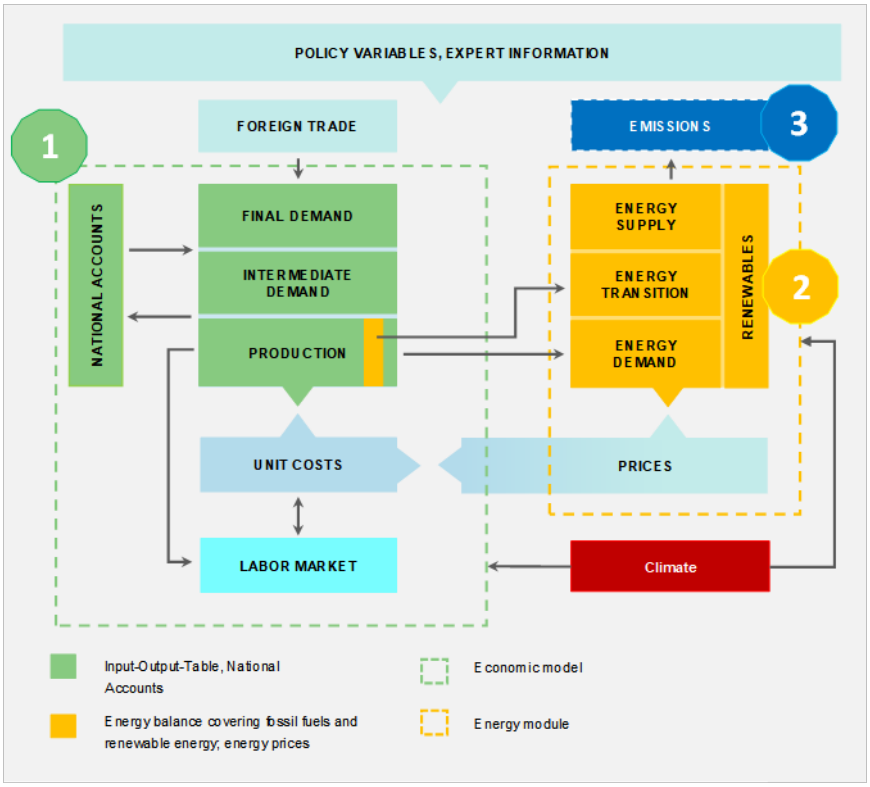


**Figure 1: Illustration of the e3.kz model**

This approach results in two contrasting scenarios: one scenario includes EWE without adaptation measures. The other scenario combines both. Following this approach helps to understand the economic impacts of CC and how potential adaptation measures minimize or even avoid these effects.

For the model to consider the future economic impacts of EWE, climate projections for Kazakhstan are linked to past economic damages. Occurrence and intensity of country specific climate hazards (drought, heatwave, flooding etc.) are provided for the RCP 8.5 scenario by experts from the University of the Balearic Islands associated with CORDEX (Coordinated Regional Climate Downscaling Experiment). Sectoral economic damages from past climate hazards are collected by screening of scientific (national and international) literature, media, and expert surveys. The damage data serves as a benchmark for estimating future CC costs. Adjustments will be made to the benchmarks in scenarios to reflect the expected intensity of climate hazards by assuming that, for example, the doubling of hazards per year will also double the benchmark damages.

The economic damage data enters the model and causes chain reactions within the E3 modelling system. The results of the CC scenario are then contrasted with a CC adaption scenario. Costs and benefits of the adaptation measure serve as scenario input. While the benefits are implemented into e3.kz as the reverse impacts of CC damages, costs are mainly caused by the required investments.

The results of a drought scenario (Figure 2) show that the CC impacts are damaging the economy, in particular in the agricultural and energy sector where the wheat harvest is destroyed, and electricity generation of hydropower is limited. Consequently, export options for wheat cannot be realized and higher imports of wheat and electricity to satisfy the demand dampen the economic growth. Furthermore, lower employment and income levels reduce the spending opportunities of private households. Other imports are decreasing due to lower economic activity and support economic growth. The import dependency is generally high in

Kazakhstan and thus lower demand for intermediate and finished products results in lower imports.

Drought intensity is increasing over time and causes increasingly stronger economic impacts. Between the drought years, the economy recovers but not fully due to lagged reactions in investments and government consumption.

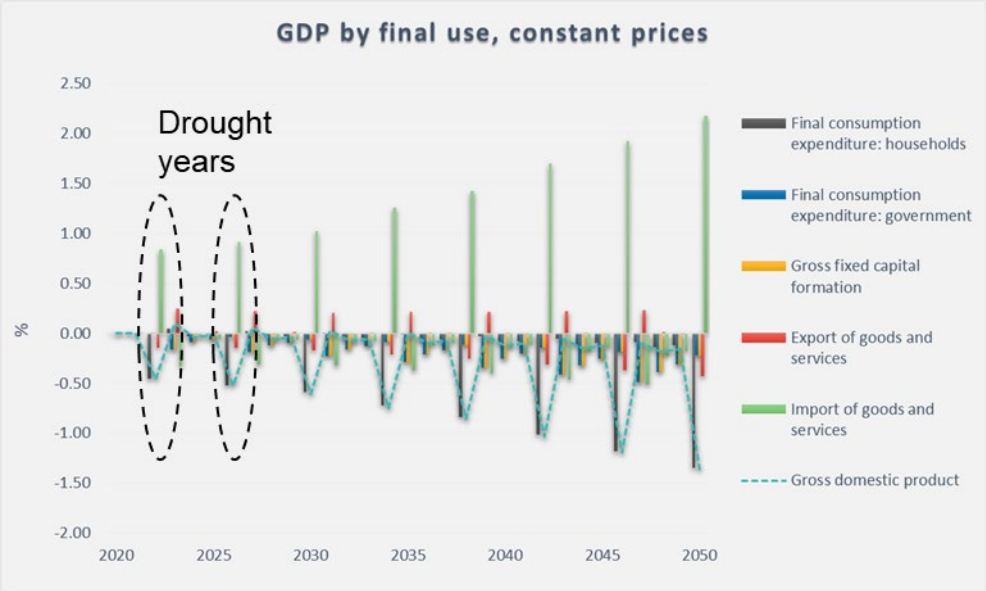


**Figure 2: "Drought" scenario: macroeconomic effects, 2020-2050, deviations compared to a hypothetical no CC scenario in percent**

The negative impacts of a drought can be minimized by e. g. installing irrigation systems. Wheat yield losses are lower, thus exports can be increased and imports reduced. However, the costs of water use in agriculture are increasing. The investment in irrigation systems is associated with high imports which impacts the economy negatively. Nevertheless, the overall impact of this adaptation measure in terms of employment and growth is positive for Kazakhstan.

There are other adaptation measures to tackle the effects of drought which can be analyzed with the Excel-based model e3.kz, e. g. the use of drought-resistant crops. E3.kz can quickly calculate a wide range of different scenarios and supports policymakers in finding suitable solutions by comparing the outcome of different adaptation scenarios which may enter the process of developing the National Adaptation Plan.

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