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National Bank of Georgia

NBG'S CLIMATE STESS TESTING FRAMEWORK

2024

Climate Stress Testing Framework for Georgia

2024

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Content

Acronyms and Abbreviations

ARDL	Autoregressive Distributed Lag
CO2	Carbon Dioxide
CR	Coverage Ration
DC	Domestic Currency
ECB	European Central Bank
EIB	European Investment Bank
ESG	Environmental, Social and Governance
FC	Foreign Currency
FX	Foreign Exchange
GDP	Gross Domestic Product
GEL	Georgian Lari
GEOSTAT	National Statistics Office of Georgia
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GVA	Gross Value Added
HH	Household
IAM	Integrated Assessment Model
IO	Input-Output
LGD	Loss-given-default
LGL	Loss-given-liquidation
LRM	Long-run Multiplier
LTV	Loan-to-Value
MEEM	Mixed Endogenous/Exogenous Model
NBG	National Bank of Georgia
NDC	Nationally Determined Contribution
NEER	Nominal Effective Exchange Rate
NGFS	Network for Greening the Financial System
NPL	Non-performing Loan
REER	Real Effective Exchange Rate
REP	Real Estate Prices
SF	Sustainable Finance
SR	Sales Ratio
STD	Short-term Disorderly
YoY	Year-over-Year

Introduction

Climate-related risks, including both physical and transition risks, pose significant threats to financial stability. Physical risks, such as extreme weather events (e.g., floods, heatwaves, landslides, and storms), can cause immediate and severe economic disruptions. Transition risks, associated with the shift towards a low-carbon economy, can lead to long-term structural changes in the economy. These risks have the potential to adversely impact asset values, increase credit risk, and disrupt the functioning of financial markets, thereby threatening the overall stability of the financial system.

Given the critical nature of these risks, it is imperative for financial authorities to assess them systematically to ensure that financial institutions are adequately prepared. Stress testing is a vital tool in this process, enabling the evaluation of the resilience of banks and other financial entities under various climate-related scenarios. In response to this need, the National Bank of Georgia (NBG) has developed a comprehensive Climate Stress Testing Framework that integrates multiple analytical modules and specialized tools to assess both acute physical risks and transition risks.

This Climate Stress Testing Framework is a key component of the NBG's broader Sustainable Finance Framework, which has been under development since 2017. As the central bank of Georgia, the NBG is committed to advancing the role of the financial sector in supporting the sustainable development of the country. The NBG's Sustainable Finance Framework[1] emphasizes the integration of Environmental, Social, and Governance (ESG) considerations within the financial sector. This framework aims to manage risks associated with ESG factors and to reorient capital flows towards greener and more sustainable activities, ultimately contributing to financial stability and the sustainable growth of the economy.

Georgian financial institutions, through their operations, may face increased exposure to risks and opportunities arising from policy changes aimed at promoting greener and more inclusive growth, as well as from the broader impacts of climate change and environmental degradation. Recognizing the importance of addressing climate-related and other ESG risks to safeguard financial stability, ESG Risk Management has been identified as one of the four key pillars of the NBG's Sustainable Finance Framework, as outlined in the Roadmap for Sustainable Finance in Georgia[2].

The development of the Climate Stress Testing Framework falls under this ESG Risk Management pillar. The Framework has been developed as a policy tool to effectively manage climate-related risks. This framework is designed to assess these risks at both the system and individual bank levels. Additionally, it provides financial institutions with climate scenarios and key assumptions to conduct bottom-up stress testing exercises, ensuring they are well-prepared to address the challenges posed by climate change and contribute to the sustainable development of Georgia's economy.

[1] https://nbg.gov.ge/en/page/sustainable-finance

[2] NBG. The Roadmap for Sustainable Finance in Georgia. 2019: https://nbg.gov.ge/en/page/sustainable-finance-roadmap

NBG's Climate Stress Testing Framework

The NBG's Climate Stress Testing Framework is an integrated approach that combines several analytical modules to comprehensively assess climate-related risks. Each module focuses on a specific aspect of climate risk, ensuring a thorough examination of potential impacts on the economy and financial sector. The framework employs a top-down approach that leverages the NBG's existing Top-down stress testing methodology, and it includes several satellite models and tools designed to project and stress-test various economic and financial impacts. By covering both physical and transition risks, the framework provides a holistic view of the challenges posed by climate change. It also uses NGFS scenarios as reference scenarios to align the stress tests with globally recognized standards. The framework is comprehensive, covering both retail (Household sector) and non-retail portfolios (Corporate sector), ensuring that all significant exposures within Georgia's financial sector are evaluated for potential climate-related vulnerabilities.

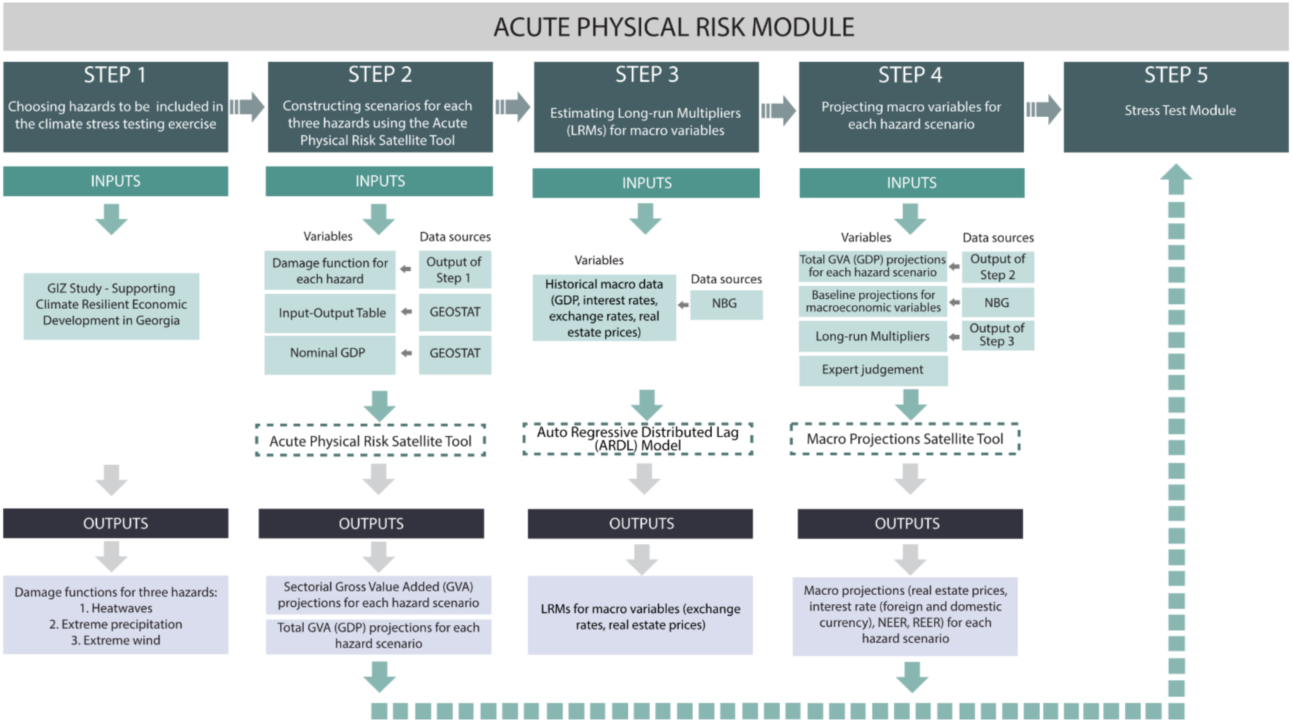
The framework includes:

1. **Acute Physical Climate Risk Module,** which focuses on assessing the immediate impacts of extreme weather events on the Georgian economy and financial system. This module utilizes historical data, scenario construction, and advanced modeling techniques to project the economic damage associated with specific hazards such as heatwaves, extreme precipitation, and wind events. These projections are then used to evaluate the broader economic impacts, including potential changes in GDP and sectoral outputs.
2. **Transition Risk and Chronic Physical Risk Module,** which addresses the longer-term risks associated with gradual climate change and the transition to a low-carbon economy. By analyzing scenarios such as delayed transition pathways, this module examines how abrupt policy changes, technological shifts, and market dynamics can affect the financial sector.
3. **Stress Test Module for Corporate Sector** is designed to assess the exposure of corporate loans to climate-related risks, focusing on the potential impacts on non-performing loans (NPLs), loan loss provisions within each sector and banks' capital adequacy. It integrates outputs from both the acute physical and transition risk modules to project sector-specific NPL ratios under various climate scenarios. This approach allows for a detailed analysis of how different industries within the corporate sector might be affected by climate-related risks, particularly those industries that are more carbon-intensive or less able to pass on costs associated with climate policies. The module uses NBG's Top-Down Stress Test Model to simulate the financial impacts on bank capital and overall sector stability.
4. **Stress Test Module for Household Sector** evaluates the impact of climate-related risks on household loans, focusing on NPL ratios, loan loss provisions and their effect on banks' capital adequacy. It utilizes projections of key variables, such as real estate prices and loan-to-value ratios, under different climate scenarios. By assessing the household sector's vulnerability to both acute physical and transition risks, this module provides insights into the broader impacts on financial stability, enabling a comprehensive evaluation of potential stress factors on household loan portfolios.

Each of these modules works in conjunction to provide a holistic view of the potential economic disruptions and financial stability challenges posed by climate change. The detailed description of each module is provided below.

Acute Physical Climate Risk Module

Acute physical climate risks are related to extreme events such as floods, extreme drought, heat waves, wildfires, whose frequency and severity are being affected by climate change. The Acute Physical Climate Risk Module is focused on assessing the immediate impacts of extreme weather events on the Georgian economy and financial system. This module involves five critical steps, utilizing various data sources and satellite tools:



1. **Choosing hazards to be included in the Climate Stress Testing exercise**:

The NGFS does not provide acute climate risk assessments and scenarios specific to Georgia; therefore, alternative sources were needed. The GIZ Study, "Supporting Climate Resilient Economic Development in Georgia[3]," offers essential information on historical and projected climate hazards and their economic effects for Georgia. In particular, it analyzes past extreme climate events and the resulting monetary damages. These findings are then utilized to synthesize the anticipated differential effects of heatwaves, extreme precipitation, and extreme wind events on various sectors of the Georgian economy.

The study identifies three specific hazards that are most relevant to Georgia's climate context: heatwaves, extreme precipitation, and extreme wind. These hazards are chosen based on their potential to cause significant economic and financial disruptions. Consequently, the Acute Climate Risk Module also considers these three hazards, as damage functions for other hazards are not available for Georgia.

[3] GIZ. 2022. Supporting Climate Resilient Economic Development in Georgia: https://www.giz.de/en/downloads/giz2022-en-supporting-climate-resilient-economic-development-georgia.pdf

The output of this step is the identification of damage functions for each selected hazard. These functions quantify the expected economic damage associated with each type of extreme weather event, providing a foundation for further analysis.

