

---

# Integrating climate risk management in infrastructure PPPs in developing countries: Key concepts, best practices, and broader considerations

Jyoti Bisbey<sup>1</sup>, Chang-Boong Lee<sup>2</sup>, Patrick Ryan<sup>3</sup>

---

## Abstract

Climate change is one of the largest threats to global economic growth and financial stability. While international cooperation to address climate change has increased in recent years, progress has been limited in transition to more climate-proof infrastructure management. Stakeholders involved in infrastructure development must urgently understand and integrate climate-related risks (CRR) from all three physical, transition, and liability aspects. As public-private partnerships (PPPs) are a key modality in delivering infrastructure projects, PPP process cycle provides many venues to proactively manage CRR that could arise throughout the whole infrastructure life cycle. To such an end, this paper identifies the specificities of CRR for infrastructure PPPs, providing illustrations on the relevant types of climate-related risks, conceptual analyses of the systemic implications, broader ecosystem-wide considerations facing the key stakeholders as well as granular practical recommendations to adapt the PPP process cycle. Finally, the broader considerations for key stakeholders, particularly the public sector, policymakers, and private sector are discussed. In doing so, this paper aims to contribute towards the development of good practices among PPP practitioners and stakeholders for managing climate-related risks.

**Keywords:** *stranded assets, valuation, public investment planning, infrastructure economics, climate change, public-private partnerships*

## PAPER INFORMATION:

Received: 6 June 2022

Accepted: 5 July 2022

Available online:

5 August 2022

Winner of the “Most practical application of PPPs in developing countries” award at the WAPPP Annual Congress 2022

## CORRESPONDING AUTHOR:

Jyoti Bisbey, [jbisbey@yahoo.com](mailto:jbisbey@yahoo.com)

## CITATION:

Bisbey, Lee & Ryan (2022). Integrating climate risk management in infrastructure PPPs in developing countries, *WAPPP Journal* 2022

## DOI:

10.55898/wappp2022\_climate\_risks\_PPPs

## COPYRIGHT:

Copyright © 2022 by author(s) and World Association of PPP Units & Professionals. This work is licensed under the Creative Commons Attribution-Non-Commercial 4.0 International License (CC BY-NC 4.0). <http://creativecommons.org/licenses/by/4.0/>

---

<sup>1</sup> Executive Committee Member, World Association of PPP Units & Professionals (WAPPP)

<sup>2</sup> School of International and Public Affairs, Princeton University, USA

<sup>3</sup> School of International and Public Affairs, Princeton University, USA

## Table of Contents

Abstract	1
1. Introduction	3
2. Background	4
3. Climate-Related Risks in Infrastructure	6
3.1. Physical Risks	6
3.2. Transition Risks	8
3.3. Liability Risks	9
3.4. CRR through the Lens of Traditional PPP Risk Categories	10
4. The Economic and Financial Impact of CRR in Infrastructure	11
4.1. Infrastructure, PPPs, and Economic Development	12
4.2. Economic Value and Asset Pricing of Infrastructure	14
4.3. Infrastructure Asset Class and CRR in the Financial System	15
5. Managing Risks from a Force Majeure Event: Lessons Learned from COVID-19	16
6. Recommendations for Integrating CRR in the PPP Process Cycle	17
7. Recommendations for Key Stakeholders	21
7.1. Public Sector	21
7.2. Policymakers and Financial Institutions	23
7.3. Non-financial Private Sector	24
8. Concluding Remarks	25
References	26

## 1. Introduction

**The global infrastructure financing gap is massive and might further widen given the needs for climate change mitigation and adaptation.** The OECD estimated that an average of USD 6.3 trillion in infrastructure investment is required annually between 2016 and 2030 to meet global development needs (OECD, 2017). However, an additional USD 0.6 trillion per year would be necessary over the same time frame to make these investments compatible with climate goals (ibid.).

**Developing robust and climate-aligned infrastructure project pipelines is key to achieving climate change mitigation and adaptation goals.** While the global saving glut provides a unique opportunity to invest in infrastructure that helps meet the Sustainable Development Goals (SDGs) and climate priorities, the lack of high-quality projects remains a major bottleneck that constrains investment in climate-aligned infrastructure (Zelikow & Savas, 2022).

**Public-private partnerships (PPPs), as a key modality in delivering infrastructure projects, are essential to the formation of sustainable infrastructure pipelines.** While not all infrastructure projects are suitable for PPPs, carefully selected and structured PPP projects could provide potential benefits towards pipeline formation including increased efficiency in project delivery, crowding in private investments, life-cycle cost management, and risk sharing (ADB, EBRD, IDB, IsDB, & WBG, 2016).

**Climate-proofing PPPs requires a better understanding and management of climate-related risks (CRR) by PPP contracting authorities and other key stakeholders.** Given that the PPP process cycle encompasses a comprehensive set of activities from project screening, contractual agreement, partner selection to performance monitoring, it provides many venues to proactively manage CRR that could arise throughout the whole infrastructure project life cycle. While this can be driven by PPP contracting authorities, the efforts should follow a multi-stakeholder approach given the scale and breadth of CRR in infrastructure PPPs.

**Private sector participation in infrastructure is not easy to come by in the first place, especially in developing economies.** Even in normal course, governments need robust sectoral frameworks, good governance, proper process to screen bankable projects for PPPs, PPP contracts to clarify both parties' rights and obligations and solid contract management, among other success factors.

**In view of the multi-faceted challenges, the main research objective of this paper is to focus on improvements needed to integrate CRR in the current PPP frameworks and practices in developing countries.** Particularly, the following questions are addressed:

- What are the relevant types of CRR in the context of infrastructure PPPs?
- What are the economic and financial implications of CRR on infrastructure PPPs and assets?
- What are the broader ecosystem-wide considerations facing the key stakeholders?
- What are the recommended best practices and principles for PPP contracting authorities to incorporate CRR into the PPP process cycle?

The main contribution of this paper is to identify the specificities of climate-related risk management for infrastructure PPPs. Specifically, our analysis focuses on economic infrastructure in developing countries.<sup>4</sup> Given the recent developments in greening the financial system, CRR have become

---

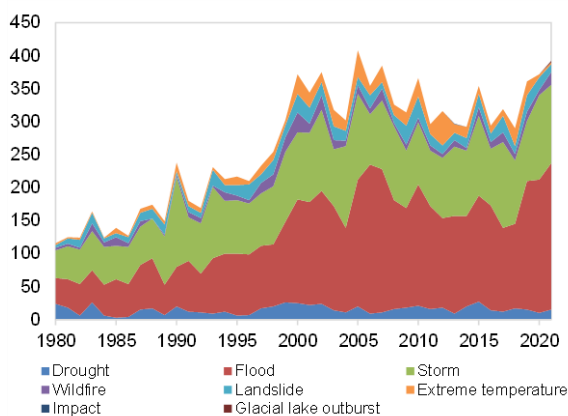
<sup>4</sup> Economic infrastructure refers to those that enable business activities. This categorization includes Energy, Telecommunications, Transport, and Water and other Utilities. For more information, see APMG PPP Certification Guide, 2016.

increasingly salient among the stakeholders in the financial markets. However, significant knowledge gaps remain in certain application areas, including infrastructure PPPs. As such, this paper aims to fill such knowledge gaps and contribute towards the development of best practices among PPP practitioners.

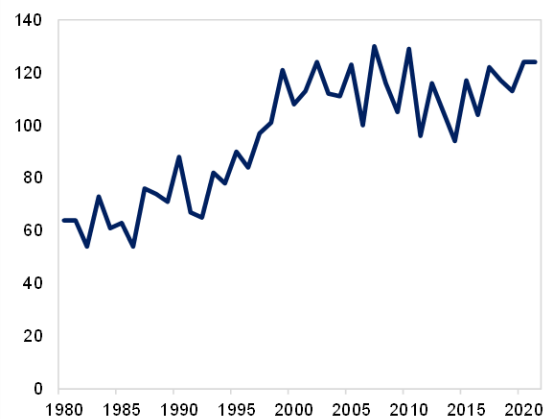
## 2. Background

**Climate change is one of the largest threats to global economic growth and financial stability.** The frequency of weather-related natural disasters has been increasing over time, highlighting the increasing economic and human costs associated with climate change (Figure 1). In addition, the number of countries impacted by climate-related natural disasters has nearly doubled over the last four decades - from 64 countries in 1980 to 124 in 2021 (Figure 2).

**Figure 1. Frequency of Climate-Related Disasters (1980-2021, Count)**



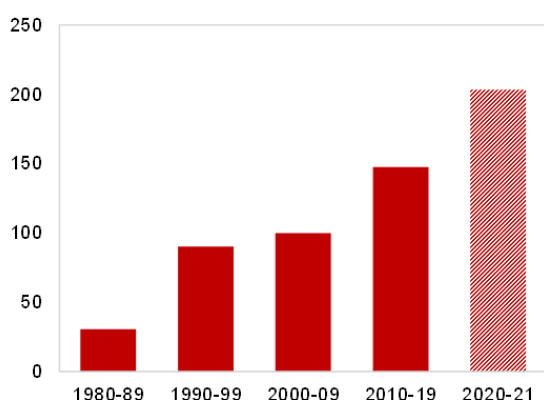
**Figure 2. Number of Countries Affected by Disasters (1980-2021, Count)**



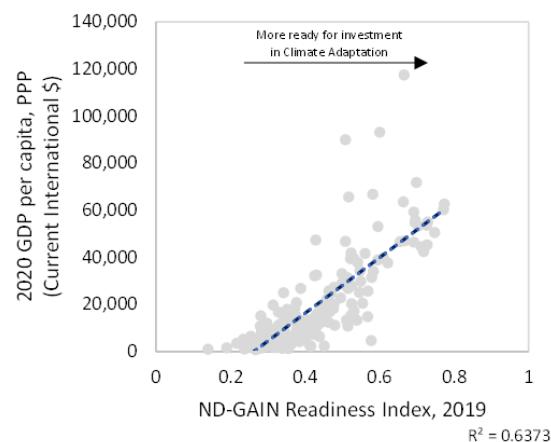
Source: EM-DAT Database, Authors' calculations.

**As the frequency of climate-related disasters has been increasing, so too have their costs (Figure 3).** Moreover, lower income countries are less prepared for investment in climate adaptation than their higher-income peers (Figure 4). Together, these trends highlight increasing threats to economic growth in developing countries. Developing countries will likely face the highest costs from climate change given their vulnerability to climate-related risks, sectors most exposed to climate change, and limited ability to invest in climate-resilient infrastructure (UNEP, 2020).

**Figure 3. Average Costs of Climate-Related Disasters**  
(1980-2021, USD Billions)



**Figure 4. National Income and Climate-Readiness**  
(2019-2020, Units)



Source: EM-DAT Database, ND-GAIN Index, World Bank World Development Indicators, Authors' calculations.

