Coastal and River Flood Protection: Future Risk Tolerance and Construction Costs Shape Costs

In low- and middle-income countries, infrastructure—defined here as water and sanitation, electricity, transport, irrigation, and flood protection—falls short of what is needed to address public health and individual welfare, environmental considerations, and climate change risks, let alone achieve economic prosperity or middle-class aspirations. How can this situation be reversed? This policy note is drawn from *Beyond the Gap: How Countries Can Afford the Infrastructure They Need while Protecting the Planet,* edited by Julie Rozenberg and Marianne Fay, Sustainable Infrastructure Series (Washington, DC: World Bank, 2019). *Beyond the Gap* not only contends that the focus should be on the service gap—not the investment gap as is typically the case—but also offers a careful and systematic approach to estimating the funding needed (capital and operations and maintenance) to close the service gap. The results presented here were developed specifically for this report, based on clearly specified access and climate goals and using numerous scenarios to explore both uncertainty and the consequences of policy choices.

Policy Note 5—one of six drawn from *Beyond the Gap*—explores the costs of coastal and river flood protection strategies. Policy Note 1 provides an overview of the report; Policy Note 2 focuses on water, sanitation, hygiene, and irrigation; Policy Note 3 focuses on the power sector; Policy Note 4 focuses on the transport sector; and Policy Note 6 focuses on climate change.

Key messages

- **Over 2015–30, investments to protect against both coastal and river floods could cost low- and middle-income countries (LMICs) between 0.06 percent and 1 percent of gross domestic product (GDP), depending primarily on the level of risk that is acceptable to local populations and the uncertainty pertaining to construction costs.**
- **Our "preferred" strategy—involving the adoption of Dutch standards of coastal flood protection for cities and the acceptance of higher risks from river floods based on a cost-benefit analysis—would cost LMICs about 0.32 percent of GDP.**
- **Failure to secure the appropriate financial tools, institutions, and governance mechanisms to ensure maintenance—and thus continuous protection over time—would increase risk and could result in catastrophic failures. Absent a firm commitment to reliable maintenance, a combination of nature-based protection, land-use planning, and retreat should be favored.**

Flood damages are expected to increase significantly over the 21st century as sea-level rise, more intense precipitation, and extreme weather events combine with socioeconomic developments to put an ever-rising number of people and an ever-more-expensive value of assets at risk in coastal and riverine floodplains. While increased damages and corresponding adaptation costs might well be the most costly impacts of climate change, little attention has been paid so far to the investments needed in flood protection.

To shed light on these costs, *Beyond the Gap* undertakes a comprehensive quantification of future investment needs for LMICs in coastal and river protection infrastructure by 2030.

Key cost drivers are construction costs and risk tolerance

Our costing exercises rely on specialized models that consider (a) different *levels* of protection (reflecting different levels of risk aversion, as described in box 1); (b) different *means* of providing that protection (through different protection technologies, like surge barriers or river dikes); and (c) uncertainties surrounding the costs of protection, future socioeconomic changes, and climate change.

For both coastal and river floods, uncertainty regarding construction costs and the protection strategy (defined by risk tolerance) are the key drivers of costs—much more so than uncertainties about climate change or socioeconomic change (GDP, population), even though climate and socioeconomic changes are critical inputs for choosing areas to protect and how to protect them.

For coastal protection, capital costs range from US$2 billion to US$56 billion per year, on average, between 2015 and 2030, depending on construction costs and the protection strategy pursued. This represents between 0.006 percent and 0.05 percent of LMICs' GDP per year, on average, for the least expensive strategy (constant relative risk) and between 0.04 percent and 0.19 percent of LMICs' GDP per year, on average, for the most expensive one (optimal protection) (figure 1, panel a).

For river flood protection, capital costs range from US$20 billion to US$280 billion per year, on average, between 2015 and 2030, depending on the protection strategy pursued, when using the same range of construction costs as for coastal flood

The protection strategy determines which coastal and inland areas invest in "hard" protection (surge barriers or dikes) and the level of protection (such as the return period of floods that the protection can manage). Absent this protection, communities would need either to cope with floods and their impacts or to retreat.

For river flood protection, three strategies are examined: (a) achieving an optimal level of protection based on a simple cost-benefit analysis that minimizes the sum of protection costs (capital and maintenance) and residual flood damage (to assets) to 2100; (b) keeping the current *absolute* level of flood risk constant in each country, in U.S. dollars; and (c) keeping the current *relative* level of flood risk constant in each country, as a percent of GDP.

