Georgia: *Economy-wide Effects of Adaptation in Agriculture*

Applying the e3.ge Macro-econometric Model to the Cases of Irrigation Systems and Windbreaks

SEPTEMBER 2021

Executive summary

Agricultural production heavily depends on climate conditions. The effects of the already ongoing and forecasted climate changes on the agriculture sector in Georgia range from the displacement of agri-climatic zones, the reduction of crop productivity due to extreme weather events, the reduction of the agricultural lands' fertility, the reduction of irrigated land areas to a higher demand for irrigation water (see MEPA 2017). Thus, **climate change negatively impacts the economic and social welfare and increases both sector and economy development risks.**

The alignment of economic development planning with climate resilient sector strategies like the National Adaptation Plan of Georgia's agriculture sector to Climate Change (AgriNAP) is important. Several options exist to adapt to climate change in agriculture. The adaptation measures can reduce the climate change induced costs and risks and provide benefits not only to the agriculture sector, but to the whole economy. **A macroeconomic analysis of such adaptation measures evaluates the economy-wide effects and allows to identify those with the highest positive effects on the economy.**

The analysis of two adaptation measures (irrigations systems and windbreaks) in this policy brief illustrates that investments in adaptation provide co-benefits: while on the one hand the damages from climate change in the agricultural sector are reduced, on the other hand the crop yields in all years can be increased and the up- and downstream industries benefit. **The domestic economy gets positive impacts resulting from an increased domestic production, which also calls for additional jobs.**

Published by:
giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

On behalf of:
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
of the Federal Republic of Germany

MINISTRY OF ECONOMY AND SUSTAINABLE DEVELOPMENT OF GEORGIA

In cooperation with:
GWS SPECIALISTS IN EMPIRICAL ECONOMIC RESEARCH

Current situation in agriculture

Agriculture is one of the most important economic sectors in Georgia, employing about 40% of the population, but only having a share in GDP of 8.4% in 2020. This share has fallen significantly over the past decades (see *USAID 2017*). However, the dependence on agriculture is likely to continue into the medium-term future, and it is one of the greatest challenges to improve its productivity, increase farmers' incomes and reduce rural poverty (see *MoA 2017*). Agriculture is one of the most vulnerable sectors to climate change in any country's economy, maybe the most important in Georgia (see *MoE 2015*). Thus, climate change increases sector development risks and negatively impacts economic and social welfare (see *MEPA 2017*). Consequently, the Georgian Agriculture Development Strategy (2015-2020) focused on three inter-linked challenges: ensuring food security through improvement of productivity and incomes, adaptation to climate change, and promotion of climate change mitigation. To assist the government in the implementation of the agriculture strategy, the National Adaptation Plan of Georgia's agriculture sector to Climate Change (AgriNAP) becomes an integral part of the Agriculture Development Plan.

Options for building climate resilience in agriculture

There are several ways for farmers to adapt to the expected changes due to climate change. The cultivation of adapted varieties and new crop types in connection with adapted cultivation methods can contribute to soil conservation and water saving, reducing the possible effects of climate change. Other options for adaptation include efficient irrigation systems (e.g., drip irrigation), fertilization to realize higher yields, and improved crop protection to limit pests and diseases. Improved weather forecasting and early warning systems for extreme weather events can also help to limit the damages caused by climate change. Frost protection measures (e.g., frost protection irrigation), hail protection nets, hail guns and windbreaks are further structural adaptation measures. Insurance against crop failures compensates farmers, but the foregone harvest needs to be compensated in other ways (e.g., by increasing imports).

Macroeconomic analysis of adaptation measures

A macro-econometric simulation model for Georgia has been developed to analyse the overall macroeconomic impacts of climate change and sector-specific adaptation measures. This so-called **e3.ge model (economy, energy, environment; Georgia)** considers also indirect and induced effects of adaptation measures. It helps identifying those adaptation measures that have positive effects on the economy, employment, and environment. From an economic point of view, they should be considered first when setting up an adaptation strategy in Georgia.

For the purpose of this analysis, different scenarios are developed. A scenario is a consistent set of assumptions about the future development of certain characteristic model quantities. For instance, a climate change scenario is built from assumptions on the frequency of expected future extreme weather events (e.g., a heatwave occurs every 5 years) and their respective damages and effects on the economy (e.g., reduced labour productivity, reduced harvest). In addition, the costs and benefits of the respective adaptation measures are being implemented in further scenarios. The model results not only show the direct effects but also the macroeconomic consequences for Georgia due to the economic interrelationships in the model. The results raise the awareness for climate change and options for adaptation and can be used for prioritizing adaptation measures.

