CDRI
Coalition for Disaster Resilient Infrastructure

Global Infrastructure Resilience Working Paper

Impacts on Businesses

The Hidden Cost of Disasters

GIR GIRS
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 *Impacts on Businesses: The Hidden Cost of Disasters*, provides a comprehensive global perspective on how large businesses, infrastructure companies, and small and medium enterprises (SMEs) are confronting climate and disaster risks while highlighting the critical role of resilient infrastructure services in enabling business continuity, safeguarding profitability, and supporting faster recovery across value chains. 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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Global Infrastructure
Resilience Working Paper

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Acronyms

AAL	Average Annual Loss
AIVR	Automated Intelligent Video Review
BCG	Boston Consulting Group
BCP	Business Continuity Plan
CDRI	Coalition for Disaster Resilient Infrastructure
DRM	Disaster Risk Management
EBITDA	Earnings Before Interest, Taxes, Depreciation, and Amortization
ESG	Environmental, Social, and Governance
FGD	Focus Group Discussion
GDP	Gross Domestic Product
GIR	Global Infrastructure Resilience
GIRI	Global Infrastructure Risk Model and Resilience Index
ITC	International Trade Centre
IV	Intravenous
LiDAR	Light Detection and Ranging
MTA	Metropolitan Transit Authority
NTPC	National Thermal Power Corporation
PG&E	Pacific Gas & Electric
SME	Small and Medium Enterprise
SOP	Standard Operating Procedure
UNDP	United Nations Development Programme

Key Messages

A survey of over 500 businesses across close to 50 countries was conducted across all regions to understand the impacts of disasters on infrastructure, business operations, and profitability.

Most large businesses are prepared for disasters, with 82 percent reporting that they have a business continuity plan in place. However, close to 40 percent have never tested these plans. Additionally, 40 percent do not have detailed standard operating procedures or execution guidelines for their disaster response plans. Building the resilience of businesses requires more than isolated interventions; it demands a systemic approach that embeds resilience at every stage of the business lifecycle—from strategy and planning to operations.

Firms that build end-to-end resilience capabilities can better absorb, respond to, and recover from disasters, resulting in shorter downtime and faster market share recovery.

The survey results show that nearly two-thirds of the participating companies lack access to reliable providers of resilience solutions. The market opportunities are therefore significant. While insurance penetration is high among large businesses, more than 40 percent are aware that they do not have sufficient coverage for disasters.

The vulnerability of businesses is determined not only by the geo-climatic hazards faced by company sites but also by the resilience of their suppliers, logistics, and customers. For many industries, value-chain risks, such as disruptions in input supply and blocked logistics nodes, may be more important than direct damage to their facilities. According to the results, 85 percent of large firms do not take supplier resilience into account during vendor selection.

Businesses consistently call for greater engagement from governments in strengthening infrastructure services. As many as 77 percent of respondents report that government policies for resilience are either absent or poorly enforced.

The survey results show that infrastructure operators are better prepared for disasters than other large businesses. As infrastructure services are their core business, they place greater emphasis on resilience. Small and medium enterprises are the least able to cope: while they understand the impacts of infrastructure failures, they lack the capacity and financing to absorb and respond to such shocks.

Executive Summary

1. Executive Summary

The Pilot Global Business Survey on Infrastructure Resilience offers a comprehensive global view of how large businesses, infrastructure companies, and small and medium enterprises (SMEs) are confronting rapidly escalating risks posed by geo-climatic hazards and disasters. With inputs from over 500 respondents across more than 50 countries and diverse industry sectors, the results of the survey shed light on preparedness gaps, emerging resilience practices, and areas requiring urgent systemic intervention.

The survey results also underscore the critical role of resilient infrastructure services in enabling business continuity, safeguarding profitability, and supporting faster recovery across the value chain. Together, these insights inform both business decision-making and policy action aimed at strengthening resilience at scale.

1.1 The Rising Cost of Inaction

The world is now experiencing nearly 9,000 disasters every 25 years, a twofold increase over the previous quarter-century. Economic losses have quadrupled, exceeding $3.7 trillion[1] globally during 2000–2025 (Centre for Research on the Epidemiology of Disasters, n.d.). In addition to the physical destruction of infrastructure, disasters have cascading impacts—disrupting energy, water, and telecommunications systems; halting business operations; and reshaping supply chains and employment structures.