**While international cooperation to address climate change has increased in recent years, progress has been limited in actual transition to more climate-proof infrastructure.** An enormous infrastructure financing gap exists in developing countries (UNCTAD, 2018). Yet these estimates understate the scale of the problem and abstract away from much needed improvements in infrastructure service delivery. Financing gap estimates do not include costs linked to escalating risks associated with climate change, which are not yet fully incorporated into the maintenance of existing infrastructure and investments in new infrastructure (Minh, Leow, and Seiderer, 2020). Moreover, enhancing service delivery requires much more than increased capital expenditure, it also requires improvements in spending efficiency (Rozenberg and Fay, 2019).

**Investing in the resilience of infrastructure in developing countries is cost effective.** The increase in costs associated with more resilient infrastructure investment is small when compared to overall investment needs and can be offset by costs associated with infrastructure service disruptions over the long-term (Hallegate, Rentschler, and Rozenberg, 2020). Current climate finance investment flows are dwarfed by overall financing needs to limit global warming to 1.5 °C (Climate Policy Initiative, 2021). Fiscal constraints in developing countries implies a critical role for increased private capital to achieve climate targets (Joint Report on Multilateral Development Banks' Climate Finance, 2020).

**Rebounding private investment in infrastructure offers an opportunity to shift towards more resilient infrastructure.** Private participation in infrastructure in developing countries dropped drastically during the pandemic and, while investment has increased strongly in some regions, has yet to fully recover (World Bank, 2022). Yet, this recovery indicates signs of a move to greater resiliency. While nearly one third of all public-private partnership (PPP) investment was directed toward the energy sector, 72 percent of financing commitments are renewable electricity generation. Leveraging this recovery to incentivize the private sector to direct capital towards green and resilient infrastructure will be crucial to achieve goals set out in the SDGs and Paris Accords.

### 3. Climate-Related Risks in Infrastructure

CRR can broadly be classified into three categories and all of which impact economic development, businesses, and the general population in different ways (adapted from Bank of England, 2015):

- **Physical risks:** The immediate impacts of climate change that arise from climate-related disasters. For example, storms and floods could damage real property and raise maintenance costs, and extreme weather events such as droughts could disrupt the functions of water-intensive infrastructure involved in hydropower generation, mining, and wastewater treatment.
- **Transition risks:** The risks which could result from the process of adjusting towards a low carbon economy. For example, abrupt and unforeseen heavy fluctuations in fossil fuel prices or changes in carbon pricing policies can disrupt the business model of entire industries.
- **Liability risks:** The impacts that could arise in the present and especially future, if parties who have suffered losses or damages from the effects of climate change seek compensation from those that they hold responsible.

**Physical risks interrelate with transition risks and they may run contrary to each other.** The losses from transitioning away from a carbon-intensive economy depends on the future paths of carbon emissions (BIS, 2021). Such paths would be shaped by many factors including public policy and climate actions, which in turn could be accelerated by increased episodes of climate disasters. In other words, if stakeholders agree on rapid decarbonization in the future, transition risks will become more prevalent. If they do not, physical risks will become more relevant. Thus, CRR cannot be avoided in their entirety. What they have in common, though, is their far-reaching impact on multiple lines of business, geographies and more generally, human health, wealth and properties.

**At their core, PPPs are a risk-transfer mechanism between the government and the private sector.** Government trade-off support for infrastructure that is economically but (perhaps) not financially viable with fiscal prudence while benefiting from the ability of private sector stakeholders to manage certain types of risks better than the public sector (World Bank, 2007). Therefore, the integration of CRR management is crucial to efficiently leverage private capital for resilient infrastructure investment and ensuring fiscal sustainability.

#### 3.1. Physical Risks

**Physical climate risks can be conceptually distinguished as chronic and acute physical risks.** Chronic physical risks generally refer to the long-term shifts in climate patterns, whereas acute physical risks focus on event-driven hazards. With regards to infrastructure and PPPs, the distinction could be useful in identifying how specific climate hazards interact with each infrastructure sector and the corresponding adaptation measures. Table 1 below provides a non-exhaustive illustration of physical risks that may affect infrastructure assets and service delivery.

**Table 1: Physical Risks in Key Economic Infrastructure Sectors**

Physical risks	Key economic infrastructure sectors			
	Energy	Transport	ICT	Water & Sanitatio
<b>Chronic risks - Longer-term shifts in climate patterns</b>				
Sea-level rise	<ul style="list-style-type: none"> <li>• Permanent inundation of assets</li> </ul>			<ul style="list-style-type: none"> <li>• Permanent inundation of assets</li> <li>• Increased desalination requirements</li> <li>• Increased water storage requirements</li> </ul>
Mean temperature changes	<ul style="list-style-type: none"> <li>• Efficiency loss of generation and transmission assets</li> <li>• Increased cooling needs, especially for thermoelectric plants</li> </ul>	<ul style="list-style-type: none"> <li>• Asset damage, such as melting road surfaces and buckling railway lines</li> </ul>	<ul style="list-style-type: none"> <li>• Increased cooling needs for assets such as data centres</li> </ul>	<ul style="list-style-type: none"> <li>• Increased water needs</li> <li>• Increased evaporation from reservoirs</li> <li>• Increased need for treatment</li> </ul>
Changes in precipitation patterns and extreme variability in weather patterns	<ul style="list-style-type: none"> <li>• Damage to assets in increased frequency and severity</li> <li>• Longer and more frequent disruption of services</li> <li>• Decreased level of protection from adaptation measures</li> <li>• Increased need for storage capacity of resources for contingency uses</li> </ul>			
<b>Acute risks - Event-driven hazards, including increased severity of extreme weather events</b>				
Drought and heatwave	<ul style="list-style-type: none"> <li>• Asset damage</li> <li>• Temporary distribution network failure</li> <li>• Efficiency loss of generation and transmission assets</li> </ul>	<ul style="list-style-type: none"> <li>• Asset damage</li> <li>• Disruptions of inland marine traffic</li> </ul>	<ul style="list-style-type: none"> <li>• Disruption to facilities such as data centres with high cooling needs using water</li> </ul>	<ul style="list-style-type: none"> <li>• Rationing and service shutdown</li> <li>• Increased need for treatment</li> </ul>
Flood		<ul style="list-style-type: none"> <li>• Asset damage</li> <li>• Multi-modal traffic disruptions</li> </ul>	<ul style="list-style-type: none"> <li>• Asset damage</li> <li>• Temporary network failure</li> </ul>	<ul style="list-style-type: none"> <li>• Asset damage</li> <li>• Overflows</li> </ul>
Wildfire				<ul style="list-style-type: none"> <li>• Asset damage</li> </ul>
Hurricane, storm, typhoon, and tornado				<ul style="list-style-type: none"> <li>• Asset damage</li> </ul>
<i>Source: Authors' adaptation based on Marsh &amp; McLennan (2020), McKinsey (2020), OECD (2018)</i>				

**Chronic and acute physical risks could have varied implications on each stage of the PPP process cycle.** At the project appraisal stage, limited understanding of physical risks could affect demand projections and feasibility assessments. For instance, a long-term rise in mean temperature may cause relatively predictable efficiency loss in solar panels, which implies that the output and revenue potential of an exposed solar power project should be adjusted downward for long stretches of its lifecycle. In contrast, event-driven hazards such as floods have more sporadic impacts, which necessitate measures of a different nature such as contingency costs for service restoration.

**Physical risks can be compounded by the multiple hazards and “cascading failures”.** Oftentimes, multiple climate hazards could hit simultaneously. Also, disruptions in one sector or locality may trigger chain disruptions in connected infrastructure (McKinsey, 2020). The consequences may range from minor, short-term service disturbances to severe, long-term, and systemic failures with widespread and substantial damages. In 2012, Hurricane Sandy triggered a chain of adverse impacts, including hospital closures due to power outages, shutdowns of gas stations due to logistical difficulty, and water source pollution due to release of untreated sewage from wastewater plants (Gibson, 2017). This could pose a major challenge in delineating scopes of accountability among infrastructure owners.

**Physical risks could result in wide-ranging direct and indirect economic impacts.** For instance, floods may directly cause certain stretches of roads to be temporarily or permanently unusable, and this could in turn lead to a drastic increase in the traffic on other roads (Gibson, 2017). Given higher temperatures, the demand for power may increase to meet the needs for more air-conditioning, likewise for drinking water. Further, communities and households may have to relocate to safer locations to avoid climate hazards, and such climate migration would lead to changes in the demand for infrastructure assets and services, which may even become overstressed.

**Physical risks could pose direct threats to a whole region’s economic wellbeing due to a shared natural ecosystem.** As a case in point, physical risks related to climate change is expected to severely affect the many countries surrounding the Nile River, which include Burundi, the Democratic Republic of Congo (DRC), Egypt, Ethiopia, Kenya, Rwanda, South Sudan, Sudan, Tanzania, and Uganda (Nile Basin Initiative, 2013). To address this situation, the Nile Basin Initiative – an intergovernmental partnership of riparian states of the Nile River – promoted the adoption of climate-sensitive infrastructure planning methods among public and private sector actors in planning infrastructure investments in the region (Nile Basin Initiative, 2018).

### 3.2. Transition Risks

**Transition risks are multi-dimensional, far-reaching, and consequential to infrastructure projects.** Particularly, transition risks could significantly affect the financing strategies and legal approach in structuring PPPs. For instance, rapid advancements in green technology may heighten the perceived and actual technology risks of private investors. This implies that the government may have to commit additional fiscal resources for de-risking infrastructure projects most exposed to technology-related transition risks. Such risks may similarly necessitate a major review of contracting approach to encourage the ongoing adoption of innovations and promote technological upgrades. Table 2 below provides an overview of the relevant dimensions of transition risks and how they could potentially affect infrastructure projects and PPPs.



**Table 2: The Impact of Transition Risks on Infrastructure Projects and PPPs**

Transition Risks	Impact on Infrastructure Projects	Impact on PPPs
<b>Technology</b>		
<ul style="list-style-type: none"> <li>• Substitution of existing products and services with lower emissions options</li> <li>• Unsuccessful investment in new technologies</li> <li>• Costs to transition to lower emissions technology</li> </ul>	<ul style="list-style-type: none"> <li>• Write-offs and early retirement of existing assets</li> <li>• Reduced demand for products and services</li> <li>• Future capital investments in retrofitting new technology</li> <li>• Other costs to deploy new practices and processes</li> </ul>	<ul style="list-style-type: none"> <li>• Contractual provisions to encourage ongoing adoption of innovations and cost-sharing might be needed to promote technological upgrades</li> <li>• Investors' may perceive higher financial risks from technological obsolescence accelerated by climate transition</li> </ul>
<b>Market</b>		
<ul style="list-style-type: none"> <li>• Changing customer behaviour</li> <li>• Uncertainty in market signals</li> <li>• Increased cost of raw materials</li> </ul>	<ul style="list-style-type: none"> <li>• Higher uncertainties in economic demand and difficulty in pricing infrastructure services</li> <li>• Potential risks of cost overruns due to raw material price changes</li> <li>• Carbon pricing regime affecting input costs and output demand</li> </ul>	<ul style="list-style-type: none"> <li>• Private investors may demand additional financial support from the government to de-risk heightened climate-related market risks</li> <li>• The long-term financial viability of PPPs may be undermined if such market risks are not properly considered</li> </ul>
<b>Reputation</b>		
<ul style="list-style-type: none"> <li>• Shifts in consumer preferences</li> <li>• Stigmatization of sector</li> <li>• Increased stakeholder concern or negative stakeholder feedback</li> </ul>	<ul style="list-style-type: none"> <li>• Higher public scrutiny and political risks towards the approval of infrastructure proposals</li> <li>• Potential project delays and termination due to stakeholder protests</li> </ul>	<ul style="list-style-type: none"> <li>• Participatory processes may become increasingly important in PPP project planning and design</li> </ul>
<b>Policy and Legal</b>		
<ul style="list-style-type: none"> <li>• Increased pricing of GHG emissions</li> <li>• Enhanced emissions-reporting obligations</li> <li>• Mandates on and regulation of existing products and services</li> </ul>	<ul style="list-style-type: none"> <li>• Uncertainties in the obligations and sharing of financial costs from GHG pricing</li> <li>• Higher climate-related disclosure and other compliance costs on infrastructure operators</li> </ul>	<ul style="list-style-type: none"> <li>• PPP contracts may need either more flexibility for future revisions or forward-looking provisions to clarify how to manage the financial impact and</li> </ul>