In the following, **irrigation systems** and **windbreaks** will be analysed in more detail. Both types of measures were already active during Soviet time but were not maintained or were damaged. Against the background of impending climate changes, they are currently being discussed in Georgia and considered in policy strategies.

Irrigation systems

The rehabilitation and modernization of irrigation systems is key to support a greatly expanded horticultural crop production (see *MoA 2017*). Since the temperatures in Georgia will continue to rise and the estimated precipitation varies greatly, irrigation systems can sustain high yields in the future. The irrigation strategy in Georgia “encompasses the rehabilitation of decayed irrigation infrastructure and the development of a modern data-based professional and participatory irrigation management capacity” (see *MoA 2017*). The irrigation strategy contains several information on cost and benefits that can be used for the irrigation scenario.

Implementation and assumptions

In the climate change scenario, severe droughts are assumed to occur every 5 years, starting in 2025. The effects on agriculture are increasing over time due to the intensifying climate change. The rehabilitation of existing gravity irrigation schemes is done by construction works (e.g., canals, drainage, reservoirs). Water-saving technologies (e.g., drip irrigation systems) will be imported from abroad (China, or higher quality from Turkey and Israel, see *MoA 2017*). The local construction industry is needed for rehabilitation and installation of the irrigation systems. The benefits of irrigation systems include an increased agricultural productivity and thus increased crop yields in years without severe heat and drought, and reduced damages in years with extreme temperatures. Water availability does not seem to be constraining (see *MoA 2017*).

However, if the farmers must buy irrigation systems, they will pass their costs to the consumers by increasing the prices of agricultural products. If the government subsidizes the irrigation systems, it may have to reduce its investments elsewhere.

In addition to the direct effects (construction works, material imports, increased agricultural production), these effects account for further second-round and induced effects, e.g., an increase in production in upstream and downstream sectors of agriculture and construction as well as for price and income effects, which in turn influence consumption expenditures.

Table 1: Assumptions for modelling **irrigation systems** as adaptation measures used as input for the e3.ge model

COST AND BENEFITS OF ADAPTATION MEASURES	
Rehabilitation investment in irrigation systems	▪ 2021 to 2025: in total 700 million GEL ▪ 2026 to 2050: 50 million GEL p.a.
Allocation of investment	▪ 2021 to 2025: 85% irrigation channels, 15% drip irrigation systems ▪ 2026 to 2050: 25% irrigation channels, 75% drip irrigation systems
Increased crop yields from irrigation	▪ 2021 to 2025: steady growth up to 15% p.a. ▪ 2025 to 2050: 15% p.a.

