

CDRI
Coalition for Disaster Resilient Infrastructure

Global Infrastructure Resilience Working Paper

Governance and Institutions

The Backbone of Resilience

GIR GOVERNANCE & INSTITUTIONS
2025 WORKING PAPER

This work is a product of the Coalition for Disaster Resilient Infrastructure (CDRI), as part of a working paper series under the ambit of the second Global Infrastructure Resilience Report (GIR 2025). This Working Paper on *Governance and Institutions: The Backbone of Resilience* examines how institutional arrangements and governance frameworks can strengthen infrastructure resilience by improving coordination, accountability, and decision-making across public agencies, private stakeholders, and communities. It explores the roles and responsibilities of key stakeholders, institutional structures, regulatory frameworks, and capacity-building initiatives, while highlighting practical pathways for integrating resilience into infrastructure planning, service delivery, and post-disaster recovery. It may be accessed at https://cdri.world/resilience-dividend/global-infrastructure-resilience-report-second-edition/.

This document is a launch edition and may undergo minor changes subject to updates in the analysis.

All papers under the GIR 2025 Working Paper Series are available on the CDRI website, accessible on the web link mentioned above. They provide detailed background material, methodologies, analyses, and case studies for each chapter of the report. The papers will be released sequentially starting November 2025 through 2026.

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The cover image shows a group of people attending a meeting in a rural area, in Vietnam.
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Resilience Working Paper

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Acronyms

AAHK	Airport Authority Hong Kong
ACFC	Audit Committee and Finance Committee
ADPC	Asian Disaster Preparedness Center
ADRC	Asian Disaster Reduction Center
AFAD	Afet ve Acil Durum Yönetimi Başkanlığı (Ministry of Interior Disaster and Emergency Management Presidency)
AGWA	Alliance for Global Water Adaptation
ASEP	Association of Structural Engineers of the Philippines
AWWA	American Water Works Association
BEIS	(UK) Department for Business, Energy & Industrial Strategy
BROC	(Manila Water) Board Risk Oversight Committee
BUA	Bottom-Up Adaptation (Knowledge Platform)
BUET	Bangladesh University of Engineering and Technology
CADRI	Capacity for Disaster Reduction Initiative
CalSTA	California State Transportation Agency
Caltrans	California Department of Transportation
Cat DDOs	Catastrophe Deferred Drawdown Options
CCET	Climate Change Expenditure Tagging
CCSS	Caja Costarricense de Seguro Social
CDEM	(New Zealand) Civil Defence Emergency Management
CDEMA	Caribbean Disaster Emergency Management Agency
CDRI	Coalition for Disaster Resilient Infrastructure
CEA	Central Electricity Authority (of India)
CEFM	Climate Event Feedback Mechanism
CEO	Chief Executive Officer
CEPAL	Comisión Económica para América Latina y el Caribe (United Nations Economic Commission for Latin America and the Caribbean)
CHO	Chief Heat Officer
CONAF	Corporación Nacional Forestal (National Forestry Corporation)
COR	Centro de Operações Rio/ Rio Operations Center
CPIA	(World Bank) Country Policy and Institutional Assessment
CReLIC	(Bangladesh LGED) Climate Resilient Local Infrastructure Centre
CRO	Chief Resilience Officer

CSA	(Construction) Code-Setting Agency
Defra	(UK) Department for Environment, Food and Rural Affairs
DEHAS	(AFAD-) Earthquake Early Loss and Damage Analysis System
DESNZ	(UK) Department for Energy Security and Net Zero
DND	(Philippines) Department of National Defense
DOE	(USA) Department of Energy
DOST	Department of Science and Technology
DRI	Disaster Resilient Infrastructure
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
DRRAF	Disaster Risk and Resilience Framework
EPA	(USA) Environmental Protection Agency
ERC	(Airtel Africa's Group) Executive Risk Committee
ERM	Enterprise Risk Management
ESG	Environmental, Social, and Governance
EWDS	Early Warning Dissemination System
FEMA	(USA) Federal Emergency Management Agency
FONAG	Fondo para la Protección del Agua (Fund for the Protection of Water)
GAO	Government Accountability Office
GDP	Gross Domestic Product
GETI	(UNDRR) Global Education and Training Institute
GFDRR	Global Facility for Disaster Reduction and Recovery
GIR	(CDRI) Global Infrastructure Resilience
GIRI	Global Infrastructure Risk Model and Resilience Index
GIS	Geographic Information System
GPDP	(India) Gram Panchayat Development Plan
GTMI	(World Bank) GovTech Maturity Index
HCAI	Department of Health Care Access and Information
HKIA	Hong Kong International Airport
HLURB	Housing and Land Use Regulatory Board
HRMIS	Human Resources Management Information System
HWBP	Hoogwaterbeschermingsprogramma (Flood Protection Programme, the Netherlands)
IBC	International Building Code
IBRD	International Bank for Reconstruction and Development
ICC	International Code Council
ICCCAD	International Centre for Climate Change and Development

ICE	Instituto Costarricense de Electricidad
ICT	Information and Communication Technology
IDA	International Development Association
IDB	Inter-American Development Bank
IFC	International Finance Corporation
IFRC	International Federation of Red Cross (and Red Crescent Societies)
iGA	Istanbul Grand Airport
IMF	International Monetary Fund
INVIAS	Instituto Nacional de Vías/ National Roads Institute, Government of Colombia
IPCC	Intergovernmental Panel on Climate Change
IRA	Infrastructure Regulatory Agency
IRAX	Infrastructure Resilience Academic Exchange
IRIDeS	International Research Institute of Disaster Science
IRP	Infrastructure Resilience Professional
ISO	International Organization for Standardization
IWA	The International Water Association
KPI	Key Performance Indicator
LGED	Local Government Engineering Department
M-D	Miami-Dade
MAM	(TÜBİTAK) Marmara Araştırma Merkezi (Marmara Research Center)
MAPS	Methodology for Assessing Procurement Systems
MBIE	(New Zealand) Ministry of Business, Innovation & Employment
MCR2030	Making Cities Resilient 2030
MDB	Multilateral Development Bank
MEF	Ministerio de Economía y Finanzas (Ministry of Economy and Finance, Peru)
MIDEPLAN	Ministerio de Planificación Nacional y Política Económica (Ministry of National Planning and Economical Politics, Costa Rica)
MLIT	Ministry of Land, Infrastructure, Transport and Tourism
MoF	Ministry of Finance
MoP	Ministry of Planning
MOU	Memorandum of Understanding
MSME	Micro, Small, and Medium Enterprises
MVCT	Ministry of Housing, City and Territory
NASEO	National Association of State Energy Officials
NBC	(Nepal) National Building Code
NBRO	(Sri Lanka) National Building Research Organization

NbS	Nature-based Solutions
NCCAP	(Philippines) National Climate Change Action Plan
NCRMP	National Cyclone Risk Mitigation Project
NDMA	National Disaster Management Authority
NDRRMC	National Disaster Risk Reduction and Management Council
NEMA	National Emergency Management Agency, New Zealand (Te Rākau Whakamarumaru)
NGO	Non-Governmental Organization
NICCDIES	(Philippines) National Integrated Climate Change Database and Information Exchange System
NIDM	National Institute of Disaster Management
NILIM	National Institute for Land and Infrastructure Management (Japan)
NIST	National Institute of Standards and Technology
NRCan	Natural Resources Canada
NYC	New York City
O&M	Operations and Maintenance
OCHA	United Nations Office for the Coordination of Humanitarian Affairs
ODI	Overseas Development Institute
OECD	Organisation for Economic Co-operation and Development
Ofgem	(UK) Office of Gas and Electricity Markets
Ofwat	(UK) Water Services Regulation Authority (formerly the Office of Water Services)
ORR	Office of Rail and Road
OSDMA	Odisha State Disaster Management Authority
PAGASA	Philippine Atmospheric, Geophysical and Astronomical Services Administration
PDPS-OCD	Policy Development and Planning Service, Office of Civil Defense (the Philippines)
PDS	Plan for Sustainable Development and Climate Action
PEFA	Public Expenditure and Financial Accountability
PG&E	Pacific Gas and Electric Company
PHIVOLCS	Philippine Institute of Volcanology and Seismology
PIEVC	Public Infrastructure Engineering Vulnerability Committee
PIMA	(IMF) Public Investment Management Assessment
PPP	Public-Private Partnership
PSPS	Public Safety Power Shutoff
PUB	(Singapore) Public Utilities Board
RAMS	Road Asset Management Systems
RCP	Representative Concentration Pathway
RRM	(Caribbean) Regional Response Mechanism
SAR	Special Administrative Region

SATREPS	Science and Technology Research Partnership for Sustainable Development – Peru
SENAPRED	Servicio Nacional de Prevención y Respuesta ante Desastres
SET	Sustainability Executive Taskforce
SIGGRE	Sistema de Información Geográfica para la Gestión de Riesgos en Energía (Geographic Information System for Energy Risk Management)
SIGMA	(OECD/EU) Support for Improvement in Governance and Management
SINIA	Sistema Nacional de Información Ambiental (National Environmental Information System, Peru)
SLA	Service-Level Agreement
SMRT	Singapore Mass Rapid Transit
SOEs	State-Owned Enterprises
SOP	Standard Operating Procedure
SWEFC	Southwest Environmental Finance Center (University of New Mexico)
T-MULT	Multipurpose Terminal
TAMP	Türkiye Afet Müdahale Planı (Türkiye Disaster Response Plan)
TCFD	Task Force on Climate-Related Financial Disclosures
TISN	(Australian) Trusted Information Sharing Network
TNC	The Nature Conservancy
TOR	Terms of Reference
UELDP	Upper Egypt Local Development Program
UKCRIC	UK Collaboratorium for Research on Infrastructure and Cities
UNDP	United Nations Development Programme
UNDRR	United Nations Office for Disaster Risk Reduction
USDN	Urban Sustainability Directors Network
WASREB	(Kenya) Water Services Regulatory Board
WEF	Water Environment Federation
WRCCA	Weather Resilience and Climate Change Adaptation

Key Messages

Governance for resilient infrastructure encompasses the processes, tools, mandates, incentives, and norms of interaction used by public institutions, private actors, users, and communities to ensure reliable infrastructure services before, during, and after disasters.

Resilience is not only an engineering problem. It is an institutional and governance challenge.

Resilience is everybody's business. Several public and non-public stakeholders play important roles in making a country's infrastructure services more resilient to disasters and better adapted to the impacts of climate change.

Infrastructure agencies need to mainstream resilience across their organizations, with clear leadership, defined responsibilities, adequate budgets, risk-informed asset management, resilient maintenance practices, and operational procedures for preparedness, response, recovery, and learning.

Robust infrastructure resilience starts with strong infrastructure service delivery. Agencies that struggle to provide reliable services in normal times will find it much harder to absorb, respond to, and recover from disasters.

Infrastructure resilience is not the responsibility of infrastructure agencies alone. Ministries of finance, planning agencies, legislators, regulators, disaster risk management agencies, subnational governments, land-use authorities, code-setting bodies, hydrometeorological (hydromet) agencies, and emergency services all shape the resilience of infrastructure systems.

Coordination is indispensable for infrastructure resilience. Without clear roles, data sharing, joint planning, and standard operating procedures (SOPs) aligned across institutions, even well-designed assets can fail to deliver resilient services.

Ministries of finance and planning are central to infrastructure resilience because they determine how projects are screened, appraised, financed, prioritized, budgeted, and monitored. Resilience needs to be embedded in public investment systems, fiscal frameworks, project pipelines, procurement rules, and recovery financing.

Legislators and regulators can ensure resilience is enforced as a requirement, rather than leaving it to voluntary alignment with objectives or guidelines. Laws, regulations, licences, tariffs, public-private partnership (PPP) contracts, performance standards, and reporting obligations can all be used to strengthen infrastructure reliability and accountability.

Infrastructure systems are interdependent. Power, transport, water, telecommunications, logistics, health, and emergency services can fail together. Governments need institutional arrangements that identify cascading risks, map dependencies, share information, and coordinate restoration across sectors.

Subnational governments play a critical role in infrastructure resilience. They need to ensure clear mandates, local data, technical capacity, predictable transfers, rapid access to post-disaster finance, and effective coordination among national agencies and service providers.

Disaster risk management agencies, hydromet agencies, and emergency services should be treated as core partners to infrastructure agencies, not as external actors. Joint preparedness plans and drills, early warning systems, restoration priorities, and after-action reviews are essential for keeping infrastructure services resilient.

Private asset owners and operators are also part of the resilience system. PPPs, utilities, concessionaires, and private infrastructure operators must have clear contractual obligations, risk-informed asset management systems, emergency procedures, customer communication protocols, and incentives to maintain reliable services before, during, and after disasters.

The resilience market matters. Engineering firms, contractors, technology providers, equipment suppliers, insurers, banks, and investors shape whether infrastructure agencies can assess risks, retrofit assets, mobilize finance, manage claims, and deliver resilience investments at scale.

Users can also be partners in delivering resilience. Businesses, communities, vulnerable groups, NGOs, and civil society organizations need to be engaged before disasters occur, so that infrastructure agencies understand service continuity needs, local risks, access constraints, differentiated impacts, and recovery priorities.

Knowledge institutions can also bolster resilience capacity. Universities, research institutions, and professional associations can help translate hazard science, disaster resilient engineering practices, lessons from disasters, and new technologies into standards, incorporating these into training and certification programmes, professional skilling courses, and practical guidance for infrastructure agencies and operators.

Codes, standards, and regulations are among the most important tools for translating knowledge of risks into safer infrastructure. They need to be regularly updated, locally enforceable, connected to hazard information, supported by professional capacity building, and not only applied to new assets, but also guide retrofitting of existing infrastructure. Their enforcement matters. Resilience standards only reduce losses when permissions, inspections, professional accreditations, financing, insurance, and community demand all reinforce compliance.

Capacity building is not a one-off training activity. It requires long-term investment in people, systems, guidance, professional networks, universities, operators, contractors, local governments, and communities. Institutional reform for infrastructure resilience is a journey. Countries can follow different pathways, but progress usually requires a combination of legal mandates, institutional coordination, financing instruments, technical standards, regulatory incentives, capacity building, and continuous learning from disasters.

Infrastructure agencies should also assess their own readiness for resilience. They need to know whether mandates exist, responsibilities are clear, processes are implemented, and systems are improved in response to new risks, incidents, audits, and disasters.

What gets assessed gets improved. Practical institutional and governance assessments can help infrastructure agencies identify gaps, establish a baseline, prioritize reforms, and prepare a realistic roadmap for attaining greater resilience.

1 Introduction

Infrastructure resilience is generally discussed in technical terms: quality of construction, readiness of infrastructure assets to withstand and absorb disaster shocks, early warning systems, and financing needs. However, resilience is, at its core, the result of a series of interactions among diverse stakeholders in society—public agencies, private entities, and communities—as well as the norms and decisions that define the reliability of infrastructure services.

Resilience is not only about designing stronger and more resilient infrastructure assets. Resilience requires strong coordination across government agencies, infrastructure asset owners and operators, and the businesses and communities that rely on infrastructure services. Institutions and governance are critical factors for resilient infrastructure systems.

The degree of infrastructure systems' resilience depends on how governments, public institutions, private stakeholders, and local actors manage the full life cycle of infrastructure projects—from planning and design to long-term upkeep—and how the structures of authority, funding, and accountability shape their ability to prepare for and withstand future shocks.

This working paper seeks to understand how institutional arrangements and governance frameworks influence the resilience outcomes of infrastructure projects and services facing climate and disaster risks. It is also designed to offer practical insights for decision makers, drawn from case studies and global experience. It builds on the insights from the GIR working papers on *Views of Infrastructure Professionals: A Global Survey* (Carluccio *et al.*, 2026) and *Impacts on Businesses: The Hidden Cost of Disasters* (Kulkarni *et al.*, 2026).

The discussion in this working paper on institutions and governance for infrastructure resilience centres on service-delivery actors (e.g., public agencies, such as ministries of transport or power utilities) and private asset owners and managers (e.g., those engaged in PPPs). The paper also includes an analysis of institutional arrangements managed by multisectoral actors responsible for delivering multiple services (such as mayors and governors responsible for both transport and solid waste) or for planning and financing multiple sectors (such as ministries of finance or planning).

Many institutional and governance studies focus either on infrastructure services or on disaster risk management systems. The analysis in this working paper focuses instead on the intersection of resilience and infrastructure: how infrastructure service delivery might incorporate resilience as a core feature of operations, and how the institutions responsible for such delivery can answer the need for greater reliability and endurance in the face of disasters.

This working paper is organized into 10 sections. Following this Introduction, Section 2 discusses the definition of governance for resilient infrastructure and presents a comparative review of available definitions of disaster risk management governance and infrastructure governance. Section 3 presents the common framework used in the *Global Infrastructure Resilience Report* (CDRI, 2023a) and the three core capacities of resilient infrastructure.

Sections 4 and 5 review the roles of diverse stakeholders and the necessary relationships among infrastructure service agencies and private providers. While Section 4 reviews public-sector organizations, Section 5 focuses on non-public stakeholders. Each section covers a wide range of actors. For example, Section 4 reviews public stakeholders, such as ministries of finance, planning, and infrastructure services, and agencies related to resilience, such as those responsible for disaster risk management, code setting, land use, hydromet and other hazards, and emergency services. It also reviews the roles of high-level resilience commissions, subnational governments, and legislative bodies.

Section 5 covers non-public stakeholders, such as private asset owners and operators, private companies providing resilience services, insurance and financial service companies, businesses that depend on infrastructure services for their operations, communities, NGOs and civil society organizations, academia, and professional associations.

Section 6 looks at the typical institutional arrangements of private operators, state-owned enterprises, utilities providing infrastructure services, and government infrastructure agencies. Section 7 discusses codes, standards, and regulations for delivering resilience. Section 8 discusses capacity needs and capacity-building programmes across infrastructure agencies and other stakeholders.

The working paper concludes with a review of institutional and policy reform pathways to strengthen infrastructure resilience in Section 9, and a proposed institutional and policy assessment framework in Section 10, which is designed for use as an initial self-assessment tool to identify priority areas to strengthen institutions and governance on the journey to achieving infrastructure resilience.

2 Governance for Infrastructure Resilience

Various organizations define 'governance' in different ways. For example, the United Nations Office for Disaster Risk Reduction (UNDRR), in the context of the Sendai Framework, defines disaster risk governance as "the system of institutions, mechanisms, policy and legal framework, and other arrangements to guide, coordinate, and oversee disaster risk reduction and related areas of policy" (UNDRR, 2017b).

In the area of infrastructure, the World Bank defines 'governance' in two areas and lists their dimensions (World Bank, 2020a). The first area is the selection, design, procurement, and implementation of investment projects, along with related cross-cutting principles of integrity, transparency, and consideration of social, environmental, and climate-change risks and opportunities. The second area concerns the modalities of infrastructure service delivery and related issues of market structure and competition, the regulatory framework, corporate governance, and managerial capacity.

The International Monetary Fund (IMF), as part of its Public Investment Management Assessment (PIMA) framework, helps governments identify areas for improvement in public investment institutions and processes to build climate-resilient, low-carbon infrastructure. In this context, governance is defined as spanning five areas: planning (including national and sectoral investment plans); coordination (across layers of governments, state-owned enterprises, and PPPs); appraisal and selection; budget and portfolio management (including medium-term expenditure frameworks); and fiscal risk management (including climate risk mitigation strategies) (IMF, 2021).

The Organisation for Economic Co-operation and Development (OECD), in its *Recommendation of the Council on the Governance of Infrastructure* (OECD, 2020), discusses 10 key elements of good infrastructure governance frameworks—namely, the need for a long-term strategic vision for infrastructure; fiscal sustainability, affordability, and value for money; efficient and effective procurement of projects; transparent, systematic, and effective stakeholder participation; coordination of infrastructure policy across levels of government; a coherent, predictable, and efficient regulatory framework; a whole-of-government approach to manage threats to integrity; evidence-informed decision-making; whole-of-life asset performance; and strong critical infrastructure resilience.

As this working paper focuses on the intersection of infrastructure service delivery and resilience, it builds upon the definitions of 'governance' above and modifies the OECD Framework for the Governance and Delivery of Infrastructure (OECD, 2015) to emphasize disaster resilience. The working definition of resilient infrastructure governance used in this paper corresponds to the processes, tools, and norms of interaction, decision-making, and monitoring used by governmental organizations and their counterparts to make infrastructure services resilient. It thus relates to internal interactions across government institutions, as well as their interactions with the private sector, users, and citizens. It covers the entire life cycle of assets (from upstream sectoral planning for asset construction, maintenance, and disposal) and the resilience cycle, along with its three capacities (to absorb, respond to, and recover from disasters), as presented in Section 3.

It is important to emphasize here that institutions that provide resilient services must, first and foremost, be strong service providers. When the water supply to customers is intermittent, it is not possible to be resilient against droughts. When road maintenance is inadequate and potholes are common, roads are more easily damaged by floods. While this working paper emphasizes resilience, it assumes that the governance framework and institutional capacity to provide basic infrastructure services are strong.

3 The Three Capacities of Resilient Infrastructure

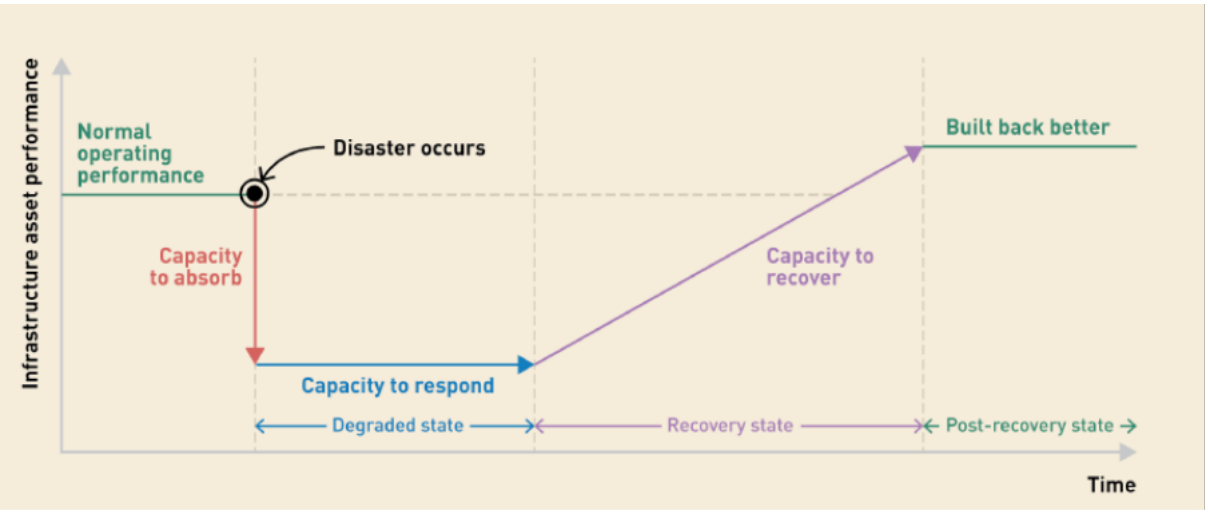
The Global Infrastructure Resilience (GIR) 2025 report uses a common framework to analyse the resilience of infrastructure. This framework examines infrastructure not only as a collection of individual assets but also as networks of connected assets and the services they provide to individuals, communities, businesses, and the economy (CDRI, 2023a).

The resilience of these networks and services depends on their capacity to i) resist and absorb the shocks caused by disaster impacts; ii) respond to the damage caused by those disasters and maintain basic levels of service continuity during crises; and iii) restore services as quickly as possible in a way that incorporates lessons learnt from the disaster and reduces future loss and damage.

It is also essential to look at the resilience of infrastructure service users, which depends on their ability to: i) be better prepared and leverage the information provided by early warning systems to reduce the shock of disasters; ii) find supplementary or alternative means to avail failed infrastructure services (e.g., back-up generators for electricity or alternative modes of transport); and iii) engage in the lesson-learning process after disasters so that they are better prepared, together with the infrastructure agencies, for future disasters.

At these three levels (infrastructure assets, services, and users), resilience should be seen not only as the capacity to absorb the next disaster but also as the ability to respond to and recover from it. Building resilience in infrastructure assets and systems requires a comprehensive view of the resilience cycle. Figure 1 illustrates this cycle and the three capacities for an individual infrastructure asset.

Figure 1: The three capacities for resilient infrastructure



Source: CDRI (2025d)

When a disaster occurs, the normal operating performance of an infrastructure asset may drop to a lower state (all the way to zero for a total failure). The magnitude of the drop depends on the capacity of that asset to absorb disaster shocks. Over a period, the asset is in a degraded state. During this time, emergency and clean-up actions are undertaken, and design and procurement of repair and reconstruction works are completed. These steps allow the infrastructure agency to start the recovery phase. The lessons learnt from the disaster, including updated risk assessments that incorporate new hazard data and projected climate change impacts, are indispensable for designing the repair and reconstruction efforts of the infrastructure asset affected by the disaster. The recovery phase can then 'build back better' those assets.

Many infrastructure agencies pay particular attention to the capacity to absorb disaster shocks by strengthening standards and regulations, implementing retrofit programmes for existing assets, and enhancing construction supervision for new, more resilient assets. They also expand maintenance and repair programmes to make assets stronger and ready for future disasters (like the cyclone season).

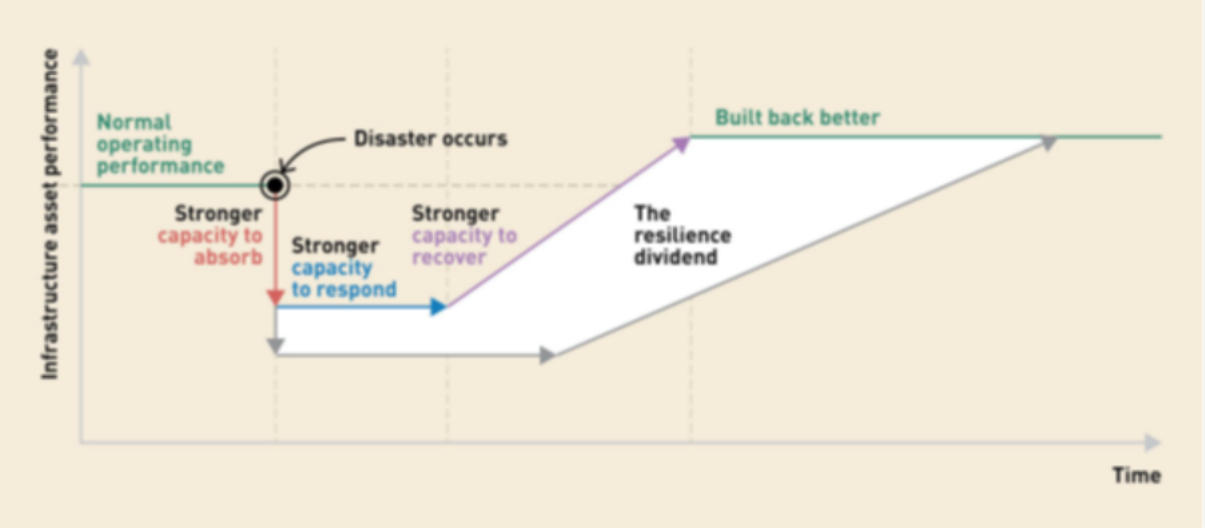
However, focusing only on the capacity to absorb disaster shocks is insufficient. The economic and livelihood impacts linked to interruptions of infrastructure services are directly related to the time it takes for the asset to be back to full or enhanced operation. The longer it takes for the infrastructure asset manager to respond and recover, the larger the impact on households, businesses, and communities.

Figure 1 can also be used to understand the resilience cycle for infrastructure networks and services, where the capacity to recover services depends on the level of redundancy of the network, and 'building back better' requires a network analysis of vulnerabilities.

For users, the capacity of individuals, households, communities, and businesses to respond to infrastructure failures depends on the quality of two-way communications between infrastructure service providers and users, as well as the users' resilience in finding alternative means of service provision.

Building the resilience of infrastructure systems requires agencies and asset managers to strengthen not only the capacity to absorb disaster shocks but also the ability to respond to shocks and recover quickly. Figure 2 shows the resilience-building process that strengthens the three capacities.

Figure 2: Strengthening the three capacities for resilient infrastructure, and the resilience dividend



Source: CDRI (2025d)

An infrastructure agency or asset owner can implement several measures to strengthen the capacity to absorb disaster shocks (shorter red line on the left-hand side of the graph), such as developing enhanced maintenance, repair, and retrofit programmes or using systems that translate early warning notices sent by hydrometeorological services into preparatory actions to protect assets.

A stronger capacity to respond requires infrastructure agencies to be better prepared for disasters, and to have strong coordination plans with the national disaster risk management agency, emergency services, and other infrastructure agencies or utilities that provide linked services that can fail in a cascade after disasters. Some actions to strengthen the capacity to respond to disasters include preparedness plans to remove debris from the asset; early procurement of stand-by repair services, including strategic location of repair materials; or use of new technologies for rapid assessment and evaluation of damage using drones.

Finally, infrastructure agencies or asset owners can strengthen their capacity to recover (represented by the purple line) by implementing post-disaster evaluation and learning activities; defining new tools (such as nature-based solutions or new technologies) to be incorporated in the repaired asset; and enhancing resilience standards in the repair and reconstruction efforts.

All the efforts in strengthening the three capacities will lead to less damage and degradation of performance, less time to respond, and more effective repair and reconstruction processes in case of a future disaster of similar magnitude. The strengthening of the three capacities will also lead to a faster restoration of services and a lesser impact on livelihoods and the economy. The white area in the graph visually represents the 'resilience dividend' of those efforts. It is defined as the value of reduced future asset loss and damage, avoided service disruption, wider social, economic, and environmental co-benefits, and reduced systemic risk that accrue over the life cycle of an infrastructure system.

This framework is consistently applied across various chapters of this report, including surveys of businesses and resilience professionals, as well as analyses of technologies, finance, nature-based solutions, and institutions for resilient infrastructure.

