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# The Macroeconomic and Fiscal Impacts of Climate Adaptation Policy in Bangladesh

**CAMA Working Paper 20/2026**
**March 2026**

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## Abstract

Bangladesh is one of the most climate-vulnerable countries. The government has proposed its National Adaptation Plan (NAP), which commits to annual investments of USD 8.5 billion in climate-resilient infrastructure through 2050. This paper assesses the macroeconomic and fiscal impacts of this investment and examines alternative financing strategies using a multi-country, multi-sector general equilibrium G-Cubed model. This analysis first constructs a scenario in which climate damages accumulate without investment in adaptation, and then simulates scenarios in which the government undertakes NAP investment, financed through concessional external financing, commercial borrowing, or domestic taxation. The results indicate that climate adaptation yields net macroeconomic benefits by reducing or even offsetting climate-related output losses. Concessional external financing yields the most favourable outcomes, while commercial borrowing remains a viable alternative despite higher financing costs and exchange-rate pressures; a tax-financed adaptation yields smaller gains due to contractionary demand effects. Sectoral results indicate that the durable manufacturing and service sectors benefit the most, while non-durable manufacturing and agriculture primarily gain through avoided losses rather than expansion. Overall, the findings underscore climate adaptation as a macro-critical policy for Bangladesh and highlight the importance of financing choices in enhancing economic resilience.

**Keywords**

climate adaptation, climate financing, macroeconomic impacts, fiscal impacts, G-Cubed, Bangladesh

**JEL Classification**

H31, H32, H54, C67, C68, E62

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**ISSN 2206-0332**

# The macroeconomic and fiscal impacts of climate adaptation policy in Bangladesh*

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* The views expressed in this paper are solely those of the authors and do not necessarily reflect the views of the Government of the People's Republic of Bangladesh or the Reserve Bank of Australia. We thank Geoff Shuetrim for technical support.

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## 1 Introduction

Bangladesh is among the most climate-vulnerable countries globally, regularly experiencing floods and cyclones, despite contributing a small share of global greenhouse gas emissions. The country has been at the forefront of natural disasters, including major tropical cyclones in 1970, 1991, 2007, and 2024, as well as massive floods in 1988 and 1998. These disasters have affected 130 million people and caused USD 13.6 billion in total damage between 2000 and 2023 (IMF, 2025). The devastating flood in 1998 that affected two-thirds of the country resulted in damages and losses of over USD 2 billion (4.8 percent of GDP), and Cyclone SIDR in 2007 cost USD 2.7 billion (3.7 percent of GDP) (IMF, 2008). The average annual extreme event-related losses are estimated at 1.8 percent of GDP for 1990-2008, according to the German watch Risk Index (2010). The country's geographic location, flat, low-lying topography, high population density, widespread poverty, and dependence on climate-sensitive sectors — particularly water resources, agriculture, fisheries, and livestock — have significantly heightened its vulnerability to climate change, which is well documented in the World Bank and IMF country reports (World_Bank, 2024, IMF, 2016). These disasters have profound economic effects, affecting agriculture by destroying crops and fisheries, damaging infrastructure such as roads and buildings, and resulting in loss of life and displacement of people. Ricardo et al. (2017) suggest that, in addition to permanent damage to public and private capital, disasters cause temporary productivity losses, inefficiencies in public investment during the reconstruction period, and damage to the country's creditworthiness. As a result, natural disasters without adaptation measures are likely to cause productivity losses in the agricultural sector, output losses, and capital stock losses.

Bangladesh has made some progress in building adaptive capacity and resilience through various policies and regulatory frameworks, such as the Bangladesh Climate Change Strategy and Action Plan (2009), Climate Fiscal Framework (CFF) (2014, 2020), Nationally Determined Contributions (NDCs) (2015, 2021), Bangladesh Delta Plan (BDP) 2100, Mujib Climate Prosperity Plan (MCPP) (2022-2041), and National Adaptation Plan (NAP) (2023-2050) (MOF, 2025). Following the Paris Agreement, the government set national targets for GHG emissions and adaptation through NDCs (2015, 2021). Bangladesh has pledged to reduce its emissions by 27.56 MT $CO_2$ (6.73% below business-as-usual, BAU) by 2030, which will require USD 32 billion in investment. BDP 2100 outlines a long-term roadmap to shift the country's economic vision toward resilience to climate-induced disasters, including cyclones, flooding, sea-level rise, erratic rainfall, and rising temperatures (GED, 2018). While the vision extends to 2100, the immediate intervention strategies focus primarily on the period up to fiscal year 2031, with selected measures extending to fiscal year 2041, in line with the country's aspiration to become an upper-middle-income country by 2031 and a developed nation by 2041. The estimated investment amounts to USD 38 billion by fiscal year 2031, equivalent to 2.5% of GDP annually. MCPP 2022-2041 outlines a macroeconomic vision that links low-carbon development with economic prosperity through investment, positioning climate action as a driver of green growth (MoEFCC, 2022). The MCPP focuses investment on resilient pathways across key sectors, including energy, water, transport, and supply chains, with an estimated cost of approximately USD 90 billion by 2030.

The NAP, developed by the Ministry of Environment, Forest and Climate Change (MoEFCC) in 2022, is the latest, comprehensive, and operational climate adaptation plan that the government is implementing to achieve a climate-resilient and prosperous Bangladesh. The NAP outlines 113 interventions across eight sectors (Table 1). The total estimated cost of these interventions is BDT 20,038 billion (approximately USD 230 billion) over a 27-year horizon (2023–2050). To effectively transform climate adaptation, investment needs to increase sevenfold, requiring approximately USD 8.5 billion annually. Approximately USD 6 billion is expected to come from external sources, including international climate funds and development partners. The government is expected to contribute USD 2.08 billion, with the remainder (USD 0.42 billion) from the private sector. The implementation of the NAP 2022 is expected to protect 1.1 million hectares of cropland from storm surges, flood inundation, sea-level rise, and salinity intrusion. This protection could enable the production of an additional 10.3 million tons of rice (MoEFCC, 2022a).

**Table 1 Adaptation sectors and the estimated cost of the NAP**

| Sector number | Adaptation Sectors | Estimated Cost (Billion USD) | Share of expenditure (%) |
|---|---|---|---|
| 1 | Water Resources | 119.2 | 51.8 |
| 2 | Disaster, Social Safety & Security | 27.0 | 11.7 |
| 3 | Agriculture | 19.1 | 8.3 |
| 4 | Fisheries, Aquaculture, and Livestock | 16.2 | 7.0 |
| 5 | Urban Areas | 38.0 | 16.5 |
| 6 | Ecosystems, Wetlands, and Biodiversity | 5.9 | 2.6 |
| 7 | Policies and Institutions | 1.6 | 0.7 |
| 8 | Capacity Development, Research and Innovation | 3.0 | 1.3 |

Source: National Adaptation Plan 2022

While the NDC 2021 reflects international commitments to mitigation and adaptation, BDP 2100 outlines the country's long-term vision for resilience against climate-induced disasters. The MCPP translates these commitments under the NDC and the long-term vision under BDP 2100 into a medium-term green economic strategy, and the NAP provides actionable, sector-specific adaptation priorities. NAP considered 11 climate stress areas in devising adaptation interventions. These interventions are aligned with the global Sustainable Development Goals (SDGs) and 52 climate adaptation projects of BDP 2100 (MoEFCC, 2022a). While these plans have some overlap, particularly in climate resilience and disaster risk reduction, the NAP offers a comprehensive and complementary approach to achieving a climate-resilient and prosperous Bangladesh. The CFF integrates climate finance, as outlined in key policy documents (BDP, MCPP, and NAP), into the national budgeting process through fiscal instruments, including green budgeting, taxation, and concessional or commercial borrowing.

This paper examines the macroeconomic impacts of the NAP investment using the G-Cubed model of the global economy (Liu et al., 2025, McKibbin and Wilcoxen, 2013, McKibbin and Shuetrim, 2026). This study first constructs a scenario with long-term climate impacts but no adaptation investment and then simulates NAP investment scenarios. For the investment scenarios, the paper considers three cases to assess whether, in the absence of securing USD 6 billion annually from international sources, the government could feasibly finance the national adaptation entirely through taxation or commercial borrowing. The paper finds that investing in the climate adaptation plan is warranted, as it prevents a decline in domestic output and, in some instances, increases it. Although concessional finance is the preferred option for climate finance adaptation, borrowing at market interest rates from international markets is also worth considering. A tax-financed adaptation plan yields lower benefits than the other two options, such as concessional or commercial borrowing. Among the sectoral analyses, the paper finds that the durable manufacturing and service sectors benefited more than the non-durable and agricultural sectors. However, this investment prevents a substantial decline in the agricultural sector, which subsequently recovers significantly.

Most of the existing climate adaptation literature in Bangladesh focused on standalone issues, such as community-based adaptation, ecosystem-based adaptation, gender, livelihood, governance, rather than examining climate adaptation challenges at the macroeconomic level (Morshed et al., 2025). This paper models how different financing mechanisms can affect fiscal outcomes and macroeconomic aggregates and offers options for implementing climate adaptation. Modelling concessionary finance in the implementation of climate adaptation projects in multi-country, multi-sectoral dynamic model settings generates a practical view of how the government implements its climate adaptation policy. By quantifying the dynamic response of macroeconomic aggregates to climate adaptation investments under different financing options, this paper contributes to a better understanding of Bangladesh's climate adaptation policy and the channels through which climate adaptation policies affect the budgetary outcome. This result provides evidence-based insights to support the implementation of planned climate adaptation policies while controlling the fiscal deficit and debt levels.

The rest of the paper is structured as follows. Section 2 provides an overview of climate financing in general and in Bangladesh specifically. Section 3 outlines the methodology, including the G-Cubed model and its baseline projection. Section 4 describes four alternative scenarios: one climate scenario and three adaptation scenarios. Section 5 discusses the responses of key macroeconomic variables and sectoral outputs. Section 6 concludes with policy recommendations.

## 2. Financing climate adaptation

Adaptation to climate change is needed as the climate will continue to change even with intensive mitigation efforts. Adaptation measures, such as strengthening infrastructure resilience, enhancing disaster preparedness, and improving water resource management, would substantially reduce the costs of climate change.  There is a growing consensus that well-designed and well-implemented adaptation measures provide significant returns (Aligishiev et al., 2022, Melina and Santoro, 2021). Investing in resilient infrastructure as complementary to standard infrastructure can raise the marginal productivity of capital, crowding in private investment, while withstanding the impact of natural disasters (Melina and Santoro, 2021, Ricardo et al., 2017).  In the long run, well-managed adaptation frees up resources and increases the government's fiscal space.

