Policy Handbook

STRATEGIES FOR A CLIMATE RESILIENT ECONOMY IN GEORGIA

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POLICY HANDBOOK

June 2025

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1. INTRODUCTION

This handbook has been prepared as part of the Global Programme on Policy Advice for Climate Resilient Economic Development (CRED), which is implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH and aims to fill a gap that exists in many countries: the lack of model-based assessments that can demonstrate how climate change affects economic growth, public finances and sector performance. By translating climate risks into concrete economic data, policy-makers can make more informed decisions and develop adaptation strategies that are grounded in evidence. This approach leads to more climate resilient policies and enables effective resource allocation.

In this context, the e3.ge (economy, energy, emissions) model – an analytical tool that incorporates economic, energy and environmental data – plays a key role. The model supports medium- and long-term scenario analysis and helps guide near-term decisions, such as budget allocations and the roll-out of initial public investment programmes in the context of strategic long-term visions. With the step-by-step guidance provided in this handbook, users learn how to identify, model and refine adaptation measures so that they yield a triple dividend – avoiding economic losses and realising economic and environmental benefits.

This handbook is aimed at policy-makers, adaptation specialists and others who contribute to climate and development planning in Georgia. Public officials can use it to align resilience measures with national strategies and inform fiscal and regulatory decisions, ensuring that climate actions are backed by robust data. Adaptation practitioners – especially those working on National Adaptation Plans (NAPs) or sector-level initiatives – can follow these guidelines to select policy scenarios, evaluate their potential outcomes and present model findings to decision-makers. By offering step-by-step instructions for scenario development, data analysis and interpretation of results, this handbook equips stakeholders to incorporate climate-focused actions into broader development programmes. It is a practical resource for designing and implementing adaptation strategies based on robust evidence and tailored to policy needs.

2. POLICY ENTRY POINTS FOR EVIDENCE-BASED ADAPTATION PLANNING

2.1. Role of climate adaptation in the country's development goals and strategic instruments

Climate adaptation is central to achieving sustainable economic development and addressing climate risks. Strategic instruments such as NAPs and Nationally Determined Contributions (NDCs) outline key priorities in terms of climate adaptation measures. In Georgia, climate adaptation is gradually being integrated into national development frameworks, although without an overarching policy framework, efforts remain fragmented. The climate bill, currently in the early stages of development, seeks to establish a comprehensive framework for addressing climate change, including adaptation, through an integrated vision, policies and institutional structures. 1 The NAP is still under development, but the first NDC outlines priority areas for adaptation. Several sectoral strategies, including those for agriculture, tourism and irrigation, have started to include climate change and adaptation considerations, focusing on reducing sectoral risks and negative effects on economic activity and social welfare. These initiatives reflect Georgia's increasing commitment to climate resilience, aligning national policies with global climate goals and creating pathways for future climate financing opportunities. Key stakeholders, such as the Ministry of Environmental Protection and Agriculture (MEPA) and its subordinate institutions, are leading the way in integrating adaptation measures into broader national and sectoral policies.

2.2. Entry points for policy integration explored in the context of the CRED project

The CRED project identifies several key entry points for incorporating climate economic modelling results into the economic development policy cycle in Georgia. 2 Policy entry points refer to the opportunities or stages in planning and decision-making processes where adaptation measures can be incorporated to most effectively influence policy outcomes. These points may include strategic frameworks, sectoral policies or fiscal planning mechanisms which provide a foundation for incorporating measures into broader goals.

There are several potential entry points for integrating climate adaptation into policy and planning in Georgia. With the ongoing process of developing the country's first-ever NAP, a key entry point lies in the development of sector-specific contributions, which will be essential components of the instrument. By utilising climate economic modelling results, MEPA and other relevant stakeholders can align sectoral adaptation priorities with the overarching goals of the NAP and NDC. Priority sectors for adaptation planning have already been identified, based on both their vulnerability to climate risks and their strategic importance for the Georgian economy. These key sectors include agriculture, tourism, forestry, energy, health and strategic infrastructure. Climate modelling results can play a crucial role in supporting the assessment of adaptation measures for each sector. Sector-specific and regional adaptation insights will ultimately form the basis for the final NAP.

[1] https://mepa.gov.ge/En/News/Details/21039/
[2] International Institute for Sustainable Development (2021). Using Climate Economic Modelling for Sustainable Economic Development: A Practitioner's Guide. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. Retrieved from https://www.giz.de/en/downloads/giz2021-en-climate-economic-modelling-practitioners-guide.pdf.

There are also other strategic instruments and national plans that represent potential entry points for incorporating modelling results. These instruments and processes include the development of Georgia's Fifth National Communication to the United Nations Framework Convention on Climate Change (UNFCCC), with its adaptation chapter, the Biennial Transparency Reports and NDCs, which serve as important frameworks outlining adaptation priorities and commitments. Furthermore, it would be relevant to incorporate the macroeconomic modelling of climate considerations into strategic instruments such as the National Environmental Action Plan and Technology Needs Assessment. Another example identified during field visits with the Ministry of Finance (MoF) is the Long-Term Fiscal Sustainability Report, which includes climate change considerations and modelling as part of the country's annual fiscal budget package.

Budgetary processes present another significant potential entry point. Currently in Georgia, climate change considerations are not part of the standard budgeting processes of ministries or municipalities. Adaptation projects and planning are largely carried out under a project-based approach. Incorporating macroeconomic modelling results for adaptation measures in the budget formation cycle or at the budget approval stage can provide greater certainty and predictability for decision-makers and ensures evidence-based decision-making in budgetary processes.

It is also important to note that for capital and investment projects, the Government of Georgia, particularly the MoF, follows a methodology that, along with the standard cost–benefit analysis (CBA), requires a quantitative assessment of economic impacts (e.g. gross domestic product (GDP) growth, employment, trade and, where applicable, emissions). For any adaptation measure that is part of such a project, these assessments will be required when obtaining funding from the government budget. The e3.ge model can serve as a useful tool for delivering this type of economic impact analysis.

2.3. Key challenges

Despite significant progress, several challenges hinder the effective integration of climate adaptation into economic policy in Georgia.

› *Lack of a cohesive policy framework* for climate adaptation in the absence of climate change legislation remains a significant challenge. Currently, climate adaptation efforts are not institutionalised within Georgia's policy and planning processes. Existing climate considerations primarily focus on mitigation and reflect obligations under international agreements, with adaptation often taking a secondary role. The newly initiated climate change bill presents an opportunity to create a comprehensive framework to address climate change issues, including adaptation, providing an integrated vision, policies and well-defined institutional structures and roles.

› *Insufficient coordination among key stakeholders* is a challenge. While the Climate Change Council serves as a valuable platform for setting the climate change agenda and discussing climate change policy issues, systematic integration of adaptation into economic planning requires more frequent and structured collaboration between ministries and relevant sectors. Greater interministerial and cross-sectoral cooperation is essential to improve the effectiveness of adaptation initiatives.

› *The availability and quality* of climate and economic data can often pose significant barriers to effective adaptation planning. Without comprehensive and high-quality data, conducting thorough vulnerability and risk assessments becomes challenging. Furthermore, there is sometimes insufficient clarity or understanding regarding the specific types of data required for certain climate adaptation assessments, which hinders informed decision-making. Issues of accountability and transparency also arise in terms of inconsistent data publication.

› *Limited capacity and stakeholder engagement* is an issue. Although local stakeholders have been trained under the CRED project, the overall level of local expertise, specifically the number of qualified people and their capacity to engage in adaptation planning, is still limited. Prioritising continued capacity building is essential to enable more staff from both government and non-government institutions to effectively engage in climate adaptation planning and decision-making.

- *Financial constraints* are another challenge because although international financial support is available to some extent, securing adequate budgetary resources and prioritising adaptation funding can be difficult.

Addressing these challenges requires a robust enabling environment that supports leadership, data sharing, capacity building and multi-stakeholder engagement. Overcoming these barriers will enable Georgia to leverage the potential of climate economic modelling, which will inform and guide its adaptation planning and economic development efforts.

SUMMARY

Integrating climate adaptation into economic development is vital for building resilience and achieving sustainability in Georgia. Strategic frameworks, such as the forthcoming NAP and NDCs, enable alignment with global climate goals. Key entry points, such as sectoral planning, budgeting processes and resource mobilisation, can help embed adaptation into Georgia's most vulnerable and economically important sectors, including agriculture, forestry, tourism and energy.

Key challenges – gaps in climate and economic data, institutional capacity, coordination, funding and stakeholder engagement – need to be addressed. By fostering collaboration, advancing evidence-based decision-making through tools such as the e3.ge model and promoting inclusive participation, Georgia can strengthen the integration of adaptation into development planning and ensure a more climate resilient economy.

3. PROCESS FOR USING THE E3 MODEL

This section provides an overview of the application of the e3 model for developing and refining adaptation policy scenarios. It draws on key insights from the Handbook on Macroeconomic Modelling for Climate Resilience3 and offers guidance on how national stakeholders can use the model effectively in their specific contexts.

The model helps to quantify the economic effects of adaptation measures by offering a consistent framework to develop data-driven policy recommendations. It includes a structured, seven-step process, from project setup to independent application, ensuring the thorough integration of adaptation considerations into macroeconomic policies.

Figure 1. Macroeconomic modelling in the adaptation policy cycle

Source: Taken from GIZ (2021); Climate-ADAPT (n.d.)4

The use of e3 templates for developing countries ensures the model's adaptability and transferability across various contexts. By incorporating economic, energy and emissions data, the e3 model serves as a robust tool for scenario analysis, guiding evidence-based adaptation planning and decision-making.5 A more detailed description is provided in the following sections.

3.1. Model overview

The e3 model is designed to capture the interlinkages between economic activity, energy use and environmental impacts. While its core components include energy, emissions and macroeconomic interactions, the model is particularly well suited for adaptation analysis. It enables the quantitative evaluation of sector-specific adaptation measures by assessing their costs, macroeconomic implications and co-benefits, such as employment effects and avoided losses.

- Its input–output (IO) basis enables it to analyse different economic sectors and their interdependencies while accounting for domestic and foreign drivers of economic growth. By incorporating both demand and supply dynamics alongside pricing mechanisms, the model effectively evaluates macroeconomic trends and provides insights into sectoral interactions and policy outcomes. The model supports detailed assessments of policy scenarios, enabling the comparison of adaptation measures across

[3] GIZ (2023). Handbook on Macroeconomic Modelling for Climate Resilience: A manual for designing technical assistance on macroeconomic modelling supporting climate resilient development. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. Retrieved from https://www.giz.de/en/downloads/giz2023-en-handbook-macromodelling-resilience.pdf.

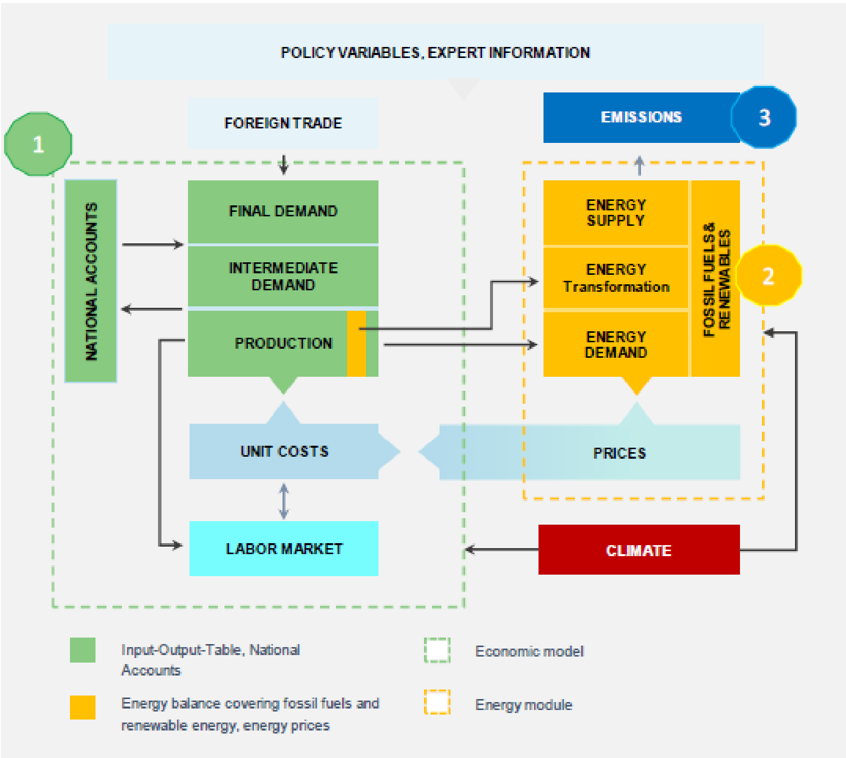
[4] GIZ (2021). Macroeconomic Models for Climate Resilience: An economic tool for adaptation and development planning. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. Retrieved from https://www.giz.de/en/downloads/giz2021-en-cred-macroeconomic-models-for-climate-resilience.pdf; European Environment Agency (n.d.). The Adaptation Support Tool – Getting started. Climate-ADAPT. Retrieved from https://climate-adapt.eea.europa.eu/en/knowledge/tools/adaptation-support-tool.

[5] GIZ (2023). Handbook on Macroeconomic Modelling for Climate Resilience: A manual for designing technical assistance on macroeconomic modelling supporting climate resilient development. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. Retrieved from https://www.giz.de/en/downloads/giz2023-en-handbook-macromodelling-resilience.pdf; GIZ (2021). Macroeconomic Models for Climate Resilience: An economic tool for adaptation and development planning. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. Retrieved from https://www.giz.de/en/downloads/giz2021-en-cred-macroeconomic-models-for-climate-resilience.pdf

sectors based on their economic relevance and feasibility.

- The energy module provides a detailed examination of energy sector dynamics, encompassing demand, supply and transformation processes across fossil fuels and renewables, as shown in energy balances. This granularity enables precise assessments of fossil fuel combustion and its related CO_2 emissions, which are further analysed in the emissions module.
- These emissions are represented in physical units, allowing the model to illustrate the impact of renewable energy deployment and energy efficiency improvements on CO_2 savings. Notably, the emissions component of the e3 model does not include feedback effects on other model variables, ensuring a clearer distinction between direct and indirect impacts.