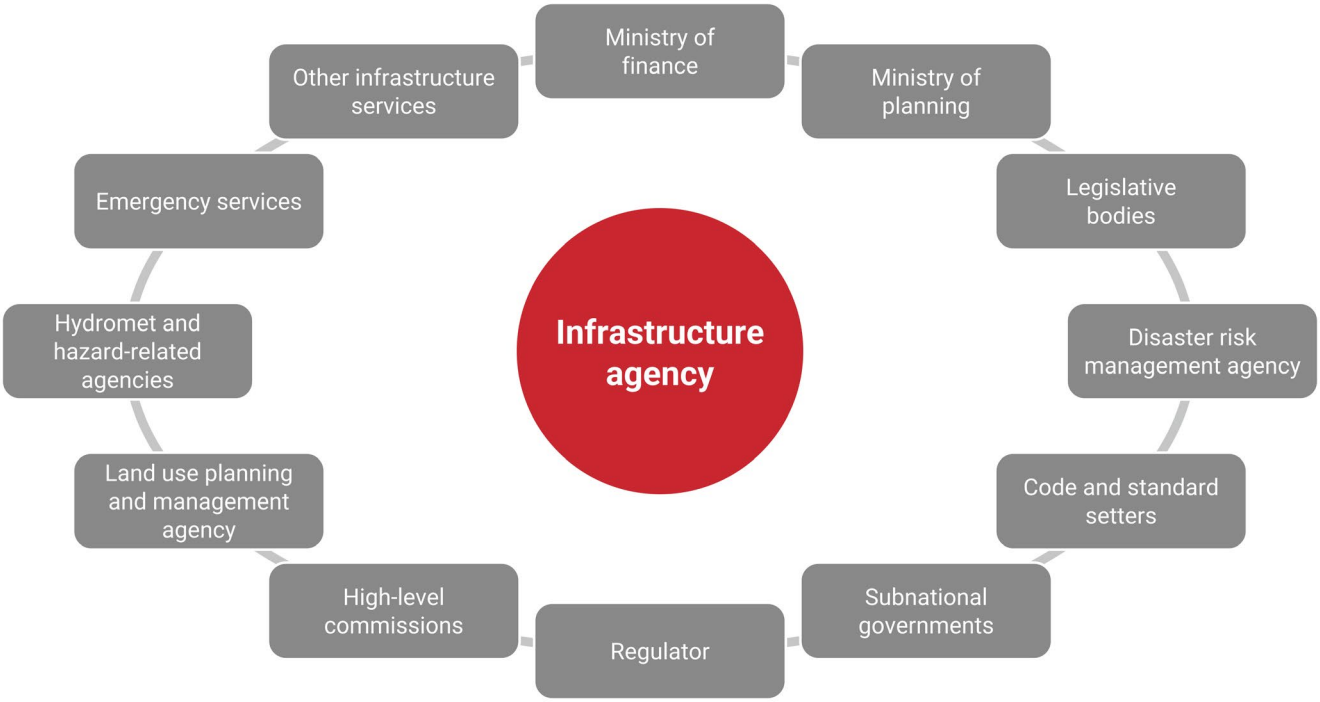
4 Public-Sector Organization for Infrastructure Resilience

This section reviews options and global best practices for the organization of public institutions to deliver resilient infrastructure services. Section 5 reviews non-public stakeholders. In some sectors, public institutions are largely responsible for infrastructure resilience, while in others, such as housing or telecommunications, private actors (e.g., homeowners, private operators, and asset owners) play an equally important role.

Infrastructure resilience is not the responsibility of infrastructure agencies, such as ministries of roads or port operators, alone. Numerous public-sector organizations need to be coordinated for governments to provide resilient, reliable infrastructure services to businesses and communities. Figure 3 shows some of the organizations most important, in varying degrees, for infrastructure resilience. Clarifying the roles and responsibilities of these organizations is critical for establishing an effective system that delivers resilient services (OECD, 2020). An infrastructure agency needs to map how well other institutions understand and fulfil their roles and identify targeted engagements to ensure progress can be coordinated.

While the list of public-sector organizations that need to support the resilient infrastructure agenda is substantial (see Figure 3), and the journey may seem overwhelming, it is important to note that countries with more advanced systems took several decades to reach this stage. What is important is to prioritize engagement, beginning with key agencies such as those responsible for finance, planning, and disaster risk management (DRM); secure buy-in and engagement from legislators; and then gradually extend these efforts to transform the remaining agencies. Furthermore, each country will have a different journey of resilience building, depending on its institutional, historical, and cultural circumstances. No two trajectories will be the same.

Figure 3: Public-sector organizations related to infrastructure resilience



Source: Authors' analysis

A recommended first step for infrastructure agencies aiming to deliver resilience is to conduct a simple assessment of the constellation of agencies that should support resilience, identify potential champions, plot practical initial steps, and define an overall engagement strategy and roadmaps. Gradually, a national strategy with clear delineation of roles and responsibilities for each agency—from the national to the local levels—must be developed.

A key objective of this journey towards resilient infrastructure is the gradual development of the necessary human resources and financial capacities within each agency, commensurate with its roles and responsibilities. Key performance indicators (KPIs), particularly those applicable to cross-agency work and to the resilience agenda, are also important.

4.1 Ministries of Finance

Ministries of finance (MoFs) have a critical role to play in improving infrastructure resilience, including: i) establishing financing instruments to support infrastructure agencies' efforts to maintain assets, retrofit vulnerable infrastructure, and build new, resilient assets; ii) creating a layered financial architecture—as discussed in the GIR 2025 working paper on *Financing: Closing the Gap to Capture the Resilience Dividend* (Chavarot et al., 2026)—to help infrastructure agencies respond to, and recover from, disasters rapidly and completely; iii) ensuring infrastructure agencies use risk and cost-benefit assessment tools (including assessments of the economic benefits from resilient infrastructure) as part of their funding proposals and budgets; and iv) shaping macro fiscal policy and fiscal risk management to be prepared for the consequences of infrastructure service failures caused by disasters (World Bank, 2019).

MoFs have tools to mainstream resilient infrastructure, ensuring options, costs, and benefits are clearly calculated and compared, given the limited funding available to address the enormous needs in infrastructure services and beyond. For example, the IMF recommends incorporating disaster and climate risks into MoFs' medium-term fiscal frameworks and debt management strategies, given the substantial risks posed by disaster-related infrastructure failures (IMF, 2022); it also helps MoFs achieve these. Tools such as CDRI's Global Infrastructure Risk Model and Resilience Index (GIRI) can help quantify contingent liabilities arising from insufficient resilience in existing infrastructure assets (CDRI, 2023b).

MoFs are also responsible for establishing public investment preparation rules, and many countries now mandate explicit use of hazard screening and cost-benefit analysis tools to assess current and future disaster risks. The OECD and the G20 recommend integrating risk assessments into infrastructure finance and project decisions (OECD, 2024b). For example, Peru reformed its public investment management system to require the integration of DRM guidelines into the project cycle (Ministerio de Economía y Finanzas, Peru, 2019).

Furthermore, where fiscal constraints are present, MoFs can issue specific guidance to help infrastructure agencies demonstrate the value for money of proposed resilience actions. In the United Kingdom, HM Treasury's Green Book now provides specific guidance on incorporating climate resilience analysis into project investment prioritization exercises (Defra, 2025b).

Finally, as discussed in the working paper on *Economic Impacts: Downstream Consequences of Infrastructure Failures* (Bassi & Andreasson, 2025), economic losses from disaster-related damage to infrastructure can be reduced through rapid, comprehensive reconstruction efforts that incorporate lessons learnt and climate adaptation measures. This requires MoFs to have liquidity instruments (such as catastrophe deferred drawdown options, or Cat DDOs; catastrophe bonds; and others) with clear procedures and transparent, efficient disbursement mechanisms (World Bank Group, 2019). Box 1 presents an example of Colombia's institutional approach to such instruments and the corresponding improvements in institutional arrangements for resilient infrastructure.

Box 1. Case study: Infrastructure resilience reform through Cat DDOs in Colombia

Colombia used a series of World Bank–financed Cat DDOs not just for emergency liquidity, but also as a platform for progressive reform in infrastructure governance. A Cat DDO (Catastrophe Deferred Drawdown Option) is a pre-approved, contingent financing line that provides rapid liquidity to a country after a disaster, once a specified drawdown trigger (for example, a government declaration of a state of emergency) is met. Since 2008, Colombia has used Cat DDOs to integrate DRM into fiscal policy and development planning. These operations, coupled with financial preparation, were supported by World Bank technical assistance and backed by institutional reforms in land use, housing, and transport (World Bank, 2012b).

The Cat DDOs were structured around a policy matrix negotiated with the World Bank (2012). Cat DDO I (2008–2012) introduced national DRM mandates linking hazard risk to investment decisions, established public asset insurance guidance, and supported territorial planning (Independent Evaluation Group, 2016). Cat DDO II (2012–2021) (World Bank, 2021) advanced local implementation by requiring municipalities to embed risk assessment in land-use plans and identify high-risk settlements (World Bank, 2012b). These requirements made resilience a legal obligation at the subnational level (World Bank, n.d.). Cat DDO III (2021–2025) emphasized sectoral integration (World Bank, 2026c). The Ministry of Transport and the Instituto Nacional de Vías (INVIAS, the National Roads Institute) adopted risk analysis protocols and issued the Green Road Infrastructure Guidelines (World Wildlife Fund, 2024). According to the World Bank, this DDO supports the institutionalization of disaster and climate risk management in public investment processes, land-use planning, and the road

transport sector. Cat DDO IV (2025–2027) aims to consolidate reforms, with an emphasis on resilient housing and land-use standards, and to formalize the INVIAS DRM Plan and geotechnical corridor analysis (World Bank, 2025e). In addition, legal instruments and monitoring should reinforce interministerial coordination (IFRC, 2024).

4.2 Ministries of Planning

Ministries of planning (MoPs) play a unique role in supporting resilient infrastructure, as they set rules for project identification and appraisal. In many countries, they operate the national infrastructure project pipeline and coordinate territorial and sectoral plans. When MoPs incorporate disaster and climate risk analysis and resilience standards into these processes, they select, design, finance, and implement more resilient infrastructure projects and systems. For example, the OECD recommends that its members incorporate resilience into infrastructure governance through clear standards, multi-level government coordination, and well-designed pipelines (OECD, 2020), all of which fall within MoPs' mandates.

MoPs can leverage several mechanisms to strengthen governance of resilient infrastructure, including:

- establishing risk screening and appraisal criteria, including rapid hazard screening for projects at the concept stage, and full disaster and climate risk evaluations as part of project appraisal when certain thresholds are exceeded (budget, exposure, or criticality) [the EC Technical Guidance on Climate Proofing Infrastructure is a useful reference (EU, 2021); in addition, Box 2 presents an example from Chile and Box 3 presents one from Costa Rica];
- tagging resilience and adaptation investments in investment portfolios, jointly with the MoFs, to allow the tracking of resilient public investments across different sectors (IMF, 2021);
- engaging in national and territorial planning, as MoPs lead or review these plans and can ensure they incorporate risk assessments, plans are coordinated to avoid projects in high-risk zones, and land-use plans are linked to sector investment plans [for example, in Viet Nam, the 2017 Law on Planning streamlines national and sectoral planning under the Ministry of Planning and Investment, and requires integrated, hierarchical plans that incorporate disaster risks (Government of Viet Nam, 2017)];
- setting procurement standards that incorporate life-cycle asset management and resilience evaluation, such as assessments of durability, post-disaster recovery, ease of maintenance, and adaptability—tools that MoPs, jointly with standards bodies and infrastructure agencies, can use to promote better designs and bidding processes that incorporate risks and resilience solutions (World Bank, 2019);
- serving as an oversight and monitoring system, which can be invaluable to understanding how different infrastructure assets absorb disaster shocks (important cross-sectoral lessons can be extracted from ex ante and ex post performance audits, which can then improve the MoP's tools and provide transparent information to civil society); and
- undertaking capacity building, especially at the subnational level, through toolkits, appraisal templates, and training for planners can help raise the bar for everybody involved in enhancing the resilience of infrastructure systems.

Box 2. Case study: Governance framework for the evaluation of resilient infrastructure in Chile

Chile's integration of disaster risk and climate resilience into public infrastructure evaluation demonstrates a proactive, institutionalized approach anchored in both national strategy and legal reform. Chile is exposed to multiple natural hazards, including floods, wildfires, tsunamis, volcanic eruptions, and landslides. As a response, the Ministry of Social Development began embedding disaster risk into project evaluation processes in 2015. This marked a shift from voluntary frameworks to mandatory compliance, reinforced by the 2022 Climate Change Law, which requires climate risk to be integrated into all public investment evaluations.

Applied to building projects, the methodology guides project formulators through risk–cost trade-offs, offering adaptation options complete with financial estimates. Pilot studies were used to test the tool's feasibility across 30 real public investment projects before a national rollout. Despite initial hesitation, updates to project preparation guidelines and training programmes helped normalize its use. The methodology has been a mandatory part of Chile's National Investment System since 2022, ensuring consistent application (Regional Observatory on Planning for Development of Latin America and the Caribbean, n.d.). Centralized tracking and performance monitoring reinforce implementation.

Box 3. Case study: Public-sector-driven resilience planning in Costa Rica

Situated across two tectonic plates, Costa Rica is prone to earthquakes and volcanic activity, as well as climate-exacerbated hazards such as floods, hurricanes, storms, droughts, and water scarcity. According to the IMF, about 80 percent of Costa Rica's population lives in high-risk areas subject to multiple hazards. Between 1998 and 2018, rainfall caused damage to infrastructure equivalent to 0.7 percent of GDP (International Monetary Fund, 2023). Infrastructure disruptions have had cascading effects, as seen in 2024, when the country simultaneously experienced drought and extreme flooding that caused landslides and damaged critical infrastructure—including water, electricity, and communications infrastructure—affecting almost 1.1 million people. To adapt, Costa Rica has empowered public operators of energy, telecommunications, and healthcare infrastructure to lead resilience innovations.

Most infrastructure is publicly operated. Key institutions—such as the Instituto Costarricense de Electricidad (ICE) for energy and telecommunications and the Caja Costarricense de Seguro Social (CCSS) for healthcare—have independently adopted resilience measures, including hazard insurance, internal risk assessments, and business continuity plans (Deubelli, 2019). For example, the CCSS-led Safe Hospital programme retrofitted healthcare facilities with high vulnerability scores to ensure service continuity. Similarly, the National Road Council launched hazard assessments to guide climate-resilient road planning. ICE's investments in preparedness were evident in 2017, when Costa Rica restored power within five hours of a regional grid failure caused by a storm, demonstrating the value of resilience.

Risk assessments are now mandated for all new public investments, and operators are required to implement institutional risk systems (SEVRIS), with support from the Ministry of National Planning and Economic Policy (Ministerio de Planificación Nacional y Política Económica, MIDEPLAN) and technical guidance (Deubelli, 2019).

4.3 Legislative Bodies

The transformation of infrastructure services towards greater resilience needs to be anchored in a well-designed set of laws and regulations. Legislative bodies, such as congresses, parliaments, and subnational assemblies or councils, are critical because of their roles and responsibilities. Their legislative work in risk-informed planning, disaster risk management frameworks, and resilience-supportive budgets is part of the roles highlighted in the Sendai Framework (UNDRR, 2023).

The actions described here by other government stakeholders have their legal basis in legislative actions. For example:

- **Disaster risk reduction legislation:** This includes mandating risk screening, climate-resilient infrastructure designs, sectoral and territorial plans that incorporate hazard information and risk assessments, and mainstreaming resilience and reliability in infrastructure services. For example, in Colombia, Law 388/1997 requires municipalities to prepare land-use plans based on risk instruments embedded in territorial planning and zoning. The risk information embedded in land-use statutes helps inform infrastructure and housing sector investment decisions (OECD, 2019).

- **Budget authority and financial architecture for infrastructure resilience:** This includes institutionalizing public finance mechanisms that incorporate and support resilience, such as maintenance funds, retrofitting programmes, disaster funds with clear and transparent triggering criteria, and contingent financing instruments for infrastructure agencies.

- **Policy coherence in roles and responsibilities:** As the Sendai Framework calls for mainstreaming disaster risk reduction within and across all sectors (UNDRR, 2015), legislative bodies can support infrastructure resilience by enacting coherent legal frameworks that are periodically reviewed to incorporate lessons learnt from disasters. In addition, legislative bodies should require consistency across national, territorial, and sector plans, as well as investment pipelines, to mainstream resilience and prevent risk from being locked in. For example, the Japan Basic Act on Disaster Management (Act No. 223/1961) clearly defines roles and responsibilities across national and local governments and clarifies financial instruments. The Act underpins integrated hazard zoning and establishes infrastructure resilience standards across infrastructure sectors (Ministry of Justice, 2021).

- **Resilience in PPP laws:** This includes requiring disclosure of risk assessments, including resilience in life cycle costing assignments, clearly assigning responsibilities for resilience action across the public and the private sectors, as well as including resilience performance indicators in PPP contracts and their financial instruments, including tariffs and subsidies (McLennan & Maclean, 2019). Box 4 presents an example from Japan, showing how legislative acts can significantly impact infrastructure resilience.

- **Oversight and accountability:** This includes holding periodic hearings requiring line ministries, large state-owned enterprises, and regulators to report on their enforcement of resilience codes and guidelines, and other actions implemented; working with supreme audit institutions for performance audits, particularly on infrastructure failures and to record lessons after disasters; and, when appropriate, mandating periodic resilience compliance reports from infrastructure agencies.

- **Inclusion and participation:** This includes required public consultation processes in planning, code revisions, and investment programmes.

Box 4. Case study: Pre-planning for rapid railway recovery in Japan

The 2011 Great East Japan Earthquake, a triple disaster that included an earthquake, a tsunami, and a nuclear crisis, devastated northeast Japan, severely damaging railway infrastructure (Ranghieri & Ishiwatari, 2014; Kaufmann & Penciakova, 2011). The rapid recovery of 90 percent of affected railways within two weeks of the disaster was attributed mainly to extensive preparation and pre-existing contractual agreements on roles and responsibilities. Long before the disaster, Japan had already established the systems that most countries improvise during a crisis. The Ministry of Land, Infrastructure, Transport, and Tourism provided strategic funding and oversight, while JR East, a major private rail company, retained full operational control, eliminating any confusion or gaps resulting from overlapping mandates and allowing repairs to begin immediately.

Continuity contracts were embedded in the company's regular business planning. Agreements with suppliers and contractors covered day-to-day operational governance, including legally binding timelines and pricing structures that did not require renegotiation in the event of a disaster. When the 2011 earthquake struck, the relevant clauses automatically took effect, allowing JR East to bypass the procurement delays that typically stall recovery efforts.

The Basic Act for Reconstruction, passed just three months after the 2011 earthquake, further codified both centralized authority and local flexibility for disaster recovery (Ministry of Justice, Japan, 2011). It gave the central government the power to reallocate budgetary resources, fast-track procurement, and override bureaucratic procedures to accelerate reconstruction (Ranghieri & Ishiwatari, 2014). The Act also structured relations with municipal governments: In Sendai and Tōhoku, local authorities were granted expanded discretion to manage debris clearance, prioritize emergency transport routes, and adapt national directives to rapidly changing on-the-ground conditions (Buchanan, 2014). This balance between central coordination and local autonomy was essential to speed and effectiveness.

4.4 Disaster Risk Management Agencies

DRM agencies can be powerful 'systems integrators' for resilient infrastructure. They have a unique vantage point that allows them to connect national DRM policies, hazard information, construction and resilience standards, and response and recovery coordination across infrastructure agencies.

Global experiences show that successful progress towards resilient infrastructure requires that DRM agencies take the lead on certain stances:

- **Legal and policy clarity, with specific responsibilities for infrastructure agencies:** DRM framework laws should clearly define the roles of these agencies in risk reduction, disaster preparedness, and service restoration. Sectoral plans also need to be coordinated with land use, territorial development, and national development plans, all of which should have resilience embedded. The DRM agency should be empowered to review and advise on infrastructure sector plans and have the incentive and regulatory tools to ensure these sectoral resilience plans are completed. For example, in Chile, Law 21.364 (2021) created the Servicio Nacional de Prevención y Respuesta ante Desastres (SENAPRED) as a DRM agency with a mandate to ensure stronger coordination and a consistent risk-management approach across all levels of government, including infrastructure agencies (Gobierno de Chile, 2022).
- **Hazard and climate risk analytics for investments:** Infrastructure agencies need to conduct risk assessments of their investment pipeline and incorporate risk mitigation and resilience measures, which the DRM agency can review for consistency across sectors and plans.

- **Permanent multi-utility coordination forum:** This is to ensure potential cascading failures are avoided through information-sharing protocols, dependency mapping, and joint drills. New Zealand Lifelines (national and regional councils) regularly meet with infrastructure agencies and have prepared a useful set of guidance and practice notes (NEMA, n.d.).
- **National guidelines for sectoral operating manuals and monitoring and evaluation systems:** National guidelines can be instituted for incident management, rapid damage assessment, emergency procurement, redundancy standards, etc. For example, the Philippines launched a results-based monitoring and evaluation system to track, among other things, infrastructural outcomes during rehabilitation and recovery, which are then used in sectoral manuals (PDPS-OCD, 2020).

In addition, DRM agencies can play a unique role in developing institutional capacities for the collection and analysis of data on risks, emergency operations and business continuity, lifeline mapping and planning, and risk-informed planning at the subnational level, among other areas.

4.5 Code-Setting Agencies

Code-setting agencies (CSAs) in the construction sector, in particular, play a critical role in developing disaster resilient infrastructure (DRI) by translating the latest science on hazards into enforceable technical requirements tailored to local conditions. Codes are among the most cost-effective risk management policies, as they ensure consistency. Furthermore, the Sendai Framework explicitly calls for countries to develop and periodically revise their codes and standards as part of risk governance (UNDRR, 2015).

Section 7 expands on the codes and standards themselves; this section focuses on the role of the CSAs.

The CSAs have five critical functions at the core of resilient infrastructure:

- **Standard-setting and updates:** CSAs must develop and update codes and standards to cover structural and non-structural elements and establish targets for lifeline functionality in the context of evolving climate hazards; they should also define regular revision timelines—for example, every three to five years—as well as learning and evaluation cycles following a large disaster (World Bank, 2025c). They should also consider performance-based provisions, such as the performance-based assessment and design provisions included in Türkiye's 2018 Earthquake Code (Efil İnşaat, 2025).
- **Hazard-based codes:** CSAs must curate national hazard maps (in coordination with the appropriate agencies) and translate them into siting restrictions in the codes.
- **Accreditation, training, and system development:** CSAs should develop and manage accreditation and training systems for professionals engaged in all phases of construction and inspection; support the development of digital permitting systems; and conduct quality assurance audits (McAllister et al., 2022). They must pay special attention to capacity building at the subnational level to ensure application and enforcement are on par with those in larger cities.
- **Retrofitting programmes:** CSAs can advise on retrofitting codes, standards, and timelines for buildings and infrastructure that need modification to comply with evolving standards. For example, since 2017, New Zealand has operated a system with deadlines to strengthen buildings through retrofitting, with current reforms targeting the highest-risk buildings (MBIE, New Zealand, 2025).

- **Active engagement in reconstruction programmes:** CSAs should support programmes that tie housing reconstruction payments to inspections, build large-scale capacity for inspectors and masons, and help prioritize critical infrastructure.

4.6 Subnational Governments

Subnational governments are the closest public agencies to people and infrastructure assets exposed to hazards. In many countries, they have broad responsibilities for infrastructure services within their administrative boundaries, exercised through sectoral departments and utilities. Local roads, drainage, water and sanitation, electricity distribution, local health and education facilities, and public buildings are generally within the purview of subnational governments. They are a critical link in the chain in the context of infrastructure resilience.

When subnational governments have well-defined legal mandates to make infrastructure services resilient, coordinating well with higher tiers of government to enable transparent allocation and timely resource transfers, the resilience of infrastructure improves. The Sendai Framework explicitly calls on local authorities to take the lead on providing mandates and financial means to mitigate disaster risks (UNDRR, 2015).

Subnational governments have unique roles in the resilience of the infrastructure services they are responsible for. In coordination with the departments and agencies within their jurisdiction, subnational governments therefore have three key roles:

- **Data:** Subnational governments sometimes have better access to local information on hazards and exposure, as well as to asset inventory and quality, and the opportunity to cut across sectoral silos to facilitate data sharing, due to their reporting lines. They are also better positioned to compile data to support post-disaster damage assessments. Box 5 presents an example from Egypt, where the central government's stronger capacities were combined with local know-how for context-sensitive capacity building, leading to stronger resilience actions.

- **Land use, zoning, and code enforcement:** In many countries, subnational governments are responsible for local land use and zoning decisions, enforcement of codes and standards, and resilience-focused operations and maintenance (such as cleaning drains before the rainy season or proactive vegetation management in the hills).

- **Local contingency planning:** The closer command structure between emergency services and infrastructure providers at the subnational level makes it easier for local governments to mobilize and undertake drills, create joint preparedness plans, and set up single-incident command centres for faster coordination and response—provided they have the capacity and mandate to do so.

Box 5. Case study: Resilient road management in Egypt

Upper Egypt is behind the rest of the country in economic growth, connectivity, and access to services (World Bank, 2022). The region's dependence on the River Nile to support its population and economy leaves it increasingly vulnerable to natural hazards such as flooding and extreme heat. The road network in Upper Egypt has particularly high-risk exposure, with unsafe road conditions and accidents during natural hazards severely disrupting access and economic activity. Inadequate technical design and road asset management systems (RAMS) further impede Upper Egypt's capacity to build resilience.

To address these challenges, the Upper Egypt Resilient Road Transport Technical Assistance (World Bank, 2022) was developed as part of the Upper Egypt Local Development Program (UELDP) to close capacity gaps by strengthening road transport resilience across four selected governorates: Qena, Sohag, Minya, and Assiut. This programme included developing RAMS to track the condition, maintenance needs, and life-cycle costs of road networks, enabling data-driven decisions to reduce vulnerability and extend the durability of infrastructure.

Rather than creating new institutional arrangements, the initiative focused on strengthening and reforming existing road departments, whose mandate had previously been limited to road maintenance. It facilitated intensive capacity-building programmes for local officials, training them in RAMS as well as risk assessment, mitigation, and recovery. Consequently, the Upper Egypt Resilient Road Transport Technical Assistance initiative extended the operational life of local roads, reduced traffic accidents, and ensured road surfaces remained defect-free and stable. By prioritizing critical local roads, the system has enhanced service continuity, though some roads remain underserviced due to limited resources.

Municipal governments tend to have more flexible learning and improvement cycles after disasters (compared to national governments in large federal systems), allowing for institutional evolution that adapts to newer, more intense disaster risks. Box 6 presents the history of adaptable resilience governance in New York City (USA) since the 2012 Hurricane Sandy disaster.

Box 6. Case study: Adaptable governance for infrastructure resilience in New York, USA

In 2012, Hurricane Sandy damaged public housing that accommodated 60,000 residents in New York City (NYC). Areas with critical facilities lost telecommunications for 11 days; 2 million people lost power; flooded tunnels displaced 5.4 million weekday transit riders; and six hospitals were forced to close, requiring the evacuation of 2,000 patients. This event was a tipping point for NYC, triggering the integration of adaptation measures into the city's sustainability strategies (NYC Mayor's Office of Climate & Environmental Justice, 2026). Since 2012, NYC governance of infrastructure resilience has evolved, updating policies and priorities to align with new data, while remaining consistent with the city's long-term plans.

The response to Hurricane Sandy brought an influx of funding, coupled with an institutional shift towards a holistic understanding of the city's risk exposures, reflected in programmatic changes. A risk requiring urgent mitigation was the siloed nature of its DRM—which required a centralized supervisory authority and collaborative structuring of new resilience institutions. NYC therefore created a task force to manage financial resources and physical assets during the immediate rebuild in the aftermath of Hurricane Sandy. Additionally, NYC created a Chief Resilience Officer within City Hall, with the power to direct funding to and convene focus agencies and other stakeholders. Over time, this became the Office of Recovery and Resilience. This centralized programme management complemented the operational project management by various agencies.

To bolster the integrity of these governing institutions, the Bloomberg administration passed legislation implementing PLANYC, an accountability mechanism for strategic planning cycles (City of New York, 2007). This requires annual public reporting of risks, trends, and progress, with a new plan drawn up every four years, guided by the city's 2050 resilience goals (City of New York, 2019). Inter-city initiatives and collectives, such as the C40, Urban Sustainability Directors Network (USDN), and 100 Resilient Cities (now the Resilient Cities Network), are valuable in shaping these four-year plans. Local engagement—garnered by the Community Affairs Unit, the Public Engagement Unit, Intergovernmental Affairs, and elected community leaders—further informs the priorities.

Subnational governments need specific support from the central government and national infrastructure agencies in four key areas:

- **Rapid access to national-level response and recovery finance:** Local governments need clear rules and easy access to finance after disasters that overwhelm their capacity. For example, in the USA, the national DRM agency has a Hazard Mitigation Grant Program that provides funding for subnational governments to develop mitigation plans and build back better after a presidentially declared disaster (FEMA, 2026).
- **Clear delineation and alignment of local and national DRM policies:** Overlapping responsibilities and unclear mandates are common reasons for delays in response and recovery of infrastructure services. For example, in Japan, the Disaster Countermeasures Basic Act clearly delineates responsibilities across national, prefectural (governor), and municipal levels (Ministry of Justice, Japan, 2021). At times, cities can take the lead on infrastructure resilience even when there is insufficient clarity on resilience policies. Box 7 showcases an example of urban power resilience in Brazil.
- **Access to national data and standards:** Subnational governments need the understanding and capacity to access and leverage national datasets on hazards and climate projections, construction design standards, procurement frameworks that include resilience, and other tools for effective local action.
- **Cross-municipality action:** Many hazards require coordinated action at the watershed or metropolitan levels to manage flood risks, share emergency services, and ensure the resilience of infrastructure that crosses municipal boundaries (from roads to power transmission). For example, 14 municipalities in the Neponset River Watershed in the Greater Boston region (USA) are working together on climate adaptation and resilience planning, with a shared flood model and watershed-wide flood mitigation strategies (Resilient Neponset, 2025).

Box 7. Case study: Urban power resilience in Rio de Janeiro, Brazil

Rio de Janeiro offers an example of a major city that has advanced its energy resilience despite having limited control over national electricity systems. Through the City Energy Resilience Framework, the city identified institutional gaps, fostered cross-sector collaboration, and prioritized investments to strengthen energy infrastructure under socioeconomic stress (Gessesse et al., 2023).

The city, located on the coast, is a key economic hub (Resilient Cities Network & Rio Prefeitura, 2023) that faces multiple environmental hazards—including rising sea levels, flooding, heatwaves, and landslides—with nearly 600,000 residents living in informal settlements that lack adequate infrastructure. The 2010 floods marked a turning point, spurring the creation of the Centro de Operações Rio (COR, the Operations and Resilience Centre) and the Sustainable Development and Climate Action Plan (Rio Prefeitura, n.d.).

The COR brings together over 30 public agencies, service operators, and emergency units to manage risks, share data, and make real-time decisions across sectors. Tools such as the Master Plan and the PDS support its objectives by embedding resilience priorities into zoning, land-use policies, and project design standards (Rio Prefeitura, n.d.). The COR's budget distribution seeks to balance strategic oversight with local responsiveness. The COR and senior secretariats provide citywide leadership, while agencies manage on-ground implementation. Public-private coordination is also central to improving service reliability and infrastructure durability. Community engagement complements formal governance by enhancing knowledge transfer and ensuring the needs of vulnerable communities are reflected in infrastructure planning.

