LIFELINES

The Resilient Infrastructure Opportunity

WORLD BANK GROUP

GFDRR
Global Facility for Disaster Reduction and Recovery

Resilient Infrastructure?

Resilient Infrastructure?

assets

Resilience of infrastructure *assets*

Resilient infrastructure is less costly to maintain and repair

Resilient Infrastructure?

services

assets

Resilience of infrastructure *services*

Resilient infrastructure provides more reliable services

Resilient Infrastructure?

Resilience of infrastructure *users*

Resilient infrastructure makes people better able to cope with and recover from shocks

People wait in line for water after the 2010 earthquake in Port au Prince, Haiti.

A traffic jam after flooding
in Chiangrai, Thailand

Resilient Infrastructure?

Infrastructure able to deliver *the services users need* during and after a natural hazard

Diagnosis

Solutions

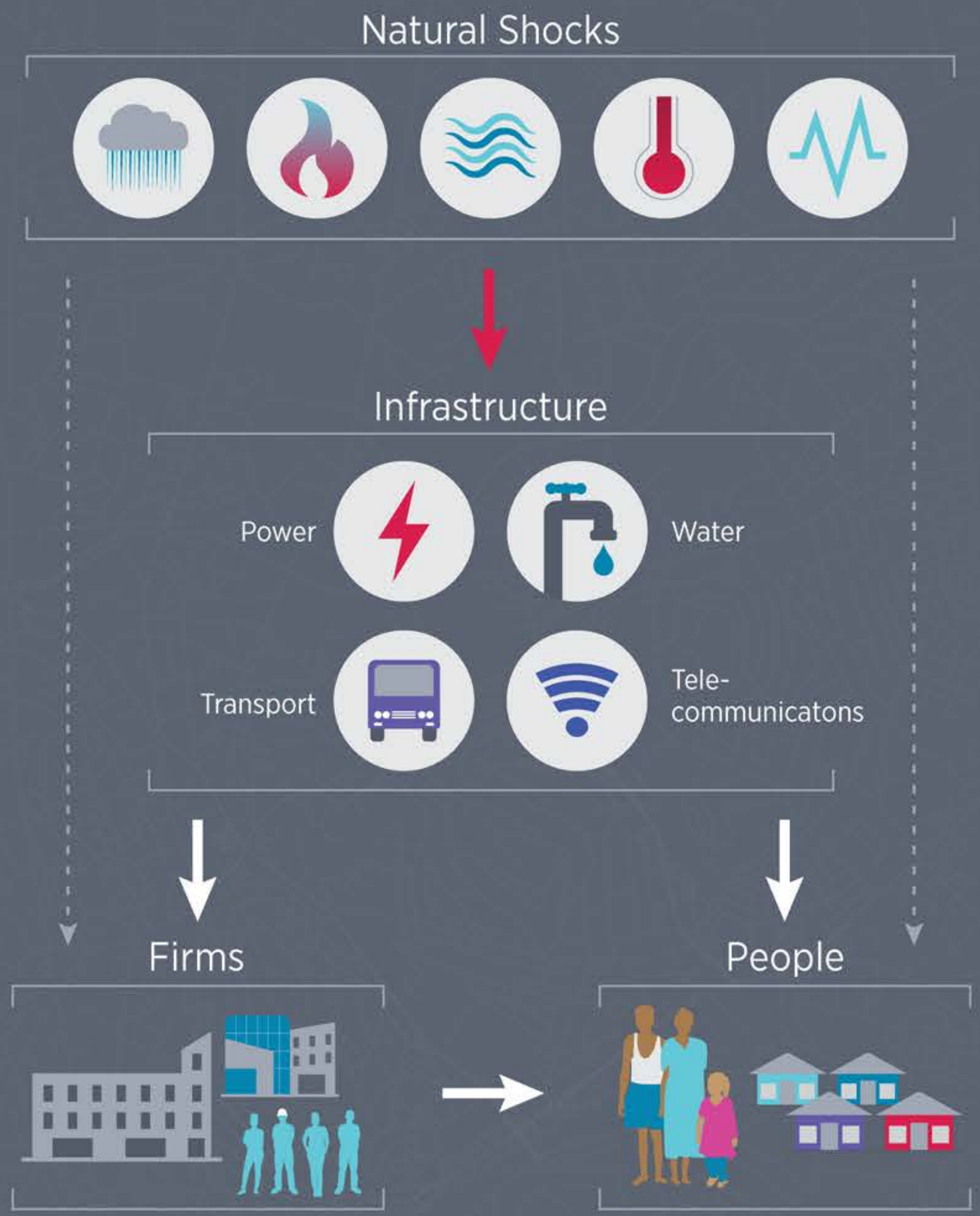
Recommendations

Diagnosis

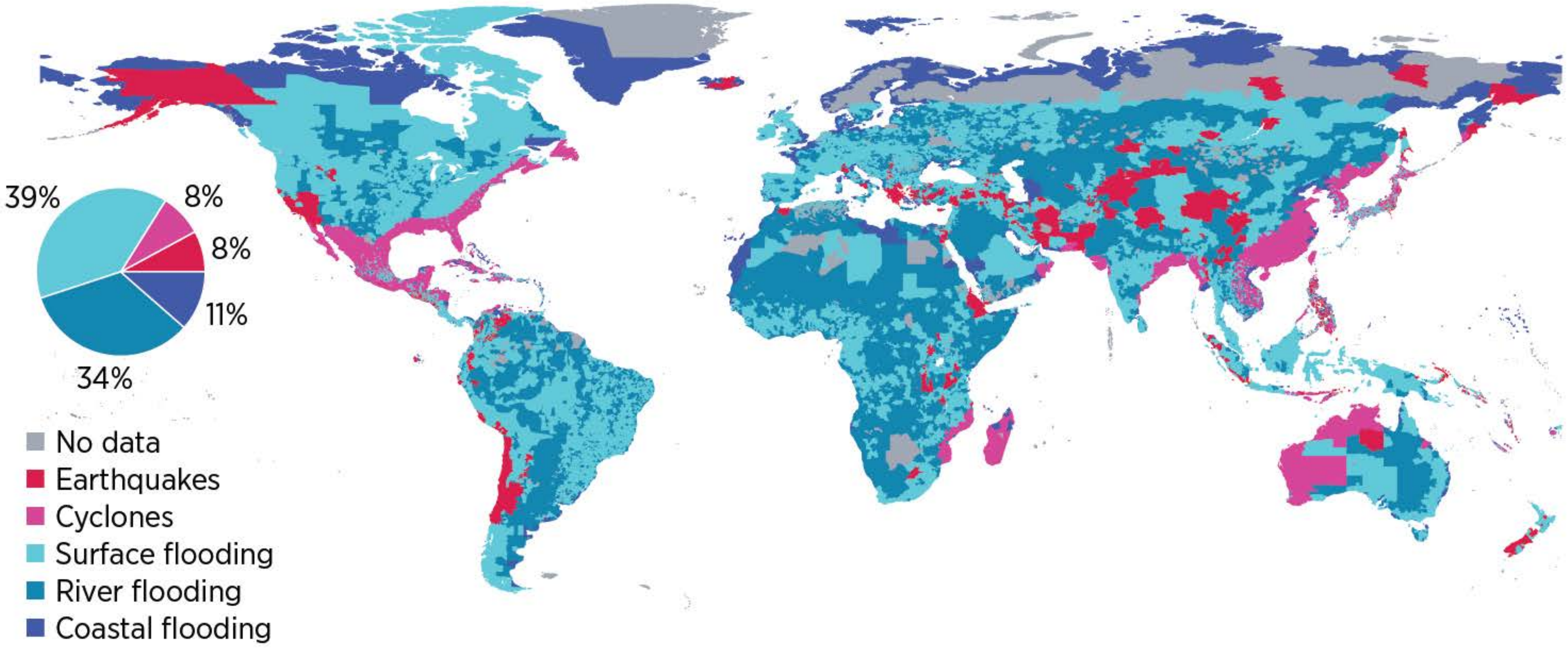
Solutions

Recommendations

The lack of resilient infrastructure is harming people and firms


Natural Shocks
Infrastructure
Power
Water
Transport
Tele-
communicatons
Firms
People

Damages and repair costs are significant …



$30 billion

Annual global damages to transport and power generation

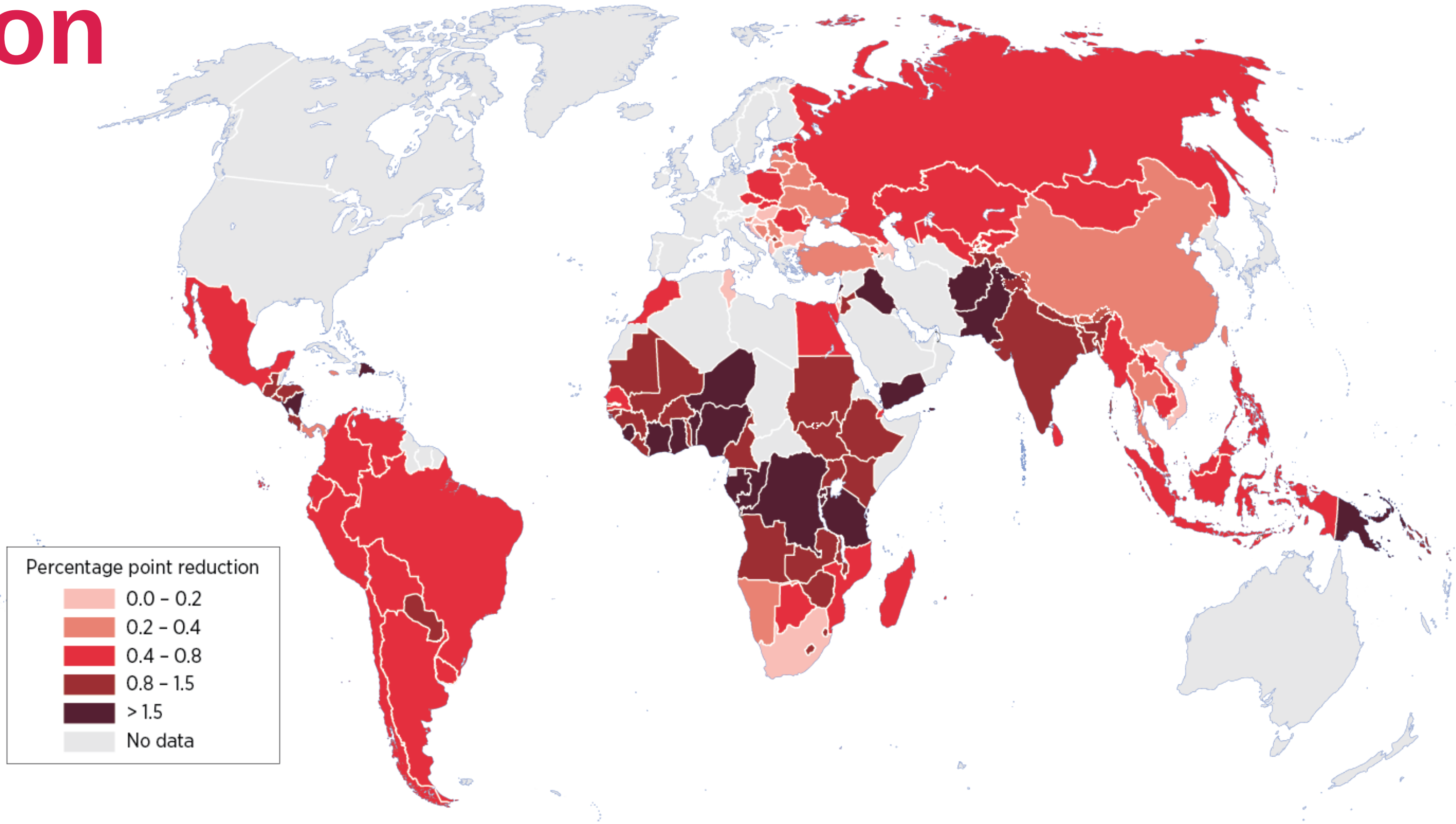
$18 billion

Annual damages to low- and middle-income countries

… but repairs are only part of the problem.

$391–$647 billion

The annual cost of infrastructure disruptions on households and firms in developing countries.