Figure 2. e3 model overview



Source: Taken from GIZ (2021); Institute of Economic Structures Research (GWS) (n.d.)[6]

The e3 model is particularly useful for scenario analysis, simulating the macroeconomic effects of various climate change scenarios and adaptation measures. This 'what if' approach addresses questions such as 'What are the macroeconomic impacts of specific climate hazards?' and 'How do sector-specific adaptation measures influence economic outcomes?' Scenarios are constructed using quantified assumptions assigned to model variables, which trigger chain reactions across the economy. The model outputs reveal not only direct effects but also indirect and induced consequences, offering a comprehensive perspective on macroeconomic outcomes.

- The analysis begins with climate change scenarios that define potential extreme weather events and their economic impacts, such as reduced labour

[6] GIZ (2021). Macroeconomic Models for Climate Resilience: An economic tool for adaptation and development planning. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. Retrieved from https://www.giz.de/en/downloads/giz2021-en-cred-macroeconomic-models-for-climate-resilience.pdf; GWS (n.d.). Energy and climate: Models. Retrieved from https://www.gws-os.com/en/energy-and-climate/models/detail/panta-rhei; https://www.gws-os.com/de/energie-klima/modelle/detail/panta-rhei

productivity or infrastructure reconstruction costs, without any intervention or adaptation measures. The climate change scenario is benchmarked against a reference case with no climate change considerations. These scenarios draw on the Shared Socio-economic Pathways (SSPs) developed by the Intergovernmental Panel on Climate Change (IPCC) to represent different climate futures and vulnerability levels.

- Adaptation scenarios are then developed to incorporate measures that minimise or prevent these impacts.
- Comparing the results of climate change and adaptation scenarios highlights the economy-wide and sector-specific effects of preventive actions, including changes in GDP, employment and emissions.

By linking adaptation measures to macroeconomic indicators, the e3 model enables policy-makers to evaluate costs, benefits and trade-offs, supporting evidence-based decision-making for sustainable adaptation planning.

3.2. e3.ge specifications

Each country's context requires the e3 model to be adapted to reflect its unique economic structure, resource endowments and policy priorities. At the same time, the scale of the sector or subsector addressed in the scenario analysis must be sufficiently large to influence the overall economy. For example, in countries that are reliant on agriculture, the model should address irrigation, crop yields and seasonal climate variability. Where water shortages, droughts or flooding are pressing concerns, further adjustment of water-related parameters may be necessary. Furthermore, each country has distinct policy objectives – such as NDCs or sectoral adaptation strategies – which must be integrated into the model framework.

In Georgia, a macro-econometric IO simulation model – the e3.ge (economy, energy, emissions – Georgia) model – has been developed to analyse the overall macroeconomic impacts of climate change and sector-specific adaptation measures.[7] The model builds on the DIOM-X framework, a tool developed for creating dynamic IO models in Excel, and is implemented using Visual Basic for Applications (VBA). This allows all parts of the e3.ge model – data, information, scenario assumptions and results – to be stored in a single Excel file, making updates and reviews straightforward.

At the core of the e3.ge model is a set of equations that describe the various model interdependencies, sector interactions and responses to external changes. Due to the complexity and high number of variables and equations, an iterative solution approach is used. Like all models, e3.ge is a simplification of real-world processes. It focuses on the relations that are most relevant for understanding certain climate change and adaptation impacts within the economy but omits other unnecessary details that are not crucial for analysing these effects. Furthermore, the approach of storing the full data set, framework and model code in a single workbook ensures that all aspects of the model can be examined, verified and extended as needed.

The e3.ge model contains three interlinked model parts: (1) the economy module, (2) the energy module and (3) the emissions module.

The central part of the economic model is the IO tables (sectoral data) and national accounts (macroeconomic data) for key and supporting industries, their interlinkages and the domestic and foreign drivers of economic growth. It also includes a labour market section to capture employment impacts and a foreign trade section combining the country's imports and exports at the sectoral level. Unit costs and prices are calculated within the model.

[7] GIZ (2022). Supporting Climate Resilient Economic Development in Georgia. Application of the e3.ge model to analyze the economy-wide impacts of climate change adaptation. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. Retrieved from https://www.giz.de/en/downloads/giz2022-en-supporting-climate-resilient-economic-development-georgia.pdf.

The energy module draws on Georgia's energy balances, which include energy supply, transformation and demand for various energy carriers. Energy demand is determined by the economic activity in the model.

The emissions module comprises the energy-related CO2 emissions.

Climate change considerations are applied to the model through three climate change scenarios (SSP1-2.6, SSP2-4.5 and SSP5-8.5) 8 with the respective adaptation strategies. Running these scenarios through the e3.ge model generates interlinked reactions across the economy, which are then compared to the reference scenario (REF), which is the benchmark for comparison. According to EarthYield Advisories, 9 the most relevant climate hazards for Georgia are floods, droughts and heatwaves. These events are projected to become more frequent and severe in the future, with less intense climate hazards occurring more frequently than those of medium or high intensity.

3.3. Process for using the e3 model in Georgia

In Georgia, the e3.ge model was developed in close collaboration with the country's Ministry of Economy and Sustainable Development (MoESD).[10] The aim was to support informed policy-making and strengthen institutional capacity to conduct macroeconomic assessments of climate change impacts and adaptation policies.

The e3.ge model is owned by the MoESD's Economic Analysis and Reforms Department. Under the CRED project, the department has received comprehensive training in updating, using and extending the model and is currently able to apply the model to support a range of analytical tasks related to economic development and climate and energy policy.

Key institutions and policy partners who are relevant for the model's application include the MoESD itself, MEPA – in particular, its Climate Change Division (CCD) which coordinates national climate change policies, adaptation strategies and communication with the UNFCCC – and the MoF and its Macroeconomic Analysis and Fiscal Planning Department. The National Bank of Georgia is also a potential user, particularly for integrating climate-related risks into macroeconomic planning.

Throughout the different phases of the CRED project and its capacity building activities, a number of workshops and training sessions have been conducted for model builders, model users and experts from public institutions and think tanks. These have included the MoESD, MEPA, the MoF and others. The goal has been to create a wider pool of national experts and engage with them to apply and incorporate the model and its capabilities into future climate and economic policy-making in Georgia.

SUMMARY

The e3 model analyses the economic impacts of climate adaptation by linking economic activity, energy use and emissions. It supports scenario analysis to evaluate climate hazards, adaptation measures and their effects on GDP, employment and emissions. The model's flexibility allows tailoring to national contexts by adjusting for economic structure, resources and policy goals.

For Georgia, the model has been adapted to reflect the characteristics of the economy, taking into account key sectors, such as agriculture, services and tourism. It also considers major climate risks, such as floods, droughts and heatwaves. The e3.ge model incorporates national data and supports the assessment of adaptation priorities within NAP development processes, sectoral strategies and climate commitments.

[8] GIZ (2025). Economy-Wide Effects of Climate Change and Adaptation in Georgia [Reuschel, S., Lutz, C.], GIZ, Berlin.

[9] GIZ (2025). Water-related climate hazards and adaptation measures in Georgia [Brundell, F., Lüttringhaus, S.] GIZ, Berlin.

[10] GIZ (2022). Lessons Learnt from Piloting Macroeconomic Modelling for Climate Resilience in Georgia, Kazakhstan and Vietnam. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. Retrieved from: https://www.giz.de/en/downloads/giz2023-en-global-report.pdf.

4. DEFINING AND FORMULATING ADAPTATION POLICY SCENARIOS

The formulation of adaptation policy scenarios is a crucial step in translating climate objectives into practical, data-informed measures. The identification of the three viable scenarios involved close collaboration with the main government stakeholders, including MEPA and several of its subordinate institutions, the MoESD and the MoF, and with international organisations and programmes implementing key projects in the different sectors under the identified scenarios, including the United Nations Development Programme (UNDP), the Asian Development Bank and ECO.Georgia. Their engagement ensures that the chosen scenarios draw on existing sectoral strategies, reflect the actual needs of local stakeholders and take into account data availability and technical constraints. This collective input also helps clarify how each measure can be incorporated into the macroeconomic model and informs discussions on required datasets and baseline information.

4.1. Selection criteria for qualitative adaptation policy scenarios

A clear and systematic framework for selecting adaptation policy scenarios is essential to ensure they are relevant, feasible and impactful.[11] Four key criteria guide this process:

(1) *Alignment with national priorities:* ensures that scenarios address the critical challenges identified in the NAP, the NDC and other policy documents and are reconfirmed with key stakeholders. It guarantees that the proposed measures support broader national strategies and development goals.

(2) *Consideration of climate impacts:* evaluates the extent to which a scenario targets critical vulnerabilities, such as land degradation, water scarcity and other climate-related risks. Adaptation measures are tailored to mitigate these threats effectively while also considering co-benefits, such as improved public health or enhanced social equity.

(3) *Economic relevance and data availability:* assesses the potential for scenarios to deliver quantifiable economic benefits, such as increased productivity or cost savings, while ensuring that the necessary data and technical expertise are accessible to support implementation. It must also be noted that the e3 model is best suited to assessing substantial measures and should not be used for minor policy changes or measures that influence a very small part of the economy.

(4) *Integration into modelling tools:* focuses on ensuring that scenarios are designed to work seamlessly with macroeconomic models. This compatibility enables the quantification of costs, benefits and long-term impacts, providing robust evidence to inform policy decisions.

In addition to these criteria, the framework is based on three principles – feasibility, impact and cost-effectiveness:

- Feasibility: examines the practical capacity for implementation, including regulatory, institutional and financial conditions
- Impact: captures how effectively the proposed measures address climate risks and their potential to deliver co-benefits
- Cost-effectiveness: evaluates whether the anticipated benefits of an adaptation measure outweigh its financial and administrative costs

Scenario selection must also reflect local priorities. For instance, in contexts where agriculture and water resource management are high-priority sectors, adaptation measures related to drought-resistant crops, irrigation infrastructure and watershed

[11] European Environment Agency (2016). Assessing and selecting adaptation options. Climate-ADAPT. Retrieved from https://climate-adapt.eea.europa.eu/en/knowledge/tools/urban-ast/step-4-0.

protection should receive special attention. By incorporating these considerations into a stakeholder-driven consultation process, decision-makers can ensure that selected scenarios balance ambition with achievability.

This approach not only strengthens the relevance of the macroeconomic modelling and analyses but also fosters national ownership of the adaptation strategy, ensuring that the selected scenarios align with both local needs and long-term development objectives.

4.2. Formulating a sound adaptation policy scenario

Once promising measures are identified, the next step involves assembling each scenario into a coherent set of measures that align with defined policy objectives. At the heart of this process is the need to articulate baseline conditions, especially for the qualitative policy scenarios – including current levels of sectoral productivity, infrastructure and climate vulnerability – against which the effectiveness of new measures can be gauged. The baseline also incorporates existing policies and sectoral targets, ensuring that proposed actions do not duplicate efforts or conflict with ongoing initiatives.

Within each scenario, it is important to specify policy levels, which may include the scale of actions (regional or nationwide), the timeline for implementation (immediate, medium-term or long-term) and any budgetary or legislative adjustments required. When designing such policy levels, stakeholder feedback is invaluable; consultations with sector ministries, international organisations implementing relevant projects and local policy advice institutions help validate assumptions about costs, benefits and technical feasibility. These consultations also clarify data availability – especially relevant for CBAs or macroeconomic modelling – and spotlight any gaps that must be addressed before finalising the scenarios.

This collective process ensures that adaptation policy scenarios are grounded in practical realities while remaining aligned with broader development goals. Once formulated and validated, the scenarios can be fed into the macroeconomic model to capture economy-wide effects, thereby informing revisions to national adaptation strategies and guiding more targeted, effective actions across key sectors.

4.3. Relationship between cost–benefit analyses and the e3 model

The CBA and the e3.ge model serve complementary functions in assessing climate adaptation measures. While the CBA focuses on the direct financial and economic implications of individual measures – such as restoring windbreaks, building flood protection infrastructure or managing forest fires and diseases – the e3.ge model assesses their broader macroeconomic effects, including indirect and induced impacts across sectors and time.

In Georgia, several approaches have been used to conduct CBAs. Cost estimates from national sectoral strategies, management plans and previously conducted regulatory impact assessments and studies served as valuable input for scenario building. In addition to conceptual support, these instruments also provided quantified assumptions for selected measures, including unit costs, investment requirements and expected benefits, such as reduced forest degradation and avoided crop losses.

These values were used to inform the structure of the adaptation policy scenarios and to quantify model parameters, such as public investment levels or productivity gains. In some cases, measures were scaled up to the national level with certain assumptions. The e3.ge model then translated these into economy-wide impacts, allowing policy-makers to examine not only the sector-specific outcomes but also the resulting shifts in GDP, employment, consumption and production.

Where such national estimates were not available, literature-based proxies and open-source benchmarks were applied and validated through expert consultations. This ensured consistency and contextual relevance while maintaining transparency around assumptions. In some cases, benefit estimates were conservatively defined to avoid overestimation in the absence of robust data.

This combination of approaches allowed the model to reflect both the financial dimension of adaptation and its systemic economic implications, even when full standalone CBAs were not available for all measures.

4.4. Potential limitations and response strategies

The formulation of adaptation scenarios and their integration into the e3.ge model faced several challenges, most of which were data related. In many cases, the process of conducting CBAs was hindered by the lack of necessary or reliable data. Georgia's diverse geography and small size further complicated the estimation of uniform costs and benefits for adaptation measures across all regions. At the same time, partial information and estimations for specific regions or subsectors are often insufficient for the e3.ge model, which requires adaptation measures and sectors that are large enough to have economy-wide effects.

To address these challenges, the CBA experts used several approaches, including:

- Developing assumptions based on previous studies and available estimates
- Conducting expert consultations to validate the assumptions
- Making careful extrapolations to fill the data gaps

Another challenge in Georgia is the absence of quantified adaptation targets across sectors. During the July 2024 meetings with policy planners, it was recognised that identifying specific data needs for strategic planning would be an essential first step in the upcoming national adaptation planning process.

For some of the adaptation measures analysed (such as the installation of windbreaks), there was a lack of baseline data at the national level. For most cases, it was also difficult to quantify many of the benefit categories, which remained either partial or qualitative. In such cases, the CBA team had to rely on reasonable assumptions based on sectoral expertise or international benchmarks.

Recommended strategies for conducting future analysis and modelling include:

- Developing sector-specific CBAs as part of national adaptation planning
- Clarifying quantitative adaptation targets for priority sectors
- Strengthening cross-agency data coordination and institutional capacity for ongoing model use

Despite these limitations, the careful combination of existing data, expert input and transparent assumptions allowed the model to generate meaningful insights and support scenario-based decision-making.