Implementing climate adaptation could be challenging, given the current level of revenue mobilization and expenditure allocation (6-7 percent of its annual budget) to climate resilience through adaptive initiatives, of which 75 percent are sourced domestically. The new adaptation plan requires the government to scale up adaptation investment more than ever before. The NAP estimated that USD 8.5 billion per year is required for investment in climate adaptation infrastructure, out of which USD 6 billion is expected to come from the international community as concessional finance, the government is expected to spend  USD 2.08 billion, and the rest (USD 0.42 billion) is expected to come from the private sector  (MoEFCC, 2022a).

Mobilization of such a large resource (1.7 percent of fiscal year 2026 GDP) requires significant government effort, as the majority of the financing is expected to come from external sources at concessionary rates. It would be difficult for the government to implement climate adaptation if the expected external concessionary finance does not flow in. As such, the government may be required to raise substantial funds through taxation or commercial borrowing from domestic or external sources.

The government has already pledged an unconditional reduction of 6.7 percent in greenhouse gas emissions below the 2030 baseline in its nationally determined contribution (NDC 2021). Phasing out fossil fuel subsidies and gradually introducing a carbon tax will increase fossil fuel prices, reduce consumption, and lower carbon emissions[1]. However, imposing a climate adaptation tax in addition to climate mitigation efforts could be challenging for the government, given its current capacity to mobilize revenue.

When the government finances its climate adaptation investment through external sources, this entails significant inflows (loans/grants) and outflows (repayments, interest, and imports tied to project execution). Such large external liabilities influence the country's balance of payments, foreign exchange reserves, and the domestic currency's exchange rate. Both concessional and commercial borrowing from the external market can appreciate the domestic currency with foreign-currency inflows, which can be challenging for policymakers to manage exchange-rate pressures (Corbo and Fischer, 1995, Kamar et al., 2010). However, persistent reliance on external borrowing, particularly when loans are not concessional, can exert downward pressure on the exchange rate when foreign exchange demand (for imports, debt servicing, and repatriation of profits) outstrips supply (exports, remittances, and foreign investment), leading to a depreciation of the domestic currency. Khatun et al. (2025) recommend that Bangladesh receive climate finance as grants rather than loans to significantly reduce the country's debt burden while addressing climate change risks. Fodha and Yamagami (2025) show that, under government indebtedness, higher public spending to finance public adaptation may be beneficial when the capital stock is sufficiently large, but harmful for countries with a low capital stock. How the government finances its adaptation spending affects private consumption and investment, and thus GDP, government revenue, government tax receipts, and public debt.

## 2.1 External concessional finance

Financing climate adaptation through concessional finance (grants, soft loans, and concessional loans) could be the preferred option for Bangladesh, where institutional and capital market

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[1] Sarker and Zaman (2023) suggest that per capita emission in Bangladesh has increased significantly in recent years with robust GDP growth, although it is much lower than that of developed countries. They suggest that by imposing a carbon tax of 10 to 25% on fossil fuels gradually, the country can reduce CO2 emissions by 50 million Metric tons and generate government revenue worth BDT 266.3 billion by 2040.

constraints limit access to traditional sources of funding and where conventional loans could worsen debt burdens. Grants function as non-tax revenue, thereby reducing the deficit and lowering the government's financing requirement. Similarly, concessional loans (low interest rates, long maturities, and grace periods) ease the government's immediate burden of loan repayments and high interest payments. Lower debt-service pressure and delayed debt repayments would enable the government to sustain its deficit, thereby preserving fiscal space more than commercial debt. This allows the government to undertake critical climate resilience investments in infrastructure, early warning systems, water and sanitation, and climate-smart agriculture without crowding out essential development spending. If these concessional funds could be used for productive adaptation projects that raise growth and productivity, tax revenues can increase over time, and the government deficit can be narrowed even without fiscal consolidation. This will also enable the government to impose lower taxes on firms and households for investing in climate adaptation. Furthermore, with low fiscal cost and delayed principal payments, the government is less likely to crowd out private investment. Therefore, mobilization of external foreign resources for climate adaptation has been emphasized by Rabbani and Tahsin (2024).

These external funds may come from international sources, such as the Green Climate Fund (GCF), the IMF's Resilience and Sustainability Trust (RST) Fund, or bilateral agreements with development partners, including Japan, the European Union, China, and USAID. However, obtaining such an extensive external resource requires strong commitment from the development partners; otherwise, it could be adversely affected by the strict terms and conditions they impose. Rabbani and Tahsin (2024) noted that Bangladesh's institutional capacity to access international climate funds may be constrained by the complex requirements for submitting project proposals. Institutional requirements for obtaining direct access to international funds are poorly aligned with Bangladesh's institutional system.

## 2.2 Domestic taxation

As the government seeks to mobilize substantial external resources to implement the NAP, this could be challenging, given the current trend in external resource inflows. Rabbani and Tahsin (2024) highlighted substantial gaps in both financial and technical support for effective climate mitigation and adaptation in Bangladesh. In the absence of adequate concessional external finance, relying on international climate funds and loans is unlikely to close Bangladesh's substantial adaptation financing gap. Global adaptation finance is far below what vulnerable countries need, with developing countries receiving only a fraction of the committed resources. This persistent gap indicates that external concessional flows cannot be the sole source of adaptation finance, given the complexity of access and the limited availability of funds.

Domestic tax-financed adaptation can play a complementary role for several reasons. First, tax revenues provide a predictable, sovereign source of funding that can be allocated to national priorities, enabling investment in resilience infrastructure, such as flood defenses and climate-resilient roads, which may not attract international finance due to their uncertain revenue prospects. Second, when concessional funds are limited or slow to materialize, domestic public finance shields adaptation planning from external volatility. Third, relying on domestic finance helps avoid over-reliance on debt-based lending, which could deepen Bangladesh's debt burden, diverting future resources away from other development needs (Ahmed, 2025). While concessional finance remains crucial, strengthening domestic tax-based financing helps ensure sustained funding, reduces debt exposure, and enhances strategic decision-making amid escalating climate impacts.

Although tax-financed investment does not create exchange rate pressure, it can be burdensome for households. As the money is not coming from the external world, there would be no exchange rate pressure, which would be conducive to the tradable sector, such as the non-durable sector's exports. If the government finances climate adaptation through domestic taxation, it may not affect the government budget balance; however, it would reduce households' disposable income and may adversely affect private consumption and investment. This could dampen GDP growth (depending on the tax type and its distortionary effects) and reduce the tax base. If the tax base is substantially affected, the government budget deficit may widen. If taxation is efficient (broad-based and low distortion) and can be used for productive adaptation investment, the deficit can be sustainable and reduced over the long run. However, weak tax administration, distortion in tax policy, and tax evasion by political elites would make it challenging to mobilize such a significant investment (IMF, 2019). The sustainability of this policy depends on its tax efficiency and its impact on GDP growth.

## 2.3 Commercial borrowing

The existing literature on climate adaptation financing highlights a substantial and persistent gap between the required adaptation finance and the available concessional support, particularly for highly vulnerable countries such as Bangladesh. While the NAP estimates annual requirements of USD 8.5 billion, current adaptation finance flows remain well below these requirements, resulting in a significant annual funding shortfall. Global adaptation finance analyses similarly emphasize that total adaptation finance available to developing countries is multiple times lower than what is required (Larsen et al., 2025). In the absence of adequate concessional external funding, the government may resort to borrowing at market interest rates from both domestic and external sources to implement the climate adaptation plan.

Commercial borrowing at market interest rates could be an easy route in the short term, as there is less scope for lender conditionality. However, higher interest rates and typically shorter maturities can be problematic in the medium- to long-term. Higher interest payments can widen the budget deficit even if the primary balance is unchanged. If the government opts for commercial borrowing, it effectively competes with the private sector, potentially crowding out private investment. External commercial borrowing also poses currency risks if the government repeatedly needs to make higher interest payments in foreign currency. Depreciation of the local currency can increase the cost of debt service. In such cases, the government must raise taxes to pay higher interest payments; otherwise, it would increase the debt level and potentially strain long-term fiscal sustainability. Moreover, if markets are unwilling or demand a higher premium, financing costs may rise, and the financing deficit becomes costly.

As the government needs to mobilize a large pool of resources for climate adaptation, selecting the appropriate financing mix is crucial to minimizing interest payments and mitigating other adverse macroeconomic effects. Each of these strategies entails trade-offs; therefore, evaluating the worst-case scenario in which the government finances its climate adaptation entirely from domestic taxation or from external sources at a commercial rate would help determine the appropriate financing mix while minimizing adverse impacts on macroeconomic stability. The government's policy documents set targets for various policy interventions; however, quantifying their impact is necessary to determine which option is most appropriate for the country.

# 3 Methodology

## 3.1 The model

The study develops a variant of the G-Cubed Model, which is a multi-country, multi-sector, inter-temporal general equilibrium model (Liu et al., 2025, McKibbin and Wilcoxen, 2013). This version contains 22 regions/countries of the global economy, including Bangladesh, with 6 sectors in each economy, as presented in Table 2 and Table 3, respectively. The model is extended to incorporate concessionary international financing provided to the Bangladeshi government. More details of the G-Cubed model are documented in McKibbin and Shuetrim (2026).

**Table 2 Countries and regions in G-Cubed**

| Region groups | Region codes | Regions |
|---|---|---|
| Advanced economies | USA | United States |
| | JPN | Japan |
| | EUW | Western Europe |
| | AUS | Australia |
| | KOR | Korea |
| | CAN | Canada |
| | NZL | New Zealand |
| Developing Asia | CHN | China |
| | IND | India |
| | INO | Indonesia |
| | PHL | Philippines |
| | VNM | Vietnam |
| | THA | Thailand |
| | MYS | Malaysia |

| | | |
|---|---|---|
| | PAK | Pakistan |
| | BGD | Bangladesh |
| | LKA | Sri Lanka |
| | ROA | Rest of Asia |
| Other developing regions | LAM | Latin America |
| | AFR | Africa |
| | MEN | Middle East and North Africa |
| | ROW | Rest of World |

ROA: Hong Kong, Taiwan, Singapore, Mongolia, and other Asian countries that are not included elsewhere; ROW: mainly Eastern Europe (including Russia and Turkey) and Central Asia.