2. **Constructing Scenarios for each hazard using the Acute Physical Risk Satellite Tool**:

In this step, the damage functions identified in Step 1, combined with data from the Input-Output Table and GDP statistics provided by GEOSTAT[4], are utilized to construct detailed scenarios for each climate hazard. The Acute Physical Risk Satellite Tool is instrumental in this process, as it allows for the mapping of damage functions onto the economic sectors using the input-output table, thereby enabling a comprehensive understanding of the economic impacts across different sectors.

A key aspect of this modeling approach is the deviation from traditional Input-Output (IO) models. Typically, in IO models, gross output is determined endogenously from the exogenous final demand. However, in the context of extreme weather events, this assumption does not hold. Such events impose significant supply-side constraints on affected industries, limiting their ability to meet future demand for their goods. As a result, for these industries, final demand can no longer be considered exogenous because it must now account for the supply limitations imposed by the climate shock.

To address this complexity, a Mixed Endogenous/Exogenous Model (MEEM) is employed. This approach accommodates the simultaneous supply and demand constraints that arise when industries face disruptions due to acute physical risks. The MEEM, as described by Miller and Blair (1985)[5], allows for a more accurate representation of the economic dynamics in scenarios where industries cannot fulfill the exogenously set demands due to physical constraints.

It should be noted, that extreme weather events are treated as one-time shocks, with effects projected for the year following their occurrence, i.e., a one-year projection. However, the impacts of these hazards on subsequent years are also incorporated through frontloading. Frontloading ensures that the cumulative effects of each hazard on GDP and sectoral Gross Value Added (GVA) are captured, providing a more comprehensive picture of the long-term economic impacts.

The scenarios generated in this step include sectoral projections of GVA and total GDP for each hazard scenario. These projections illustrate how different sectors of the economy would be affected by each type of extreme weather event.

3. **Estimating Long-run Multipliers for Macro Variables**

In addition to GDP projections, additional macroeconomic variables are required as inputs to the NBG's top-down stress test model. To cover the full spectrum of macroeconomic risk factors needed for stress testing, a suite of satellite models was developed to map GDP projections to projections of other relevant macroeconomic variables. The first stage in this process involves estimating long-run multipliers for these macroeconomic variables.

[4] National Statistics Office of Georgia: https://www.geostat.ge/en

[5] Miller, R. and Blair, P. (1985) Input-Output Analysis: Foundations and Extensions. In: Environmental Input-Output Analysis, Prentice-Hall, Upper Saddle River, Chapter 7, 236-260.

To calculate these multipliers, the Auto Regressive Distributed Lag (ARDL) model was applied. The ARDL model is a key tool for analyzing economic time series data, especially when variables may be interrelated over time. The key features of ARDL models include their flexibility in capturing dynamic relationships between variables, their ability to account for both short-term and long-term effects, and their usefulness in analyzing complex economic relationships.

ARDL model combines an autoregressive (AR) component, which includes lags of the dependent variable, with a distributed lag (DL) component, which includes lags of a vector of independent variables:

$$Y_t = \alpha + \omega_1 Y_{t-1} + \cdots + \omega_p Y_{t-p} + \beta_0 X_t + \beta_1 X_{t-1} + \cdots + \beta_q X_{t-q} + \varepsilon_t$$

The AR component accounts for the impact of past values of the variables on their current values, while the DL component captures the lagged effects of changes in one variable on another over multiple time periods. This dual capability makes ARDL models particularly valuable in scenarios where analyzing the long-run relationship between variables is essential while also considering both short-term and long-term dynamics.

In the long run (as $t \to \infty$) the relationship between the dependent and independent variable approaches the equilibrium and there are no more "shocks" (the shocks die out in the long run and the factors equal their expected values). This means that the long run relationship between Y_t and X_t in the case of ARDL(1,1) becomes the following:

$$Y^* = \frac{\alpha}{1-\omega} + \frac{\beta_0 + \beta_1}{1-\omega} X^*$$

ARDL models are particularly well-suited for studying the relationships between macroeconomic indicators (such as GDP, inflation, and interest rates) over time. They help to examine how changes in one variable affect another across different time horizons and to forecast future values of variables based on their historical patterns and relationships.

In the case of a climate stress test exercise, ARDL models are utilized to assess the long-run relationship between various macroeconomic variables—such as the nominal effective exchange rates, real estate prices—and real GDP growth. The results of these assessments are the Long-Run Multipliers (LRMs) for each macroeconomic variable, which are then used to generate projections for each variable.

4. **Projecting macroeconomic variables for each hazard scenario**:

The forecasts under the baseline scenario for any macroeconomic variable are derived from the NBG's existing models and are aligned with the forecasts published in the Monetary Policy and Financial Stability reports. For each hazard scenario, GDP projections, which are outputs from Step 2, serve as the foundational input for projecting other macroeconomic variables. To generate these projections, the estimated long-run multipliers from the previous step are also incorporated. Additionally, expert judgment is applied to adjust the results as necessary, ensuring that the projections are both robust and reflective of real-world conditions.

The following formulas are used to derive projections for specific variables:

For real estate prices (REP) and nominal effective exchange rate (NEER):

$$Y_t^{Scenario_i} = Y_t^{Baseline} - LRM^Y \left(\Delta GDP_t^{Baseline} - \Delta GDP_t^{Scenario_i} \right)$$

Where: Y represents NEER or the growth rate of REP, LRM is the corresponding long-run multiplier, and ΔGDP is the real GDP growth rate.

For the real effective exchange rate (REER):

$$REER_t^{Scenario_i} = NEER_t^{Scenario_i} + \left(Inflation\,Target_t^{Georgia} - Inflation\,Target_t^{US} \right)$$

As for interest rates, to assess the impact of climate stress on interest rates, the GDP component is excluded, and instead, one standard deviation is applied to simulate stress on interest rates. Further calculations are conducted to generate figures for the household and corporate segments across domestic currency (DC), foreign currency (FC), and the total, based on historical data.

All these calculations are executed using the Macro Projections Satellite Tool. The outputs are comprehensive projections of macroeconomic variables for each hazard scenario. These projections provide critical insights into the broader economic impacts, including potential changes in real estate prices, interest rates, and exchange rates, under various scenarios.

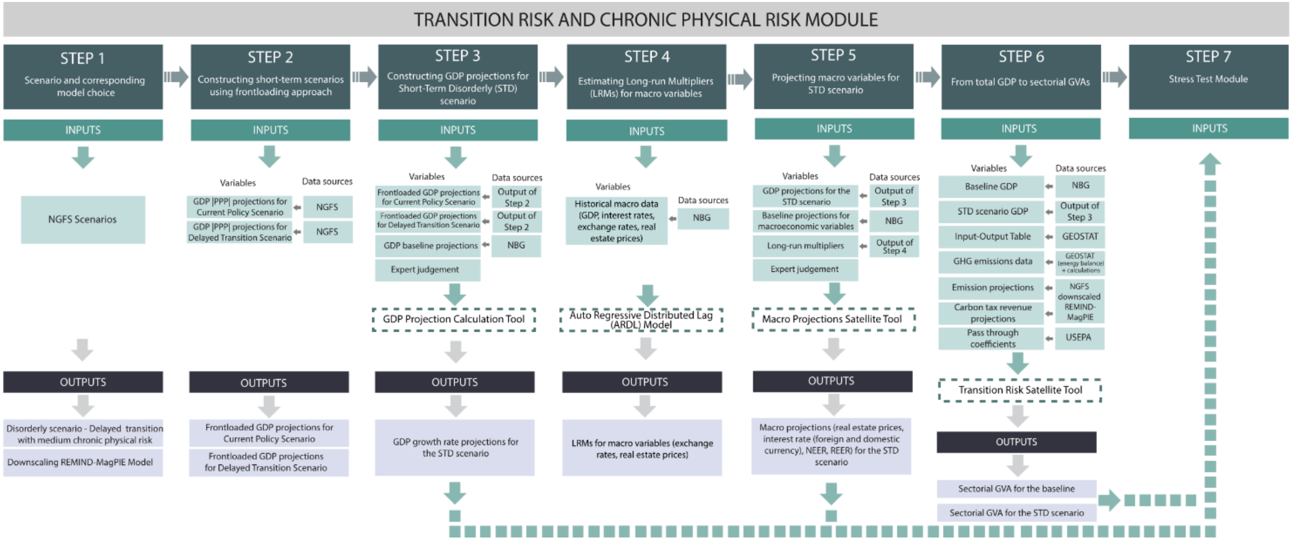
5. **Stress Test Module**:

The outputs from Step 2 and Step 4 are further utilized in the Stress Test Module. These projected macroeconomic variables are used to conduct stress tests, which evaluate the resilience of the financial system. The stress tests simulate the financial effects of various hazard scenarios, assessing the potential impacts on bank capital, loan performance, and overall financial stability. A detailed description of the stress test module is provided in the Stress Test Module for Corporate Sector and the Stress Test Module for Households Sector.

The outputs of the stress tests are comprehensive results that highlight the financial impacts of the selected climate hazards. These results provide critical insights for policymakers and financial institutions, helping them to understand and manage the risks associated with extreme weather events.

Transition Risk and Chronic Physical Risk Module

This module addresses the long-term impacts of gradual climate change and the economic adjustments required for transitioning to a low-carbon economy. It encompasses both transition risks, which arise from changes in policy, technology, and market dynamics, and chronic physical risks, such as sustained temperature increases and sea-level rise. The module involves several key components:



1. Scenario and Corresponding Model Choice

The NGFS scenarios[6] provide a robust foundation for assessing the potential impacts of climate risks on the economy and financial system. Unlike traditional forecasts, these scenarios are not intended to predict the future but rather to explore the extreme boundaries of plausible outcomes, helping financial institutions assess risk and preparedness in the face of significant uncertainty.

The NGFS scenarios provide climate and economic projections based on different policy pathways that vary in terms of transition and chronic physical risks. For Georgia, these projections are generated using three Integrated Assessment Models (IAMs): REMIND-MAgPIE, MESSAGEix-GLOBIOM, and GCAM[7]. Each of these models produces different projections of key climate-related and socio-economic variables, which are categorized into several scenarios.

The first decision that needed to be made was selecting which of the three available models to use. Georgia is classified into different regions across various models, which is a significant factor since downscaling projections depend on the region in which the country is categorized. In GCAM, which includes 32 world regions, Georgia is placed under Central Asia. In contrast, MESSAGEix-GLOBIOM and REMIND-MAgPIE, which both feature 11 world regions, categorize Georgia under the "Former Soviet Union" and "Reforming Economies" regions, respectively. Notably, the regions defined by MESSAGEix-GLOBIOM and REMIND-MAgPIE contain the same set of countries. The primary reason for excluding GCAM as an option for further use is that its regional coverage, compared to the other two models, does not adequately account for Georgia's main trading partners and economies with similar structures.