For coastal protection, the same three strategies are examined, and a fourth one is added: the "low-risk-tolerance" strategy, which entails keeping average annual losses below 0.01 percent of local GDP for protected areas (defined on the basis of density). We take this (high) Dutch standard as the acceptable risk standard in a low-risk-tolerance world.

high in the low-risk strategy (keeping absolute risk levels constant) as in what the cost-benefit analysis suggests is the optimal level of investment. This is because 1 kilometer of dike along the coast can protect, on average, many more square kilometers of land than 1 kilometer of dike along a river.

To increase the efficiency of dikes, policy makers will need to adopt complementary policies—such as land-use planning to prevent people from settling in flood-prone areas or nature-based solutions to increase water storage, decrease runoff, and reduce the cost of dikes. Also needed will be early-warning systems and communication about residual risk.

Maintenance matters greatly

Once maintenance costs are factored in, LMICs would have to spend between 0.10 percent and 0.52 percent of their GDP per year for coastal and river flood protection by 2030 if they followed the economically optimal strategy, depending on construction costs, economic growth, urbanization, and climate change.

Although these costs appear affordable, the development of appropriate institutions and governance mechanisms to deliver maintenance as well as the necessary funding streams is essential for an infrastructure-based protection strategy to be effective. Failure to do so would increase risk and could result in catastrophic failures, putting lives, not just assets, at risk. Absent a firm commitment to reliable maintenance, a combination of land-use planning and retreat should be favored.

protection (red dots in figure 1, panel b). This represents between 0.05 percent and 0.81 percent of LMICs' GDP per year on average. Contrary to coastal flood protection, where investment costs are highest under the optimal strategy as defined by a cost-benefit analysis, for river floods, investment costs are more than twice as

FIGURE 1   Protection levels and construction costs shape capital costs

Average annual cost of investment in LMICs, by construction costs and risk-taking strategy, 2015–30
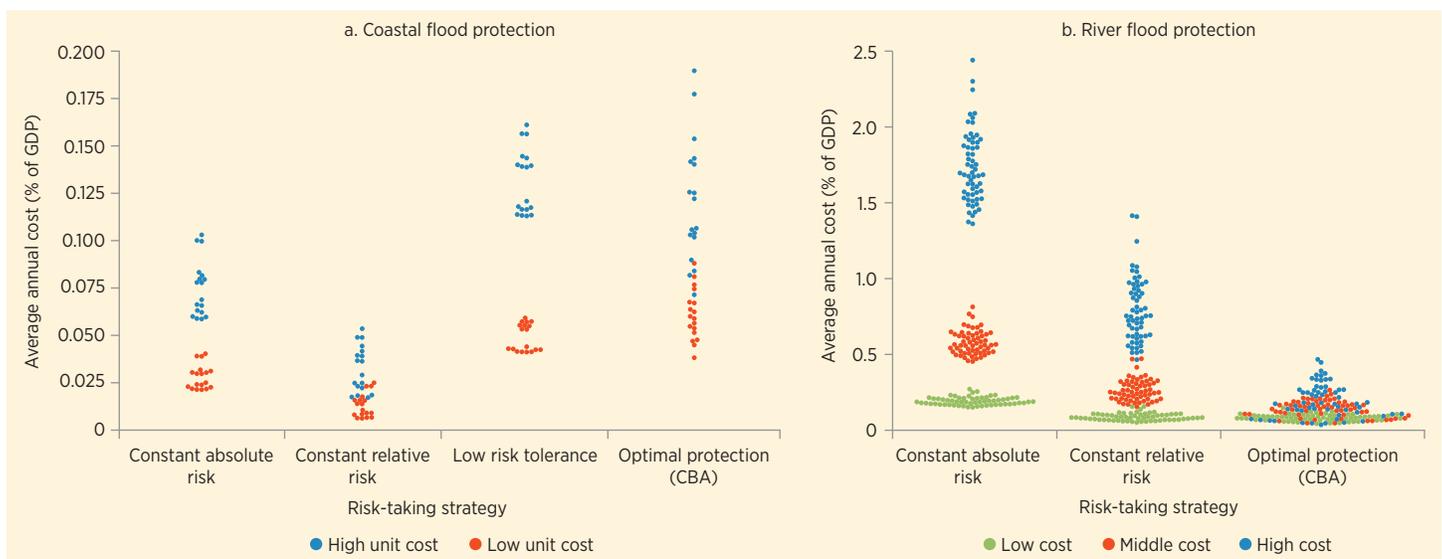
Sources: See figure 5.1 (for panel a) and figure 5.3 (for panel b) in the full report.
Note: CBA = cost-benefit analysis; LMICs = low- and middle-income countries.