5. POLICY RECOMMENDATIONS AND RESULTS

5.1. Adaptation in agriculture: Windbreaks

Background

Wind erosion is an important environmental problem, especially in dryland areas (GIZ 2021)[12]. This natural process by which wind removes soil particles can lead to land degradation and soil loss, reducing crop yields and agricultural productivity and causing environmental damage. In Georgia, wind erosion is exacerbated by various factors in different regions; dry climates create favourable conditions for wind erosion, and some agricultural practices, such as overgrazing, can weaken soil resistance to wind erosion.

Windbreaks, once a common feature of Georgia's agricultural landscapes, could be a promising solution. Introduced during Soviet times as a measure against wind erosion, many were cut down by local people for fuelwood during the energy crises of the 1990s (GIZ 2021). Currently, fire and livestock grazing remain significant threats to the remaining windbreaks (IBiS 2016)[13]. Residue burning, a widespread agricultural practice, further threatens their functionality. The 2015 fires in Dedoplistskaro, Kakheti, exemplify the destructive impact of residue burning. They caused the destruction of many windbreaks in the region, which produces about 74% of all Georgia's wheat (Westerberg et al. 2016)[14].

Installing windbreaks and ensuring their efficient operation could potentially reduce the impacts of climate change and wind erosion in Georgia. By acting as natural barriers, windbreaks can reduce wind speeds over crops, providing benefits including soil protection, improved crop yields, reduced crop damage and increased water use efficiency. They also have other environmental benefits, such as increased carbon stocks. However, to ensure that windbreaks are effective in reducing the impacts of wind erosion and improving the sustainability of the agricultural sector, their strategic placement in agricultural landscapes and proper maintenance are key. Furthermore, such efforts should be accompanied by measures to prevent future damage, particularly from fires and grazing.

Despite agriculture's relatively small share in Georgia's GDP (6.9% in 2023), it remains a crucial component of the economy, employing over 35% of the population (National Statistics Office of Georgia – Geostat). Reliance on agriculture is likely to continue in the medium term, given its role in food security and the livelihoods of rural households. However, Georgia's agricultural sector faces many challenges, including low productivity, vulnerability to climate change, low farm incomes and rural poverty (GIZ 2021). There are steps that can be taken to adapt to the expected impacts of climate change on agriculture, including growing adapted crop varieties, using innovative farming techniques, implementing efficient irrigation systems, improving fertilisation practices, improving crop protection and using weather forecasting tools. Among these, windbreaks stand out as a nature-based solution that can protect against wind erosion, reduce wind speeds, protect crops from damage and conserve soil, ultimately leading to increased agricultural productivity and resilience.

Scenario Description

This adaptation policy scenario builds on the earlier windbreak policy scenario developed in the context of the CRED project, expanding the focus to address factors that hinder the effectiveness of restored

[12] https://www.giz.de/en/downloads/giz2021-en-georgia-sectoral-policy-brief-agriculture.pdf.

[13] https://biodivers-southcaucasus.org/uploads/files/Approach%20Windbreak%20Rehabilitation%20Georgia.pdf.

[14] https://www.researchgate.net/publication/315154104_Cost_Benefit_Analysis_of_Agricultural_Burning_Practices_in_the_Dedoplistskaro_Municipality_Georgia.

windbreaks, including fires (from agricultural residue burning), illegal logging and grazing.

Reactivating and rebuilding the windbreak system is a costly endeavour. The planting of windbreaks requires not only financial investment but also additional machinery and irrigation systems to ensure their ongoing maintenance. The original windbreak modelling exercise estimated the economic benefits of investing in natural windbreaks, projecting a positive impact on Georgia's GDP growth of up to 1.2% a year and an increase in consumption expenditure of up to 1.1% a year (GIZ 2021). However, these calculations did not take into account the negative effects of certain factors contributing to windbreak degradation.

This enhanced policy scenario acknowledges the critical link between the effectiveness of windbreak investments and various detrimental practices, including the burning of agricultural residues and illegal logging. Studies from the Dedoplistskaro (Kakheti) area show that burning is a major threat to existing windbreaks and that, without intervention, the remaining windbreaks are likely to be lost in less than 10 years (Westerberg et al. 2016). Additionally, illegal logging for fuelwood further undermines windbreak integrity.

Thus, the previously calculated economic benefits of windbreak restoration investments may overstate the adaptation potential, which is diminished by ongoing damage to windbreak infrastructure as a result of fires and logging. Taking these factors into account not only provides a more realistic estimate of the economic benefits of windbreak investments but also makes it possible to quantify the costs of these harmful practices in the context of climate change adaptation and the economic benefits of enforcing policies to prevent them.

In addition to enhancing the adaptive capacity of windbreaks, promoting the prevention of burning practices may have direct effects on overall agricultural efficiency by improving crop yields, thereby increasing GDP. Preventing burning practices can also have co-benefits, such as reduced air pollution and improved public health.

To maintain the long-term effectiveness of windbreaks by reducing damage from residue burning and illegal logging, this scenario relies on stronger enforcement measures, such as monitoring tools and surveillance systems.

Implementation and Assumptions

Due to the expected increase in heavy winds as a result of climate change and the corresponding increase in wind erosion, crop yields are projected to decline. The average annual increase in the number of extreme wind events in Georgia is assumed to be 0.2% through to 2050, leading to an annual reduction in crop production of 1%. Furthermore, an additional annual reduction of 1.5% is expected because of wind erosion.

Modelling of the adaptation scenario suggests that restoring and maintaining windbreaks will help mitigate these losses. It involves various activities, such as land preparation, fencing, irrigation system installation and the provision of other agricultural services and machinery. It is also essential to protect windbreaks from fires and logging by installing monitoring systems and operating them throughout the period analysed.

The benefits of windbreaks include increased productivity, with reduced crop yield loss and irrigation costs and increased land value.

Table 1. Cost and benefit categories for windbreaks

COSTS AND BENEFITS OF THE ADAPTATION MEASURE (WINDBREAKS)	
COSTS[15]	Investment costs: - Preparation and planting: GEL 243.6 million - Monitoring and surveillance equipment: GEL 80.1 million - Administrative costs: GEL 13.4 million Operational costs:

[15] The costs relate to the two regions analysed in the CBA – Shida Kartli and Kakheti – in which a total of 7,691.8 ha of windbreaks are to be restored and maintained. For modelling, this was scaled up to the national level, assuming that 11,914.14 ha of windbreaks will be restored. This results in total investment costs of GEL 522 million and annual operational costs of GEL 48.9 million for the first five years and GEL 6.5 million for subsequent years.

	- Maintenance and irrigation: GEL 27.4 million (in the first five years) - Protection and remote observation: GEL 3.7 million - Monitoring and evaluation (M&E): GEL 0.5 million
BENEFITS	- Reduced crop yield loss: 16% - Savings in irrigation costs: 20% - Increased land value: 1%

Source: GIZ (2025). Economy-Wide Impacts of Climate Change and Adaptation in Georgia [Reuschel, S., Lutz, C.], GIZ, Berlin.

Further Assumptions

- The costs associated with investment in windbreaks are distributed as follows: 70% from the government, 20% from international organisations and 10% from the private sector.
- With regard to the maintenance and operation costs, it is assumed that initially the government owns 90% of the windbreaks and the private sector 10%. Over time, the government's share would decrease while the private sector's involvement and ownership share would increase. The assumption is that 30% would be held by the state and 70% by the private sector in 2050. The costs are distributed over time accordingly.
- The CBA was carried out for the two regions most vulnerable to high-speed winds, Shida Kartli and Kakheti. A total of 7,691.8 ha of windbreaks are to be restored and maintained in the two regions. To upscale the analysis to the national level, it was assumed that windbreaks in Category 1 regions (wind speeds above 9 m/s), totalling 11,914.14 ha, will be restored.
- These 11,914.14 ha of windbreaks protect 196,294 ha of agricultural land.
- In Years 1 and 2, 40% of the windbreaks are restored each year, and the remaining 20% in Year 3.
- Windbreak maintenance and irrigation is only required for the first five years; other operational costs are incurred annually.
- Total investment and operational costs over the period amount to around GEL 885 million.
- The benefits of the windbreaks planted begin to pay off five years after rehabilitation. For the sake of simplicity, it is assumed that this effect does not increase further over time.
- Further benefits resulting from windbreaks, such as their potential for carbon storage and sequestration, are currently not included in the modelling but could have an additional impact.

Modelling Outcomes and Macroeconomic Results: GDP and Employment

According to the macroeconomic results, implementing the adaptation measure, investing in natural windbreaks and protecting windbreak integrity has a positive impact on GDP, employment and the overall economy. These benefits are due to improved agricultural productivity and reduced climate-related losses, with positive effects observed across various sectors.

In e3.ge modelling, the first step is to estimate the negative economic effects of climate hazards under the climate change scenario with no adaptation. These effects are shown in percentages and absolute values in Figure 3 and Figures 3-4 respectively. Increased heavy wind events and wind erosion are expected to reduce agricultural productivity and lead to crop losses. As a result, agricultural imports increase and GDP declines by up to 0.19% a year. Over the years, these losses accumulate into significant absolute values (Figures 3-4).

Figure 3. GDP impacts under the climate change scenario (in %)

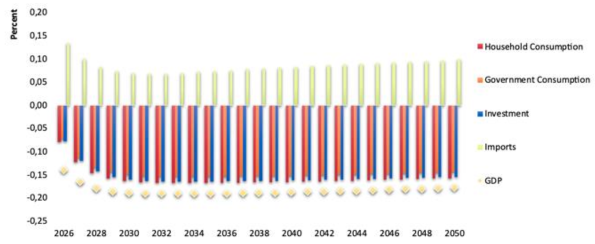
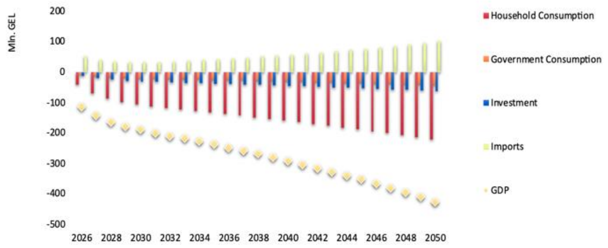


Figure 4. GDP impacts under the climate change scenario (in millions of GEL)



Source: GWS based on e3.ge

Figure 5. GDP impacts of windbreak rehabilitation (in %)

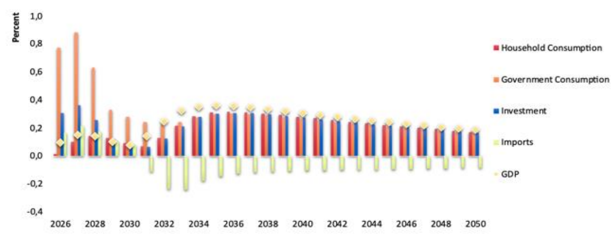
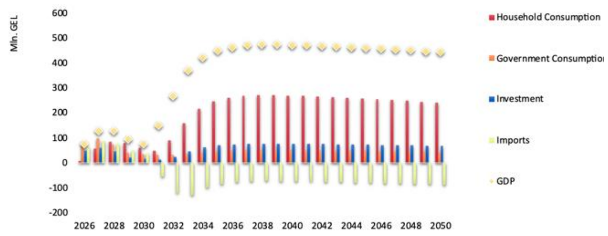


Figure 6. GDP impacts of windbreak rehabilitation (in millions of GEL)



Source: GWS based on e3.ge

On the other hand, investing in the rehabilitation and operation of windbreaks will lead to clearly positive macroeconomic impacts. These effects are illustrated in the modelling results of the new adaptation scenario, which incorporates updated measures to prevent residue burning and unauthorised logging through improved surveillance and enforcement. The results show the relative deviations from the climate change scenario for GDP and its components (Figures 5-6).

As a result of the implementation of the adaptation measures, household and government consumption increases, as does gross fixed capital formation. Household consumption expenditure alone grows by up to 0.3% a year. Another positive effect on GDP comes from the reduction in agricultural imports, driven by higher crop yields locally. Altogether, these effects contribute to GDP growth of up to 0.36% annually.

The GDP dynamics reflect the measures implemented and their effects over time. In the first three years, when the adaptation investment costs are incurred, government consumption increases, and so therefore does GDP. In the following years (up to 2031), operational costs are still high, keeping government consumption somewhat higher than in subsequent years.

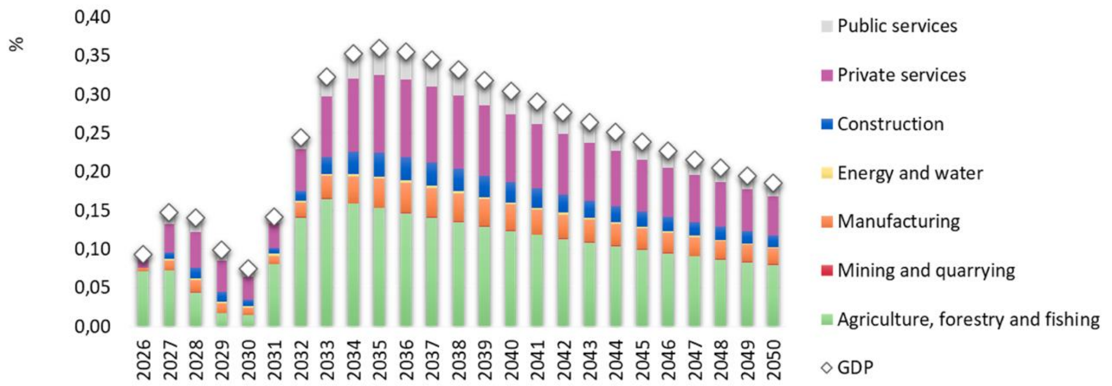
The GDP increase from 2031 onwards reflects the effects of improved crop yields, suggesting that by then the windbreaks have grown enough to provide better crop protection and increase agricultural production. As a result, agricultural imports start to decrease, and GDP and its domestic components are higher than in the climate change scenario. These positive effects on GDP are primarily driven by increased crop yields after windbreak rehabilitation.

Activities under the adaptation scenario affect a range of sectors, including agricultural and construction services, investment in technology and infrastructure, public administration activities and ongoing maintenance and monitoring. These activities stimulate various parts of the economy over time, as illustrated in Figure 7. The effects are most pronounced in agriculture and services but also extend to the manufacturing and construction sectors.