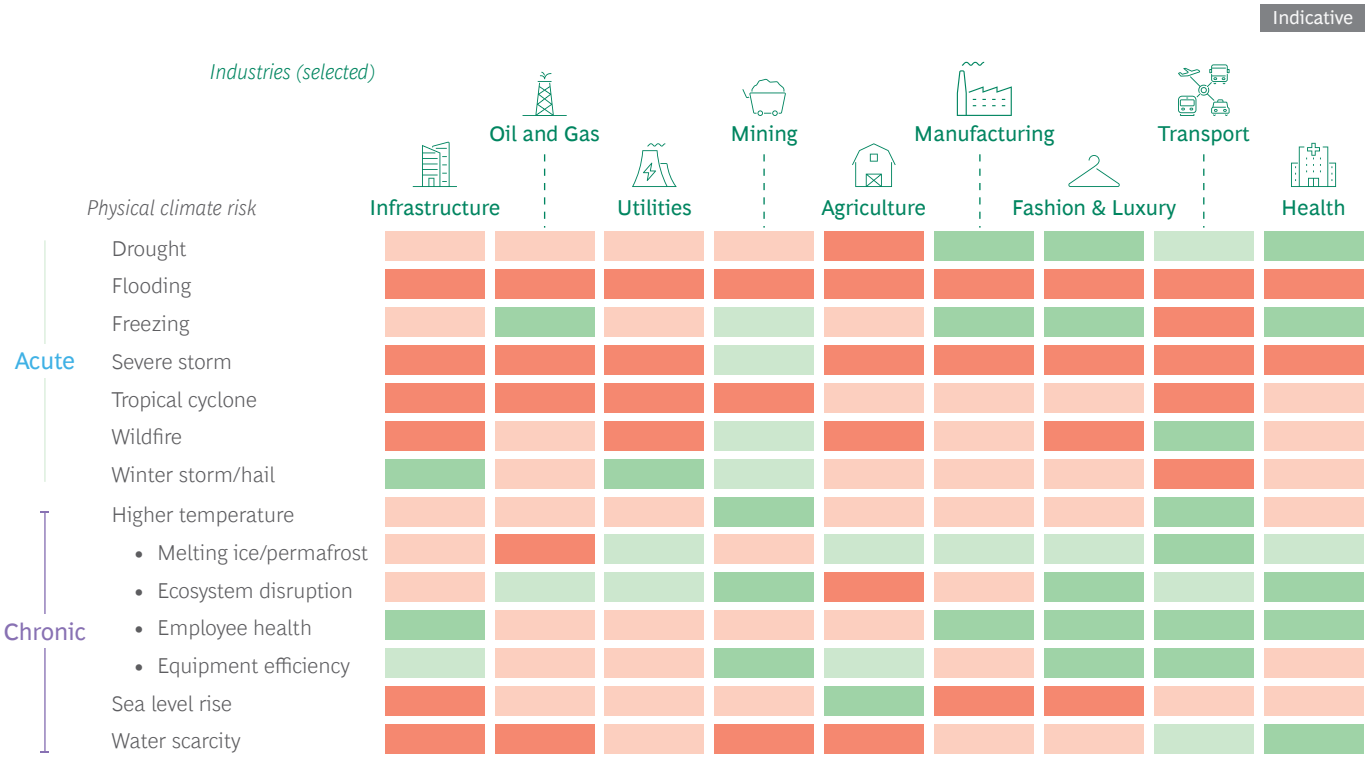
Lifeline infrastructure sectors, such as transport, power, water, and telecommunications, face the most direct exposure, with damage to shared networks rapidly propagating across the entire economy. Businesses across sectors—large enterprises and SMEs—are deeply affected by interdependent vulnerabilities embedded throughout their value chains, from sourcing and manufacturing to logistics, retail, and access to end markets. Disruptions in infrastructure services can stall operations for weeks, erode revenues, and generate significant opportunity costs, even for firms with otherwise resilient internal processes.

Together, these dynamics underscore how the rising cost of inaction on infrastructure resilience is translating into mounting economic, operational, and systemic risks. It is important to acknowledge the impacts of disasters on SMEs that could, in turn, impact the gross domestic product (GDP) of a country.

In addition to damage to physical assets of businesses, disasters have cascading impacts due to critical infrastructure failures and service disruptions. These impacts are already being felt by companies across all sectors (BCG, 2023) (Figure 1).