More in depth analysis was performed to compare the REMIND-MAgPIE and MESSAGEix-GLOBIOM models. The REMIND-MAgPIE was selected over MESSAGEix-GLOBIOM, for several key reasons:

[6] https://www.ngfs.net/ngfs-scenarios-portal/

[7] For a detailed description of each model, please refer to NGFS. 2022. NGFS Scenarios for Central Banks and Supervisors: https://www.ngfs.net/sites/default/files/medias/documents/ngfs_climate_scenarios_for_central_banks_and_supervisors_.pdf.pdf

- Geographical Relevance: The REMIND-MAgPIE model groups Georgia into a region that is more aligned with its primary trading partners and economies with similar structures. This regional classification is crucial for accurate downscaling of projections, making REMIND-MAgPIE a more appropriate choice for modeling Georgia's economic and environmental conditions.
- Consistency with National Data: While both models showed discrepancies when compared to Georgian national data, the REMIND-MAgPIE model was found to be closer in its CO2 emissions projections, particularly in the energy sector. This suggests that REMIND-MAgPIE is better calibrated to reflect Georgia's actual emissions profile, despite some inconsistencies.
- Accuracy in Emissions Projections: REMIND-MAgPIE was observed to provide more realistic projections, especially under the Net Zero 2050 scenario. The model anticipates a significant reduction in emissions, aligning more closely with Georgia's national policy goals, such as the recently adopted law aiming for a net-zero economy by 2050.
- Carbon Pricing and Government Revenues: The REMIND-MAgPIE model also predicted lower and more plausible carbon prices and government carbon-tax revenues compared to MESSAGEix-GLOBIOM. The latter's projections were deemed overly ambitious and potentially unrealistic, whereas REMIND-MAgPIE offered more feasible outcomes.
- Energy Consumption Dynamics: The REMIND-MAgPIE model displayed more logical and consistent relationships between GDP growth and energy consumption, particularly in the industrial sector. This coherence suggests a more accurate reflection of how energy demand might evolve under different climate policies, supporting the model's reliability.

Given these factors, the REMIND-MAgPIE model was selected as the preferred tool for analyzing long-term climate change scenarios relevant to Georgia. It provides more credible and regionally tailored projections, making it a better fit for the climate stress testing of the Georgian banking system. However, additional expert judgment was applied to the results to make them more relevant and appropriate to the Georgian context.

The second critical decision in this step is the selection of an appropriate scenario. The NGFS scenarios are differentiated by their levels of physical and transition risks, which are shaped by factors such as policy ambition, timing, coordination, and technological advancements. These scenarios range from those exploring insufficient or delayed climate action, leading to severe physical risks, to those where ambitious climate policies are implemented successfully, transitioning the global economy to a low-carbon future.

The NGFS has designed seven scenarios as part of its Phase IV, all of which share similar socio-economic assumptions and account for the recent energy market implications, such as those arising from the war in Ukraine. These scenarios are categorized into four groups:

1. Orderly Scenarios:
   - Net Zero 2050: Limits global warming to 1.5°C through stringent climate policies and innovations, achieving global net zero CO2 emissions around 2050.
   - Low Demand: Assumes significant behavioral changes and reduced energy demand, alongside carbon pricing and technology efforts, to reach global net zero CO2 emissions around 2050.
   - Below 2°C: Gradually increases the stringency of climate policies, giving a 67% chance of limiting global warming to below 2°C.

2. Disorderly Scenarios:
   - Delayed Transition: Assumes global emissions do not decrease until 2030, requiring strong policies thereafter to limit warming to below 2°C. This scenario involves higher transition risks due to delayed and uneven policy implementation across countries.
3. Hot House World Scenarios:
   - Nationally Determined Contributions (NDCs): Includes all pledged targets, even if not yet supported by effective policies.
   - Current Policies: Assumes that only currently implemented policies are maintained, leading to high physical risks.
4. Too Little, Too Late Scenarios:
   - Fragmented World: Assumes a delayed and divergent climate policy response, leading to high physical and transition risks globally. Some countries partially achieve net zero targets, while others follow current policies, resulting in significant climate-related risks.

For each scenario, the NGFS provides estimates of economic damages based on probabilistic global mean temperature pathways. These include both median and high damage estimates across three temperature percentiles (5th, 50th, and 95th). The median damages (from the 50th percentile) are referred to as medium chronic physical risk damage estimates, while the high damages (from the 95th percentile) represent high chronic physical risk damage estimates.

Given the broad range of scenarios offered by the NGFS, the selection process focused on identifying a scenario that would provide a rigorous test of the financial sector's resilience to climate-related risks. After careful consideration, the Delayed Transition with Medium Chronic Physical Risks scenario was chosen from the Disorderly category. This scenario was selected because it represents one of the highest transition risk scenarios, reflecting the substantial challenges that may arise if global climate action is delayed and then implemented abruptly.

This scenario was deemed particularly suitable for the first climate stress test exercise conducted by the NBG because it allows for the assessment of how the financial sector might cope with significant and sudden policy shifts aimed at achieving climate targets. The focus on medium chronic physical risks also ensures that the scenario captures both the transition risks associated with delayed policy action and the ongoing physical risks from climate change.

However, The NBG's Climate Stress Testing Framework and the corresponding analytical tools are designed to be flexible, allowing for the analysis of any NGFS scenario. This flexibility ensures that future stress tests can adapt to different climate risk scenarios as needed. However, for the inaugural exercise, the Delayed Transition scenario with medium chronic physical risk was chosen due to its relevance and the significant challenges it poses.

The final outcome of the Step 1 involves two critical decisions: scenario selection — the Delayed transition with medium chronic physical risks, and; model selection — REMIND-MAgPIE, downscaled and tailored to Georgia's national context. These decisions ensure that the climate stress test is both challenging and relevant, providing valuable insights into the potential vulnerabilities and resilience of Georgia's financial sector in the face of climate change.

2. Constructing Short-Term Scenarios Using Frontloading Approach

In the climate stress test framework, the NBG's existing top-down stress testing methodology, which is typically used to assess the financial sector's resilience against shocks over a three-year horizon, is also applied to the climate stress test exercise. Given the framework's focus on short-term resilience, it was necessary to construct short-term scenarios that align with this timeframe.

To simulate the impact of long-term climate risks on the banking system within a shorter period, a frontloading approach was employed. This approach compresses the effects of a 30-year transition risk scenario into a three-year period. The objective is to assess how the banking system would be affected if it faced the full force of climate-related economic shocks within this condensed timeframe, without allowing the economy the opportunity to gradually adapt to these changes.

Under this short-term transition risk scenario, which spans a three-year horizon, it is assumed that the balance sheet remains unchanged. Following the ECB methodology[8], the frontloading approach is applied to capture the cumulative effects of climate dynamics within this shorter period. Specifically, GDP projections from the Current Policies and Delayed Transition scenarios are shifted forward to represent earlier years: GDP for 2035 is frontloaded to represent the year 2024, GDP for 2040 is frontloaded to represent the year 2025, and GDP for 2045 is frontloaded to represent the year 2026.

This method ensures that the stress test captures the intensity of the economic impacts associated with long-term climate risks within a short-term scenario, providing valuable insights into the banking system's resilience under rapid and severe climate-related economic shocks.

3. Constructing GDP Projections for Short-Term Disorderly (STD) Scenario

The construction of GDP projections under the Short-Term Disorderly (STD) scenario is a critical step in assessing the resilience of Georgia's economy to abrupt climate-related transitions. This scenario is designed to simulate the economic impacts of a rapid and unplanned transition to a low-carbon economy over a condensed three-year period, reflecting a disorderly adjustment without allowing the economy time to adapt gradually.

The real GDP growth projections under the STD scenario are based on data from the REMIND-MAgPIE model, specifically utilizing projections from the "Current Policies" and "Delayed Transition" paths. The approach leverages the relative differences between GDP projections under these two scenarios for the years 2035, 2040, and 2045, which are then used as a scalar to adjust the baseline GDP growth projections to reflect the more stressful conditions of the STD scenario. In particular, to study the stress on GDP, the "baseline" scenario considered is "Current Policies," while the stress scenario is "Delayed Transition." The variable studied from the NGFS data is "GDP|PPP|including medium chronic physical risk damage estimate" in billion US dollars, indexed to 2010 prices.

The process of obtaining GDP growth under the STD scenario involves several steps. To begin, the compounded growth for each year in the baseline scenario is calculated using the following formula:

[8] European Central Bank, ECB. 2022. 2022 Climate Risk Stress Test: https://www.bankingsupervision.europa.eu/ecb/pub/pdf/ssm.climate_stress_test_report.20220708~2e3cc0999f.en.pdf

$$Compounded\ growth_t^{Baseline} = Compounded\ growth_{t-1}^{Baseline} \times \left(1 + \frac{GDP\ growth\ rate_t^{Baseline}}{100}\right)$$

Where t represents the years 2024, 2025, and 2026, with the compounded growth value for the year 2023 set at 100. These baseline GDP projections incorporate forecasts from the NBG, ensuring consistency with existing economic outlooks (please see Step 5).

Next, to capture the effects of a disorderly transition on GDP, a scalar is calculated to measure the relative difference between GDP under the "Delayed Transition" scenario and the "Current Policies" scenario. This scalar is essential for adjusting the baseline GDP projections to reflect the harsher conditions expected under the STD scenario. The GDP scalar is calculated as follows:

$$GDP\ scalar_t = \left(\frac{GDP_t^{Delayed\ Transition}}{GDP_t^{Current\ Policies}} - 1\right) \times 100$$

Where t represents the years 2024, 2025, and 2026, with the GDP scalar for 2023 set to 0.

It should be noted that given that Georgia is grouped with other former Soviet Union countries in the REMIND-MAgPIE model, and considering that Georgia's economy is greener than others in this group, the GDP scalar was halved. This adjustment reflects the expectation that Georgia will experience less severe impacts from the transition compared to its regional counterparts.

Next, the compounded GDP growth for the STD scenario is calculated using the following formula:

$$Compounded\ growth_t^{STD} = Compounded\ growth_t^{Baseline} \times \left(1 + \frac{GDP\ scalar_t}{100}\right)$$

Finally, the GDP growth rate for the STD scenario is derived by adjusting the compounded growth for each year:

$$GDP\ growth\ rate_t^{STD} = \left(\frac{Compounded\ growth_t^{STD}}{Compounded\ growth_{t-1}^{STD}} - 1\right) \times 100$$

Where t represents the years 2024, 2025, and 2026, with the compounded growth for 2023 under the STD scenario set at 100.

This detailed process ensures that the GDP projections under the Short-Term Disorderly scenario accurately reflect the economic stress that would occur if Georgia were to experience a rapid, unplanned transition to a low-carbon economy, providing a robust basis for evaluating the potential impacts on the banking system and broader economy.