Firms

- **Reduced utilization rate ($151 billion)**
- **Lost sales ($82 billion)**
- **Self-generation costs ($65 billion)**
- Increased inventories
- More expensive localization choices
- Higher barriers for entry of new firms
- Less competition and innovation
- Labor-biased technologies

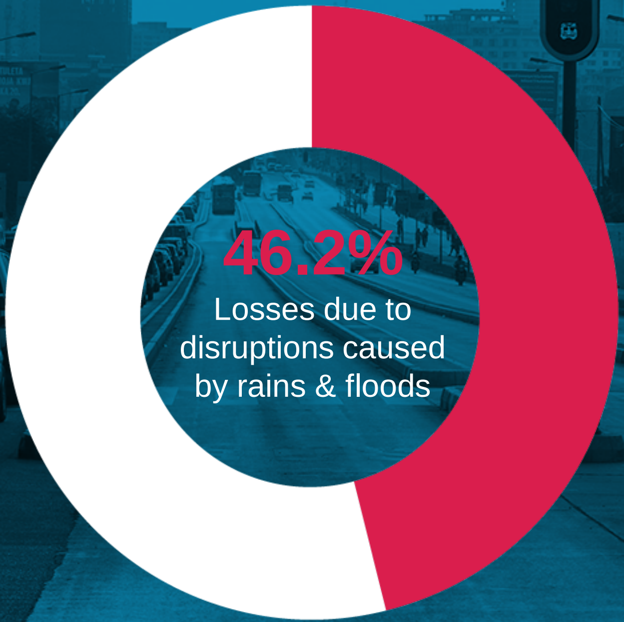
Household

- **Willingness-to-pay ($90–$343 billion)**
- **Health expenditures ($3–$6 billion)**
- Income impact and gender implications

What fraction is caused by natural hazards?

Zoom on Tanzania.

Transport

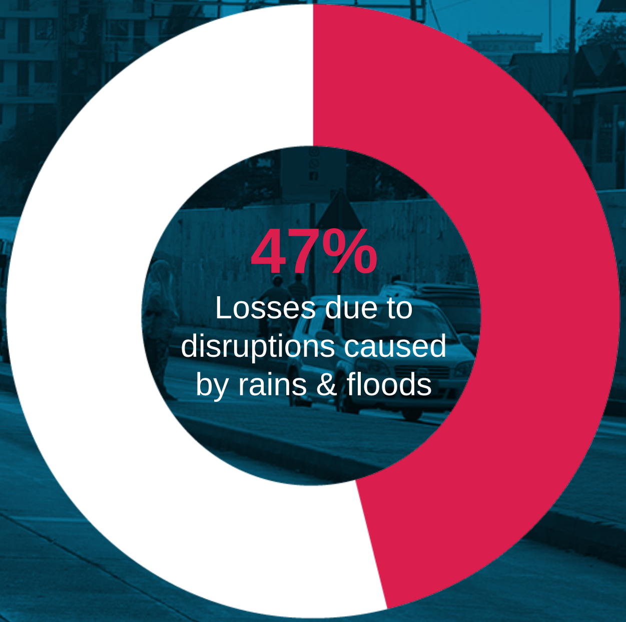


Total utilization losses per year:

$640 million

Or 1.8 percent of GDP

Power



Weather-related losses per year:

$250 million

Or 0.7 percent of GDP

Diagnosis

Solutions

Recommendations

Investing in more resilient infrastructure is sound, profitable, and urgent


Quality infrastructure
Resilience of infrastructure *users*
Resilient infrastructure makes people better able to cope with and recover from shocks
Resilience of infrastructure *services*
Resilient infrastructure provides more reliable services
Resilience of infrastructure *assets*
Resilient infrastructure is less costly to maintain and repair

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Starting from engineering options

Type	Natural hazard: Hazard	Natural hazard: Intensity	Critical system/component: Component	Critical system/component: Engineering improvement	Critical system/component: Quality improvement	Damage probability: Baseline	Damage probability: Improved	Incremental cost (including quality control)
Urban (roadway) bridges	EQ motion	Mw 7 PGA 0.4g	Bridge superstructure, abutments, footings	Use CA or Japan seismic design, columns as fuse	Construction inspection, testing, qualify contractors	0.35	0.04	0.2
	Liquefaction	PGD 250 mm	Bridge foundation	H pile or prestressed pile foundation	Geotechnical testing, construction inspection	0.4	0.1	0.3
	Wind	Small events	Connection of diaphragms to steel girders	Reduce dissertation-induced fatigue cracking, redundant nonfracture critical design	Inspection of welded connections, reduce section loss by corrosion prevention	0.1	0.03	0.05
	Flood	Large events	Pier and abutment foundations	Mitigation of local scour, use rocks or pier walls	Regular inspection, construction quality control	0.03	0.02	0.01
	Landslide	N/A						
Unpaved tertiary roads	EQ motion	Mw 7 PGA 0.4g	Road surface and underlying material	Provide seismic reinforcement, compact the underlying material	Use earthquake-resistant foundations	0.1	0.05	0.1
	Liquefaction	Large PGD: more than 0.3 m	Road surface and underlying material	Provide reinforcement against large ground displacement	Soil improvement, avoid areas vulnerable to liquefaction	0.1	0.05	0.05
	Wind	N/A						
	Flood	Large floods	Road surface	Provide barriers, improve drainage	Maintain the roads	0.1	0.05	0.03
	Landslide	ND	Road surface	Add retaining wall, stabilize slope, shotcrete, soil nails	Construction monitoring	0.2	0.02	0.05

Source: Miyamoto International (2019)