Rio's resilience strategy focuses on enhancing the capacity and durability of its energy infrastructure. Key measures include modernizing substations, reinforcing distribution networks, and incorporating decentralized solar PV to reduce reliance on centralized systems. The COR uses digital tools for early warning, infrastructure monitoring, coordinating responses, and improving system adaptability during disruptions. Metrics such as the System Average Interruption Duration Index and Frequency Index (Energy Market Authority, 2026) are key indicators of service continuity, particularly in upgraded areas.

Many cities and provinces have established 'chief resilience offices' to coordinate actions across departments, including infrastructure agencies and utilities. The Resilient Cities Network brings together more than 100 cities from all continents to share lessons learnt on institutional and governance approaches to resilience. Some cities have specialized offices that tackle a specific hazard across all local spheres, including infrastructure services.

4.7 Infrastructure Regulatory Agencies

Infrastructure regulatory agencies (IRAs) constitute an important group of stakeholders in resilient infrastructure, because they can: set service quality and reliability requirements; embed resilience into operating licences, price–quality tariffs, and investment plans; enforce emergency preparedness standards; and ensure reporting and disclosure of risks across public and private providers (World Bank, 2019).

At the core, resilience is a regulatory value-for-money challenge. Well-designed price–quality regulations and performance incentives can be more flexible and effective than construction standards or DRM protocols, as they require utilities and infrastructure service providers to internalize risks and optimize the resilience of life-cycle costs (maintenance, retrofitting, new asset acquisition, and response and recovery). For example, New Zealand's Commerce Commission embeds reliability and resilience into core incentives in its regulatory regime (Commerce Commission, New Zealand, 2024). India is working with telecom companies to embed resilience into sectoral governance as well (Box 8).

Box 8. Case study: Institutionalizing telecom resilience in India

India is exposed to multiple hazards. About 58 percent of its land is earthquake-prone, 12 percent is vulnerable to floods, and much of its 7,500 km coastline is exposed to cyclones. Telecommunications is a critical infrastructure sector for sustaining economic activity and is indispensable for keeping people connected during disasters.

To address these vulnerabilities, the Department of Telecommunications, the National Disaster Management Authority (NDMA), and CDRI developed India's first systemic effort to embed resilience in telecom governance: the Disaster Risk and Resilience Framework (DRRAF) of 2024–2025. The DRRAF was piloted in Assam, Gujarat, Odisha, Tamil Nadu, and Uttarakhand, incorporating governance lessons from other countries with similar hazard profiles, including Japan, the Philippines, and Indonesia (CDRI, 2025c).

DRRAF takes a structured approach, with multi-hazard mapping of 770,000 towers, stakeholder consultations, resilience indices, and actionable state-level roadmaps. It proposes institutional innovations such as Licensed Service Area-level disaster task forces, mandatory data repositories, and a National Disaster Resilience Lab. The aim is to embed resilience across planning, operations, finance, and regulation. DRRAF identifies redundancy, robustness, responsiveness, and information flow as key performance and governance indicators. Its technical resilience recommendations include cells on wheels, multiple submarine cable landings, satellite backups, and seismic resilience upgrades. On the governance front, DRRAF proposes a move towards digital approvals, enhanced mechanisms to regulate performance standards, and new enforcement approaches.

IRAs have four core tools to embed resilience in the infrastructure services they regulate:

- **Licences, codes, and technical standards:** For example, sector codes can include hazard-specific requirements (such as wind loads or flood levels), as well as redundancy and restoration protocols. The Central Electricity Authority (CEA) of India has prepared a disaster management plan for the power sector to guide service providers (CEA, 2024). The Philippines Energy Regulatory Commission has also issued the Philippine Small Grid Guidelines to ensure quality and reliability of power supply in smaller island systems (Energy Regulatory Commission, Philippines, 2024).
- **Resilience-based, price–quality, and performance-based regulations:** These regulations can recognize capital and operating expenditures associated with resilience actions and allow revenues to deliver specific resilience outputs (such as preserving food security) as well as nature-based solutions (NbS) and outcomes (reduced outage frequency and duration during disasters). At the same time, penalties and bonuses can be linked to reliability targets in the face of disasters (Hesmondhalgh et al., 2012).
- **Consumer protection and emergency protocols:** These look to ensure service continuity and fair cost recovery after disasters. For example, Jamaica's Office of Utilities Regulation issued directions on billing fairness after Hurricane Beryl in 2024 and oversaw drawdowns from an Electricity Disaster Fund to support recovery (Wilson, 2024).
- **Integrated system planning requirements:** These include coverage for current hazards and future climate scenarios, potential cascading impacts, and priority services to preserve critical functions (hospitals, water treatment facilities, etc.). For example, the UK Office of Gas and Electricity Markets links the *Centralized Strategic Network Plan* and other regulatory mechanisms to resilience to climate-related disasters (Ofgem, 2025). Kenya's Water Services Regulatory Board

(WASREB) requires utilities to conduct risk assessments, monitoring, and contingency planning per its Guideline on Water Safety Planning (WASREB, 2019).

4.8 High-Level Resilience Commissions

The need for decisive coordinated action on resilient infrastructure may require an institutional arrangement at the highest level, coordinated by a prime minister, minister of finance, or high-level commissioner. Because disasters can cause a cascade of disruptions across sectors and many infrastructure risks are systemic, a government-wide risk governance approach (with central coordination) is a useful mechanism.

Typical functions of a high-level resilience commission include:

- having a mandate and convening power to set cross-sector resilience standards and compel coordination;
- applying budgetary leverage to align investments with prioritized resilience needs, based on common risk-assessment and cost-benefit methodologies;
- developing shared tools and data for harmonization of sectoral practices; and
- creating accountability and transparency tools, such as results frameworks and progress reports.

For example, the Netherlands Delta Programme Commissioner leads a statutory, cabinet-level coordination mechanism that integrates flood safety, freshwater security, and climate-resilient spatial planning under a multi-decade Delta Programme supported by a dedicated Delta Fund. This fund is designed to stabilize financing for resilient water and spatial adaptation across election cycles. The Commissioner reports annually to the cabinet and parliament. This enables consistent national-to-local delivery and long-term asset management across infrastructure systems (National Delta Programme, n.d.e).

Another delta programme is the Delta Plan 2100 of Bangladesh, which was approved by its National Economic Council, chaired by the prime minister. The programme establishes a long-term, cross-government platform for water, climate, and infrastructure resilience (Roome, 2021).

Other high-level commissions have also been established to undertake large-scale reconstruction programmes after disasters. In Peru, the Autoridad para la Reconstrucción con Cambios (Authority for Reconstruction with Changes) was created in 2017 under the Prime Minister's Office to lead and implement a nationwide, resilience-focused reconstruction plan after the El Niño-inflicted disasters. Upon completion of its objectives, the Authority was dissolved in 2023.

4.9 Land-Use Planning Agencies

Land-use planning agencies play a key role in the resilience of infrastructure agencies by helping them avoid exposure of new assets, enabling the use of NbS, and mobilizing innovative land-based financing instruments for resilience.

Land-use planning agencies have several core functions directly related to infrastructure resilience. They can:

- develop risk-informed land-use plans that clearly define territorial zones that all new infrastructure assets must avoid and zones that will help those assets adapt to future climate

hazards (World Bank, 2017a) (for example, in the Philippines, national regulations require local governments to integrate climate and disaster risks into the comprehensive land-use plans and zoning ordinances in their jurisdiction; these are then overseen by the land-use authority [HLURB Philippines, 2013]);

- tie project screening and approval, right-of-way acquisition, and infrastructure and building work permits to risk-sensitive criteria;
- define in advance the legal mandates for post-disaster land-use planning to facilitate faster recovery and reconstruction (GFDRR, 2020);
- maintain and openly share authoritative geospatial data that can be used by infrastructure agencies for sectoral planning;
- enforce land-use plans, including relocation instructions for infrastructure assets that have been constructed in high-risk unauthorized areas;
- integrate specific land uses for specific territories (floodplains, wetlands, coastal buffers) into zoning regulations to support NbS for infrastructure resilience, as discussed in the GIR 2025 working paper on *Nature-based Solutions: Partnering with the Environment* (Boogaard *et al.*, 2026); and
- use land value–capture instruments to mobilize financing for infrastructure resilience. For example, Colombia's Law 388/1997 has been the foundation of a successful land value–capture model that links land-use decisions to funding for new infrastructure assets [it may be feasible for such a model to ensure resilience actions (Grafakos *et al.*, 2019)].

4.10 Hydromet and Other Hazard-Focused Agencies

Infrastructure agencies need high-quality, relevant data on hazards impacting their assets and services. These hazards must then be modelled, forecast, and monitored by specialized public agencies (such as meteorological services, hydrological institutes, geological surveys, and volcano observatories). Resilient infrastructure requires effective institutional coordination between infrastructure agencies and hazard-related agencies (such as hydromet agencies for cyclones and storms or geological agencies addressing landslides, etc.).

This institutional coordination requires: i) integration of hazard data into the infrastructure cycle—from siting and planning, to construction and resilience-enhanced maintenance; ii) operation decision-making informed by hazard forecasts (including hydropower operations, reservoir management, power-grid operations, and road and railway closures); and iii) access to shared hazard-data infrastructure, allowing multiple infrastructure agencies to reduce duplication and costs across sectors.

In many cases, insufficient institutional coordination leads to hazard data being produced but not systematically shared or used by infrastructure agencies. Sometimes, hazard-related agencies produce data that is difficult to link to specific infrastructure assets or to embed within the infrastructure life cycle. Sometimes, limited use of hazard data by infrastructure agencies stems from a lack of interoperable formats, standards, and access rules. Finally, many countries suffer from chronic underfunding of monitoring networks (hydromet stations, seismic networks, landslide inventories) and geospatial data. Even where donor-funded programmes provide the equipment, hazard-related agencies may lack sufficient financial and human resources to manage the telecom, hydrological data collection, and other networks and data systems.

Some best practices have emerged, however, from developed countries such as Norway, New Zealand, and Japan.

The Norwegian Public Roads Administration has strong institutional ties with geotechnical institutes and national avalanche-warning services, with hazard science tightly embedded in day-to-day infrastructure management. Data-sharing is not limited to periodic reports, but entails continuous, real-time exchanges, allowing hazard observations and forecasts to rapidly trigger road closures, maintenance interventions, and preventive measures such as slope stabilization. Bringing together real-time data flows and operational protocols enables hazard information to directly guide infrastructural safety measures and maintain service continuity (Statens vegvesen, n.d.).

In New Zealand, infrastructure operators in the electricity, water, transport, and telecommunications sectors have structured partnerships with hazard-related agencies and research institutions such as GNS Science[1] and the National Emergency Management Agency (NEMA), as part of their Lifelines model (National Emergency Management Agency, 2026). These stakeholders jointly produce vulnerability assessments that integrate hazard data (earthquakes, floods, volcanic risks) with infrastructure interdependencies. This collaborative structure ensures that hazard information is systematically incorporated into investment planning, asset management, and contingency strategies across sectors (New Zealand Lifelines Council, 2023).

In Japan, infrastructure operators work closely with the Japan Meteorological Agency, which provides high-resolution forecasts and real-time hazard information (e.g., typhoons, heavy rainfall). These are then translated into operational decisions, such as adjusting maintenance schedules, pre-positioning crews, managing reservoir levels, and implementing road or railway closures. The system emphasizes impact-oriented forecasting, enabling infrastructure agencies to act on expected consequences rather than raw data (Japan Meteorological Agency, n.d.).

Boxes 9 and 10 show examples from the Philippines and Chile that illustrate how infrastructure agencies can establish structured institutional ties with hazard-related agencies to enhance the resilience of services.

Box 9. The Philippines: GeoRiskPH, a multi-agency hazard-data platform

The Philippines' GeoRiskPH platform is maintained by its Department of Science and Technology (DOST). The platform integrates multi-hazard datasets from key science agencies—including the Philippine Institute of Volcanology and Seismology (PHIVOLCS) and the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA)—into a unified, user-friendly platform accessible to government agencies, local governments, and infrastructure planners. The system includes applications such as HazardHunterPH (site-specific hazard screening), GeoMapperPH (hazard mapping and visualization), and GeoAnalyticsPH (risk analysis), all of which are accessible to planners, engineers, and decision makers (GeoRiskPH, n.d.b; GeoRiskPH, n.d.c). Web-based tools allow even resource-constrained local governments to access sophisticated hazard analysis without specialized software.

Infrastructure projects—schools, hospitals, roads, bridges, and housing developments—are screened for multiple hazard risks, using information provided by GeoRiskPH, before approval. Local government units are guided by GeoRiskPH to guide zoning, relocation, and siting decisions. Finally, the platform can

[1] GNS Science merged with the National Institute of Water and Atmospheric Research (NIWA) on 1 July 2025 to form Earth Sciences New Zealand.

support rapid hazard assessment for contingency planning and prioritization of critical infrastructure protection.

Box 10. Chile: Energy-sector GIS and multi-hazard data—SIGGRE and the National Resilience Roadmap

The energy sector in Chile has developed the Sistema de Información Geográfica para la Gestión de Riesgos en Energía (SIGGRE, the Geographic Information System [GIS] for Energy Risk Management), which combines multi-hazard data with detailed information on energy assets (generation plants, transmission lines, substations, and fuel infrastructure). The platform was developed through a public-private roundtable led by the Ministry of Energy and including the Ministry of Interior, the National Emergency Office, Corporación Nacional Forestal (CONAF, National Forestry Corporation), and transmission and distribution companies. The platform's initial focus was on wildfires. The platform monitors wildfires in real time to determine the exposure of nearby energy infrastructure. Data on tsunamis and volcanic eruptions is also included (Ministerio de Energía [Ministry of Energy], Chile, 2018).

These examples show that formal platforms and mandates are critical for sustaining institutional collaboration. The platforms are most effective when they connect hazard data to specific infrastructure assets, rather than to general geographic areas. Notably, countries that have achieved good results invest in shared platforms rather than isolated databases. These can also analyse the cascading impacts from disasters. Finally, commencing sectoral pilot studies (such as the one carried out in Chile), alongside creation of a strong GIS platform in a critical sector (such as energy) can demonstrate value and inspire other infrastructure sectors to follow.

4.11 Emergency Services

Emergency services (such as fire services, ambulance, police, civil protection, search and rescue, or emergency medical aid) depend on functioning infrastructure systems. For example, roads and bridges are needed for emergency personnel to access a disaster zone; electricity is crucial for hospitals to continue operating and communications to be maintained among emergency service personnel; water is a critical resource for both firefighting and health; and ports and airports are an indispensable component of relief logistics.

Infrastructure agencies must be acknowledged as integral entities in disaster planning—not seen as supporting stakeholders but accepted as core partners. When command structures are fragmented, restoration protocols are unclear, continuity plans for infrastructure services are weak, or learning protocols are not applied after a disaster, the overall effectiveness of emergency services suffers.

For example, Hurricane Maria in 2017 caused a near-total collapse of Puerto Rico's power grid, with cascading impacts on the water supply, telecommunications, and health facilities. According to post-disaster assessments and lessons learnt from analyses conducted by the USA's National Institute of Standards and Technology (NIST) and the USA's Government Accountability Office (GAO), these cascading infrastructure failures critically undermined the functioning of Puerto Rico's emergency services at the time (NIST, 2021; US GAO, 2021).

While many hospitals, telecom towers, and emergency facilities had generators in Puerto Rico, many of these also failed due to lack of maintenance, insufficient capacity, or fuel shortages. The collapse of cellular networks and limited interoperability among regional communication systems disrupted coordination among emergency responders, government agencies, and utilities. Furthermore, government officials in the islands lacked timely, accurate information on outages, road conditions, and infrastructure

damage, making it difficult for them to prioritize actions and allocate resources. Finally, there was confusion over ownership of responsibilities among federal agencies, local authorities, and private utilities, particularly for telecom restoration (US GAO, 2021).

The 2011 Great East Japan Earthquake and Tsunami also provided important lessons for institutional relations between infrastructure service providers and emergency services. While the tsunami destroyed many transport assets, isolating communities, Japan had pre-identified redundant inland routes and alternative corridors that still allowed emergency services to access affected communities promptly. Its utility services also had pre-agreed service restoration priorities that privileged hospitals, shelters, water systems, and emergency command facilities. Restoration of priority power, water, and telecom services was treated as an urgent response action, not as post-disaster reconstruction and recovery tasks. Finally, infrastructure agencies were present at incident command centres, enabling real-time decision-making on access, service restoration priorities, and resource allocations.

At the same time, the 2011 disaster provided important lessons. Fuel supply chains proved a significant constraint for emergency vehicles and generators. Telecommunications failures in the immediate aftermath of the disaster underscored the need for redundant communication systems, including satellite communications, mobile emergency networks, and priority communication channels for emergency services and utilities. Finally, the movement of relief supplies proved to be more challenging than originally surmised. Japan has since strengthened its emergency logistics systems, adding pre-designated logistics hubs, improving coordination with the private sector (e.g., logistics companies and retailers), and better integrating ports and airports in the system (Ranghieri & Ishiwatari, 2014).

Boxes 11, 12, and 13 present case studies on the resilience of disaster response systems in the Caribbean, Türkiye, and India.

Box 11. Case study: The Caribbean Regional Response Mechanism (RRM)

The Caribbean Disaster Emergency Management Agency (CDEMA) operates the RRM. This mechanism allows Caribbean states to rapidly mobilize regional support when national systems are overwhelmed after disasters (CDEMA, n.d.). The mechanism brings together military and police units, engineering teams, public works departments, port and airport authorities, telecom providers, and humanitarian agencies, ensuring that infrastructure restoration is embedded within the emergency response priorities.

After Hurricane Maria struck Dominica in September 2017, the RRM was activated. The hurricane caused catastrophic damage to infrastructure assets, severely constraining emergency access and relief delivery. Caribbean security forces and engineering units were deployed to clear debris, reopen roads, and restore access for isolated communities, enabling emergency services to reach affected populations. Regional support helped re-establish airport and port operations, which were critical for the arrival of relief supplies, medical teams, and equipment. Temporary telecommunications systems were deployed to restore coordination between emergency services and government agencies (Government of the Commonwealth of Dominica, 2017).

The CDEMA RRM demonstrates how small countries with limited national capacity can work together through pre-arranged regional institutional coordination between infrastructure agencies and emergency response services.

Box 12. Case study: Türkiye—Using scenario-based planning to integrate infrastructure resilience and emergency response

Türkiye has developed an integrated system that links infrastructure resilience with emergency response through the Afet ve Acil Durum Yönetimi Başkanlığı (AFAD, the Ministry of Interior Disaster and Emergency Management Presidency) and its scenario-based planning tools, including the new AFAD Earthquake Early Loss and Damage Analysis System (AFAD-DEHAS). The system combines data on seismic hazards, risk exposure for buildings and populations, and lifeline infrastructure (transport, energy, water, and telecommunications) to estimate damage and service disruptions from major earthquakes. Its integrated modelling allows authorities to estimate gaps between expected demand (casualties or rescue needs) and available capacities, and then to plan accordingly (General Directorate of Earthquake and Risk Reduction, 2026).

These outputs are used to stress-test the emergency-response capacity under conditions of infrastructure failure and to guide preparedness, response planning, and investment decisions, including i) determining the number and location of search-and-rescue teams, medical facilities, and logistics hubs; ii) identifying critical infrastructure assets for retrofitting or redundancy; and iii) defining alternative routes, staging areas, and emergency logistics corridors.

AFAD ensures centralized coordination across infrastructure sectors and emergency services, linking ministries responsible for transport, energy, environment and urbanization, health, and interior affairs with operational actors such as search-and-rescue teams, police, fire services, and medical responders. The Türkiye Afet Müdahale Planı (TAMP, Türkiye Disaster Response Plan) defines sectoral roles and responsibilities across all major infrastructure and service domains, ensuring that infrastructure agencies are fully integrated into emergency-response structures rather than operating in parallel (AFAD, 2014).

After the 2023 Türkiye–Syria earthquake, Türkiye's centralized system enabled the rapid mobilization of national and international search-and-rescue teams and the launch of large-scale logistics operations (World Bank, 2025d). However, widespread infrastructure failures (such as damaged roads, disrupted airports, power outages, and telecom breakdowns) constrained access and coordination, particularly in the early phase (ReliefWeb, 2023). An important lesson is that scenario-based planning needs to explicitly account for severe infrastructure disruption and cascading failures, not just hazard intensity.

Box 13. Case study: Odisha, India—Coordinating infrastructure agencies and emergency services for cyclone preparedness

The state of Odisha is widely recognized as a global example of best practice for integrated disaster preparedness, given its linking of infrastructure services and emergency response systems. Since the late 1990s, Odisha has progressively built a multilayered institutional system by way of the Odisha State Disaster Management Authority (OSDMA, n.d.), enabling strong coordination among emergency services (police, fire, and search-and-rescue), district administrations, and infrastructure service providers (power utilities, public works, telecommunications, and water agencies).

As part of pre-disaster preparedness, the state deploys repair crews, transformers, generators, heavy equipment, fuel, and communication systems to high-risk districts before a cyclone's landfall. Infrastructure agencies and emergency services participate in coordinated drills and preparedness exercises. During the response phase, public works agencies coordinate with police and emergency responders to restore access routes for rescue operations; telecom providers work with authorities to restore communications for command and control; and hospitals, cyclone shelters, water systems, and

emergency operations centres are prioritized for provision of backup power and protection, in accordance with a pre-determined order. The system was tested—with positive results—during cyclones Phailin (2013) and Fani (2019), with a strong post-disaster 'lessons-learnt' exercise to ensure continuous improvements (Government of Odisha et al., 2013; Dora & Padhee, 2019).

As these case studies and lessons learnt show, emergency services should be treated as priority users of infrastructure systems. This requires well-planned service-restoration priorities after disasters and the pre-positioning of all materials and crews to enable a rapid response. At the same time, infrastructure agencies should be seen as core responders—they must be represented in command centres for live and efficient coordination and be provided with common maps, outage dashboards, data on access constraints, and related information. After-action reviews are critical for extracting lessons and improving backup systems, fine-tuning institutional roles, and prioritizing resilience-enhancing infrastructure maintenance.

4.12 Cascading Impacts across Infrastructure Services

Disasters rarely impact infrastructure services in isolation. For example, power outages disable telecommunications services, water pumps, traffic systems, and fuel stations. Telecom outages weaken water pump–dispatch systems and emergency services. Infrastructure resilience requires institutional arrangements among service providers across sectors, including joint preparedness plans, data-sharing agreements, priority restoration protocols, common operating dashboards, and joint post-disaster learning exercises.

The Roadmap for Infrastructure Resilience in the Republic of Chile (2025), prepared with the support of CDRI and UNDRR, takes an integrated look at the resilience of energy, water, information and communication technology (ICT), and transport as interconnected systems exposed to earthquakes, wildfires, droughts, floods, and other hazards. The report recommends that national resilience roadmaps should combine asset-level risk data with institutional mapping: which operators depend on which services, who shares what data, and who coordinates restoration (Gobierno de Chile, 2024).

In Australia, the Trusted Information Sharing Network (TISN) is a national public-private mechanism that brings together critical infrastructure owners and operators, supply-chain companies, and national, state, and local governments. TISN is evolving as a flexible network that enables all stakeholders to collaborate within and across sectors to support cross-network resilience. TISN offers opportunities for infrastructure owners and operators to discuss dependencies, risks, and preparedness (Cyber and Infrastructure Security Centre, 2023a, 2023b).

Box 14 presents three cases from the Philippines, the UK, and the USA on the cascading impacts of disasters on infrastructure services, which led to enhanced coordination and the incorporation of lessons learnt.

Box 14. Lessons learnt from cascading impacts across infrastructure services

Typhoon Haiyan caused catastrophic damage across the central Philippines, exposing critical dependencies between telecommunications and power services. Up to 90 percent of telecommunications infrastructure in affected areas was damaged or non-functional, largely due to power outages, tower damage, and lack of backup systems. This collapse caused significant constraints for emergency services and relief support (Hall & Ashcroft, 2014).

Since then, the Philippines has improved coordination between the government, telecom operators, and humanitarian actors, expanded the use of satellite communications and mobile emergency units for rapid deployment after disasters, and integrated telecom resilience into national disaster-planning frameworks (Emergency Telecommunications Cluster, n.d.; NDRRMC, n.d.).

Storm Arwen (2021) led to over 1 million customers losing electricity, with some outages lasting more than a week, and caused cascading impacts on telecommunications and water supply. Studies found weak cross-sector coordination, with limited real-time information sharing between electricity, telecommunications, and emergency agencies, leading to slowed response efforts. Since then, the government and utilities have enhanced resilience standards for electricity networks, put in place strengthened mutual-aid arrangements among electricity distribution operators, and improved the coordination protocols between infrastructure operators and government agencies (DESNZ & BEIS, UK, 2022; BEIS, UK, 2022).

In the USA, the severe winter storms in Texas and neighbouring states in 2021 caused power outages affecting millions of customers and impacted water systems serving nearly 15 million people, leading to more than 1,100 advisories on boiling water, the use of which continued for weeks in some communities even after power was restored. The costs reached billions of dollars (Oxner & Garnham, 2021). The USA's Environmental Protection Agency (EPA) and Department of Energy (DOE) have identified the key interdependencies between power outages and disruptions to water and wastewater systems and have accordingly developed guidance for these utilities (US EPA, 2025). Some states have addressed these interdependencies and their impacts in their energy resilience plans. The National Association of State Energy Officials (NASEO) has issued guidance on studying the interdependencies between critical electricity and water infrastructure and the ways in which states can reduce risks and enhance resilience (NASEO, 2021).

Certain lessons emerge from these cases:

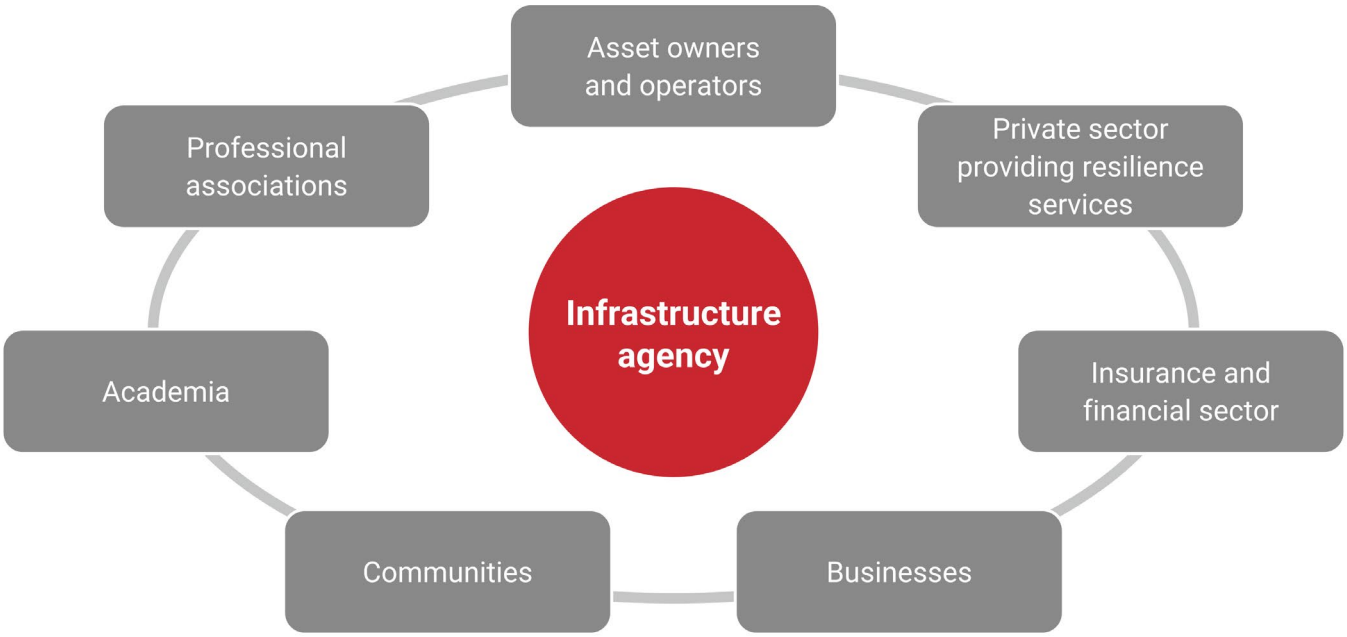
- Power services have a special vulnerability amid cascading impacts, given so many other infrastructure services depend on them.
- Countries need cross-sector platforms to ensure infrastructure resilience—spaces specifically to discuss the cascading impacts and prepare shared dependency maps, where specific assets that depend on other infrastructure assets and their services are clearly identified.
- Post-disaster reviews must examine cascading failures, and not only whether individual services survive the disaster, but whether the infrastructure system in toto was able to continue functioning across sectors.

5 Non-Public Stakeholders with a Role in Infrastructure Resilience

Section 4 reviewed the public-sector ecosystem of organizations involved in the resilience of infrastructure assets and services. There are also a broad range of non-public stakeholders in the resilience of infrastructure services—they may be providers of resilience goods and services, private partners delivering infrastructure services, or customers of the infrastructure agencies. An infrastructure agency needs to map and progressively improve the engagements with these actors to enhance the resilience of infrastructure services.

While Section 4 focused on how other public institutions should support infrastructure agencies' efforts to enhance the resilience of their services, this section focuses on what infrastructure agencies can do to engage non-public stakeholders to jointly work towards the resilience of both services and users. Figure 4 shows the main non-public stakeholders considered in this section.

Figure 4: Non-public stakeholders related to infrastructure resilience



Source: Authors' analysis

5.1 Private Asset Owners and Operators

In PPPs for infrastructure services, the private party is responsible for reliable service delivery. This requires risk-informed designs and maintenance of infrastructure assets, emergency-response SOPs, and continuous learning and improvement based on prior disasters.

To ensure resilient delivery of infrastructure services, the PPP contract must clearly allocate each risk to the party—private or public—that can better handle it. Good contracts match incentives (positive and negative) to reliability standards applicable after disasters. They should also have hard-wired engagements on resilience issues with regulators, DRM agencies, land-use agencies, and other government institutions, as described in Section 4.

The contracting infrastructure agency can take four actions to work with the private party in the PPP to enhance the resilience of services—they can:

- incorporate in the PPP contract specific guidance on how to handle *force majeure*, insurance, and the intensity of disasters above which government-funded relief and compensation will be provided (so that uninsurable catastrophic events do not leave the private contractor stranded);
- support resilient asset management, including resilient maintenance and materials, redundancy requirements, and storage of spare critical components in key locations (National Highways [UK], n.d.);
- require the establishment of data-sharing agreements with hydrometeorological and geological agencies for early warning systems, preventive maintenance, and operations (OECD, 2019b); and
- request annual resilience reports on disaster incidents, lessons learnt, adaptation investments, and resilience-related performance indicators (Climate ADAPT, 2025).
- Private operators already have every incentive to mainstream resilience in their operations, as prolonged service disruptions lead to revenue losses and declines in profitability. These infrastructure service operators tend to have better resilience systems than other private businesses, as discussed in the GIR 2025 working paper on Impacts on Businesses: The Hidden Cost of Disasters (Kulkarni et al., 2026). Box 15 presents an example from Brazil.