4. Estimating Long-Run Multipliers (LRMs) for Macro Variables

As mentioned earlier, in addition to GDP projections, other macroeconomic variables are required as inputs to the NBG's top-down stress test model. However, among the macroeconomic variables, the NGFS projections for Georgia cover only GDP. To address the full spectrum of macroeconomic risk factors needed for stress testing, similar to the approach used in acute risk modeling, satellite models are employed to map GDP projections to projections of other relevant macroeconomic variables. The first step in this process involves estimating long-run multipliers for these macroeconomic variables. Since the Long-Run Multipliers for these variables are derived from historical data, they remain consistent for both acute physical risk modeling and transition risk modeling. For a detailed description of this step, please refer to Step 3 of the Acute Physical Climate Risk Module.

5. Projecting Macro Variables for STD Scenario

Similarly to the Acute Physical Risk Module, the forecasts for any macroeconomic variable under the baseline scenario are derived from the NBG's existing models and are aligned with the forecasts published in the Monetary Policy and Financial Stability reports. For the transition scenario, the GDP projection from Step 3 serves as the foundational input for projecting other macroeconomic variables. To generate these projections, the estimated long-run multipliers from the previous step are also incorporated. Additionally, expert judgment is applied to adjust the results as necessary, ensuring that the projections are both robust and reflective of real-world conditions.

The formulas used to derive projections for specific variables are presented in Step 4 of the Acute Physical Climate Risk Module. Again, all calculations are executed using the Macro Projections Satellite Tool. The outputs are comprehensive projections of macroeconomic variables for the transition scenario.

6. From Total GDP to Sectorial GVA

The goal of this step is to translate total GDP projections into sector-specific Gross Value Added (GVA) figures, taking into account the varying impacts of transition risks, such as carbon taxation, across different sectors. This step ensures that the broader economic impacts of climate-related risks are accurately reflected at the sectoral level, providing a more granular understanding of how different industries are affected.

The process includes various steps to ensure that each sector's economic contribution is adjusted to reflect the specific risks and impacts it faces:

- Calculating Initial Sectorial GVA: GVA of an industry is calculated as the difference between its total output and intermediate consumption. According to the income method of calculating GDP, it is derived as the sum of the economy's GVA and net taxes on products. The latter originate from both intermediate demand transactions and final demand transactions within sectors including households, government, exports, and gross capital formation.

  To begin, the initial GVA for each industry i in year t is calculated using the following formula:

  $$GVA_{i,t} = \sigma_i \cdot (1 - \theta) \cdot GDP_t$$

  Where: σ_i is the share of industry i in total GVA, derived from the Input-Output (IO) Table; θ represents the share of net product taxes in GDP; and GDP is frontloaded GDP projections from the NGFS Delayed Transition scenario, which is the output of Step 2.

  This calculation assumes that the economic structure has remained consistent with the base year of the IO Table, allowing the interrelationships between industries to be considered stable.

- Incorporating Differential Sectoral Transition Risk Effects:
  - Adjusting for Sectoral Carbon-Tax Costs: Given limited availability of carbon-tax revenues' variables for Georgia NGFS REMIND model and several issues related to the available variable, a conceptual procedure combined with expert judgment is used to allocate carbon-tax revenues from NGFS REMIND to NACE rev.2 sectoral carbon-tax costs. These "Scope 1" emissions-related costs are then deducted from the initial GVA values for each sector.

  - Incorporating Cost Spillovers – Pass-Through Effects: Cost spillovers occur as sectors pass a portion of their carbon-tax costs to their downstream customers. The pass-through effect is quantified using coefficients ($\rho_{i,t}$) that estimate the ratio between the price increase and the size of the cost shock. These coefficients are derived from elasticity estimates adapted from U.S. data[9] and adjusted for the Georgian economy.

    The iterative process involves the following:

    1. *Initial Carbon Costs*: The initial "Scope 1" sectoral carbon costs $c^0 = (c_1^0, \quad c_2^0, \quad \cdots, \quad c_{37}^0)$ are derived for 37 industries.

    2. *Pass-Through Iterations:* In each iteration t, the costs passed on by each sector are calculated:

    $$c^t \times \rho = (c_1^t \rho_1, \quad c_2^t \rho_2, \quad \cdots, \quad c_{37}^t \rho_{37})$$

    3. *Retention of Costs:* The costs retained by sectors are calculated as:

    $$c^t \times r = (c_1^t r_1, \quad c_2^t r_2, \quad \cdots, \quad c_{37}^t r_{37})$$

    4. Accumulated Carbon Costs: After each iteration t, the accumulated carbon costs for each sector are updated:

    $$C^t = \sum_{\tau=0}^{t} c^\tau \times r.$$

    The iterative process continues until the additional costs passed on in subsequent iterations become insignificant. For this exercise, the procedure terminates after six iterations. The result after pass-through procedure is the final distribution of carbon-tax costs to sectors, which are then deducted from the respective $GVA_{i,t}$ values.

  - The adjusted GVA values for each sector i after accounting for carbon-tax costs are represented as:

    $$\Gamma_{i,t} = GVA_{i,t} - Carbon\,Tax\,Cost_{i,t}$$

    Where $\Gamma_{i,t}$ represents industry i's downward-adjusted GVA.

    Define the vector of these in year t by Γ_t and derive the vector of shares of the sectoral GVAs in GDP_t as $\phi_t = \frac{1}{GDP_t} \Gamma_t$ to be used in the next step.

[9] U.S. Environmental Protection Agency (USEPA). (2011). Regulatory Impact Analysis: Standards of Performance for New Stationary Sources and Emission Guidelines for Existing Sources: Commercial and Industrial Solid Waste Incineration Units. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards (OAQPS), Air Economics Group Risk and Benefits Group (MD-C439-02), Research Triangle Park, NC 27711. February 2011.

- Deriving Sectoral GVA for STD Scenario: To derive the STD transition risk effects, the negative effects of the Delayed Transition on the GDP values in 2035, 2040, and 2045 are calibrated onto the NBG's 2024-2026 baseline GDP forecasts (growth rates) to get the STD estimates of GDP_{2024}, GDP_{2025}, and GDP_{2026} (see the Step 3). After that, these GDP values are multiplied by vector ϕ_t from the previous point to derive:

$$\Gamma_\tau = \phi_t \cdot \mathrm{GDP}_\tau = \frac{\mathrm{GDP}_\tau}{\mathrm{GDP}_t} \cdot \Gamma_t,$$

Where: $(\tau, t) \in \{(2024,2035), (2025,2040), (2026,2045)\}$.

The final sectoral GVA figures are obtained after all adjustments for carbon-tax costs, pass-through effects, and the specific impacts of the STD scenario. These figures provide a detailed assessment of how each sector will be affected under the stress test conditions, ensuring that the broader economic impacts of climate-related risks are accurately reflected at the sectoral level.

All procedures in this step are executed using the Transition Risk Satellite Tool, which automates the calculations and adjustments necessary to derive the final sectorial GVA projections.

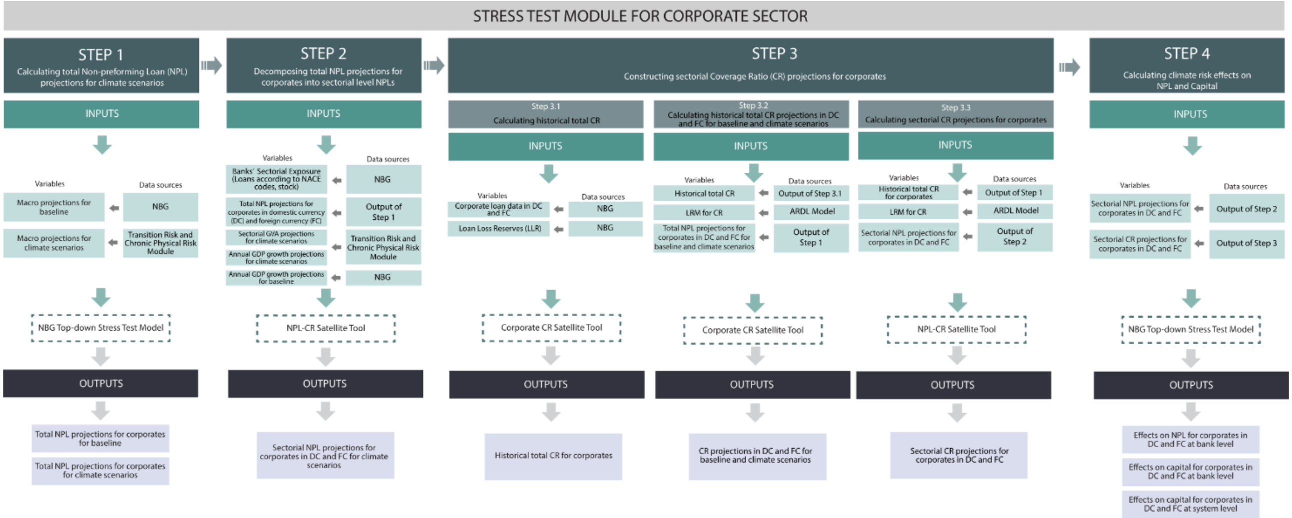
7. Stress Test Module

Similar to the outputs from the Acute Climate Risk Module, the key outputs of the Transition Risk Module are further utilized in the Stress Test Module. Specifically, the outputs from Step 3, Step 5, and Step 6 serve as crucial inputs for the Stress Test Module, which is designed to evaluate the resilience of the financial system under different climate scenarios. The stress tests simulate the financial effects of various transition scenarios, assessing the potential impacts on bank capital, loan performance, and overall financial stability. A detailed description of the stress test module is provided in the Stress Test Module for Corporate Sector and the Stress Test Module for Households Sector.

The outputs of the stress tests are comprehensive results that highlight the financial impacts of the selected transition scenarios. These results provide critical insights for policymakers and financial institutions, helping them understand and manage the risks associated with the transition to a low-carbon economy.

Stress Test Module for Corporate Sector

The Stress Test Module is the final component of the Climate Stress Testing Framework, integrating the outputs from the acute physical risk and transition risk modules to evaluate the financial system's resilience. Due to the need for different modeling approaches, the module is developed separately for the corporate sector and the household sector. The Stress Test Module for the Corporate Sector is designed to assess the exposure of corporate loans to climate-related risks, with a particular focus on how these risks could affect non-performing loans (NPLs) loan loss provisions within the sector and banks' capital adequacy. It is important to note that this module does not differentiate between acute physical risk and transition risk assessments. Depending on the climate scenario of interest, it will utilize inputs either from the Acute Physical Risk Module or the Transition Risk Module and will follow the same steps to obtain the final results. The Stress Test Module for the Corporate Sector follows a structured approach, involving several key steps:



1. Calculating total Non-Performing Loan (NPL) projections for corporate sector

The first step in the Stress Test Module for the corporate sector involves projecting the total Non-Performing Loan (NPL) ratios across the corporate portfolio under both baseline and climate stress scenarios. Given that default rate data are not available for the Georgian banking system, the NBG employs a set of panel regressions that model the NPL ratio as a function of various macroeconomic variables. These regressions are integral to both credit stress testing and climate stress testing, allowing the projection of NPL ratios over a specified horizon, typically set at three years.