The implementation of the adaptation measure also has positive effects on employment (Figure 8). For example, around 4,280 more people could be employed in 2035, which corresponds to an increase of up to 0.2% in that year. Over the entire analysis period, around 73,000 additional jobs are created.

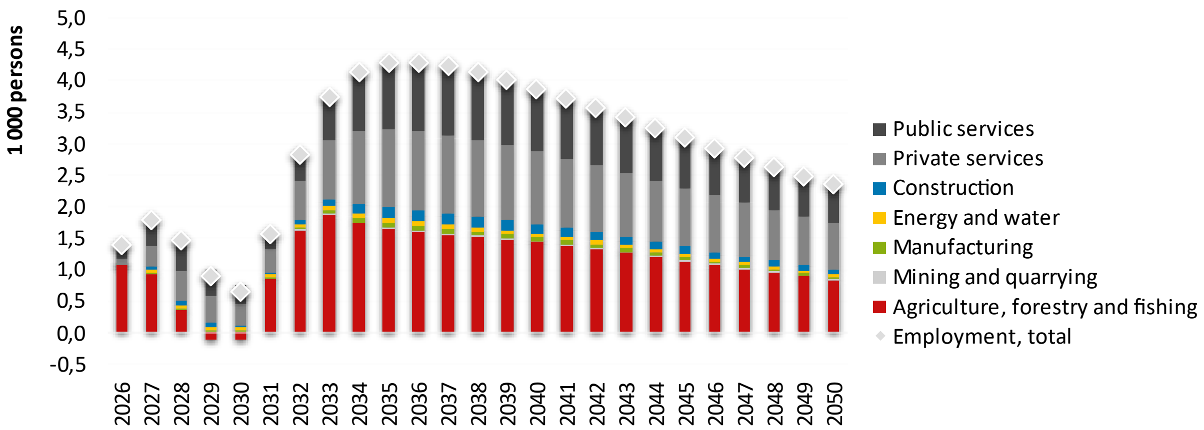
Sectoral employment effects follow a similar pattern to GDP impacts. Additional employment takes place across various sectors, primarily in agriculture and public administration but also in private services, transportation and other sectors. The employment effects decrease over time but remain clearly positive.

Figure 7. Production effects of windbreak rehabilitation (compared to climate change scenario, scaled to GDP change in %)



Source: GWS based on e3.ge

Figure 8. Employment effects of windbreak rehabilitation (compared to climate change scenario)



Source: GWS based on e3.ge

Policy Recommendation

SUMMARY

In light of the expected benefits showcased by the modelling results, which highlight the long-term economic benefits of increased GDP, additional job creation and reduced agricultural imports, it is recommended that investment in the restoration and sustainable maintenance of windbreaks should be prioritised. The measures directly improve agricultural productivity by preventing wind erosion and increasing crop yields and income for farmers. Maintaining windbreaks and addressing the factors that affect their integrity is essential for their continued effectiveness and for ensuring the economic benefits identified in the macroeconomic analysis. From a policy perspective, investing in the restoration and maintenance of windbreaks is a strategic step towards a more resilient agricultural sector in Georgia in the future.

Steps for implementation

To reap the economic benefits of windbreak restoration measures in Georgia, a clear, phased approach is recommended. The following steps can create an enabling environment for effective implementation.

1. *Strengthening the policy and institutional framework*

Coordination among relevant institutions is essential for the success of windbreak restoration efforts in Georgia. Key stakeholders include MEPA's Hydro-melioration and Land Management Department, the National Agency for Sustainable Land Management and Land Use Monitoring (Land Management Agency), the Rural Development Agency (RDA), the Department of Environmental Supervision (DES), local governments, farmers and private sector actors.

The institutional framework should be consistent with existing windbreak legislation and address gaps such as the lack of clarity regarding the responsibilities of different actors. While MEPA oversees the overall process, including resource allocation and land use policies, local governments should play a key role in engaging communities and supporting farmers in managing windbreaks. The ongoing inventory of windbreaks – the key element of the windbreak restoration process – should be prioritised by the Land Management Agency, with the supervisory body (DES) enforcing regulations to prevent illegal logging and the burning of agricultural residues.

The RDA should be tasked with developing financial and technical support mechanisms for farmers, including low-interest loans and grants for windbreak investments and maintenance. The Environmental Information and Education Centre (EIEC) will lead awareness campaigns, ensuring that both farmers and the private sector are well informed about the benefits of windbreaks.

Furthermore, MEPA's CCD should coordinate windbreak restoration efforts within the broader context of Georgia's NAP processes, ensuring that windbreaks are included in climate change adaptation strategies.

2. *Strengthening legislative frameworks*

To enhance the effectiveness of windbreak restoration, it is important for the existing windbreak law and related legislation to be updated and for new guidelines to be created and supplemented with specific provisions, including:

- Defining strategic placement and maintenance of windbreaks in different regions
- Establishing guidelines for the construction and maintenance of windbreak infrastructure, such as fencing, irrigation systems and monitoring tools, and defining clear ownership responsibilities
- Establishing monitoring and enforcement mechanisms to ensure compliance with windbreak-related laws and regulations and addressing illegal activities such as logging and agricultural residue burning by conducting inspections and imposing penalties
- Providing financial mechanisms for farmers to access low-interest loans and grants for windbreak investments and maintenance

3. *Windbreak ownership*

The current legislation defines three types of ownership for windbreaks: state, community and private. Previous studies and the regulatory impact assessment of the Georgian windbreak law suggest that a public–private ownership and management model, involving both farmers and municipalities, was considered the most advantageous option. However, there is currently no specific information on the actual distribution of ownership of windbreaks between public and private owners.

At the same time, private sector participation is essential for the efficient operation and maintenance of windbreaks. To make progress in this direction in the Georgian context, it will be necessary to demonstrate the benefits of windbreaks to farmers, especially smallholders. Engaging this group will be particularly challenging and will require strategically planned, extensive and ongoing awareness raising initiatives. Such campaigns should be supported by government programmes that provide both financial assistance, such as grants, and technical support, including training for both farmers and the private sector, to encourage investment in establishing and maintaining windbreaks.

Given the current lack of incentives and limited interest from the private sector, most of the investment costs are expected to be borne by the public sector and international organisations. While the private sector may bear the initial costs, it is reasonable to expect that a large part of this will be subsidised, which means that the cost will ultimately fall on the government or international organisations.

Regarding the distribution of windbreak ownership, it is reasonable to assume that the transition from the current situation to an increased role for the private sector will be gradual. Over time, as targeted awareness campaigns and subsidy programmes take effect, there should be a decrease in the government's share and an increase in private sector involvement and ownership.

4. *Phased implementation*

Given that only about a third of windbreaks have as yet been inventoried, the implementation of windbreak restoration should proceed in parallel with the ongoing inventory, focusing on vulnerable regions and farmer engagement.

Phase 1. Pilot project (Years 1 and 2)

- Launch a pilot in the most vulnerable areas identified through the inventory
- Develop financial and technical support mechanisms in these areas to incentivise farmer participation
- Initiate awareness campaigns to educate farmers on the benefits of windbreaks for productivity and soil conservation
- Provide training to ensure farmers are equipped with the knowledge required to establish and maintain windbreaks
- Advance the windbreak inventory and aim for nationwide completion
- Implement a M&E system to assess pilot effectiveness, track progress and plan for future phases

Phase 2. Scaling up and policy integration (Years 3 to 5)

- Finalise the inventory and incorporate data for informed planning
- Expand restoration efforts to additional regions based on inventory data
- Continue providing incentives and support to farmers
- Encourage increased private sector involvement through investment and greater maintenance responsibilities
- Continue M&E to track progress and adjust strategies as needed

Phase 3. Full-scale implementation and sustainability (Year 6 and beyond)

- Complete restoration activities across remaining areas, with ongoing rehabilitation, maintenance and expansion, based on the inventory and monitoring data
- Continue providing financial incentives and technical support to farmers and carrying out awareness campaigns
- Maintain ongoing M&E to ensure sustainability

5. *Data collection and analysis*

Completing the windbreak inventory is a crucial first step for effective data collection and analysis. At the same time, as restoration efforts begin, regular collection and analysis of the data on windbreak health, soil quality and crop yield improvements will be essential for planning and monitoring progress. This will support decision-making, track success and help adjust strategies as needed.

6. M&E

A comprehensive M&E framework should be established to assess the effectiveness of windbreak restoration and its benefits. It should focus on:

- Environmental indicators: monitoring improvements in soil quality, reduced wind erosion and vegetation recovery to assess the ecological impact of windbreaks
- Agricultural indicators: measuring improvements in crop yields, reductions in irrigation costs and increases in land value, which demonstrate the direct benefits to farmers
- Socio-economic indicators: assessing how windbreak restoration affects farmers' income stability over time, access to sustainable farming practices and overall community resilience

Financing

Financing the restoration and maintenance of windbreaks is a critical component in the successful implementation of the measures. The preliminary study conducted under the CRED project[16] identifies several barriers, with financial constraints being a key issue, and suggests potential solutions.

Limited financial resources in the national budget make it difficult to fund the large-scale windbreak rehabilitation and management projects that are urgently needed now so that they are effective by mid-century. Lack of access to private finance is also a challenge. Farmers face difficulties in accessing low-interest, long-term finance for assets and operational costs.

According to the study, the following actions can be taken to address barriers to financing the envisioned measures:

- Sovereign lending: provision of budget support for public investment in planting and rehabilitating windbreak infrastructure and the implementation of capacity building measures for farmers through RDA programmes
- Non-sovereign lending: support for commercial farmers to enable them to invest in windbreaks and sustainable agricultural businesses (capital and operational expenditure)
- Certification of CO2 sequestration potential: support for public and private entities in obtaining green certificates for carbon sinks and sustainable agricultural practices, enabling their access to private green finance through carbon markets, capital markets and financial institutions; revenue from carbon offsetting by public entities becomes a sovereign contribution to the measure
- Windbreak rehabilitation tax: establishment of a fee/tax on farmers benefitting from publicly managed windbreaks

Addressing financial challenges to windbreak rehabilitation and climate adaptation in Georgia could involve the implementation of a sector development programme (SDP) encompassing market-based sovereign lending (corresponding to the upper middle-income status of Georgia), blended with grant funds for capacity building and investment in climate adaptation measures (i.e. provided by trust funds or global climate and environment funds). Further, the SDP will encompass a policy-based approach, requiring the Government of Georgia to establish and build relevant policies and institutions in the initial project phase, before sector investments in windbreak infrastructure are made. Grant funds will be provided for capacity building measures for farmers (through the RDA) on agricultural business management, sustainable agriculture, carbon accounting and access to green/sustainable finance.

Carbon offsetting mechanisms can be utilised by private and public entities with regard to investments in sustainable agricultural practices and windbreak rehabilitation. Beyond the scope of the measure, private agricultural holdings will be able to access private green finance (loans from multilateral and domestic financial institutions, securities to investors)

[16] GIZ (2025). Financing Options for Sectoral Adaptation Programmes in Georgia [Wehnert, B.] GIZ, Berlin

to further finance investment in windbreaks and sustainable agricultural practices.

According to high-level estimates, cost requirements for all these project components (including carbon offsetting mechanisms) would be USD 7 million to USD 10 million (technical assistance) and USD 405 million (blended sovereign lending).

Key Takeaways

In Georgia, windbreaks can play a critical role in increasing agricultural climate resilience by protecting crops from wind erosion, thereby improving crop yields and increasing agricultural productivity. Investing in windbreak restoration is expected to have positive long-term economic effects, contributing to an increase in Georgia's GDP (up to 0.37% a year). To effectively realise the economic benefits of windbreak rehabilitation, it is important to focus on ensuring their functionality and long-term maintenance by proactively addressing factors that undermine their integrity, such as logging practices and fires from residue burning.

For the restoration work, a phased implementation approach is recommended, beginning with pilot projects in vulnerable regions and scaling up with stronger policy and institutional frameworks. Over time, greater private sector involvement should be encouraged to ensure sustainability.

For investment costs, which include land preparation, planting, fencing, monitoring, capacity development and awareness raising, the development of effective funding strategies is crucial, particularly those aimed at supporting the private sector and encouraging its involvement.

5.2. Enhanced flood protection

Background

Georgia's regions face significant risks from floods and flash floods, which cause recurrent damage to communities and infrastructure and considerable loss of land resources and economic damage.[17] *The Atlas of Natural Hazards & Risks of Georgia*[18] provides an analysis of flood exposure, detailing the vulnerability of various sectors of the economy and society, as summarised in the table below.

Table 2. High exposure to flood risks

HIGH EXPOSURE TO FLOOD RISKS IN GEORGIA				
CATEGORY	Amount exposed	Country total	Share of exposure	Unit
POPULATION	234	3,704	6.3%	thousands of people
ROADS	2,104	32,619	6.5%	km
GDP	688	17,968	3.8%	millions of GEL
PIPELINES	75	1,082	6.9%	km
BUILDINGS	69	1,387	5.0%	thousands of buildings
PROTECTED AREAS	289	4,516	6.4%	km^2
FORESTS	648	29,782	2.2%	km^2
CROPS	435	8,133	5.3%	km^2

Source: Table created based on information from the CENN Atlas (2017) and Geostat.

[17] https://www.researchgate.net/publication/337286978_The_Georgian_Road_Map_on_Climate_Change_Adaptation
[18] http://drm.cenn.org/index.php/en/background-information/paper-atlas

The increasing flood risk requires the identification of effective and sustainable adaptation strategies from an economic, social and environmental perspective. Evaluating such strategies involves assessing both their effectiveness in damage reduction and the economic costs of building and maintaining the required infrastructure. Different flood risk reduction measures can mitigate the increased flood risk, with varying cost effectiveness projections. For example, the strengthening of dyke systems or the use of retention areas requires substantial investment but can greatly reduce the economic and human impact, with dyke strengthening resulting in an estimated reduction in economic damage of 41% to 68% and savings of 2 to 2.9 times the amount invested.[19]

Ultimately, the primary goal of flood protection measures is to reduce private and public losses from flooding, maximising net economic benefits and reducing the social and economic costs caused by flooding.[20] Beyond the immediate impact on local communities and regions, these measures can generate positive economy-wide effects that contribute to GDP growth and increased economic activity.

