RESEARCH

The DIGNAD Model Applications and a New Toolkit

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Zamid Aligishiev
Azar Sultanov

TECHNICAL

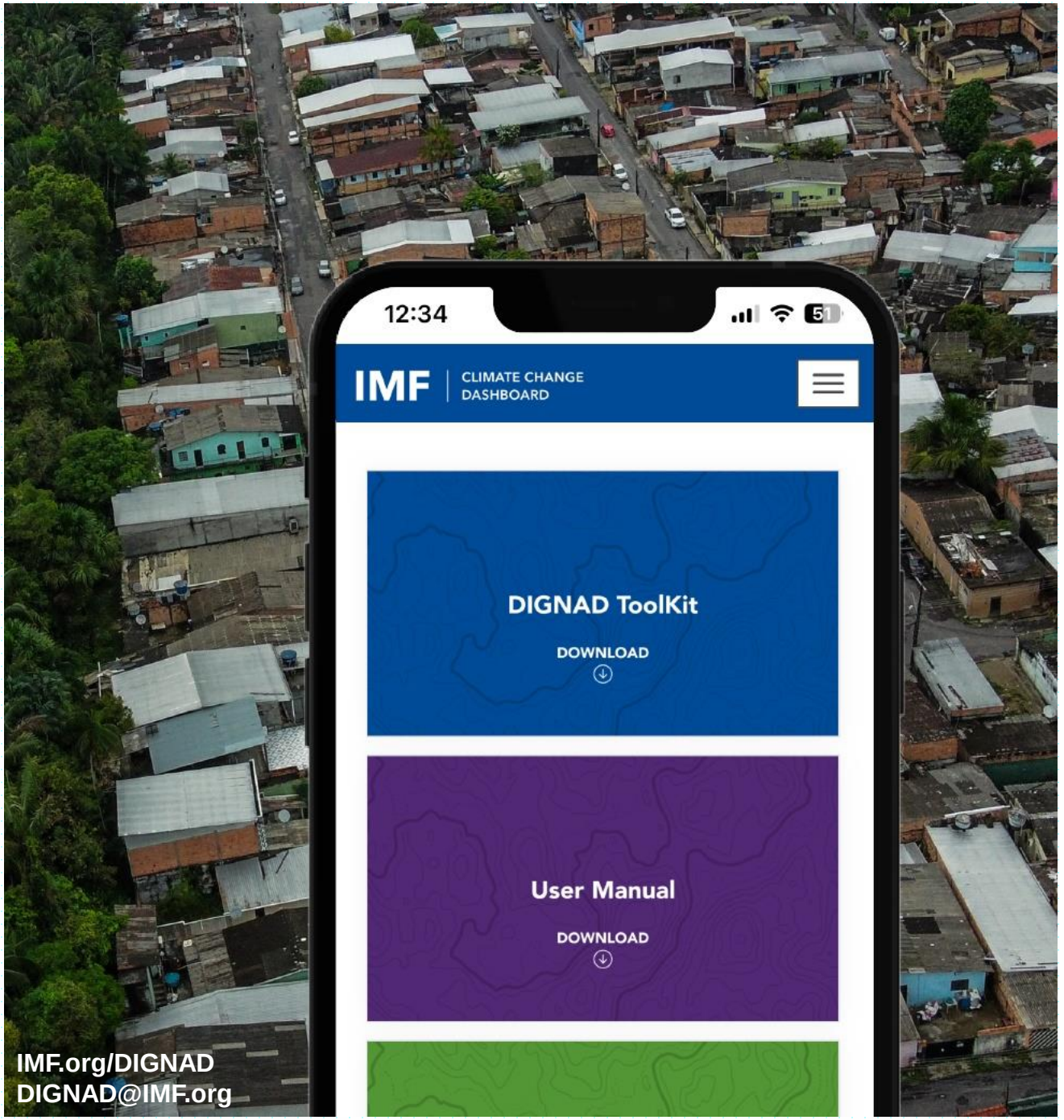
NOTES & MANUALS

User Manual for the DIGNAD Toolkit

Zamid Aligishiev, Cian Ruane, and Azar Sultanov

TNM/2023/03

INTERNATIONAL MONETARY FUND



DIGNAD: Debt-Investment-Growth-Natural-Disasters

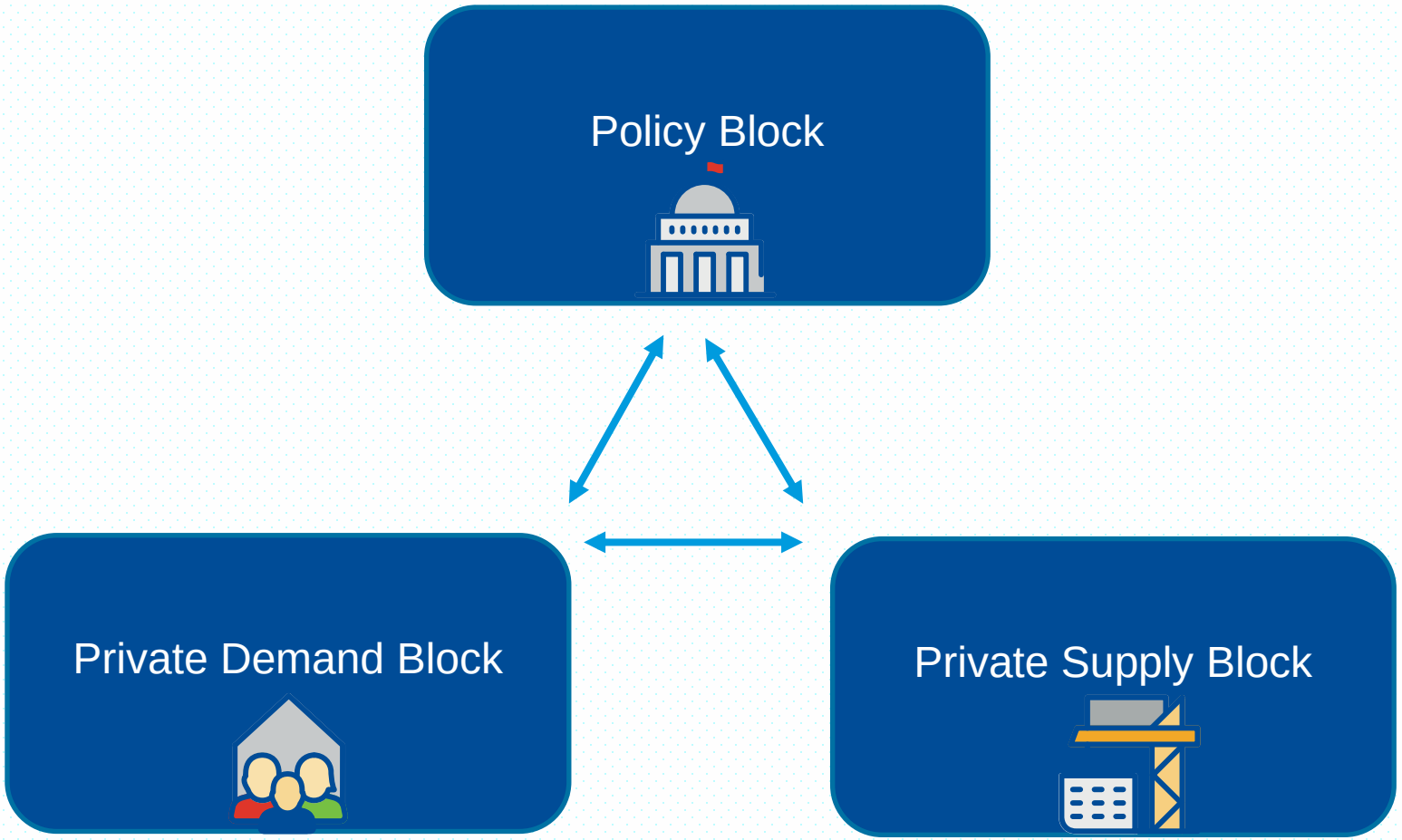
Extension of the Debt-Investment-Growth (DIG) model suitable for EMDEs **prone to natural disasters**