The NBG Top-Down Stress Test Model utilizes the macroeconomic inputs to generate NPL ratio projections for the corporate sector. These projections are made at the aggregate portfolio level, providing a broad overview of potential credit risk under different economic conditions, including both domestic currency (DC) and foreign currency (FC) lending.

The output of this step is total NPL projections for the corporate sector under both baseline and climate stress scenarios, which serve as the foundation for further sector-specific analysis in subsequent steps.

2. Decomposing total NPL projections for corporates into sectoral level NPL projections

Following the aggregate NPL projections in Step 1, the second step focuses on disaggregating these projections into sector-specific NPL ratios. This is necessary to assess the differential impacts of climate risks across various sectors, particularly how CO2 costs might affect different industries.

The sectoral projection of NPL ratios is generated in two steps:

The first step is the projection step: The NPL ratios at the aggregate level (from Step 1) are adjusted based on the sectorial GVA growth rates. This adjustment scales the aggregate NPL impacts by considering how different sectors grow relative to the overall economy:

$$NPL_{t+i}^{n} = NPL_{t+i} + (GVAg_{t+i}^{n} - GVAg_{t}^{n})\frac{(NPL_{t+i} - NPL_{t+i,baseline})}{(GDPg_{t+i} - GDPg_{t+i,baseline})}$$

Where NPL_{t+i} is total NPL projection under the climate risk scenario starting in period t for the projection horizon $t+1,\dots,t+h$, where h is typically set to 3 for Transition Risk Module and 1 for Acute Risk Module (Output of Step 1), $NPL_{t+i,baseline}$ is the total NPL projection under the baseline scenario, GVA_t^n are GVA values across sectors n, and $GVAg_{t+i}^n$ their corresponding projections of GVA growth, obtained from either Transition Risk Module or Acute Risk Module, $GDPg_{t+i}$ are projected scenario GDP growth rates under the short-term disorderly scenario for years $t+1,\dots,t+h$ and $GDPg_{t+i,baseline}$ are projected GDP growth rates under the baseline scenario for years $t+1,\dots,t+h$.

The projection step ensures that sectors with slower growth (or contraction) due to higher CO_2 costs or other climate-related impacts reflect higher NPL ratios, and vice versa.

The second step is the scaling step. After calculating the initial sector-specific NPL ratios, a scaling step ensures that the weighted average of all sectorial NPL projections aligns with the aggregate NPL ratio projection obtained in Step 1. In particular, NPL_{t+i}^n is adjusted by a multiplicative scalar so that the weighted average of the sectoral NPL projections equals the aggregate portfolio-level NPL projection:

$$\sum_{n=1}^{N} w_n NPL_{t+i}^n = NPL_{t+i}$$

Where w_n denotes the sector shares of corporate lending, either in domestic or foreign currency. This scaling step maintains consistency between the sectorial and aggregate projections, ensuring that the sectoral breakdown does not deviate from the overall risk profile projected for the corporate portfolio. Technically, the scaling is implemented through an optimization routine in Excel using the NPL-CR Satellite Tool.

The output of the Step 2 is sector-specific NPL ratio projections, reflecting the differential impacts of climate risks, particularly CO2 costs. Sectors that are more CO2 intensive and have a lower ability to pass these costs onto consumers are projected to have higher NPL ratios, indicating greater credit risk. These sectorial projections are critical for understanding the vulnerability of specific industries to climate-related financial risks.

3. Constructing sectorial Coverage Ratio (CR) projections for corporates

The goal of this step is to project the Coverage Ratio (CR) for different sectors within the corporate segment under both Baseline and climate scenarios. The CR serves as a proxy for Loss Given Default (LGD) due to the lack of LGD data for the Georgian banking system.

The CR for the corporate sector is modeled using an approach based on the work by Frye (2013[10]). This methodology is designed to align with the dynamics specific to corporate loans, both in domestic (DC) and foreign currencies (FC).

It involves three steps:

[10] Frye, Jon (2013): Loss given default as a function of the default rate, Federal Reserve Bank of Chicago

- Calculating Historical Total CR: Historical CR is calculated using aggregated data on corporate loans and loan loss reserves. The total sum of loans for both DC and FC is considered as the exposure, and the loan loss reserves are used to calculate the CR:

$$Coverage\ Ratio\ = \frac{Corporate\ loan\ loss\ reserves}{Corporate\ Exposure}$$

- Projecting total CR under baseline and climate scenarios: The forecasted CR is obtained for both currencies (DC and FC) under both the Baseline and climate scenarios. The forecast is based on historical CR, Long-run Multiplier (LRM), and NPL projection data:

$$Coverage\ Ratio_t^{i,j}\ =\ Coverage\ ratio_{t-1}^{i,j} + LRM\ \times \left(NPL_t^{i,j} - NPL_{t-1}^{i,j}\right)$$

Where t = 2024, 2025 and 2026, i = DC and FC, and j = baseline and climate scenario.

It should be noted that LRM for CR is obtained using ARDL model. Specifically, the ARDL technique is employed to estimate the long-run relationship between coverage ratios and non-performing loans (both in foreign and domestic currencies). For a detailed description of the ARDL model, please refer to Step 3 of the Acute Physical Climate Risk Module.

- Sectorial Coverage Ratio Projections: The sector-specific CR projections are calculated by applying the same methodology across different sectors within the corporate loan portfolio. This step ensures that the CR projections reflect the varying impacts of economic and climate stress on different industries.

The projections generated in this step provide a detailed view of the CR across different sectors, allowing for a more granular analysis of the potential impacts on the corporate segment under climate stress scenarios. These projections are essential for understanding the varying levels of risk across sectors and help in assessing the overall stability of the financial system.

4. Calculating climate risk effects on NPL and Capital

The final step in the climate stress test framework utilizes the results from previous steps to assess the impact of climate risks on Non-Performing Loans (NPL) and capital adequacy at both the bank and system levels, using the NBG's Top-Down Stress Test Model.

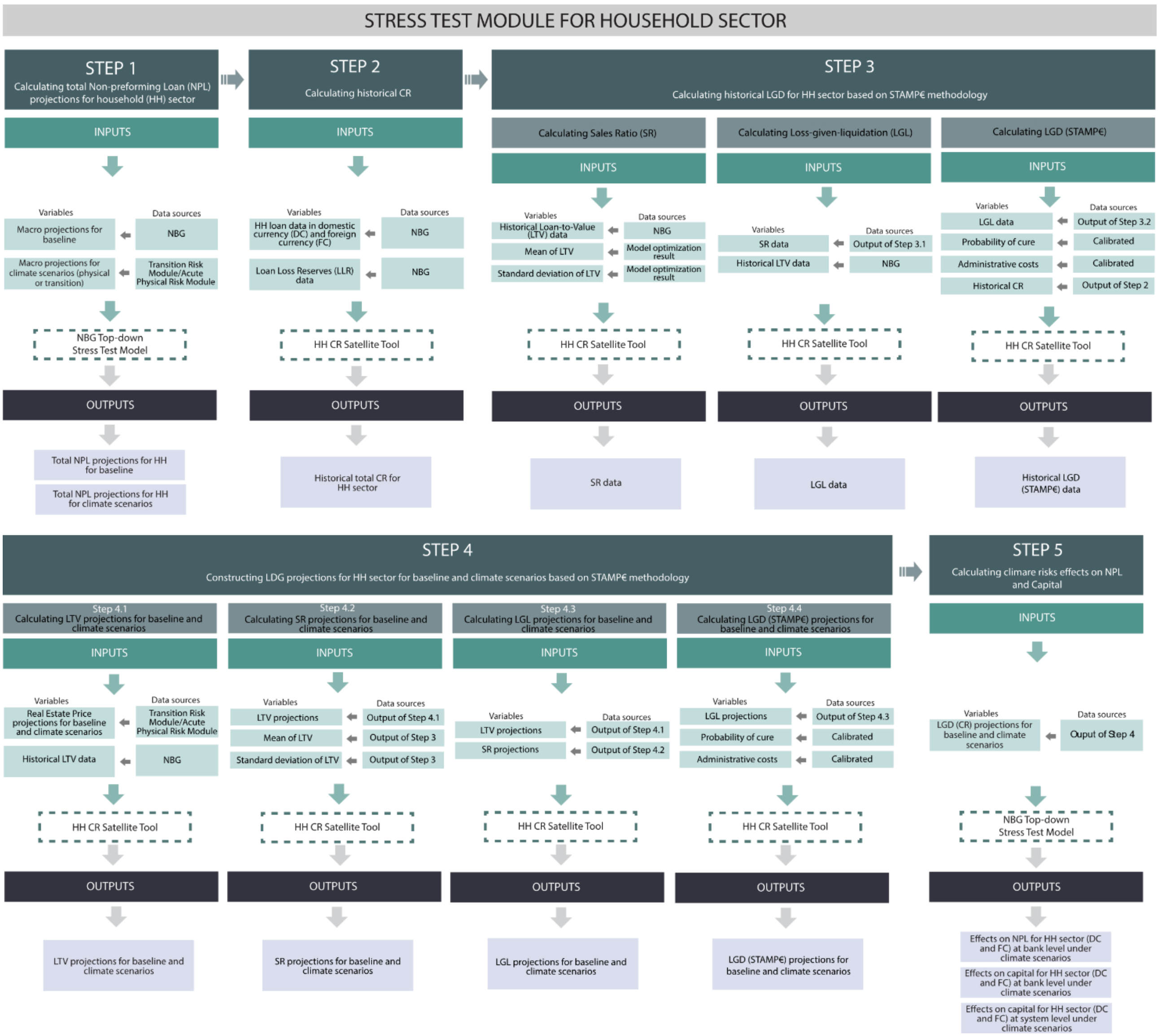
This step integrates sector-specific NPL projections (from Step 2) to calculate their cumulative effect on the total NPL ratio for the corporate sector. The NPL impacts are then applied to assess the required loan loss provisions, which directly affect the capital buffers of banks.

Using the NBG's Top-Down Stress Test Model, the capital adequacy is stress-tested under baseline and climate scenarios to determine how these climate-induced changes in NPLs could erode capital ratios. The analysis highlights the resilience of banks and the overall financial system, identifying potential vulnerabilities that may require additional capital.

Step 4 ensures a comprehensive evaluation of how climate risks translate into financial risks, impacting NPL ratios and capital adequacy, thereby helping to gauge the banking system's resilience under stressed climate scenarios.

Stress Test Module for Households Sector

The Stress Test Module for the Households (HHs) Sector is designed to assess the exposure of HHs loans to climate-related risks, with a particular focus on how these risks could affect NPLs, loan loss provisions and their impact on banks' capital adequacy. As in the case of the corporate sector, this module does not differentiate between acute physical risk and transition risk assessments. Depending on the climate scenario of interest, it will utilize inputs either from the Acute Physical Risk Module or the Transition Risk Module and will follow the same steps to obtain the final results. The Stress Test Module for the HHs Sector follows a structured approach, involving several key steps:



1. Calculating total Non-performing Loan (NPL) projections for household (HH) sector

This step is similar to Step 1 of the Corporate Sector Module and involves projecting the total NPL ratios across the household (HH) portfolio under both baseline and climate stress scenarios. Again, the NBG Top-Down Stress Test Model is used to generate these projections, distinguishing between baseline and climate scenarios. The outputs include total NPL projections for the HH sector in domestic and foreign currencies, which serve as the basis for further stress testing in subsequent steps.