To manage flood risks effectively and define relevant adaptation measures, it is important to consider the river basin as a whole. Changes in conditions within the river basin (e.g. urban development, other flood prevention measures, land use changes) can alter flood vulnerability in adjacent areas. Therefore, a basin-wide management approach, which treats a river basin as a single system, is a common method in flood management planning.

From a policy-making perspective, proactive investment in flood protection measures can be seen as an opportunity to protect lives, businesses and critical infrastructure, which is a strategic investment for a resilient future. Understanding the potential return on investment, including reduced infrastructure damage, economic impact and social costs, strengthens the case for planning for flood protection at the national level.

Scenario Description

A basin-wide management approach, as described above, is currently being applied in Georgia through a project implemented by the UNDP,[21] which is developing multi-hazard risk management (MHRM) plans for the country's 11 river basins. These plans identify the most vulnerable areas with respect to seven hydro-meteorological hazards, including flooding, and prioritise adaptation measures based on cost estimates provided by multi-criteria effectiveness analysis. They also define responsible agencies, timeframes and funding sources for the implementation of these measures. Currently, MHRM plans for four river basins (Chorokhi-Adjaristskali, Khobistskali, Enguri and Rioni) have been developed. The remaining seven river basin management plans, including those covering eastern Georgia, will be developed later in 2025.

These plans aim to establish a national-level investment plan for comprehensive adaptation measures, guiding the strategic allocation of funds. They feature adaptation measures with the corresponding cost estimates and prioritised based on cost-effectiveness. However, the studies for the plans do not include analysis to estimate the economy-wide effects of the recommended measures. To address this gap, insights from the CRED project and the e3.ge model can play a critical role, informing prioritisation and decision-making processes at the national level by furnishing evidence on macroeconomic impact estimates.

In the development of the flood protection scenario for Georgia, MHRM plans served as a starting point for identifying flood adaptation measures. This alignment ensured that the scenario reflects real-life conditions relevant to Georgia's context. Furthermore, the pre-assessment analysis provided in the plans supported the CBA, allowing relatively accurate cost estimates to be made for the identified

[19] https://publications.jrc.ec.europa.eu/repository/handle/JRC118425

[20] https://www.unescap.org/sites/default/d8files/knowledge-products/Manual%20and%20Guidelines%20for%20Comprehensive%20Flood%20Loss%20Prevention%20and%20Management.pdf

[21] UNDP project: Reducing the risk of climate-driven disasters in Georgia.

adaptation measures. To enhance the effectiveness of the selected measures and to achieve stronger economy-wide benefits, the initial actions were supplemented with additional adaptation options relevant to Georgia's context. These additions aimed to strengthen the overall strategy and ensure that the selected measures contribute to comprehensive and impactful flood protection across the country.

Flood management measures are generally categorised as either structural or non-structural. Structural measures, such as dams, gabions, dikes, embankments and diversion channels, aim to keep water away from the population to reduce flood risks. Non-structural measures, including policies, public awareness campaigns, flood warnings, education, evacuation and land use adjustment, aim to keep people away from water to reduce flood vulnerability.[22]

The final policy scenario that analyses the impact of implementing flood protection measures in Georgia incorporates a set of structural and non-structural adaptation measures, which reflect both the physical and institutional dimensions of flood resilience.

Structural measure:

- Construction and renovation of flood protection infrastructure (e.g. gabions and other physical barriers)

Non-structural measures:

- Flood risk zoning
- Introduction of flood resistant building codes
- Development of early warning systems
- Insurance schemes

These measures form an integrated strategy that considers Georgia's geographical, institutional and socio-economic context. The scenario aims to provide model-based evidence to support decision-making by assessing how such actions can contribute to climate resilience and economic sustainability in the face of increasing flood risks in Georgia.

Implementation and Assumptions

Climate change and increased precipitation patterns are expected to exacerbate riverine flooding in Georgia, posing growing risks to infrastructure, buildings and material assets. Flood-related damage can affect critical sectors such as agriculture, transportation and public utilities while also disrupting livelihoods and increasing public expenditure on disaster response and recovery. Without adaptation, the economic costs of flood events are expected to rise substantially. However, modelling suggests that targeted adaptation measures can help reduce these impacts, bringing benefits such as avoided economic damage, prevented agricultural losses and reduced infrastructure destruction.

The CBA estimating the impacts of adaptation measures was conducted for the two major river basins in Georgia – Rioni and Mtkvari. The analysis included both investment and longer-term operational costs associated with the activities under the identified structural and non-structural measures as well as the anticipated benefits.

Table 3. Cost and benefit categories for flood protection

COSTS AND BENEFITS OF THE ADAPTATION MEASURE (FLOOD PROTECTION)	
COSTS[23]	Investment costs: - Flood protection infrastructure: GEL 246.1 million - Flood risk zoning: GEL 9.1 million - Flood resistant building code (nationwide): GEL 85.8 million - Early warning system: GEL 92.4 million - Insurance: GEL 57.2 million Operational costs: - Insurance costs (for agriculture, property and buildings): GEL 128.9 million
BENEFITS	- Reduced losses in agriculture: 50% - Reduced losses in buildings/properties: 70%

Source: GIZ (2025). Economy-Wide Effects of Climate Change and Adaptation in Georgia [Reuschel, S., Lutz, C.] GIZ, Berlin.

[22] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9713350/#:~:text=Keeping%20water%20away%20from%20populations,gates%2C%20diversion%20channels%2C%20etc.

[23] Unless otherwise indicated, the costs refer to the two river basins – Rioni and Mtkvari – based on the estimates resulting from the CBA carried out by Remissia.

Further Assumptions

The assumptions regarding the temporal allocation and financing of the adaptation measures are important for the temporal course of the economic effects. Most of the measures are implemented in the first few years and quickly lead to benefits.

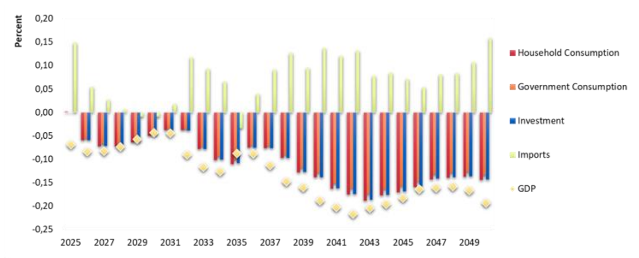
- The costs associated with the investments are wholly borne by government
- Investment costs are distributed over the period as follows: 30% in Year 1; 30% in Year 2; 30% in Year 3; 10% in Year 4
- Operational costs are incurred annually from Year 2 onwards
- Total investment and operational costs over the period amount to around GEL 3.7 billion
- The benefits begin to pay off from Year 2 onwards

Modelling Outcomes and Macroeconomic Results: GDP and Employment

According to the e3.ge modelling results, the implementation of flood protection adaptation measures leads to positive effects on the Georgian economy, including GDP growth, job creation and increased investment. The adoption of a range of measures leads to enhanced economic activity across multiple sectors.

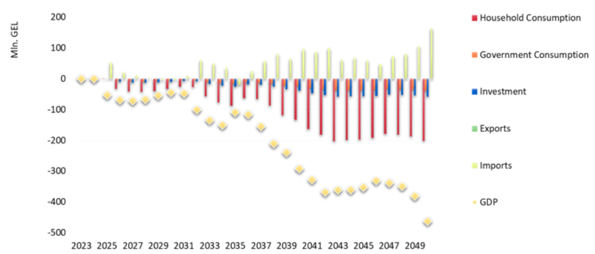
In the initial stage, under the climate change scenario with no adaptation, the model quantifies the anticipated economic damage caused by climate hazards and flooding in Georgia over the years. These adverse impacts are shown in percentage terms (Figure 9) and absolute values (Figures 9-10). Projections suggest that this type of climate change impact could result in a GDP reduction of up to 0.22% a year. The absolute values of losses are expected to increase dramatically by mid-century (Figures 9-10).

Figure 9. GDP impacts under the climate change scenario (in %)



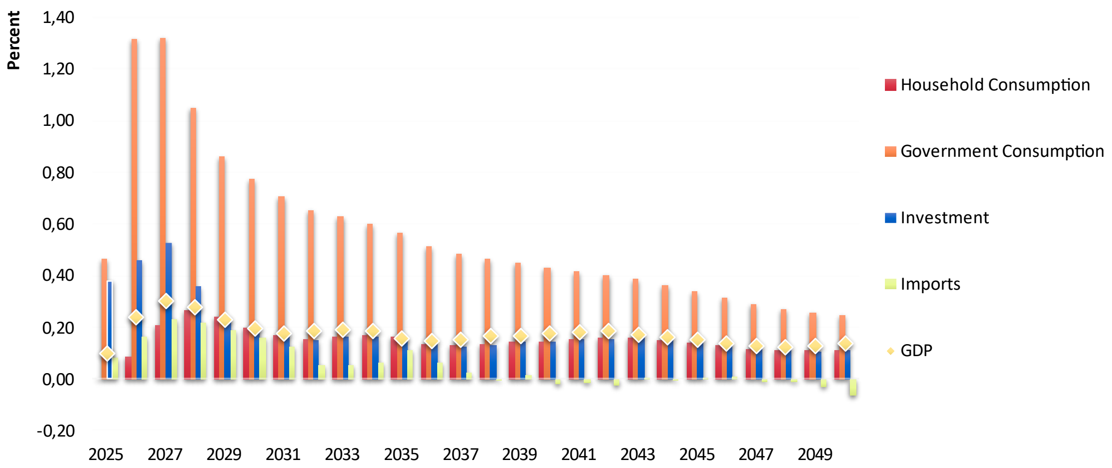
Source: GWS based on e3.ge

Figure 10. GDP impacts under the climate change scenario (in millions of GEL)



On the other hand, investing in flood protection adaptation generates significant positive economic benefits, as shown in the adaptation scenario. Measures such as the installation of early warning systems, including meteorological stations, meteorological and hydrological posts and their ongoing maintenance, stimulate investment in scientific and technology-related services while also promoting capacity building. Other measures such as flood risk zoning and developing land use planning policies and guidelines require institutional strengthening and capacity building, which increase government consumption. Simultaneously, the construction and rehabilitation of flood protection infrastructure stimulates the construction industry and creates demand for services from local workers. Another component – the introduction of insurance schemes – involves the government subsidising insurance premiums, which benefits the financial sector and enhances agricultural resilience. The implementation of all these measures together will lead to increased consumption expenditure by households and government and higher fixed capital formation and overall GDP growth (Figure 11).

Figure 11. Adaptation scenario: Flood protection (compared to climate change scenario, in %)



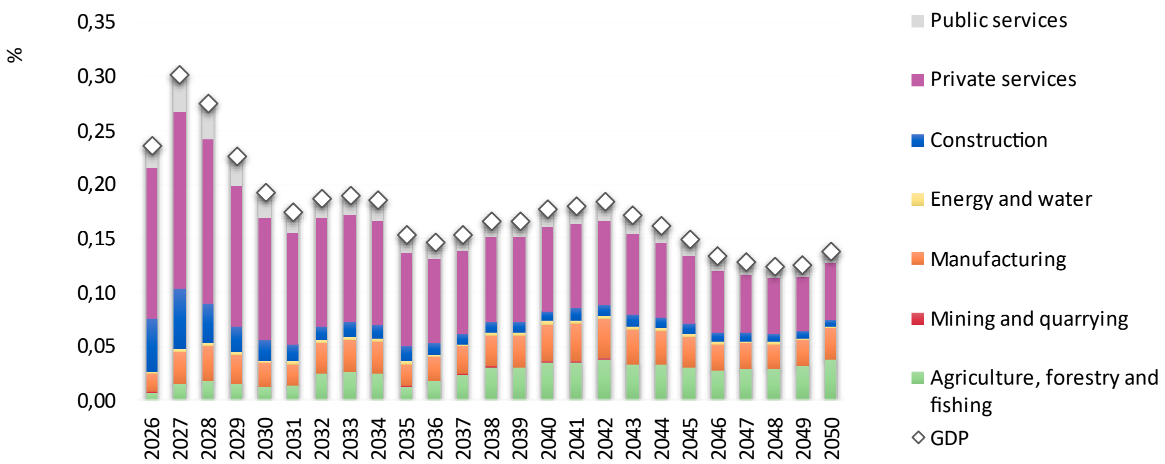
Source: GWS based on e3.ge

In the first four years of implementation, GDP growth and overall economic effects are largely due to upfront adaptation investments, particularly in early warning systems and flood protection infrastructure. These drive public sector consumption and investment. Over the longer term, the macroeconomic benefits come from reduced losses and enhanced resilience across the economy and society. As shown in Figure 11, these adaptation measures lead to sustained economic growth throughout the assessment period, reflected in continued growth in investment and household and government consumption, with GDP growth reaching around 0.19% annually.

At the sectoral level, flood protection adaptation measures lead to similar increases in both production (Figure 12) and employment (Figure 13 below). Notable growth in economic activity is expected particularly in private services (up to 0.16%), but also in other sectors including construction (0.06%), manufacturing (0.04%) and agriculture (0.4%).

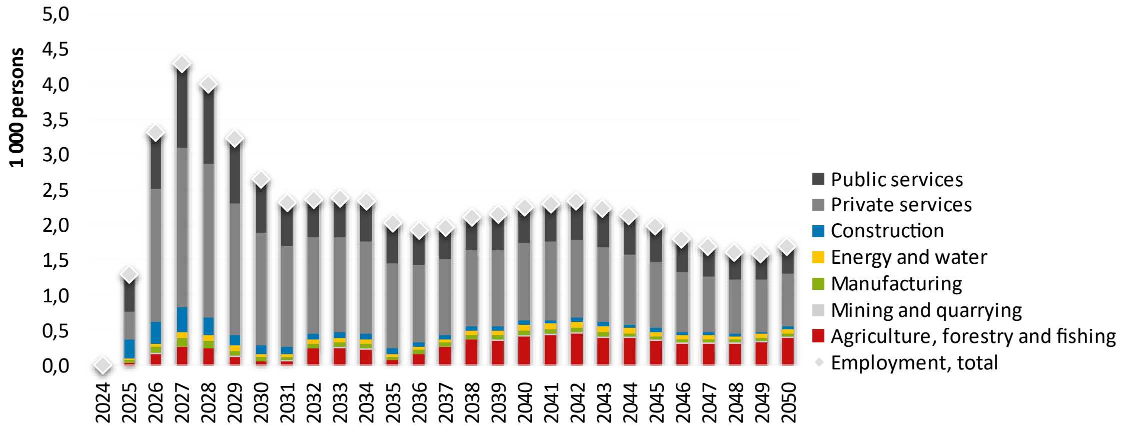
Implementing adaptation measures also drives job creation. For example, by 2027, up to 3,660 additional people could be employed, corresponding to a 0.2% rise in employment for that year (Figure 13). Over the entire analysis period, around 57,000 additional jobs are created cumulatively.