Evaluates **macroeconomic dynamics** of key variables under alternative scenarios (e.g., structural reforms, ex-ante adaptation vs. ex-post reconstruction

User-friendly **Excel-based toolkit**

- Buffie, Berg, Pattillo, Portillo and Zanna (2012) Public Investment, Growth, and Debt sustainability: Putting Together the Pieces, IMF WP 12/144
- Marto, Papageorgiou and Klyuev (2018) Building Resilience to Natural Disasters: An Application to Small Developing States, Journal of Development Economics 135. 574–586, IMF Working Paper No. 2017/223

The DIGNAD Model Structure



The DIGNAD Model Structure: Private Demand Block

- **Two types of households:**
  - Liquidity-constrained – cannot save
  - Savers can access to financial instruments

- **Households**
  - Earn labor income and domestic transfers
  - Consume domestic and foreign goods
  - Savers choose where to invest

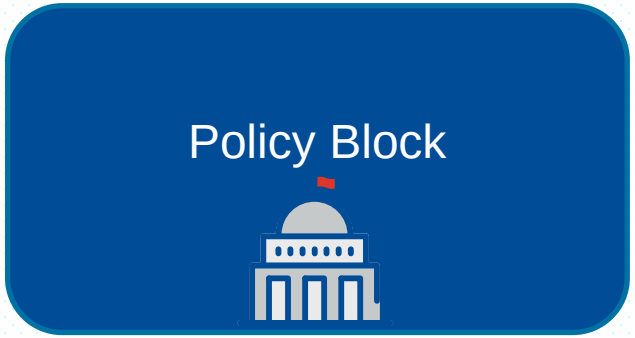
The DIGNAD Model Structure: Private Supply Block

- **Firms operating in two sectors:**
  - Tradable
  - Non-tradable
- **Firm production requires inputs:**
  - Labor
  - Private capital
  - Public Infrastructure
    - Standard
    - Climate-Resilient (aka Adaptation)

$$y = A\left(z^{\psi}\right)k^{\alpha}\, l^{1-\alpha}$$

$$z = \left[\left(z^{i}\right)^{\frac{\xi-1}{\xi}} + \left(\nu_a z^{a}\right)^{\frac{\xi-1}{\xi}}\right]^{\frac{\xi}{\xi-1}}$$

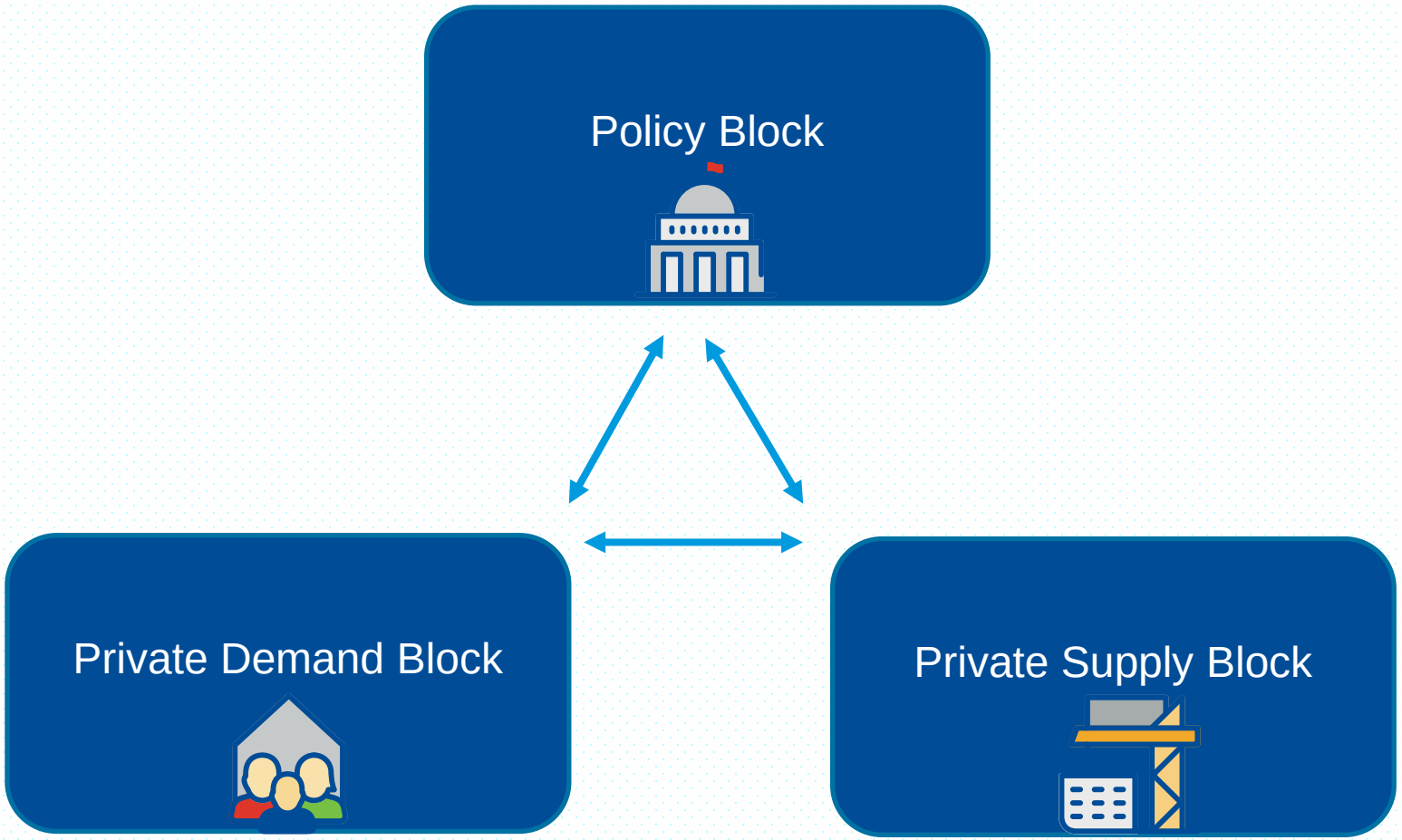
The DIGNAD Model Structure: Policy Block



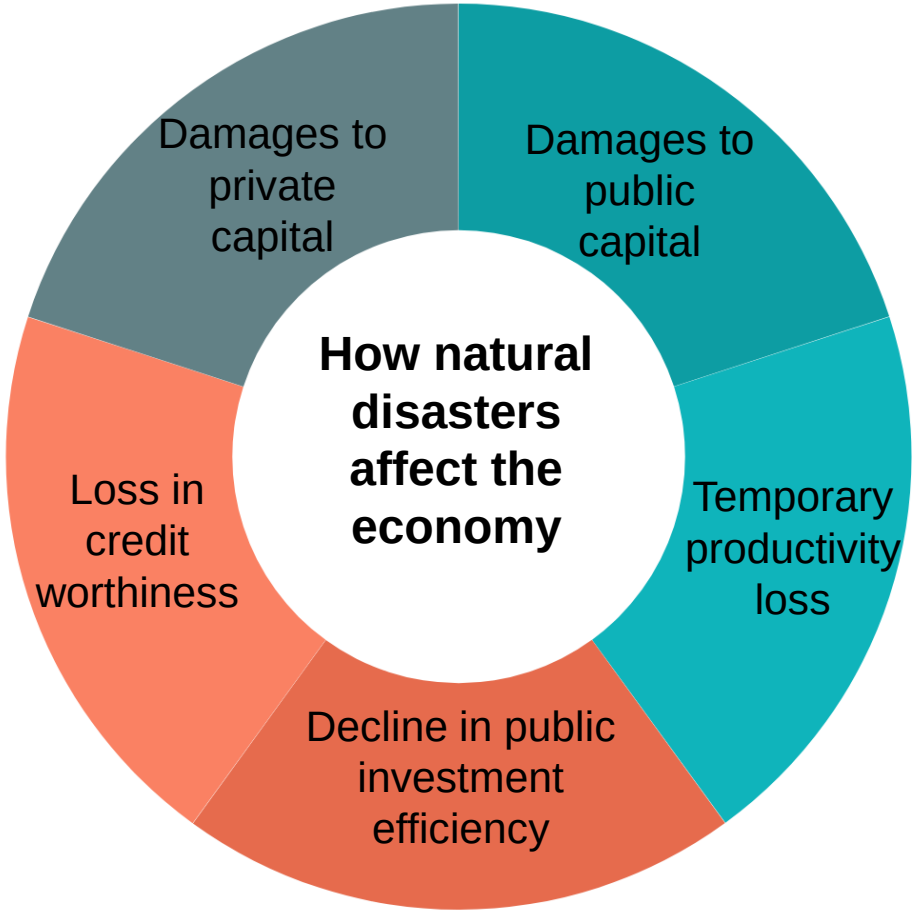
- **Fiscal instruments:**
  - E.g. Consumption and labor taxes (VAT)
- Investments in public infrastructure
  - Standard or climate-resilient
- **Debt instruments:**
  - E.g. Domestic or external debt
- **Other:**
  - E.g. Donor grants