2. Calculating historical CR

Step 2 focuses on determining the historical coverage ratio (CR) for the household sector by using data on household loans in domestic (DC) and foreign currencies (FC), along with loan loss reserves (LLR).

Similar to the corporate sector, the CR serves as a proxy for Loss Given Default (LGD) due to the absence of LGD data for the Georgian banking system. The CR is calculated using the following formula:

$$Coverage\ Ratio = \frac{HHs\ Loan\ loss\ reserves}{HHs\ Exposure}$$

Loan loss reserves are allocated to the household segment, and when the segmentation between DC and FC is not available, the reserves are considered collectively. The exposure represents the total sum of loans extended to the household segment in both DC and FC. Notably, while the data for loan loss reserves for the household segment are not categorized by DC and FC, data for household loans are available in both DC and FC categories.

The outcome of this step is the historical CR for the household (HH) segment.

3. Calculating historical LGD for HH sector based on STAMP€ methodology

In Step 3, the historical LGD for the household sector is calculated using a structured model based on the STAMP€ methodology proposed by the ECB (2017) [11]. This approach is tailored to the Georgian banking system's context, where direct LGD estimates are not available. The LGD model is designed to handle housing-related loan portfolios by referencing recent country-level LGD data and adjusting collateral values based on changes in house prices. This ensures that LGD assessments are timely and accurately reflect the current market conditions.

For the calibration of historical LGD for HH segment, the STAMP€ methodology involves three steps:

- Calculation of the Sales Ratio (SR): The SR is determined using historical Loan-to-Value (LTV) ratios, incorporating the mean and standard deviation of these LTVs. The SR formula adjusts the value of loan collateral during liquidation and is expressed as:

$$SR = \mu\left[\phi\left(\frac{LTV-\mu}{\sigma}\right) - \phi\left(\frac{-\mu}{\sigma}\right)\right] + \frac{\sigma}{\sqrt{2\pi}}\left[e^{-\frac{\mu^2}{2\sigma^2}} - e^{-\frac{(LTV-\mu)^2}{2\sigma^2}}\right] + LTV\left[1-\phi\left(\frac{LTV-\mu}{\sigma}\right)\right]$$

  The mean and standard deviation of LTVs are adjusted during calibration to minimize the sum of squared differences between the LGD derived from the STAMP€ methodology and the approximated LGD in the form of CR.

[11] European central Bank, ECB (2017): *STAMP€: Stress-Test Analytics for Macroprudential Purposes in the euro area:* https://www.ecb.europa.eu/pub/pdf/other/stampe201702.en.pdf

- Calculation of Loss-Given-Liquidation (LGL): The LGL, representing the expected loss in the event of asset liquidation, is incorporated into the LGD calculation. The LGL is calculated using the formula:

$$LGL_t = 1 - \frac{SR_t}{LTV_t}$$

This step quantifies the loss severity associated with the liquidation of collateral.

- Calculation of the LGD (STAMP€): The final LGD is calculated using the STAMP€ methodology, incorporating calibrated SR and LGL values, with assumptions on the probability of cure and operational costs. The formula used is:

$$LGD = \big((1 - Probability\ of\ Cure) \times LGL\big) + Costs$$

For this exercise, the probability of cure is set at 40%, and administrative costs are assumed to be 0.05%.

It should be noted that the simulation process involves adjusting the mean and standard deviation of SR to minimize the sum of squared differences between the LGD calculated from CR (output of Step 2) and the LGD calculated using the STAMP€ methodology (output of Step 3.3). This calibration ensures that the LGD projections align closely with historical performance and the specific dynamics of the Georgian household loan portfolio.

This step ultimately provides the calibrated historical LGD data as well as estimated mean and standard deviation of SR, which serves as the foundation for developing LGD projections under both baseline and climate scenarios, taking into account changes in real estate values and market conditions.

4. Constructing LGD projections for HH sector for baseline and climate scenarios based on STAMP€ methodology

In Step 4, the projected LGD for the household segment is derived for both baseline and climate scenarios using the structured STAMP€ methodology described in Step 3. This step builds on the historical LGD calculations and coverage ratio projections developed in the previous steps, ensuring that the projections reflect the evolving economic environment, particularly changes in Real Estate Prices (REP) and Loan-to-Value (LTV) ratios.

For the projection LGD for HH segment, the STAMP€ methodology involves the following steps:

- Calculating LTV Projections for Baseline and Climate Scenarios: To project the LTV ratios, real estate price (REP) forecasts under both baseline and climate scenarios are utilized. The forecasted LTV for each year (2024, 2025, and 2026) is calculated using the initial LTV value from 2023, adjusted inversely to the cumulative growth of REP in the respective scenario. The formula applied is:

$$LTV_{t+i}^{j} = LTV_{2023} \times \frac{1}{REP\ Cumulative\ growth_{t+i}^{j}}$$

where j represents the Baseline or climate scenarios, and i corresponds to the years 1, 2, and 3, or specifically 2024, 2025, and 2026. This approach ensures that the forecasted LTVs are responsive to changes in property values, a critical factor influencing the household sector's LGD.

- Calculating SR Projections for Baseline and Climate Scenarios: Using the projected LTVs from Step 4.1, the Sales Ratio (SR) projections are calculated, using the formula described in Step 3, to reflect the potential liquidation value of collateral in response to varying real estate market conditions. The SR projections are crucial for determining the LGL and, ultimately, the LGD.
- Calculating LGL Projections for Baseline and Climate Scenarios: With the projected SR and LTV values, the LGL is recalculated for each forecast year under both scenarios. The LGL captures the expected loss severity if the collateral were to be liquidated, adjusting for market conditions as forecasted by REP changes.
- Calculating LGD (STAMP€) Projections for Baseline and Climate Scenarios: Finally, the projected LGD under the STAMP€ methodology is obtained by incorporating the recalculated LGL values, the assumed probability of cure (40%), and the administrative costs (0.05%). This step ensures that the LGD projections accurately reflect both the evolving risk environment and the economic resilience of the household sector.

By following these steps, the projected coverage ratios and LGDs for the household sector are generated for each scenario, providing a detailed view of potential credit risk impacts under both baseline and climate scenarios. These projections are vital inputs for the subsequent stress testing of household loans and their influence on banks' NPLs and capital adequacy in Step 5.

5. Calculating climate risks effects on NPL and capital

The final step in the climate stress test framework utilizes the results from previous steps to assess the impact of climate risks on Non-Performing Loans (NPL) and capital adequacy at both the bank and system levels, using the NBG's Top-Down Stress Test Model.

The step integrates CR projections from Step 4, alongside NPL projections from Step 1, to assess the effects on NPLs and capital at both the bank and system levels under baseline and climate scenarios. This comprehensive assessment helps determine the overall vulnerability of the household loan portfolio to climate-related stress factors.

Similar to the corporate sector, using the NBG's Top-Down Stress Test Model, the capital adequacy is stress-tested under baseline and climate scenarios to determine how these climate-induced changes in NPLs could erode capital ratios. The analysis highlights the resilience of banks and the overall financial system, identifying potential vulnerabilities that may require additional capital.

This module effectively captures the potential impacts of climate change on household sector loans, providing critical insights into the resilience of financial institutions under stressed conditions.

Results of the First Climate Stress Test Exercise

The first climate stress test exercise for Georgia aims to evaluate the potential impact of climate-related risks—both acute physical risks and transition risks—on the country's financial sector. Climate risks, including extreme weather events and long-term environmental changes, have the potential to cause significant disruptions to economic stability. As climate-related risks continue to grow, it is increasingly important to understand their implications for financial resilience. This exercise, therefore, assesses the effects of various climate scenarios on key financial indicators, such as Non-Performing Loan (NPL) ratios and capital adequacy ratios, to provide insights into the banking sector's capacity to withstand climate-induced shocks.

The assessment is divided into two primary areas: Acute Physical Risk, and Transition and Chronic Physical Risk. The acute physical risk component focuses on the immediate economic impacts of extreme weather events, such as heatwaves, extreme precipitation, and extreme wind, evaluating how these shocks influence GDP and other macroeconomic variables. Meanwhile, the transition and chronic physical risk component addresses the long-term consequences of shifting towards a low-carbon economy and gradual climate changes, utilizing the Delayed Transition with Medium Chronic Physical Risks scenario. This dual approach ensures a comprehensive analysis of both short-term and extended risk horizons, capturing the different ways in which climate change could affect financial stability.

Acute Physical Risk

The first climate stress test exercise for Georgia evaluates the impact of three acute climate hazards—heatwaves, extreme precipitation, and extreme wind—chosen for their potential to cause substantial economic and financial disruptions (see Acute Physical Climate Risk Module). Each of these extreme weather events is modeled as a one-time shock, with effects projected for the year following the event to capture its immediate impact. Additionally, frontloading is applied to extend the projected impact, ensuring that the cumulative effects of each hazard on GDP and sectoral Gross Value Added (GVA) are fully considered, offering a comprehensive view of the long-term economic impacts.

The scenarios generated in the Acute Climate Risk Module include projections for total GDP, Nominal and Real Effective Exchange Rates, Real Estate Prices and Real Interest Rates (see Table 1) as well as sector-specific GVA (see Appendix 1) under each hazard scenario. These projections provide critical insights into the economic consequences of each extreme weather event, including potential shifts in real estate prices, interest rates, and exchange rates.

In these stress test scenarios, the macroeconomic baseline forecasts are derived from the NBG's existing models and aligned with its published Monetary Policy and Financial Stability reports. The baseline projections, combined with the acute physical risk scenarios, provide a foundation for evaluating the resilience of Georgia's financial system by simulating the impacts of each climate hazard on bank capital, loan performance, and overall financial stability (see Stress Test Module for Corporate Sector, Stress Test Module for Households Sector).