Source: Adapted from MoA 2017

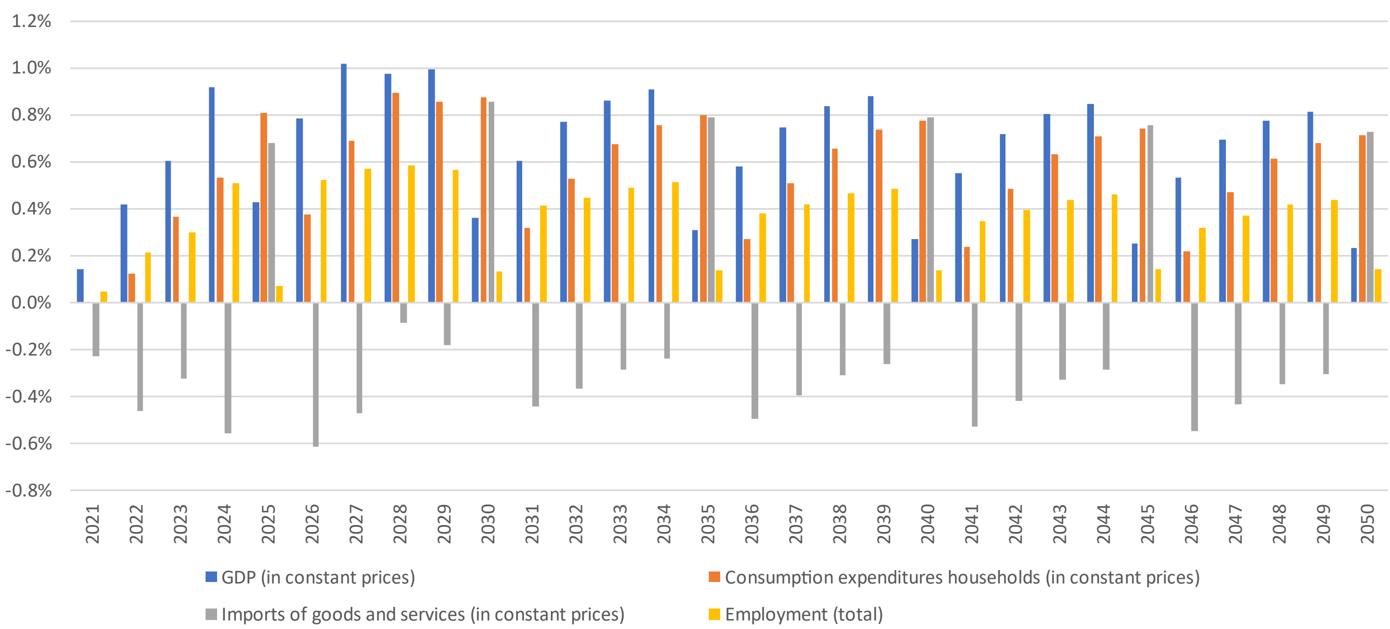
Results

The overall economic effects of the adaptation measure ***irrigation systems in agriculture* are positive**. Figure 1 shows the economic effects of implementing irrigations systems in the e3.ge model on the components of GDP. The figure shows the relative differences between a scenario with adaptation and climate change and a scenario with climate change only.

The GDP increases by up to 1% in one year in the period under review (see Figure 1). While the annual investment in construction of irrigation channels have a positive effect on the GDP, the import of drip irrigation systems has a negative impact. After the rehabilitation of the irrigation channels in the year 2025 (according to the irrigation strategy, see Table 1 and *MoA 2017*), the annual construction investment is small but still positive. More is being invested in drip irrigation systems. The positive effects on GDP result in lagged positive effects on consumption and investment, which in turn also have a positive impact on other economic sectors and thus on the GDP. The consumption expenditures increase by up to 0.9% in one year in the period under review (see Figure 1). Since the government subsidizes the irrigation systems, the government's consumption expenditures are reduced elsewhere.

***Figure 1**: Economic effects of the adaptation measure **irrigation systems in agriculture** on components of GDP and employment (differences in percent compared to drought scenario)*

LONG-TERM ECONOMIC BENEFITS OF ADAPTATION



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The biggest economic effects are to be expected from the increase in production in agriculture due to the additional irrigation. The overall effect on imports results on the one hand from additional imports due to higher consumption and investment and on the other hand from reduced imports of agricultural products. The production is increasing not only in the agricultural sector, but also in those sectors delivering inputs for the agricultural sectors and those sectors using agricultural products as an input. Higher employment results in more people having higher wages (e.g., for consumption purposes). Although there are still crop losses due to droughts and high temperatures, damages can be significantly reduced.

The implementation of the adaptation measure Irrigation systems in Agriculture has also positive effects on employment. Up to 10,000 additional people can be employed. This corresponds to an increase of up to 0.6% in one year in the period under review (see Figure 1). Analogous to the effects mentioned above, this additional employment takes place in different economic sectors: on the one hand directly in the agricultural sector, but on the other hand also in the sectors for additional consumption and in the transportation sector. Since the model assumes an increasing productivity in the respective economic sectors, the additional employment decreases over time but remains clearly positive.

Example of an irrigation channel in Georgia

Windbreaks

Wind erosion is a problem especially in dry land areas. The wind removes and transports soil material and causes land degradation. As a result, the crop yields are reduced. Windbreaks can reduce wind speeds over fields, which protects the soil and thus provides additional protection for the plants in the fields. Thus, when designed for wind reduction purposes, windbreaks can enhance crop production, improve crop quality, reduce fruit rubbing, decrease fruit drop, increase water-use efficiency, and offer control of blowing snow and dust, to mention some of the positive effects (see *Smith et al. 2021*). The windbreaks usually consist of trees and bushes that are placed at the edge of the fields or between the fields (see *IBiS 2019*). While these windbreaks were already implemented during Soviet time, they have been cut down by local people and used as firewood during the energy crises in the 1990s. Today, fire and grazing cattle are the biggest threats (see *IBiS 2019*). However, the restoration of the windbreaks is one key element to adapt to the effects of climate change. This restoration could be done in a way that the new trees and bushes are climate resilient and even multifunctional, not only providing protection from the wind but also providing additional food security through the introduction of fruit species.