[1] Unless otherwise specified, all values preceded by the '$' symbol are in US dollars.

Figure 1: Acute and chronic climate-related hazards affecting different industries



Source: BCG (2023)

The impacts of infrastructure failures due to disasters on businesses are twofold:

- **Direct impacts**: These include damage to buildings, physical assets, and shared facilities. These impacts can cause depreciation, require replacement or relocation, lead to production stoppages or interrupted business operations, and increase insurance and reconstruction costs over time.
- **Indirect impacts**: These are owing to damages to critical infrastructure systems and the disruption of services such as transportation (railways, roadways, ports, and airports), water supply systems, telecommunications (antennas or cables), and energy systems (electric grids and gas and oil pipelines). These may lead to supply chain disruptions, market changes, workforce availability issues, and significant opportunity costs due to slowed or interrupted business operations.

The survey categorized entities into three distinct groups to enable a comparative understanding of resilience gaps and capacities across organizational scale and function.

- **Large non-infrastructure businesses**: These include businesses in sectors such as manufacturing, agribusiness, real estate, and logistics, which are highly dependent on critical infrastructure and

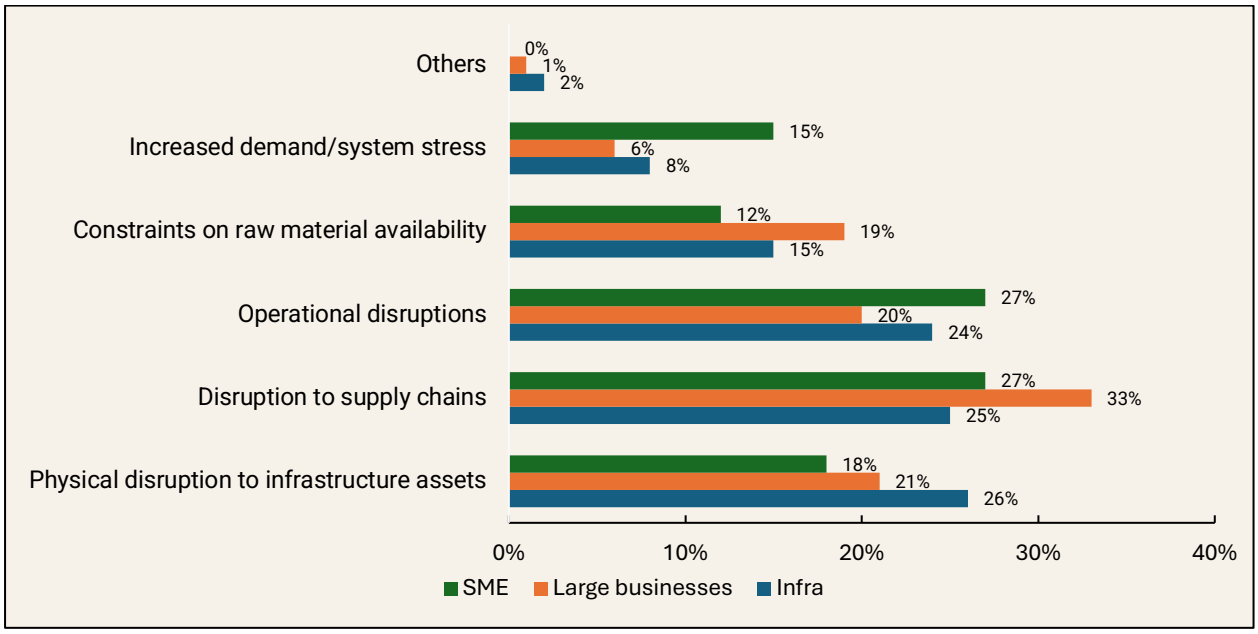
services to support operations and supply chains. Infrastructure failures caused by climate and disaster events translate rapidly into production stoppages, lost revenue, cost spikes, and working capital constraints. For large businesses, risk is not limited to their own sites; disruptions across the value chain (suppliers, transport corridors, utilities, and customers) can exceed direct asset damage and trigger cascading, system-wide impacts.

- **Private infrastructure companies and state-owned enterprises providing infrastructure services:** These include water and power utilities, railways, ports and airports, and telecommunications operators. These entities manage and operate critical infrastructure assets that are lifelines for communities, businesses, and the economy during both normal conditions and emergencies.