	<ul style="list-style-type: none"> <li>• Write-offs, asset impairment, and early retirement of assets due to policy changes</li> </ul>	regulatory challenges from new climate policy
<p><i>Note:</i> Litigation risk in the policy and legal dimensions is further discussed in the next section  <i>Source:</i> Authors' adaptation based on TCFD (2017).</p>		

### 3.3. Liability Risks

**Liability risks towards parties involved in PPPs may arise due to climate change (Setzer & Higham, 2021).** For clarity, liability risks herein specifically refer to litigation risks. The basis for such climate-related legal challenges may include i) the failure to mitigate impacts of climate change, ii) the failure to adapt to climate change, and iii) insufficient disclosure around material financial risks. Globally, more than 1,000 cases of climate litigations were made in the 6 years from 2015 to 2021 – an explosive growth considering only about 800 cases were filed in the 28 years between 1986 and 2014 (ibid.).

**Further, liability risks could directly stem from physical and transition risks of infrastructure projects (ibid.).** For instance, legal challenges may involve claims for failure to adapt infrastructure design and related services to hazards of extreme weather conditions or claims that contest the permit or activities for building carbon-intensive infrastructure by activist groups or members of the public.

**Parties undertaking infrastructure PPPs could face increasing liability risks on various grounds.**

- **Failures to mitigate impacts of climate change.** In *Save Lamu et al. v. National Environmental Management Authority and Amu Power Co. Ltd.*, Kenya's National Environmental Tribunal revoked a license issued to the power company for constructing a coal power plant (UNEP, 2020). The tribunal found that the license was granted without adequate stakeholder consultations. Further, it required the power company to re-do its Environmental Impact Assessment based on all applicable policies including Kenya's Climate Change Act 2016 and Energy Act 2019.
- **Failures to adapt to climate change.** In *Von Oeyen v. Southern California Edison Co.*, residents of Malibu, California sought monetary damages from the local utility company in the court following a severe wildfire (UNEP, 2020). Plaintiffs argued the defendants failed to maintain and operate their infrastructure facilities properly despite the known increased risks of wildfire.
- **Insufficient disclosure around material financial risks.** In *York County v. Rambo*, bond investors claimed that the utility Pacific Gas and Electric Company (PG&E) failed to disclose "the heightened risk caused by PG&E's own conduct and failure to comply with applicable regulations governing the maintenance of electrical lines, and the hundreds of fires that were already being ignited annually by the Company's equipment." (UNEP, 2020).

**Liability risks are rising in developing countries with growing climate activism.** Since the 2000s, climate-related lawsuits have been made in more than 50 nations across North America, Europe, Asia Pacific, Latin America, and Africa (Verisk Maplecroft, 2021). While the US and EU accounted for 90 percent of these lawsuits, there is an increasing trend in other regions, noticeably in developing countries such as Argentina, India, and South Africa (ibid.).

**Further, the legal landscape that governs the environment and climate will likely evolve significantly in various countries.** For instance, in 2017, India's Ganges and Yamuna Rivers and New Zealand's Whanganui River were granted the status of a legal person by the national courts or legislature (Kothari, Margil & Bajpai, 2017). This would likely increase the likelihood of success for environmental lawsuits, as traditionally the lack of legal standing by the plaintiffs is often a basis for dismissal. In 2022, as a global precedent for climate litigation, judges and court-appointed experts visited a glacial lake in Peru's Cordillera Blanca mountain range to assess whether Germany's largest electricity provider, RWE, is partially liable for the rise in greenhouse gases that could trigger a devastating flood (Collyns, 2022).

#### 3.4. CRR through the Lens of Traditional PPP Risk Categories

**CRR may manifest through multiple types of commonly known PPP risk categories for infrastructure.** For instance, physical risks could affect the whole PPP life cycle of an infrastructure. For one, extreme climate events may lead to delays during construction: flooding could directly damage equipment and require additional time for site restoration, and outdoor exposure to extreme heatwave could increase employees' health risks including potentially life-threatening heatstroke. In addition, physical risks could increase market risk: if traffic is re-routed due to flooding of adjacent locations, the economic demand for the affected toll roads could decrease substantially.

**CRR may lead to a complex interplay of different PPP risk categories.** To address physical risks, engineers in the past could reliably use historical weather data to predict future climate events but this is no longer true due to climate change (Lempert, 2016). As such, physical risks would raise the project design risks of infrastructure projects if the resilience measures could be rendered inefficacious in the face of changing climate hazards. Further, this may give rise to liability risks from climate litigations due to failures to adapt the infrastructure design to climate change.

**Therefore, the rise of CRR necessitates changes in how PPP risks are understood, managed, and allocated.** Existing PPP risk categories which have traditionally been used for analytical purposes are still relevant. However, there are notable conceptual distinctions in consideration of CRR: First, the magnitude of risks has been amplified due to CRR; Second, the sources of risk will become more varied; Third, the frequency of risks being manifested will likely become higher; Finally, the predictability of the risks will become even lower. As such, PPP contracting authorities must develop a more comprehensive and nuanced understanding of the interaction between CRR and PPP risks and incorporate these considerations into the PPP process cycle.

### Box 1. CRR could increase contingent liability risks for ministries of finance

**CRR could impact public finances by realizing contingent liabilities whose ex-ante fiscal costs may be known or unknown.** Contingent liabilities with “ex-ante known fiscal costs” include minimum revenue guarantees under infrastructure PPPs – these contingent liabilities could be estimated based on the PPP agreed terms in a relatively reliable manner.

**CRR specific contingent liabilities with “ex-ante unknown fiscal costs” could be even more difficult to estimate due to their uncertain and contingent nature.** For instance, while the government could allocate funds for legal proceedings, compensations to firms and citizens for climate-related litigations are highly variable. Another example is the disaster recovery allocation for critical infrastructures which is contingent upon highly uncertain future climate impacts and risk materialization.

**CRR may cause contingent liability risks with ex-ante unknown fiscal costs to become more likely and severe.** This is partly driven by physical risks that used to be considered highly unlikely tail risks but are now expected to manifest at greater frequency and magnitude.

**In view of these trends, the Coalition of Finance Ministers for Climate Actions calls for the adoption of forward-looking scenario analysis to manage contingent liability risks.** As ministries of finance have powerful risk management levers through budgets, policy, and regulation, these scenario analyses would be instrumental to help identify the most effective risk management levers.

Source: Dunz & Power (2021) for the Coalition of Finance Ministers for Climate Actions

## 4. The Economic and Financial Impact of CRR in Infrastructure

**CRR in infrastructure have macroeconomic consequences and impact the stakeholders involved in the delivery and financing of infrastructure services.** Public investment and infrastructure are key drivers of economic development in developing countries. Thus, the interruption of public investment or the damage of infrastructure assets due to climate-related disasters can have ripple effects throughout the economy. Incorporating these risks into the price of existing infrastructure and valuations of future projects impacts the balance sheets of both the public and private sectors. These negative balance sheet impacts entail greater risk in the financial and insurance industries and require that the private sector, more broadly, adopt enhanced risk management strategies in the delivery of infrastructure.

### 4.1. Infrastructure, PPPs, and Economic Development

**Investment in infrastructure can bolster current economic activity and enhance future growth potential.** However, the impact that these investments have on economic growth depends on many factors including the efficiency of spending (value for money) and the productivity impact of the infrastructure asset (Mandl, Dierx, and Ilzkovitz, 2008). Developing countries benefit more from increases in infrastructure investment than advanced economies but face tighter financial constraints. More prominent employment effects of public investment in developing countries support larger observed public investment multipliers in developing relative to advanced economies (Izquierdo,

Lama, Medina, and Puig, 2019; Moszoro, 2021). Yet, fiscal space constraints limit the ability of countries to reap the growth benefits from increasing investment for more resilient infrastructure (OECD, 2021).

**As a result, private financing of public investment is also critical for maximizing an infrastructure project's value for money.** Better infrastructure governance can lead to larger output effects of investments, with the planning and implementation stages of the public investment process having the largest influence (Miyamoto, et al., 2020). These results suggest an important role for supporting a favorable climate for alternative infrastructure financing through PPPs and the private sector while maintaining a competitive and transparent procurement process. Moreover, the ability to crowd in, rather than crowd out, additional private investment influences the fiscal multiplier of public investment. Private investment is boosted most when corporate balance sheets have low leverage (Espinoza, Gamboa-Arbelaez, and Sy, 2020).

**CRR further complicates the already difficult process of public investment management and threatens the positive output effects of infrastructure investment.** In addition to assessing the affordability, economic viability, and inclusivity of infrastructure; policymakers must also assess the impact of physical, transition, and liability risks arising from CRR. Infrastructure continues to be built in areas with significant natural disaster risk, suggesting that CRR are not fully incorporated in project appraisals (Minh, Leow, and Seiderer, 2020). Infrastructure that is damaged or destroyed by climate-related disasters has an immediate negative impact on a government's balance sheet and affects an ecosystem of stakeholders – resulting in decreased economic activity (Rentschler, et al., 2019). An analysis of how climate-related disasters propagate through this ecosystem is illustrated in Table 3. The wide-ranging impacts of damaged infrastructure suggest that it is cost-effective to invest more, ex ante, in resilient infrastructure (Hallegate, Rentschler, and Rozenberg, 2019).