- Policy instruments can be *exogenous* or respond *endogenously* to fiscal gap
- Fiscal rule: taxes endogenously respond to fiscal gap and debt deviations

The DIGNAD Model Structure: General Equilibrium



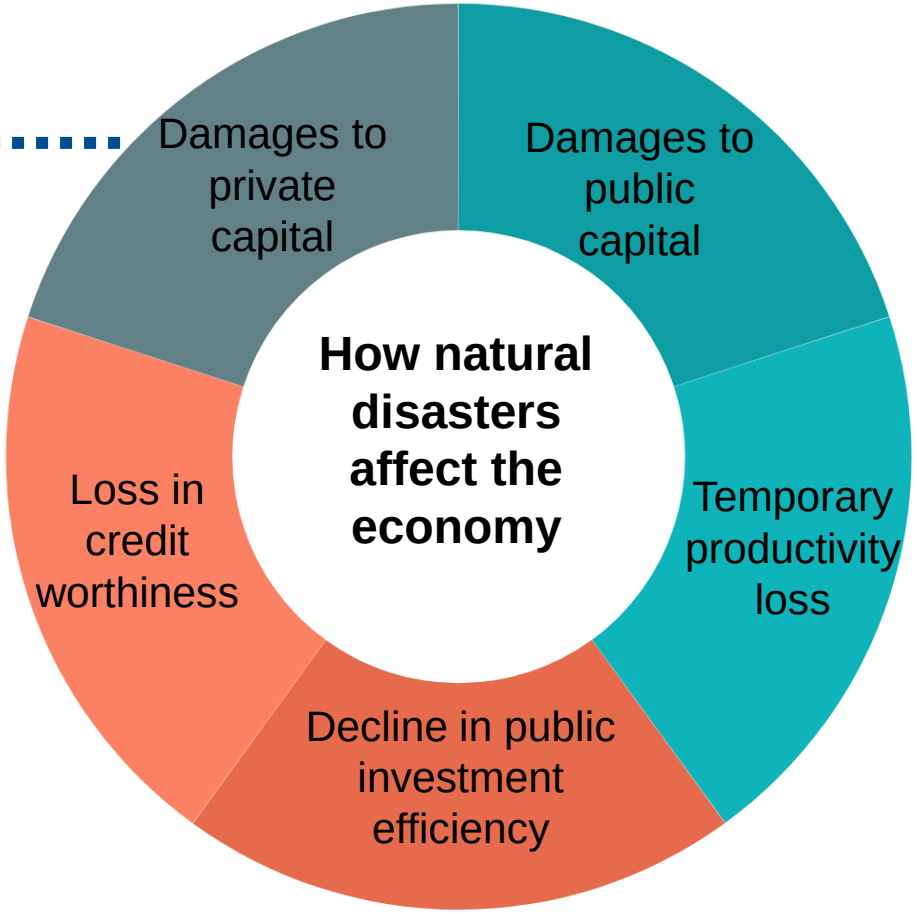
Natural Disasters in the DIGNAD Model



Damages to output: $(1 - D)$ **y**

Natural Disasters in the DIGNAD Model

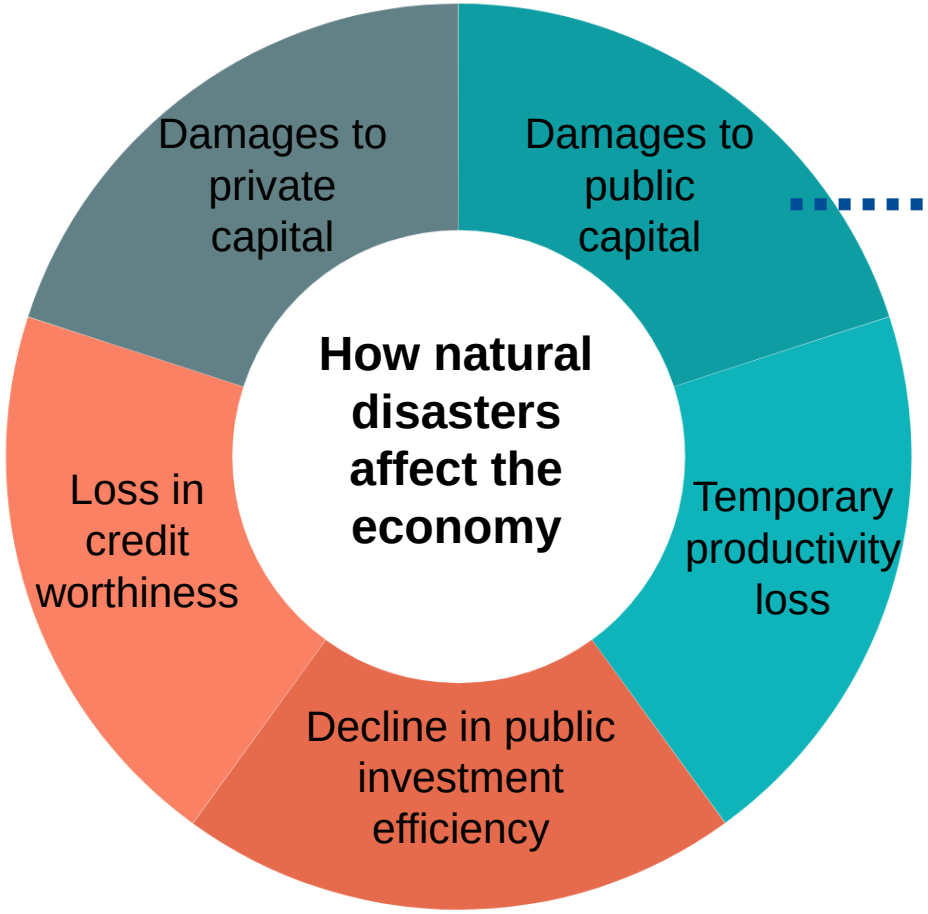
- *Direct impact of disaster*
- *Less capital available for production*