**Table 3 Sectors in G-Cubed**

| Number | Sector |
|---|---|
| 1 | Energy |
| 2 | Mining |
| 3 | Agriculture |
| 4 | Durable Manufacturing |
| 5 | Non-Durable Manufacturing |
| 6 | Services |

This model assumes that all countries, including Bangladesh, have access to concessionary finance from the USA. They can borrow at an official interest rate (1% real interest rate) in addition to their commercial borrowing. Concessionary loans are recorded as a separate debt stock, called official debt, and the total debt stock equals commercial debt stock plus official debt stock. If the government is unable to make interest payments on concessionary loans in a given year, scheduled interest payments will be accumulated as official debt stock.

The model considers all trade and financial links between countries and allows for inter-industry input-output linkages, the movement of factors of production, and consumption and investment dynamics. It distinguishes between the stickiness of physical capital within sectors and countries and the flexibility of financial capital, which flows to sectors and countries with the highest returns. Households and firms are considered as two types of agents-one group takes its decision based on forward-looking expectations, and the other group takes its decision based on the rule of thumb, which is optimum in the long run. The model allows for short-run wage rigidity, which, in turn, can lead to significant periods of unemployment, depending on the labour market equilibrium in each country. It assumes labour is perfectly mobile within a region and immobile across regions. It also assumes that labour supply is completely inelastic in the long run and is exogenously determined by population growth.

In terms of policy closures, the model assumes government spending is exogenous, and the government deficit is endogenous. Fiscal sustainability is maintained by imposing a lump-sum tax on households equal to the change in interest servicing costs. It implies that the fiscal deficit can change permanently, but the debt-to-GDP ratio will eventually stabilize at a new level. Central banks set short-term nominal interest rates to target their macroeconomic mandates, such as inflation, unemployment or the exchange rate. Long-run inflation rates are anchored while allowing for short-term fluctuations through monetary rules. Central banks do not change their view of potential output and therefore do not take any action regarding climate damage or government investment.

The paper considers the government's 8-sector NAP as a reference for the investment in climate adaptation. Ricardo et al. (2017) discuss five channels through which natural disasters affect the economy: permanent damage to public infrastructure, permanent damage to private capital, temporary productivity losses resulting from economic and social disruption, inefficiencies in public investment during the reconstruction period, and damage to the sovereign's creditworthiness. The government's total investment is assumed to increase labour productivity and total factor productivity. The government's 8-sector climate adaptation plan outlined in the NAP is mapped to the 6-sector G-Cubed Model (Table 4). The benefits from the government investment outlined in the NAP are converted into improvements in labour-augmented productivity and total factor productivity under various assumptions (Table 7). This investment contributes to increasing labour productivity in the agriculture and service sectors and to increasing total factor productivity across the agriculture, durable manufacturing, non-durable manufacturing, and service sectors. These benefits are offset by sectoral productivity losses stemming from the global climate shock.

**Table 4 Mapping the NAP to the G-Cubed model**

| Sector | Adaptation Sectors (Share of total investment) | Mapped G-Cubed Sector | How to feed into G-Cubed |
|---|---|---|---|
| 1 | Water Resources (51.8) | Services/ Agriculture/ Durable Manufacturing | Water-related infrastructure, early warning system for hydro-met disasters, transboundary cooperation, basin management: **Public investment and TFP in agriculture & services.** |
| 2 | Disaster, Social Safety & Security (11.7) | Services | Disaster preparedness with cyclone shelters, flood shelters, and early warning systems for lightning and landslides. Building climate-resilient housing facilities, mitigating disruptions in livelihood, safety nets, and security: **Public transfers, insurance spending, or public investment in services.** |
| 3 | Agriculture (8.3) | Agriculture | Direct productivity shocks (e.g., improved irrigation), input subsidies, or adaptation capital expenditure: **TFP in agriculture.** |
| 4 | Fisheries, Aquaculture, and Livestock (7.0) | Agriculture | Livestock and aquatic food systems (part of the agriculture sector): **TFP in agriculture.** |
| 5 | Urban Areas (16.5) | Services | Investment in urban drainage and heat islands, green and blue infrastructure, health, and wash facilities: C**apital accumulation in durable goods/services.** |
| 6 | Ecosystems, Wetlands, and Biodiversity (2.6) | Services /Agriculture | Sustainable management of forestry, land, haor, wetlands, invention of stress-tolerant plant species, management of marine and ocean ecosystems for blue economy, forest-dependent livelihoods, and ecosystem-based adaptation. |
| 7 | Policies and Institutions (0.7) | All sectors | Integrate climate change into development planning, improve the efficiency, reduce leakage and corruption: **TFP** |
| 8 | Capacity Development, Research and Innovation (1.3) | All sectors | **TFP growth** |

## 3.2 Baseline

The model is solved from 2023, with forward-looking variables adjusted so that the model's 2023 solution replicates the data for that year.[2] To generate a baseline for the future, key inputs include

[2] The solution algorithm is described in detail at https://documentation.gcubed.com/papers/Solving%20G-Cubed%20without%20policy%20optimisation.pdf.

exogenous projections of age-specific population growth and the economy's sectoral labour-augmenting productivity growth. The dynamics of endogenous variables, such as national and sectoral output, are driven by labour force growth and productivity growth. A brief description is provided below, while more details are available in Fry-McKibbin et al. (2025).

Individuals in each region are assumed to follow a hump-shaped age-productivity profile, so the aggregate effective labour supply at any given time is the sum across all age cohorts of age-specific productivity weighted by each cohort's size. Population data are sourced from the United Nations World Population Prospects 2024 (the medium variant), while age-specific labour income data are sourced from the National Transfer Account database.

In addition, we introduce sector-specific labour-augmenting productivity growth that varies across sectors but is independent of age; within each sector and region, all workers experience the same productivity growth regardless of age. The projection of labour-augmenting productivity growth by sector and region follows a catch-up mechanism. We assume that US labour productivity grows at an annual rate of 1.4% (US CBO 2023), with this rate applied uniformly across all sectors. Non-US regions are assumed to catch up with the United States across sectors, gradually closing initial productivity gaps. Consequently, regions initially behind the United States would generally grow faster than the United States. We customize catch-up rates to account for differences across countries and sectors, ensuring that near-term GDP growth rates in each region are roughly consistent with their historical growth performance.

## 4 Climate adaptation scenarios

After generating a baseline projection of the model under no climate shocks and no policy changes, we consider four alternative scenarios. Scenario 1 posits that the country faces a climate shock but that the government takes no action to mitigate the damage. Scenario 2 assumes that the country faces a climate shock and that the government invests in resilience infrastructure. Scenario 2.1 assumes that the government finances its adaptation investments with concessional finance. Scenario 2.2 assumes that the government funds adaptation through domestic taxes. Scenario 2.3 assumes that the government invests in resilient infrastructure with commercial borrowing (standard loans).

**Scenario 1**: Climate shock without adaptation investment

With this scenario, the government faces global climate shocks that reduce labor and total productivity, yet it takes no initiative to mitigate the damage. In the event of a natural disaster, as both public infrastructure and private capital are lost, overall capital per worker will decrease, and each worker will produce less; thus, labour-augmenting productivity and total productivity will be affected. Damage functions, which show the relationships between climate variables (typically average temperature or humidity, or heating days and economic variables (potential income, productivity, resource endowments), are widely used to trace the various mechanisms through which the climate can affect the economic system. In a general equilibrium setting, it is possible to account for second-order effects linked to variations in relative prices, which are often relevant. Roson and Sartori (2016) estimate parameters of damage functions for 140 countries and regions, including Bangladesh, in the GTAP9 dataset, and for six climate impacts: sea level rise, variation in crop yields, heat effects on labour productivity, human health, tourism, and household energy demand.

In this scenario, historical climate damage relative to the 1985-2005 average serves as a climate-damage shock for four sectors (Agriculture, Durable manufacturing, Non-durable manufacturing, Services) of the Bangladesh economy, following Fernando et al. (2021) and Liu et al. (2025). The damage functions, based on historical data, are used in conjunction with future temperature projections (global temperatures are projected to increase by approximately 2ºC between the 1985-2005 average and 2050 or by 1.3ºC between 2025 and 2050, consistent with projections under the SSP5-8.5 scenario (Kikstra et al., 2022)) to generate expected future climate shocks. The productivity losses are presented in Table 5.

**Table 5 Sectoral productivity loss (from baseline) due to climate shock (percentage point)**

| Year\Variable | Labour Productivity in agriculture | Labour productivity in services | TFP in agriculture | TFP in durable manufacturing | TFP in non-durable manufacturing | TFP in services |
|---|---|---|---|---|---|---|
| 2026 | -2.78791 | -0.69991 | -1.20352 | -0.00009 | -0.00009 | -0.00009 |
| 2027 | -2.79646 | -0.70846 | -1.20352 | -0.00010 | -0.00010 | -0.00010 |
| 2028 | -2.80502 | -0.71702 | -1.20353 | -0.00010 | -0.00010 | -0.00010 |
| 2029 | -2.76132 | -0.71392 | -1.18013 | -0.00010 | -0.00010 | -0.00010 |
| 2032 | -2.94340 | -0.77420 | -1.25034 | -0.00012 | -0.00012 | -0.00012 |
| 2033 | -3.10905 | -0.81805 | -1.32055 | -0.00012 | -0.00012 | -0.00012 |
| 2034 | -3.32744 | -0.87404 | -1.41416 | -0.00013 | -0.00013 | -0.00013 |
| 2035 | -3.54650 | -0.93070 | -1.50777 | -0.00014 | -0.00014 | -0.00014 |
| 2036 | -3.76623 | -0.98803 | -1.60138 | -0.00015 | -0.00015 | -0.00015 |
| 2037 | -3.93436 | -1.03436 | -1.67159 | -0.00016 | -0.00016 | -0.00016 |
| 2038 | -4.10300 | -1.08120 | -1.74180 | -0.00017 | -0.00017 | -0.00017 |
| 2039 | -4.27214 | -1.12854 | -1.81201 | -0.00018 | -0.00018 | -0.00018 |
| 2040 | -4.44177 | -1.17637 | -1.88222 | -0.00019 | -0.00019 | -0.00019 |
| 2041 | -4.66416 | -1.23636 | -1.97583 | -0.00020 | -0.00020 | -0.00020 |
| 2042 | -4.83496 | -1.28536 | -2.04604 | -0.00022 | -0.00022 | -0.00022 |
| 2043 | -5.05851 | -1.34651 | -2.13966 | -0.00023 | -0.00023 | -0.00023 |
| 2044 | -5.33498 | -1.41998 | -2.25667 | -0.00024 | -0.00024 | -0.00024 |
| 2045 | -5.56422 | -1.48507 | -2.35119 | -0.00026 | -0.00026 | -0.00026 |
| 2046 | -5.82913 | -1.57118 | -2.45320 | -0.00027 | -0.00027 | -0.00027 |
| 2047 | -6.09471 | -1.65796 | -2.55521 | -0.00028 | -0.00028 | -0.00028 |
| 2048 | -6.36096 | -1.74540 | -2.65723 | -0.00030 | -0.00030 | -0.00030 |
| 2049 | -6.56581 | -1.81615 | -2.73374 | -0.00031 | -0.00031 | -0.00031 |
| 2050 | -6.77117 | -1.88741 | -2.81025 | -0.00033 | -0.00033 | -0.00033 |

Source: Liu et al. (2025).