**Table 3: Example of Macroeconomic Consequences of CRR in Infrastructure by Stakeholder**

Affected Economic Variables	Impact of CRR on Infrastructure	Examples of PPP Risks
<b>Firms: Producers and Suppliers of Infrastructure</b>		
<ul style="list-style-type: none"> <li>• Input Costs</li> <li>• Diversification of Supply</li> <li>• Lower Profitability</li> </ul>	<ul style="list-style-type: none"> <li>• Supply chain disruptions due to CRR can result in higher input costs</li> <li>• Diversifying supply chains to mitigate CRR can result in less economic activity for local markets</li> <li>• Worsening financial performance due to CRR can also result in less purchases from local suppliers</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Site risk</b> - Both public and private sector must manage risks arising from land acquisition, e.g. land quality deterioration and resettlement needs.</li> <li>• <b>Project design risk</b> - Private sector stakeholders generally manage risks associated with ensuring project design meets not only economic needs but also resilience goals.</li> </ul>
<b>Labor: Delivery of Infrastructure Assets</b>		

<ul style="list-style-type: none"> <li>• Employment Levels (permanent and temporary)</li> <li>• Wages</li> </ul>	<ul style="list-style-type: none"> <li>• Unexpected costs due to CRR can lead to underperforming projects</li> <li>• Firms may seek to cut costs to hit profit targets, leading to less employment and lower wages; with temporary contractors at highest risk</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Construction risk</b> - Private sector stakeholders may face risks from lower labor productivity due to extreme climate events, complicating occupational safety and labor management</li> </ul>
<b>Consumers: End-Users of Infrastructure Services</b>		
<ul style="list-style-type: none"> <li>• Price Levels</li> <li>• Infrastructure Efficiency</li> <li>• Infrastructure Quality</li> </ul>	<ul style="list-style-type: none"> <li>• Increases in OPEX / CAPEX may result in higher prices</li> <li>• Number of customers serviced may drop if CRR impact output or consumer demand</li> <li>• Drop-in economic activity due to decreased availability of quality inputs leading to worse-functioning infrastructure</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Regulation risk</b> - Public sector generally manages risks associated with the regulation of user fees, but the changes may significantly affect consumers under the user-pays model.</li> <li>• <b>Operation &amp; Maintenance (O&amp;M) risk</b> - Private sector is responsible for risks from O&amp;M costs which will likely increase given CRR and may pass on to consumers.</li> </ul>
<b>Governments: End-Owner / Manager of Infrastructure Assets</b>		
<ul style="list-style-type: none"> <li>• Tax Revenue</li> <li>• Contingent Liabilities</li> </ul>	<ul style="list-style-type: none"> <li>• Worse financial performance due to CRR can result in lower tax revenues from infrastructure assets</li> <li>• Lower consumer demand for infrastructure services may result in unexpected increases in government spending due to contractual obligations (e.g., Minimum Revenue Guarantees)</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Market risk</b> - All stakeholders must manage market risks such as unexpected changes in user demand.</li> <li>• <b>Default risk</b> – Governments are the ultimate risk bearer should the private partners become financially unviable due to CRR.</li> </ul>

Source: Authors' adaptation based on Stenek, Amada, & Connell (2011) and Fouad, Matsumoto, Monteiro, Rial, & Sakrak (2021).

#### 4.2. Economic Value and Asset Pricing of Infrastructure

**CRR and the associated increase in uncertainty influences both the value of existing infrastructure assets and the pricing of future investments.** Incorporating physical and transition risks into asset pricing models implies a positive and increasing risk premium (Jensen and Traeger, 2021). Moreover, the increasing likelihood of climate-related disaster suggests a shorter lifespan of existing infrastructure than initially anticipated.

**Increased likelihood of CRR materializing may result in increased volumes of stranded assets.** Premature write-downs occurring from a climate-related event or from asset revaluations will

weaken the financial health of asset owners. Stranded assets can give rise to difficult policy trade-offs, as governments must decide when maintenance and rehabilitation expenses outweigh the economic gains from infrastructure assets – which is complicated with strategically important infrastructure assets, such as roads or bridges which are critical for supply chains and support economic activity.

**Valuation of future infrastructure assets will also have to adjust downward with increasing materializations of CRR over the next few decades.** The downside risks to assets and the probability of these risks occurring will increase over time – lowering the present value of future cash flows and future earnings (i.e., due to larger discount rates and betas in the Capital Asset Pricing Model). Increasing risk requires that project finance models incorporate scenarios that assess how portfolios will perform under a regime with increased climate-related disasters (Christophers, 2019).

**The influence of CRR on the economic value of existing and future infrastructure assets negatively impacts public and private sector balance sheets and investment decisions.** One of the largest items on a government balance sheet is the stock of nonfinancial assets, which comprises public capital stock and natural resource assets (IMF, 2018). Physical and transition risks negatively impact both items, leading to a decrease in a government's net worth. Since financial markets account for government assets and net worth, CRR could result in higher sovereign borrowing costs (Yousefi, 2019). Decreased value of future cash flows may complicate and weigh on private sector investment decisions – as companies deploy more active asset and liability management to reduce their default risk.

**If severe enough, this erosion of assets on balance sheets may lead to heightened risk of financial instability** (Feyen, et al., 2020).<sup>5</sup> CRR can have a tremendous impact on the financial sector, such as commercial and state-owned banks, insurance companies, any type of investors, financial markets and even central banks and other regulatory agencies through various interconnected channels that ultimately imperil financial stability. Adverse shock on one specific sector, such as banking, may lead to ripple effects in other industries, which may further exacerbate the overall impact on the financial sector. This could form a vicious cycle if the risks are not disclosed, priced, and addressed properly.

**Adjusting to CRR means adapting infrastructure to be fit for purpose, requiring adjustments in maintenance and rehabilitation costs.** Policymakers must improve public asset management and implement strategies to increase maintenance expenses for existing infrastructure. For developing countries, this goal is complicated by the need to improve institutions and governance frameworks for delivering infrastructure maintenance services (Rozenberg and Fay, 2019). Moreover, fiscal policy must incorporate future increases in maintenance costs and investments in climate-resilient infrastructure.

#### 4.3. Infrastructure Asset Class and CRR in the Financial System

**Within the financial system, the infrastructure asset class is susceptible to CRR.** Such vulnerabilities can be differentiated based on the proximity of the underlying activities to the infrastructure sector (See Table 4). Certain financial assets such as debt and equities of companies involved in providing power and water utilities could be directly impacted by CRR that manifest over their physical infrastructure. As PPPs are used to finance many infrastructure investments, CRR will impact a wide range of financial assets of the concessionaire and the public partner's fiscal liabilities. Notably, CRR could also trigger the public partner's contingent liabilities, leading to fiscal costs that are difficult to

---

<sup>5</sup> The impact of CRR on the financial sector are discussed in detail in Section 4.3.

estimate (Dunz & Power, 2021). There could also be second-order or knock-on effects on financial assets of companies that are highly dependent on physical infrastructure to conduct their business.

**Table 4. Impact of CRR on Financial and Insurance Markets**

Categories	Examples
<b>Directly impacted by infrastructure CRR</b>	
Financial assets tied to infrastructure	<ul style="list-style-type: none"> <li>• Debt and equities of power &amp; water utilities and communications companies</li> <li>• Debt and equities of public and private transportation infrastructure</li> </ul>
Financial assets tied to enterprises involved in infrastructure development and services	<ul style="list-style-type: none"> <li>• Debt and equities of firms involved in infrastructure construction, operations, and maintenance</li> </ul>
Financial assets tied to infrastructure insurance providers	<ul style="list-style-type: none"> <li>• Insurance and reinsurance company debt and equities</li> <li>• Insurance linked securities (ILS)</li> </ul>
Financial assets tied to streams of government revenue pledged	<ul style="list-style-type: none"> <li>• Subnational bonds</li> <li>• Sovereign bonds</li> </ul>
<b>Susceptible to knock-on effects of infrastructure CRR</b>	
Financial assets tied to sectors highly dependent on infrastructure services	Equities and debt of firms in the following sectors: <ul style="list-style-type: none"> <li>• Agriculture</li> <li>• Airlines and the broader transportation sector</li> <li>• Automobiles</li> <li>• Cement, steel, chemicals, plastics</li> <li>• Energy, including coal, oil, and gas production</li> <li>• Metals and mining</li> <li>• Power generation</li> <li>• Service and infrastructure providers to oil and gas</li> </ul>
Financial assets tied to real estate & property	<ul style="list-style-type: none"> <li>• Residential mortgages</li> <li>• Mortgage-backed securities (MBS)</li> <li>• Real estate bank loans</li> <li>• Real Estate Investment Trusts (REITs)</li> </ul>

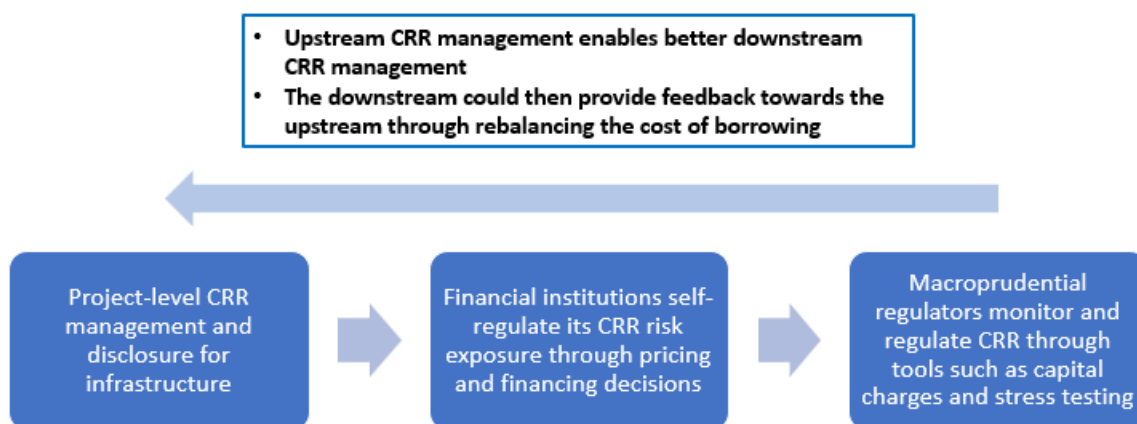
Source: [CFTC \(2020\)](#), Authors' analysis.

**Such interconnectedness means that the integration of CRR management in infrastructure PPPs could further support other downstream efforts in managing CRR in the financial system.** For instance, when the CRR considerations are incorporated in the PPP process cycle as proposed in Section 6, the risk profile of a PPP would improve and the disclosure of CRR information would also be enhanced through project documentation. This would enable investors to price in CRR more accurately during financial close, to the extent information is available. Insurance companies would have more and better data to enhance their risk model and premium pricing. In turn, these financial institutions could assign proper risk ratings for each project's CRR exposure and provide granular disclosure to regulators. Consequently, macroprudential regulators such as central banks and securities commissions could review the CRR exposure in each regulated entity's infrastructure portfolio to monitor the systemic climate-related financial risk.



**This could help create a feedback loop where macroprudential regulation shapes the investment decisions and the cost of capital offered by financial institutions to infrastructure projects.** As macroprudential regulators focus on system-wide implications of CRR towards the financial system, they could deploy regulatory instruments such as capital charges and stress testing to ensure that financial institutions properly consider the tail risk of CRR (Figure 5). As a result, when the financial system fully accounts for CRR in their infrastructure portfolio, the financial institutions could help ensure capital is allocated towards PPP projects and parties that are most prepared to mitigate CRR. As such, PPP projects that do poorly in CRR management would be penalized through higher cost of capital. Ultimately, this could contribute towards financial stability by managing the financial impacts arising from CRR.

**Figure 5: The feedback loop between the infrastructure sector and financial system**



*Source: Authors' analysis*

## 5. Managing Risks from a Force Majeure Event: Lessons Learned from COVID-19

**The onset of the COVID-19 pandemic led to large scale delays and cancellations of PPP infrastructure projects.** The most common reason for these delays or cancellations stemmed from pandemic-induced shipping disruptions and inability to find laborers. However, delayed tender processes, lower demand projections, and government budget reallocations also contributed to project delays and cancellations (World Bank, 2020).