Box 15. Case study: Private-sector leadership in coastal infrastructure in Brazil

The Port of Açu in Rio de Janeiro, Brazil, showcases how a fully private port complex can institutionalize climate resilience without waiting for a crisis. By embedding scenario-based planning and international technical collaboration into governance, it offers a transferable model of proactive, life-cycle-based resilience, which is rare among large-scale coastal operations.

Located in São João da Barra, the $4.5 billion Port of Açu is operated by Prumo Logística SA and spans 130 km². Though launched in 2014 with robust infrastructure, growing awareness of climate risks led to a voluntary climate-risk assessment in 2020. The assessment was integrated into a *Port Master Plan 2050*, a long-term framework outlining zoning, infrastructure development, and environmental standards for sustainable growth (Porto do Açu Operações SA, 2022). The key climate risks for the port include a projected rise of the sea level by 0.48–0.78 m, increase in extreme rainfall by up to 20 percent, and moderate wind and wave changes that may impact drainage, cargo handling, and activities at dry bulk terminals. Still, the port's location remains relatively favourable for long-term resilience.

Prumo Logística SA led a working group that included its subsidiaries Gas Natural Açu (liquefied natural gas and power), Ferroport (iron ore export), and Vast Infraestrutura (logistics and infrastructure), alongside Deltares and Port of Antwerp International. As operators of key terminals, the subsidiaries' participation was essential for aligning resilience with core operations. This model combined operational and technical expertise, marking a shift towards resilience-oriented governance.

Port structures were evaluated under the Intergovernmental Panel on Climate Change's (IPCC) high-emissions scenario (Representative Concentration Pathway 8.5, or RCP 8.5), which revealed adequate resilience in the caisson breakwaters and quay walls against the projected sea-level rise and wind conditions (Lee *et al.*, 2023). However, the assessment predicted that the drainage system of the Multipurpose Terminal (T-MULT)—dedicated to dry bulk–handling—might be overwhelmed by the expected increase in rainfall. On the other hand, the rise in sea level might reduce sedimentation in some zones, lowering dredging needs. These insights were incorporated into the long-term plan, with periodic reviews to adjust operations as conditions evolve.

5.2 Private Companies Providing Resilience Services

Infrastructure agencies need to embed resilience in planning, design, delivery, and operations and maintenance (O&M) stages to ensure reliable services. They can only do that if the private-sector ecosystem providing services at each of these stages has the capacity and receives the incentives to implement the best practices supported by resilience science. To ensure this capacity is developed, the public infrastructure agencies can:

- **Send signals to the market for upcoming pipelines that will require specific resilience services:** These signals will incentivize private companies to build the resilience capacities to support those services.
- **Introduce outcome-based resilience requirements** (e.g., recovery times after disasters, allowable failure probabilities for disasters of different intensities, resilience-informed life-cycle costs, etc.): This would incentivize the private sector to innovate and propose new ideas for the planning and design stages. This requires infrastructure agencies to also mobilize their data departments and other agencies to publish hazard maps, asset conditions and vulnerabilities, and historic loss and damage data (OECD, 2020).
- **Modify O&M contracts to mainstream resilience:** For example, Argentina's and Brazil's O&M contracts in the roads sector are beginning to incorporate resilience-based performance indicators as part of network maintenance contracts (Raffo et al., 2021). Similar arrangements are being applied to O&M contracts by water utilities, reducing non-revenue water losses in their distribution networks (Kingdom et al., 2006).

5.3 Insurance and Financial Sectors

The GIR 2025 working paper on *Financing: Closing the Gap to Capture the Resilience Dividend* (Chavarot *et al.*, 2026) discussed the tools that insurance and financial industries can provide to enhance the resilience of infrastructure services. Insurance companies can provide risk-analytics tools, risk-transfer products, and resilience-based pricing to encourage stronger standards and adaptation measures. The financial industry can support infrastructure agencies through a wide range of instruments, including resilience-linked credit lines, securities, and catastrophe bonds, as well as project financing with catastrophe clauses.

To take advantage of these opportunities, infrastructure agencies need to:

- design a resilience-financing strategy that layers multiple instruments;
- build high-quality asset registers, collect exposure data, and use probabilistic risk-modelling tools (such as GIRI) to ensure productive engagement with insurance companies (this information, combined with a clear, bankable pipeline, will reduce perceived risks and lower the cost of capital [OECD, 2024b]; in addition, transparent disclosure and reporting procedures, including hazard–reliability dashboards, will be very useful to lenders and investors);
- proactively engage with the insurance industry to reduce premiums through resilience and adaptation investments that reduce risks. Adopting higher resilience standards for infrastructure assets can secure more advantageous underwriting terms (Insurance Development Forum, n.d.);
- explore regional insurance-pool arrangements to diversify risks and lower insurance costs; and
- develop the capacity to certify infrastructure resilience investments that follow the *Criteria for Certification under the Climate Bonds Resilience Taxonomy* (Climate Bonds Initiative, 2025).

5.4 Businesses

The failure of infrastructure services causes substantial losses in the productivity and profitability of businesses, as documented by the GIR 2025 working paper on *Impacts on Businesses: The Hidden Cost of Disasters* (Kulkarni *et al.*, 2026). However, infrastructure agencies and utilities can engage productively with businesses to enhance their resilience, even in the face of disasters that overwhelm the operational capacity of infrastructure assets and services. For example, infrastructure agencies and utilities can:

- convene roundtables that bring together utilities, regulators, line ministries, major business users, and chambers of commerce or industry to discuss risk standards, continuity priorities, and mutual support protocols (Casado Asensio & Kato, 2021);
- create internal functions to liaise with critical business customers and co-develop resilience and continuity plans with, for example, micro, small, and medium enterprise (MSME) clusters and industrial parks;
- mandate utility–industry liaisons to co-develop continuity plans with industrial estates and MSME clusters (HM Government of UK, 2022), as has been done in Indonesia and Viet Nam (Japan International Cooperation Agency, 2015);
- conduct joint exercises to extract 'lessons learnt' after a disaster. For example, the Bangladesh Preparedness Partnership brings together the Ministry of Disaster Management and Relief, infrastructure agencies, the Federation of Bangladesh Chambers of Commerce and Industry, and civil society to develop guidance, drills, and information systems for disaster preparedness (Bill & Melinda Gates Foundation et al., 2025);
- bring businesses into recovery planning as strong partners, so that pre-disaster arrangements can facilitate effective post-disaster data-sharing, agree on priority repair corridors, and develop guidelines for temporary infrastructure services during and after disasters. New Zealand's Lifelines programme offers valuable lessons on this (New Zealand Lifelines Council, 2023); and
- explore the use of disaster risk–financing tools such as contingent lines of credit or parametric insurance, combined with PPP contracts, to fund and operate shared back-ups for industries in an area (e.g., mobile generators, spare transformers, satellite links).

5.5 Communities, NGOs, and Civil Society

The local information, knowledge, and social capital of communities, NGOs, and civil-society organizations make them invaluable partners for infrastructure agencies aiming to maintain resilience. Without their engagement and partnership, infrastructure agencies and utilities cannot achieve effective resilience actions that strengthen the abilities of households and communities to withstand the impact of service failures due to disasters. Specifically, infrastructure agencies and utilities can

- adopt policies and SOPs that ensure community engagement across the entire risk management cycle, from assessment to learning. This will require setting up multi-stakeholder platforms (such as community resilience advisory panels, NGO resilience engagement forums, etc.).
- set aside an adequate budget for engagement and an organizational structure that allows effective communication and co-creation of solutions with communities, especially vulnerable and excluded members. Having community liaison officers well-trained on resilience issues and local facilitation partners who are knowledgeable and trusted by communities is indispensable (Ofwat, 2025). This trust is particularly important for the success of warnings issued before a disaster strikes and announcements of alternative service-provision plans during emergencies (such as advisories on boiling water, alternative bus routes, or expected timelines to resolve power outages).
- blend professional expertise with local community knowledge, including community-generated data, for enhanced risk-identification and co-designing of resilience solutions (Open Cities Africa, 2019).
- include specific solutions for vulnerable users—such as informal settlements—to enhance their resilience during and after disasters, including emergency kiosks, mobile treatment units, and utility-based social-protection measures (Mansur et al., 2017).

Box 16. Case study: Institutional arrangements with civil society to enhance resilience of water sources for utilities in Quito, Ecuador

In 2000, Quito created the Fondo para la Protección del Agua (FONAG, Fund for the Protection of Water), a public-private trust to secure long-term financing for conservation and restoration of the fragile upstream watershed that supplies the city's drinking water (TNC, 2026). The Fund provides resources for ecological restoration, community conservation agreements, and the management of protected water reserves. The Fund receives a 2 percent surcharge on the water tariff and is cofinanced by private-sector organizations, NGOs, and donors. As of 2025, the Fund had an endowment of about $12 million and an annual budget of $2 million. Independent analyses estimate the avoided costs at $2.15 per dollar invested (Green Finance Institute Hive, 2025).

5.6 Academia

The subject of resilience in infrastructure services is relatively new and remains an active area of research. Academia should play an important role in developing resilient infrastructure services, applying new evidence-based approaches and systemwide solutions, as well as testing prototypes (WEF, 2017).

Effective engagement with academia requires purposeful, results-focused action from infrastructure agencies and utilities. They might:

- co-define research questions that are directly related to the resilience challenges faced by the agencies and utilities;
- create joint labs and testbeds, and consider sharing facilities and datasets (based on the asset, hazard, and vulnerability data platform) to accelerate the timeline from research to field applications and implementation at scale (UKCRIC, n.d.; Deltares, n.d.; IRIDeS, 2019);
- use challenge calls, hackathons, and multi-year framework agreements to enable research consortia to produce studies of the clear resilience impacts in the field;
- identify specific areas of training, propose modifications to the curricula, and build talent pipelines to strengthen the intake of professionals with deep technical training on resilience in order to enhance the capacity of infrastructure agencies and utilities; or
- engage with research groups to undertake horizon-scanning exercises that seek out new technologies, as described in the GIR 2025 working paper on *Technologies: Harnessing the Full Potential* (Stone, 2025).

CDRI has launched the Infrastructure Resilience Academic Exchange (IRAX) programme, which connects "leading universities" with strong DRI programmes and "associate universities" seeking to build capacity (CDRI, 2025a). Members benefit from curriculum development, research collaboration, faculty–student exchanges, and access to funding. The initiative aims to create a bridge between academia and industry, fostering innovation and creating skilled resilience professionals (CDRI, 2025b).

Some examples in this field include the University of the Philippines Resilience Institute, which has developed impact-based flood-forecasting resources for use by local governments and utilities to take anticipatory resilience actions (Evangelista, 2024). In Peru, the National University of Engineering has installed monitoring instruments on transport vehicles to develop seismic risk reports for infrastructure agencies (SATREPS, 2022). The Bangladesh University of Engineering and Technology (BUET) has trained staff at the Local Government Engineering Department (LGED) on climate-resilient infrastructure analytics (The Business Standard, 2024).

5.7 Professional Associations

Professional associations, such as engineering institutes, utility associations, and regulator networks, can be helpful partners in building infrastructure resilience. These associations can break silos to connect institutions, bring together professionals with similar interests to curate best practices, facilitate support platforms, and build capacity. In many countries, professional associations operate as an 'honest broker' taking the lead on actions and coordination efforts where an individual government agency may not be as effective. For example, in countries such as the Philippines, professional associations have led the design of codes and standards for resilient infrastructure, as discussed in Section 7.

Infrastructure agencies and utilities, in turn, can greatly benefit from such professional associations by:

- bringing their members into groups that steer infrastructure agencies towards resilience by helping them identify challenges, provide strategic advice, and develop next-generation solutions;
- working on joint standards in developing key resilience tools, such as risk assessments, disaster resilient designs, and business continuity protocols;
- leveraging the associations' training platforms to build the capacities of members and utility staff in risk assessment as well as resilience, emergency, and preparedness planning;

- creating ‘communities of practice’, with moderated forums on resilience, knowledge sharing, and post-event lesson-extraction exercises (IWA, 2026);
- developing mutual-aid networks anchored and administered by associations that help infrastructure agencies and utilities pre-arrange post-disaster support (the American Water Works Association, AWWA, has an interesting model with useful lessons in this area) (AWWA, 2026);
- working with infrastructure engineering professional associations to harmonize resilience-benchmarking exercises across utilities and to publish scorecards compiled by the association as a neutral party (SWEFC, n.d.); and
- leveraging the convening power of associations to bring together suppliers, contractors, and academia for rapid screening and vetting of new resilience technologies.

5.8 Bringing It All Together

The journey to continuously strengthen resilience in infrastructure systems cannot conclude overnight. It will require many years of dedicated effort and progressive inclusion of different government agencies and stakeholders. Further, each country’s resilience journey will follow different trajectories, depending on the individual champions and opportunities available and able to drive policy and institutional change. No two countries can have the same pathway. Nor does this working paper propose a rigid priority order of interventions or institutions to work with. Section 10 includes self-assessment checklists to help infrastructure agencies identify priority actions at the national level and priority actors to engage with, while gradually establishing relationships, mobilizing support, and building partnerships to strengthen the resilience of the services being provided.

Box 17 presents an example of a multi-year institutional transformation process that took a ‘whole society’ approach to building resilience against the impacts of cyclones in India.

Box 17. Case study: The National Cyclone Risk Mitigation Project (NCRMP) in India—a ‘whole society’ success story

The 7,500-km densely populated coastline of India is periodically subjected to cyclones. The 1999 super cyclone that hit Odisha left 1.5 million people homeless and killed close to 10,000 people. After this disaster and the Indian Ocean tsunami of 2004, the Government of India launched the National Cyclone Risk Mitigation Project (NCRMP) in 2010. Fast-forward to 2020, Cyclone Amphan—with a wind speed over 200 km/h—called the NCRMP into taking preventive evacuation action, which required moving more than 0.5 million people to safety; fewer than 100 people were killed in this incident, by contrast. Indeed, over the last 15 years, this programme has transformed the resilience of India’s coastal areas against cyclones.

The NCRMP was deployed in two phases. Phase I, covering Andhra Pradesh and Odisha, was approved in 2011 and completed in 2018, while Phase II—covering Goa, Gujarat, Karnataka, Kerala, Maharashtra, and West Bengal—was approved in 2015 and completed in March 2023 (Ministry of Home Affairs, 2026). The Project facilitated the implementation of critical cyclone resilience interventions such as EWDS, multi-purpose cyclone shelters, evacuation roads and bridges, saline embankments, underground cables, technical support for multi-hazard risk management, capacity building, and project implementation.

This programme’s success emerged from a multi-agency ‘whole society’ effort led by the Ministry of Home Affairs and the NDMA. It provided overall policy direction, a central implementation authority, programme and fiduciary oversight, and interstate coordination (DM Division, India, 2017). The

Department of Economic Affairs coordinated finance mobilization, including with the World Bank. Eight state governments established state-level project implementation units and sectoral implementation units (for rural construction works such as roads and bridges). The State Disaster Management Authority in each state led DRM planning, training, and drills, and also managed shelter operations.

The India Meteorological Department also played a critical role, sending out cyclone forecasts and early warnings. At the local level, an extensive, last-mile, early warning system was set up, including watchtowers, siren arrays, and mass messaging to all coastal communities. The infrastructure agencies interfaced with the NCRMP to secure investments in their respective sectors. The government set up cyclone-shelter management and maintenance committees at the local level—these played a major role during emergencies.

The government also set up project monitoring units at the national and state levels to ensure effective project implementation and enhance coordination. The programme also invested in training, public awareness, and institutional capacity building to complement disaster preparedness and underpin the long-term sustainability of resilience interventions (Ministry of Home Affairs, 2026).

6 Institutional Arrangement for Disaster Resilience and Climate Adaptation

The previous sections of this working paper have examined the external relations and institutional arrangements that infrastructure agencies, owners, and operators need to strengthen the resilience and climate-change adaptation of their assets and services. This section focuses on good practices that infrastructure stakeholders have put in place internally to better prepare themselves to understand the risks they face, prioritize the resilience actions needed, and implement and monitor their execution.

This section is divided into two parts. The first part examines private infrastructure owners and operators, as well as state-owned enterprises providing infrastructure services, such as utilities. The second part looks at government institutions responsible for infrastructure services that provide public services and do not necessarily operate on a commercial basis.

Resilience depends on how infrastructure agencies organize themselves internally. Typical questions that an organization needs to answer to be better prepared to tackle resilience challenges include:

- Who or what unit(s) own the resilience agenda?
- Is resilience managed by operations, asset management, enterprise risk, the sustainability department, engineering, or a dedicated resilience and climate adaptation unit?
- What is the role of senior management and the board in resilience actions?
- How are resilience and climate adaptation actions reported internally and externally to allow decision makers in the organization to make informed choices on resilience and adaptation?
- What are the processes by which resilience priorities are translated into capital planning, maintenance standards, standard operating procedures, emergency procedures, etc.?

Some of the typical organizational challenges that infrastructure institutions face when dealing with disasters and climate risks include fragmented ownership between sustainability, risk, engineering and operations teams; weak authority and financial resources for resilience staff; board oversight that focuses on climate disclosure rather than operational resilience; and unclear organizational arrangements to translate impacts and data from disasters into operational standards and future investment plans.

6.1 Institutional Arrangements in Private Infrastructure Companies, State-Owned Enterprises, and Utilities

This section presents a series of good organizational practices in institutional arrangements adopted by private infrastructure organizations, state-owned enterprises (SOEs), and utilities to make resilience and climate-change adaptation integral to their strategic and daily operations. This section concludes with key lessons learnt from these industry leaders.

Box 18. UK Network Rail embedding resilience into operations and not just governance

UK's Network Rail is a public-sector infrastructure owner and manager responsible for the operations of most of Great Britain's railway network, including about 33,000 km of track and 30,000 bridges, tunnels, and viaducts. The railway network's asset base was valued by the government at about £490 billion in 2025. Network Rail is investing a further £2.8 billion during 2024–2029 to strengthen the railways against floods, storms, extreme heat, landslides, coastal erosion, vegetation risk, and other climate-related disruptions, as part of a broader £45.4 billion infrastructure upgradation plan.

Network Rail's December 2024 published governance model to strengthen the resilience and climate adaptation of its services combines centralized technical expertise with regional delivery responsibilities. Furthermore, it links long-term adaptation, asset management, and day-to-day operational responses to weather impacts. The company's resilience and adaptation actions are presented in the *Network Rail Fourth Adaptation Report* (Network Rail, 2024a). The guiding team for weather and climate adaptation is in the System Operator's Industry Weather Response Directorate. This directorate was established in June 2023, bringing together the National Weather Team, the Weather Risk Taskforce, and the former Climate Change Adaptation Team, which was transferred from the Technical Authority's Environment and Sustainability Team in September 2024 and became the Climate Change Resilience and Adaptation Team within the Directorate. However, responsibility for delivering resilience and adaptation actions lies within the ambit of each of the regions, routes, and national functions. Each region follows a similar approach for developing local plans and delivering resilience on the ground.

These changes were triggered by the organization's review of the 2020 Carmont derailment near Stonehaven, Scotland, caused by debris washed onto the track by a drainage system, following intense rainfall. Three people died and six others were injured. The accident exposed weaknesses in drainage asset management, response to extreme weather, and the translation of weather warnings into route control (such as speed restrictions or line closures).

The December 2024 report describes two parallel internal governance routes: one involving the Health, Safety and Sustainability National Strategy Committee, and another involving the Train Service Delivery National Strategy Committee. Progress against the adaptation report commitments was set to be monitored through the System Operator Industry Weather Response Directorate and the Railway Fit for the Future Steering Group, with updates provided to the Executive Leadership Team and the board-level sustainability committee (Network Rail, 2024a). Furthermore, the UK's Office of Rail and Road (ORR), which is Britain's independent economic and health and safety regulator for its railways, has oversight responsibilities for resilience and adaptation, as described in its *Climate Change Adaptation at the Office of Rail and Road* report (ORR, 2024).

Network Rail's actions and operations towards resilience go beyond corporate governance, because resilience is embedded into regional plans, asset-management processes, and operational weather-management, training, and investment programmes.

The regional *Weather Resilience and Climate Change Adaptation* (WRCCA) plans are the main mechanism for translating Network Rail's central policy into local action (Network Rail, 2024a). These plans are integral to asset management and operations across each region. They emphasize that adaptation should be embedded into asset management and operations, not treated as a separate environmental exercise (Network Rail, 2024b). The chief engineer is responsible for bridging climate risk and engineering practices by mainstreaming resilience into asset policies, standards, specifications, route asset management, and capital-delivery projects. The engineering function owns the asset standards and specifications formulated or selected to produce resilience.

Finally, it is important to emphasize that Network Rail's approach to resilience and adaptation integrates three time horizons into its operations. Operational weather response addresses short-term conditions; asset management and engineering address medium- and long-term asset performance; and climate adaptation addresses future climate risk and investment planning (Network Rail, 2024a).

Box 19. Manila Water treats resilience as a core enterprise risk issue

The Manila Water Company, Inc. is the concessionaire providing water and wastewater services to Metro Manila's East Zone, while also operating other Philippine and international water businesses. In 2024, Manila Water reported serving about 9.3 million people and delivering close to 1.3 million m^3 of potable water across its operations. These figures make Manila Water a significant infrastructure operator in a climate-exposed urban context, where resilience requires managing a range of hazards, including droughts, floods, raw water–quality shocks, earthquakes, and long-term security of water sources (Manila Water Company, Inc., 2024).

Manila Water's approach is to embed resilience into its enterprise risk management (ERM) programme, which is based on ISO 31000:2018. The company's Board Risk Oversight Committee (BROC) oversees management functions relating to all types of significant risks, including water security concerns, disasters, and environmental threats (Manila Water, 2024). In addition, the Board's Environmental, Social, and Governance (ESG) Committee oversees climate-related risks and opportunities and discloses its actions in its *Sustainability Content Report* (Manila Water, 2024).

Manila Water treats climate and disaster resilience not only as an environmental or sustainability mandate, but as a way to manage a core enterprise risk. The company does not rely on a single standalone resilience office. Instead, resilience expertise is distributed across ERM, sustainability and climate governance, operations, water-resource planning, business continuity, watershed management, and asset resilience functions.

Climate and disaster resilience are connected to operations and business continuity. The company's business continuity framework includes risk management, incident management, and business continuity management, with drills, awareness campaigns, and investment in human resources and training in partnership with local governments and the National Disaster Risk Reduction and Management Council (NDRRMC) to achieve its goals (IWA, 2022).

As an example of its strategies, the company identified climate-change risks associated with El Niño as one of its top risks for 2024. To ensure an adequate water supply despite El Niño, Manila Water completed water source–development projects, repaired and/or replaced critical infrastructure, implemented stricter monitoring of dam inflows to ensure proper water allocation at the portal, and optimized various water resources and projects.

Manila Water also undertook facility vulnerability and resilience assessments, which have informed retrofitting of existing assets and construction of new climate-resilient assets. Furthermore, the company rehabilitated 2,459 ha, planting more than 1.25 million native trees (as of 2021), as part of its climate-adaptation strategy (Manila Water, 2024; BUA Knowledge Platform, 2022).

Box 20. Climate resilience deeply embedded in Airtel Africa's risk management system

Airtel Africa plc is one of sub-Saharan Africa's largest telecommunications groups, operating in 14 countries, with 183.5 million total customers in 2026, up 10.5 percent year-on-year, including 84.2 million data customers and 54.1 million Airtel Money customers. For the half-year ended 30 September 2025, Airtel Africa generated $2.98 billion in revenue. The company continued to expand infrastructure, reaching over 38,300 sites, with 98.5 percent of the sites being 4G-enabled, added more than 81,000 km of fibre-optic cable, and achieved around 81.5 percent of population coverage within its footprint in this region (Airtel Africa, 2026).

Airtel does not see the challenge of achieving climate resilience as a single-asset problem, because disasters affect the performance of data centres, network operating centres, switching centres, tower sites, leased infrastructure, energy systems, fibre-optic links, supply chains, tower companies that partner with it, and operating-company teams across very different climate and infrastructural contexts. The company has begun treating climate resilience as a groupwide risk, and thus eschews reliance on country-by-country operational contingency planning. Its 2025 Task Force on Climate-Related Financial Disclosures (TCFD) report states that in 2023–2024, it analysed three climate scenarios to assess business resilience (Airtel Africa, 2025b).

Climate resilience is deeply embedded in the group's risk-management system. The Group Executive Risk Committee (ERC) evaluates and prioritizes the principal risks that could undermine its strategy, business model, and solvency. In addition, Airtel uses a federated risk model across its headquarters and operating companies (Airtel Africa, 2026). This approach allows the company to handle diverse hazards, from tropical storms and cyclones in Madagascar and Malawi, to increasing risk of extreme temperature increases (which impact cooling costs) in Chad, Niger, and parts of Northern Nigeria (Airtel Africa, 2025a).

For Airtel, climate resilience is relevant to its technologies, supply chain, and operational functions, as many resilience actions for the company, such as cooling efficiency, data-centre resilience, renewable backup power, and supply-chain continuity, are closely linked to operations. Furthermore, business continuity is explicitly linked to physical climate-risk mitigation. Airtel states that it mitigates physical climate risks through business continuity–management processes and climate initiatives. Finally, the company engages tower companies and suppliers as resilience partners. Supplier engagement, ESG assessments, roundtables, and contract terms all require adaptation actions when infrastructure is leased or outsourced (Airtel Africa, 2025b).

Box 21. Hong Kong International Airport (HKIA) engages with airport partners to ensure resilience

The Airport Authority Hong Kong (AAHK) is wholly owned by the government of the Hong Kong Special Administrative Region (SAR), with a commercial operating mandate, but also a public-interest responsibility to protect a critical national and regional infrastructure asset. In FY 2024–2025, it handled 54.9 million passengers, 5.0 million tonnes of cargo, and 373,000 aircraft movements. The newly commissioned three-runway system increases its long-term capacity to 120 million passengers and 10 million tonnes of cargo annually (HKIA, n.d.a).

The airport's coastal, low-lying, island location and its exposure to tropical cyclones (specifically, typhoons), extreme rainfall, lightning, and other severe weather events make resilience a key operational challenge. AAHK completed a climate resilience study in 2020–2021 (Chan, 2021) and subsequently began implementing a series of climate adaptation and resilience activities. In 2024, AAHK added a

Climate Event Feedback Mechanism (CEFM) to capture detailed information on operational impact and damage from climate-related events, creating a feedback loop between the actual disruption experienced and adaptation planning for the future (HKIA, n.d.b).

AAHK's resilience arrangements are anchored in a multilayered governance model that links its board, board committees, executive management, sustainability functions, risk management, and operating departments. At the board level, the Audit Committee and Finance Committee (ACFC) oversees its sustainability strategy and also reviews risk management and internal controls. The ACFC is supported by the Sustainability Executive Taskforce (SET), chaired by AAHK's CEO and including all its executive directors.

An important feature of AAHK's resilience approach is engagement with airport partners, going beyond just an internal function. Many critical activities related to the airport—from airline scheduling to ground handling, fuel supply, and passenger services, among others—are carried out by partners, not directly by AAHK. Therefore, its resilience governance includes airport community groups, environmental forums, and technology working groups. As part of this approach, AAHK conducts airport-wide drills. A recent drill in April 2026 simulated a tropical cyclone escalating to Hurricane Signal Number 10 and involved 700 participants from about 30 organizations, with actions all the way to taxi queue management and land transport coordination for recovery (HKIA, n.d.b).

Box 22. Ayala Land: Housing in the Philippines

Ayala Land, Inc. is the Philippines' largest integrated real-estate developer, with a portfolio spanning master-planned estates, residential projects, malls, offices, industrial estates, hotels and resorts, construction, and property management. In its 2024 corporate report, the company reported more than 10,000 ha of land bank and a footprint across 53 estates. In addition to being a real-estate developer, Ayala Land is also a long-term owner and operator of urban infrastructure and commercial assets (Ayala Land, 2025).

Ayala Land mainstreams resilience in its ERM activities, board oversight, long-term estate planning, investment decisions, and operating-unit implementation. Its urban real-estate portfolio is exposed to typhoons, floods, heat, water stress, erosion, and other geohazards. The company thus must consider the long-term risks of climate change and short-term impacts of extreme weather conditions and geohazards (Ayala Land, 2026).

A distinctive institutional feature is that resilience is not restricted to project-level environmental and resilience compliance. It is embedded in all operations through its Risk Committee, chief risk officer, ERM unit, Risk Council, business-unit risk champions, sustainability and environmental stewardship functions, estate planning, and execution at the business unit level.

It is interesting to note that resilience is increasingly linked to sustainable finance and project-development processes. In 2025, the International Finance Corporation (IFC) provided Ayala Land a second sustainability-linked loan, as it became the first developer in East Asia to embed the Corporation's Building Resilience Index (IFC, 2025).

Box 23. Actis: An infrastructure asset management company

Actis is a sustainable infrastructure investor with more than 20 years of experience building and operating core infrastructure, having raised approximately $26 billion[2] since its inception while managing 74 portfolio companies. Actis invests globally in energy infrastructure, long-life infrastructure, digital infrastructure, real estate, and private equity (Actis, n.d.).

Actis operationalizes resilience by placing a sustainability team member on every deal team. Each such team member works with investment professionals to evaluate climate risks and opportunities, attends Investment Committee discussions, and advises on material resilience considerations.

Actis explicitly distinguishes between resilience actions for greenfield and for brownfield projects. For greenfield projects, it considers exposure to natural hazards in the asset design. For brownfield assets, it considers adaptation needs and engages portfolio companies to analyse exposure to climate hazards and implement resilience measures against material risks (Actis, 2026a).

The firm commissioned a climate-scenario analysis across its infrastructure portfolio in 2024, covering 225 unique asset locations. Acute and chronic hazard indicators were computed at asset level within a 25 km radius, using a baseline year of 2000, a medium-term horizon of 2030, and a long-term horizon of 2050 (Actis, 2026b).

The institutional model that Actis deploys for disaster resilience and climate adaptation is based on a clear line of accountability from sustainability specialists to deal teams, portfolio companies, fund leadership, risk governance, and investment committees. This is a useful structure for PPP investors, because resilience decisions often require trade-offs among capital expenditure, insurance, service continuity, contract performance, and long-term asset value (Actis, 2025).