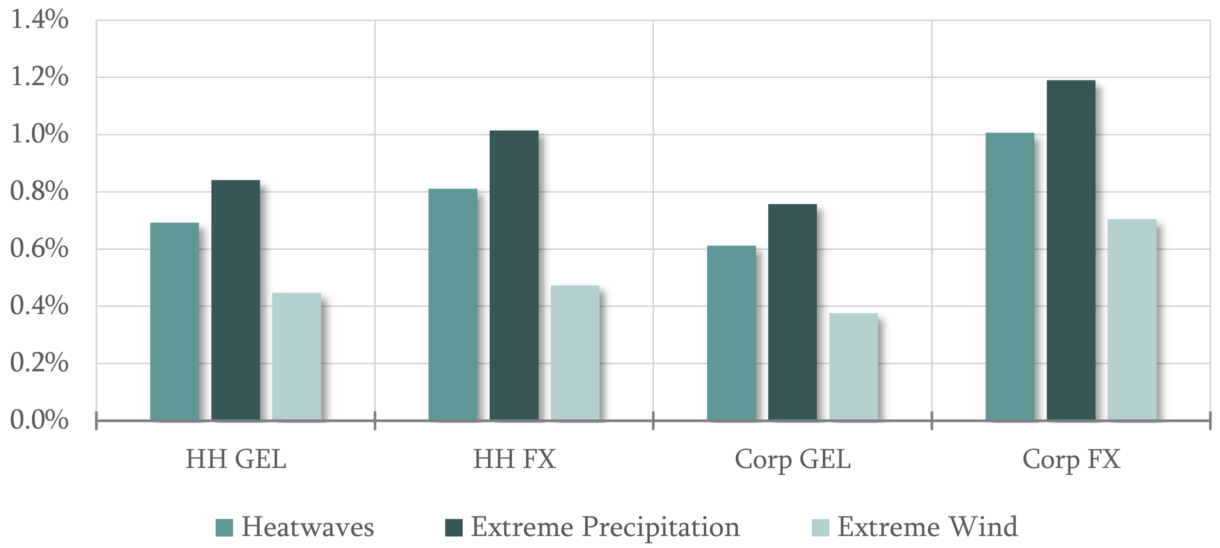
Table 1. Macroeconomic Assumptions for Acute Physical Risk Scenarios

Macro Variables	Scenario			
	Baseline	Heatwaves	Extreme Precipitation	Extreme Wind
Real GDP annual growth	5.03	4.59	4.44	4.86
Interest rate - Total	10.93	12.4	12.4	12.4
Interest rate - Domestic currency	13.45	15.03	15.03	15.03
Interest rate - Foreign currency	7.45	8.76	8.76	8.76
Real estate prices (YoY percentage change)	5.5	5.06	4.91	5.32
Real effective exchange rate (REER*) (YoY percentage change)	1.00	0.69	0.58	0.88
Nominal effective exchange rate (NEER*) (YoY percentage change)	0.00	-0.31	-0.42	-0.12

Source: NBG

The Diagram 1 illustrates the impact of three acute physical risks—heatwaves, extreme precipitation, and extreme wind—on Non-Performing Loan (NPL) ratios across various segments, compared to a baseline scenario. The segments analyzed include household (HH) loans in Georgian Lari (GEL) and foreign currency (FX), as well as corporate (Corp) loans in GEL and FX.

Diagram 1. Effect of Acute Physical Risks on NPLs, Compared to the Baseline (pp)



Source: NBG

* Increase means appreciation.

The analysis reveals that the NPL ratios for household loans in GEL and FX are most affected by extreme precipitation, with increases nearing 1.0 percentage points for HH FX and slightly less for HH GEL. Heatwaves and extreme wind have comparatively lower impacts on NPLs in both household segments, with heatwaves showing the least effect. Corporate loans in FX experience the highest increase in NPL ratios across all scenarios, with extreme precipitation causing an increase of over 1.2 percentage points, followed by heatwaves and extreme wind. Corporate loans in GEL also show increased NPL ratios, though the impact is less severe than in the FX segment.

Overall, the results indicate that extreme precipitation poses the highest risk to loan performance across both household and corporate sectors, particularly for loans in foreign currency. This analysis underscores the importance of preparing for climate-related risks, as they can lead to notable increases in NPL ratios, potentially affecting the financial stability of the sector.

The Table 2 presents the impact of three acute physical risk scenarios on key capital ratios compared to the baseline. The capital ratios analyzed include the Total Capital Adequacy Ratio, Tier I Capital Ratio, and Core Tier I Ratio. Key observations from the table indicate that both heatwaves and extreme precipitation result in a lower Total Capital Adequacy Ratio by 0.96 percentage points compared to baseline scenario, while extreme wind has a slightly modest impact, resulting in the 0.87 percentage points deviation from the baseline. Similar to the Total Capital Adequacy Ratio, heatwaves and extreme precipitation lowers baseline Tier I capital ratios by 0.98 and 0.97 percentage points, respectively, while extreme wind leads to a 0.87 percentage point difference. The Core Tier I Ratio experiences the largest decrease across all capital ratios, with heatwaves and extreme precipitation lowering it by 0.99 and 0.98 percentage points, respectively. Extreme wind has a slightly smaller effect, reducing the Core Tier I Ratio by 0.88 percentage points compared to baseline scenario.

Overall, the results indicate that heatwaves and extreme precipitation have a more pronounced impact on capital ratios compared to extreme wind. However, despite these reductions, the banking sector maintains significant capital buffers, underscoring its resilience in the face of acute physical risks.

Table 2. Effect of Acute Physical Risks on Capital, Compared to the Baseline (pp)

Capital Ratios	**Scenarios**		
	Heatwaves	Extreme Precipitation	Extreme Wind
Total Capital Adequacy Ratio	-0.96%	-0.96%	-0.87%
Tier I Capital Ratio	-0.98%	-0.97%	-0.87%
Core Tier I Ratio	-0.99%	-0.98%	-0.88%

Source: NBG

In summary, while the climate stress test results indicate substantial potential losses associated with acute physical risks, Georgia's banking sector remains highly capitalized and resilient, capable of withstanding these climate-related challenges. This resilience underlines the sector's preparedness and its capacity to absorb losses from severe climate events.

Transition Risk and Chronic Physical Risk

In addition to physical risk, the first climate stress test exercise also evaluated the effect of transition risk on the Georgian financial sector. Specifically, it addresses the long-term impacts of gradual climate change and the economic adjustments required for transitioning to a low-carbon economy.

To assess transition risk, the Delayed Transition with Medium Chronic Physical Risks scenario was chosen from the Disorderly category of the NGFS scenarios (see Transition Risk and Chronic Physical Risk Module). This scenario was selected for the first climate stress test exercise as it enables the evaluation of how the financial sector might cope with significant and abrupt policy shifts aimed at achieving climate targets. The focus on medium chronic physical risks also ensures that the scenario captures both the transition risks associated with delayed policy action and the ongoing physical risks from climate change.

As described in the Transition Risk Module, to utilize the NBG's existing top-down stress testing methodology—typically applied to assess the financial sector's resilience against shocks over a three-year horizon—it was necessary to adapt the NGFS scenario to construct a short-term scenario that aligns with this timeframe. To simulate the impact of long-term climate risks on the banking system within a shorter period, a frontloading approach was employed. Specifically, GDP projections from the Current Policies and Delayed Transition scenarios were shifted forward to represent earlier years, resulting in the Short Term Disorderly (STD) Scenario. Under the STD scenario, which spans a three-year horizon, it is assumed that the balance sheet remains unchanged. This approach allows the stress test to capture the intensity of economic impacts associated with long-term climate risks within a short-term scenario, offering valuable insights into the banking system's resilience to rapid and severe climate-related economic shocks.

Table 3. Macroeconomic Assumptions for Transition Risk and Chronic Physical Risk Scenario

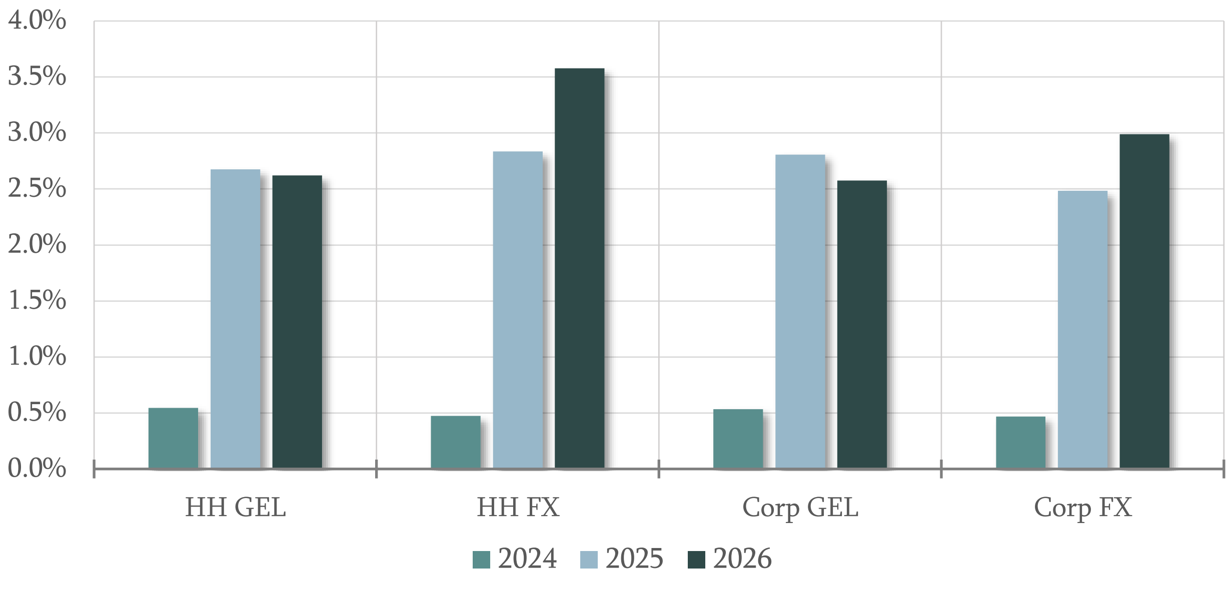
Macro Variables	Scenarios	2024	2025	2026
Real GDP annual growth	Baseline	5.03	4.81	4.94
	Short-term disorderly	3.56	-0.70	1.80
Interest rate - Total	Baseline	10.93	9.73	9.20
	Short-term disorderly	12.40	11.20	10.67
Interest rate - Domestic currency	Baseline	13.45	12.38	12.00
	Short-term disorderly	15.03	13.96	13.58
Interest rate - Foreign currency	Baseline	7.45	6.08	5.33
	Short-term disorderly	8.76	7.39	6.64
Real estate prices (YoY percentage change)	Baseline	5.50	5.50	0.00
	Short-term disorderly	4.99	3.58	-1.10
Real effective exchange rate (REER) (YoY percentage change)	Baseline	1.00	1.00	1.00
	Short-term disorderly	-0.03	-2.86	-1.20
Nominal effective exchange rate (NEER) (YoY percentage change)	Baseline	0.00	0.00	0.00
	Short-term disorderly	-1.03	-3.86	-2.20

Source: NBG

The STD scenario generated in the Transition Risk and Chronic Physical Risk Module include projections for total GDP, Nominal and Real Effective Exchange Rates, Real Estate Prices, and Real Interest Rates (see Table 3), as well as sector-specific GVA (see Appendix 2) for the STD scenario. The macroeconomic baseline forecasts are again derived from the NBG's existing models and aligned with its published Monetary Policy and Financial Stability reports. The baseline projections, combined with the STD scenario, provide a foundation for evaluating the resilience of Georgia's financial system by simulating the impacts of transition and chronic physical risks on bank capital, loan performance, and overall financial stability (see Stress Test Module for Corporate Sector, Stress Test Module for Households Sector).