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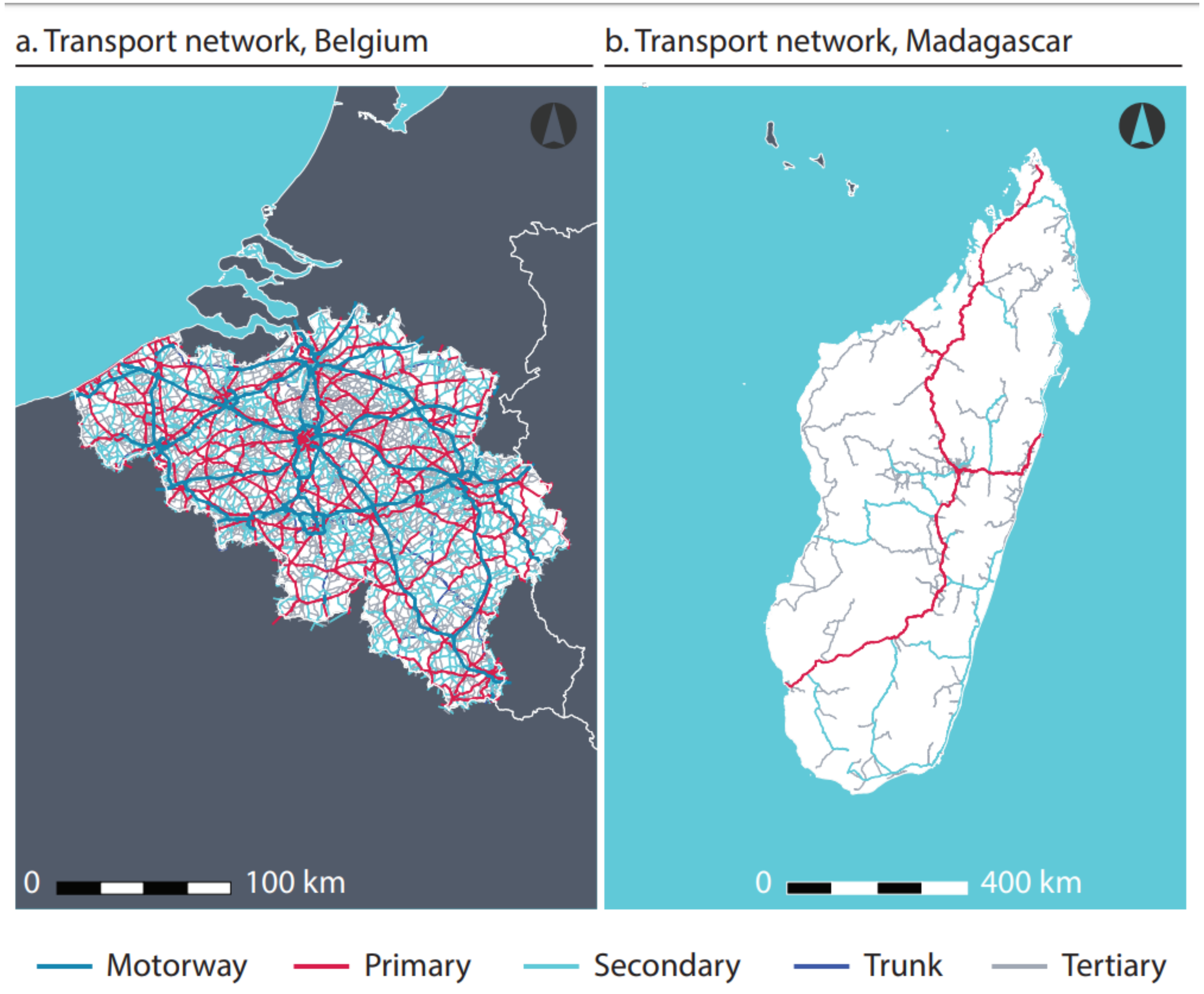
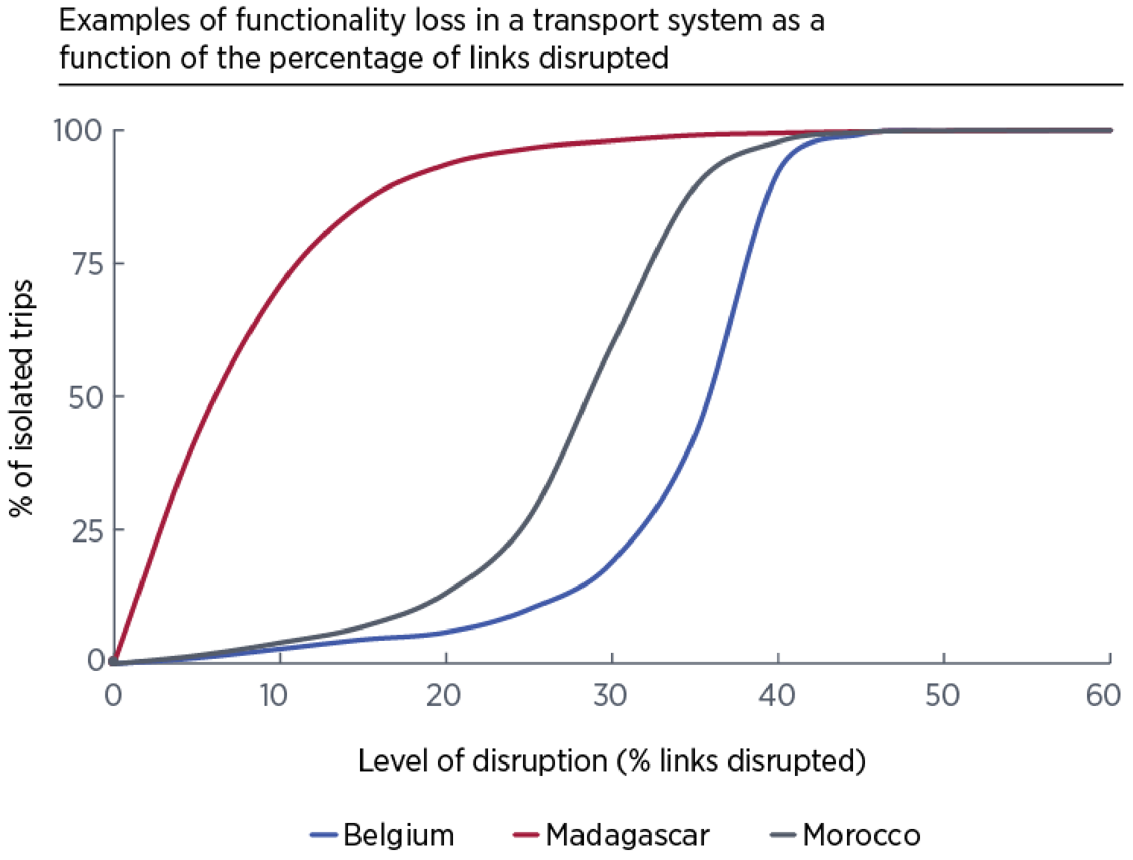
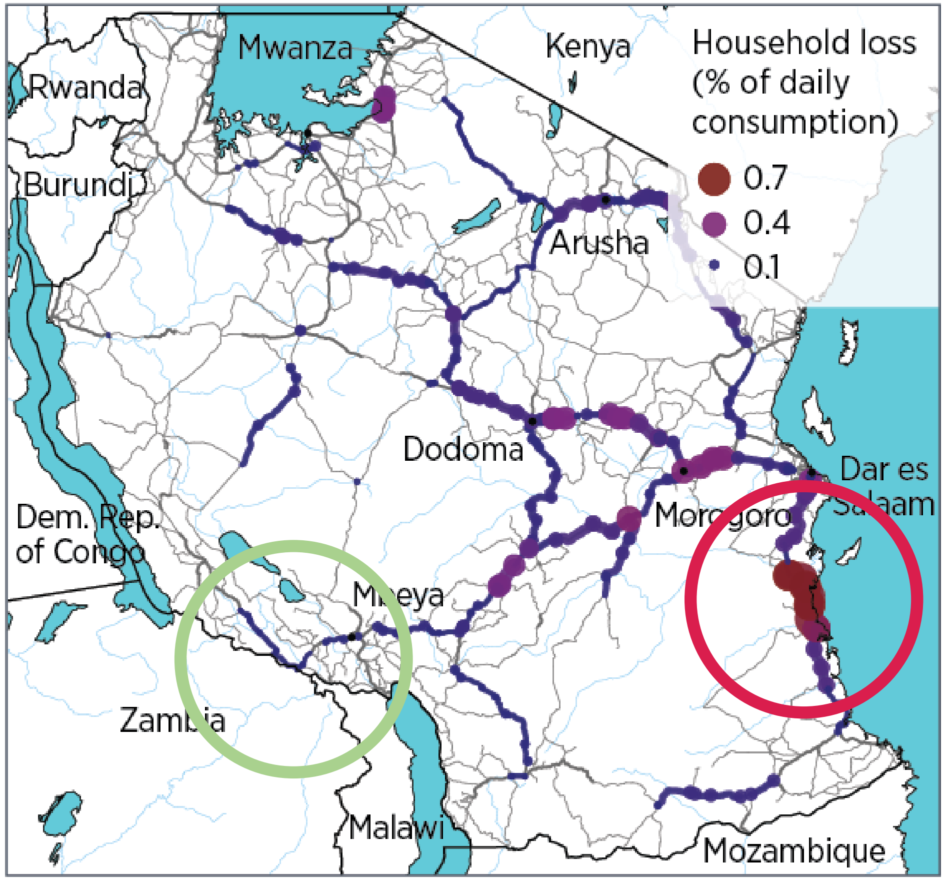
Asset and system vulnerabilities can be very different