The cases presented in this section provide several key lessons:

- **Resilience needs clear ownership**, but must be mainstreamed throughout the organization. Resilience expertise should sit in risk, sustainability, operations, asset management, engineering, business continuity, strategy, and regional and local units. However, these roles need to be explicit and well-connected to board and management committees through risk registers and reporting lines.
- **The board and CEO must have visibility into all steps towards resilience** for it to remain central to the company's operations. Resilience and climate adaptation often require trade-offs—higher capital cost now to avoid service disruption later, changes in design standards, asset relocation, redundancy, etc. These decisions require attention from the board and executives; they cannot be left only to the operational teams on the ground. Several companies place ultimate accountability for resilience at the board or board committee level, often through a risk and/or sustainability committee.
- **Regarding ERM as the 'spine' of resilience governance is a common arrangement.** Resilience is then treated as a business risk affecting service continuity, revenue, cost, capital planning, regulation, insurance, and reputation. Many companies use ERM to identify, prioritize, monitor, and escalate climate and disaster risks.
- **Measures against disaster risks and climate shocks should not stop at risk registers.** Resilience must be embedded in asset management, engineering, and capital delivery. Hazards and risks

[2] All amounts denoted by the "$" symbol are in US dollars.

must translate into design standards, operating rules, retrofit programmes, investment prioritization, and asset-renewal decisions.

- **Resilience must be operationalized at the regional, local, or site levels** to have the best impact. When infrastructure operators have multi-site portfolios, central teams can provide methods, standards, tools, and oversight, but local teams should own the site-specific risk identification and execution processes.
- **Many companies integrate resilience within their sustainability structures, but they must ensure this is not a limitation.** Sustainability teams often take the lead on climate risk analysis, reporting, disclosures, and stakeholder and investor engagement. However, resilience needs to be linked to operations and investments, going beyond the confines of corporate sustainability reporting.
- **Business continuity is where disaster risks become real and operational.** Hazards become material when they disrupt services. Business continuity management translates disaster risk analysis into backup procedures, emergency operations, drills, supply arrangements, restoration priorities, and service-continuity metrics. At the same time, resilience should combine long-term adaptation and short-term emergency readiness. Furthermore, good companies treat incidents and disasters as organizational learning opportunities.
- **Supplier and partner governance is part of internal resilience.** Many infrastructure operators depend on assets or services they do not control: airport suppliers, tower companies, port tenants, road or railway connections, energy providers, water suppliers, municipalities, contractors, and emergency services. Internal organizational arrangements for resilience must extend to contract management, supplier engagement, tenant requirements, and partnership governance.

6.2 Institutional Arrangements in Infrastructure Government Agencies

This section presents a series of organizational best practices that government agencies responsible for infrastructure assets and services might adopt for disaster resilience and climate adaptation. This section concludes with key lessons learnt from these practices.

Sections 4 and 5 showed the importance of interagency relationships and structured engagements for enhancing the resilience of infrastructure assets and services. However, the most important decisions are made inside line ministries and infrastructure agencies. Unfortunately, resilience expertise inside these institutions is frequently fragmented, with unclear mandates and reporting lines.

Yet engineering departments understand assets; planning units define project pipelines; maintenance departments know the weakest assets; emergency teams handle the organizational response to disasters; and finance or programming units decide what gets funded. The institutional challenge is for these agencies to ensure resilience and climate adaptation remain part of their asset management, project appraisal, design standards, maintenance planning, emergency operations, and budget prioritization.

Boxes 24 to 28 present case studies of line ministries and infrastructure agencies that have embarked on a journey to institute or improve internal processes and standards for enhanced resilience through adaptation of their assets and services.

Box 24. Case study: Netherlands' Ministry of Infrastructure and Water Management's integrated mandate

Rijkswaterstaat is the executive agency of the Dutch Ministry of Infrastructure and Water Management and is responsible for managing, maintaining, and developing the Netherlands' main road network, main waterway network, and main water system. The same organization deals with flood protection, water management, navigation, roads, bridges, coastal protection, traffic management, drought-related water operations, and climate adaptation. This is particularly useful as water and mobility resilience cannot be treated separately from climate adaptation in low-lying countries and deltas. Roads, waterways, flood defences, storm-surge barriers, freshwater supplies, drought management, and coastal systems are interdependent. Rijkswaterstaat's integrated mandate helps connect those systems (Government of the Netherlands, n.d.a).

Rijkswaterstaat's institutional model for resilience and adaptation can be characterized as distributed ownership within an integrated asset-owner agency. Rijkswaterstaat describes itself as working with others to ensure that the country is protected against flooding, has sufficient green space and clean water, and enables citizens to travel safely and quickly (Rijkswaterstaat, n.d.b).

Within the broader Ministry, the Directorate-General for Water and Soil Affairs is responsible for policy development on water and water projects, flood risk management, climate adaptation, and soil issues. Rijkswaterstaat ensures that those policies are implemented (Government of the Netherlands, n.d.b).

Rijkswaterstaat's work is connected to national policy reporting through the Delta Programme, which is the Netherlands' long-term central programme for flood risk management, freshwater availability, and spatial adaptation (Government of the Netherlands, n.d.a).

An area of special attention for resilience enhancement is asset management, such that climate and resilience priorities are translated into maintenance, renewal, replacement, and network performance decisions. Rijkswaterstaat explicitly frames climate resilience as part of the challenge of managing roadways, waterways, and water systems under constrained finance and labour conditions (Rijkswaterstaat, n.d.a).

Box 25. Case study: Bangladesh's Local Government Engineering Department embeds resilience across infrastructure levels

Bangladesh's LGED is one of the country's largest public-sector infrastructure agencies, responsible for rural roads and bridges, urban infrastructure, cyclone shelters, small-scale water-resource infrastructure, and other local public works, including more than 411,000 km of roads across 64 districts nationwide (LGED, 2026).

Over the last few years, the LGED has worked to elevate climate resilience from project-level pilot studies into permanent internal organizational attributes, through measures such as the establishment of the Climate Resilient Local Infrastructure Centre (CReLIC); the creation of three permanent standing committees on asset management, resilient infrastructure, and capacity building; and the proposed incorporation of a new asset management wing into the LGED (CDRI, 2026).

CReLIC's objective is to systematically integrate climate-change adaptation into decision-making on infrastructure planning, supervision, and maintenance at the LGED through a centre of excellence that

creates and bundles expertise on climate-resilient local infrastructure. The centre includes a knowledge and information hub and an innovation laboratory.

The LGED has developed a range of standards and documents for resilience (Green Roads for Water, 2025), including the *Climate Resilient Rural Road Manual* (Alam & Hoque, 2019), *Road Design Standards of LGED 2021* (Physical Infrastructure Division, 2021) *Guideline for Implementation of Rural Roads and Culverts Maintenance Program* (Rural Infrastructure Maintenance Management Unit, 2010), LGED guidelines on roadside tree plantations (LGED, 2003), and LGED Asset Management Plan (Road) (LGED, 2021)

Furthermore, with support from the World Bank, the LGED is working towards the enhanced operationalization of a systematic damage, loss, and needs–assessment methodology that will allow the agency to move from ad hoc reconstruction to evidence-based repairs and transparent decision-making—to build back better (World Bank, 2022).

Box 26. Case study: California Department of Transportation, USA, uses tools to make climate risks visible to decision makers

The California Department of Transportation, or Caltrans, manages the state highway system in one of the world's most hazard-diverse jurisdictions. California transportation assets are exposed to wildfires, extreme heat, rising sea levels, storm surges, coastal erosion, flooding, intense precipitation, landslides, drought-related ground movement, and post-fire debris flows (Caltrans & WSP, 2021).

At the highest institutional level, the *Caltrans 2024–2028 Strategic Plan* makes climate action one of the agency's strategic goals, with particular emphasis on a more resilient transportation system (Caltrans, 2024a). Caltrans' resilience agenda is implemented through a distributed model that includes: i) statewide climate-adaptation planning as part of transportation planning (particularly the climate-adaptation work associated with the Office of Smart Mobility and Climate Change); ii) assessment of local vulnerabilities and setting of priorities for each of the 12 districts in the state; iii) environmental analysis for projects (led by the Division of Environmental Analysis); iv) asset management and project delivery.

Caltrans uses several reporting and decision-making support tools that make climate risks visible to managers, districts, programme staff, and external stakeholders, including:

• district-level climate-vulnerability assessments that identify segments and assets exposed to climate impacts and provide a technical basis for local and statewide understanding of exposure (Caltrans, 2020);

• a statewide vulnerability-assessment summary that synthesizes the district-level findings and helps Caltrans understand how climate change may affect the highway system and identify assets for further analysis;

• adaptation priority reports that use the vulnerability-assessment findings to identify the highest-priority assets that would be first in line for asset-level climate-impact studies and adaptation projects (Caltrans, 2021); and

• a State Climate Resilience Improvement Plan for Transportation (Caltrans, 2024b) that brings together the reports described above and provides a project priority list to support a range of climate-adaptation

needs for transportation—from planning studies to capital projects—to make the multimodal transportation system safer, more reliable, and more resilient to future climate risks.

Together, these tools create a reporting chain that encompasses aspects as diverse as technical risk identification, district-level prioritization, statewide policy alignment, and decision-making on capital programmes and grant programmes.

Box 27. Case study: Freetown, Sierra Leone, and its heat action plans

Freetown is Sierra Leone's capital, its largest city, and its main Atlantic port. It generates about 30 percent of Sierra Leone's GDP and houses about 15 percent of the national population (around 1.35 million residents). The city's current development agenda is based on the Transform Freetown programme (Freetown City Council, 2025b) and the *Freetown Development Agenda: Transform Freetown—Transforming Lives* (Freetown City Council, 2024). *Freetown's First Climate Action Strategy 2022–2030* (Freetown City Council, 2023) notes that the city has experienced deadly landslides, flooding, and coastal erosion, and its 2025 Heat Action Plan links heat risk to rapid urbanization, change in land use, and vulnerability in informal settlements and outdoor markets (Freetown City Council, 2019).

Resilience in Freetown is a mayor-led, programmatic model with several visible ownership points. The first owner is the mayor, together with the City Council leadership, through the city's development agenda. One of the four clusters of the 2024–2028 *Freetown Development Agenda* is climate action (Freetown City Council, 2024).

The second owner is the chief heat officer, a visible, specialized role focused on extreme heat, vulnerable residents, and cooling interventions (Baughman McLeod, 2021). The chief heat officer is responsible for raising awareness about extreme heat risk, coordinating across stakeholders for better planning and heatwave response, and supporting cooling projects and long-term reduction of heat risks (Freetown City Council, 2025b).

The third owner is the Freetown TreeTown programme, which focuses on ecological infrastructure and urban greening, with plans to plant, grow, and digitally track 5 million trees and restore 5,000 ha of land by 2030, contributing to carbon sequestration while reducing flooding, extreme heat, and landslide risks (Freetown City Council, 2025b).

Box 28. Case study: Japan embeds resilience into its Ministry of Land, Infrastructure, Transport, and Tourism

Japan's Ministry of Land, Infrastructure, Transport, and Tourism (MLIT) has embedded resilience expertise within its core focus on infrastructure, rather than creating a separate resilience or climate office. The MLIT's resilience model is distributed across technical bureaus and research arms, while also linking up with ministry-wide planning for climate adaptation and environmental action (Cabinet Secretariat, Government of Japan, n.d.). The Water and Disaster Management Bureau, the Road Bureau, and the Ports and Harbours Bureau have specific resilience expertise. In addition, the organization chart of the National Institute for Land and Infrastructure Management (NILIM) shows specialized departments and research coordinators for water-supply disaster management, integrated water disaster management, sediment disaster prevention, road disaster prevention, road structures recovery,

earthquake disaster management, urban disaster mitigation, and coastal and marine disaster prevention (NILIM, n.d.).

Japan's *Climate Change Adaptation Plan* includes KPIs for sectoral and basic measures, as well as progress management for the plan as a whole (Ministry of the Environment, Japan, n.d.). MLIT developed its own *Climate Change Adaptation Plan*, with the plan, summary, and reference materials available as public documents (Cabinet Secretariat, n.d.).

For water-related disasters, MLIT uses expert council reports to translate disaster experience and climate science into policy and technical changes. The 2020 National Land Development Council report on *Water-Related Disaster Risk Reduction Considering Climate Change—Transition to River Basin Disaster Resilience and Sustainability by All* lays out a transition plan leading to river-basin resilience, climate change–informed flood-control planning, and mainstreaming disaster risk prevention across administrative processes and economic activities (National Land Development Council, Japan, 2020). Together, these mechanisms create a reporting chain that runs from sectoral plans and standards to ministry-level adaptation plans, to national KPI follow-up and public reporting.

The case studies presented in this section provide several key lessons:

- Transformational resilience needs a combination of centres of expertise with specific mainstreaming in planning, design, asset management, maintenance, and investment-programming units. Resilience cannot be seen only as a function of environmental compliance.
- Leadership from ministerial offices and heads of agencies is critical for operationalizing resilience. If it is a responsibility that remains only with technical staff, institutional transformation towards climate adaptation will be limited. In addition, ministerial leadership must venture beyond vision statements; leadership on resilience must become embedded in operational procedures and reporting protocols, with leaders maintaining a clear line of sight into ground operations.
- Climate adaptation cannot be isolated from continuity of service. The most persuasive argument within infrastructure agencies is not that for climate compliance, but that for avoiding road closures, restoring power faster, minimizing bridge failures, ensuring greater safety for communities, lower repair costs, and continuity of essential services.
- Design standards and manuals are powerful tools to mainstream resilience into the organization's regular operations. At the same time, climate and disaster risks should inform asset inventories, condition assessments, risk registers, and capital renewal.
- Furthermore, investment appraisal rules that consider losses avoided, service continuity, and life-cycle benefits will help raise resilience within an agency.
- Institutional transformation for resilience requires permanent structures, and not just 'project units'. While project units may be useful as transitional mechanisms, having a clear sunset deadline for these and a plan for their absorption into a permanent home within the organization is critical. The institutional transformation journey towards resilience can (at least in developing countries) start with a small team in the planning or design department, with clear rules for hazard screening applied at appraisal, expecting enhanced resilience from design standards, and a small budget for resilience-focused maintenance and priority retrofits.

7 Building Codes, Standards, and Regulations for Delivering Resilience

Safe and secure buildings keep governments and businesses operating, providing stability to societies and economies. Building codes, standards, and regulations are essential components for developing and maintaining their resilience. They shape how buildings are designed, constructed, and maintained to withstand hazards, adapt to climate risks, and provide safe living conditions.

This section explores the institutional structures that lay the foundation for codes and standards; the methods and considerations in developing codes; the key stakeholders involved in the process; enforcement tactics; and approaches to retrofitting and to managing informal buildings. While resilience codes span multiple sectors, this section focuses on buildings, given their complexity and urgency. As the GIR 2023 report (CDRI, 2023a, 2023b) showed, the average annual losses to buildings from disasters far exceed the losses to other infrastructure assets.

7.1 Legal and Administrative Structures

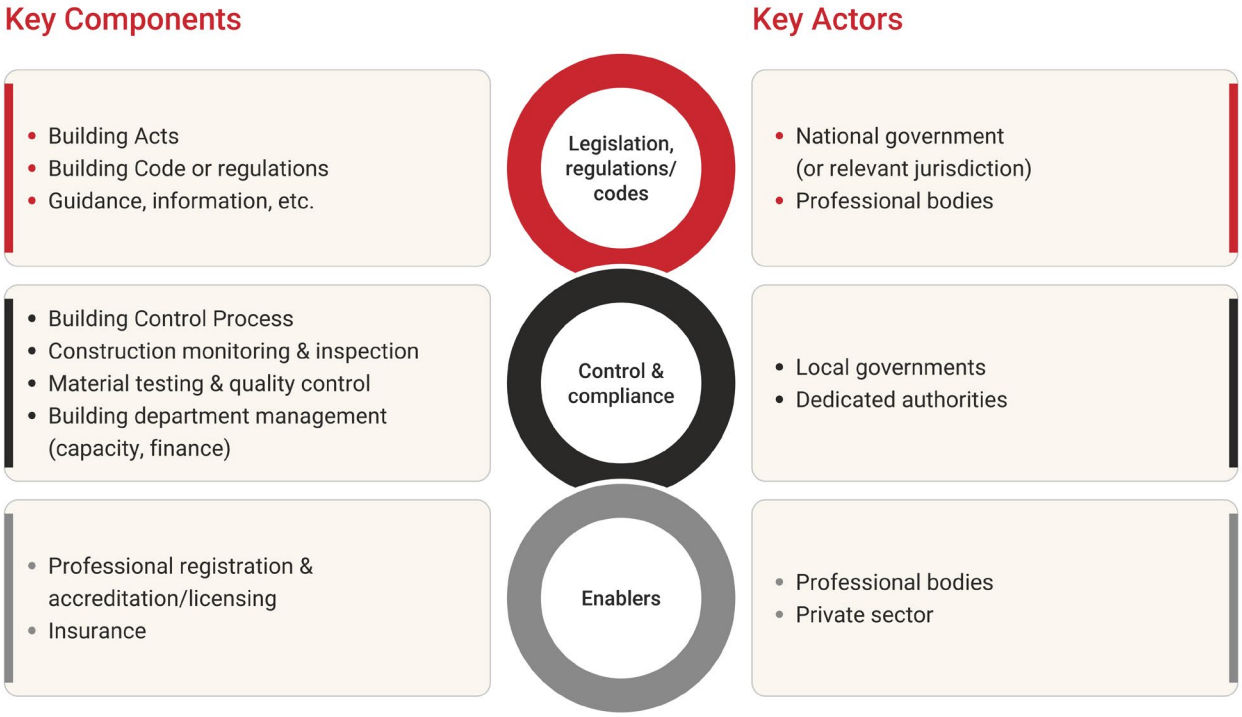
Resilience begins with a governance framework. A building regulatory framework typically includes three pillars: i) a legal and administrative foundation, ii) the codes themselves, and iii) local enforcement mechanisms (World Bank, 2020b). While they are all parts of the ecosystem, codes, standards, and guidelines each play a distinct role in resilience: Codes are legally enforceable, standards provide technical references, and guidelines are advisory rather than binding. The combination of these three creates a regulatory framework that establishes provisions for building design and functional requirements, which may include compliance mechanisms, education and training requirements, product testing and certification, professional qualifications, and licensing schemes (World Bank & GFDRR, 2023).

For example, in Colombia, the regulations and guidance tend to be in separate legal documents that sometimes cross-reference each other. They are anchored and given legal enforcement by Law 400/1997 (Función Pública, 1997). An interesting feature is the creation of a statutory Permanent Advisory Commission for the Earthquake-resistant Construction Regime (Asociación Colombiana de Ingeniería Sísmica, 2022), which periodically updates guidance documents, provides clarifications on compliance, and provides structured governance of the code that cuts across political cycles.

Frequently, there are coordinated groups of documents or entirely separate legal documents. This disaggregated approach can complicate knowledge management and consistency; however, it can also be a powerful tool in addressing varied climate risks when hazards differ substantially within the governed area. If one area of a country is prone to drought and extreme heat hazards, while another experiences frequent hurricanes and flooding, having one centralized building code may not effectively address the unique regional needs.

Furthermore, at the subnational level, the capacity to apply these codes may be limited, so specific guidance documents per the disaggregated approach can be useful. For example, in Nepal, the National Building Code (NBC) includes easy-to-apply guidelines for low-rise buildings. The guidelines target masons in small municipalities to improve their best practices (Department of Urban Development and Building Construction, Nepal, 2024). The World Bank's *A Global Assessment of Building Codes* provides an overview of key components and the corresponding actors in the regulatory framework (Figure 5) (World Bank & GFDRR, 2025).

Figure 5: Key components and actors in the building regulatory framework



Source: GFDRR (2026)

7.2 Development and Maintenance of Codes and Standards

Code development is highly context specific. Countries may draft original codes, adapt model codes (e.g., the International Building Code, IBC), or adopt regional frameworks (such as the Eurocodes). The approach to code development depends on the structure of the current regulatory framework, the scope of the amendments needed, the maturity of the existing code, and the time and resources available (World Bank & GFDRR, 2025).

Choosing between developing a new code, adopting an extant model, or iterating on existing codes depends on the country context and the maturity of its existing codes. Countries with mature building codes—a strong foundation that may have gaps in resilience measures—may opt to update and enhance the existing provisions. Countries with a large stock of informal buildings and strong investments in new buildings due to rapidly growing economies and cities will need more flexible approaches adapted to their country context. Bridging international standards with country context helps provide assurance to investors in building construction in these growing economies.

For example, Sri Lanka has building codes dating back to colonial times, which have been progressively updated. However, doing so introduced confusion to the mandates of authority. Sri Lanka had been updating its existing codes as a stopgap until a centralized code was developed. To develop this central code, Sri Lanka's government tasked the National Building Research Organization to prepare a proposal for a comprehensive, resilient national building code (Office of the Cabinet of Ministers, Sri Lanka, 2025).

The *National Structural Code of the Philippines* is periodically updated by the Association of Structural Engineers of the Philippines (ASEP, 2024). The Association has released several editions of the code (the last two updates were completed in 2010 and 2015) (ASEP, 2016).

Public- and private-sector representatives also play a critical supporting role in the design of codes and regulations, as they can provide industry standards, set expectations, and provide a hands-on perspective of what it might take to design and implement buildings in compliance with these codes. The specifics of key stakeholders and their roles can be found in Section 7.3.

7.2.1 Motivating Factors for Code Updates

Disasters have historically been the most powerful catalysts for the reform of building regulations. Earthquakes in Chile, hurricanes across the Caribbean, and recurrent floods in South Asia have each led governments to adopt stricter codes and standards in the wake of catastrophic losses. Beyond disasters, international agreements, climate imperatives, and insurance pressures also shape building code evolution.

Insurance and reinsurance markets increasingly require that buildings comply with codes and standards before approving coverage. The World Bank recommends having legislation that establishes a cycle for code updates, triggered not only by lessons learnt from disasters but also by shifts in hazard intensities, innovations in construction, and global imperatives to reduce greenhouse gas emissions.

Yet, as codes are repeatedly amended, disaggregated or overlapping regulations may emerge, introducing confusion and inconsistency across jurisdictions. This tendency suggests that while updating codes is essential, ensuring clarity, coherence, and coordination across the institutions responsible for their implementation is equally important.

7.2.2 Use and Localization of International Codes and Standards

Adapting international building codes to local contexts is both necessary and complex. Many countries begin with model frameworks such as the International Codes (I-Codes), a set of 15 building and safety codes coordinated by the International Code Council (ICC, n.d.a). Box 29 highlights the activities of the ICC.

Box 29. What the ICC does

The ICC is a non-profit association based in the USA that develops model codes and standards for resilient buildings, following a stakeholder-based process for code update, typically carried out every three years. Its model codes can serve as templates that countries can adapt. The ICC provides technical assistance to its members (more than 50 countries) in code development and enforcement as well (ICC, n.d.a).

The ICC's innovations leverage digital tools for online code access, e-permitting, remote inspections, and other actions to improve transparency and manage enforcement efficiently (ICC, n.d.b). The ICC is also working towards climate-related, resilience-based approaches that incorporate forward-looking elements in code design (Global Resiliency Dialogue, 2021).

One of the prominent I-Codes is the IBC, based on USA building codes.

While the IBC is often used as a starting point, tailoring I-Codes to address distinct hazard profiles and governance realities is essential. In the Caribbean, for example, hurricane-resistant codes from the USA have been modified to reflect regional wind loads and construction practices, ensuring that imported standards are relevant to local risks. Nepal has drawn on Indian codes to compensate for limited domestic technical capacity, while Sri Lanka has incorporated Eurocodes through National Annexes to align with its seismic and climatic conditions (World Bank, 2020b).

The International Organization for Standardization (ISO, n.d.) is engaged in several activities related to resilient infrastructure. Some examples include *ISO 14090:2019: Adaptation to Climate Change—Principles, Requirements and Guidelines* (ISO, 2019), which is relevant to infrastructure owners, operators, and regulators as it provides a framework that can be applied organization-wide to integrate climate risk into decision-making. *ISO 2394:2015: General Principles on Reliability for Structures* (ISO, 2015) focuses on

risk- and reliability-based approaches used across structural and infrastructure codes. *ISO 55000:2024: Asset Management—Asset Management System—Requirements* (ISO, 2024) is used by utilities and infrastructure agencies to embed life-cycle risk management for enhanced resilience.

The ISO is currently also working on several additional standards, including for community resilience, sustainable cities and communities, and continuous mainstreaming of climate considerations across all new and revised standards.

7.3 The Role of Stakeholders

Resilient regulation depends on the engagement of a wide spectrum of stakeholders, each with distinct responsibilities and incentives. Construction companies are responsible for compliance, but frequently resist the higher costs associated with resilience measures. Inspectors and regulators act as the primary gatekeepers of enforcement, though their role is often undermined by capacity gaps or integrity risks.

On the other side, financial institutions increasingly tie mortgage lending to code compliance, while insurers offer incentives by way of premium reductions for resilient design. End-users and civil society also exert their influence, demanding safe housing and equitable access.

The effectiveness of this ecosystem materializes when each actor treats quality control as non-negotiable: banks withholding loans without insurance, insurers requiring certified compliance, appraisers validating certificates, and homebuyers rewarding trustworthy construction with demand. Without buy-in from stakeholders throughout the building life cycle, codes, standards, and regulations lose meaning. However, once these checks align, it creates a virtuous cycle of accountability and trust that propels resilience.

The type of building further determines the stakeholders involved. Critical infrastructure, such as hospitals, requires not only compliance with national building codes, but also input from industry-specific councils, professional health associations, and specialized regulators. With these specialists engaged, resilience features can be integrated into the design, maintenance, and operation of buildings.

For example, in California, there is a Department of Health Care Access and Information (HCAI) that oversees the design and construction of hospital buildings. This department requires hospitals to meet higher building performance regulations for resilience against seismic activity, fire, and indoor environments (e.g., air pollution) (World Bank, 2025b). Special pre-approval design checks and increased monitoring and inspection are also required. This stricter set of requirements keeps the hospitals operating under hazardous conditions, thanks to expert input by health professionals and public pressure to ensure the resilience of these buildings is prioritized.

7.4 Enforcement Systems

Implementation through a strong enforcement system is integral to the legitimacy and effectiveness of codes. Regulatory implementation includes an approvals/permits stage (planning and building permits), an enforcement/construction stage (inspection and occupancy certification), and a post-construction stage (inspection/testing and demolition/renovation permit) (World Bank & GFDRR, 2025). For each of these stages, governments must have the capacity, maintain the integrity, and address disparities to successfully implement the codes and achieve resilience.

While codes and regulations are often set by the federal government, it is local governments and municipalities that are charged with the implementation. Therefore, capacity at the local level must be considered. While local authorities may be knowledgeable about the risks and conditions of the buildings

within their jurisdiction, they frequently lack resources and technical capacity. To address this, some governments enlist the private sector to add capacity and, in doing so, promote the integrity of the enforcement system.

In countries where the private sector is involved in enforcement, it is critical to include them also as stakeholders in the design of the codes. Private-sector actors may also provide systems for professional accreditation, training, certifications, and guidance, improving the local capacity of building professionals, such as architects and engineers. For example, Colombia created a novel system of leveraging the private sector to enforce the integrity of building codes and standards (Box 30).

Box 30. Case study: PPPs for building codes in Colombia

Colombia models governance of resilient building codes through a hybrid public-private system that promotes technical rigour and institutional integrity. It has undergone rapid urbanization, which has placed immense pressure on informal settlements and infrastructure in hazard-prone zones. It also faces regular threats from earthquakes, landslides, and floods, which disproportionately affect informal urban communities. In response, Colombia's Ministry of Housing, City and Territory (MVCT) partnered with the World Bank to create the Resilient and Inclusive Housing Project (2021–2026) (World Bank, 2021a). This work supports upgrades to existing housing and integrates national reforms in building codes and governance mechanisms.

Colombia's building code governance is centred around a 2010 law, the Reglamento Colombiano de Construcción Sismo Resistente [NSR-10] (Colombian Earthquake-Resistant Building Code), a single, unified document that consolidates all technical requirements for structural, seismic, and safety performance (President of the Republic of Colombia, 2010; World Bank et al., 2023). This code increases compliance clarity, enhances transparency, and eases enforcement by ensuring all actors operate from a common regulatory baseline.

A defining feature of Colombia's approach is its use of "urban curators" (*curadores urbanos*), private professionals appointed through public merit-based processes to manage the review and approval of building permits (El Colegio Nacional de Curadores Urbanos, 2024). New curators are appointed every five years to limit the risk of entrenched relationships, promote fresh expertise, and maintain integrity in enforcement. The role is nationally regulated and spread across 48 cities. By 2020, this model had helped reduce the average building permit review time from 1,080 days in 1996 to 132 days. The urban curators are all legally mandated to charge the same rate for their services to protect the integrity of the system.

7.5 Informality

Informal housing presents perhaps the greatest challenge to resilient regulation. In sub-Saharan Africa, for example, the vast majority of homes are built outside formal planning and regulatory systems, leaving them beyond the reach of conventional codes and enforcement mechanisms (World Bank & GFDRR, 2023). In reality, this means that building codes alone cannot secure resilience in the housing sector here.

Instead, governments and partners must complement regulatory frameworks with incremental upgrade programmes, simplified standards, and community-driven approaches that meet residents where they are. By integrating informal builders, households, and neighbourhood organizations into resilience planning, authorities can gradually raise safety standards without imposing prohibitive costs that would only deepen exclusion. Addressing informality in this way recognizes both the scale of the challenge and the opportunity: Rather than attempting to force compliance from outside, effective policy engages communities as partners in progressively safer and more resilient urban development.

For example, in Türkiye, the 2023 earthquakes left thousands of buildings in need of repairs. Before modern seismic building codes were introduced in 2000, most housing was highly vulnerable to seismic hazards. As many as 6.7 million residential buildings in the country require retrofitting (World Bank, 2021d). Several programmes with multiple partners are providing financial and technical support for seismic retrofitting of existing housing. Advisory hubs and financing innovations are tackling some of the most significant barriers to retrofitting informal housing (Build Change, 2025).

7.6 Retrofit Programmes

Retrofitting existing structures is a critical priority, as the majority of today's buildings were constructed before resilience standards were widely adopted. Without simplified and accessible retrofit provisions, especially for small-scale housing, vulnerable structures will remain outside the reach of formal safety improvements. Many codes remain geared towards new construction, leaving homeowners and local authorities with little guidance on strengthening existing buildings. To address this challenge, the Philippines developed simplified guidelines for low-cost seismic retrofits to reinforce schools and houses using local materials and community labour (World Bank & GFDRR, 2025). This incremental, affordable approach demonstrates how governments can enhance the resilience of structures that would otherwise remain highly exposed to earthquakes and typhoons.