**Scenario 2**: Climate shock with adaptation investment

In contrast to scenario 1, this scenario assumes government investment of USD 8.5 billion annually through 2050 in resilience infrastructure for climate change adaptation. The government's planned investment in the NAP is assumed as a reference. As the government investment remains the same each year, the investment size drops to 0.7 percent of GDP in 2050 from 1.7 percent of GDP in 2026 (Figure 1).

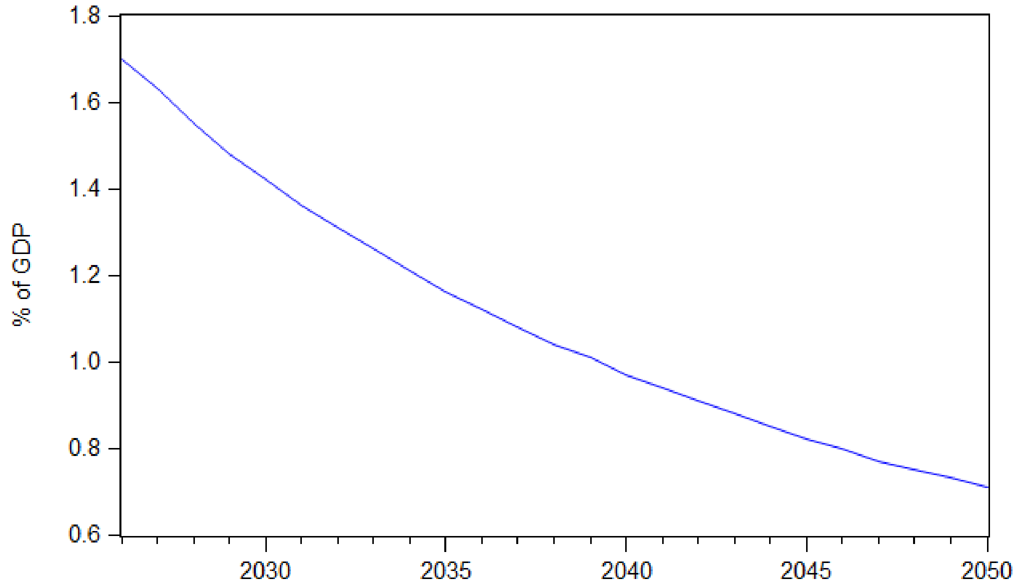


**Figure 1 Government investment for climate adaptation (% GDP)**

Investment in resilience infrastructure increases labour productivity and total factor productivity. Productivity gains from this investment (relative to the baseline) are estimated under various assumptions (see details in the Appendix Table 7) and then netted against the sectoral productivity losses from historical climate damage. The net productivity gains are presented in Table 6.

**Table 6 Net sectoral productivity gain (from baseline) due to adaptation investment (percentage point)**

| Year\Variable | Labour Productivity in agriculture | Labour productivity in services | TFP in agriculture | TFP in durable manufacturing | TFP in non-durable manufacturing | TFP in services |
|---|---|---|---|---|---|---|
| 2026 | -2.73379 | -0.55691 | -1.11629 | 0.05219 | 0.03733 | 0.02991 |
| 2027 | -2.69074 | -0.42908 | -1.03309 | 0.10204 | 0.07302 | 0.05852 |
| 2028 | -2.64999 | -0.30737 | -0.95362 | 0.14966 | 0.10711 | 0.08584 |
| 2029 | -2.55914 | -0.17968 | -0.85422 | 0.19521 | 0.13972 | 0.11198 |
| 2032 | -2.61122 | 0.10358 | -0.71486 | 0.32078 | 0.22962 | 0.18404 |
| 2033 | -2.73694 | 0.16524 | -0.72070 | 0.35934 | 0.25722 | 0.20616 |
| 2034 | -2.91693 | 0.21070 | -0.75242 | 0.39642 | 0.28377 | 0.22744 |
| 2035 | -3.09904 | 0.25170 | -0.78645 | 0.43212 | 0.30932 | 0.24792 |
| 2036 | -3.28316 | 0.28844 | -0.82268 | 0.46649 | 0.33393 | 0.26764 |
| 2037 | -3.41699 | 0.33279 | -0.83757 | 0.49964 | 0.35765 | 0.28666 |
| 2038 | -3.55252 | 0.37343 | -0.85441 | 0.53161 | 0.38054 | 0.30500 |
| 2039 | -3.68970 | 0.41054 | -0.87310 | 0.56247 | 0.40263 | 0.32271 |
| 2040 | -3.82846 | 0.44427 | -0.89355 | 0.59228 | 0.42396 | 0.33981 |
| 2041 | -4.02101 | 0.46312 | -0.93907 | 0.62109 | 0.44459 | 0.35634 |
| 2042 | -4.16296 | 0.49037 | -0.96277 | 0.64895 | 0.46453 | 0.37232 |
| 2043 | -4.35859 | 0.50299 | -1.01137 | 0.67591 | 0.48383 | 0.38779 |
| 2044 | -4.60803 | 0.50096 | -1.08481 | 0.70201 | 0.50251 | 0.40276 |
| 2045 | -4.81109 | 0.50506 | -1.13711 | 0.72729 | 0.52060 | 0.41726 |
| 2046 | -5.05062 | 0.48601 | -1.19822 | 0.75179 | 0.53814 | 0.43131 |
| 2047 | -5.29159 | 0.46426 | -1.26056 | 0.77555 | 0.55515 | 0.44494 |
| 2048 | -5.53396 | 0.43990 | -1.32409 | 0.79860 | 0.57164 | 0.45816 |
| 2049 | -5.71564 | 0.43038 | -1.36325 | 0.82097 | 0.58765 | 0.47100 |
| 2050 | -5.89850 | 0.41858 | -1.40349 | 0.84269 | 0.60320 | 0.48346 |

Figure 2 shows changes in productivity from the baseline (percentage points), with and without adaptation investment. The gap between the two lines presents sectoral productivity gain from the adaptation investment. Higher productivity helps sustain the growth trajectory despite adverse climatic change.

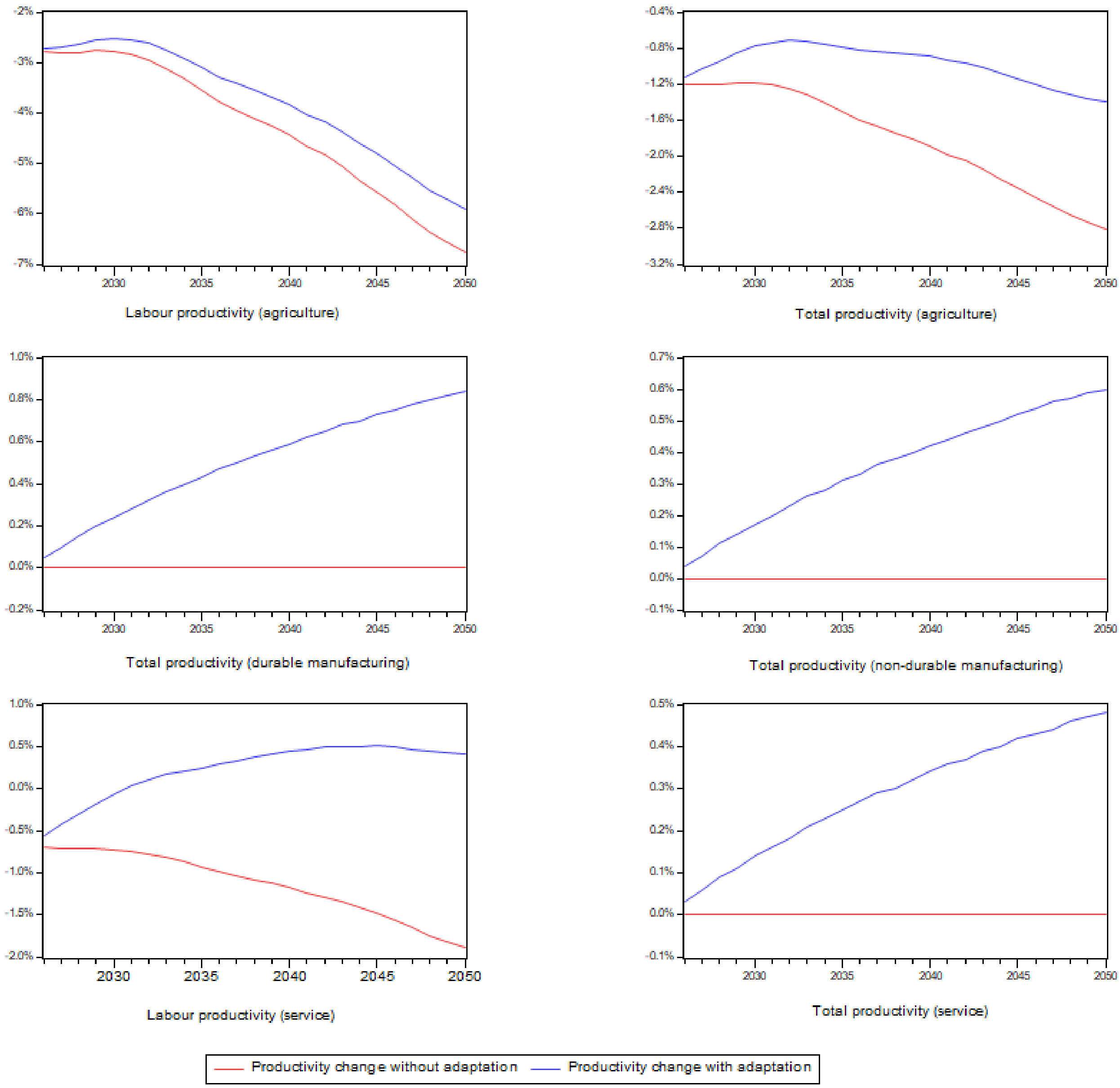


**Figure 2 Change in productivity (relative to baseline) without and with adaptation (percentage point)**

As the government planned to mobilize USD 6 billion (71 % of the total finance) as concessional finance out of USD 8.5 billion from development partners, for simplicity, this paper assumes that the government finances the entire climate adaptation investment either from i) concessional external financing, or ii) domestic taxation, or iii) commercial borrowing.