This combination of protection and production can be a significant incentive to reactivate the windbreaks (see *Smith et al. 2021*). However, the reactivation and re-construction of the windbreak system is very costly. Since the income level in agriculture is low, the role of the government becomes crucial. Not only does the planting of windbreaks require financial resources, but there is also a need for further machinery and irrigation products to maintain the windbreaks. Field experiments showed that rehabilitation of windbreaks without additional watering in subsequent years (at least in the first two years) is not possible (see *IBiS 2019*).

Implementation and assumptions

Beginning in 2025, heavy wind is assumed to occur every 5 years, which destroys 5% of the annual crop yield. In addition, an annual loss in crop yields of 1.5% due to wind erosion is being assumed. The installation of windbreaks calls for seedlings and additional plastic tubes to protect the trees. These seedlings are planted by local workers, providing agricultural services. Irrigation systems are also installed. The benefits of windbreaks include an increased agricultural productivity and, thus, increased crop yields in years without heavy wind, and reduced damages in years with heavy wind.

Table 1*: Cost-benefit-analysis of* ***windbreaks****; Input for the e3.ge model*

COST AND BENEFITS OF ADAPTATION MEASURES	
Investment in windbreaks	▪ Plants: 6 million GEL p.a. ▪ Plastics: 4 million GEL p.a. ▪ Agricultural services: 5,2 million GEL p.a. ▪ Machinery: 2 million GEL p.a.
Increased crop yields from windbreaks	▪ Maize: 18% ▪ Wheat: 15% ▪ Barley: 25% ▪ Potato: 15% ▪ Fodder crops: 20% ▪ Vegetables: 15% ▪ Others: 15% **Total (weighted by share in agriculture): 17.8%**

Source: Geostat; Moore

However, if the farmers have to buy windbreaks, they will pass their costs to the consumers by increasing the prices of agricultural products. If the government subsidizes the windbreaks, it may have to reduce its investments elsewhere.

As with the irrigation systems, the implementation of windbreaks also accounts for further second-round and induced effects, e.g., an increase in production in upstream and downstream sectors of agriculture as well as to price and income effects, which in turn have an effect on consumption expenditures.

Results

The overall economic effects of the adaptation measure ***windbreaks in agriculture* are positive**. Figure 2 shows the economic effects of implementing windbreaks in the e3.ge model on the components of GDP. The figure shows the relative differences between a scenario with adaptation and climate change and a scenario with climate change only.

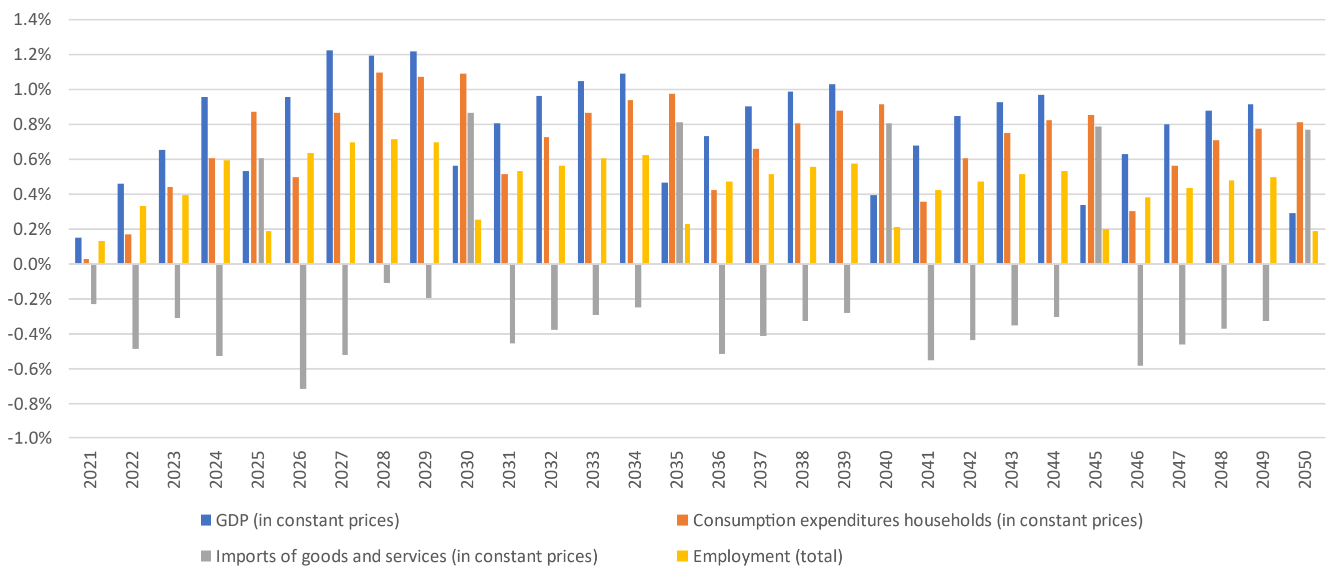
The GDP increases by up to 1.2% in one year in the period under review (see Figure 2). The annual investment in planting the windbreaks has a positive effect on the GDP. While on the one hand the increased demand for seedlings calls for a higher production in the agricultural sector, also the additional agricultural services increase the production in the respective sector.