Damages to output: $(1 - D)$ **y**

k ↓

Natural Disasters in the DIGNAD Model

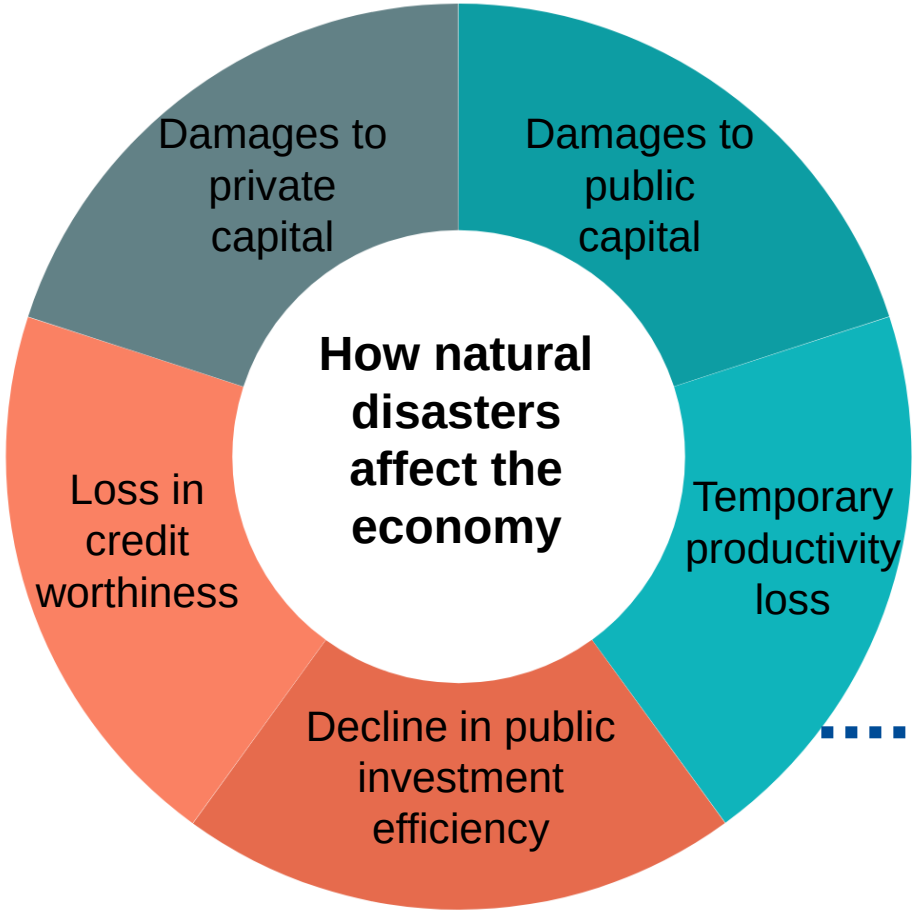


Direct impact of disaster on roads, bridges, etc.

Damages to output: $(1 - D)$ **y**

z ↓

Natural Disasters in the DIGNAD Model



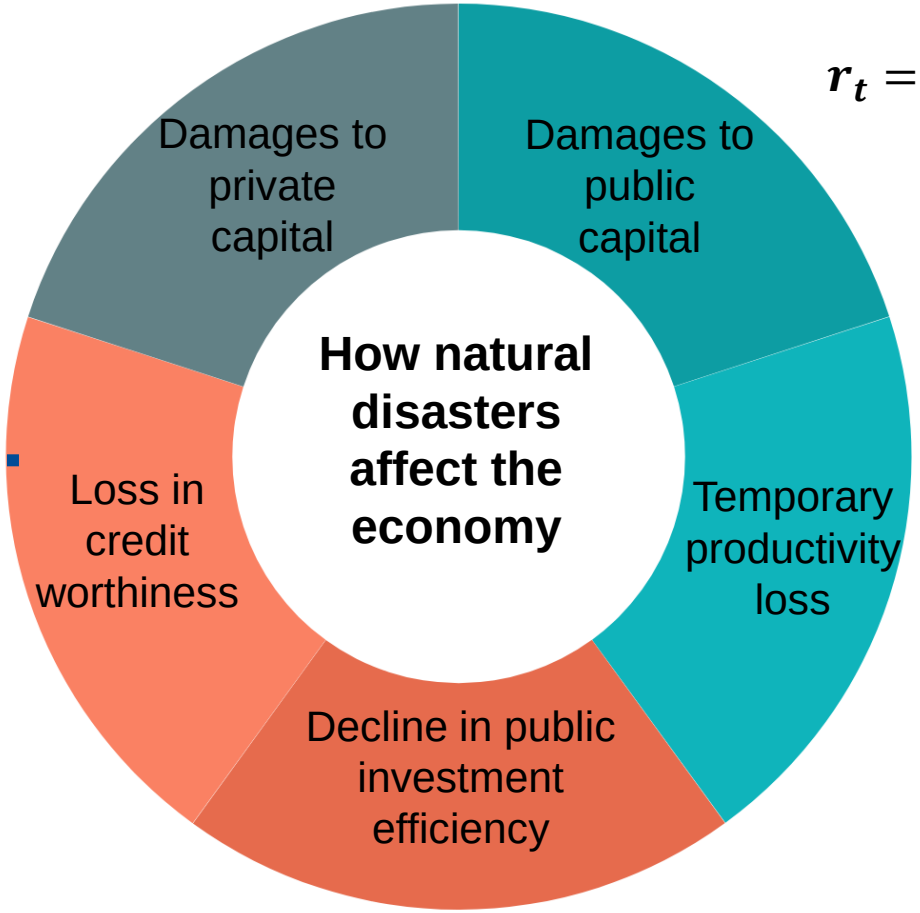
• Impact of disruption

Damages to output: $(1 - D)$ **y**

A ↓

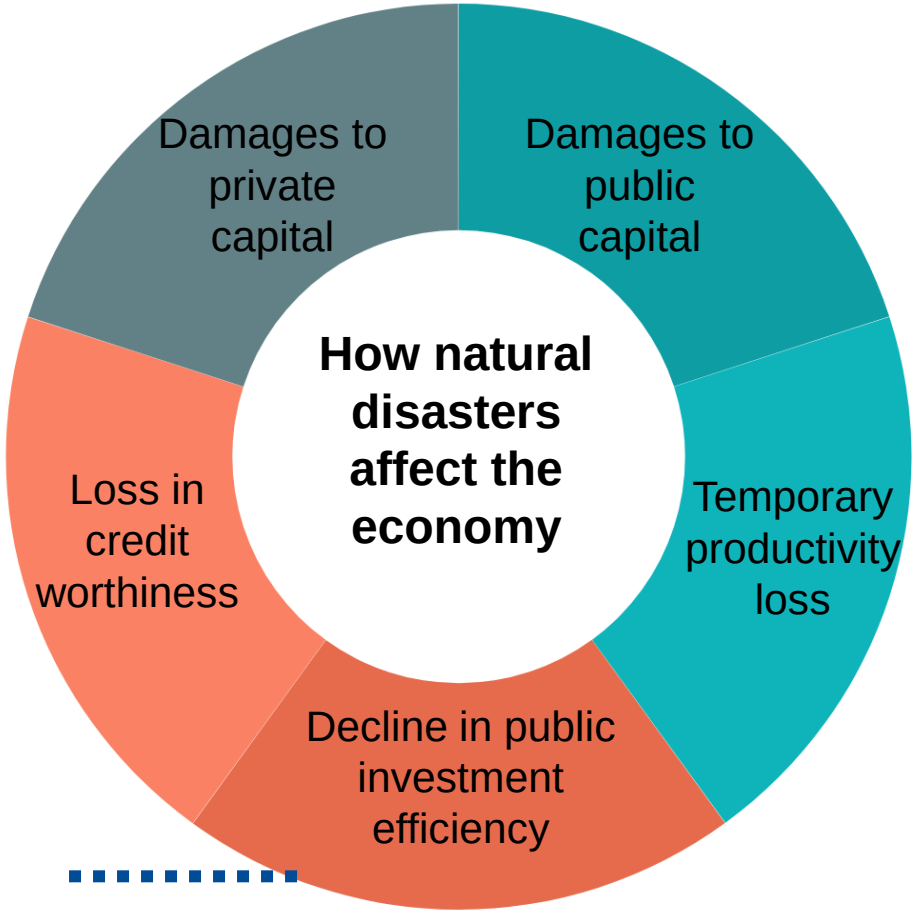
Natural Disasters in the DIGNAD Model

$$r_t = (1 + D_r)(r_f + \cdots)$$



- Downgrade of credit ratings
- More expensive to borrow externally

Natural Disasters in the DIGNAD Model



$$i^e = (1 - D_s)\, s\, i_z$$

- More expensive to reconstruct public capital
- Capacity constraints

Resilient Infrastructure

- **Resilient Infrastructure has three distinct benefits:**
  - More durable (lower depreciation rate) $\delta_{za} < \delta_{zi}$
  - Suffers smaller damages from natural disasters $\frac{D}{(1+\pi z^{a})}$
  - Higher rate of return (higher MRPK) $R^{za} > R^{zi}$
- **But may be more expensive to build**

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DIGNAD Applications

Some Previous Applications of the DIGNAD Model

- **IMF Working Papers**:
  - Vanuatu (2017), St Lucia (2019), Maldives (2021)
- **Selected Issues:**
  - Solomon Islands (2018), Uganda (2022), Timor-Leste (2022), Philippines (2023), Rwanda (2023)
- **Pilot CMAPS:**
  - Samoa (2022) and Madagascar (2023)
- **RST Pilots:**
  - Rwanda (2022) and Bangladesh (2023)
- **RST:**
  - Seychelles (2023), Kenya (2023), Benin (2023), Mauritania (2023), Moldova (2023), Cameroon (2023), Cote d'Ivoire (2024), Tanzania (2024)

Applying the DIGNAD Model

- **Model designed to evaluate impact of one-off natural disaster**
  - Calibrate size using historical data on economic losses
- **Evaluate macroeconomic dynamics of key variables:**
  - GDP, debt, fiscal deficit, public and private investment, etc.
- **Under various possible scenarios:**
  - Ex-ante infrastructure investments, structural reforms, etc.