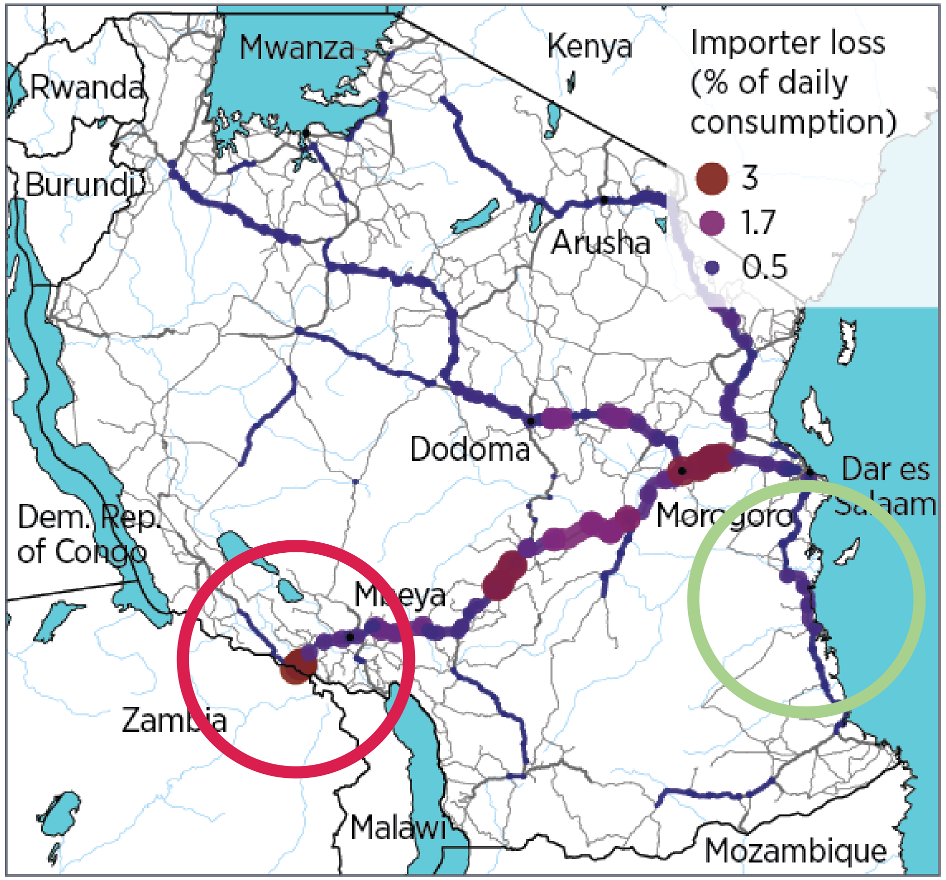


Criticality analyses show where strengthening is more important and beneficial

a. Impacts of disruption on households

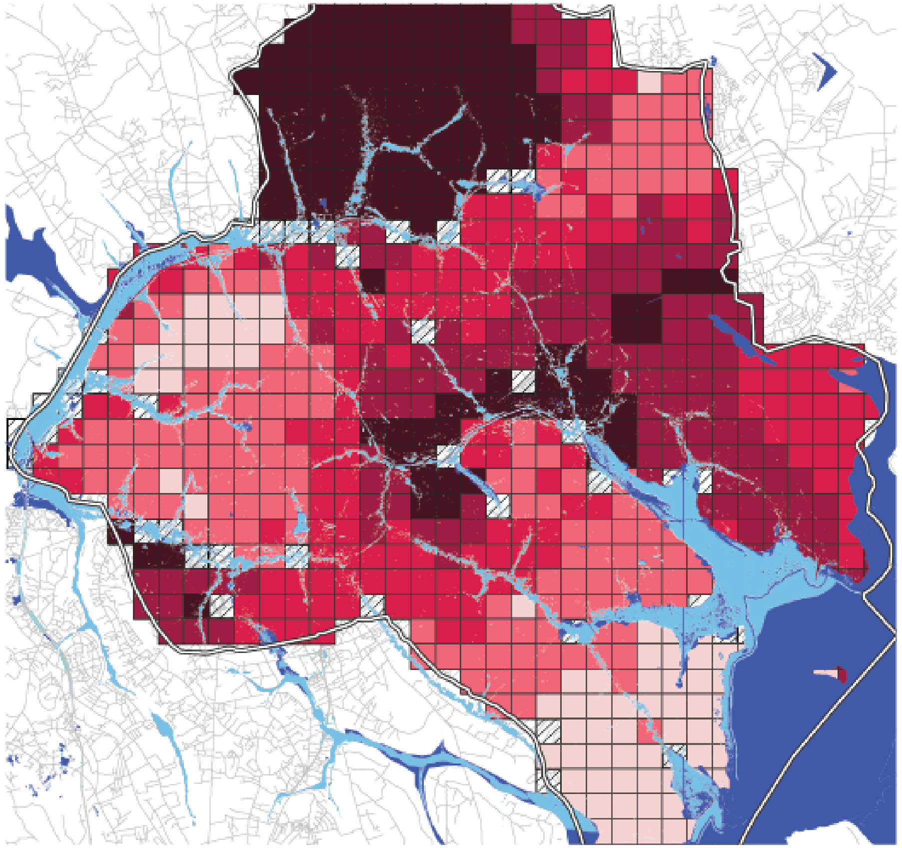


b. Impacts of disruption on international clients



Criticality analyses show where strengthening is more important and beneficial

Increases in travel times from locations across Inner Kampala to hospitals in a 10-year flood



Increase in travel time (%)

- 0–27
- 27–36
- 36–47
- 47–70
- >70
- Trips no longer possible

- 10-year flood extent
- Bodies of water
- Area of analysis
- Roads

A wetland park in Colombo helps to mitigate flood risk and offers recreational opportunities, such as bird-watching towers.