**Recent increases in economic uncertainty and tightening of credit conditions underscore an even greater need for increased participation of the private sector in infrastructure investments.** Specific country case studies during the COVID-19 pandemic highlights how countries can promote greater resilience in the event of a force majeure event (e.g., climate-related disasters) and support private investment from a policy and public financial management perspective.

## Box 2. Country Case Studies in Increased Flexibility and Resilience to Manage CRR

### Colombia

Following the onset of the COVID-19 pandemic, Colombia designed new policies with increased contingency planning in the event of force majeure events. New legal and regulatory measures, defined by periods of mobility restrictions and/or states of emergency, are now written into PPP contracts. During these contingency periods, compensation will equal 90 percent of the difference between actual toll collection and what tolls would have been collected under normal conditions. These policies and contract amendments were designed to minimize the financial burden on governments servicing PPP contracts.

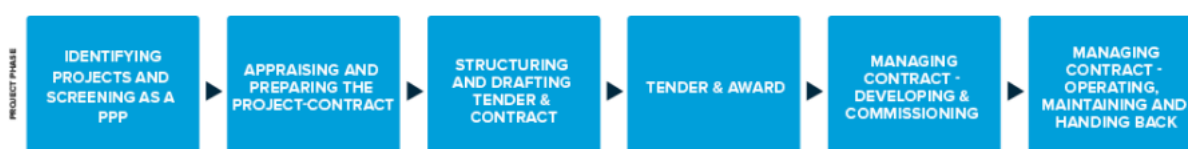
### Jamaica

Jamaica created a Natural Disaster Contingency Fund in 2018, a few years before the pandemic. As an island nation, this fund was designed to support and guide resilience following natural disasters. The Fund enabled the government to supplement its budget to cover unanticipated expenses which arose during the COVID-19 pandemic. In addition, Jamaica has instituted policies which require greater disclosure of natural disaster risks in PPP contracts. The government has recommended that the disclosure of climate-related vulnerabilities is incorporated in the identification of public investment projects. Moreover, greater insurance requirements have increased resilience in project selection processes.

*Source: IDB, 2020; IDB, 2021; Author's analysis.*

## 6. Recommendations for Integrating CRR in the PPP Process Cycle

Figure 6: The Standard PPP Process Cycle



*Source: ADB, EBRD, IDB, IsDB, & WBG in the APMG PPP Certification Program Guide, 2016 (“PPP Guide, 2016” for in-text citation)*

**This section identifies the key considerations and recommendations in integrating CRR in the PPP process cycle.** Recognizing the extensive needs to improvise the processes in practice, the main goal of this section is to provide directions for further learning in this emerging field.

### **A. Identifying projects and screenings as a PPP**

This stage typically aims to identify the suitable project proposals based on a country’s infrastructure needs, evaluate project economics, and determine their PPP suitability (PPP Guide, 2016). The incorporation of CRR must start from this very first stage, given its decisive roles in project selection. A key challenge during the early project preparation stages is to understand country-specific exposure to CRR, which is likely to further vary by sector as illustrated in Section 3.

**PPP contracting authorities should consider the alignment of infrastructure projects with a country’s long-term climate policy, framework, and transition needs.** Ensuring alignment with the

long-term priorities is an important starting point in managing CRR, which sets the current and future parties involved in PPP on the path towards more climate-aligned downstream activities and investments. This could happen through direct incorporation of the climate goals and realities in the technical, economic, and financial analyses or forming an overarching strategy that considers the climate priorities as one of the distinctive evaluation areas.

**PPP contracting authorities should seek to fill knowledge and information gaps by making good use of the country's climate-related strategic plans.** It is important to understand the Nationally Determined Contributions (NDCs), which are at the heart of the Paris Agreement and instrumental in a country's climate change mitigation goals. Next, the National Adaptation Plans (NAPs) are key to understanding a country's adaptation strategies: as of March 2021, 22 developing countries had completed their NAPs and 126 are in the process of formulating and implementing their NAPs (UNFCCC, 2021). Other relevant sources include national strategic and sectoral frameworks which are often prepared to supplement and operationalize the NDCs and NAPs.

**Further, PPP contracting authorities should consider how project selection could incorporate inputs from the Environmental Impact Assessment (EIA) and Climate Risk and Vulnerability Assessment (CRVA).** An EIA evaluates a project's potential environmental impact, which could provide an important starting point to understand the project CRR. While EIA is commonly required by government regulation in project approvals, it is crucial to actively make use of EIA's inputs for managing CRR, instead of viewing EIA as a "box-ticking exercise". Rather, EIA should be deemed as a key existing process that provides fundamental inputs to CRR management. A CRVA assesses climate-related physical risks to the project and helps incorporate adaptation measures in the project design (ADB, 2015). This may involve i) analysis of climate data and projections, ii) impact assessments on infrastructure and performance, and iii) technical and economic feasibility studies of adaptation options. CRVA is more common in projects funded by development finance agencies but should be urgently mainstreamed in all infrastructure projects in view of emerging CRR.

**Where possible, these technical inputs should be quantified and translated into economic and financial inputs that could be factored into the cost and benefit analysis and project finance modeling.** These economic and financial analyses are crucial entry points for CRR inputs, because all three types of CRR (i.e. physical, transition, and liability risks) could have material economic and financial implications.

**Further, the technical inputs could also guide the scoping of projects and the assessment of the appropriateness of project design and engineering plans.** One other role of PPP contracting authorities at this stage is to facilitate decision-making on adaptation solutions which may affect project viability. For instance, nature-based solutions – such as conserving coral reefs to address coastal flooding and developing green roofs to mitigate extreme urban heat – have been identified as potential measures to increase infrastructure resilience (IDB, 2020). To effectively implement such adaptation solutions, it would be important to recruit and involve the necessary technical experts, especially when project developers have limited experience and knowledge on their costs and benefits.

## **B. Appraising and preparing the project contract**

This stage involves more detailed assessment and preparation of the projects, including finalization of cost and benefit analysis, PPP commercial feasibility study, due diligence, and pre-structuring the PPP and procurement plans (PPP Guide, 2016).

**PPP contracting authorities should incorporate CRR as part of the risk screening and allocation process.** In Section 3, the complexities in identifying CRR in PPP are discussed. Further, it is important to consider what are the types of risks that could be actively mitigated and the parties that are most suited in bearing such risks. The general principles for risk allocation are also applicable in this context for CRR. Each risk should be allocated to the party best able to i) control the likelihood of the risk occurring, ii) control the impact of the risk on project outcomes, and iii) absorb the risk at lowest cost (World Bank Institute; PPIAF, 2012). This could have major implications in the drafting of project contracts and subsequent negotiation with the bidders.

**PPP contracting authorities should ensure that the projects' life-cycle cost analysis (LCCA) considers the long-term cost implications of CRR.** It is likely that increasing climate hazards would raise the long-term cost of infrastructure projects and the challenge lies in quantifying the magnitude of such cost impact under multiple scenarios. For instance, in Ontario, Canada, under the medium-emissions scenario, the cumulative operation and maintenance (O&M) costs of public buildings are projected to increase by \$0.8 billion per annum over the rest of the 21st century; however, this figure would rise substantially to \$1.5 billion under the high-emissions scenario (Financial Accountability Office of Ontario, 2021). Thus, CRR presents an added layer of complexity and uncertainty to LCCA and must be addressed proactively at early stages of the PPP process.

**PPP contracting authorities should assess whether the project scope and pre-design incorporate the appropriate adaptation measures.** The authorities could fulfill the roles by ensuring that the commissioned study and design explicitly consider relevant dimensions of CRR. Where limited to no adaptation measures are incorporated, the authorities should seek confirmation that the projects are deemed to have limited CRR exposure based on technical assessments.

**PPP contracting authorities should consider whether participatory processes such as public consultations are necessary to solicit feedback and socialize the project based on its CRR profile.** Even before considering the context of rising CRR, participatory processes have key roles to play given that PPP could have higher visibility, political exposure, and risk of public controversy than traditional government procurement processes (PPP Guide, 2016). Therefore, CRR consideration only adds another layer of importance to engaging stakeholders in participatory processes. This is especially pertinent in the regions or countries where significant transition and liability risks exist.

**The goals of participatory processes are not only to solicit feedback, but also to socialize or communicate the project so that its public acceptance is higher.** While such processes do not eliminate the relevant CRR, it could help parties involved in PPP to anticipate the challenges and address issues in a preemptive manner. As discussed in Section 3, transition and liability risks must not be ignored – their manifestations may come in the form of public protests and legal challenges which could delay, disrupt, or even terminate the whole project.

### **C. Structuring and drafting tender & contract**

This stage involves defining and developing a PPP contract solution and tender process that best fits with the specific features of the project contract to protect and optimize value for money (PPP Guide, 2016).

**PPP contracting authorities should determine whether any CRR should be reflected in the contractual terms.** Performance requirements are particularly important in this regard as it sets the standards to which the contractors will be required to deliver in terms of asset and service quality from the construction stage through operations and hand-back. In the context of CRR, such requirements may come in the form of service continuity standard, asset maintenance standard,

environmental-social safeguards, and emergency preparedness and response planning (Global Center for Adaptation, 2021). Other key venues for innovation include adjustment mechanisms which allow for changes to the PPP contract and legal remedies such as the termination of PPP agreement. This is particularly crucial in view of the highly uncertain nature of CRR, which could be shaped by a multitude of forces internationally and locally as climate change and green transition intensify.

**Force Majeure Events are especially pertinent to the management of CRR as traditionally climate and natural disaster risks fall under this bracket.** While Force Majeure Events are undoubtedly crucial to discharge parties of uncontrollable risks, it could be beneficial to take a more nuanced approach in defining such events to incentivize proactive risk reduction (Frisari et al, 2020). For instance, in Japan, some PPP agreements determine Force Majeure Events related to earthquakes based on seismic intensity; as some low-intensity earthquakes are excluded, the private developers shoulder responsibilities to address such risks which are relatively manageable and expected (ibid).

**PPP contracting authorities should determine whether proposal requirements and evaluation criteria should reflect any needs for capabilities to manage CRR.** Selecting the right partners with the necessary technical and management capabilities is essential to the success of PPP – the same is true when it comes to the management of CRR in infrastructure projects. PPP contracting authorities should consider what kinds of the staff qualifications add value to the partnerships, for instance climate resilience specialists who can integrate post-disaster service recovery strategies into the operations and maintenance plans. Such expectations could then be reflected in proposal requirements and evaluation criteria to solicit the inputs and interest from private sector participants on their experience and innovative approaches.

#### **D. Tender & award**

This stage aims to manage and implement the previously designed process to select the best value proposal in a competitive and regulated environment and execute the contract with the most suitable and reliable bidder (PPP Guide, 2016).