- **SMEs**: The lifeblood of both infrastructure companies and large businesses, SMEs include suppliers, service providers, and operational linkages across value chains. From logistics and construction to agribusiness and manufacturing, they ensure continuity and efficiency in day-to-day operations. As there is no universal definition of SMEs, this survey used an annual turnover–based classification for small enterprises (less than $10 million) and medium enterprises ($10–$50 million).

Figure 2: Top risks faced by large businesses, infrastructure companies, and SMEs

Respondents' views of the top risks to their businesses/infrastructure assets posed by geo-climatic events and disasters



1.2 The Path Forward: Embedding Resilience Across the Project and Business Lifecycles Is a Must

A lifecycle and system-wide approach is essential. This working paper underscores the importance of embedding resilience at every phase—Absorb, Respond, and Recover—using five strategic levers.

Building resilience requires a lifecycle and system-wide approach that spans the full range of how large businesses, infrastructure companies, and SMEs plan, operate, and evolve. This working paper highlights three interlinked stages of resilience (as per the integrated analytical framework) across the project and business lifecycles—Absorb, Respond, and Recover—that together determine a business entity's ability to withstand shocks, limit disruptions, and sustain long-term value.

Absorb
Refers to the ability of businesses, infrastructure companies, and SMEs to withstand shocks without complete failure by embedding resilience upfront. The absorption capability encompasses proactive governance, regulatory compliance, resilient technologies, financial buffers, and operational redundancies, such as back-up systems and alternative sourcing. Strong absorption minimizes immediate business or service disruptions and cascading failures across interconnected value chains.

Respond
Refers to the ability to act swiftly and decisively during a disruption to stabilize operations and protect critical services. Effective response capability encompasses apt and fit-for-purpose crisis management protocols, real-time data and technology deployment, flexible supply chains, and empowered decision-making. Rapid response reduces downtime, prevents escalation, and preserves trust with customers, employees, and partners.

Recover
Refers to the ability to restore and normalize operations quickly while strengthening future resilience. Recovery capability goes beyond repair: it leverages financial reserves, technology, and governance mechanisms to rebuild better, adapt operating models, and embed the lessons learned. Faster and smarter recovery enables businesses and infrastructure providers to regain financial stability, restore supply chains, and emerge from the disasters more competitive.

This working paper further explores how these resilience capabilities could be enabled through five strategic levers—policy and regulation, technology, finance, governance, and capacity building—which together shape how resilience is embedded and sustained at scale across large businesses, infrastructure companies, and SMEs. These levers have been critically chosen as they comprehensively cover any business entity's operations:

- **Policy and regulation**: This lever represents the fundamental government interface of a business entity. The better the policies and regulations of any country, the greater the investment by the private sector, leading to a stable growing economy. They also play a critical role in building resilience. This working paper explores the impacts of policy and regulations on all types of business entities.
- **Technology**: Technology plays an important role in embedding resilience in operations, and the working paper explores through case studies and best practices, the technologies and trends that entities have utilized.
- **Finance**: Building resilience in planning/design and across the project and business lifecycles can prevent or minimize significant economic losses. Adequate financial resources must be allocated upfront within cash flows to embed resilience. This working paper explores how different financing instruments have been utilized by business entities.
- **Governance**: An effective internal governance structure is the cornerstone of resilience building. This working paper provides evidence showing that business entities with strong internal governance structures have fared better during disasters.
- **Capacity building**: People are at the centre of any business entity. As the frequency and types of disasters increase globally, continuous workforce learning demands immediate attention. This working paper attempts to bring relevance to capacity development by examining trends and case studies across all operational aspects.

Stakeholders must work together to drive systemic change; governments, infrastructure operators, businesses, financiers, SMEs, and consumers all have distinct and complementary roles to play.

Governments must set clear policy signals and enable resilient infrastructure investment; infrastructure operators must integrate resilience across planning, operations, and recovery; financiers and insurers must align capital and risk pricing with resilience outcomes; and businesses, including SMEs, must embed adaptability throughout their value chains. Consumers and communities also play a critical role by shaping

demand for reliable, resilient services. Only through coordinated action across this ecosystem can resilience be scaled to protect economic stability and long-term growth.