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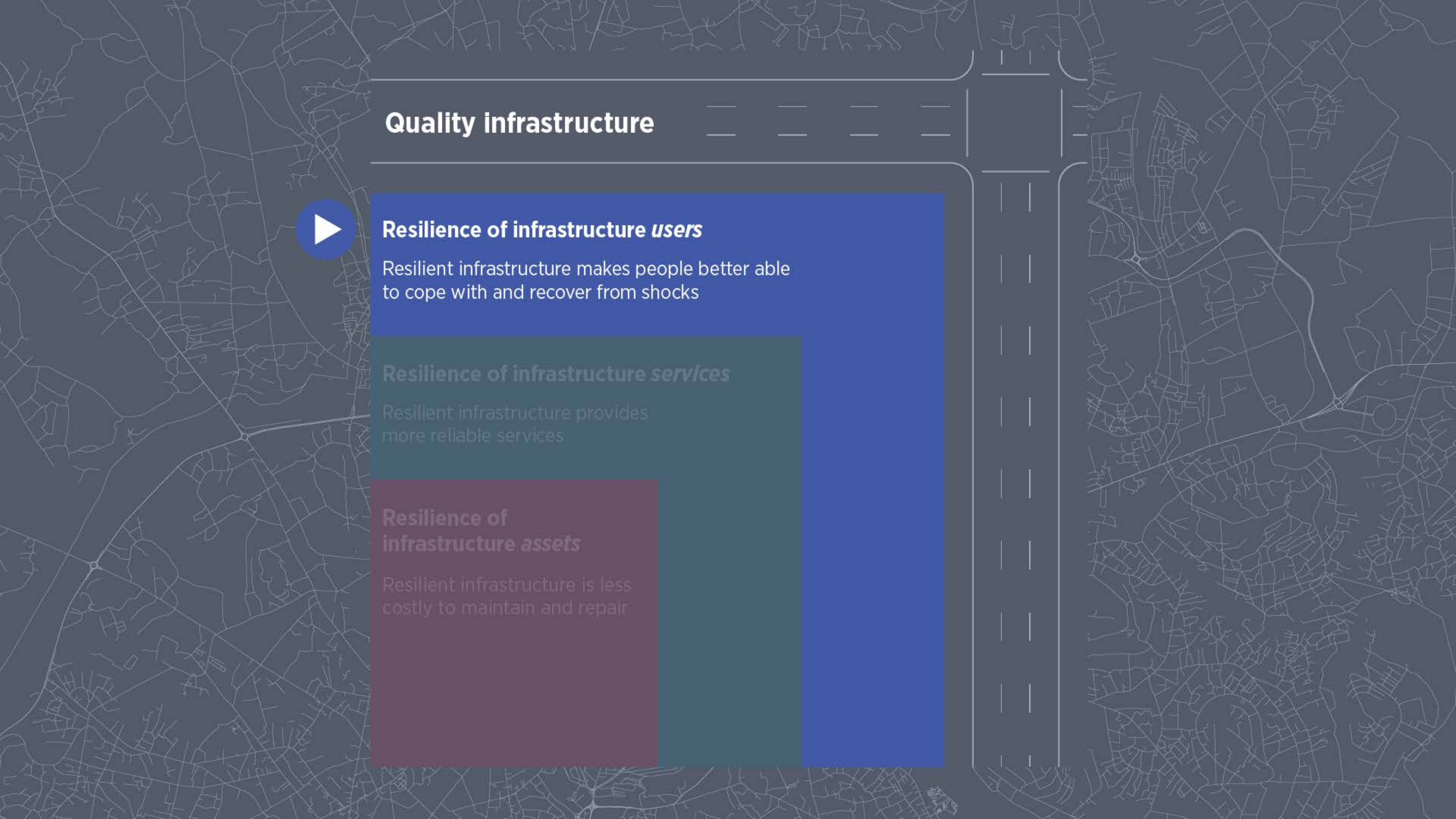

