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FINANCING CLIMATE RESILIENCE: ESTIMATING INDIA'S DAMAGE COSTS

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EXECUTIVE **SUMMARY**

Climate change impacts are becoming starkly visible, particularly in developing regions such as Asia and the Pacific, which are warming at a rate faster than the global average. In 2023, these regions experienced their second highest recorded mean land temperature, 1.87°C above the 1961–1990 average temperature (World Meteorological Organization, 2024), along with a surge in climate-related disasters ranging from floods and storms to heatwaves and droughts. These events are becoming more frequent and intense, placing immense pressure on already resource-constrained economies.

Climate change posses significant macroeconomic risks, particularly for developing economies such as India. The transmission mechanisms through which climate change affects the macroeconomy are varied and often non-linear: declining crop productivity yields, disruptions to trade and migration patterns, impact on public health, loss of natural capital, and recurrent fiscal liabilities from disaster response and adaptation expenditures. These channels create compounding risks that undermine long-term growth potential and resiliency building. Dell et al. (2014a) emphasized that quantifying these effects is critical to understanding how climate variability shapes long-run economic growth.

This underscores the urgent need for a comprehensive outlook to assess economic risks due to climate change, accounting for a full spectrum of impacts beyond temperature anomalies, including sea-level rise, precipitation variability, and its cascading socio-economic disruptions. Furthermore, these stresses can converge into systemic shocks, overwhelming institutional capacity and undermining both macroeconomic stability and human development.

Given the profound macroeconomic impact of climate change on the economy, the study aimed to examine the impact of five key climate stresses, such as rainfall variability, floods, droughts, sea level rise, and heat stress, on the Indian economy. These impacts were mapped through sectoral pathways and weighted by exposure indices, which captured the degree to which individuals, communities, and ecosystems are vulnerable to climate-related risks. The resulting Economic Impact of Climate Change (EICC), capturing the aggregate economic loss emanating from sectoral direct and indirect climate change induced damages, was expressed as a percentage of national GDP at 2022-23 current prices and projected for 2050.

Using a multi-step framework to estimate the EICC, the methodology followed the empirical framework established by Nicholson et al. (2023), adapted for the Indian context. Exposure to climate change refers to the degree to which individuals, communities, and ecosystems are vulnerable to climate-related risks, including extreme weather events, shifts in temperature and precipitation patterns, and long-term changes in environmental conditions. The first step involved calculating an exposure index to quantify India's vulnerability to each climate stress.

Second, the direct and indirect marginal impacts of climate change on sectoral impact pathways were identified through a systematic literature review. Impact pathways refer to the mechanisms or channels through which climate risks are translated into tangible socio-economic implications and damages, giving rise to sectoral inequities and loss in productivities (Nicholson et al., 2023). In other words, impact pathways act as a bridge between climate hazards, their respective associated damages, and ultimate impact on sectoral GDP. Through identification and synthesization of empirical studies that quantified the relationship between climate tress and their associated damages, 14 unique pathways were identified along with their respective marginal impacts. These marginal impacts, used as coefficients, were systematically extracted from the regression results of the selected studies. However, due to dearth of literature, marginal impacts for certain pathways were determined using three-stage least squares (3SLS) regressions. These coefficients were suitably scaled using multipliers to capture the economy-wide effect at the national level.

Subsequently, impact pathway coefficients were multiplied by appropriate economic values. These were further combined with exposure indices to capture both the direct and indirect impact of climate stresses on the most affected sectors and the associated ripple effects across the economy. As the final step of the methodology, these

coefficients were combined with projected climate parameters to ascertain the long-term impact of climate change on sectoral productivity and the economy as a whole. The parameters were projected until 2050 for the RCP 4.5 projection scenario. This enabled the estimation of sector-specific economic losses attributable to each climate stressor at the current prices. The resulting values were used to calculate economic losses as a share of the country's GDP, thereby predicting the maximum EICC. The analysis examined the expected losses for the base year, i.e., 2022-23, and projected them for 2050, adjustd for changes in climate parameter and sectoral economic values.

The results revealed that rainfall variability and flood exposure present the highest current climate risks, with drought and sea level rise also showing growing threats. These indices collectively highlighted the increasing climate vulnerability across India's diverse regions.

Further, upon estimating the sectoral economic losses by combining the effects from impact pathways, exposure indices, and variability in climate stresses, it was observed that electricity, gas, water supply, and other utility sectors emerged as the most affected. The losses stemmed from damages to public property, electricity losses, and a loss in water availability, among which water supply experienced the highest loss, closely followed by the service sector. Other sectors that observed a decline in GDP included biodiversity and coastal wetlands, indicating that climate-induced damages spill beyond economic sectors.

Meanwhile, in 2050, the projected economic losses were observed to have increased significantly. The service sector emerged as the most affected, while agriculture and allied sectors trailed behind with the second-highest decline in output share. Other sectors and services, such as manufacturing, health, biodiversity, and coastal wetlands, also experienced a decline in their output.

At the national level, the EICC was reported to be at a loss of 7.38 per cent of the GDP at current prices for 2022-23, while the projected loss in 2050 was estimated at 15.42 per cent of the GDP. The EICC as a percentage of GDP presents the country's climate-induced damage costs, providing crucial insight into the quantum of finance required to mitigate the climate change-induced damages, which are highly vulnerable to climate shocks in the present study.

Taken together, these findings underscore the critical need for a comprehensive, well-targeted, and forward-looking adaptation finance investment. Such a strategy must integrate climate risk into fiscal and development planning and prioritize interventions that enhance resilience among the most vulnerable populations. Inaction could result in compounding economic losses, deepening poverty, and heightened macroeconomic instability.

Looking ahead, as climate change-induced damages exacerbate, the gap between adaptation spending and the cost of inaction should decline through scaling up of adaptation measures, paving the way for a more climate-resilient economy. This would require aligning the policies and reforms

towards adaptation intervention that address localized climate risks. The study sheds light on several measures that can inform and support policies which include developing a robust repository of data to conduct vulnerability assessments at the local level, development of region-specific climate stress profiles and hazard maps to identify localized risk, engaging local communities in decisions making processes, strengthening institutional capacity, and deploying targeted localized sectoral policies.

The current assessment provides a comprehensive method to estimate the damages arising from climate risks and the direct and in-direct economy-wide impacts. This can be further suitably adapted and modified to incorporate other climate stresses and their associated damages transmitted through various direct and indirect channels, cumulatively impacting the GDP of the country. It provides a robust framework for quantifying the quantum of finance required to address the damages induced by climate change, informing the quantum of finance required to scale adaptation relevant interventions. Furthermore, robust studies are required to analyse the current adaptation expenditure to identify the finance gap. Such assessments can help in identifying the potential financing sources and mechanism to bridge the adaptation finance gap.