**Scenario 2.1 (concessional financing):** This scenario assumes that the government finances the entire $8.5 billion investment (1.7% of fiscal year 2026 GDP) from the USA at a concessional rate[3]. A lower interest rate reduces the government's interest payments, thereby moderating the government's budget deficit and exerting less pressure on government debt.

**Scenario 2.2 (domestic taxation)**: This scenario considers a case in which the government receives no assistance from external sources or the private sector. Consequently, the government finances the entire investment with domestic taxation. Although climate adaptation finance may not directly affect the budget deficit, taxation imposes a burden on the economy, potentially reducing domestic consumption or investment demand and slowing economic activity. Lower GDP growth will affect government revenue and government expenditure, and hence the budget balance.

**Scenario 2.3 (commercial borrowing)**: This scenario assumes that the government receives no concessionary finance from development partners and finances the entire investment through commercial borrowing, i.e., interest rates are endogenously determined by the market. The funds could come from the domestic or international market.

The paper examines how key macro variables such as interest rate, inflation, consumption, investment, GDP, exchange rate, government budget deficit, government debt, and sectoral output (agriculture, durable manufacturing, non-durable manufacturing, and services) respond to climate shock without any adaptation measure and with adaptation measures as outlined in the NAP. The paper also identifies which financing mode is less burdensome for the government and whether it is preferable to proceed with commercial borrowing or to impose domestic taxes in the event of a reduced flow of concessional external funding.

[3] The concessional interest rate is assumed as 1 percent real interest rate.

## 5 Results

This section reports the responses of key macroeconomic variables, including real interest rates, inflation, consumption, investment, GDP, budget deficits, government debt, and real exchange rates relative to the baseline. Sectoral results are also considered and presented, as some sectors benefit more than others. All reported responses are expressed as deviations from the baseline, measured either as percentages or percentage points, over the period from 2026 to 2050.

### 5.1 Macroeconomic Variables

Figure 3 presents the results of private investment. Without adaptation, investment declines as productivity decreases due to climate shocks. However, the government's climate adaptation spending increases investment, completely offsetting the climate impacts. Government investment affects private investment through multiple channels, including productivity improvement, higher public spending, intertemporal reallocation of the government budget, and changes in real interest rates. Among them, productivity improvements increase private investment, whereas higher public spending crowds out private investment. The overall dynamics and magnitude of the effects also depend on the financing method. While the long-run effects are similar across the three financing options, the short- and medium-run effects differ. Private investment responds mostly strongly to concessional financing, as the government leverages external resources at the lowest cost, thereby reducing the burden of immediate, higher-interest payments. If the government finances adaptation through commercial borrowing, the investment response is weaker than with concessional financing because of higher interest costs. In the case of tax financing, the short-run investment response is the weakest, as increased taxes partially crowd out private investment. However, in the long run, tax-financed investment attracts more investment, as the government avoids accumulating public debt and thus reduces debt servicing costs.

Fodha and Yamagami (2025) explore the trade-off between higher public debt used to finance adaptation and the risk that it raises interest rates and crowds out private investment. As adaptation spending on infrastructure, such as resilient roads, water systems, and flood protection, increases the productivity of private capital, it can crowd in private investment. In particular, private firms may increase investment if the government investment reduces the risk of climate disasters and improves the business environment through better water management, transport, and energy supply. John Nana et al. (2024) find that public investment complements private investment by raising the marginal productivity of private investment. An additional dollar of public investment increases private investment by 1.6 dollars, based on panel data across 109 developing countries. In the context of climate change, government investment in climate adaptation can reduce the frequency and severity of climate-related shocks, thereby improving the return to private investment and lowering the risk premium, encouraging private investment.

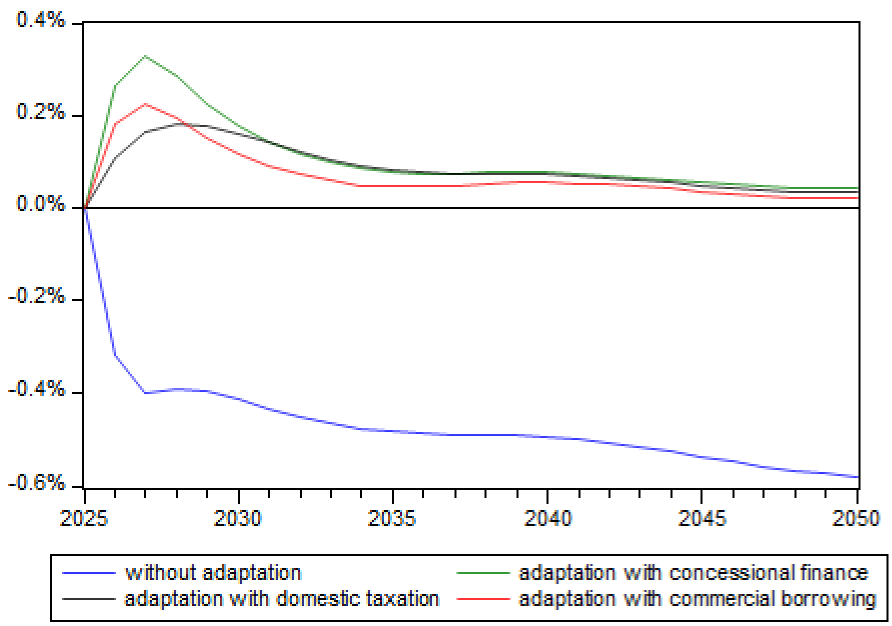


**Figure 3 Response of investment relative to baseline**

Figure 4 presents the results of the real interest rate. In the climate scenario without government investment, as productivity declines, the real interest rate falls by approximately 0.4 percentage points (40 basis points). In the short term, the initial inflation spike from the supply contraction in scenario 1 prompts the central bank to temporarily raise interest rates. Also, in the adaptation scenarios, government spending typically acts as a fiscal expansion, increasing demand for goods and services. Higher demand for goods and services can lead to higher output and potentially inflationary pressures. In the medium term, climate adaptation projects, such as flood control, coastal protection, and climate-resilient infrastructure, can enhance the productive capacity and reduce production risks. As climate adaptation improves the efficiency of private investment, it crowds in private investment, potentially raising the real interest rate. Regardless of financing options, in the short and medium run, the overall effect is dominated by climate adaptation, keeping the real interest rates above the baseline. Among the three financing options, tax financing has the weakest effect on the real interest rate. As the model assumes a lump-sum tax on households, a higher tax reduces household disposable income and suppresses domestic demand. Overall, an increase in government spending raises domestic demand and increases the real interest rate. In the long run, however, the impact of climate damage outweighs the adaptation effect as the productivity gains from adaptation diminish over time, leading the real interest rate to fall below the baseline.

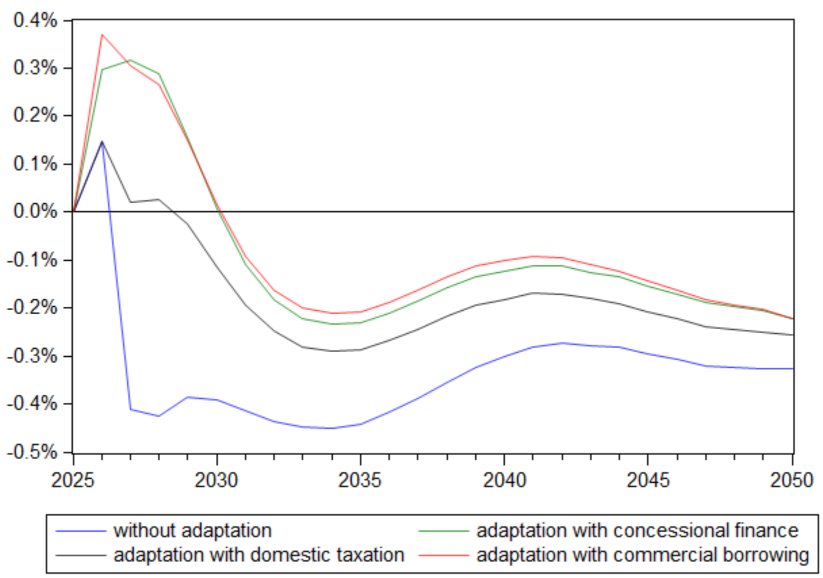


**Figure 4 Response of the real interest rate relative to baseline (percentage points)**

Figure 5 shows the responses of private consumption. Domestic consumption continues to fall over time in response to climate shocks. Government spending for climate adaptation raises short-term aggregate demand through direct purchases of goods and services. As a result, workers and firms in construction, materials, and services experience higher incomes, which can raise household consumption, especially if households are liquidity-constrained or have a high marginal propensity to consume. In addition, as government spending in climate adaptation increases private productivity, households expect higher lifetime income, thereby encouraging higher consumption through forward-looking behaviour. However, the financing method of government spending also has important implications for consumption dynamics in the short and medium run. If the government finances adaptation from domestic taxation, it reduces households' disposable income and adversely affects private consumption. This negative tax effect dominates the positive spending and productivity effects, resulting in the overall response to fall below the baseline. In contrast, for concessional financing, the positive spending and productivity effects significantly outweigh the tax effect, leaving the overall response well above the baseline.