Application to Rwanda

- The DIGNAD model can demonstrate the impact of investing in ex-ante adaptation on output growth and public debt, in countries vulnerable to climate induced disasters.

- The model is calibrated to Rwanda and is simulated for a hypothetical disaster mimicking once-in-100-years flooding;

- Resulting in lowering GDP in 2028 by about 4 percent;

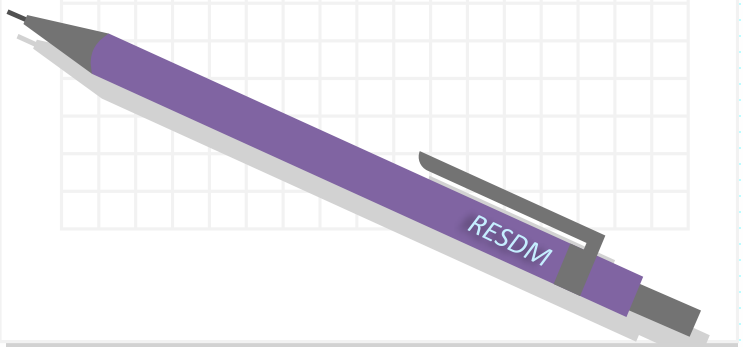
- The decline in GDP arises mainly due to the damages to infrastructure.

Standard vs. Resilient Public Infrastructure plan

Scenario 1: Baseline

a. No resilient infrastructure;

b. A natural disaster hits in year 5.



Scenario 2: Adaptation Investment

a. Investment in resilient infrastructure;

b. Budget envelope of 1.5 percent of GDP per year, financed through private financing and concessional borrowing for 5 consecutive years;

c. A natural disaster occurs as soon as plan is completed.

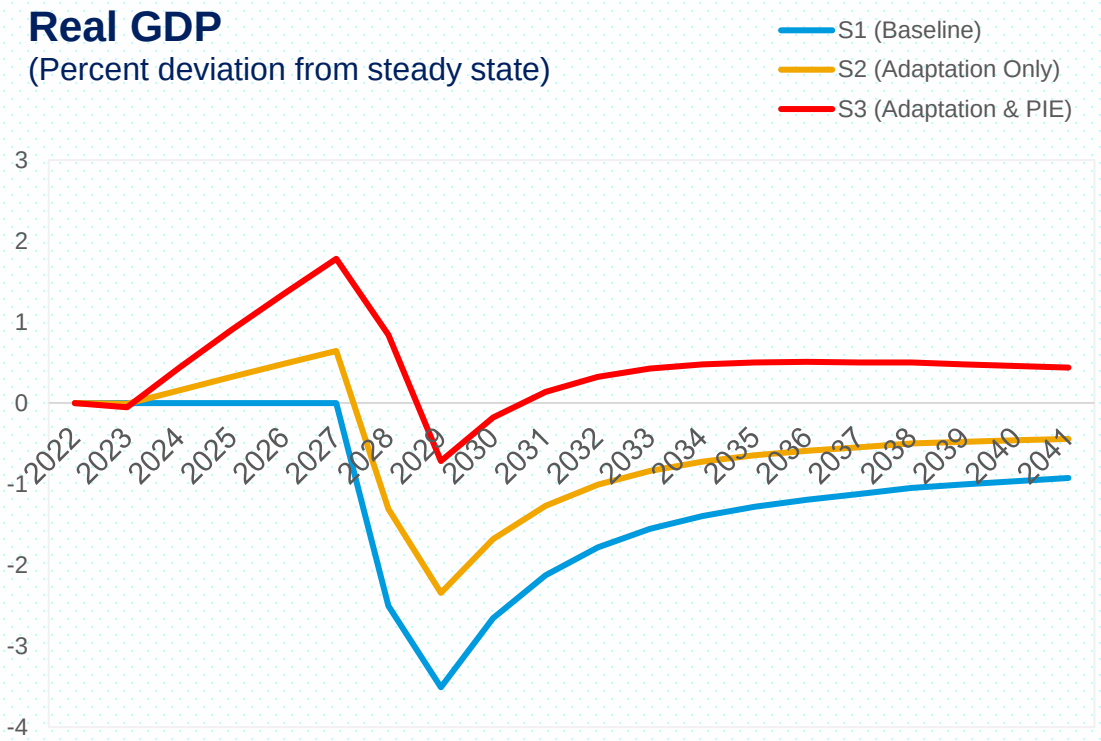
Scenario 3: Adaptation & Reforms

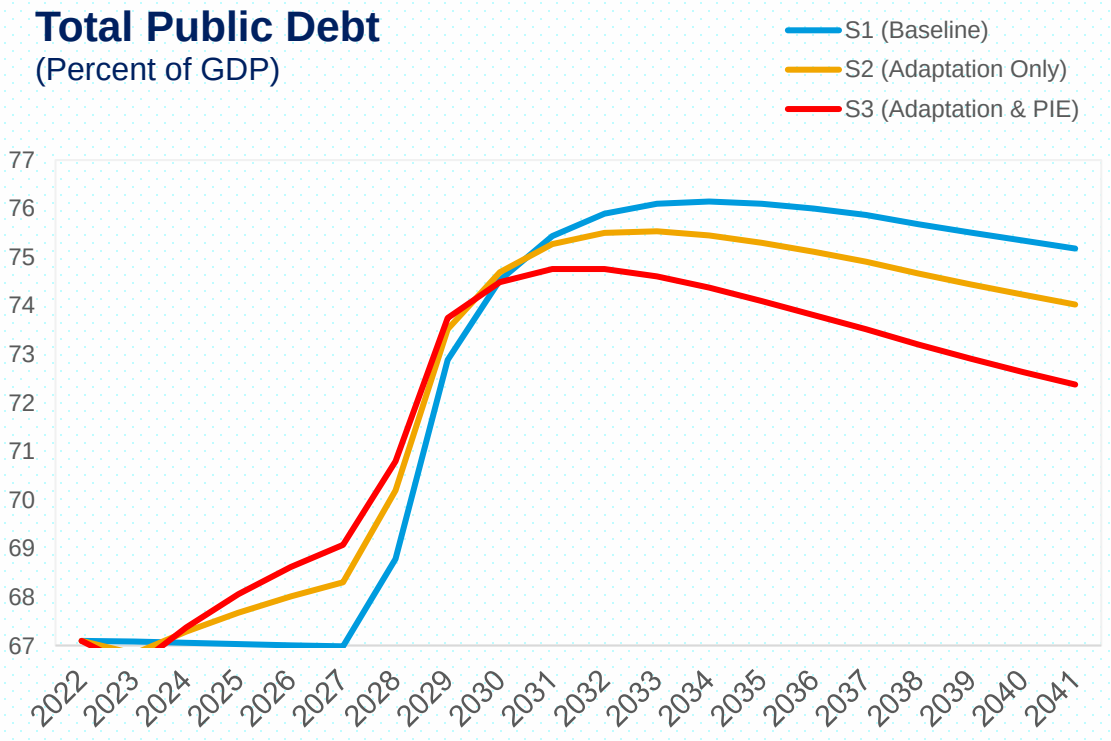
a. Investment in resilient infrastructure;

b. Reforms related to climate PIMA and green PFM, raising the efficiency of public investment by 20 percentage points;

c. Accompanied by catalyzed green financing from the private sector and DPs and by additional 1.5 percent of GDP.