Urban retrofit programmes further illustrate how resilience can be institutionalized at scale. In Mexico City, authorities launched a large initiative in 2017–2018 to retrofit public schools and hospitals after devastating earthquakes, combining engineering standards with regulatory mandates and international financial support (Global Program for Safer Schools, 2018). Retrofitting health facilities offers additional lessons: For example, integrating structural upgrades with resilience planning, financing, and governance demonstrates that retrofitting is not only a technical intervention but also a governance challenge (World Bank, 2025b). Addressing this challenge requires sustained political will, financing innovation, and institutional coordination.

8 Capacity Building for Resilience and Climate-Change Adaptation

Infrastructure resilience depends on the capacity of assets and systems to absorb, respond to, and recover from disasters. While the strength of assets is critical, the capacity of infrastructure agencies is equally important. Staff from these agencies need to understand the hazards, exposure, and vulnerabilities of the assets they manage. They also need to interpret risk information, make operational decisions under uncertainty, repair and build assets differently, be prepared for and respond to emergencies, and learn from disruptions.

Most infrastructure agencies in developing countries have strong engineering expertise, but their disaster risk capabilities are still being developed. Design and operational staff have been working with historical design standards that are now inadequate to the potential impacts of climate change on the hazards. Many infrastructure agencies and operators manage resilience through emergency response rather than through the entire asset management cycle, which would require different competencies and skills. In addition, lessons that could have been learnt after disasters are not always incorporated into the procedures, standards, and staff capacities of organizations.

As highlighted by UNDRR (2018), capacity building for disaster resilience and climate-change adaptation is not a series of standalone training activities. Instead, it defines capacity building as a shared agenda across stakeholders and sectors in six key areas: i) strengthening disaster risk reduction (DRR) in organizations; ii) institutionalizing DRR capacity sharing; iii) applying risk information before and after disasters; iv) enabling collaborative action at national and local levels; v) strengthening external support mechanisms; and vi) advancing and expanding DRR capabilities. Training is necessary, but unless public agencies and partners can incorporate new skills through mandates, budgets, procedures, standards, monitoring systems, and accountability mechanisms, the learnings cannot be transformed into action.

This section is organized into two parts. The first part reviews the capacity-building experiences of infrastructure agencies. However, strong infrastructure-resilience programmes also require strong capacities in the private sector (designers, contractors, inspectors), university programmes, other government agencies (finance, regulators, financial institutions), and professional associations. The second part reviews good experiences and lessons learnt during capacity-building activities for these various stakeholders.

8.1 Capacity-Building Programmes from Infrastructure Agencies

Infrastructure agencies around the world are taking diverse approaches to building internal capacity for resilience actions, using different combinations of training, hiring skills, and contracting external expertise to supplement internal capacities. Each pathway needs to be adapted to local circumstances and requires careful consideration. This section presents three diverse case studies of infrastructure agencies' efforts to build their capacities using different models. The section concludes with common lessons that may apply to infrastructure agencies both public and private.

Box 31. Case study: SMRT, the Singapore urban transport operator, trains and drills for flood resilience

Singapore Mass Rapid Transit (SMRT) is one of the nation's two railway operators (in the public transport sector) and operates four MRT lines with 185 km of track and 119 stations. It also has Singapore's second-largest bus fleet, with 75 bus routes (SMRT, 2025a). The hazards most relevant for the SMRT system are intense rainfall, flash flooding, lightning, and heat.

SMRT's approach to building capacity for resilience is based on three overlapping systems: i) SMRT Institute as the in-house training arm, ii) recurrent operational and engineering training, and iii) annual flood response–preparedness exercises at each station. SMRT's capacity-building model is primarily internally delivered, through the SMRT Institute, station staff training, line operations, engineering staff, and the flood response team.

SMRT's 2024–2025 group review document, *From Strength to Strength: Building a Resilient Future* (SMRT, 2025a), states that SMRT Institute has developed 162 e-learning modules to date, while the 2024–2025 sustainability report *From Strength to Strength: Building a Resilient and Sustainable Future* (SMRT, 2025b) reports an average of 65.8 hours of structured training per employee in FY 2024–2025. ESG education via e-learning and video training is integrated into onboarding and refresher training. While ESG training goes beyond DRM and climate adaptation, SMRT uses this platform to build organization-wide awareness, while operational drills build station-level and line-level competence for flood response.

An example of the annual flood response–preparedness exercise took place at one-north MRT station on 12 December 2024. It tested three specific capabilities: i) monitoring for flood threats using the high water–level alert system owned by the Public Utilities Board (PUB); ii) activating SMRT's graduated flood-response plan; and iii) deploying flood barriers safely and quickly at station entrances (SMRT, 2024). SMRT works with PUB, Singapore's national water agency, and the Land Transport Authority as key stakeholders in its flood-preparedness exercises.

Box 32. Case study: Fourfold capacity building at PG&E, USA

The Pacific Gas and Electric Company (PG&E) operates electricity and gas infrastructure across Northern and Central California, serving roughly 16 million customers. Its power system is exposed to wildfire, drought, extreme heat, storms, flooding, and landslides, among other hazards. A series of high-impact wildfires led to more comprehensive regulatory oversight in this area, requiring the utility to document training, staffing, qualifications, compliance, and progress towards wildfire-mitigation targets (Correa Lopez, 2024).

PG&E's capacity-building programme was gradually developed across four areas:

First, PG&E strengthened mandatory fire-prevention rules for field work. The company's most explicit hazard-specific training requirement is the SAFE-1503WBT, Fire Danger Precautions training, now referenced in Utility Standard EMER-4102S, *Preventing and Mitigating Fires While Performing PG&E Work* (PG&E, 2024a). The standard applies to PG&E employees and contract partners performing work outdoors on or near forest-, brush-, or grass-covered lands. This training is mandatory and is generally completed annually between 1 January and 1 April (PG&E, 2024a).

Second, wildfire training was integrated into structured emergency-management exercises, as part of a multi-year training-and-exercise planning cycle. PG&E's 2023 Annual Report on Compliance states that in 2023 (PG&E, 2024b), it completed a functional exercise on public safety power shutoff (PSPS) and

wildfire response in May and a tabletop exercise in June, held an Integrated Preparedness Planning workshop, and developed a training and exercise schedule for 2024.

Third, PG&E expanded its workforce planning for wildfire mitigation, now requiring specific qualifications and training for vegetation-management inspectors and inspection personnel, encompassing both employee and contractor roles (PG&E, 2025).

Fourth, safety became a matter of PG&E's corporate culture, through the implementation of an Enterprise Leadership Development Program, which includes safety-leadership training for supervisors and crew leads, as well as an enterprise-wide safety-recognition programme (PG&E, 2024c).

Box 33. Case study: iGA Istanbul Airport, Türkiye, trains for resilience

The contractor for Istanbul Grand Airport (iGA), iGA Istanbul Airport Inc. operates one of the world's largest airport hubs. In 2024, it handled more than 80 million passengers and more than 517,000 flights to more than 330 destinations, with over 110 scheduled airlines (iGA, 2025a).

iGA builds its organizational resilience capacity through an internal training platform called the iGA Academy and a partnership with TÜBİTAK Marmara Araştırma Merkezi (MAM, Marmara Research Center), a specialized external scientific centre that provides climate-simulation and scientific risk-analysis capabilities (iGA, 2026). iGA Academy delivered close to 200,000 employee-hours of training in 2024, through close to 21,000 training sessions (iGA, 2025b).

The Academy is internally anchored but draws on expertise from across the airport. This is important for its resilience, because airport disruption management requires cross-functional competence, covering terminal operations, facility management, passenger services, digital systems, stakeholder coordination, and emergency response.

Climate adaptation came to be more formalized through the 2023 Climate Change Adaptation Action Plan Project with TÜBİTAK MAM (iGA Istanbul Airport, 2026). This added a specialized dimension of climate science and long-term adaptation planning to what had previously been a broader sustainability and operational-continuity agenda (iGA, 2024).

These case studies highlight some practical lessons:

- Infrastructure agencies need to build their internal capacities and not rely solely on national disaster agencies or climate-research centres.
- Resilience should be seen not as a planning concept alone, but as an aspect of operational competence. Resilience training for staff in infrastructure agencies needs to connect the dangers of geophysical and climate hazards with their operational realities.
- Segment-specific training is important, alongside general-awareness training, for all staff in the infrastructure agency. It must cover climate hazards and operational consequences, strategic planning for senior management, and operational modules for ground staff.
- Training should be closely linked to institutional change. As manuals, standards, and operating procedures are developed, and institutional responsibilities change to enhance resilience action, training needs to be adapted to those changes to reinforce their use in planning, design, and operations.

- Lessons learnt from disasters should be incorporated into training modules—not only for the technical value they add, but also because they bring the realities of the risks to infrastructure services closer to the operational teams' daily work.
- Classroom learning alone may not be as effective as a combination of approaches that reinforce the use of material learnt. A combination of classroom learning, e-learning, AI-supported learning, drills, and simulations can be most effective.
- A combination of internal training capabilities and high-level expertise contracted for specific topics appears to be the most effective strategy. While external consultants can help launch a programme, durable capacity generally requires an internal unit.

8.2 Capacity-Building Programmes for Other Stakeholders

Infrastructure agencies need diverse stakeholders with a strong understanding, knowledge, and capacities to integrate resilience to disasters and adaptation to climate change. Planners, private engineering and consulting companies, finance and insurance professionals, academics, and professional associations are all indispensable partners for infrastructure agencies to improve their resilience.

There is a wide range of options for setting up capacity-building programmes to reach diverse stakeholders. Examples can take various shapes:

National programme linked to a new tool: GeoRiskPH is an example of a capacity-building programme linked to a national risk-information platform, designed to give local officials, engineers, and planners access to tools for land-use planning, infrastructure development, emergency preparedness, exposure mapping, and risk assessment (GeoRiskPH, n.d.a). The institutional model combines national science agencies, local governments, civil defence organizations, and interior or local government agencies. By September 2025, the programme had trained staff from 831 Local Government Units, almost half of the Philippines' 1,820 provincial, city, and municipal governments (Meniano, 2025).

National capacity building through a government institution: India's National Institute of Disaster Management (NIDM, 2026a) is a statutory national institution for disaster-management training and capacity building. Its capacity-building programme serves a wide range of professionals, including civil servants, state disaster-management authorities, public-sector officials, and academics. The Institute is under the aegis of the Ministry of Home Affairs and operates from campuses in Delhi and Vijayawada. NIDM also has partnerships with central, state, and local governments; academic, research, and technical organizations; and bilateral and multilateral agencies. Recent training programmes suggest an evolving focus beyond conventional disaster management to include climate change and disaster risk reduction, climate-induced risks, resilient infrastructure, disaster mitigation finance, emerging technologies, and local-level disaster risk reduction through programmes such as the integration of DRR into Gram Panchayat Development Plans (GPDP) (NIDM, 2026b). According to NIDM's public trainee database, the Institute reports 473,178 total trainees from academic year 2009–2010 to 2025–2026 (NIDM, n.d.).

National capacity building through a university: The International Centre for Climate Change and Development (ICCCAD) in Bangladesh is a university-based knowledge centre for the Global South (ICCCAD, 2026a). ICCCAD is based at Independent University, Bangladesh, and was founded to generate and share practical knowledge on climate adaptation, loss and damage, locally led adaptation, and climate-resilient development. Its capacity-building programme encompasses research, short courses, practitioner networks, conferences, and local action research in the South (ICCCAD, 2026b). The institution draws on expertise and support from international partnerships and local NGOs to bring

university-based research, knowledge, and training to city officials and other practitioners. ICCCAD short courses are often organized with international NGOs and partner organizations.

Regional capacity-building institution: The Asian Disaster Preparedness Center (ADPC), based in Bangkok, Thailand, is a multinational regional capacity-building institution that has been focused on DRM and climate resilience for decades (ADPC, 2025). The Knowledge Academy is the training arm through which ADPC delivers face-to-face, online, and tailored courses. Its capacity-building model is regional rather than national, as it aggregates demand from many countries, draws on international faculty and practitioners, and maintains a large alumni network. The capacity-building offerings have evolved over the years from emergency management alone to incorporate risk-informed planning, financing, and resilience. ADPC reports more than 14,000 graduates from regional trainings worldwide (ADPC, n.d.).

Global capacity-building programme focused on a network of cities: The UNDRR Global Education and Training Institute (GETI) (UNDRR, n.d.) and the Making Cities Resilient 2030 initiative (MCR2030, n.d.a) together provide a global capacity-building model focused on the resilience of cities. More than 1,900 cities across 97 countries and territories are part of the MCR2030 network. This approach combines a global campaign and network, practical tools for climate resilience in cities (including city scorecards), training-of-trainers programmes, peer learning through recognized Resilience Hubs, and partner support for implementation. By mid-2025, MCR2030 and its partners reported that its annual certificate training programmes had benefitted over 17,500 practitioners from more than 1,100 cities in 155 countries (Kishore et al., 2025).

Global consortium of universities: CDRI's IRAX programme is a global academic capacity-building initiative launched in 2023 to mainstream DRI into higher education, research, and professional development. Its purpose is to create a pipeline of industry-ready infrastructure professionals by linking universities with strong DRI capacity to universities seeking to build capacity. IRAX facilitates curriculum development, research collaboration, faculty and student exchanges, fellowships, resilience centres and labs, and industry partnerships. The IRAX University Consortium now has 25 universities spanning 17 countries. Potential future activities may include competitive funding, model curricula, university partnerships, and professional training programmes (CDRI, 2025a).

Capacity-building programme led by a professional association: Engineers Canada (n.d.), the national federation representing Canada's provincial and territorial engineering regulators, convened the Public Infrastructure Engineering Vulnerability Committee (PIEVC) (Climate Risk Institute, 2023c) in the mid-2000s to help engineers incorporate climate change into infrastructure planning, design, operations, maintenance, and asset management. With support from Natural Resources Canada (NRCan, n.d.), Engineers Canada developed and validated the PIEVC Engineering Protocol (PIEVC, n.d.), a structured risk-assessment method for evaluating how current and future climate hazards could affect infrastructure systems. Engineers Canada later launched the Infrastructure Resilience Professional (IRP) designation in 2015 to formalize resilience competencies for engineers, including training in climate science, asset management, risk management, the PIEVC Protocol, and climate-change law (Climate Risk Institute, 2023b). The programme has since moved from Engineers Canada to the Climate Risk Institute (2023a), which now manages PIEVC training, the IRP credential, and related professional-development activities.

Some of the most useful lessons from these programmes include:

- Linking capacity-building efforts to tools, standards, or financing mechanisms increases the likelihood that skills learnt will be applied immediately after the course, yielding direct practical benefits.

- Having universities and technical institutions as anchors can multiply the reach of capacity-building programmes and enhance their credibility.
- Infrastructure resilience requires planners, engineers, finance officials, emergency managers, academics, and private providers to use compatible concepts and data. Multistakeholder cohorts can help reduce fragmentation, develop a common language and approaches, and establish networks of professionals across diverse cohorts.
- Going beyond classroom and online teaching to add support for alumni networks, communities of practice, mentoring programmes, and training of trainers can help capacity-building initiatives evolve from one-off activities to broader learning platforms.
- Having strong monitoring and evaluation systems that continue to follow programme participants to understand how they apply the lessons, tools, and new capacities in their work is critical to improving programme design, delivery, and impact.
- Planning for diverse sources of funding from the beginning helps programmes stay sustainable. The most successful ones rely on a combination of public funding, donors, course fees, professional accreditation fees, and licences.

9 Institutional and Policy Reform for Infrastructure Resilience

Countries may follow different trajectories to strengthen their institutional and policy environments, leading to better disaster-resilience practices within infrastructure agencies.

Generally, countries first establish a national mandate for disaster and climate resilience. This statutory mandate is then translated into infrastructure planning regulations, financing mechanisms, technical standards, and operational procedures for infrastructure agencies. The final step is coordinated action across stakeholders, which—as the OECD notes in its discussion of climate-resilient infrastructure—is indispensable, but complex to design and implement (OECD, 2018). These stakeholders range from infrastructure owners and operators to regulators, land-use planning agencies, urban planners, environmental agencies, DRM agencies, and many others, as discussed in Sections 4 and 5 of this working paper.

Ideally, an institutional and policy development pathway for resilient infrastructure would include:

- **Establishing a national policy, legal, or strategic DRM mandate** that gives public agencies and infrastructure operators a formal mandate concerning resilience. The mandate can be through legislative initiatives, such as a disaster-risk law, or through strategies such as a national resilience strategy or a climate-adaptation plan. Ideally, these mandates assign clear, differentiated responsibilities to central infrastructure ministries, disaster-risk agencies, climate agencies, planning ministries, finance ministries, sector ministries, regulators, local governments, and infrastructure operators.
- **Building risk information systems and applying them to infrastructure decisions,** such as risk-informed planning and territorial development or land-use plans; project siting, design, appraisal, permitting, and operational procedures; and disaster recovery plans. One of the most important infrastructure decisions for building resilience is the approval and financing of projects using risk information to define the public investment pipeline.
- **Updating engineering standards, building codes, and sectoral technical guidelines,** as discussed in Section 7. These standards and codes include building codes, seismic design standards, school and hospital safety guidelines, coastal protection standards, disaster- and climate-resilient infrastructure design manuals, and retrofit standards, among others.
- **Mainstreaming resilience into infrastructure agencies and operators** by translating regulations and standards into all aspects of these organizations, including asset management, capital planning, maintenance, emergency preparedness, business continuity, procurement, design review, and contract management.
- **Ensuring regulation and public disclosure are common features** of more advanced institutional set-ups, so that infrastructure regulators begin to monitor resilience as a parameter through PPP performance standards, utility resilience plans, service-continuity requirements, results indicators tied to investment authorizations or tariff-setting, and disaster- and climate-risk disclosures.
- **Reforming spatial planning SOPs to incorporate risks,** including land-use, urban, territorial, and watershed planning. These reforms enable diverse stakeholders to jointly understand hazards, reduce exposure and vulnerability, and avoid hazard amplification or maladaptation across sectors.

This section reviews some examples of institutional and policy-reform trajectories taken by different countries. Section 9.1 looks at the OECD countries and Section 9.2 reviews some developing countries. The possibilities for institutional and policy-reform journeys are quite diverse, so this working paper only covers a few examples in an attempt to sample some of the many options available.

9.1 Institutional and Policy Reform for Infrastructure Resilience in OECD Countries

This subsection looks at four OECD countries with diverse institutional and policy-reform pathways to infrastructure resilience: Japan (Box 34), the UK (Box 35), the Netherlands (Box 36), and New Zealand (Box 37).

Box 34. Case study: Leveraging recurrent disasters into stronger infrastructure resilience in Japan

The numerous and varied hazards that Japan faces and the recurrent disasters—some with quite a large impact, such as the 2011 Great East Japan Earthquake—have led to lessons learnt that have resulted in continuous improvement of its national resilience framework for infrastructure planning and public works. *The Basic Act for National Resilience Contributing to Preventing and Mitigating Disasters for Developing Resilience in the Lives of the Citizenry* of 2013 requires the government to promote disaster prevention, mitigation, recovery, and reconstruction measures in a comprehensive and systematic manner (Ministry of Justice, Japan, 2013). This Act helped the country to move from having simply a disaster-response policy to an explicit national resilience system.

The Act also establishes the National Resilience Promotion Headquarters, a high-level government body under the Prime Minister's Office that is responsible for coordinating national efforts to build a disaster resilient Japan. This body brings together all relevant ministries, agencies, and local governments to develop and implement resilience strategies (Prime Minister's Office of Japan, 2025). For example, recently, the Government of Japan announced an investment of over ¥20 trillion over five years (from FY 2026–2027) to integrate resilience into processes such as infrastructure retrofitting, strengthening of essential utilities, repairing of roads and bridges, upgrading of telecommunications, and leveraging of new technologies for resilience (The Yomiuri Shimbun, 2025).

Under this national umbrella, the infrastructure sectors develop institutional and policy reforms for resilience. For example, the Ministry of Land, Infrastructure, Transport, and Tourism (MLIT) developed a resilient road-sector programme to strengthen the road network and formulate a five-year programme for disaster prevention, mitigation, and national resilience (National Land Development Council, 2021). The focus of this reform is to integrate resilience throughout infrastructure agencies' SOPs, rather than creating separate units for resilience or climate adaptation. To achieve this, Japan's model relies on cabinet-level plans, annual plans, public-infrastructure programmes, and published measures of progress.

Box 35. Case study: Infrastructure resilience through regulatory structures in the UK energy sector

The UK's energy-sector resilience is based on its regulator–operator structure. Its legal foundation mandates that the government assess climate risks and implement a National Adaptation Programme to manage the impacts of unavoidable climate change (UK Parliament, 2008). Operationally, the UK's Department for Environment, Food and Rural Affairs (Defra) calls on government agencies to periodically report on their climate change–adaptation actions under the Climate Change Act 2008 (UK Parliament, 2008).

The UK Office of Gas and Electricity Markets (Ofgem) regulates the monopoly companies that run the gas and electricity networks. Following Defra's guidance, Ofgem prepares periodic round reports to show how the sector is tackling climate resilience and integrating climate considerations into upcoming regulatory decisions. The most recent is the *Ofgem Climate Resilience Report—Fourth Round Reporting* (Ofgem, 2025).

In the UK energy sector, institutional resilience reforms are undertaken through regulated company planning, asset management, resilience standards, and price-control incentives rather than as a single building-code reform. The 2025 Ofgem report frames its role as supporting regulated companies to manage climate risks and helping prioritize their remaining challenges. This institutional approach uses laws, regulator expectations and actions, and public disclosure to influence and guide asset operators.

Operators complete adaptation-reporting processes as part of the same cycle followed by the government, reporting on their climate-risk assessments, governance arrangements, and resilience actions (Defra, 2025a).

Box 36. Case study: The Netherlands' whole-of-government approach to flood-risk management

The Netherlands' Delta Programme is a permanent national planning-and-implementation system designed to protect the country from flooding, ensure sufficient freshwater, and make the country climate resilient. The Programme is one of the world's most advanced examples of institutionalized climate adaptation and flood-risk governance.

The Delta Programme is more than a flood-risk management programme. It is a formal public planning and reporting mechanism. The first Delta Programme was established in 2011 and focused on improving flood-risk management and maintaining adequate freshwater supplies in the next century (National Delta Programme, n.d.d). The Delta Act of Water Safety and Freshwater Supply came into force on 1 January 2012. It anchored the Delta Programme in the Dutch Water Act, created statutory arrangements for the Delta Programme, established the Delta Fund, and defined the role of the Delta Commissioner. The Delta Fund gave the programme a dedicated long-term financing mechanism (National Delta Programme, n.d.c). The Delta Act obliges the government to update the Delta Programme annually, while the Delta Programme Commissioner presents annual progress reports to Parliament (Government of the Netherlands, n.d.a).

The Ministry of Infrastructure and Water Management is the central national ministry responsible for the policy framework within which the Delta Programme operates. The Rijkswaterstaat is the executive arm of the Ministry of Infrastructure and Water Management. It manages, maintains, and develops the Netherlands' three major infrastructure networks: the main road network, the main waterway network, and the main water system (Government of the Netherlands, n.d.b).

The HoogWaterBeschermingsProgramma (HWBP, or Flood Protection Programme) was launched in 2014. It is the largest operational project in the Delta Programme. It is implemented jointly by the 21 regional water authorities and the Rijkswaterstaat to ensure that all primary flood defences comply with new standards by 2050. The HWBP is rolling and adaptive. It covers a block of six years at a time, while looking ahead at the next six years, updating priorities and project sequencing to that end (National Delta Programme, n.d.b).

The Netherlands' flood-management standards have evolved through three broad generations: i) traditional flood management engineering standards since 1953; ii) risk-based and climate-informed standards; and iii) standards linked to spatial planning and long-term climate uncertainty.

The new risk-based standards came into effect on 1 January 2017. The Delta Decision for Flood Risk Management sets a national protection objective. By 2050, the probability of mortality due to flooding for the population behind the dikes should not exceed 1 in 100,000 per year (National Delta Programme, n.d.a).

From 2017 onwards, the Delta Programme changed the logic of flood standards. Instead of relying mainly on the probability of high-water events or design water levels, the Dutch system moved towards a risk approach. In this approach, standards reflect both the probability of flooding and the consequences if flooding occurs (National Delta Programme, n.d.e).

Through the annual reviews, the government and other stakeholders realized that the numerous changes taking place—from rising sea levels to land subsidence, extreme rainfall, and population growth—required a different planning approach. The Delta Programme then moved beyond flood defences and freshwater to include spatial adaptation. The Delta Plan for Spatial Adaptation was added in 2018. This was a significant institutional expansion, which meant adaptation was no longer confined to water infrastructure, but became connected to land use, urban development, and public works (National Delta Programme, n.d.a).

On 1 January 2024, the Water Act was merged into the Environment Act. The flood-risk standards remained central, but the legal architecture became part of the broader environmental and spatial-planning framework. This change marked a shift of perspective, from regarding defence against floods as a sectoral issue, to water and soil issues informing overall spatial planning. The 2025 Delta Programme for Spatial Adaptation aims to reduce waterlogging, drought, heat stress, and flood impacts, with the goal of making the Netherlands climate-proof and water-resilient by 2050 (Climate Adaptation Platform Netherlands, n.d.).

Box 37. Case study: New Zealand's National Adaptation Plan and lifeline infrastructure

New Zealand uses a National Adaptation Plan and lifeline-infrastructure collaboration to address cross-sectoral infrastructure vulnerabilities and coordinated resilience actions. New Zealand's first National Adaptation Plan sets out the government's long-term adaptation strategy for 2022–2028. It responds to risks identified in the *National Climate Change Risk Assessment* (Ministry for the Environment, New Zealand, 2022).

In parallel, the Civil Defence Emergency Management (CDEM) Act 2002 and the National CDEM Plan (NEMA, 2015) establish duties so that lifeline utilities continue functioning during and after emergencies. The 2023 New Zealand Critical Lifelines Infrastructure National Vulnerability Assessment is the central risk-information instrument used on this collaboration platform (New Zealand Lifelines Council, 2023). It was developed with input from the lifeline utilities, government, researchers, and community. The lifelines framework supports sectoral and regional resilience planning, seismic strengthening, response and recovery planning, and prioritization of resilience projects.

New Zealand's resilience mainstreaming model relies on legally defined lifeline utilities and collaborative planning, treating infrastructure operators as not only sectoral utilities, but as members of a national emergency-management and resilience system (NEMA, n.d.). This model is built upon a shared evidence

base that acknowledges cross-sectoral dependencies and vulnerabilities. This is a practical model for infrastructure systems where failures cascade across electricity, transport, water, telecommunications, fuel, ports, and emergency logistics.

9.2 Institutional and Policy Reform for Infrastructure Resilience in Developing Countries and Emerging Economies

Developing countries are at different stages of institutional resilience and policy-building for resilience. Many have incorporated lessons learnt from OECD countries to leapfrog into more advanced arrangements for resilient infrastructure organization. There is a vibrant tapestry of pathways being followed in the developing world. Many of these countries have built their institutional and policy reform processes with the support of UNDRR, multilateral development banks (MDBs), and development partners. The following case studies (Boxes 38 and 39) represent a small sample.

The Cat DDOs, as described in Section 4.1, constitute a set of financial instruments from the World Bank and other MDBs that provide a contingent credit line for rapid post-disaster budgetary support. At the same time, they are policy-based instruments, which help countries strengthen the institutional, legal, and operational foundations of disaster and climate resilience (World Bank, 2026b). Many World Bank client countries have used this type of instrument to develop the resilience architecture of their institutions and policies.

Box 38. Case study: Colombia's journey from nationwide DRM mainstreaming to resilient housing, territorial planning, and green road infrastructure

Colombia has a long tradition of DRM institutions. In the early 2000s, the country began a significant institutional and policy shift, from a civil protection and response–oriented approach to a system that treated disaster risk as a development problem tied to land use, public investment, housing, roads, fiscal risks, and local planning. This process was supported by the World Bank through a series of Cat DDO operations. The first one, for $150 million, was approved in 2008 and aligned with this transition. It supported the inclusion of a disaster risk–reduction and management strategy in the 2006–2010 National Development Plan (World Bank, 2017b).

The next significant policy reform took place in 2012, with Law 1523, which established the National Disaster Risk Management Policy and created the National Disaster Risk Management System (Congreso de Colombia, 2012). This law replaced the earlier prevention-and-response system with a broader framework organized around knowledge of risks, risk-reduction strategies, and disaster management, and it clarified responsibilities across national, departmental (subnational), municipal, and sectoral actors (Government of Colombia, 2012).

The second World Bank Cat DDO, approved in 2012, built on that institutional-reform momentum. This second phase of operations identified two key drivers of risk in Colombia—namely, inappropriate land-use planning and insufficient access to safe low-income housing. Accordingly, the operation focused on strengthening institutional DRM and planning capacity, integrating DRM into land-use planning, and reducing risk in the housing sector (World Bank, 2012a).

The third Cat DDO, approved in December 2021, represents the strongest infrastructure-specific stage in the operations in Colombia. This Cat DDO supported three areas of policy and institutional development: i) development of DRM and climate-change policies; ii) fiscal resilience to disaster, climate, and public-health risks; and iii) sectoral and subnational co-responsibilities for DRM and climate adaptation (World

Bank, 2021c). This operation also supported transport-sector reforms, including the Ministry of Transport's Green Road Infrastructure Guidelines and the National Roads Institute's DRM planning (World Bank, 2021c). The transport reform here moved beyond generic road-emergency response to earlier stages of planning and design, based on risk analyses and climate-sensitive engineering.

The Colombia model is a progressive mainstreaming model. It begins with DRM in national development planning, moves through a legal reform that creates a whole-of-government DRM system, and then gradually deepens into instruments to support territorial planning, housing, and the transport sector.

Box 39. Case study: Philippines' journey from national DRRM law to building standards, local recovery planning, and climate risk–informed investment

The foundations of the Philippines' institutional and policy reform for infrastructure resilience were laid by two landmark laws: first, the Climate Change Act of 2009 (Republic of the Philippines, 2009), which created the Climate Change Commission (n.d.) and provided a national policy as the basis for adaptation and mitigation actions; and, second, the Disaster Risk Reduction and Management Act of 2010, which established the National Disaster Risk Reduction and Management Council (NDRRMC, n.d.) and created a comprehensive, all-hazard, multisectoral, interagency, and community-based approach to DRM (Climate Change Commission, the Philippines, 2011).

The first World Bank Cat DDO, approved in 2011, supported this initial implementation phase. This operation helped build institutional capacity, create DRRM offices at subnational levels, incorporate DRR into development planning, and establish disaster-risk financing and insurance strategies (World Bank Independent Evaluation Group, 2022).

Another important milestone was the *National Disaster Risk Reduction and Management Plan 2011–2028*, which organized the national DRM agenda around prevention and mitigation, preparedness, response, and rehabilitation and recovery, all based on the 'build back better' principle (ADRC, 2011).