The greatest economic effects are to be expected from the increased crop yields in agriculture due to the windbreaks. The overall effect on imports results on the one hand from additional imports due to higher consumption and investment and on the other hand from reduced imports of agricultural products.

As with the irrigation systems, the production is increasing not only in the agricultural sector but also in those sectors delivering inputs for the agricultural sectors and those sectors using agricultural products as an input, resulting in higher employment rates and more people having higher wages (e.g., for consumption purposes). The consumption expenditures increase by up to 1.1% in one year in the period under review (see Figure 2).

Figure 2: *Economic effects of the adaptation measure* ***windbreaks in agriculture*** *on components of GDP and employment (differences in percent compared to wind scenario)*

LONG-TERM ECONOMIC BENEFITS OF ADAPTATION



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Key messages

The consequences of climate change are already noticeable and will become more frequent and more severe. Since agriculture is one of the most important economic sectors in Georgia, and agriculture is one of the most vulnerable sectors to climate change, actions must be taken. Otherwise, not only food security, but also jobs and income are endangered in the Georgian economy. The implementation of adaptation measures to climate change is one possible action.

- **The results of the scenario analysis with the e3.ge model provide an economic evaluation of different adaptation measures.** However, since the future is uncertain with respect to climate change and the economy, the results are subject to uncertainties themselves and should be considered as an information that can serve as a starting point for the development of an adaptation strategy. They should raise the awareness and illustrate how the economy in Georgia is developing under the effects of climate change and what the economic benefits of adaptation to climate change are.
- The two adaptation measures under consideration, irrigation systems and windbreaks, were already used in Soviet times to increase productivity in agriculture. With the experience from the past, the still existing remnants of the infrastructure as well as the application of new technologies, the crop yields and productivity in agriculture can be increased even with regard to the effects of climate change. **Both adaptation measures analyzed with the e3.ge model show that investments in adaptation provide co-benefits:** not only can the damages in years with climate change effects in the agricultural sector be reduced, but also the crop yields in every year can be increased and the up- and downstream industries benefit. The domestic economy gets positive impacts resulting from an increased domestic production, which in turn calls for additional jobs. However, it is important where the products come from since imports reduce performance in the domestic GDP. Other adaptation measures like site-adapted selection of species, the cultivation of drought-resistant species, an improved ground coverage, the adaptation of crop rotations and a water-efficient soil cultivation add up to this and can further enhance these positive effects.
- **Financing of adaptation measures through international funds was not assumed.** Given the promises of the industrialized countries to support climate protection measures such as adaptation measures with USD 100 billion per year in the future, the prospects for (partial) funding of the measures are good. In this case, the **macroeconomic effects of the measures would be even better**.
- Although the financial and economic impacts are relevant for policymakers to prioritize adaptation measures, other criteria must be considered as well such as health aspects and ecosystem services (biodiversity, regulation of the water balance) to get a more comprehensive evaluation of a measure, and to formulate an appropriate adaptation strategy. The economic effects should only be one possible basis for decisions on the selection of adaptation measures in Georgia.

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The current work “Sectoral Policy Brief: Economy-wide Effects of Adaptation in Agriculture” was developed by the experts of GWS (Gesellschaft für Wirtschaftliche Strukturforschung GmbH), in the framework of the IKI (International Climate Initiative) Global Programme on Policy Advice for Climate Resilient Economic Development (CRED), implemented by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH on behalf of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU).

Current data used and basic assumptions behind are mostly up to date for the current project time being period under which study was conducted. Further contextualization and expansion of the results of the scenario analysis and economic evaluation of different adaptation measures presented should be respectively coordinated with the Ministry of Economy and Sustainable Development of Georgia (MoESD).

Published by:
Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

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This programme is part of the International Climate Initiative (IKI). The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) supports this initiative on the basis of a decision adopted by the German Bundestag.

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Concept & Design:
Atelier Löwentor GmbH, Darmstadt
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