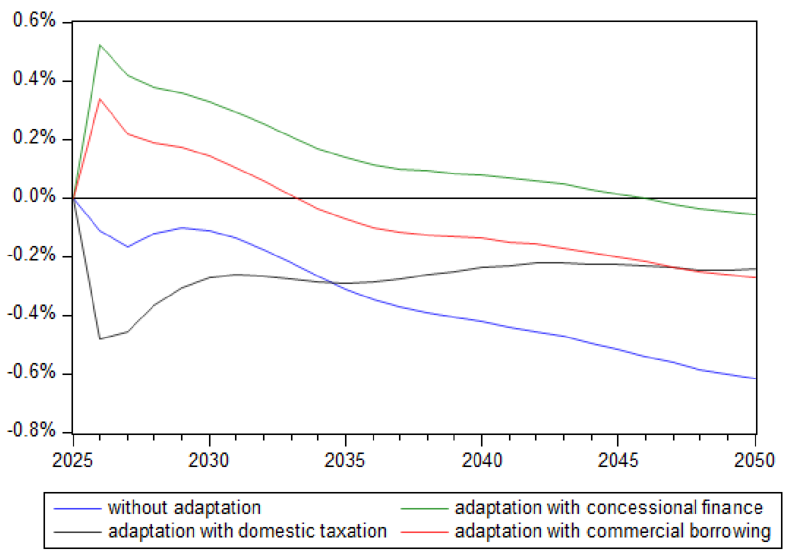


**Figure 5 Response of consumption relative to baseline**

Figure 6 presents the results of GDP, showing that adaptation spending initially causes real GDP to fall in the short run due to the strong climate impact in the first several years. In the medium term, resilient infrastructure, such as roads, drainage, irrigation, and coastal defences, can raise total factor productivity, thereby raising GDP. Moreover, as the frequency and severity of disasters decline due to adaptation investment, it helps prevent crop losses, infrastructure damage, and health impacts. Avoiding these losses can help achieve higher output. Furthermore, if public investment is complementary and can crowd in private investment, the gain in GDP may be greater. Adarov et al. (2024) suggest that public investment can significantly boost economic growth in emerging markets and developing economies, and that the multiplier increases with efficient investment, potentially reaching 1.6 percent during recessions and in capital-scarce economies. In our scenarios, adaptation investments primarily offset losses from historical climate damage, and the output remains close to the baseline.

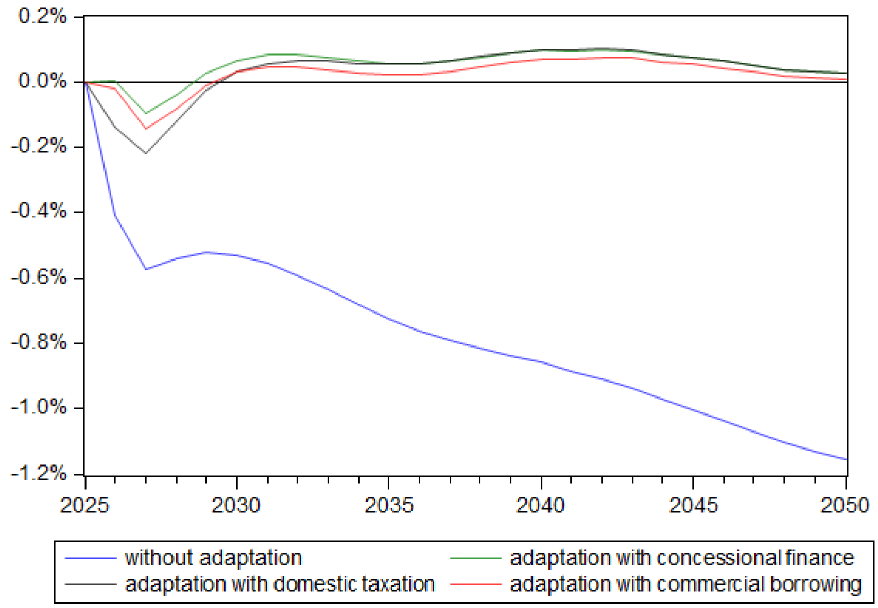


**Figure 6 Response of real GDP relative to baseline**

Figure 7 shows that the budget deficit responses are due to climate adaptation expenditure. The magnitude of responses varies across climate financing modes. Climate financing through commercial borrowing immediately increases the government's liability by raising interest and principal payments. The budget deficit increases by 1 percentage point in the short run and remains 0.8 percentage points above the baseline in the long run. However, when the government finances climate adaptation with concessional finance, it significantly eases its fiscal pressure through lower interest payments, long grace periods, and delayed principal payments. Thus, the budget deficit increases by only 0.2 percentage points in the long run. The budget deficit remains close to the baseline when the government finances the climate adaptation with domestic taxation.

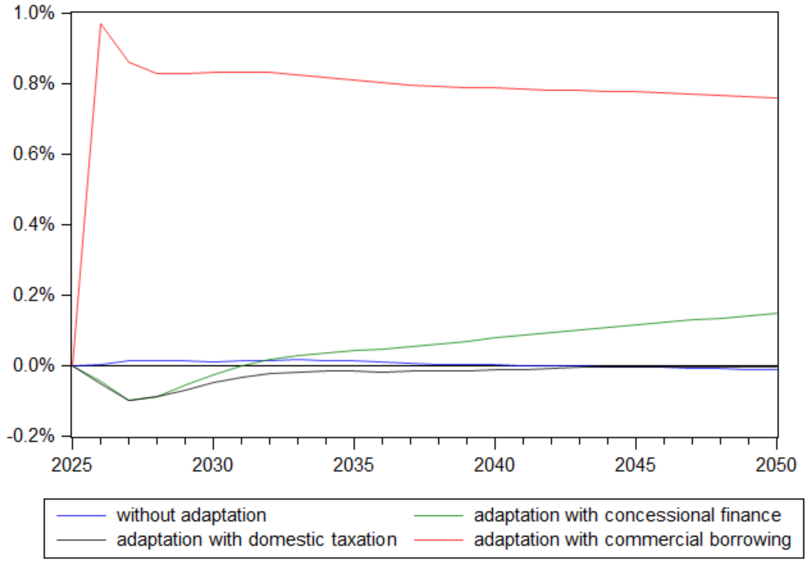


**Figure 7 Response of the budget deficit relative to baseline**

Figure 8 shows the responses of government debt. As the budget deficit rises quickly through government financing via commercial borrowing, government debt rises rapidly as well. Government debt rises to approximately 7 percentage points above the baseline by 2050. In contrast, under concessional finance, as interest payments gradually increase due to lower interest rates and a delayed repayment schedule, government debt rises by 1 percent of GDP relative to the baseline in 2050. As the budget deficit remains close to the baseline with domestic taxation, government debt also remains close to the baseline.

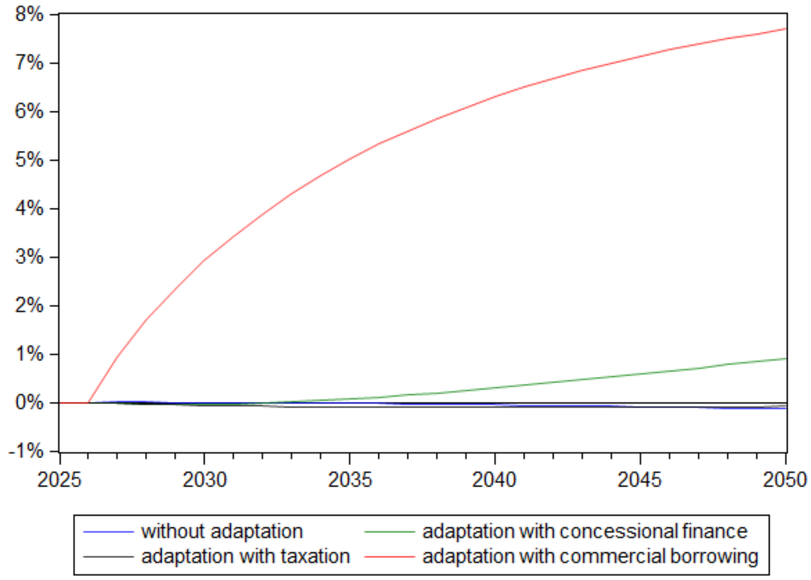


**Figure 8 Response of government debt relative to baseline**

Figure 9 shows the initial spike in inflation as the government spending stimulates the domestic demand in the short run. Without any investment in adaptation, inflation remains above baseline due to climatic impacts, and the central bank is assumed not to change the potential growth target. In Bangladesh, food accounts for nearly 46 percent of the consumption basket and contributes significantly to the consumer price inflation (CPI) compared to other emerging and developing economies (HIES, 2022). Raihan (2025) underscores that price inflation in Bangladesh reflects deeper structural challenges, such as inefficiencies in supply chains, price distortions, and disruptions in the agriculture and energy sectors. The larger weight of food in the CPI basket indicates that food price fluctuations due to climate shocks are likely to have a greater impact on the CPI in Bangladesh. Although government spending initially stimulates domestic demand and inflation, improved infrastructure resilience may reduce supply disruptions and agricultural losses. Therefore, inflation declines relative to the baseline, as supply-side constraints ease and climate-related disruptions become less frequent. Among the three financing modes, tax financing appears to have a smaller impact than the baseline, as taxes reduce disposable income and offset domestic demand pressure.

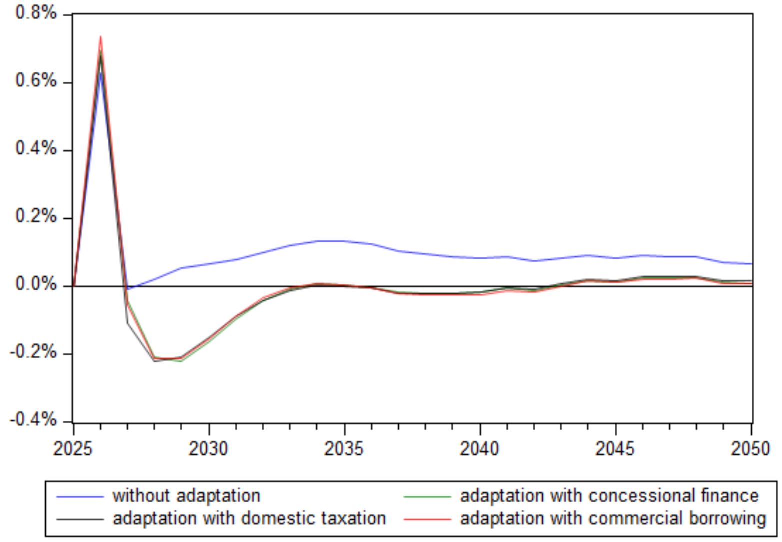


**Figure 9 Response of inflation relative to baseline**

Figure 10 shows the responses of the real exchange rate. In climate adaptation, when both concessional finance and commercial borrowing are used, the exchange rate appreciates significantly as capital inflows increase demand for non-tradables (construction and services), thereby raising their prices relative to tradables. Moreover, higher imports for project inputs can put pressure on the trade balance and the nominal exchange rate. In the medium term, if external funds are used for productive public capital that raises tradeable-sector productivity or reduces production losses from climate shocks, the exchange rate appreciation can be reversed or moderated. The appreciation of the exchange rate also gradually moderates as climate adaptation increases capital productivity. If the government finances climate adaptation through domestic taxation, higher taxes reduce disposable income, lower domestic demand and imports, and thus improve the trade balance and lower prices for non-tradable goods, leading to a depreciation of the real exchange rate. However, if taxes are partly allocated to productive investment, supply effects may offset some of the depreciation.  Figure 10 also confirms that climate financing with taxation has a minimal effect on the exchange rate appreciation.