**PPP contracting authorities should proactively communicate the existence of material CRR to bidders and negotiate any resulting contractual revisions.** While this helps to raise awareness on CRR, the process could also solicit the private sector responses on potentially overlooked CRR and provide clarification where necessary. This process is key to ensure that the bidders and eventual contract winner are aware and prepared to manage the specific CRR profile and address any issues proactively. The iterative and consultative approach could also provide space for learning, brainstorming, and troubleshooting with regards to the appropriateness of PPP arrangements and contracts in dealing with CRR.

**PPP contracting authorities should evaluate the CRR management capabilities of bidders and proposals based on predetermined criteria.** While this process is standard to any PPP procurement procedures, there is a higher likelihood that no bidders could fully satisfy the needs of the projects. This is because the practice of incorporating climate mitigation and resilience elements is fast-evolving and may require climate-related expertise that is not traditionally engaged by private developers and operators in their “business-as-usual” mode of conduct. This may be especially pertinent in some developing countries. In that case, the PPP contracting authorities should consider requesting technical assistance through the public partners from international development agencies and broadening the tendering timeline to allow for new bidders or existing bidders to acquire the capabilities through potential sub-contractors.

#### **E. Managing contract – Developing, commissioning, operating, maintaining, and handing back**

This stage aims to proactively manage the contract to avoid or minimize the impact of risks and threats associated with changes, claims, and disputes. In this phase, it is especially important to monitor compliance with construction requirements (PPP Guide, 2016). This process is key for monitoring the performance of contractors and controlling the hand-back of the asset at the contract expiration date.

**PPP contracting authorities should be ready to address any CRR that manifests during the different stages through contractual remedies.** A key challenge may lie in determining the appropriate contractual remedies that can be used to redress the situation. The most severe form of remedy is the application of default and termination procedures: If the private developers persistently neglect its obligations as provided in the PPP agreement to manage CRR, the PPP contracting authorities may require the private parties to take remedial actions within a certain timeframe or the PPP agreement may be terminated.

**PPP contracting authorities may also make use of adjustment mechanisms to initiate contractual changes to the PPP agreement to address unforeseen scenarios due to changing environments.** At this stage, the feasibility of revision depends substantially on the previously built-in procedures for negotiating and executing the contractual changes.

**Nearing the expiry of the PPP agreement, PPP contracting authorities would have to ensure that private parties who fail to meet the required standards for hand-back make the necessary renewal investments.** This responsibility could act as an incentive to make sure the private parties proactively take into account and manage CRR during the earlier life cycle processes.

**In addition, PPP contracting authorities should be aware that CRR will likely increase the frequency and extent in applying safe-harbor provisions that offer protection or reliefs to private developers.** These include: 1) Compensation Events, in which the public sector bears the costs and agrees to pay compensation to the private developers to restore their conditions to the state before the Compensation Event; 2) Relief Events, in which the private developers are expected to take financial risks but granted relief from performance failures due to events that are insurable and not expected to be protracted; and 3) Force Majeure Events, which are considered to be beyond control of any parties and hence free both parties from their obligations (Frisari et al, 2020).

**As shown above, the use of contractual remedies to address CRR bears similarities to the typical practice in PPP risk management.** However, the complications may lie in understanding the nature of specific CRR which could be distinctive from traditional infrastructure-related risks and require more climate-related knowledge. **Thus, understanding CRR or climate considerations in general are increasingly important in designing a climate-sensitive legal architecture for infrastructure PPPs.**

## 7. Recommendations for Key Stakeholders

**The insights into CRR in infrastructure PPPs bring forth an array of opportunities for policymakers and relevant stakeholders to regulate activities and reform frameworks.** Most importantly, it is important to recognize infrastructure PPPs do not exist in vacuum – there are broad intersections with the roles of many actors in managing their CRR. Hence, the final section identifies key policy initiatives for each major stakeholder, which may affect infrastructure PPPs directly or indirectly.

### 7.1. Public Sector

At the country level, some of the following mechanisms must be integrated into the government's fiscal policy framework and public investment planning.

## 1. Designing ex-ante fiscal policies

**Ex-ante fiscal policies can reduce losses from CRR by promoting mitigation and risk reduction.** However, public spending on risk reduction must be consistent with fiscal space, debt sustainability, and macroeconomic absorptive capacity. Nations and local governments should take the following elements into consideration while designing fiscal risk reduction and prevention strategies:

- **Infrastructure programs:** A stronger infrastructure could offer better protection against disasters. Examples include more effective seawalls along urban coastlines to protect against hurricanes and tsunamis; maintenance and reinforcement of bridges and buildings to improve their resistance to floods, earthquakes, and hurricanes; and investment in earthquake- and flood-resilient construction.
- **Fiscal incentives:** Targeted subsidies can strengthen resilience by encouraging the retrofitting of existing properties, supporting drought-resilient crops, protecting and expanding forest coverage, and preserving scarce water resources
- **Access to information:** Accurate, adequate information about risks can influence decisions relating to the locations and construction of commercial and residential properties. For example, risk maps outlining flood zones, areas at risk from coastal erosion, and landslide areas can provide valuable information to property investors and policymakers.

## 2. Fiscal buffers

**A risk-based approach to fiscal management can help determine the fiscal buffers and self-insurance necessary to mitigate the impacts of CRR.** Some steps towards this approach include:

- **Quantifying Vulnerabilities:** Obtaining accurate estimates of potential fiscal costs is necessary to facilitate appropriate post-disaster responses. Such estimates could be informed by a country's own history of natural disasters and those of its peers.
- **Investing in risk reduction:** The public investment strategy should strengthen infrastructure resilience against disaster risks and incorporate regular diagnostic tests to enhance the efficiency of public investments
- **Adopting flexibility while preserving credibility:** Budgets should have the flexibility to ensure timely and effective disaster response. Countries that employ fiscal rules should include well-defined escape clauses in their frameworks.
- **Developing contingency financing plans:** Contingency plans for financing disaster relief and recovery should rely on a mix of self-insurance (contingency reserves and funds); contingent plans for disaster responses using borrowed or grant resources; and risk transfer arrangements using insurance, state-contingent debt instruments (SCDIs), and other capital market options
- **Building fiscal buffers:** Depending on the extent of vulnerability, international experience suggests reserving up to 3 percent of spending to deal with the fiscal risks associated with natural disasters (Cebotari and others 2009). Unused funds could, within certain limits, be transferred at the end of the budget year to a notional fiscal buffer for use during a future disaster.<sup>6</sup>

**In practice, the main challenge is to identify the optimal level of fiscal buffers because earmarking fiscal resources for CRR management could involve substantial opportunity costs.** As such, there

---

<sup>6</sup> (Cevik Serhan, 2018)

could be a tradeoff between CRR management and other productive uses of fiscal resources, which must be carefully navigated and managed politically.

### 3. Risk transfer mechanisms through financial instruments:

**Governments could transfer some of their CRR through traditional insurance, parametric insurance, and state-contingent debt instruments (SCDIs).** In the context of infrastructure PPPs, governments as the ultimate owners could potentially use these instruments to address fiscal risks arising from CRR.

- **Parametric insurance:** These payouts are based on predetermined triggers such as hurricane wind speed, rainfall levels, or ground acceleration from earthquakes. The key advantages of parametric insurance are lower transaction costs, swift payouts, and standardized contracts. However, the main disadvantage is the basic risk: model parameters are only loosely related to losses (for example, wind speed may fail to fully capture a storm's destructive power).<sup>7</sup>
- **Catastrophe bonds (CAT bonds):** CAT bonds are risk-linked securities that transfer parts of catastrophe risks from sponsors (typically insurance companies) to investors. If by the maturity date no catastrophe occurs, the bond issuer will pay investors bond principals and premiums, and if a disaster occurs, the principals will be forgiven, and the issuer can use the proceeds to pay for the losses. These bonds offer institutional investors a high-yield bond investment opportunity that helps diversify investors' portfolio. In return, they free up the issuer's financial resources to a certain degree so they can be used to cover post-disaster recovery. Hence, CAT bonds facilitate quick action in the event of a disaster, while simultaneously protecting investors from the moral hazards arising from asymmetric information (IMF 2016b).
- **State-contingent debt instruments (SCDIs).** SCDIs base a sovereign's debt service payments on its capacity to pay which depends on real world variables or events (IMF, n.d.). For example, SCDIs can be structured to alter its coupon rates based on movements in a country's GDP, commodity prices, or the occurrence of natural disasters such as earthquakes and hurricanes.

**Currently, the state of market development for these instruments may be relatively nascent, so policy-driven market initiatives may be necessary to develop these markets.** For example, the Pacific Catastrophe Risk Assessment and Financing Initiative (PCRAFI), and Africa Risk Capacity (ARC) are innovative examples of risk assessments and transfers. Since 2016, the PCRAFI has provided Pacific Island states with insurance against tropical cyclones, earthquakes and tsunamis. Vanuatu, Tonga, the Marshall Islands, Samoa and the Cook Islands were the first policymakers to join PCRAFI in 2016.<sup>8</sup> Programs like these build on regional coordination and provide both risk information and disaster risk-management tools at the regional level, as well as financing when a natural disaster happens.

#### 7.2. Policymakers and Financial Institutions

**Central banks and other regulatory agencies play important roles in regulating CRR exposure of financial institutions, including insurance companies.** This could affect infrastructure PPPs through feedback on intermediaries' financing decisions and projects' borrowing costs (See Section 4.3).

<sup>7</sup> (The Disaster Riskscape Across Asia Pacific, 2019)

<sup>8</sup> (The Pacific Catastrophe Risk Assessment and Financing Initiative (PCRAFI), n.d.)



**To this end, central banks and regulatory agencies must collectively develop appropriate tools for the supervision and mitigation of CRR in the financial system.** International cooperation is needed to exchange knowledge on trans-border scenarios and develop mitigation tools since CRR will not be isolated within borders. An important forum is the Central Banks' and Supervisors' Network for Greening the Financial System (NGFS) established in 2017. The NGFS is an international network of central banks and supervisors that aims to promote a sustainable financial system via supervision, sharing of best practices and provision of technical guidance. The following are some NGFS recommendations, as released in their report in April 2019.

1. **Scenario Analysis and Stress Tests:** Conducting these tests would assess the short-term impact of climate events on financial institution's balance sheets, including banks, insurance companies, pension funds, mutual funds and brokerage houses. This also involves monitoring returns on various financial instruments of climate vulnerable sectors, including infrastructure.
2. **Inclusive prudential framework:** Central banks and supervisors could integrate CRR into supervision by setting up relevant risk management and governance expectations. This could be facilitated by integrating climate risks into the prudential framework.
3. **Developing taxonomies:** Presently, no universal taxonomy exists for defining which activities and sectors could be considered environmentally sustainable (green) or harmful (brown). Such a labeling of green activities would enable financial intermediaries to measure and disclose its CRR, providing a basis for entity-level and regulatory rebalancing of CRR exposure.<sup>9</sup>

### 7.3. Non-financial Private Sector

**A comprehensive CRR disclosure system in the private sector is needed to assess the levels of CRR and sources of vulnerabilities.** The Task Force on Climate-related Financial Disclosures (TCFD) has developed such a system for companies. Governments and regulatory agencies need to step up and incentivize or enforce the adoption of TCFD by local companies. TCFD can enhance businesses' understanding of how CRR will affect them and thus make them more inclined to comply with CRR disclosure regulations.