1.3 Key Insights from the Business Survey

The insights presented below are anchored in five strategic levers and highlight resilience gaps across three phases of the resilience lifecycle.

Large Businesses

The survey responses in Table 1 show that most businesses have governance systems for risk management; 82 percent report that they have a business continuity plan (BCP) in place. However, 39 percent have not tested these plans, and 40 percent indicate that they do not have detailed standard operating procedures (SOPs) or execution guidelines for their disaster response plans.

The survey responses show that while 61 percent of businesses conduct annual risk assessments, less than half use publicly available climate and disaster risk assessment tools. Furthermore, only 37 percent indicate that they have dependable access to vendors or service providers of early warning systems and digital risk analytics.

Regarding the ability to respond to disasters, the survey results show that even large businesses have not institutionalized disaster response procedures, with 60 percent relying on ad hoc responses. Furthermore, 40 percent cited a lack of clarity in regulations, funding, or risk data as significant barriers to the design and implementation of effective disaster response systems.

Fifty-two percent of the respondents indicate that they do not have a dedicated crisis response team. Many businesses still assess geo-climatic hazards in isolation and miss opportunities to leverage real-time, data-driven insights from national and global forecasting systems. Furthermore, coverage often focuses on site-level hazards, overlooking another critical layer of exposure, namely, the indirect risks embedded across the value chain. For many industries, value-chain risks, such as disruptions in input supplies and blocked logistics nodes, may be greater than direct exposure in the form of damage to owned facilities.

Table 1	Survey insights from large non-infrastructure businesses

Sector	Absorb	Respond	Recover
Policy and regulation		77% said that government policies for climate/disaster-related risks and resilience are either absent or poorly enforced	Of the remaining, ~60% have benefitted from • concessional loans • tax incentives • subsidies
Technology	70% use climate/disaster resilient technologies, such as • digital tools for climate risk analysis • early warning systems • physical risk reduction measures		
	Yet only 37% have reliable access to suppliers or service providers		
Finance	58% have allocated 1%–10% of their budget for resilience and emergency preparedness; 37% have not allocated any funds		87% have insurance, but 42% only have partial coverage
			52% rely solely on traditional insurance; only 8% use parametric or catastrophe bonds
Governance	82% have a BCP for operational continuity during disruptions, but 39% have not fully tested it		
	82% have a disaster risk management plan (DRM) of which 40% lack detailed SOPs/guidelines		
	61% conduct risk assessments annually	60% have underestimated risks or rely on ad hoc measures, while 40% cited lack of regulatory clarity, data, or funding as the key barriers to not implementing a DRM policy	72% recovered within a month after the last hazard/disaster
	Yet, 47% are unaware of or do not use publicly available risk assessment tools		33% cited delays caused by slow external support (e.g., government aid) when restoring critical operations
	3% reported >10% loss in the last five years; 5% have not assessed their losses		
Capacity building	16% reported a shortage of skilled personnel when restoring critical operations	52% lack a crisis management team or find that existing ones are ineffective in responding to geo-climatic hazards or events	
	Only 30% are planning to improve internal capabilities, focusing on workforce preparedness and leadership training		

Infrastructure Companies

The survey included a special focus on infrastructure companies (public and private) that provide infrastructure services on a commercial basis across different sectors, such as aviation, rail, port, and road transport; telecommunications; power and energy; and water and sanitation. These sectors are highly vulnerable to geo-climatic disasters, as shown by the Global Infrastructure Risk Model and Resilience Index (GIRI) in the *Global Infrastructure Resilience* (GIR) 2023 report.

Not only do these sectors incur direct damage from geo-climatic hazards and disasters, but their disruption causes widespread downstream impacts due to the high degree of interdependence. For example, a power outage that knocks out pumps and mobile networks has the potential to amplify socioeconomic consequences and threaten the continuity of essential services.

Table 2 presents globally aggregated survey findings based on responses from infrastructure businesses.

The survey results show differences between the responses of infrastructure companies and those of large businesses. For example, infrastructure companies perceive a higher degree of government policy support and enforcement for resilience (71% versus 77% for large businesses).

The sectors that perceive lower levels of government policy support and enforcement for resilience are ports (83%), rail (77%), and roads (76%). At the other end of the spectrum, water companies report the highest levels of policy support and enforcement, with only 44 percent indicating an absence of policies or poor enforcement. This perception may be related to a greater understanding of the need for resilience for services considered by users and communities to be critical to their health and well-being.