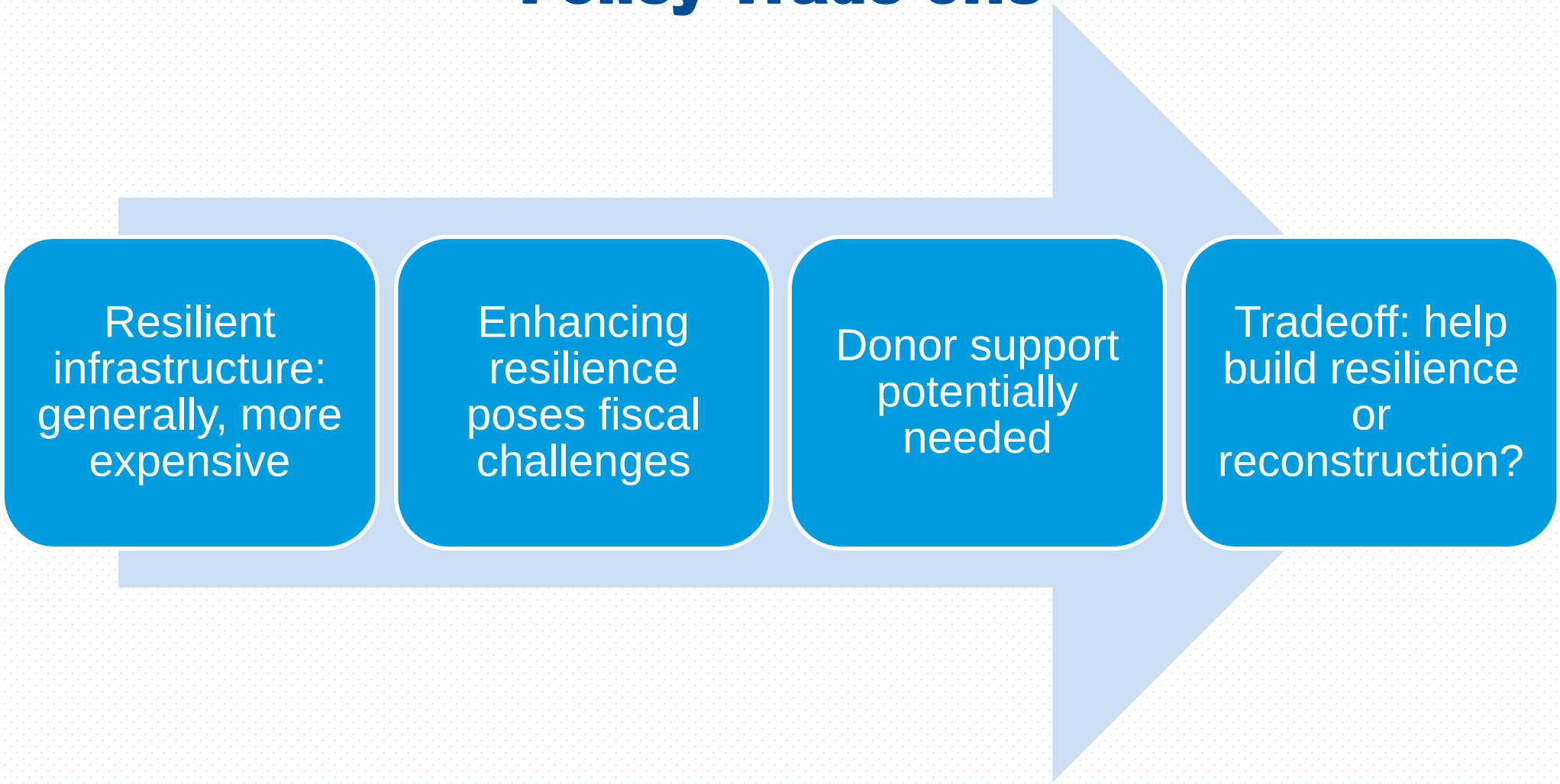
Policy Lessons from DIGNAD Simulations





Source: IMF staff calculations

Policy Trade-offs



Discounted Net Savings of International Donors* (percent of reconstruction costs)

Hazard Magnitude	Net Savings
Average historical (AH) impact	9.3%
AH+10%	14.1%
AH+20%	18.1%
AH+30%	21.6%

*Net savings are calculated as the difference between fiscal savings in the reconstruction phase and cost of extra investment spending. Both are discounted at 5 percent rate and measured in percent of reconstruction costs under no policy change.

Source: IMF staff calculations

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DIGNAD Toolkit

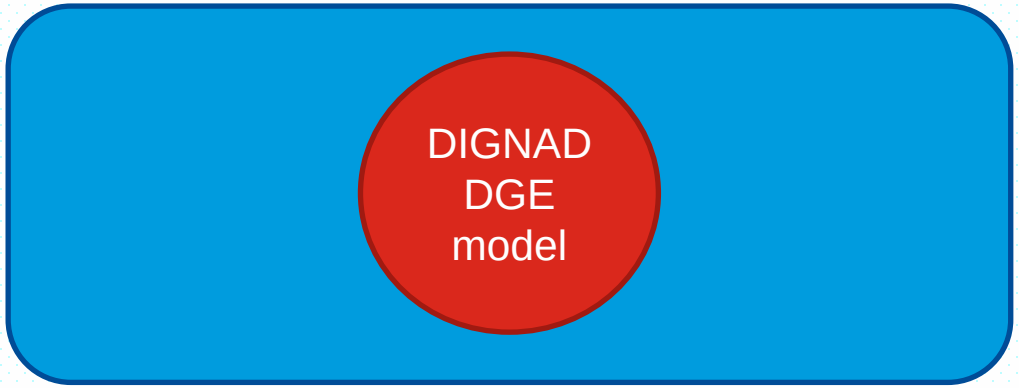
A New Toolkit

- **Enhanced user-friendliness for calibrating model:**
  - User-interface entirely in Excel
  - Easily specify initial and end period for natural disaster impact and reconstruction
  - Specify different financing scenarios

- **New modules:**
  - Realism module: robustness to degree of resilience of adaptation infrastructure
  - Alignment module : match user-provided GDP dynamics after natural disasters
  - Donor savings module: automate donor savings calculations
  - PIE module: simulate public investment efficiency (PIE) reform

Excel interface for the DIGNAD toolkit

- User-friendly interface that requires little to no knowledge of Matlab/Dynare.



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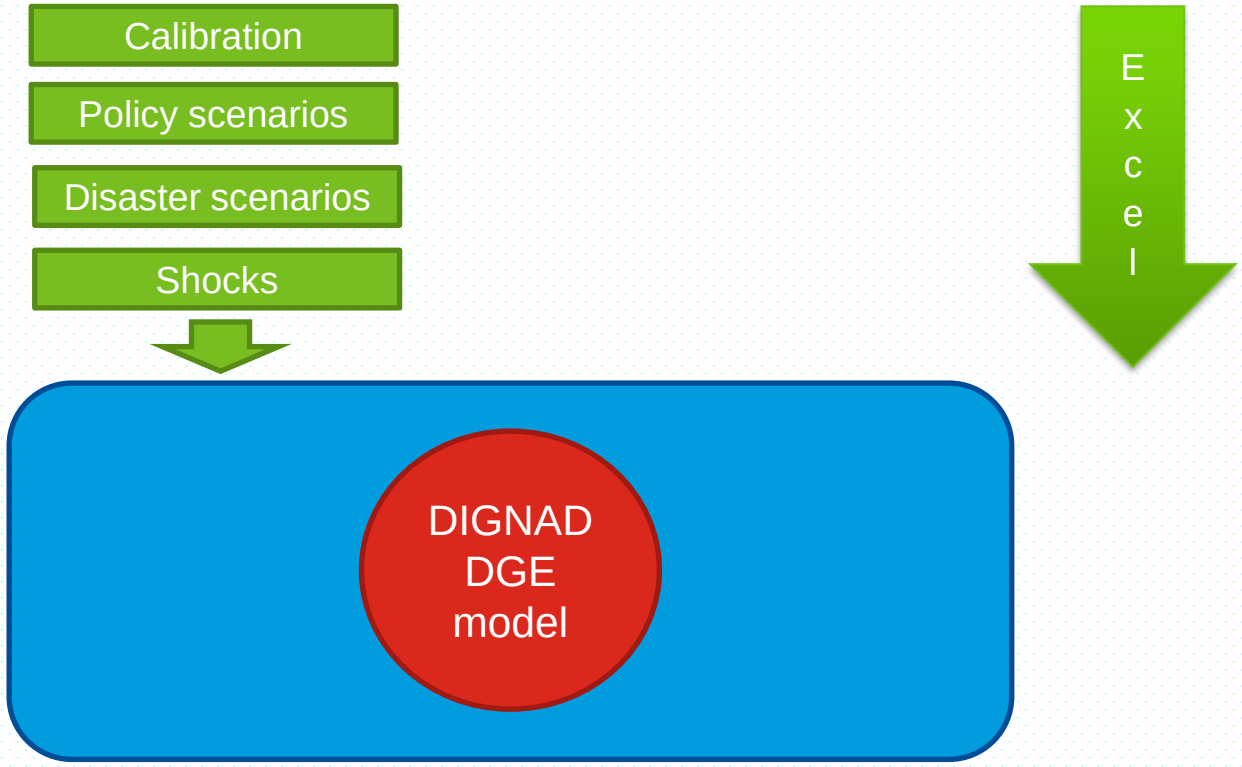
- All inputs for calibration, policy and disaster scenarios, exogenous shocks provided in an excel spreadsheet.