**This could affect infrastructure PPPs through the private partners, especially if the PPPs involve subsidiaries of public-listed companies that are often on the frontline of mandated CRR disclosure.** In addition to their CRR disclosure, private companies' progress in the following areas could also affect their roles and performance in infrastructure PPPs in general.

1. **CRR as business risks:** Enterprise risk management, business continuity planning, scenario planning are some approaches to help companies identify and assess the relevant CRR. Areas of focus include assets (impact on facilities), raw materials and logistics (vulnerability of supply chain and transport systems), people (impact on employees and customers), process (impact on production processes) markets (changing demands for goods and services) and finance sector (insurance cost, hedging).
2. **Stakeholders and community engagement:** Companies, both local and global rely on the respective local and overseas communities for employees, suppliers, customers. They also depend on local resources, services, and infrastructure. As climate risks are bound to impact

---

<sup>9</sup> (ECB, 2019)

these communities, these groups must be involved in consultations to frame the risk management strategies. Similarly, companies should also regularly engage in robust dialogue with stakeholders across the value chain and integrate stakeholder feedback into strategic planning and operational decision making. Stakeholder engagement helps companies understand their key environmental and social impacts, build support for their operations, and develop innovative solutions.

3. **Internal capacity building:** Companies should raise awareness and train employees, ensure that board members are informed, engage outside experts as appropriate, integrate climate strategies into core business processes, work with supply chain partners, develop internal champions, and secure executive level commitment.<sup>10</sup>

## 8. Concluding Remarks

**The impact of climate change, arguably the biggest crisis of the century, is already manifesting and the worst is yet to come.** Unfortunately, as the impact from climate change has not surfaced as severely as Covid-19 pandemic and other emerging threats, governments do not act as decisively on climate action. However, the Covid-19 crisis has shown that governments can act quickly. Among other lessons, this crisis has highlighted the importance of proactive risk management and emergency preparedness – the lack of which can result in immense detrimental impacts on the society. When it comes to climate actions, the world is facing a crucial window of opportunity to act and prepare quickly and proactively before escalating climate hazards turn into a full-blown climate crisis.

**Ensuring the alignment of infrastructure systems towards climate mitigation and adaptation goals is an essential way to address the impact of climate change.** As infrastructure assets are long-lived and form the backbone of the economy and society, decisions regarding infrastructure choices and how they are built will lock in climate footprint and vulnerabilities. Thus, stakeholders in infrastructure PPPs must urgently incorporate the relevant measures to climate-proof PPPs and the resulting infrastructure assets and services.

**While CRR may be managed at the project level, key stakeholders of infrastructure PPPs must not lose sight of the systemic implications.** On one end, the infrastructure sector and PPP arrangements could act as a channel through which CRR manifests and translates into actual financial and fiscal impacts, affecting the whole economy and wide-ranging actors. On the other end, the viability of infrastructure PPPs may well be impacted by the macroeconomic and knock-on effects of CRR on the wider economy. While part of this paper attempts to analyze some of these interlinkages, further research is necessary to understand how climate-related risk management in different parts of the economy and financial system relate.

**Failures to manage CRR in infrastructure PPPs will be costly and such costs will eventually be borne by the governments, taxpayers, and the public.** Depending on the severity, CRR could potentially lead to economic and financial crises, to the extent CRR continues to be misunderstood, underestimated, under-reported, and thus not mitigated and regulated properly. Although these effects mostly lie in the future, all relevant stakeholders must act now to collaboratively plan, assess, screen, and mitigate CRR. The outcomes of such efforts will be consequential towards the larger global objectives of meeting the Paris Agreement and Sustainable Development Goals.

---

<sup>10</sup> (Physical Risks from Climate Change, 2011)

## References

- Abiad, A., Furceri, D., and Topalova, P. The macroeconomic effects of public investment: Evidence from advanced economies. *Journal of Macroeconomics*, 50(C): 224-240. Retrieved from: <https://www.sciencedirect.com/science/article/pii/S0164070416300374?via%3Dihub>
- ADB. (2015). Economic analysis of climate proofing investment projects. Retrieved from: <https://www.adb.org/publications/economic-analysis-climate-proofing-investment-projects>
- ADB, EBRD, IDB, IsDB, and WBG. (2016). The APMG Public-Private Partnership (PPP) Certification Guide. Washington, DC: World Bank Group. License: Creative Commons Attribution CC BY 3.0 IGO
- Bank of International Settlements (BIS). (2021). Climate-related risk drivers and their transmission channels. Retrieved from: <https://www.bis.org/bcbs/publ/d517.htm>
- Baxter, M., and King, R. 1993. Fiscal policy in general equilibrium. *American Economic Review*, 83(3): 315-334. Retrieved from: <https://www.jstor.org/stable/2117521?seq=1>
- Bova, E., Ruiz-Arranz, M., Toscani, F. & Ture, H. E. (2016). The Fiscal Costs of Contingent Liabilities: A New Dataset. IMF Work. Pap. 16, 1.
- Business & Human Rights Resource Centre. (2020). *International Finance Corporation Lawsuit (re financing of coal-fired plant in India)*. Retrieved from: <https://www.business-humanrights.org/en/intl-finance-corp-lawsuit-re-financing-of-coal-fired-plant-in-india>
- Bank of England. (2015). *Speech by Mark Carney: Breaking the Tragedy of the Horizon – climate change and financial stability*. Retrieved from: <https://www.fsb.org/wp-content/uploads/Breaking-the-Tragedy-of-the-Horizon-%E2%80%93-climate-change-and-financial-stability.pdf>
- Christophers, B. 2019. Environmental beta or how institutional investors think about climate change and fossil fuel risk. *Annals of the American Association of Geographers* 109(3): 754-774. Retrieved from: <https://www.tandfonline.com/doi/full/10.1080/24694452.2018.1489213>
- Climate Policy Initiative. 2021. Global landscape of climate finance 2021. Retrieved from: <https://www.climatepolicyinitiative.org/publication/global-landscape-of-climate-finance-2021/>
- Collins, D. (2022). German judges visit Peru glacial lake in unprecedented climate crisis lawsuit. Retrieved from <https://amp.theguardian.com.cdn.ampproject.org/c/s/amp.theguardian.com/environment/2022/may/27/peru-lake-palcacocha-climate-crisis-lawsuit>
- Dunz, N. and Power S. (2021). Climate-Related Risks for Ministries of Finance. Coalition of Finance Ministers. Retrieved from <https://www.financeministersforclimate.org/news/coalition-publishes-new-report-climate-related-risks-ministries-finance-overview>

- ESCAP. (2019). *Asia-Pacific Disaster Report (2019)*. Retrieved from: [https://www.unescap.org/sites/default/files/publications/Asia-Pacific%20Disaster%20Report%202019\\_full%20version.pdf](https://www.unescap.org/sites/default/files/publications/Asia-Pacific%20Disaster%20Report%202019_full%20version.pdf)
- Espinoza, A., Gamboa-Arbelaez, J., and Sy, M. 2020. The fiscal multiplier of public investment: The role of the corporate balance sheet. IMF Working Paper 20/199. Retrieved from: <https://www.elibrary.imf.org/view/journals/001/2020/199/article-A001-en.xml>
- EPA. (2017). *Climate Impacts on Agriculture and Food Supply*. Retrieved from United States Environmental Protection Agency: <https://archive.epa.gov/epa/climate-impacts/climate-impacts-agriculture-and-food-supply.html#main-content>
- Feyen, E., Utz, R., Huertas, I., Moon, J. 2020. Macro-financial aspects of climate change. Policy Research Working Paper 9109, Washington, DC: World Bank. Retrieved from: <https://openknowledge.worldbank.org/handle/10986/33193>
- Financial Accountability Office of Ontario. (2021). Costing Climate Change Impacts to Public Infrastructure: Assessing the financial impacts of extreme rainfall, extreme heat, and freeze-thaw cycles on public buildings in Ontario. Retrieved from <https://www.fao-on.org/en/Blog/Publications/cipi-buildings>
- Fouad, M., Matsumoto, C., Montiero, R., Rial, I., and Sakrak, O. 2021. Mastering the risky business of public-private partnerships in infrastructure. IMF Departmental Papers 21/10. Washington, D.C.: International Monetary Fund. Retrieved from: <https://www.elibrary.imf.org/view/journals/087/2021/010/087.2021.issue-010-en.xml>
- Frisari, G., Mills, A., Silva, M., Ham, M., Donadi, E., Shepherd, C., & Pohl, I. (2020). *Climate Resilient Public Private Partnerships: A Toolkit for Decision Makers*. Inter-American Development Bank. Retrieved from <https://doi.org/10.18235/0002365>
- Gibson, J.R. (2017). *Built to Last: Challenges and Opportunities for Climate-Smart Infrastructure in California*. Union of Concerned Scientists. Retrieved from: <https://www.ucsusa.org/sites/default/files/attach/2017/11/gw-whitepaper-smart-infrastructure.pdf>
- Grippa, P., Schmittmann, J. & Suntheim, F. (2019). Climate Change and Financial Risk: Central banks and financial regulators are starting to factor in climate change. *Finance & Development*, December 2019, Vol. 56, No. 4. Retrieved from <https://www.imf.org/external/pubs/ft/fandd/2019/12/climate-change-central-banks-and-financial-risk-grippa.htm>
- Global Center for Adaptation. (2021). *Climate-Resilient Infrastructure Officer Handbook*. Retrieved from <https://gca.org/reports/climate-resilient-infrastructure-officer-handbook/>
- Hallegatte, S., Rentschler, J., and Rozenberg, J. 2019. *Lifelines: The resilient infrastructure opportunity*, Washington, DC: World Bank. Retrieved from: <https://openknowledge.worldbank.org/handle/10986/31805>
- Interamerican Development Bank. (2020). *Improving climate resilience in public private partnerships in Jamaica*. IDB Technical Note. Washington, DC. Retrieved from:

<https://publications.iadb.org/en/publications/english/document/Improving-Climate-Resilience-in-Public-Private-Partnerships-in-Jamaica.pdf>

Interamerican Development Bank. (2021). Impacto del COVID-19 en el desarrollo de infraestructura en América Latina y el Caribe y el rol de las asociaciones público-privadas en tiempos de crisis en la region. Retrieved from: <https://publications.iadb.org/es/impacto-del-covid-19-en-el-desarrollo-de-infraestructura-en-america-latina-y-el-caribe-y-el-rol-de>

Interamerican Development Bank. (2020). Increasing Infrastructure Resilience with Nature-Based Solutions (NbS). Retrieved from: [https://publications.iadb.org/en/increasing-infrastructure-resilience-with-nature-based-solutions-nbs#:~:text=Nature%2Dbased%20Solutions%20\(NbS\)%20are%20a%20cost%20effective%20way,structuring%20these%20type%20of%20projects.](https://publications.iadb.org/en/increasing-infrastructure-resilience-with-nature-based-solutions-nbs#:~:text=Nature%2Dbased%20Solutions%20(NbS)%20are%20a%20cost%20effective%20way,structuring%20these%20type%20of%20projects.)