The second Cat DDO, approved in 2015, supported the evolution of the agenda for institutional and policy reform to grow closer to infrastructure regulation and sector tools. This Cat DDO supported the strengthening of the government's technical and financial capacity to manage disaster risks and the socioeconomic and fiscal impacts of disasters, as well as to improve outdated national building regulations (World Bank, 2020c). One infrastructure-related result was the integration of DRR measures into the revised National Building Code of the Philippines, developed by the Department of Public Works and Highways and approved by the House of Representatives in 2023 as House Bill No. 2500.

Later, the Philippines developed its Climate Change Expenditure Tagging (CCET) system, which allows national and local governments to track climate-related programmes, projects, and activities and to align local priorities with the National Climate Change Action Plan (NCCAP) (NICCDIES, 2026).

In summary, the Philippines model of institutional and policy reform can be described as a localization and standards model. The national laws created a DRR and climate-adaptation mandate; then DRRM was institutionalized across levels of government; the next step was building-code and sector-regulation reforms; and most recently, DRM was integrated into local recovery planning, budget-tagging, and climate risk–informed investment programming. This model is particularly relevant for countries where local governments own or influence much of the infrastructure resilience agenda, even as the national government controls standards, fiscal transfers, and recovery financing.

10 Institutional and Policy Assessment Framework

This section brings together the various institutional and governance perspectives of resilient infrastructure into a diagnostic tool that can be used by infrastructure agencies. This assessment tool is similar to those presented in other working papers of the *Global Infrastructure Resilience 2025* series (CDRI, 2025d). The tool is intended to support initial screening for self-diagnosis by infrastructure agencies. The tool is structured around a series of questionnaires, with guidance to collect evidence. An initial rapid preliminary assessment by infrastructure agency staff can help identify critical gaps, establish a baseline, and help the organization understand where to focus more detailed assessment and institutional analysis.

The questionnaires are structured around specific issues discussed earlier in this working paper, with questions to assess each issue and evidence or documentation to review and compile. This documentation will be invaluable for later studies and assessments. The final output from this self-assessment is an initial diagnostic report identifying the issues in areas where organizational arrangements are in place for resilience management and yet gaps exist.

The initial screening based on these questionnaires can be followed by a more detailed institutional assessment to verify the quality, implementation, maturity, and performance of the various dimensions analysed, leading to a scored maturity plan and a capacity-building plan. These findings can then be translated into a more detailed roadmap for improvement, with a clear sequence of institutional and policy reforms, including plans for staffing, systems, budgets, training, and operational changes needed.

In line with the organization of this working paper, Section 10.1 presents a questionnaire for internal capabilities, while Section 10.2 presents a questionnaire for the organization's arrangements and capabilities to engage with external stakeholders.

Section 10.1 first presents a table for public infrastructure agencies, such as ministries, departments, national and local agencies, and similar government entities, to explore. As state-owned infrastructure enterprises, utilities, and privately managed infrastructure operators tend to have different organizational structures and arrangements, Section 10.1 then presents a second table with supplementary questions for these types of agencies.

The questionnaire in Section 10.2 engages with external stakeholders, both public entities (as discussed in Section 4) and non-public ones (as presented in Section 5). This questionnaire is designed to assess the capacity of an infrastructure agency to build effective relationships with other agencies and stakeholders. Of course, the infrastructure agency does not control ministries of finance, planning agencies, regulatory and other government institutions, but it should have the internal capacity to engage with them systematically.

Each questionnaire presents four types of questions for each issue:

- **Existence:** Does the mandate, process, unit, system, or budget exist?
- **Clarity:** Are roles, responsibilities, rights of decision-making, and reporting lines clear?
- **Implementation:** Is the expected engagement actually seen in planning, budgeting, operations, maintenance, response, and recovery?
- **Learning:** Is the arrangement updated based on new risks, incidents, audits, and post-disaster lessons?

As this is designed to be an initial screening tool, the questions should be answerable using information that an agency usually has readily available, such as mandates, organograms, strategies, asset-management plans, budgets, emergency procedures, and internal reports. This screening would help determine whether resilience is formally recognized, whether internal responsibilities are clear, whether relevant departments are involved, and whether the agency has basic systems in place to plan, finance, operate, maintain, respond, recover, and learn in expectation of or in response to disasters and climate risks (GFDRR, 2017).

It is very important that the questionnaires are not answered based only on perceptions or general statements. Hence, a series of documents that can serve as basic evidence is proposed for each issue. For example, a question on the senior leadership's accountability for resilience should be answered using evidence from organograms, terms of reference (TOR), management committee minutes, or performance agreements. A question on asset management and resilience integration should be answered using asset registers, maintenance plans, risk maps, capital investment plans, or life-cycle costing tools.

Furthermore, the assessment team filling out the questionnaire should use interviews to test whether formal rules are being applied in practice, identify implementation constraints, and understand incentives and bottlenecks.

Finally, the output of the initial screening should be structured to support a more detailed assessment later. As an initial diagnostic tool, this questionnaire does not try to answer every technical or institutional question in depth. Instead, it aims to identify inadequate capacity, information gaps, and areas where deeper review is required. For example, if the screening finds that an agency has a climate-risk assessment, but no evidence that the information shapes maintenance planning, a later assessment can examine the quality of the risk assessment, the decision rules applied by the maintenance department, the budget implications, and the extent to which field offices apply the guidance.

Infrastructure agencies and other service providers (SOEs, utilities, and private operators) will not have full answers to every question in the assessment tool. This is perfectly normal.

Once the main gaps are identified, they should be grouped into a smaller number of intervention areas. Intervention areas are not individual recommendations. They are reform families that organize recommendations around the main systems that need to change. A well-defined intervention area is broad enough to capture several related actions, but specific enough to guide implementation. Examples of recommendations for a reform cluster built around a single intervention area include strengthening the legal framework; improving regulatory instruments; developing data systems; clarifying institutional responsibilities; strengthening enforcement; building professional capacity; improving public awareness; or mobilizing finance. Identifying intervention areas in this way helps government counterparts see the overall reform architecture, avoids a long, unstructured list of actions, and clarifies which institutions or units need to work together.

It is advisable to write out the recommendations as clear reform directions, rather than general aspirations. Each recommendation should state what needs to be changed, created, clarified, strengthened, or implemented. It should be specific enough to guide action, but not so detailed that it anticipates technical design before key stakeholders have reviewed the recommendation. This is an important first step in the action plan. At this stage, it is important to focus on whether each recommendation is necessary, realistic, and within the scope of the assessment, rather than how it shall be carried out.

After that, priority actions can be decided: the practical steps needed to implement a recommendation. They should translate the recommendations into specific tasks that can be assigned, costed, supported,

monitored, and sequenced. For example, a recommendation to improve permitting processes may require the priority actions of mapping the current workflow, drafting decision guidelines, clarifying fee calculations, digitizing records, training staff, and communicating changes to the public. A recommendation to develop standards may require establishing a technical committee, reviewing existing international standards, identifying locally used materials, drafting priority standards, creating certification arrangements, and strengthening the responsible authority. Thus, a single recommendation typically requires several actions over time.

Prioritization of the proposed actions needs to be transparent and defensible. Possible prioritization criteria could include:

- **Urgency:** Would a delay increase risks, create legal uncertainty, or prevent critical functions from operating?
- **Feasibility:** Can the action be implemented with available/existing or realistically mobilizable political support, technical capacity, budgets, and institutional authority?
- **Implementation capacity:** Does the entity expected to deliver the action have the necessary staff, equipment, systems, and resources?
- **Inclusivity and public acceptance:** Does the action affect vulnerable groups, informal practices, or public behaviour? Does it require consultation and communication?
- **Sustainability:** Can the action be maintained beyond the initial reform phase through available or readily mobilized funds, existing or easily created procedures, training, and accountability mechanisms?

These criteria do not need to become a complex scoring model, but they should be discussed systematically.

An important step before the finalization of recommendations and priority actions is a validation exercise. The purpose of this step is to build consensus, and also test for accuracy, feasibility, sequencing, and ownership. This exercise involves stakeholders trying to identify factual errors, missing institutions, unrealistic assumptions, and political or administrative constraints. They should also consider whether an alternative sequence may be more effective and whether lower-hanging fruits have been overlooked.

A concise implementation plan or roadmap is often more useful for decision makers than a long list of recommendations. This plan or roadmap should clearly show which actions can begin immediately, which require preparatory work, which depend on legal or institutional decisions, and which require sustained capacity building. The roadmap should remain flexible, because government priorities, budgets, and institutional arrangements may change. However, it should be specific enough to support dialogue, resource mobilization, and monitoring.

This discussion concludes with Section 10.3, which contains a list of lessons learnt from various institutional and organizational assessments that may serve as useful examples for those undertaking this exercise. Annex 1 presents a list of other diagnostic tools (with application beyond infrastructure agencies) that have been designed to assess national frameworks and institutional arrangements for DRM and climate-change adaptation. These tools can be complementary to the questionnaires presented in this section. The questions and structure of the tool in this section are inspired by or borrow from the tools presented in Annex 1.

10.1 Internal Institutional and Governance Assessment Tool for Infrastructure Agencies

This section presents a list of assessment questions to help infrastructure service providers carry out an initial analysis of their organization to identify priority areas for reform and strengthening. Part 1 of Table 1 presents questions that are applicable to all types of infrastructure agencies (public enterprises and others). Part 2 presents additional questions that are more focused on additional issues specific to SOEs, utilities, and privately managed infrastructure operators.

SOEs, utilities, and privately managed operators share many of the same resilience requirements as public infrastructure agencies. However, they usually operate within a more corporatized, contractual, commercial, or regulated environment. Their resilience obligations may arise not only from public-policy or sectoral mandates, but also from board decisions, shareholder expectations, licences, concession agreements, PPP contracts, tariff determinations, lender requirements, insurance arrangements, service-quality standards, and customer commitments. These characteristics are reflected in the additional questions presented in Part 2 of Table 1.

Table 1: Initial screening tool: Questionnaire for internal institutional and organizational assessment for resilience

Part 1: Public Infrastructure Agencies				
No.	**Issue**	**Issue description**	**Questions to assess the issue**	**Evidence to review**
1	Formal agency mandate for resilience and adaptation	Assesses whether disaster resilience and climate adaptation are part of the agency's formal mandate	Does a law, decree, charter, or founding instrument assign the agency responsibility for resilient infrastructure, climate adaptation, service continuity, DRR, or emergency response and recovery? Does the mandate cover existing assets as well as new assets?	Laws, decrees, agency charter, sectoral policies, ministerial regulations
2	Internal policy statement on resilience	Assesses whether the agency has translated its mandate into an internal policy	Has the agency issued a policy, circular, strategy, or management directive on disaster resilience and climate adaptation? Does it define objectives, responsibilities, and expected outputs?	Internal policy, circulars, strategy documents, management directives
3	Senior leadership accountability	Assesses whether resilience has a clear owner at a senior level	Is a minister, permanent secretary, director general, deputy director, chief engineer, or equivalent senior official accountable for resilience and adaptation? Is this accountability reflected in performance agreements or management reporting?	Organogram, senior management TOR, performance agreements, management minutes
4	Internal governance structure	Assesses whether the agency has an internal mechanism to coordinate resilience across departments	Is there a resilience unit, climate unit, or internal steering committee? Does it have the requisite authority, staff, budget, and a reporting line to senior management?	Organogram, committee TOR, unit mandate, budget, staffing table
5	Departmental role clarity	Assesses whether departments know	Are resilience responsibilities defined for planning, engineering, design, construction, maintenance,	Departmental TORs, job descriptions, process manuals,

		their resilience responsibilities	operations, finance, procurement, emergency management, monitoring, and internal audit?	responsibility matrix
6	Integration into strategic planning	Assesses whether resilience is part of the agency's core strategy	Does the strategic plan identify relevant hazards, exposed assets, climate trends, service-continuity risks, and adaptation priorities? Are these linked to targets, timelines, and responsible departments?	Strategic plans, corporate plans, sectoral plans, annual work plans
7	Coverage of the resilience cycle	Assesses whether the agency addresses prepare/absorb, respond, and recover/adapt	Does the agency define actions for DRR and preparedness, emergency response, service restoration, reconstruction, and adaptation? Are all three capacities covered or is the agency focused mainly on response?	Strategies, emergency plans, recovery plans, asset-management plans, capital plans
8	Risk-informed project identification	Assesses whether new projects are identified using hazard and climate information	Are disaster and climate risks considered when identifying projects? Are high-risk locations avoided, modified, or justified? Are exposed and vulnerable communities or services prioritized?	Project identification guidelines, pipeline documents, screening forms, planning manuals
9	Project appraisal and selection	Assesses whether resilience affects project prioritization	Does appraisal require hazard screening, climate-risk assessment, life-cycle costing, avoided-loss analysis, or service-continuity benefits? Are high-risk projects subject to deeper analysis?	Appraisal manual, feasibility studies, investment committee papers, cost-benefit analyses
10	Asset inventory	Assesses whether the agency has a reliable record of all its assets	Does the agency have a complete and georeferenced asset inventory? Does it include location, age, condition, ownership, function, replacement value, and maintenance history?	Asset register, GIS, RAMS, condition surveys, inventory reports
11	Hazard-exposure mapping	Assesses whether the agency knows which assets are exposed to hazards	Are assets mapped against floods, storms, heat, drought, wildfire, landslides, earthquakes, sea-level rise, or other relevant hazards? Are future climate scenarios included, where available?	Hazard overlays, GIS maps, exposure assessments, climate-risk studies
12	Asset-criticality assessment	Assesses whether the agency identifies assets most important for service continuity	Has the agency classified assets by criticality, redundancy, users served, economic importance, emergency function, and consequences of failure?	Criticality maps, service-continuity analyses, risk register, asset hierarchy
13	Vulnerability assessment	Assesses whether exposed assets have been evaluated for likely damage or failure	Has the agency assessed physical vulnerabilities and functional vulnerabilities of critical assets? Are weaknesses documented by hazard type and asset class?	Engineering assessments, vulnerability studies, inspection reports, technical audits

14	Asset-management integration	Assesses whether resilience is embedded in whole-of-life asset management	Does the asset-management system integrate hazard exposure, asset condition, criticality, maintenance needs, renewal timing, and adaptation options?	Asset-management policy, asset-management plan, ISO 55000-related documents, life-cycle models
15	Preventive maintenance for resilience	Assesses whether routine maintenance reduces disaster vulnerability	Are maintenance plans adjusted for more hazardous seasons and overall climate risks? Are drainage cleaning, slope stabilization, vegetation management, culvert maintenance, generator testing, and other risk-reducing tasks formally scheduled?	Maintenance plans, work orders, inspection reports, seasonal preparedness plans
16	Design standards and technical specifications	Assesses whether internal engineering standards reflect current and future risks	Do design manuals incorporate relevant hazard maps, climate projections, safety margins, redundancy, robustness, drainage, heat tolerance, seismic resistance, flood protection, or other sector-specific requirements?	Design manuals, technical specifications, standard drawings, engineering-review records
17	Updating of standards	Assesses whether the agency updates standards as risks and evidence change	Is there a defined process to update design, construction, maintenance, and operating standards after new climate data, disaster events, technical studies, or regulatory changes?	Records of the standards committee, revised manuals, post-disaster technical reviews
18	Retrofitting and upgrading	Assesses whether the agency has a programme for vulnerable existing assets	Has the agency identified assets requiring retrofit, relocation, redundancy, protective works, or operational upgrades? Are priorities based on risk, criticality, cost, and service impact?	Retrofit programme, capital plan, risk-ranking tool, engineering studies
19	Capital-investment programming	Assesses whether resilience priorities are translated into funded investments	Are resilience and adaptation actions included in the medium-term capital-investment plan? Are they embedded in new projects, renewals, retrofits, and rehabilitation programmes?	Capital-investment plan, budget submissions, investment-committee papers
20	Budgeting and financial planning	Assesses whether the agency has resources for resilience functions	Are budgets allocated for risk assessment, data systems, staff, training, maintenance, retrofitting, emergency preparedness, and post-disaster recovery? Are recurrent and capital needs both covered?	Budget documents, expenditure reports, programme budgets, medium-term expenditure submissions
21	Internal risk management	Assesses whether disaster and climate risks are part of institutional risk management	Are disaster and climate risks included in the agency's risk register? Are owners, mitigation actions, deadlines, residual risks, and escalation procedures defined?	Risk register, risk-management policy, reports from senior management

22	Emergency-preparedness procedures	Assesses whether the agency has internal arrangements to mount a disaster response	Are emergency SOPs documented for relevant hazards? Are roles, decision-making rights, escalation levels, staff mobilization, emergency procurement, and communications defined?	Emergency SOPs, incident command procedures, duty rosters, emergency manuals
23	Business continuity	Assesses whether the agency can keep core functions operating during disruptions	Are headquarters, regional offices, depots, control centres, laboratories, IT systems, payroll, procurement, and communications covered by business-continuity plans?	Business-continuity plan, IT disaster-recovery plan, backup site plan, test records
24	Service restoration plan	Assesses whether the agency has internal priorities for restoring services	Are priority assets, routes, facilities, users, and service areas identified for disaster situations? Are time objectives and sequencing rules defined for service restoration?	Restoration plans, priority-assets list, emergency works plan, incident-response manual
25	Recovery and build-back-better procedures	Assesses whether the agency can move smoothly from response to resilient reconstruction	Are procedures pre-defined for damage assessment, temporary works, reconstruction design, procurement, financing, and technical approvals? Do these procedures require adaptation, rather than like-for-like replacement, where justified?	Damage assessment forms, reconstruction manuals, emergency procurement rules, recovery plans
26	Contractor and outsourced-service readiness	Assesses readiness of contractors for maintenance, emergency repairs, call centres, security, IT, and specialized functions	Are resilience obligations defined for contractors engaged? Are standby contracts, emergency mobilization procedures, safety requirements, pricing, and response times pre-agreed?	O&M contracts, contractor panels, emergency-framework agreements, SLAs
27	Internal data systems	Assesses whether data supports risk-informed decisions	Are asset, hazard, maintenance, incident, outage, cost, procurement, and investment data connected? Can managers access usable dashboards or reports?	GIS, asset-management systems, dashboards, data governance policies
28	Internal reporting to management	Assesses whether resilience information reaches decision makers	Are resilience risks, incidents, maintenance backlogs, adaptation investments, emergency readiness, and recovery actions reported regularly to senior management?	Management reports, board papers, quarterly reviews, risk-committee minutes
29	Resilience KPIs	Assesses whether performance is monitored	Does the agency track indicators such as percentage of critical assets assessed, exposed assets, maintenance backlog, retrofit progress, outage duration, restoration time, emergency-drill completion, and post-disaster recovery progress?	KPI dashboard, annual report, performance agreements, monitoring reports

30	Human resources and skills	Assesses whether the agency has the skills required to manage resilience	Does the agency have staff skilled in climate risk, hydrology, geotechnics, structural engineering, asset management, GIS, emergency management, emergency procurement, financial planning, and monitoring? Are gaps documented?	Staffing table, job descriptions, skills assessment, HR plan
31	Training and internal learning	Assesses whether resilience capacity is continuously built	Are staff trained in risk-screening, resilient design, resilience-informed asset management, resilience-informed maintenance, emergency response, damage assessment, business continuity, and adaptation planning? Are lessons learnt incorporated into future training?	Training plan, attendance records, curricula, after-action reviews
32	Procurement and contracting	Assesses whether procurement supports resilient infrastructure	Do procurement documents include resilience specifications, life-cycle cost criteria, quality assurance, contractor emergency obligations, and post-disaster repair provisions?	Procurement manuals, standard bidding documents, contract templates, evaluation criteria
33	Internal audit and assurance	Assesses whether resilience-related processes are reviewed independently	Does internal audit review compliance with risk-screening, design standards, maintenance obligations, emergency preparedness, data quality, and budget execution? Are corrective actions tracked?	Internal audit reports, quality-assurance reviews, corrective action logs
34	Decentralized implementation capacity	Assesses whether regional and local units can implement resilience requirements	Do regional offices have staff, equipment, budget, guidance, and delegated authority for inspections, maintenance, emergency response, damage reporting, and local recovery?	Delegation rules, regional staffing records, field budgets, regional work plans
35	Institutional learning after disasters	Assesses whether the agency changes systems after shocks	Are after-action reviews conducted after disasters and near-misses? Are findings translated into revised standards, maintenance plans, budgets, training, and SOPs?	After-action reviews, updated manuals, management action plans, audit follow-up records
36	Institutionalization beyond champions	Assesses whether resilience depends on systems, rather than individuals	Would resilience functions continue if key staff left? Are responsibilities, budgets, standards, data systems, reports, and decision processes formalized?	Organogram, policies, budget history, succession plans, management systems
Part 2: Additional Questions for SOEs, Utilities, and Private Infrastructure-Service Operators				
37	Board-level fiduciary oversight of resilience	Unlike many public agencies, SOEs and private operators usually have boards with fiduciary responsibilities, audit/risk committees, and corporate governance obligations. Assesses	Does the board or a board committee review disaster and climate risks? Are resilience, reliability, safety, and adaptation included in board risk oversight? Are board decisions translated into management actions? Are there board committees specifically tasked with ensuring resilience and adaptation?	Board charter, board minutes, audit/risk committee papers, corporate governance reports

		whether these are present		
38	Shareholder, owner, and concession expectations	SOEs and private operators are often governed by shareholder compacts, concession agreements, licences, PPP contracts, or performance agreements. Assesses whether these are in use	Do shareholder expectations, concession obligations, licences, or PPP contracts require resilience, adaptation, reliability, emergency preparedness, or service restoration? Are obligations measurable and enforceable?	Shareholders compact, concession agreements, PPP contracts, licences, performance agreements
39	Commercial incentive structure	Utilities and private operators respond to revenues, penalties, bonuses, insurance, financing covenants, and reputational incentives. Assesses whether this is the case here	Do tariffs, availability payments, penalties, bonuses, service-quality regimes, or financing covenants reward resilience and penalize avoidable service failures? Do incentives encourage preventive investment rather than deferred maintenance?	Tariff orders, PPP payment mechanisms, regulatory determinations, loan covenants, performance regime
40	Contractual allocation of disaster and climate risks	PPPs and concessions require explicit allocation of force majeure, insurance, emergency works, restoration obligations, compensation, and relief events. Assesses whether these allocations are available	Are disaster and climate risks allocated clearly and separately to the public authority and the operator? Are thresholds, compensation rules, insurance obligations, emergency works, and restoration timelines defined?	PPP contracts, concession agreements, force-majeure clauses, insurance clauses, relief-event provisions
41	Regulatory compliance and resilience reporting	Utilities and private operators may have formal reporting obligations to regulators, shareholders, lenders, or contract managers. Assesses whether these obligations are being honoured	Can the operator produce reliable reports on outages, asset conditions, climate risks, emergency readiness, restoration times, investment delivery, and service-quality indicators?	Regulatory reports, lender reports, contract compliance reports, ESG/sustainability reports
42	Tariff or revenue treatment of resilience investments	Utilities often need regulatory approval or contractual mechanisms to recover resilience-related capital and operating expenditures. Assesses whether these are in place	Are resilience investments eligible for tariff recovery, availability payments, pass-throughs, grants, subsidies, or shareholder funding? Are recurrent costs for maintenance and preparedness financially recognized?	Tariff submissions, financial models, regulatory determinations, business plans, budgets

43	Corporate enterprise risk management	SOEs and private operators often have enterprise risk management systems that should incorporate physical climate and disaster risks. Assesses whether these are in place	Are physical climate risks, disaster risks, service-interruption risks, asset-failure risks, supply-chain risks, and liability risks included in the enterprise's risk register? Are these linked to mitigation controls and executive owners?	Enterprise risk register, ERM policy, risk appetite statement, risk committee reports
44	Insurance and risk transfer	Private and corporatized operators typically use insurance, captives, reserves, guarantees, or other risk-transfer tools more systematically than public agencies. Assesses the shape and health of these	Are assets insured against relevant hazards where feasible? Are deductibles, exclusions, business-interruption coverage, claims procedures, and coverage gaps reviewed? Does insurance influence risk-reduction investments?	Insurance policies, claims history, broker reports, risk financing strategy, board papers
45	Customer-service and communications obligations	Utilities and private operators usually have direct customer relationships and may face regulatory obligations for outage communications and vulnerable customers. Assesses the health of these relationships	Are customer notification, outage communication, complaint handling, alternative service arrangements, and vulnerable-customer protocols defined internally?	Customer-communication plan, outage protocols, call-centre scripts, vulnerable-customer register
46	Workforce safety and continuity under commercial operations	Assesses whether procedures are in place to protect staff and contractors while maintaining service under hazardous conditions	Are staff- and contractor-safety rules defined for floods, heat, storms, electrical hazards, confined spaces, contaminated water, landslides, or other sectoral risks? Are fatigue prevention, accommodations, transport, and protective equipment addressed?	HSE plans, emergency HR policies, contractor-safety procedures, incident reports
47	Management incentives and executive scorecards	Corporatized entities can embed resilience into executive incentives and departmental scorecards more directly than many public agencies. Assesses whether this is being done	Are executives and managers evaluated on reliability, maintenance completion, outage reduction, restoration time, asset condition, safety, emergency readiness, and resilience investment delivery?	Executive scorecards, performance contracts, incentive plans, departmental KPIs
48	ESG, sustainability, and climate disclosure alignment	Assesses whether SOEs and private operators are submitting reports under ESG, sustainability, climate-risk, or lender-disclosure frameworks	Are physical climate risks and adaptation actions disclosed consistently with internal risk management, investment plans, and board oversight? Are disclosures evidence-based rather than narrative-only?	ESG reports, sustainability reports, climate disclosures, lender reports, internal data packs

49	Financial viability and resilience trade-offs	Utilities and private operators may face tensions between short-term financial performance, dividends, tariff constraints, and long-term resilience investment. Assesses whether such concerns are being anticipated and addressed	Are decisions on dividends, cost reduction, deferred maintenance, debt service, and capital expenditure assessed for resilience consequences? Does the operator protect critical maintenance and adaptation budgets during financial stress?	Financial statements, business plans, dividend policies, maintenance backlog reports, board documentation
50	Continuity after ownership or contract changes	Assesses whether ownership changes, contract renegotiation, refinancing, or operator replacement for utilities and PPP assets are anticipated and whether there is a plan in place for such circumstances	Are resilience data, asset records, emergency plans, design records, and maintenance histories preserved across ownership or contract transitions? Are handover requirements defined?	Handover protocols, data-room requirements, concession-transfer provisions, asset-condition reports

Source: Authors' analysis

10.2 External Institutional and Governance Assessment Tool for Infrastructure Agencies

This initial self-diagnostic framework can help infrastructure agencies determine whether they have the capacity to engage, coordinate, exchange information, plan, finance, prepare, respond, recover, and learn with other public and non-public organizations and groups in areas related to disaster resilience and climate-change adaptation.

Table 1 focused on infrastructure agencies' internal organizational arrangements. The questionnaire in this section, in Table 2, focuses on the agencies' capacity in external relationships as a measure of agency capability. This tool does not assess whether the other stakeholders have adequate capacity, however; instead, it focuses on whether the infrastructure agency under consideration has the internal functions, tools, protocols, agreements, staff, and management systems needed to work effectively with these external entities.

The questionnaire is based on the discussions in Sections 4 and 5, where the relationships between key stakeholders were discussed in the context of resilient infrastructure. Relationships among ministries of finance, planning agencies, DRM agencies, land-use authorities, regulators, subnational governments, other infrastructure providers, businesses, communities, members of academia, and professional associations all influence whether infrastructure services remain reliable before, during, and after disasters.

This diagnostic evaluates both vertical relationships and horizontal relationships. Vertical relationships include those between agencies and central ministries, regulators, subnational governments, and oversight bodies. Horizontal relationships include those with other infrastructure providers, peer utilities, emergency services, and private-sector contractors, businesses, and communities.

The questions in Table 2 are organized in a similar fashion to those in Table 1. This assessment has four types of questions:

- **Existence:** Does the relationship, platform, agreement, protocol, process, or focal point exist?
- **Clarity:** Are roles, responsibilities, information flows, decision rights, and escalation routes clear?
- **Implementation:** Is the mechanism being discussed actually used in planning, budgeting, asset management, emergency preparedness, response, recovery, and learning?
- **Learning:** Is the mechanism updated after disasters, drills, audits, new climate information, or changes in institutional mandates?

The assessment also includes a list of potential documentary and operational evidence for each question. This evidence can include memoranda of understanding (MOUs), inter-agency protocols, committee TORs, minutes of inter-agency meetings, regulatory submissions, budget submissions, public investment guidelines, emergency response plans, joint drills, data-sharing agreements, GIS platforms, stakeholder engagement records, community consultation records, complaints data, post-disaster reviews, after-action reports, annual resilience reports, and audit findings.