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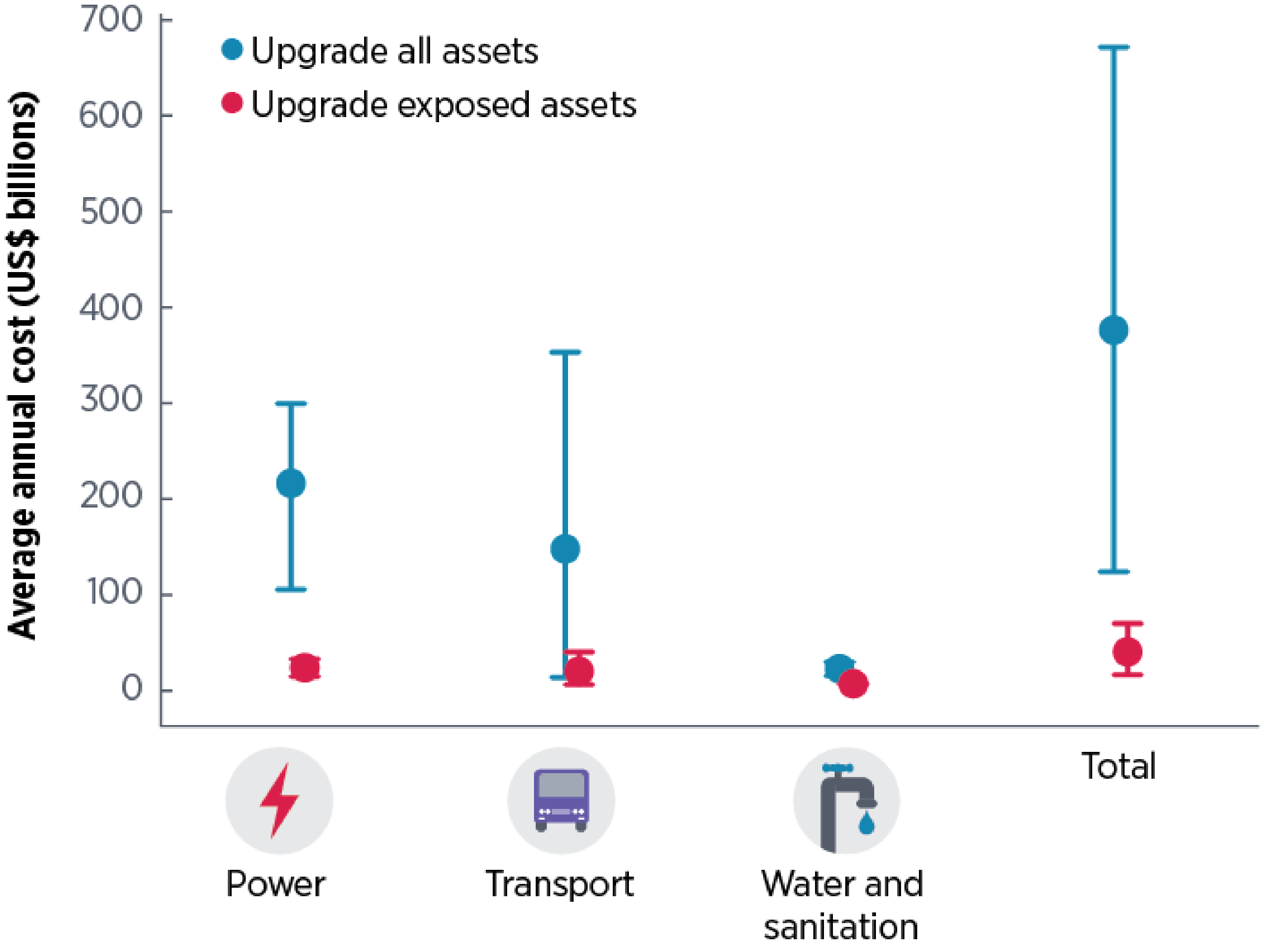
Opportunities for cheaper resilience by making users better able to manage disruptions

Critical services

Business continuity plans

Home emergency supply

With the right data, strengthening assets would cost $11–$65 billion per year—3 percent of total needs



Altogether: Investing in resilience is sound, profitable, and urgent

$4

In net benefit for each $1 invested in infrastructure resilience

$4.2 trillion

Net benefit from building new infrastructure to higher resilience standards

$100 billion

Cost of delaying action by one year

Good infrastructure management is the necessary basis for resilient infrastructure—but targeted actions are also needed.

Five obstacles to making infrastructure more resilient

OBSTACLES TO INFRASTRUCTURE MANAGEMENT

Poor design, operation, and maintenance of infrastructure systems

↓

Get the basics right

Five obstacles to making infrastructure more resilient

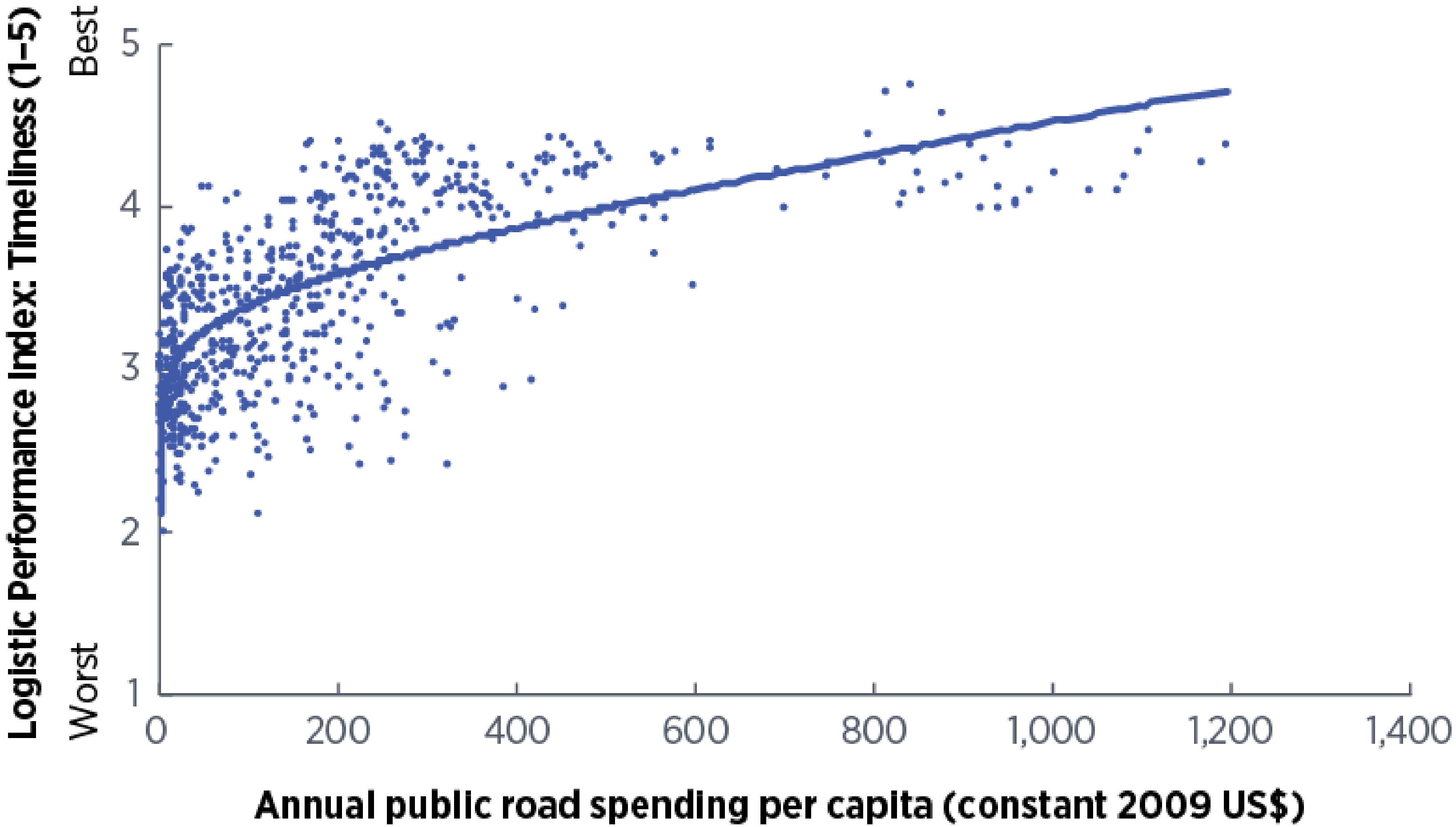
OBSTACLES TO INFRASTRUCTURE MANAGEMENT	OBSTACLES TO INFRASTRUCTURE RESILIENCE			
Poor design, operation, and maintenance of infrastructure systems	Political economy, coordination failures	Lack of incentives to increase resilience	Inadequate data, models, skills, or tools	Affordability and financing constraints
↓	↓	↓	↓	↓
Get the basics right	Build institutions for resilience	Create regulations and incentives for resilience	Improve decision-making	Provide financing