International Monetary Fund. 2018. Managing public wealth. IMF Fiscal Monitor, October 2018. Washington, DC. Retrieved from: <https://www.imf.org/en/Publications/FM/Issues/2018/10/04/fiscal-monitor-october-2018>

International Monetary Fund. (n.d.) State-Contingent Debt Instruments for sovereigns. Retrieved from <https://www.imf.org/en/About/Key-Issues/state-contingent-debt-instruments>

Izquierdo, A., Lama, R., Medina, J.P., Puig, J. (2019). Is the public investment multiplier higher in developing countries? An empirical exploration. IMF Working Paper 19/289, Washington, DC. Retrieved from: <https://www.imf.org/en/Publications/WP/Issues/2019/12/20/Is-the-Public-Investment-Multiplier-Higher-in-Developing-Countries-An-Empirical-Exploration-48836>

Jensen S., Trager, C. 2021. Pricing climate risk. CESifo Working Paper No. 9196. Retrieved from: [https://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=3892620](https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3892620)

Joint Report on Multilateral Development Banks' Climate Finance. 2020. Retrieved from: <https://thedocs.worldbank.org/en/doc/9234bfc633439d0172f6a6eb8df1b881-0020012021/original/2020-Joint-MDB-report-on-climate-finance-Report-final-web.pdf>

Kothari, A., Margil, M., & Bajpai, S. (2017). Now rivers have the same legal status as people, we must uphold their rights. The Guardian. <https://www.theguardian.com/global-development-professionals-network/2017/apr/21/river-s-legal-human-rights-ganges-whanganui>

Le, T., Leow, W., Seiderer, F. 2020. Building resilience in infrastructure to climate change. *Well Spent: How strong infrastructure governance can end waste in public investment*. Washington, DC: International Monetary Fund. Retrieved from: <https://www.imf.org/en/Publications/Books/Issues/2020/09/03/Well-Spent-How-Strong-Infrastructure-Governance-Can-End-Waste-in-Public-Investment-48603>

Lempert, R. J. (2016). Infrastructure Design Must Change with Climate. Retrieved from <https://www.rand.org/blog/2016/08/infrastructure-design-must-change-with-climate.html>

Madl, U., Dierx, A., and Ilzkovitz, F. 2008. The effectiveness and efficiency of public spending. Economic Papers 301, European Economy, European Commission, Brussel. Retrieved from: [https://ec.europa.eu/economy\\_finance/publications/pages/publication11902\\_en.pdf](https://ec.europa.eu/economy_finance/publications/pages/publication11902_en.pdf)

- McKinsey. (2020). *Climate Risk and Response, Full Report*. Retrieved from: <https://www.mckinsey.com/~media/McKinsey/Business%20Functions/Sustainability/Our%20Insights/Climate%20risk%20and%20response%20Physical%20hazards%20and%20socioeconomic%20impacts/MGI-Climate-risk-and-response-Full-report-vF.pdf>
- Miyamoto, H., Baum, A., Gueorguiev, N., Honda, J., and Walker, S. 2020. Growth impact of public investment and the role of infrastructure governance. *Well Spent: How strong infrastructure governance can end waste in public investment*. Washington, DC: International Monetary Fund. Retrieved from: <https://www.imf.org/en/Publications/Books/Issues/2020/09/03/Well-Spent-How-Strong-Infrastructure-Governance-Can-End-Waste-in-Public-Investment-48603>
- Moszoro, M. 2021. The direct employment impact of public investment. IMF Working Paper 21/131, Washington, DC. Retrieved from: <https://www.imf.org/en/Publications/WP/Issues/2021/05/06/The-Direct-Employment-Impact-of-Public-Investment-50251>
- NGFS. (2019). *A Call for Action: Climate change as a source of financial risk*. Retrieved from Institute for Climate Economics (I4CE): [https://www.banque-france.fr/sites/default/files/media/2019/04/17/ngfs\\_first\\_comprehensive\\_report\\_-\\_17042019\\_0.pdf](https://www.banque-france.fr/sites/default/files/media/2019/04/17/ngfs_first_comprehensive_report_-_17042019_0.pdf)
- Nile Basin Initiative (2013). *Climate Change Strategy 2013*. Retrieved from: <http://nileis.nilebasin.org/sites/default/files/23.10.13%20climate%20change%20strategy.pdf>
- Nile Basin Initiative (2018). *Climate Services for Infrastructure Baseline Assessment Report for the Nile Basin Countries*. Retrieved from: <https://www.nilebasin.org/images/docs/CSI/Climate-Services-Baseline-report.pdf>
- Marsh & McLennan. (2020). *Global Risks for Infrastructure: The Climate Challenge*. Retrieved from: <https://www.marshmcclennan.com/insights/publications/2020/august/global-risks-for-infrastructure---the-climate-challenge.html>
- McKinsey. (2020). *Will infrastructure bend or break under climate stress?* Retrieved from: <https://www.mckinsey.com/business-functions/sustainability/our-insights/will-infrastructure-bend-or-break-under-climate-stress>
- OECD. (2017). *Investing in Climate, Investing in Growth*. OECD. <https://doi.org/10.1787/9789264273528-en>
- OECD. (2018). *Climate-resilient Infrastructure*. Retrieved from: <https://www.oecd.org/environment/cc/policy-perspectives-climate-resilient-infrastructure.pdf>
- OECD. (2019). *Investing in Climate, Investing in Growth*. Retrieved from: <https://www.oecd-ilibrary.org/docserver/9789264273528-en.pdf?expires=1593493553&id=id&accname=guest&checksum=3709EA46CBCCF66E4049907FE04EAB0E>
- OECD, 2021. *Tax and fiscal policies after the COVID-19 crisis. OECD Policy Responses to Coronavirus (COVID-19)*. Paris, France. Retrieved from: <https://www.oecd.org/coronavirus/policy-responses/tax-and-fiscal-policies-after-the-covid-19-crisis-5a8f24c3/>

- OJK. (2019). Indonesia's Financial Sector: Contributing to Sustainable Finance. Retrieved from: [https://www.unescap.org/sites/default/files/21\\_Session%207%20Mr.%20Imansyah\\_OJK.pdf](https://www.unescap.org/sites/default/files/21_Session%207%20Mr.%20Imansyah_OJK.pdf)
- Rentschler, J., Kornejew, M., Braese, J., & Obolensky, M. 2019. Underutilized potential: The business costs of unreliable infrastructure in developing countries. Policy Research Working Paper 8899. Washington, DC: World Bank. Retrieved from: <https://openknowledge.worldbank.org/bitstream/handle/10986/31919/WPS8899.pdf?sequence=7&isAllowed=y>
- Reuters. (2019). *Climate Change Risk Should Be Part of Monetary Policy: ECB's Villeroy* . Retrieved from <https://www.reuters.com/article/us-ecb-policy-villeroy/climate-change-risk-should-be-part-of-monetary-policy-ecbs-villeroy-idUSKCN1TE218>
- Rozenberg, J., Fay, M. 2019. Beyond the gap: How countries can afford the infrastructure they need while protecting the planet. World Bank Sustainable Infrastructure Series. Washington, DC: World Bank. Retrieved from: <https://openknowledge.worldbank.org/handle/10986/31291>
- Stenek, V., Amada, J.C., & Connell, R. 2011. Climate risk and financial institutions: Challenges and opportunities. Washington, D.C.: International Finance Corporation. Retrieved from: <https://openknowledge.worldbank.org/handle/10986/27888?locale-attribute=en>
- Setzer, J. and Higham, C. (2021). Global trends in climate change litigation: 2021 snapshot. Retrieved from: [https://www.lse.ac.uk/granthaminstitute/wp-content/uploads/2021/07/Global-trends-in-climate-change-litigation\\_2021-snapshot.pdf](https://www.lse.ac.uk/granthaminstitute/wp-content/uploads/2021/07/Global-trends-in-climate-change-litigation_2021-snapshot.pdf)
- TCFD. (2017). Final Report: Recommendations of the Task Force on Climate-related Financial Disclosures. Retrieved from: <https://assets.bbhub.io/company/sites/60/2020/10/FINAL-2017-TCFD-Report-11052018.pdf>
- United Nations Conference on Trade and Development. 2018. Scaling up finance for the Sustainable Development Goals: Experimenting with models of multilateral development banking. Retrieved from: [https://unctad.org/system/files/official-document/gdsecidc2017d4\\_en.pdf](https://unctad.org/system/files/official-document/gdsecidc2017d4_en.pdf)
- UNEP. (2020). Global Climate Litigation Report. 2020 Status Review. Retrieved from: <https://wedocs.unep.org/bitstream/handle/20.500.11822/34818/GCLR.pdf?sequence=1&isAllowed=y>
- United Nations Environment Programme. 2020. Adaptation Gap Report 2020. Retrieved from: [https://www.unep.org/resources/adaptation-gap-report-2020?\\_ga=2.246262215.2140795102.1650911227-602052979.1650911227](https://www.unep.org/resources/adaptation-gap-report-2020?_ga=2.246262215.2140795102.1650911227-602052979.1650911227)
- UNFCCC. (2021). National Adaptation Plans: 2020 Progress in the Formulation and Implementation of NAPs. Retrieved from: <https://unfccc.int/sites/default/files/resource/NAP-progress-publication-2020.pdf>
- UNEP. (2019). *Cut global emissions by 7.6 percent every year for next decade to meet 1.5°C Paris target - UN report*. Retrieved from: <https://www.unenvironment.org/news-and-stories/press-release/cut-global-emissions-76-percent-every-year-next-decade-meet-15degc>

- UNEPI. (2018). *Issues Paper on Climate Change Risks to the Insurance Sector*. Basel: International Association of Insurance Supervisors.
- Verisk Maplecroft. (2021). Environmental Risk Outlook 2021. Retrieved from: <https://www.maplecroft.com/insights/analysis/carbon-heavy-corporates-in-crosshairs-as-risks-of-climate-lawsuits-grow/#report-form-container>
- World Bank. 2007. Government guarantees: Allocating and valuing risk in privately financed infrastructure projects. Washington, D.C.: World Bank. Retrieved from: <https://ppp.worldbank.org/public-private-partnership/library/government-guarantees-allocating-and-valuing-risk-privately-financed-infrastructure-projects>
- World Bank. 2022. Private participation in infrastructure: 2021 Report. Washington, D.C.: World Bank. Retrieved from: <https://ppi.worldbank.org/content/dam/PPI/documents/PPI-2021-Annual-Report.pdf>
- World Bank Institute; PPIAF. (2012). Public Private Partnership Reference Guide Version 1.0. World Bank, Washington, DC. Retrieved from <https://openknowledge.worldbank.org/handle/10986/16055>
- Yousefi, R. 2019. Public sector balance sheet strength and the macro economy. IMF Working Paper 19/170. Washington, DC: IMF. Retrieved from: <https://www.imf.org/en/Publications/WP/Issues/2019/08/06/Public-Sector-Balance-Sheet-Strength-and-the-Macro-Economy-48529>
- Zelikow, D. & Savas, F. (2022). Mind the gap: Time to rethink infrastructure finance. Retrieved from <https://blogs.worldbank.org/ppps/mind-gap-time-rethink-infrastructure-finance>