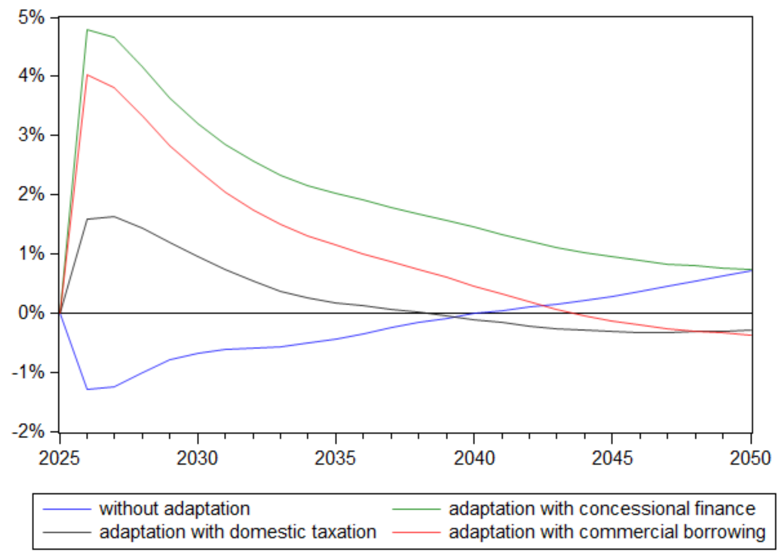


**Figure 10 Response of the real exchange rate relative to baseline**

## 5.2 Sectoral Variables

This subsection presents the output results for four sectors: agriculture, durable manufacturing, non-durable manufacturing, and services. The results show strong heterogeneity across sectors and scenarios.

Figure 11 illustrates the responses of agricultural output to different financing modes for climate adaptation. Without any investment in adaptation, agricultural output declined persistently (by approximately 2 percentage points in 2050). Delaporte and Maurel (2018) also estimate that climate shocks disproportionately affect the agricultural sector in Bangladesh. With the implementation of climate adaptation measures, agricultural output recovers substantially relative to the baseline (within 0.8 percentage points of the baseline). Climate adaptation investments are largely construction- and service-intensive, generating demand for construction-related works and materials, such as cement, steel, skilled labour, and machinery. Higher wages and input prices draw workers out of the agricultural sector, since agriculture is labor-intensive and employs 46 percent of the country's workforce.[4] As the sector is already constrained by labour shortages and seasonal labour movements, when construction wages rise, workers leave the agriculture sector in search of better-paying jobs. This might prevent the agricultural sector from recovering from losses caused by climate shocks despite investment in adaptation. The agricultural sector recovers slightly more when the government finances its adaptation with external financing, especially through concessional finance. The agriculture sector may benefit from exchange rate appreciation resulting from external inflows of foreign finance, as agricultural inputs such as fertilizer are imported. In contrast, tax-financed adaptation reduces households' disposable income and subsequent investment in the agricultural sector, and prevents the sector from recovering early.

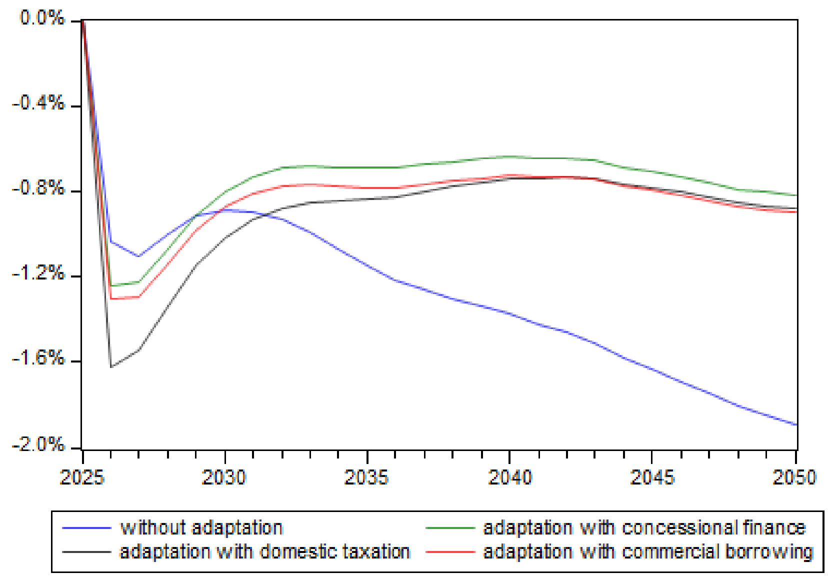


**Figure 11 Response of the agricultural output relative to baseline**

Without any adaptation, the output of the durable Manufacturing sector continues to fall, dropping by 1.7 percentage points below the baseline by 2050 (Figure 12). However, the government's climate adaptation investment has a strong long-run effect on the durable manufacturing sector. Climate adaptation investments increase local demand for durable goods, as they entail the construction of embankments, flood defenses, cyclone shelters, water and sanitation infrastructure,

[4] Quarterly Labour Force Survey 2024 Bangladesh by Bangladesh Bureau of Statistics.

and energy-resilient equipment. These projects need steel, cement, heavy equipment, electrical systems, and construction vehicles. Therefore, the demand for durable manufacturing increases as the adaptation plan is implemented. The durable manufacturing sector recovers earlier under domestic tax financing because external borrowing leads to an appreciation of the real exchange rate (Figure 10), thereby reducing the competitiveness of tradable sectors and increasing import penetration. In contrast, domestic taxation avoids large capital inflows and preserves export competitiveness, allowing the durable manufacturing sector to recover more quickly despite the short-run contractionary effects of taxation. However, in the long run, the durable manufacturing sector will also recover with external financing. Overall, the durable manufacturing sector benefits from this investment in adaptation until 2050.

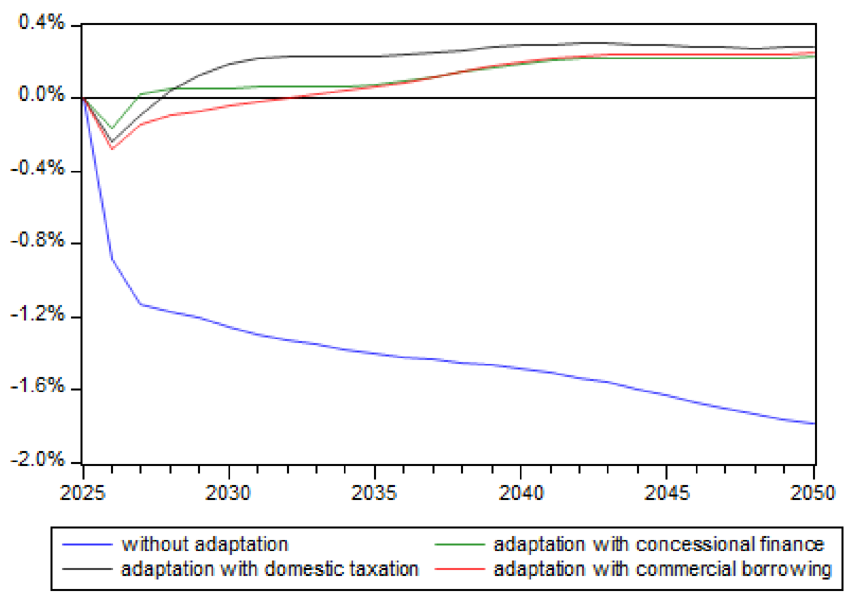


**Figure 12 Response of the durable manufacturing output relative to baseline**

Figure 13 shows that without any adaptation, the output of the non-durable sector continues to fall from the baseline by approximately 1.2 percentage points by 2050. However, with the government investment in adaptation, the non-durable sector gradually recovers from the initial negative short-run impact. The initial adverse impacts stem from the appreciation pressure on the domestic currency in the case of external financing of the adaptation. The non-durable manufacturing sector in Bangladesh includes garments, textiles, food processing, beverages, and basic consumer goods.

The largest non-durable manufacturing sector is ready-made garments and textiles, which are highly export-oriented. If the government finances its climate adaptation with external finance, whether concessional or commercial borrowing, large capital inflows increase the foreign-currency supply and appreciate the domestic currency (Figure 10), thereby making Bangladeshi exports more expensive and reducing their demand in the rest of the world. Kamar et al. (2010) find that capital flows in developing countries lead to exchange rate appreciation and could have detrimental effects on competitiveness, jeopardizing exports. Domestic consumers also substitute cheaper foreign goods for domestic consumer goods. The tax-financed adaptation also initially suppresses the non-durable sector; however, it shows a slightly less adverse impact with domestic taxation, reflecting less pressure from domestic-currency appreciation. Furthermore, climate adaptation projects, which are inherently designed to benefit other sectors, such as the services sector, could divert resources from the non-durable sector.

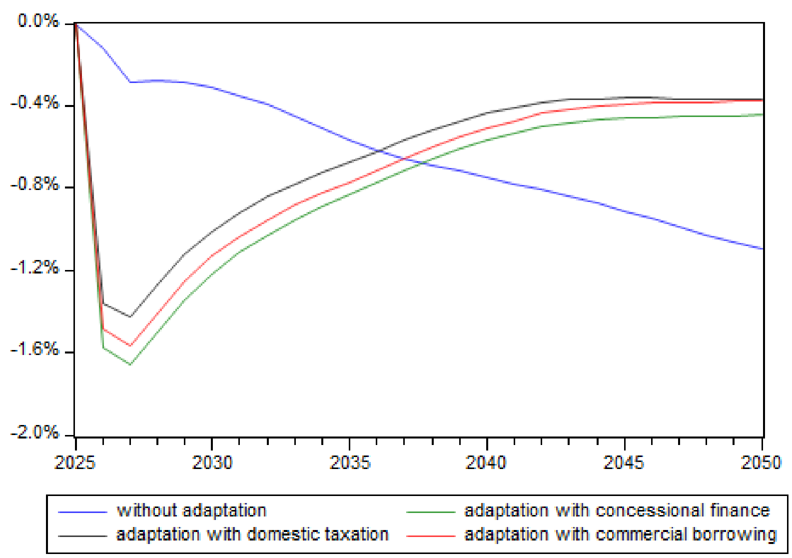


**Figure 13 Response of non-durable manufacturing output relative to baseline**

Figure 14 shows the service sector's response to the government's investment plan. Without any investment in adaptation, the service output remains below the baseline. In all adaptation scenarios, the service sector expands above the baseline. Climate adaptation investments primarily flow to the service sector. Climate spending increases the demand for construction work and construction materials, such as cement, steel, transport, skilled labour, and machinery. The service sector's productivity will improve with new capital investment. Therefore, the service sector bid up wages and input prices, diverting resources from other sectors, such as agriculture. Even when the government finances adaptation through domestic taxes, service-sector output remains above the baseline through 2050.