The survey responses show that infrastructure companies tend to use resilience-building technologies more frequently (78% versus 70% for other large companies). In terms of sectoral breakdown, power (87%), water (80%), and roads and ports (76%) have the highest usage rates of technological solutions for resilience building (such as risk analysis, early warning systems, and risk reduction assessment tools), while rail companies have a 74 percent usage rate. Infrastructure companies also have greater access to reliable suppliers of resilience-building technologies (46% versus 37% for other large companies), indicating that the resilience goods and services market is increasingly focusing on infrastructure companies as clients.

Table 2 **Survey insights from infrastructure businesses**

Sector	Absorb	Respond	Recover
Policy and regulation		71% said that government policies for climate/disaster-related risks and resilience are either absent or poorly enforced	Of the remaining, ~67% have benefitted from • concessional loans • tax incentives • subsidies
Technology	78% use climate/disaster resilient technologies, such as • digital tools for climate risk analysis • early warning systems • physical risk reduction measures		
	Yet only 46% have reliable access to suppliers or service providers		
Finance	61% have allocated 1%–10% of their budget for resilience and emergency preparedness; 24% have not allocated any funds		90% have insurance, but 45% only have partial coverage
			50% rely solely on traditional insurance; only 13% use parametric or catastrophe bonds
Governance	86% have a BCP for operational continuity during disruptions, but 37% have not fully tested it		
	80% have a DRM policy of which 28% lack detailed SOPs/guidelines		
	63% conduct risk assessments annually	57% have underestimated the risks or rely on ad hoc measures, while 37% cited lack of regulatory clarity, data, or funding as the key barriers to not implementing a DRM policy	79% recovered within a month after the last hazard/disaster
	Yet, 33% are unaware of or do not use publicly available risk assessment tools		37% cited delays caused by slow external support (e.g., government aid) when restoring critical operations
	4% reported >10% loss in the last five years; 5% have not assessed their losses		
Capacity building	23% reported a shortage of skilled personnel when restoring critical operations	42% lack a crisis management team or find that existing ones are ineffective in responding to geo-climatic hazards or events	
	Only 27% are planning to improve internal capabilities, focusing on workforce preparedness and leadership training		

SMEs

SMEs are the lifeblood of both infrastructure development and large businesses, serving as suppliers, service providers, and operational linkages across value chains. From logistics and construction to agribusiness and manufacturing, they ensure continuity and efficiency in day-to-day operations. They account for roughly 60 percent of employment globally; this figure rises to as much as 90 percent in certain low-income regions (World Bank, 2019). In addition to employment generation, SMEs often engage low-skilled, informal, and socially vulnerable groups, including women, youth, and the previously unemployed, providing income where formal systems fall short. However, their role in sustaining large systems is in sharp contrast with their own vulnerability.

Recent disasters have revealed the outsized vulnerability of SMEs to climate shocks. SMEs are often located in high-risk areas, including coastal zones and unplanned urban settlements, making some sectors, such as fisheries, tourism, and small-scale manufacturing, susceptible to flooding, tropical cyclones, and infrastructure failures. SMEs often operate informally, lack access to structured financial services, and are excluded from technical and institutional support systems. Their limited access to early warning systems, insurance, and tailored recovery support leaves them more exposed to disasters than large firms. This geographic and systemic vulnerability underlines the urgent need to integrate SMEs into national and local disaster preparedness, risk communication, and resilience-building strategies.

Table 3 presents globally aggregated survey findings based on responses from SMEs. The majority of responses in this segment were from medium-sized enterprises in the Global North. To complement these, several focus group discussions were conducted with small enterprise associations and companies located in South Asia; the results are presented later in this chapter. The survey results consistently showed that smaller companies face greater resilience challenges than large businesses.

For most SMEs, resilience planning has begun but remains untested, with only 67 percent reporting that they have a detailed BCP in place. Policies and continuity frameworks exist, but they often lack the rigour and practice needed to withstand real disruptions. Regular risk assessments are conducted, but they rarely leverage publicly available tools or translate findings into preventive action.