Table 2: Initial screening tool: Questionnaire for external institutional and organizational assessment for resilience in infrastructure agencies

No.	Issue title	Issue description	Questions to assess the issue	Evidence to review
1	External resilience relationship mandate	Assesses whether the agency has a formal mandate to coordinate with other organizations on resilience and adaptation	Does the agency's legal mandate, charter, licence, concession, or policy framework authorize or require it to coordinate with other public and non-public actors on disaster resilience and climate adaptation? Are responsibilities for external engagement clearly assigned internally?	Laws, charter, licences, concession agreements, sectoral policies, agency strategy, organograms
2	Mapping of external stakeholders	Assesses whether the agency knows which organizations affect infrastructure resilience	Has the agency mapped the public, private, community, academic, financial, and professional actors that influence resilience? Does the map distinguish planning, finance, regulation, hazard data, emergency response, recovery, service interdependencies, users, and suppliers?	Stakeholder map, institutional analyses, resilience strategies, emergency plans, risk assessments
3	Prioritization of external relationships	Assesses whether the agency prioritizes the most important relationships, instead of engaging with all actors equally	Has the agency identified which relationships are critical for absorb, respond, and recover/adapt capacities? Are priority relationships reviewed periodically? Are focal points assigned for each priority actor?	Relationship matrix, stakeholder engagement plans, focal-point list, management minutes
4	Internal responsibility for external coordination	Assesses whether the agency has staff or units responsible for managing external relationships	Are there units, teams, or designated officers responsible for interagency coordination and stakeholder engagement on resilience? Are roles defined across planning, operations, asset management, emergency management, legal, communications, and finance departments?	Organogram, job descriptions, departmental TORs, coordination protocols
5	Relationship management procedures	Assesses whether engagement is systematic, rather than dependent on personal contacts	Does the agency have procedures for initiating, maintaining, documenting, and escalating relationships with external actors? Are meetings, commitments, data requests, and follow-up actions tracked?	Stakeholder engagement procedures, meeting tracker, action logs, correspondence files
6	Coordination with the MoF	Assesses whether the agency can engage with the MoF for resilience funding, fiscal risk, and recovery finance	Does the agency regularly engage with the MoF on resilience investment needs, maintenance funding, retrofitting, contingent liabilities, emergency liquidity, insurance, and post-disaster reconstruction finance? Are budget submissions supported by risk-benefit and cost-benefit analyses? Does the agency raise with the MoF issues or weaknesses related to financing of resilient infrastructure?	Budget submissions, fiscal risk notes, investment proposals, meeting minutes, financing plans

7	Coordination with the MoP or public investment authority	Assesses whether the agency aligns resilience priorities with national planning and public-investment systems	Does the agency coordinate with planning authorities on project screening, appraisal, pipeline development, territorial plans, climate-risk assessment, and prioritization of resilient investments? Are agency projects consistent with national or regional resilience plans? Does the agency raise weaknesses in the planning system with respect to resilient infrastructure?	Public investment submissions, appraisal files, pipeline documents, planning guidance, correspondence
8	Engagement with legislative or oversight bodies	Assesses whether the agency can provide information on resilience needs and performance to legislative bodies or oversight institutions	Does the agency report to parliament, councils, audit institutions, or oversight bodies on infrastructure resilience, disaster losses, maintenance gaps, adaptation needs, and recovery progress? Are hearings, reporting requirements, or audit recommendations tracked? Is resilience one of the issues discussed in engagements with legislative or oversight bodies?	Legislative reports, hearing notes, audit reports, responses to oversight bodies, annual reports
9	Relationship with DRM agencies	Assesses whether the infrastructure agency is integrated into national or subnational DRM systems	Does the agency coordinate with the DRM agency on risk reduction, preparedness, early warning systems, emergency response, damage assessment, recovery, and reconstruction? Are infrastructure-specific roles included in DRM plans?	DRM plans, sectoral emergency plans, interagency protocols, drill records, incident reports
10	Joint risk assessment with DRM authorities	Assesses whether the agency works with DRM authorities to understand infrastructure risks	Does the agency share asset data with DRM authorities and receive hazard, exposure, vulnerability, and risk information? Are infrastructure risks incorporated into national or local risk assessments?	Risk assessments, shared GIS layers, data-sharing agreements, joint technical reports
11	Coordination with code-setting and standards bodies	Assesses whether the agency engages with institutions responsible for codes, standards, and technical guidance	Does the agency participate in the development or updating of infrastructure-related codes and standards? Does it provide lessons from asset failures, maintenance records, and post-disaster damage to standard-setting bodies?	Standards committee records, technical submissions, updated design manuals, post-disaster engineering reports
12	Relationship with subnational governments	Assesses whether the agency coordinates with local governments that manage land use, local roads, drainage, emergency response, permits, or local infrastructure	Does the agency have structured relations with municipalities, provinces, districts, or regions where its assets are located? Are local hazard information, local infrastructure priorities, access constraints, and recovery needs incorporated into agency planning? Are there periodic engagements on resilient infrastructure with subnational governments?	MOUs, regional-coordination minutes, local plans, joint-inspection records, recovery plans
13	Alignment with local-development	Assesses whether the agency coordinates with local planning	Are infrastructure siting, right-of-way, drainage, access, and expansion decisions checked against	Land-use plans, zoning maps, permit files,

	and land-use plans	authorities to avoid creating or worsening risk	local land-use plans, hazard zones, zoning rules, and relocation plans?	project screening documents, siting approvals
14	Coordination with land-use and spatial planning agencies	Assesses the agency's ability to work with national or regional land-use institutions on risk-sensitive siting and nature-based solutions	Does the agency engage with land-use agencies to avoid high-risk zones, protect floodplains, preserve drainage corridors, use nature-based solutions, and plan post-disaster relocation or reconstruction?	Spatial plans, land-use protocols, environmental planning documents, project approval files
15	Relationship with infrastructure regulators	Assesses whether the agency or operator engages with the regulators on resilience, reliability, service quality, tariffs, and emergency obligations	Does the agency provide the regulator with information on resilience risks, service interruptions, investment needs, emergency preparedness, and recovery performance? Does regulatory engagement support resilience investment and service-continuity targets?	Regulatory submissions, tariff filings, licence reports, service-quality reports, correspondence with regulators
16	Coordination with high-level resilience commissions or national platforms	Assesses whether the agency participates in central resilience-coordination bodies where they exist	Is the agency represented in national, regional, or city-level resilience commissions, climate councils, infrastructure resilience platforms, or reconstruction authorities? Does participation influence agency plans and budgets?	Commission minutes, national resilience plans, action matrices, agency follow-up reports
17	Relationship with hydromet and meteorological agencies	Assesses whether the agency can access and operationalize weather, rainfall, flood, drought, heat, storm, and climate information	Does the agency receive forecasts, warnings, climate projections, and historical data in formats useful for planning, maintenance, and operations? Are trigger thresholds defined for operational action? Are there data-sharing platforms in place? Is there a system to translate early warnings into actions within the agency?	Data-sharing agreements, forecast bulletins, warning protocols, operational trigger matrices
18	Relationship with geological, seismic, landslide, volcano, or coastal hazard agencies	Assesses whether the agency engages specialized hazard agencies relevant to its assets	Does the agency obtain and use data on earthquakes, landslides, tsunamis, erosion, subsidence, volcanic hazards, coastal flooding, or other relevant hazards? Is this data linked to asset management and investment planning? Are there data-sharing platforms in place?	Hazard maps, technical studies, GIS layers, joint assessments, asset-risk overlays
19	Coordination with emergency services	Assesses whether emergency services are treated as priority users and operational partners	Does the agency coordinate with the police, fire service, ambulance, civil protection, search-and-rescue, and emergency medical services on access routes, backup services, restoration priorities, and incident command?	Emergency plans, priority route maps, restoration protocols, incident command procedures, drill reports

20	Joint preparedness and drills	Assesses whether external relationships are tested before disasters	Does the agency conduct tabletop exercises, simulation drills, field drills, or scenario exercises with DRM agencies, emergency services, local governments, regulators, operators, contractors, and other infrastructure providers? Are lessons documented and acted upon?	Drill plans, attendance records, exercise reports, after-action reviews, corrective action plans
21	Coordination on rapid damage assessment	Assesses whether the agency has arrangements to collect, verify, and share damage information after disasters	Are damage-assessment roles agreed with DRM agencies, local governments, finance ministries, insurers, emergency services, and other infrastructure providers? Are assessment forms, data standards, and reporting timelines harmonized?	Damage assessment protocols, forms, mobile data tools, post-disaster reports, training records
22	Coordination on post-disaster recovery and reconstruction	Assesses whether the agency can work with public institutions during reconstruction	Are procedures agreed upon for emergency works, temporary service restoration, reconstruction standards, financing, procurement, environmental and social review, and build-back-better decisions?	Recovery framework, reconstruction plans, emergency procurement procedures, financing agreements
23	Relationship with other infrastructure service providers	Assesses whether the agency manages cross-sector infrastructure dependencies	Has the agency identified dependencies with power, water, telecom, transport, drainage, fuel, ports, airports, hospitals, and emergency facilities? Are dependency maps and priority restoration protocols agreed upon?	Dependency maps, inter-utility agreements, restoration protocols, outage dashboards, joint plans
24	Cascading failure analysis	Assesses whether the agency works with other providers to understand how failures can propagate	Does the agency participate in joint analysis of cascading impacts, such as power–water, power–telecom, transport–fuel, or telecom–emergency response failures? Are findings used to guide resilience investment and emergency planning? Have coordination mechanisms been tested for compound events such as flood plus power outage, heat plus water stress, storm plus telecom failure, or earthquake plus transport disruption?	Interdependency studies, scenario analyses, risk workshops, post-disaster reviews
25	Shared outage and incident information	Assesses whether the agency shares operational information during disruptions	Are there arrangements for real-time or near-real-time sharing of information on outages, access, damages, crew location, road closures, power availability, water availability, telecom status, and restoration timelines?	Common operating dashboards, incident logs, data protocols, records from emergency-operations centres

26	Priority restoration coordination	Assesses whether restoration priorities are agreed upon with other agencies and providers	Are priority users and assets—such as hospitals, shelters, emergency command centres, water systems, fuel depots, telecom hubs, ports, airports, and critical routes—identified jointly? Are restoration sequences coordinated across sectors?	Priority restoration plans, critical-customer lists, emergency-operations plans, inter-agency agreements
27	Relationship with insurance and financial sector	Assesses whether the agency engages with insurers, reinsurers, banks, and financial institutions on risk financing and resilience incentives	Does the agency work with insurers or financial institutions to understand asset risk, insurance coverage, claims processes, business interruption, risk-reduction incentives, and financing options for resilience investments?	Insurance policies, claims records, risk financing strategy, lender agreements, valuation reports
28	Engagement with businesses dependent on infrastructure services	Assesses whether the agency understands how service disruptions affect businesses and supply chains	Does the agency engage with businesses, business associations, industrial zones, logistics firms, ports, tourism operators, farmers, or other major users to understand service-continuity needs and economic impacts of disruptions?	Business-consultation records, service-continuity studies, customer surveys, economic-impact assessments
29	Engagement with communities and users	Assesses whether the agency engages with ordinary users on resilience planning and recovery	Does the agency consult communities and users on service disruptions, local hazards, access constraints, maintenance problems, emergency communications, and recovery priorities? Are engagement results reflected in plans?	Consultation records, grievance logs, community-meeting minutes, user surveys, social-assessment reports
30	Engagement with vulnerable and excluded groups	Assesses whether the agency accounts for differentiated impacts of infrastructure failures	Does the agency identify and engage with groups that may be disproportionately affected by service disruptions, such as low-income communities, informal settlements, elderly people, persons with disabilities, remote communities, women, schools, and health facilities?	Vulnerability assessments, stakeholder-engagement plans, social-inclusion records, recovery-prioritization criteria
31	Relationship with NGOs and civil society organizations	Assesses whether the agency can work with organizations that support communities before, during, and after disasters	Does the agency engage NGOs, community-based organizations, humanitarian organizations, or civil-society groups that can support preparedness, communication, local risk identification, and post-disaster recovery?	MOUs, consultation records, emergency communication plans, community-

				preparedness records
32	Risk communication with users and communities	Assesses whether the agency communicates clearly before, during, and after disruptions	Are communication channels, messages, languages, responsibilities, and escalation procedures defined for warnings, service interruptions, closures, restoration timelines, safety instructions, and recovery updates?	Communication strategy, warning protocols, SMS/social media records, call-centre scripts, public notices
33	Relationship with academia and research institutions	Assesses whether the agency uses academic and technical knowledge to improve resilience	Does the agency work with universities or research institutions on hazard analysis, resilience-engineering studies, climate projections, asset-vulnerability analyses, innovation, and training? Are research findings operationalized?	Research agreements, technical studies, training records, pilot studies, joint publications
34	Relationship with professional associations	Assesses whether the agency works with professional bodies to strengthen standards and skills	Does the agency engage with engineering, architecture, or construction associations on standards, training, certification, lessons learnt, and professional capacity?	Association MOUs, training records, standards consultations, conference proceedings, certification records
35	Participation in resilience networks and peer learning	Assesses whether the agency learns from peers and contributes to sector-wide improvement	Does the agency participate in national, regional, or international infrastructure resilience networks, peer exchanges, utility associations, city networks, or sector platforms? Are lessons adapted to agency practice?	Membership records, peer-learning reports, workshop records, adopted guidance, action plans
36	External reporting and transparency	Assesses whether the agency shares resilience information with external stakeholders	Does the agency publish or provide information on climate and disaster risks, service interruptions, resilience investments, emergency preparedness, recovery progress, and lessons learnt? Is the information accessible and credible?	Annual reports, sustainability reports, resilience reports, regulatory filings, public dashboards
37	Grievance, feedback, and accountability mechanisms	Assesses whether users and stakeholders can raise concerns about resilience and service disruption	Are there channels for communities, businesses, local governments, and other stakeholders to report risks, asset failures, drainage blockages, access problems, service disruptions due to disasters, or recovery concerns? Are complaints tracked and acted upon?	Grievance logs, complaint dashboards, call-centre data, records of corrective action

38	Legal and contractual tools for external coordination	Assesses whether relationships are supported by formal instruments where needed	Are key relationships supported by MOUs, SLAs, data-sharing agreements, emergency protocols, PPP contracts, mutual-aid agreements, or regulatory requirements? Are they updated and enforceable?	MOUs, SLAs, contracts, protocols, mutual-aid agreements, legal opinions
39	Financing coordination for resilience investments	Assesses whether the agency can coordinate with external actors to mobilize financing	Does the agency have clear coordination mechanisms with the MoF, DRM and reconstruction agencies, regulators, donors, lenders, insurers, private partners, and local governments to fund resilience investments, retrofits, preparedness, and recovery?	Financing plans, donor agreements, tariff submissions, budget proposals, investment plans
40	Coordination on procurement and emergency contracting	Assesses whether the agency can work with other institutions to accelerate procurement during emergencies	Are emergency procurement rules, framework contracts, supplier mobilization, quality assurance, and anti-corruption safeguards coordinated with finance, procurement, audit, and oversight institutions?	Emergency procurement procedures, framework contracts, audit guidance, supplier panels
41	Post-disaster learning with external actors	Assesses whether the agency learns jointly with partners after disasters	Are after-action reviews conducted with DRM agencies, emergency services, local governments, regulators, contractors, communities, and other infrastructure providers? Are lessons converted into updated protocols, designs, budgets, and training?	After-action reviews, lessons-learnt reports, revised protocols, corrective-action trackers
42	Monitoring of relationship performance	Assesses whether the agency measures the effectiveness of external coordination	Does the agency track indicators such as number of joint drills, data-sharing timeliness, unresolved interagency actions, restoration-coordination performance, stakeholder satisfaction, and completion of joint resilience actions?	KPI dashboard, coordination scorecards, management reports, action trackers

Source: Authors' analysis

10.3 Lessons Learnt from Institutional Assessments of Public Organizations

The self-assessment tools presented in Tables 1 and 2 are inspired by a wide range of existing tools and methodologies for institutional assessment of public organizations and national systems. Many of these tools are designed for DRM and climate-change adaptation. Annex 1 presents a summary of these tools.

Institutional assessments are most useful when they are treated not as standalone reports, but as structured processes helping infrastructure agencies to shape organizational change, prioritize scarce resources for capacity building, and drive consensus on necessary reforms. Drawn from the tools presented in Annex 1, the following list of lessons is applicable to infrastructure agencies on an institution-strengthening journey:

- **Both formal mandates and actual practice must be assessed:** Many public organizations in developing countries have formal mandates that look adequate on paper but are not implemented in practice. Institutional assessments therefore need to distinguish between de jure arrangements, such as laws, decrees, cabinet decisions, official national strategies or policy documents, and de facto arrangements that define who actually convenes meetings, controls data, allocates budget, approves plans, manages crises, and resolves conflicts (World Bank, 2021b).

- **Institutional capacity requires an enabling environment, organization, and individuals:** Capacity weaknesses rarely sit at one level only. A ministry may have capable staff, but no legal authority; a local government may have a legal mandate, but no fiscal space; an emergency agency may have equipment, but weak protocols; a resilience unit may have expertise, but no influence over planning or budget decisions (UNDP, 2008).

- **Capacity building of institutions should not be reduced to training:** Training may be useful, but it will not solve problems caused by unclear mandates, fragmented budgets, absent data-sharing rules, weak incentives, high turnover, or lack of authority to coordinate other agencies (UNDP, 2009).

- **Build ownership through participation, but do not let self-assessment replace evidence:** The institutional assessments that rely partly on self-assessment, workshops, scoring, or facilitated dialogue are more effective, because public officials recognize the gaps themselves and agree on priorities. However, self-assessment can also produce optimistic scoring, institutional defensiveness, or consensus around the least controversial issues. The best assessments therefore combine participatory scoring with documentary evidence, administrative data, budgetary data, field observations, simulations, and structured interviews (MCR2030, n.d.b).

- **Assessments must impact budget and implementation:** Institutional assessments often fail because they produce recommendations that are not linked to budget cycles, public-investment systems, civil-service rules, or sectoral planning processes. The more useful recommendations are those that specify the decision instrument through which reform will happen: a legal amendment, a cabinet decision, a budget circular, a public-investment guideline, a staffing plan, an M&E framework, an operating procedure, an intergovernmental transfer rule, or a training curriculum (Bird et al., 2012).

- **It is more useful to prioritize a sequenced reform roadmap rather than address a long list of gaps:** Public organizations in developing countries often operate under severe constraints such as limited staff with insufficient skills, weak data, political turnover, low recurrent budgets, overlapping mandates, donor fragmentation, and limited implementation bandwidth. A diagnostic

that identifies every weakness is not very helpful per se. A stronger approach is to classify recommendations into immediate actions that can be undertaken by existing authorities; medium-term reforms requiring budgetary or administrative changes; and longer-term reforms requiring legal, institutional, or fiscal change (World Bank, 2012b).

- **Institutional assessments should clarify not only capacity gaps, but accountability:** Accountability gaps happen when no one is clearly responsible for maintaining data, convening agencies, enforcing standards, updating plans, reporting progress, or funding local implementation. In these cases, adding more capacity without clarifying accountability will not solve the problem. A stronger assessment asks questions such as: Who is accountable for the function? To whom do they report? What happens if the function is not performed? Are responsibilities duplicated or unfunded? Is there a public reporting mechanism? Are there performance indicators? (World Bank, 2021b)

- **Assessments should not only make the political economy visible, but translate it into practical reform choices:** Institutional assessments are not political-economy studies, but they should recognize that institutional and policy reforms affect power, budgets, staffing, authority, and visibility. An institutional assessment should determine the feasibility of reform by asking which changes are technically necessary, which are politically feasible, which require coalition-building, and which are best sequenced later (World Bank, 2012b).

- **Institutional assessments should encompass frontline delivery units, not only headquarters:** Assessing only central units or headquarters may miss a major source of implementation failures. For infrastructure, DRM, and adaptation, the most important capacity constraints may sit in district offices, municipal engineering teams, road maintenance units, water utilities' district offices, inspection teams, or schools. Headquarters may have strategies and standards, while frontline units lack staff, equipment, operating budgets, delegated authority, or practical guidance (World Bank, 2003).

- **Data governance should be addressed as an institutional function, not only as a technical issue:** Many institutional assessments identify "lack of data" as a constraint but do not examine why data is missing, inaccessible, low-quality, or unused. For public institutions, data governance is an institutional issue: Who owns the data? Who updates it? What standards apply? Who can access it? Are there protocols for sharing? Is data linked to planning, budgeting, procurement, asset management, emergency response, and public reporting? In the context of DRM and climate adaptation, fragmented data on hazards, exposure, and assets, as well as inadequate fiscal and socioeconomic data, can prevent agencies from making risk-informed decisions even when technical models exist (World Bank, 2026a).

- **Findings must translate into different products for different decision makers:** A common weakness of institutional assessments is that they produce a single long report, ostensibly intended for all audiences. In practice, ministers, permanent secretaries, agency heads, technical directors, budget officials, local offices, donors, and implementation teams need different products. Senior officials may need a short decision note with 3–5 reform choices. Technical teams may need a detailed action matrix. Budget officials may need only the costing and fiscal implications. Local offices may need guidance notes, templates, or training materials.

- **Assessments must pay special attention to the organization's capacity to learn and adapt over time:** Public institutions working on disasters, climate adaptation, infrastructure, and public-service delivery face changing risks. Institutional assessments should therefore examine whether the organization has mechanisms to learn, such as after-action reviews, post-disaster lessons

learnt, audit follow-ups, citizen feedback portals, complaint mechanisms, peer learning, or communities of practice, among others (OECD, 2025).

- **The assessment of external accountability mechanisms is critical, especially where public trust matters:** Institutional assessments should examine not only internal government capacity but also how institutions are accountable to citizens, firms, civil society, parliament, audit institutions, regulators, affected communities, and service users. This is especially important for infrastructure agencies where decisions affect public safety, tariffs, public investment, and access to services. External accountability mechanisms can include publication of plans and budgets, public dashboards, grievance redressal processes, parliamentary reporting, audit follow-ups, stakeholder consultations, independent monitoring, and citizen feedback (Open Government Partnership, 2025).

Annex 1. Institutional and Organizational Tools and Frameworks for Public Institutions and DRM/Climate Change Adaptation Systems

Methodology/Tool	Primary use	Core approach	Institutional dimensions commonly assessed	Strengths	Best use in DRM/adaptation
UNDP Capacity Assessment Methodology (UNDP, 2008)	General capacity assessment for development planning, public institutions, and capacity-development responses: It is not DRM- or adaptation-specific, but is frequently used or adapted in climate and disaster-risk contexts	Provides a step-by-step methodology for assessing existing and desired capacities and using the findings to formulate a capacity-development response	Enabling environment, organizational capacity, individual capacity, stakeholder engagement, situation assessment, policy formulation, budgeting, implementation, and evaluation	Flexible, applicable to many types of public organizations, and explicitly links diagnosis to capacity development	Useful as a foundational methodology for assessing ministries, local governments, DRM agencies, climate units, or interministerial mechanisms where the main focus is institutional capacity for planning, implementation, coordination, and monitoring
UNDP Institutional and Context Analysis (UNDP, 2012)	Analysis of the political economy and the institutional context to support development programming, reform-feasibility assessment, and risk management	Provides practical guidance for understanding formal and informal institutions, incentives, actors, power relations, and political constraints that affect whether reforms can be implemented	Formal and informal institutions, stakeholder incentives, power relations, risks, reform coalitions, enabling environment, and feasibility of policy implementation	Helps avoid technically sound but politically unrealistic recommendations; useful for understanding why formal mandates may not translate into action	Useful when DRM or adaptation reforms require changes in mandates, budget authority, interministerial coordination, decentralization, land-use controls, or enforcement systems
World Bank Climate Change Institutional Assessment (World Bank, 2021b)	Assessment of national institutional frameworks for climate-change governance, with emphasis on how governments organize, coordinate, finance, implement, and sustain climate action	Identifies strengths and weaknesses in the institutional framework for climate-change governance. It is aimed at centre-of-government agencies, climate policy–lead agencies, planning and finance institutions, and interministerial climate bodies	Climate-policy mandates, coordination, planning, finance, implementation, accountability, continuity across political cycles, and links between central agencies and sector institutions	Well-suited to diagnosing whether a country has the institutional architecture needed to mainstream climate change across government	Useful when governments need to understand whether climate-change responsibilities are clearly assigned, whether central agencies are effectively involved, and whether climate priorities are linked to planning, finance, and implementation systems
CADRI Capacity Diagnosis and Planning Tool (CADRI, 2021)	National, local, and sector-specific capacity diagnosis for DRR and	Partnership-based capacity-diagnosis methodology that assesses capacities for	Policies, institutional arrangements, governance, implementation capacity, financing, knowledge,	It can be applied nationally, locally, or sectorally and is designed to move from diagnosis to	Useful when a government wants a broad, system-level assessment of

	climate-change adaptation	reducing disaster and climate risks. It can focus on DRR and climate adaptation, disaster preparedness, adaptation, or risk-information capacity	technology/equipment, skills, methodologies, coordination, inclusion, gender responsiveness, and attention to vulnerable groups	capacity-development planning	DRM and climate risk–management capacity as well as a capacity-development roadmap
UNDRR Disaster Resilience Scorecard for Cities (UNDRR, 2017a)	Local-government assessment of disaster resilience, aligned with the Sendai Framework and the Making Cities Resilient agenda (UNDRR, 2015)	Provides a structured assessment for local governments, organized around UNDRR's *Ten Essentials for Making Cities Resilient* (MCR2030, n.d.c). Supports baseline analysis, Sendai Framework monitoring, and preparation of DRR and resilience strategies	Governance, risk understanding, financial capacity, urban development, ecosystem protection, institutional capacity, infrastructure resilience, societal capacity, and disaster response and recovery	Practical, participatory, and accessible for cities, it creates a structured conversation across municipal departments and stakeholders and can lead directly to a city resilience–action plan	Useful for municipalities and metropolitan governments seeking to assess disaster resilience, identify institutional gaps, and prepare or update local resilience strategies
World Bank / GFDRR Ready2Respond Diagnostic (World Bank, 2025a)	Assessment of emergency preparedness and response systems at the national, subnational, or municipal level	Assesses the strength of an emergency-preparedness and response system through a structured framework covering facilities, equipment, personnel, information systems, and legal frameworks	Legal and institutional arrangements, staffing and personnel, emergency facilities, equipment, information systems, command-and-coordination arrangements, alert systems, and response protocols	Operational and investment-oriented, it produces a diagnostic report and an investment plan for short-, medium-, and long-term emergency-preparedness investments	Useful when the reform question concerns readiness to respond to shocks: emergency operations centres, alert systems, staffing, equipment, command arrangements, information flows, and response protocols
GFDRR Building Regulatory Capacity Assessment: Level 1 Initial Screening (GFDRR, 2017)	Initial screening of building regulatory capacity, especially where governments need to understand whether building-code and construction-permitting systems can reduce disaster and climate risks in the built environment	Provides an initial diagnostic for assessing the capacity of building regulatory systems; helps identify whether deeper assessment or reform support is needed for building regulation, code implementation, permitting, inspection, and enforcement	Legal and regulatory framework, institutional mandates, building-code administration, permitting, inspection, compliance, enforcement, professional capacity, data, coordination, and implementation gaps	Practical entry-point tool for governments and development partners; useful for quickly identifying weaknesses in building regulations before designing deeper reforms	Useful in DRM and adaptation when unsafe construction, weak enforcement of building codes, informal expansion, seismic risk, flood risk, wind risk, or climate-resilient construction standards are central concerns
Climate Public Expenditure and	Assessment of the relationship between climate policy, institutions,	Examines linkages between the national climate policy, institutional	Policy coherence, institutional responsibilities, budget formulation, expenditure	A useful tool for linking institutional mandates to actual financial flows; helps	Useful when governments need to understand

Institutional Review (Bird *et al.*, 2012)	and public expenditure	structures, and resource-allocation processes through which public funding is made available	classification, climate relevance of spending, intergovernmental fiscal arrangements, and monitoring of climate finance	identify whether climate and adaptation priorities are reflected in budgets	whether climate or adaptation policies are backed by budget allocations and whether institutions have systems to plan, tag, track, and report climate-related spending
OECD Climate Adaptation Investment Framework (OECD, 2025)	Guidance on governance, policy coherence, and investment conditions for climate adaptation	Provides non-prescriptive guidance on domestic policy areas that enable adaptation investment and support credible national adaptation strategies, plans, and frameworks	Policy coherence, planning, finance, investment-enabling conditions, monitoring systems, institutional coordination, and governance arrangements for adaptation	Useful for connecting adaptation governance to finance, investment, and whole-of-government policy coherence	Useful as a benchmark for assessing whether adaptation-governance arrangements have created credible, investable, and monitorable adaptation programmes
PEFA—Public Expenditure and Financial Accountability Framework (PEFA, 2016)	Assessment of public financial-management systems at the national or subnational level	Provides a standardized framework for assessing and reporting on the strengths and weaknesses of an organization engaged in public financial management	Budget reliability, transparency of public finances, management of assets and liabilities, policy-based fiscal strategy and budgeting, predictability and control in budget execution, accounting and reporting, external scrutiny and audit	Widely recognized, comparable across countries and over time, and useful for identifying whether public institutions can plan, allocate, execute, and account for public resources	Useful when DRM or adaptation reforms depend on budget credibility, climate-budget tagging, contingency funds, fiscal transfers, procurement, audit, or execution of public investment
MAPS—Methodology for Assessing Procurement Systems (MAPS Initiative, 2025)	Assessment of public procurement systems at the national, sectoral, or agency level	Provides an international standard and harmonized methodology to evaluate public procurement systems	Legal and regulatory framework, institutional and management capacity, procurement operations, market practices, integrity, accountability, transparency, e-procurement, professionalization, and sustainable procurement	Highly relevant to reform design because procurement weaknesses often explain why policy priorities are not implemented; supports harmonized system-development and reform initiatives	Useful when DRM or adaptation investments require transparent, efficient, climate-sensitive, emergency-ready, and sustainable procurement systems
World Bank Country Policy and Institutional Assessment—CPIA (World Bank, 2022)	Annual assessment of the quality of a country's policy and institutional framework, especially for IDA countries	Assesses the conduciveness of policy and institutional frameworks to poverty reduction, sustainable growth, and effective use of development assistance	Economic management, structural policies, policies for social inclusion and equity, and public-sector management and institutions that operate in the public-sector cluster, which includes property rights, governance, budgetary and financial	Broad, comparable, and useful as a country-level institutional benchmark, though less operational than a detailed diagnostic	Useful as background context for DRM and adaptation operations, especially to understand broader public-sector management, transparency,

			management, revenue mobilization, public administration, transparency and accountability		budget, and institutional-risk conditions
OECD/SIGMA Principles of Public Administration Assessment Methodology (OECD, 2024a)	Assessment of public administration systems, especially in EU candidate and neighbourhood contexts, but relevant as a public-administration benchmark more broadly	Provides a comprehensive framework for assessing public administration against *The Principles of Public Administration* (OECD, 2023), with the SIGMA methodology examining both formal pre-conditions and actual performance in practice	Strategic framework for public administration reform, policy development and coordination, public service and HR management, accountability, service delivery, public financial management, procurement, and external audit	Strong whole-of-government public administration framework; valuable because it assesses both rules and actual implementation	Useful where DRM or adaptation reforms depend on civil-service capacity, policy coordination, accountability, service delivery, decentralization, or public financial management
World Bank GovTech Maturity Index—GTMI (Dener, 2022)	Assessment of public-sector digital transformation and GovTech maturity	Measures maturity across four GovTech focus areas, using 48 indicators	Core government systems, shared digital infrastructure, digital public services, citizen engagement, strategy, institutions, laws and regulations, digital skills, innovation policies, and programmes	Useful for assessing whether public organizations have the digital foundations needed for modern administration, transparency, service delivery, and data-driven management	Useful where DRM or adaptation reforms rely on digital registries, risk-data platforms, early warning systems, digital service delivery, citizen engagement, or interagency data-sharing
World Bank Government Analytics Handbook approach (Rogger & Schuster, 2023)	Diagnostic use of administrative data to assess public administration and organizational performance	Introduces "government analytics", using government administrative data and records to diagnose public administration and improve public-sector productivity	Payroll, HRMIS, procurement, case-management, budget, service delivery, text, and administrative-workflow data; organizational productivity; staffing patterns; management practices; and performance bottlenecks	Moves institutional assessment beyond interviews and organograms by using administrative microdata to diagnose how public organizations actually work	Useful where DRM or adaptation agencies need to diagnose staffing, workload, procurement delays, case backlogs, data quality, implementation bottlenecks, or service-delivery performance

Source: Authors' analysis

Notes: HRMIS: Human Resource Management Information System

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