Figure 12. Effects of flood protection on production (compared to climate change scenario, scaled to GDP change in %)



Source: GWS based on e3.ge

Figure 13. Effects of flood protection on employment (compared to climate change scenario, in thousands of people)



Source: GWS based on e3.ge

Sectoral employment effects follow a similar pattern to GDP impacts. Additional jobs are created across various sectors, primarily in private services but also in public services, agriculture and the construction and energy sectors. The additional employment effects remain consistently positive throughout the analysis period.

Policy Recommendation

SUMMARY

The positive economic impacts demonstrated by the modelling results – GDP growth, increased employment and reduced losses due to climate change and increased flood risks – highlight the importance of prioritising the comprehensive flood protection measures analysed in the scenario. Proposed actions that combine structural and non-structural measures can play a crucial role in reducing Georgia's vulnerability to riverine floods and provide long-term socio-economic benefits. Even though the upfront costs of flood risk management can be significant, the long-term benefits in terms of avoided losses and enhanced resilience make it a forward-looking investment. The significant economic benefits underscore the importance of integrating flood protection further into national development and fiscal planning.

Activities for the implementation of the adaptation measures

Under the adaptation measures analysed, implementation of the following activities is considered:

1. *Flood risk zoning*

- Flood risk zoning: development of hazard and inundation maps
- Development of a policy framework and guidelines for land use planning in Georgia

Flood risk zoning will support long-term land use planning in Georgia. The maps will guide local governments in revising spatial plans, regulating new developments and identifying appropriate areas for protective measures. Zoning efforts will be supplemented by legal reforms and institutional guidance to ensure land use decisions are informed by updated flood risk assessments.

2. *Flood resistant building codes*

- Development and implementation of a climate change risk-based building code for flood resistant construction in high-flood risk areas

A new national building code will introduce mandatory standards for flood resistant construction in high-risk zones. These standards will apply to new developments and renovations, requiring flood-proof design elements and certification for local market construction materials. Builders and municipal authorities will receive technical training to ensure effective implementation. To support uptake, financial instruments such as concessional loan schemes can be introduced to help households and developers comply with the new requirements.

3. *Insurance schemes*

- Design and deployment of climate risk insurance products (for agricultural and property insurance)
- Implementation of a premium subsidy mechanism for the schemes

In view of the importance of the agricultural sector and its exposure to flood risks, the scenario includes insurance solutions to offer financial protection against residual flood risks. The scheme also covers property and assets in high-flood risk areas. This measure provides additional solutions for areas where structural measures alone are insufficient to prevent economic losses.

The implementation of agricultural insurance will start in 10 high-risk agricultural municipalities, where flood risk assessments and feasibility studies will guide the design of tailored insurance options. To pilot the process and ensure affordability, it is considered that the government will subsidise up to 75% of premiums during the initial rollout, with the funds potentially drawn from the budgets allocated to weather-related losses. Capacity building efforts will target insurance providers, supporting the development of climate risk products, pricing mechanisms, asset liability management and regulatory compliance. Public–private cooperation will be fostered to expand these services and to link insurance schemes with sovereign tools such as contingent disaster financing.

4. *Early warning systems*

- Deployment of monitoring infrastructure and forecasting tools
- Establishment and operationalisation of flood warning communication systems at the national and local level, led by the National Environmental Agency (NEA)
- Capacity building and institutional strengthening

To support flood forecasting and decision-making, meteorological and hydrological stations and posts will be installed. They will collect data on weather conditions and river runoff parameters, including flow speed and depth, which will be used in an integrated forecasting system, supporting short- and long-term flood predictions. Additional tools, such as a web platform and dedicated communication network, will facilitate the timely dissemination of alerts at both the national and local level.

The early warning systems will be supported by extensive capacity building initiatives targeting national and local institutions. Technical staff at MEPA, NEA and municipal authorities will receive specialised training to manage, maintain and interpret the data generated by the system. This will ensure that the hardware and software components of the system are maintained and effectively incorporated into Georgia's broader emergency response protocols.

5. *Flood protection infrastructure*

- Construction and rehabilitation of flood protection infrastructure (including gabions and other river embankment measures)

In locations where residual flood risk remains high despite zoning, insurance and early warning systems, structural protection is essential. In the proposed scenario, priority sites across the Rioni and Mtkvari river basins have been identified for physical interventions to directly reduce the risk to people, property and important infrastructure. Implementation of the structural measures will be coordinated with local governments to ensure maintenance and sustainability.

Steps for implementation

For the implementation of the proposed flood protection measures and the respective activities, the following steps are recommended to create an enabling environment across institutions and sectors.

1. *Strengthening policy and institutional frameworks*

The implementation of flood adaptation measures can only be successful with coordinated efforts and cooperation among the different agencies responsible. Key actors include MEPA, NEA, the

Ministry of Regional Development and Infrastructure (MRDI), the Emergency Management Services (EMS) under the Ministry of Internal Affairs, the Roads Department, the MoF and local governments and municipalities in the high-flood risk areas.

In the proposed scenario, MEPA coordinates the activities and aligns them with the broader climate adaptation framework as part of the development of the NAP. NEA, as a technical body under MEPA, is best positioned to manage the monitoring of flood hazards and the implementation of early warning systems. The MRDI will play a key role in integrating flood risk considerations into infrastructure planning and investment, while the MoF will support the financial dimension of the efforts, including sovereign lending, contingent disaster financing instruments and coordination with development partners.

The participation of the private sector, in particular insurance companies, will be necessary to scale up risk transfer solutions. Cooperation between insurance companies and public authorities will be necessary for the development of insurance products.

Overall, successful implementation will depend on establishing clear institutional mandates and mechanisms for coordination among the partners involved.

2. Legislative and regulatory enhancements

A number of specific legislative initiatives and amendments will be required to enable the effective implementation of the flood protection measures outlined in the scenario, particularly with regard to the following:

- Flood risk zoning – it will be necessary to develop national guidelines for flood risk zoning and the use of hazard and inundation maps in spatial planning.
- Flood resistant building codes – building regulations will need to be amended to mandate the inclusion of flood resistant design standards in building codes, especially in high-risk zones. This can also include certification requirements for flood resilient materials.
- Early warning systems – legislation should define roles and responsibilities for establishing and maintaining early warning systems at the local and national level and for incorporating forecasting tools into emergency response protocols.
- Insurance schemes – a regulatory framework for climate risk insurance will be needed, particularly for agriculture and residential property. It should enable effective public–private partnerships and define eligible risks and the role of the government in providing subsidies and supervision.

3. M&E and data collection

M&E will be essential to understand the effectiveness of the proposed flood adaptation measures and determine whether they are delivering the intended outcomes. Each measure – from zoning and infrastructure to insurance and early warning systems – needs to be assessed over time to determine its effectiveness in reducing risk exposure, economic loss and community vulnerability.

In this context, relevant data collection will be crucial for monitoring progress and informing decision-making. In practical terms, M&E will rely on regularly collected data, such as flood events, hydrometeorological data, infrastructure performance records, land use changes and insurance uptake rates. Most of this data will come from the institutions already involved in implementation, such as NEA. Pilot projects, such as those for insurance schemes, will serve as testing grounds and help define indicators and feedback systems for further improvement of specific activities.

Financing

Effective flood risk management requires significant public investment to reduce the exposure and vulnerability of people, property and infrastructure to climate-related hazards. Financial barriers are analysed and potential solutions are proposed in a study under the CRED project.[24]

To manage costs effectively, the Government of Georgia is advised to adopt a comprehensive disaster

[24] GIZ (2025). Financing Options for Sectoral Adaptation Programmes in Georgia [Wehnert, B.] GIZ, Berlin.

risk financing strategy with sovereign risk retention instruments. These may include sovereign budget reserves, sovereign contingent disaster financing and commercial risk transfer mechanisms for assets (asset insurance). In the medium term, the government should subsidise insurance premiums (up to 75%) to ensure agricultural insurance uptake among farmers.

Public investment will need to be financed in three areas:

- Investment in structural measures for flood protection infrastructure, including flood barrier systems along riverbanks, dikes, gabions, upgraded urban drainage and sewage systems and restoration of natural ecosystems and floodplains
- Investment in non-structural measures, such as early warning systems, contingency planning, and resettlement and relocation of extremely exposed people or settlements
- Investment in awareness raising and institutional capacity building to enhance the transfer of retained flood risks through insurance solutions

It is proposed that the measure be implemented as a SDP, combining market-based sovereign lending (corresponding to Georgia's upper middle-income status) with grant facilities for capacity building and investment in climate adaptation. The SDP will adopt a phased, policy-based approach, with initial efforts focused on institutional and policy reforms, followed by sector investment in flood protection infrastructure and early warning systems.

According to the study, the high-level estimation of project costs for the Rioni and Mtkvari river basins includes an investment of approximately USD 161 million for the financial component and USD 27 million for the technical component, with annual operational costs of around USD 45 million.

Key Takeaways

Flooding is an increasing threat to Georgia's economy, infrastructure and communities, which is exacerbated by climate change. However, the analysis confirms that investing in a comprehensive flood protection strategy – comprising both structural measures (e.g. gabions, embankments) and non-structural measures (e.g. zoning, building codes, early warning, insurance) – can significantly reduce damage and enhance the economy's climate resilience.

Macroeconomic modelling shows that such actions can create positive economic impacts, resulting in GDP growth of 0.19% and creating new jobs, particularly in financial services, agriculture and the construction sector.

To realise these benefits, the country must prioritise the development of a strong institutional framework, effective regulations and sustainable financing mechanisms.

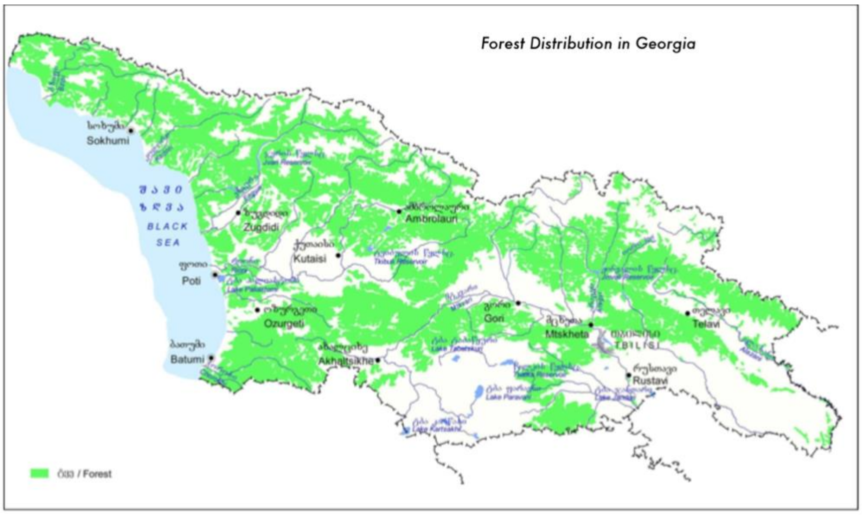
5.3. Forestry: Adaptation against forest fires and forest diseases

Background

Rising temperatures and changes in precipitation patterns have a direct impact on forests. The effects are visible in Georgia, including an increased risk of forest fires, pest and disease outbreaks, landslides, floods and droughts. The vulnerability of Georgia's forests to climate change is exacerbated by unsustainable forest use practices (e.g. for fuelwood). As a result, 35.4% (807,178 ha) of Georgia's forested area is degraded, according to Georgia's First National Forest Inventory (2023).[25]

[25] https://mepa.gov.ge/En/Reports

Figure 14. Forested areas of Georgia



Source: WWF-Caucasus

This degradation negatively affects forest ecosystem services, such as water storage capacity, recreational services for tourism, and soil protection and carbon sequestration for climate protection.

The tourism sector, a rapidly growing component of the Georgian economy, contributes around GEL 5.9 billion to GDP, with a 7.3% share in the total (2024).[26] The numbers of visitors to protected areas and forests are rising each year, contributing to achieving the strategic vision of developing ecotourism.[27] Maintaining healthy and sustainable forests is therefore also crucial to supporting this industry and its continued growth.

In addition, forests play a critical role in terms of maintaining the hydrological cycle, which is essential for human and economic activities. Their water storage capacity helps regulate the flow of water throughout the year, ensuring a steady water supply for agriculture, drinking water provision and hydropower generation. The water retention capacity of upstream forests and ecosystems is vital for sustaining these activities which rely on a constant flow of water.

Furthermore, forests can provide a range of essential products for local communities and industries, with potential for further development. These include firewood, biomass, timber and non-timber forest products, such as berries and honey. Table 4 gives an overview of the types of ecosystem services offered by forests.

Table 4. Overview of forest ecosystem services[28]

OVERVIEW OF FOREST ECOSYSTEM SERVICES		
PROVISIONING SERVICES	Regulating services	Cultural services
WATER	Water flow regulation	Tourism and recreation
FIREWOOD	Soil retention	
TIMBER	Carbon sequestration	
NON-TIMBER FOREST PRODUCTS	Carbon storage	
	Pollination	

[26] https://www.gnta.ge/en/research/en-ekonomikuri-machveneblebi-2

[27] https://ecotourism.ge/wp-content/uploads/2023/02/Ecotourism-Strategy-for-Georgia-2020-2030.pdf

[28] Prepared from: https://www.environment.vic.gov.au/__data/assets/pdf_file/0034/459574/Ecosystem-services-from-forests-in-Victoria-Assessment-of-Regional-Forest-Agreement-regions.pdf.