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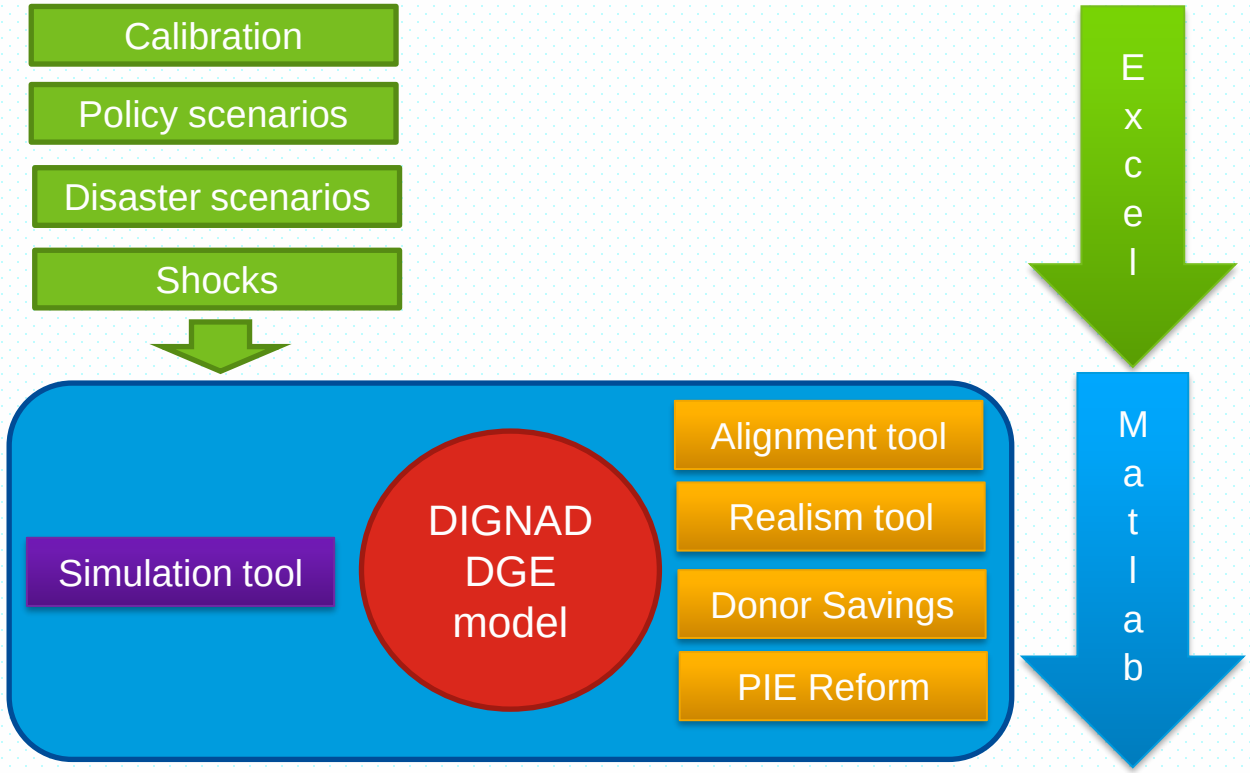

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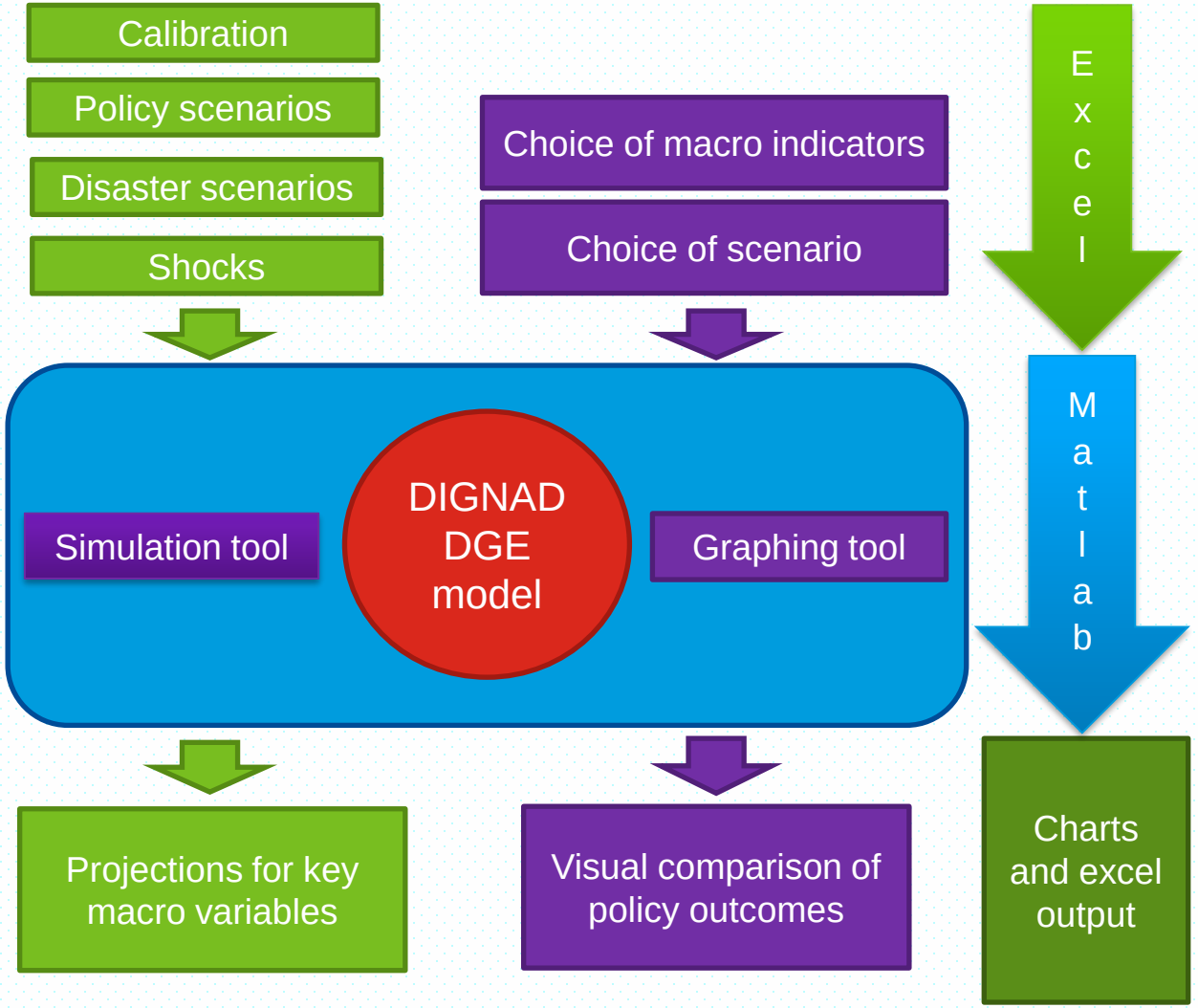
- All inputs for calibration, policy and disaster scenarios, exogenous shocks provided in an excel spreadsheet.
- A series of Matlab/Dynare codes run behind the scenes.
- Output produced in charts and a separate excel file to retrieve projected time series.
- A graphing tool allows comparing scenarios.