The Diagram 2 illustrates the impact of transition and chronic physical risks on Non-Performing Loan (NPL) ratios across household (HH) and corporate (Corp) loan segments in both Georgian Lari (GEL) and foreign currency (FX) over a three-year period (2024, 2025, and 2026), compared to the baseline scenario. NPL ratios for household loans in both GEL and FX increase progressively over the three years, with HH FX loans experiencing the largest rise by 2026, reaching nearly 3.5 percentage points, while HH GEL loans peak around 3.0 percentage points, reflecting growing vulnerabilities in the household segment, particularly in FX loans, as these risks materialize. Corporate loans also show a similar upward trend in NPL ratios, with corporate FX loans most affected by 2026, exceeding 3.5 percentage points, while corporate GEL loans are slightly less impacted, with an NPL ratio around 3.0 percentage. This pattern indicates that foreign currency loans, especially within the corporate sector, are particularly susceptible to transition and chronic physical risks.

Diagram 2. Effect of Transition and Chronic Physical Risks on NPLs, Compared to the Baseline (pp)



Source: NBG

Overall, the results demonstrate a gradual increase in NPL ratios across all segments from 2024 to 2026, with foreign currency loans, especially in the household and corporate sectors, facing the highest risks. This highlights the potential for sustained financial pressure due to transition and chronic physical risks, underscoring the need for ongoing risk management in these areas.

Table 4 shows the impact of transition and chronic physical risks on key capital ratios—Total Capital Adequacy Ratio, Tier I Capital Ratio, and Core Tier I Ratio—over a three-year period (2024, 2025, and

2026), compared to the baseline scenario. The results indicate a progressive decline in capital ratios over time, reflecting the growing financial strain from these risks. The Total Capital Adequacy Ratio in relation to baseline decreases steadily, from -0.45 percentage points in 2024 to -1.29 percentage points in 2026. Similarly, the deviation of Tier I Capital Ratio from baseline varies from -0.46 percentage points in 2024 and increasing to -1.40 percentage points by 2026. The Core Tier I Ratio experiences the largest cumulative impact, with a deviation of -0.48 percentage points in 2024, reaching -1.50 percentage points by 2026.

Table 4. Effect of Transition and Chronic Physical Risks on Capital, Compared to the Baseline (pp)

Capital Ratios	2024	2025	2026
Total Capital Adequacy Ratio	-0.45%	-0.99%	-1.29%
Tier I Capital Ratio	-0.46%	-1.08%	-1.40%
Core Tier I Ratio	-0.48%	-1.15%	-1.50%

Source: NBG

The results indicate lower capital adequacy ratios compared to the baseline scenario, with the most significant differences observed by the end of 2026. These trends underscore the cumulative impact of transition and chronic physical risks, revealing a gradual erosion of capital buffers over time. This emphasizes the critical need for robust capital management to sustain resilience under prolonged risk conditions.

The results of Georgia's first climate stress test reveal that both acute physical and transition risks could have notable effects on the financial sector, though the sector exhibits resilience under these challenging scenarios. Extreme precipitation was found to have the most substantial impact on NPL ratios within the acute physical risk category, particularly for loans in foreign currency, while the delayed transition scenario demonstrated a cumulative decline in capital adequacy ratios over the three-year period. Although capital buffers are eroded progressively, the banking sector remains well-capitalized and resilient to climate-induced shocks, underscoring its preparedness to manage such risks. However, these findings emphasize the importance of continuous monitoring and robust capital management strategies to ensure sustained resilience against climate-related risks, as well as the need for proactive policies and risk management practices that support the financial sector's adaptability in a climate-conscious future.

Appendix

Appendix 1. Sectoral Gross Value Added (GVA) Projections for Acute Physical Risk Scenarios

N	NACE Code	Industry	GVA Growth Rate under Different Acute Risk Scenarios		
			Heatwave	Extreme Precipitation	Extreme Wind
1	A1-A3	Agriculture, forestry and fishing	-12.59%	1.18%	3.48%
2	B5-B9	Mining and quarrying	5.07%	4.78%	4.98%
3	C10-C12	Food products, beverages and tobacco products	11.37%	3.49%	4.72%
4	C13-C15	Textiles, wearing apparel and leather products	5.05%	3.49%	4.72%
5	C16-C18	Wood and paper products, and printing	5.71%	3.49%	4.72%
6	C19	Coke and refined petroleum products	4.96%	3.49%	4.72%
7	C20	Chemicals and chemical products	4.33%	3.49%	4.72%
8	C21	Basic pharmaceutical products and pharmaceutical preparations	5.95%	3.49%	4.72%
9	C22-C23	Rubber and plastics products, and other non-metallic mineral products	5.44%	3.49%	4.72%
10	C24-C25	Basic metals and fabricated metal products, except machinery and equipment	5.18%	3.49%	4.72%
11	C26	Computer, electronic and optical products	5.10%	3.49%	4.72%
12	C27	Electrical equipment	5.13%	3.49%	4.72%
13	C28	Machinery and equipment n.e.c.	5.13%	3.49%	4.72%
14	C29-C30	Transport equipment	5.03%	3.49%	4.72%
15	C31-C33	Furniture; other manufacturing; repair and installation of machinery and equipment	5.24%	3.49%	4.72%
16	D35	Electricity, gas, steam and air conditioning supply	10.91%	4.98%	5.02%
17	E36-E39	Water supply; sewerage, waste management and remediation activities	5.01%	4.40%	4.98%
18	F41-F43	Construction	5.10%	5.00%	5.02%
19	G45-G47	Wholesale and retail trade, repair of motor vehicles and motorcycles	5.28%	4.74%	4.96%
20	H49-H53	Transportation and storage	5.00%	4.43%	4.91%
21	I55-I56	Accommodation and food service activities	5.06%	4.99%	5.02%
22	J58-J60	Publishing, audiovisual and broadcasting activities	5.16%	4.96%	5.01%
23	J61	Telecommunications	5.16%	5.00%	5.02%
24	J62-J63	Computer programming, consultancy and related activities; information service activities	5.14%	5.01%	5.02%
25	K64-K66	Financial and insurance activities	4.88%	4.64%	4.92%
26	L68	Real estate activities	5.22%	4.73%	4.97%
27	M69-M71	Legal and accounting activities; activities of head offices; management consultancy activities; architecture and engineering activities; technical testing and analysis	5.72%	4.90%	5.00%
28	M72	Scientific research and development	5.03%	5.03%	5.03%
29	M73-M75	Advertising and market research; other professional, scientific and technical activities; veterinary activities	5.75%	4.50%	4.90%
30	N77-N82	Administrative and support service activities	5.39%	4.87%	4.99%
31	O84	Public administration and defence; compulsory social security	5.03%	5.03%	5.03%
32	P85	Education	5.04%	5.03%	5.03%
33	Q86-Q87	Human health activities	9.81%	5.02%	5.03%
34	Q88	Social work activities	5.03%	5.03%	5.03%
35	R90-R93	Arts, entertainment and recreation	5.03%	5.03%	5.03%
36	S94-S96	Other service activities	5.34%	4.98%	5.02%
37	T97-T98	Activities of households as employers of domestic personnel and undifferentiated goods and services production of households for own use	5.03%	5.03%	5.03%
TOTAL			4.59%	4.44%	4.86%

Appendix 2. Sectoral Gross Value Added (GVA) Projections for Transition and Chronic Physical Risks Scenario

N	NACE Code	Industry	GVA Growth Rate for Transition and Chronic Physical Risks Scenario		
			2024	2025	2026
1	A1-A3	Agriculture, forestry and fishing	3.39%	-0.79%	1.84%
2	B5-B9	Mining and quarrying	-1.73%	-6.65%	5.39%
3	C10-C12	Food products, beverages and tobacco products	2.55%	-1.69%	2.38%
4	C13-C15	Textiles, wearing apparel and leather products	2.72%	-1.45%	2.25%
5	C16-C18	Wood and paper products, and printing	2.37%	-1.93%	2.52%
6	C19	Coke and refined petroleum products	2.37%	-1.84%	2.48%
7	C20	Chemicals and chemical products	-8.88%	-15.73%	11.79%
8	C21	Basic pharmaceutical products and pharmaceutical preparations	3.31%	-0.90%	1.92%
9	C22-C23	Rubber and plastics products, and other non-metallic mineral products	-20.00%	-20.00%	3.32%
10	C24-C25	Basic metals and fabricated metal products, except machinery and equipment	-18.65%	-20.00%	9.12%
11	C26	Computer, electronic and optical products	3.45%	-0.77%	1.85%
12	C27	Electrical equipment	-1.47%	-6.12%	5.09%
13	C28	Machinery and equipment n.e.c.	-12.14%	-20.25%	15.60%
14	C29-C30	Transport equipment	2.33%	-1.89%	2.48%
15	C31-C33	Furniture; other manufacturing; repair and installation of machinery and equipment	2.68%	-1.56%	2.31%
16	D35	Electricity, gas, steam and air conditioning supply	3.01%	-0.92%	1.83%
17	E36-E39	Water supply; sewerage, waste management and remediation activities	3.30%	-0.84%	1.85%
18	F41-F43	Construction	0.56%	-3.96%	3.73%
19	G45-G47	Wholesale and retail trade, repair of motor vehicles and motorcycles	3.29%	-0.82%	1.86%
20	H49-H53	Transportation and storage	-6.38%	-4.19%	4.35%
21	I55-I56	Accommodation and food service activities	3.15%	-0.93%	1.89%
22	J58-J60	Publishing, audiovisual and broadcasting activities	3.42%	-0.77%	1.83%
23	J61	Telecommunications	3.51%	-0.73%	1.81%
24	J62-J63	Computer programming, consultancy and related activities; information service activities	3.46%	-0.74%	1.82%
25	K64-K66	Financial and insurance activities	3.46%	-0.74%	1.82%
26	L68	Real estate activities	3.49%	-0.74%	1.81%
27	M69-M71	Legal and accounting activities; activities of head offices; management consultancy activities; architecture and engineering activities; technical testing and analysis	3.41%	-0.79%	1.84%
28	M72	Scientific research and development	3.50%	-0.74%	1.81%
29	M73-M75	Advertising and market research; other professional, scientific and technical activities; veterinary activities	3.31%	-0.87%	1.87%
30	N77-N82	Administrative and support service activities	3.35%	-0.80%	1.85%
31	O84	Public administration and defence; compulsory social security	3.42%	-0.77%	1.82%
32	P85	Education	3.48%	-0.74%	1.81%
33	Q86-Q87	Human health activities	3.39%	-0.79%	1.84%
34	Q88	Social work activities	2.11%	-1.49%	2.12%
35	R90-R93	Arts, entertainment and recreation	3.38%	-0.78%	1.83%
36	S94-S96	Other service activities	3.38%	-0.80%	1.84%
37	T97-T98	Activities of households as employers of domestic personnel and undifferentiated goods and services production of households for own use	3.56%	-0.70%	1.80%
TOTAL			3.56%	-0.70%	1.80%

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