Table 5. Degradation of Georgia's forests by type

Climate-related degradation

TYPE OF DEGRADATION	LEVEL OF DEGRADATION	AREA (HA)
PESTS AND DISEASES	1 – Slight	81,106
	2 – Average	56,084
	3 – Strong	8,196
FIRE-AFFECTED	1 – Slight	5,176
	2 – Average	2,157
	3 – Strong	2,157
GRAZING	1 – Slight	27,610
	2 – Average	29,767
	3 – Strong	15,530
UNCONTROLLED FELLING	1 – Slight	157,898
	2 – Average	107,853
	3 – Strong	70,320
LOW DENSITY (UNNATURALLY OPEN-CANOPIED STANDS WITH LESS THAN 0.3 DENSITY)	1 – Slight	143,229
	2 – Average	128,130
	3 – Strong	89,734
OTHER TYPES OF DEGRADATION	1 – Slight	5,608
TOTAL DEGRADED AREA		807,178
TOTAL FOREST AREA (EXCLUDING TEMPORARILY OCCUPIED TERRITORIES)		2,278,760

Source: First National Forest Inventory, MEPA, 2023

Despite their importance, Georgian forests are facing degradation due to factors such as illegal logging, overexploitation and climate change consequences, including forest fires and pests and diseases. Table 5 provides an overview of the degradation of Georgian forests and its causes.

This degradation threatens the ecosystem services forests provide, both in terms of environmental and economic benefits. Addressing forest degradation, particularly that driven by climate change, should be a strategic priority. Implementing targeted adaptation measures to sustain healthy forest ecosystems can generate benefits not only for the environment but also for various sectors that depend on forestry. In Georgia, the potential positive impacts, extending across multiple industries, include:

- Timber industry productivity
- Promotion of tourism and recreation
- Non-timber forest products (e.g. nuts, berries, fruits and other additional economic opportunities for local communities)
- Increased carbon sequestration that can be rewarded financially[29]
- Water resource management
- Hydropower generation

Scenario Description

In the context of climate change challenges, adaptation considerations play an increasingly important role in the future of forest management. These considerations are important for ensuring that forest ecosystems can withstand and recover from the impact of climate stressors, pests, diseases, fires and

[29] For example, participation in carbon offset programmes in the longer term if current obstacles, such as the alignment of national forestry definitions with Food and Agriculture Organization (FAO) standards, are resolved.

extreme weather events. The ECO.Georgia project,[30] co-funded by the Green Climate Fund (GCF), is also expected to increasingly emphasise adaptation considerations in forest management and policy planning. In this process, considering the economic benefits of adaptation action in forest management can help identify the most suitable policy measures.

This forestry adaptation scenario results from the principles of sustainable forest management (SFM), through which forest health, resilience and productivity as well as long-term economic benefits can be achieved. MEPA has already taken steps to reform the forest sector and adopt systematic forest management practices. These include the adoption of the Forest Code of Georgia (2020)[31] and the National Forest Inventory (2019–2023).[32]

The scenario focuses particularly on *forest fire* and *disease outbreak* control. Prioritising action to deal with these threats reflects their increasing relevance due to the effects of climate change and supports climate resilient forest management. These two factors are important drivers of forest degradation in Georgia, explicitly highlighted in the Forest Code and recognised as critical by high-level authorities overseeing forest management.[33]

Both forest fire and pest and disease management are integral to SFM, which relies on key principles that ensure a good understanding of the forest ecosystem, proactive management and long-term planning, taking into account the dynamic nature of ecosystems and their ability to adapt. SFM measures therefore cover a range of areas, including legal and regulatory frameworks, the implementation of monitoring systems as a technical prerequisite for evidence-based management and informed policy planning and field practices, including sustainable logging, replanting and forest rehabilitation.

Given the diverse characteristics of Georgia's forested areas and the regional differences in exposure to risks, the forestry adaptation scenario assesses forest fire prevention and pest and disease management as separate measures. This distinction reflects the different ways in which forest fires and pest and disease outbreaks occur and spread and allows for the development of targeted adaptation measures and assessment of their outcomes for each threat.

For forest fire prevention, the selected adaptation measures involve the installation of a monitoring system for forest fire and heat index trends. This improves early warning, which allows authorities to respond to fire risks before they escalate, leading to faster containment of fires and reducing the damage to forest ecosystems. Other measures include the construction of fire roads and water ponds and providing relevant services with fire protective clothing and equipment and fire vehicles.

For pest and disease management, the adaptation measure focuses on early detection and prevention through a forest disease monitoring system. This includes digital tools for tracking heatwave trends and climatic parameters, software for heat index calculations and disease risk assessment, and pathology laboratory services for early-stage pathogen detection. These investments allow for timely identification of disease outbreaks, facilitating rapid intervention and reducing the risk of large-scale forest degradation. The benefits arise from preventing widespread tree loss, maintaining ecosystem stability and reducing long-term restoration costs.

In both cases, the measures also include the rehabilitation of forest areas previously damaged by fires and pest and disease outbreaks.

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[30] The GCF co-funded project ECO.Georgia, implemented by GIZ and the Government of Georgia, aims to implement forest sector reform and reduce emissions through SFM, with a view to reducing fuelwood consumption, which is the major contributor to forest degradation. Component 1 of the project covers SFM, supporting the government in developing key building blocks for SFM at the national level, including fostering the necessary policy and legal environment and improving knowledge and data management and capacity building. The National Forestry Agency (NFA) will be implementing practical SFM measures.

[31] https://www.fao.org/faolex/results/details/en/c/LEX-FAOC196014/

[32] https://mepa.gov.ge/En/Reports

[33] Based on research by Remissia.

Implementation and Assumptions

Climate hazards such as temperature rise and heatwaves and their consequences for Georgia's forests, including forest degradation and the spread of pests and diseases, are expected to cause substantial environmental and economic losses. Projections indicate that the damage caused by forest diseases will be much higher than that caused by forest fires. At the same time, as suggested by the e3.ge modelling results, the implementation of adaptation measures against fires and forest diseases can significantly reduce these negative impacts and help avoid economic damage.

In line with the qualitative forestry policy scenario developed and the adaptation measures identified for (1) forest fires and (2) pests and diseases, two separate CBAs were conducted. They estimate economic cost and benefit categories over time, providing a foundation for the e3.ge model analysis.

For the estimation of the costs and benefits of forest fire adaptation measures, the CBA focuses on three forest regions – Samtskhe–Javakheti, Kakheti and Imereti – which are in the highest category for forest fire risk in Georgia. These regions account for 40% of the country's forests and 74% of the forest areas burned between 2016 and 2030.

For pest and disease management measures, the CBA is based on an analysis of the areas that are particularly vulnerable to heat stress and disease outbreaks. These are Samegrelo–Zemo Svaneti, Imereti and Adjara, which account for 90% of the forest areas damaged by diseases. For modelling purposes, the costs and benefits were scaled up for nationwide estimations.

Table 6. Cost and benefit categories for the forestry scenario

COSTS AND BENEFITS OF THE ADAPTATION MEASURE (FORESTRY)	
FOREST FIRES	
COSTS	Investment costs: - Sensors, computer technology, software and drones: GEL 2.6 million - Construction of roads and water ponds: GEL 71.1 million - Fire protective equipment: GEL 0.02 million - Rehabilitation of damaged forests: GEL 44.3 million Operational costs: - Labour costs (annually): GEL 0.7 million
PESTS AND DISEASES	
COSTS	Investment costs: - Sensors, computer technology and software: GEL 1.4 million - Laboratory: GEL 1.1 million - Capacity building: GEL 8.6 million - Rehabilitation of damaged forests: GEL 1,274.7 million Operational costs: - Labour costs (annually): GEL 7.8 million
BENEFITS	- Reduced losses due to adaptation against forest fires: 70% - Reduced losses due to adaptation against forest diseases: 70%

Source: GIZ (2025). Economy-Wide Impacts of Climate Change and Adaptation in Georgia [Reuschel, S., Lutz, C.] GIZ, Berlin.

Further Assumptions

- The costs associated with the investments are wholly financed by government
- Investment costs are distributed over the period as follows: 40% in Year 1; 40% in Year 2; 20% in Year 3
- Operational costs are incurred annually from Year 2 onwards (2026–2050)
- Total investment and operational costs over the period amount to GEL 2.5 billion
- The economic impact of increased carbon sink capacity is not included in the projections

Modelling Outcomes and Macroeconomic Results: GDP and Employment

According to the results of the e3.ge model, the implementation of adaptation measures targeting forest fires and forest diseases leads to positive macroeconomic outcomes, increasing GDP and employment. The measures not only reduce the long-term economic damage caused by climate-related risks but also stimulate economic activity across various sectors.

To showcase the expected damage caused by climate hazards to forests and the overall economy over time, the model first estimates a climate change scenario without any adaptation. These effects are visualised in Figure 15 and Figures 15-16, in percentage and absolute terms respectively. Climate change is projected to reduce GDP by up to 0.11% annually, which translates into significant losses in absolute values over time (Figures 15-16).

Figure 15. Climate change impacts on GDP (in %)

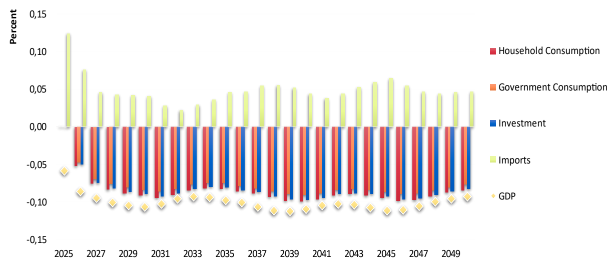
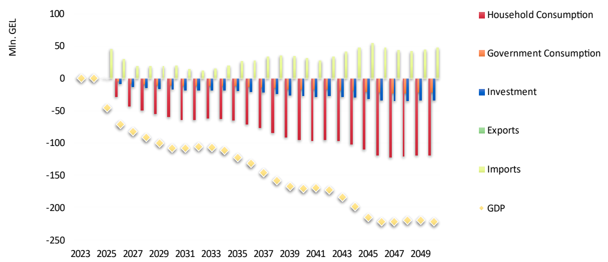


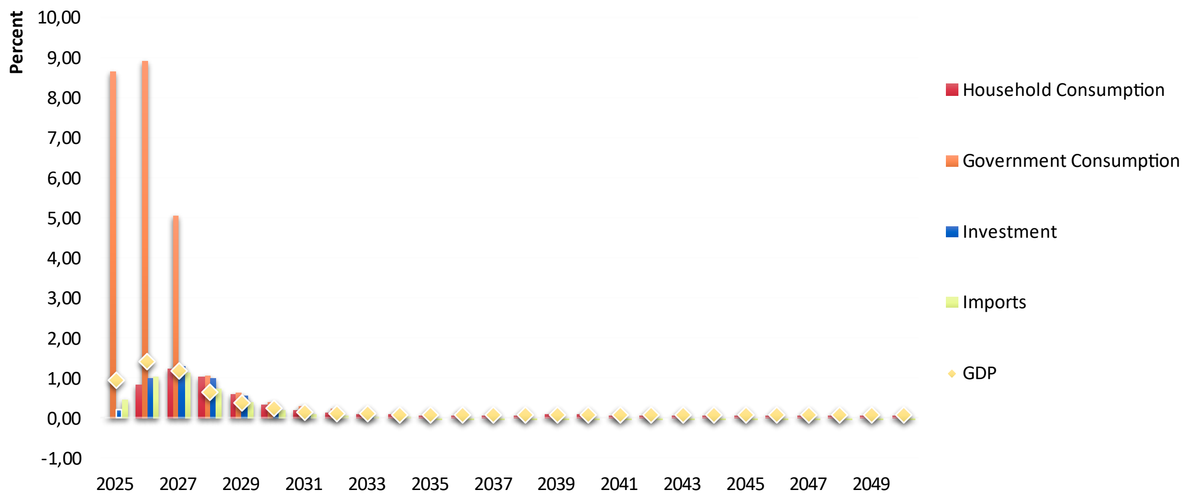
Figure 16. Climate change impacts on GDP (in millions of GEL)



Source: GWS based on e3.ge

By contrast, investing in adaptation measures in the forestry sector generates significant positive effects, as shown in the adaptation scenario. Measures that involve the installation of monitoring and early warning systems, including computers, software, sensors, drones and laboratories, stimulate investment in scientific and computer-related services. Furthermore, constructing roads and water ponds creates demand for services from the local construction industry. Afforestation of previously damaged areas will create employment for local workers providing agricultural services. The implementation of all these measures will lead to an increase in consumption expenditure by households and government as well as higher gross fixed capital formation and overall GDP growth (Figure 17).

Figure 17. Adaptation scenario: GDP impacts of forest fires and forest diseases (in %)

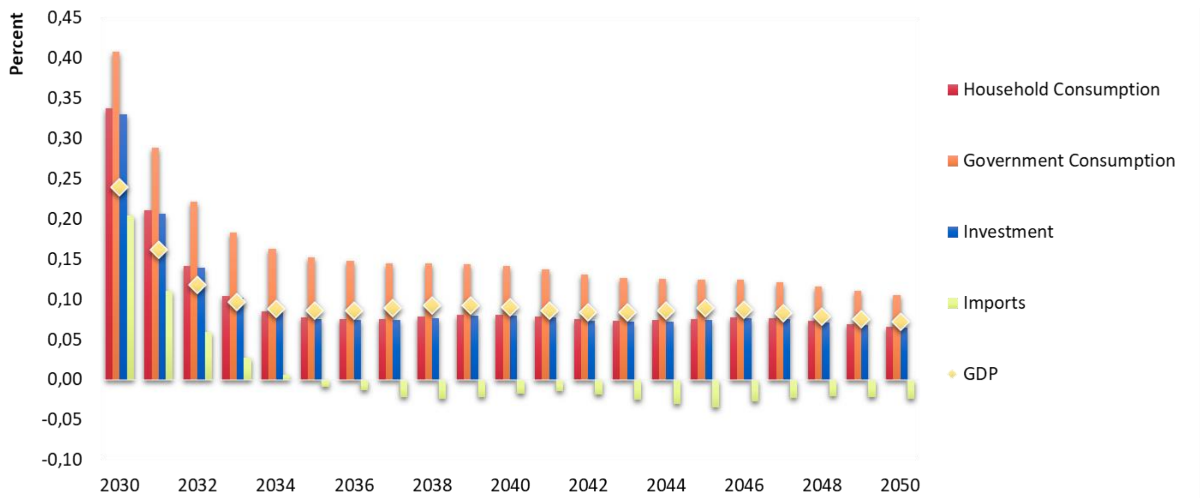


Source: GWS based on e3.ge

The economic effects in the early years of the analysis (2025–2029) are mostly driven by upfront adaptation investment, which boosts government consumption and investment. To better understand the long-term macroeconomic impacts, Figure 18 illustrates how the measures lead to sustained increases in economic activity in the later years (2030–2050), through household and government consumption, investment, reduced imports and the resulting increase in GDP of around 0.24% in the earlier stages, followed by a stable annual increase of around 0.10% in subsequent years.