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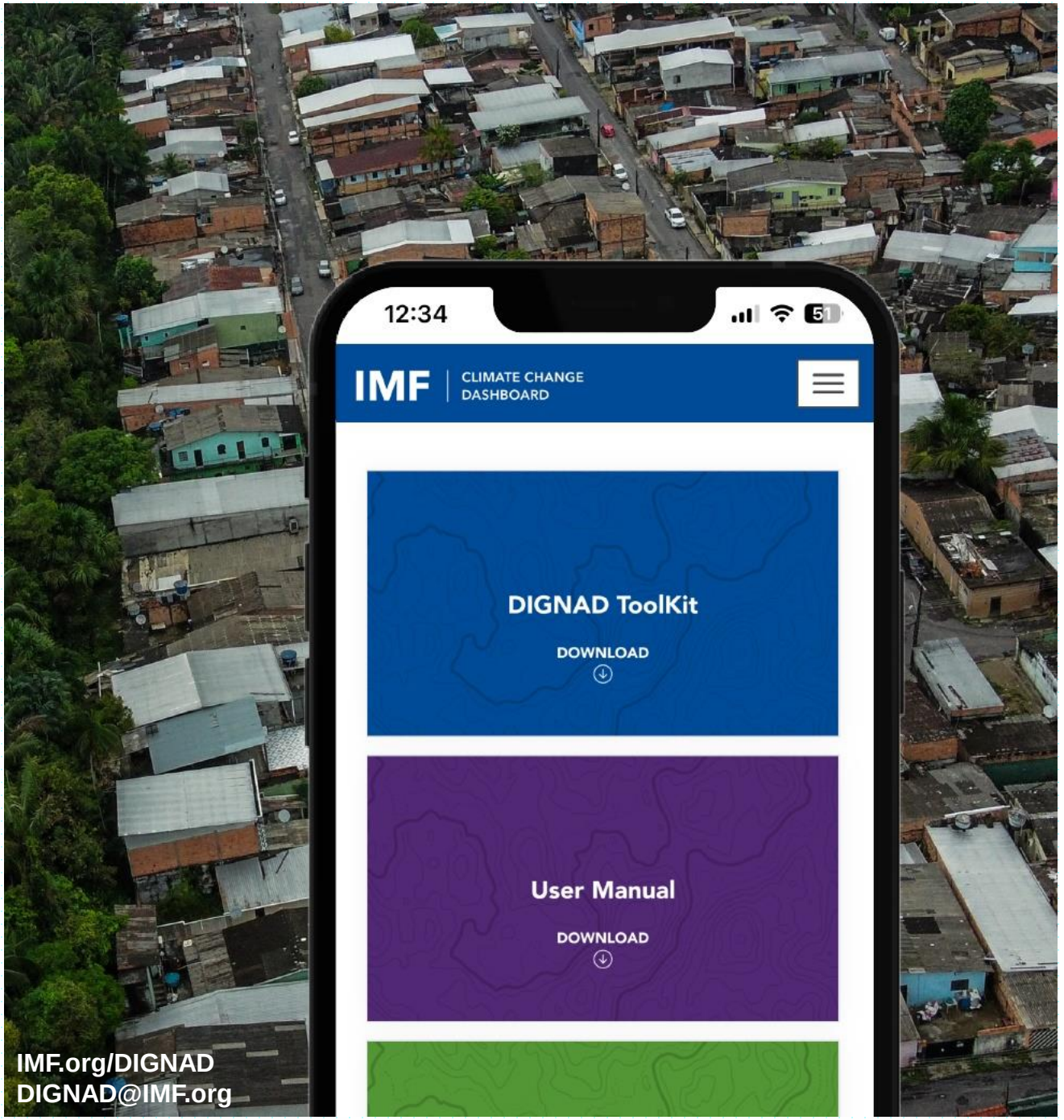

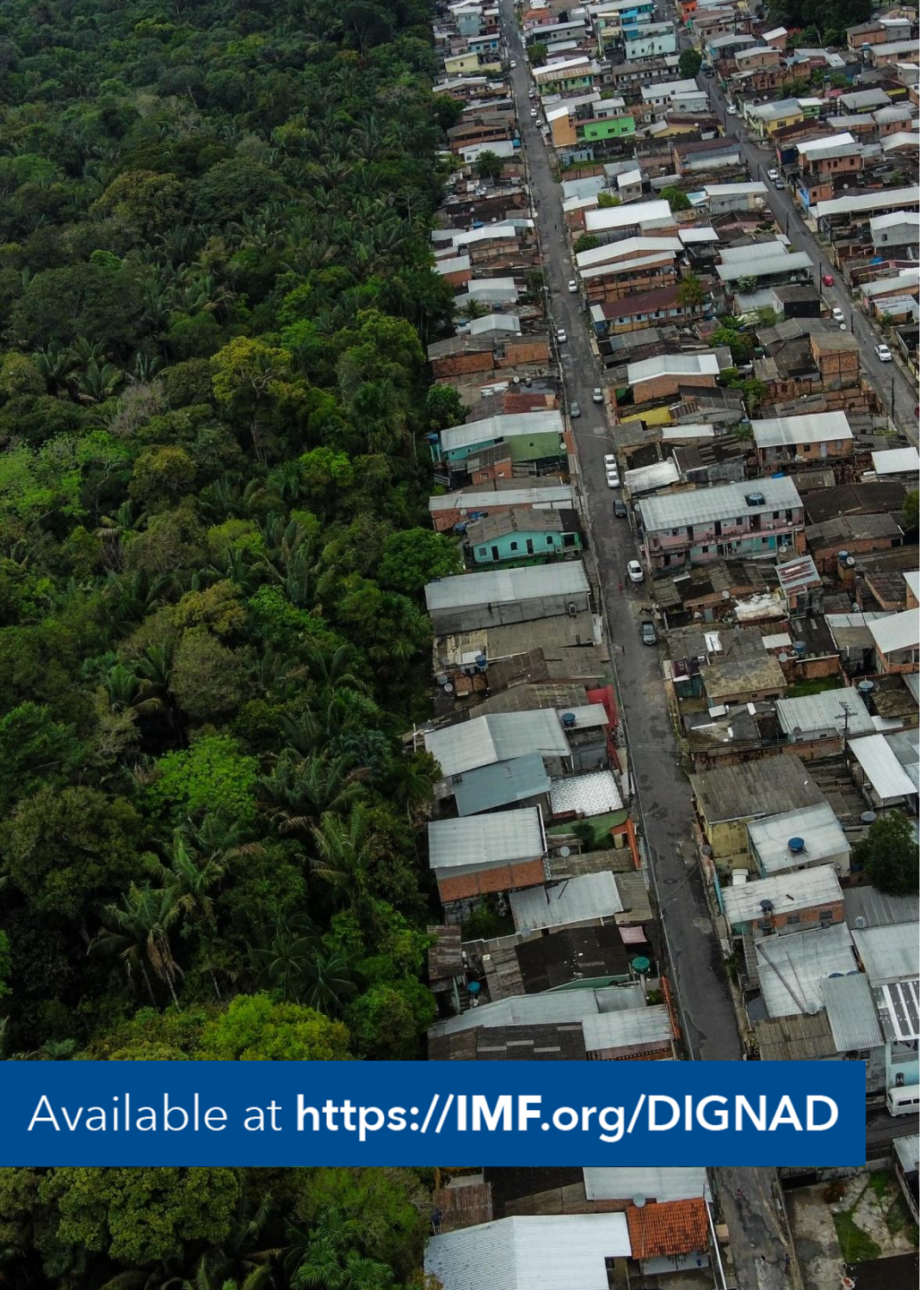

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Thank You

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