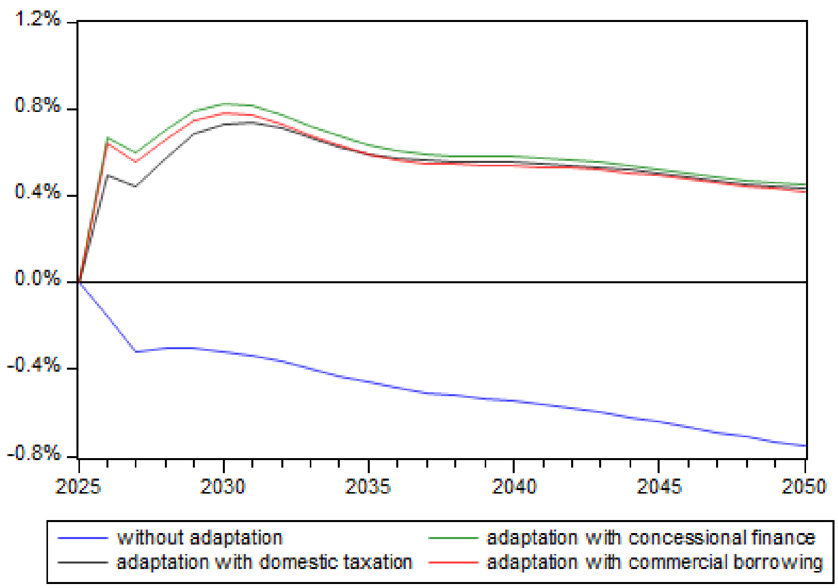


Figure 14 Response of service sector output relative to baseline

## 6 Conclusion

Climate change poses a significant threat to the Bangladeshi economy. To minimize the economic damage from climate shocks, Bangladesh must invest in effective adaptation strategies. With significant public investment directed toward resilience infrastructure, quantifying the macroeconomic, fiscal, and sectoral implications of climate adaptation financing is essential for selecting an appropriate financing mix. This paper presents one of the first quantitative, model-based assessments of Bangladesh's large-scale climate-adaptation investment of USD 8.5 billion from 2026 to 2050, along with its financing options, within a global general-equilibrium framework.

The results show that Bangladesh will be worse off if it does nothing in response to climate change damage. If the government undertakes planned investments in resilient infrastructure, the country can offset expected climate damage by improving sectoral productivity. The study finds that while concessional external finance yields the most favorable fiscal outcomes, it is subject to exchange-rate appreciation pressures that can adversely affect the tradable sector. Commercial borrowing remains a feasible alternative despite its higher financing costs and debt implications, as adaptation investment is critical to prevent productivity losses from climate shocks, given a substantial and persistent gap between the adaptation finance needed and the available concessional support. In contrast, tax-financed adaptation yields relatively smaller economic gains, reflecting contractionary effects on domestic demand. The likely scenario would be a blend of financing among concessional, non-concessional, and tax-based financing, although Khatun et al. (2025) recommend grants rather than loans for climate adaptation. However, careful consideration of concessional, commercial, and tax-based financing indicates that, when concessional finance is unavailable, the mode with the least adverse macroeconomic effects and the greatest benefit for the country is commercial borrowing. Sectoral analyses show that durable manufacturing and services benefit most from adaptation investment, whereas non-durable manufacturing and agriculture primarily gain from avoided climate-related losses rather than output expansion.

This research carries policy implications for Bangladesh, as the country is highly vulnerable to climate shocks and faces both financial and technical support for effective climate adaptation (Rabbani and Tahsin, 2024). The findings provide insights for policymakers, development partners, and researchers on the role of fiscal policy in supporting climate adaptation and strengthening resilience to climate risk. More broadly, it helps bridge existing knowledge gaps and support informed decision-making for sustainable climate financing in Bangladesh.

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## Appendix

**Table 7 Benefits from the implementation of the NAP**

| | Benefits | Mapped into productivity shock (Assumptions and estimation) |
|---|---|---|
| 1 | a) 1 million hectares of croplands from storm surges/ flood inundation, sea-level rise, and salinity. This results in 10.30 million additional tons of rice annually | -Total increase in rice production (25% of FY24) is assumed as 25% of the TFP increase in rice production.<br>- Rice accounts for 31.62% of the agriculture sector<br>- TFP gain in agriculture =25%*31.62%=**7.91%** |
| | b) 300,000 households will be protected from flood-related sickness. | Protected households, H=300,000<br>Average number of earners per household, $\bar{e}$ = 2(assump)<br>Total labor force, LF= **71.73 million (**BBS LFS2024Q4)<br>Baseline share of work time lost to **flood-related** sickness, $\phi$ =5%<br>Assuming loss reduction due to protection, m =30%<br>Affected workers' share w.r.t. to agriculture = $\frac{H.\bar{e}}{LF*s_{Agr}}$= $\frac{0.3*2}{71.73*0.46}$=1.82% (share of labour force in agriculture=46%)<br>Effective labour gain = $\frac{m\phi}{1-\phi} = \frac{0.3*0.05}{1-0.05}$=1.58%<br>Effective labour gain in agriculture, 1.82% $* 1.58\% = 0.03\%$ |
| | c) The livelihood of 4 million households dependent on fisheries will be protected from water-related disasters | Protected households, H= 4 M<br>Average number of earners per household, $\bar{e}$ = 2 (assump)<br>Total Labour Force, LF=71.73 M<br>Assume baseline share of work time lost due to flood-related sickness, $\phi$=5%<br>Assume loss reduction due to this protection, m = 30%<br>Affected worker's share, s= $\frac{H\bar{e}}{LF*s_{Agr}} = \frac{4*2}{71.73*0.46}$=24.25%<br>Effective labour gain, $\frac{m\phi}{1-\phi} = \frac{0.3*0.05}{1-0.05} = 1.58\%$<br>Effective labour gain in agriculture $= 24.25\% * 1.58\% = \mathbf{0.38}\%$ |
| | d) Livestock production will increase by 5 per cent. | Livestock production increases by = 5%<br>Share of livestock (animal farming) in Agriculture = 16.35%<br>TFP gain wrt agriculture =5%*16.35%=**0.82%** |
| | e) Communication infrastructure operation and maintenance costs after disasters will fall by 60 percent | e) Firms that pay telecoms as an intermediate input face lower unit cost when telecom O&M costs fall. A lower input price acts like a Hicks-neutral TFP increase for those firms.<br>New cost, C_new= 0.4 C_old<br>$$\frac{A\_new}{A\_old} = \frac{MC\_old}{MC\_new} = \frac{1}{0.4} = 2.5$$<br>Productivity increases by =2.5-1= 150%<br>If the communication input is 2% of the variable costs, s_com=2%<br>TFP gain in the industrial/service sector = 150%*2%= 3% |
| 2 | 30 million people in urban areas will benefit from improved drainage and reduced heat-island effects.<br>A. 10 % cost reduction for transport<br>B. 15% cost reduction for preventing water-borne diseases | Assuming a 10% cost for transport and a 15% cost reduction for preventing water-borne diseases, increases labour productivity by 10%.<br>Number of workers among this population = Pop* $\frac{LF}{WAP} * \frac{WAP}{Pop}$<br>=30*58.9%*69.9 M<br>=12.35 million<br>These workers as share of service sector = 12.35/ 26.23= 47%<br>LAP increase in the services sector =10% * 47%=4.71% |

| | | |
|---|---|---|
| 3 | 30% increase in income for marginal urban communities | If the whole income rise directly increases that group's effective labour by 30% (i.e., Labour productivity rises 30%)<br><br>In 2022, about 28.5% of urban residents were classified as poor or vulnerable (Razzaque and Rahman, 2025). Urban population share in 2022: 31.7% of the total population. Marginal urban population=28.5%*31.7%~ 9% of total population.<br><br>Economywide LAP increase $\Delta \ln B_{L,agg}$=9%×30% =2.71%<br>LAP increase wrt the service sector =$\frac{2.71\%}{51.44\%}$=5.27% |
| 4 | Protecting critical infrastructure such as EEZs, power hubs, housing, and other infrastructure from extreme water-related disasters would save 500,000 jobs and $5 billion in exports of goods and services. | <u>Channel 1: Jobs</u><br>No of jobs saved = 500,000<br>Total labour force, LF=71.73 million<br>Effective labour force increase, $\Delta B$= 0.5/71.73=0.68%<br><u>Channel 2: Exports</u><br>Saving $5bn from exports prevents a loss of output = 5 bn $<br>GDP in FY2025 =450.461 bn $<br>$\frac{\Delta Y}{Y} = \frac{5}{450.461}$=.0111<br>Economy-wide TFP increases= 1.11%<br>TFP gain wrt to Industry = $\frac{1.11\%}{37.37\%}$=2.97% |
| 5 | The vulnerabilities of 15 million climate migrants will decline significantly | Labour force among climate migrants =Pop* $\frac{LF}{WAP} * \frac{WAP}{Pop}$=15*58.9%*69.9%= 6.18 million.<br>This labour force as a share of the service sector =23.5%<br>Vulnerabilities of this group can be reduced by 3 channels:<br>A) unemployment falls from 20% to 10%<br>B) at baseline sick time (5%) reduced by 30%<br>C) per hour efficiency improves by 5%<br>A) LAP gain from higher employment, $\Delta \ln B$= ln $(\frac{1-u1}{1-u0})$=ln $(\frac{1-.10}{1-.20})$= 0.118<br>B) LAP gain from reduced sickness, $\Delta \ln B = (\frac{m\varphi}{1-\varphi}) = \frac{0.3*.05}{1-.05}$=.0158 (≈ 1.6%)<br>C) Per hour efficiency improvement, $\Delta \ln B$ = 5%<br>Total LAP gain =0.118+0.016+0.05=18.36%<br>LAP increase in service sector =18.36%*23.5%=4.32% |
| 6 | Tree coverage will grow by 5% | Assume that increased tree coverage increases labour productivity by 5% in the agriculture sector, as trees protect the coastal districts from natural disasters.<br><br>LAP increase in agriculture = 5% |