A menu of actions for countries to build their strategy

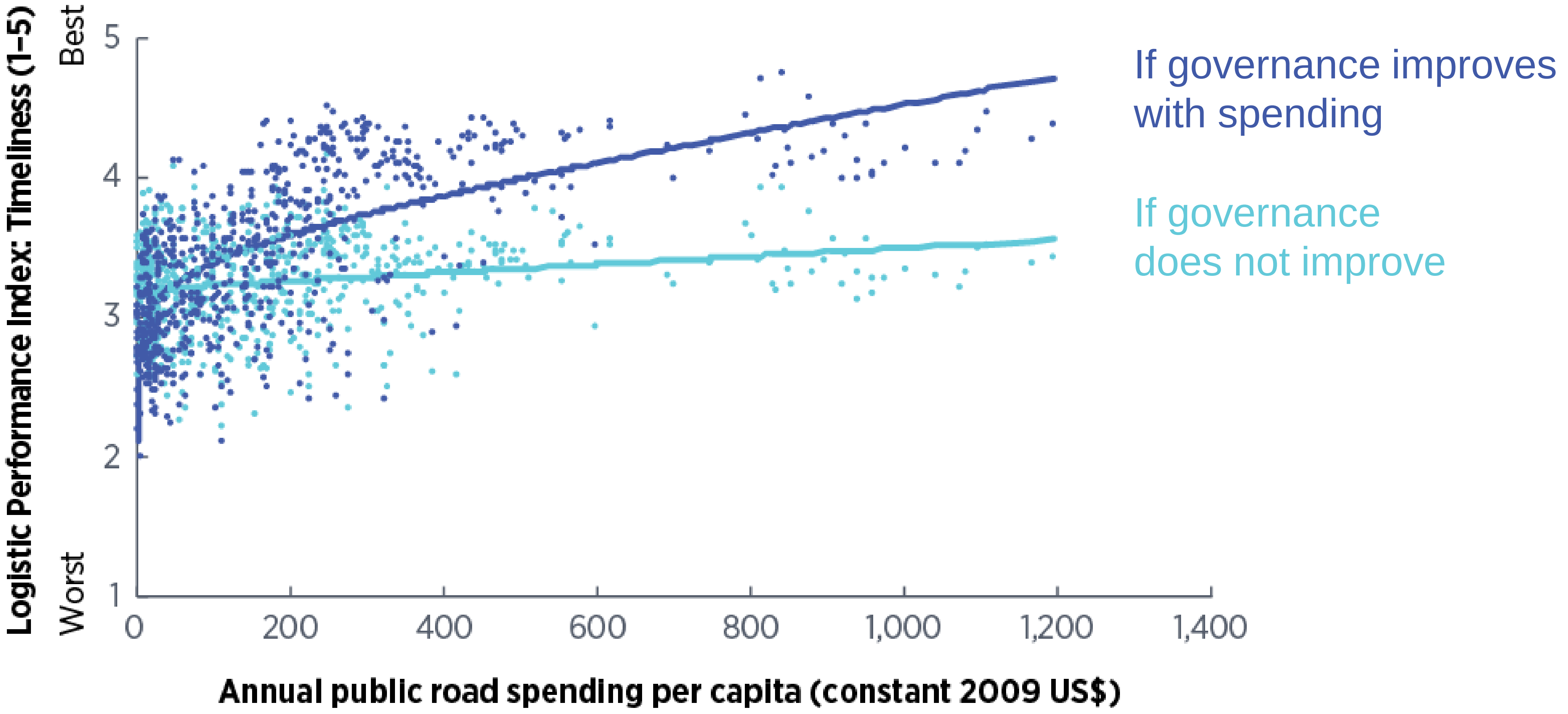
Recommendation	Actions
1: Get the basics right	1.1: Introduce and enforce regulations, construction codes, and procurement rules 1.2: Create systems for appropriate infrastructure operation, maintenance, and postincident response 1.3: Provide appropriate funding and financing for infrastructure planning, construction, and maintenance
2: Build institutions for resilience	2.1: Implement a whole-of-government approach to resilient infrastructure, building on existing regulatory systems 2.2: Identify critical infrastructure and define acceptable and intolerable risk levels 2.3: Ensure equitable access to resilient infrastructure
3: Create regulations and incentives for resilience	3.1: Consider resilience objectives in master plans, standards, and regulations and adjust them regularly to account for climate change 3.2: Create economic incentives for service providers to offer resilient infrastructure assets and services 3.3: Ensure that infrastructure regulations are consistent with risk-informed land use plans and guide development toward safer areas
4: Improve decision making	4.1: Invest in freely accessible natural hazard and climate change data 4.2: Make robust decisions and minimize the potential for regret and catastrophic failures 4.3: Build the skills needed to use data and models and mobilize the know-how of the private sector
5: Provide financing	5.1: Provide adequate funding to include risk assessments in master plans and early project design 5.2: Develop a government-wide financial protection strategy and contingency plans 5.3: Promote transparency to better inform investors and decision makers

A municipal worker cleans a drainage canal in Beira, Mozambique, to prevent clogging.

Spending more improves the reliability of transportation systems …



… but only if governance improves as well



Priority areas for financial support—how can we spend better?

FULL INFRASTRUCTURE COSTS

COST TO REGULATORS AND GOVERNMENT

- Master planning, regulation design, and enforcement
- Data and model development, research, training, education

LIFECYCLE COST TO (PUBLIC OR PRIVATE) INFRASTRUCTURE SERVICE PROVIDERS

- Project design and preparation
- Upfront investment cost
- Operational costs

  Maintenance and repair costs (and decommissioning)

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Master planning, regulation design, and enforcement	**Project design and preparation**	Upfront investment cost	Operational costs
Data and model development, research, training, education			**Maintenance** and repair costs (and decommissioning)

For instance, $1 invested in maintenance is worth $1.5 in new investment

Team members

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