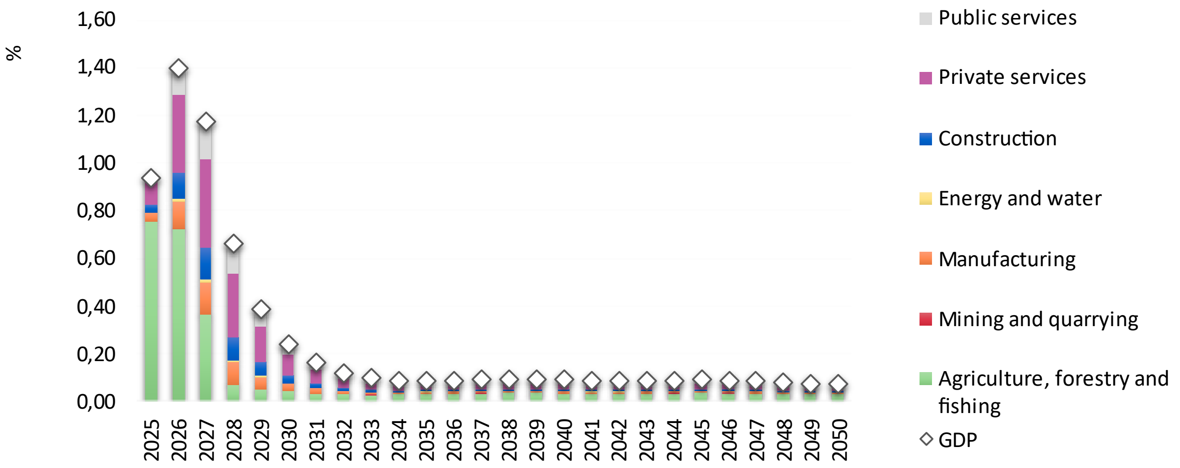
At the sectoral level, forest fire and disease adaptation measures lead to similar effects on both production (Figure 19) and employment (Figure 20). Increased economic activity is expected particularly in agriculture, forestry and fishing and in public and private services and, to a lesser extent, in the manufacturing and construction industries.

Figure 18. Adaptation scenario: GDP impacts of forest fires and forest diseases (in %, 2030–2050)



Source: GWS based on e3.ge

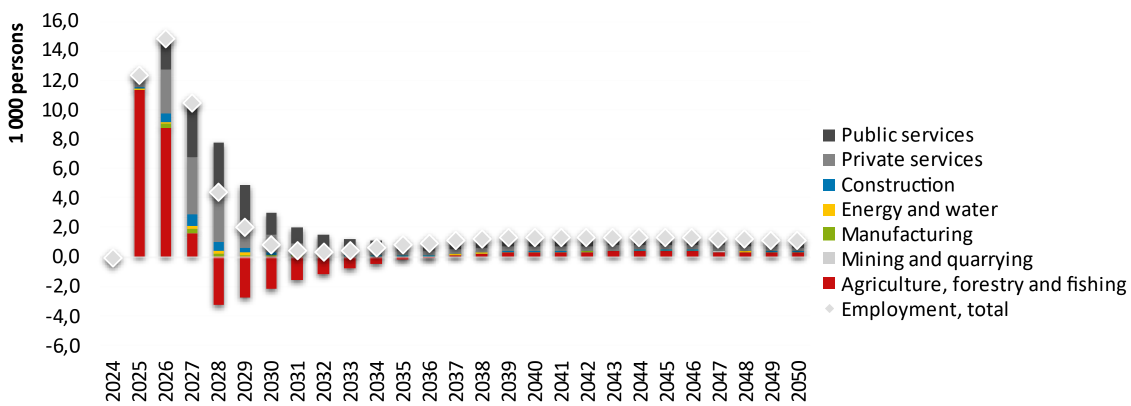
Figure 19. Adaptation scenario – production effects: forest fires and diseases (compared to climate change scenario, in %)



Source: GWS based on e3.ge

Implementing adaptation measures also drives job creation. For example, up to 14,880 additional people could be employed in 2026, corresponding to an increase of 0.7% in that year. This additional employment initially takes place mainly in the agricultural and forestry sector due to the rehabilitation of forests. The various adaptation measures also lead to additional job creation in the investment phase in public and private services and in the construction sector. Since it is assumed that most investments, including afforestation, occur in the first three years, the largest employment impacts are observed during this period. From the fourth year, total additional employment is positive, [34] for example, in 2040, 1,340 additional people could be employed (increase of 0.06%).

Figure 20. Adaptation scenario – employment effects: Forest fires and forest diseases (compared to climate change scenario)



Source: GWS based on e3.ge

34 While total employment remains positive, from the fourth year, employment in the agriculture, forestry and fishing sector initially declines. This is due to previous losses in the forestry sector caused by degradation and the time required to reverse these effects after implementing adaptation measures. Over time, additional employment in the sector becomes positive.

Policy Recommendation

SUMMARY

The expected positive impacts showcased by the macroeconomic modelling results, including GDP growth and increased economic activity and employment across sectors, provide a strong economic case for investing in targeted forest adaptation measures in Georgia. Investment in weather monitoring systems, fire and disease risk assessment tools, laboratory infrastructure and large-scale rehabilitation efforts significantly reduces economic losses and provides long-term resilience against climate-induced forest degradation. These benefits highlight the need to integrate forest adaptation efforts into national planning processes and into the NAP and the Fifth National Communication to the UNFCCC.

Steps for implementation

To realise the economic benefits of the proposed forestry adaptation measures, a coordinated approach across institutions, policy partners and stakeholders is required. This should be supported by clearly defined mandates, relevant technical capacity and sustained financial support. The following steps can create an enabling environment for the successful implementation of the efforts analysed:

- Strengthen institutional coordination and planning. MEPA, in close coordination with the National Forestry Agency (NFA) and NEA, should take the lead in initiating and coordinating the implementation processes, building on the existing institutional agenda and the partnerships already established (e.g. ECO.Georgia project and related initiatives). Other key actors will include DES and the EIEC, supported by development partners such as GIZ.

- Integrate adaptation priorities into national and sectoral strategies. Forestry adaptation measures should be aligned with the ongoing implementation of the Forest Code of Georgia and integrated into the NAP and the Fifth National Communication to the UNFCCC.

- Mobilise financial and technical resources. Public funding should be complemented by international climate finance. Evidence from macroeconomic modelling can be used to attract funding, in particular, for monitoring systems, laboratories, capacity building and rehabilitation.

- Enhance institutional and technical capacity. The agencies responsible (NFA, NEA) and regional forest management bodies need to be equipped with the skills and tools required to monitor climate risks, establish prevention infrastructure and implement protocols for forest fires and diseases.

Enhancing the legislative framework

To improve the effectiveness of forest adaptation measures, it is important to incorporate new guidelines and specific provisions for the prevention and management of forest fires and diseases into existing forest legislation. This can include the following:

- Formalise forest fire risk monitoring and response protocols, including standards for early detection, inter-agency coordination and responsibilities for implementing fire prevention infrastructure. They should be included in the provisions of the Forest Code and existing NFA and DES operating procedures.

- Establish guidelines for systematic forest disease surveillance and management, incorporating climate risk indices into forest health monitoring and management. They should also formalise the operation of a phytopathology laboratory and the adoption of integrated pest management practices.

- Define mandates and responsibilities for data sharing and coordination, in particular, between MEPA, the NFA, NEA and local forest management bodies, to ensure that the monitored data and risk assessments regularly inform policy decisions and forest management plans.

M&E and data collection and analysis

A comprehensive M&E framework will be essential to track the effectiveness of forest adaptation measures for both forest fires and diseases, with consistent data collection and coordination. Key areas include:

- Monitoring data from weather sensors, drones, software outputs (for heat and fire indices) and laboratory analyses, which will be crucial for establishing the system's early detection capacity and responsiveness.
- Assessing the environmental and economic outcomes of the measures, including reduced fire and disease incidence, restored forest area, avoided restoration costs and carbon sequestration capacity, can be used for national climate reporting and for advocating for further public and international funding.
- Establishing a feedback mechanism to continuously increase the effectiveness of the adaptation measures, by improving their design and operation.

Key Takeaways

Georgia's forests are increasingly exposed to climate-related hazards, such as forest fires and forest diseases. With more than a third of forests already degraded, addressing the challenge of forest degradation from a climate adaptation perspective is essential.

Macroeconomic modelling confirms that targeted adaptation measures, such as fire and heat monitoring systems, disease detection tools and the rehabilitation of degraded forests, are not only environmentally justified but also economically viable. They reduce economic losses, stimulate GDP growth – by up to 1.4% in the initial years and approximately 0.10% annually in subsequent years – and contribute to increased economic activity and employment across sectors.

In addition to the modelled benefits, healthy forests provide key ecosystem services, such as water regulation, reduced erosion and carbon storage, which are important for economic and human activities. In Georgia, resilient forests are especially important for sectors such as tourism, rural development and energy.

Strong institutional coordination and clearly designated roles will be required to ensure the successful implementation of forest adaptation measures and reap these economic gains. MEPA, the NFA and NEA will play a central role in operationalising these measures and ensuring their integration into forest management and policy planning. It is equally important for forestry adaptation initiatives to be strongly integrated into national strategies and planning and aligned with international climate frameworks. NAP processes and the Fifth National Communication to the UNFCCC are particularly relevant entry points, which can also improve access to finance.

Finally, the modelling results provide a robust evidence base for prioritising forest adaptation in public budget planning and for mobilising international climate finance.

6. PRACTICAL APPLICATION OF RESULTS FOR POLICY-MAKING

The policy recommendations for windbreak rehabilitation, flood management and forestry need to be effectively integrated into Georgia's broader policy framework. This section outlines the mechanisms through which research findings and quantitative results can guide actionable policies and improve implementation.

Expanding institutional involvement is crucial to ensuring the successful integration of climate adaptation policies across sectors. Effective policy action requires strong inter-agency coordination, structured financial planning and multi-stakeholder engagement.

Additionally, utilising robust economic and energy–environmental models, such as the e3.ge model, can help policy-makers assess trade-offs, predict long-term socio-economic and environmental impacts and refine adaptation strategies based on evidence-based projections. The following additional key points outline how Georgia can institutionalise its climate adaptation strategies to enhance resilience and long-term sustainability.

Role of the NAP and related processes

- The NAP processes should serve as a central platform for identifying data needs, setting sector-specific priorities and translating modelling insights into actionable adaptation strategies

- National adaptation planning should incorporate macroeconomic and sector-specific modelling to help prioritise measures with high climate and economic relevance

- Integration of the e3.ge modelling results discussed into NAPs and National Communications can support evidence-based policy-making, enhance alignment with international climate reporting and improve access to international climate funding

- Cross-sectoral policy coordination, particularly between MEPA and its agencies, the MoESD and other line ministries, should be strengthened around adaptation priorities that emerge from the NAP processes and be supported by modelling tools such as e3.ge

Table 7. Prioritisation framework for policy integration

POLICY MEASURE	EXPECTED IMPACT	TIMEFRAME	LEAD INSTITUTIONS	CLIMATE RELEVANCE	ECONOMIC RELEVANCE
RESTORATION AND SUSTAINABLE MAINTENANCE OF WINDBREAKS	Prevents wind erosion, reduces crop yield losses, increases agricultural productivity	Medium-term (3–5 years)	MEPA, Land Management Agency	High	High
FLOOD PROTECTION: STRUCTURAL AND NON-STRUCTURAL MEASURES	Improves riverine flood resilience, reduces agricultural and infrastructure losses	Medium-term (4–5 years)	MEPA, MRDI, NEA	High	High
FOREST MANAGEMENT: FIRE AND PEST AND DISEASE CONTROL	Reduces losses from climate-related forest degradation, improves forest health and maintenance	Medium-term (3–5 years)	MEPA, NEA	High	High

Strengthening governance and monitoring systems

- Establish a centralised M&E framework to track the effectiveness of policy implementation across sectors
- Incorporate real-time data systems to improve decision-making and resource allocation for climate adaptation efforts
- Ensure transparency by publishing progress reports on climate adaptation spending and outcomes
- Develop adaptive governance mechanisms that allow policy-makers to respond to emerging climate challenges with evidence-based adjustments

Successfully integrating climate adaptation policies across agriculture, flood management and forestry requires a coordinated institutional approach. By leveraging structured financial planning, inter-agency collaboration and evidence-based modelling tools such as the e3 model, policy-makers can develop more targeted and effective adaptation strategies.

With strong institutional engagement and dedicated financing mechanisms in place, Georgia can enhance its capacity to adapt to climate risks while promoting sustainable economic development and environmental resilience.

7. CONCLUSION

The development of well-structured and policy-relevant adaptation scenarios is essential for integrating climate resilience into Georgia's economic and development planning. This handbook outlines a step-by-step approach to scenario formulation, selection and integration to enable policy-makers, adaptation specialists and macroeconomic modellers to design evidence-based climate adaptation strategies. By using the e3 model, stakeholders can assess the economic impacts of climate change, quantify the benefits of adaptation measures and refine policy decisions using a data-driven approach.

The handbook provides practical guidance on how scenario modelling can support key policy processes, such as the development of NAPs, sectoral strategies and international reporting. By aligning adaptation measures with national climate priorities and development objectives, policy-makers can better assess trade-offs, prioritise measures and justify resource allocation across sectors, including agriculture, forestry and flood management, while also providing a framework for analysing adaptation measures in other priority sectors identified through ongoing national planning processes. The emphasis on institutional coordination, ownership and financial feasibility ensures that adaptation measures are not only technically sound but also tailored to Georgia's governance framework.

Nevertheless, challenges related to data limitations, institutional capacity gaps and financing constraints need to be addressed to enhance the effectiveness of scenario-based planning. To ensure that adaptation scenarios translate into actionable outcomes, it is essential to identify priority sectors and data gaps through the NAP process, foster inter-agency coordination and embed clear objectives and target setting in a robust M&E framework.

By integrating scenario development into broader development planning and refining strategies based on evolving climate risks and economic conditions, Georgia can enhance its adaptive capacity and drive resilient, sustainable economic growth. This handbook serves as a resource for national and sectoral stakeholders seeking to adopt data-driven, forward-looking adaptation measures that are aligned with Georgia's development goals and international climate commitments.