Table 3 **Survey insights from SMEs**

Sector	Absorb	Respond	Recover
Policy and regulation	43% require access to affordable finance, real-time climate/hazard information, and affordable insurance to become more resilient to climate-related or disaster risks	77% said that government policies for climate/disaster-related risks and resilience are either absent or poorly enforced	Of the remaining, ~69% have benefitted from • concessional loans • tax incentives • subsidies
Finance	59% have allocated 1%–10% of their budget for resilience and emergency preparedness; 37% have not allocated any funds		70% have insurance, but 46% only have partial coverage
			50% rely solely on traditional insurance; only 20% use parametric or catastrophe bonds
Governance	67% have a BCP for operational continuity during disruptions, but 31% have not fully tested it		
	65% have a DRM policy of which 35% lack detailed SOPs/guidelines		
	82% conduct risk assessments annually	67% have underestimated the risks or rely on ad hoc measures, while 33% cited lack of regulatory clarity, data, or funding as the key barriers to not implementing a DRM policy	68% recovered within a month after the last hazard/disaster
	Yet, 59% are unaware of or do not use publicly available risk assessment tools		50% cited delays caused by slow external support (e.g., government aid) when restoring critical operations
	8% reported >10% loss in the last five years; 3% have not assessed their losses		
	37% reported they have suffered business interruptions 1–2 times in the last five years because of climate/disaster-related events		
Capacity building	11% reported a shortage of skilled personnel when restoring critical operations	46% lack a crisis management team or find that existing ones are ineffective in responding to geo-climatic hazards or events	
	Only 27% are planning to improve internal capabilities, focusing on workforce preparedness and leadership training		

1.4 The Way Forward: Recommendations and Key Implementation Levers to Address Gaps

Building on the survey's findings, the way forward requires a shift from awareness to execution. The evidence highlights three systemic gaps: weak institutional accountability, fragmented risk data and standards, and underused financing for forward-looking resilience. Addressing these gaps requires embedding resilience throughout the governance, finance, and technology functions, as well as across value chains.

A. Institutionalize preparedness and accountability (policy and governance)

To address fragmented mandates and uneven preparedness,

- Mandate periodic testing of BCPs and DRM plans at the site and board levels
- Establish clear accountability for resilience outcomes in critical infrastructure sectors
- Integrate resilience into regulatory supervision and performance monitoring frameworks

This corresponds with the survey's finding that governance clarity and tested protocols are prerequisites for building system-wide resilience.

B. Strengthen value-chain resilience standards (policy and governance)

Given the cascading effect of disruptions in supply chains,

- Require climate risk mapping in priority value chains
- Introduce minimum resilience standards for critical suppliers (e.g., redundancy, contingency planning, and location risk screening)
- Extend resilience expectations beyond owned assets to encompass logistics providers, SMEs, and service operators

Resilience must move from firm-level preparedness to ecosystem-level risk management.

C. Secure dedicated resilience financing (finance)

To reduce overreliance on post-disaster funding,

- Ring-fence budgets for ex ante risk reduction and adaptation investments
- Blend public, concessional, and private capital to support portfolio-level resilience
- Align financial incentives to prioritize preventive investments over reactive spending

The survey findings underscore that delayed investment leads to significant 'cost of inaction' and that capital exists, but it must be mobilized strategically.

D. Modernize risk transfer and financial protection (finance)

To enhance financial shock absorption,

- Scale parametric insurance solutions for high-exposure hazards
- Pilot catastrophe bonds and pooled risk mechanisms for critical infrastructure
- Integrate liquidity tools that ensure rapid post-shock recovery

Modern risk-transfer tools complement physical resilience and improve recovery speed.

E. Digitize risk management and early warning systems (technology)

To address data fragmentation and limited interoperability,

- Integrate digital risk analytics and early warning systems into operational decision-making
- Link monitoring systems directly to automated response protocols and SOPs
- Standardize data taxonomies and interoperability frameworks across agencies and infrastructure operators

Digital integration enables real-time risk visibility and faster response across institutions.

F. Mobilize partnerships to scale up SME resilience (finance and capacity building)

To recognize SMEs' vulnerability within infrastructure value chains,

- Use public-private partnerships to expand SMEs' access to working capital, insurance, and risk analytics tools
- Provide advisory and technical support for business continuity upgrades
- Incentivize anchor firms to support supplier resilience improvements

Resilience is a value-chain characteristic; large firms, governments, and financiers must enable smaller actors to upgrade their capabilities.

1.5 Call to Action

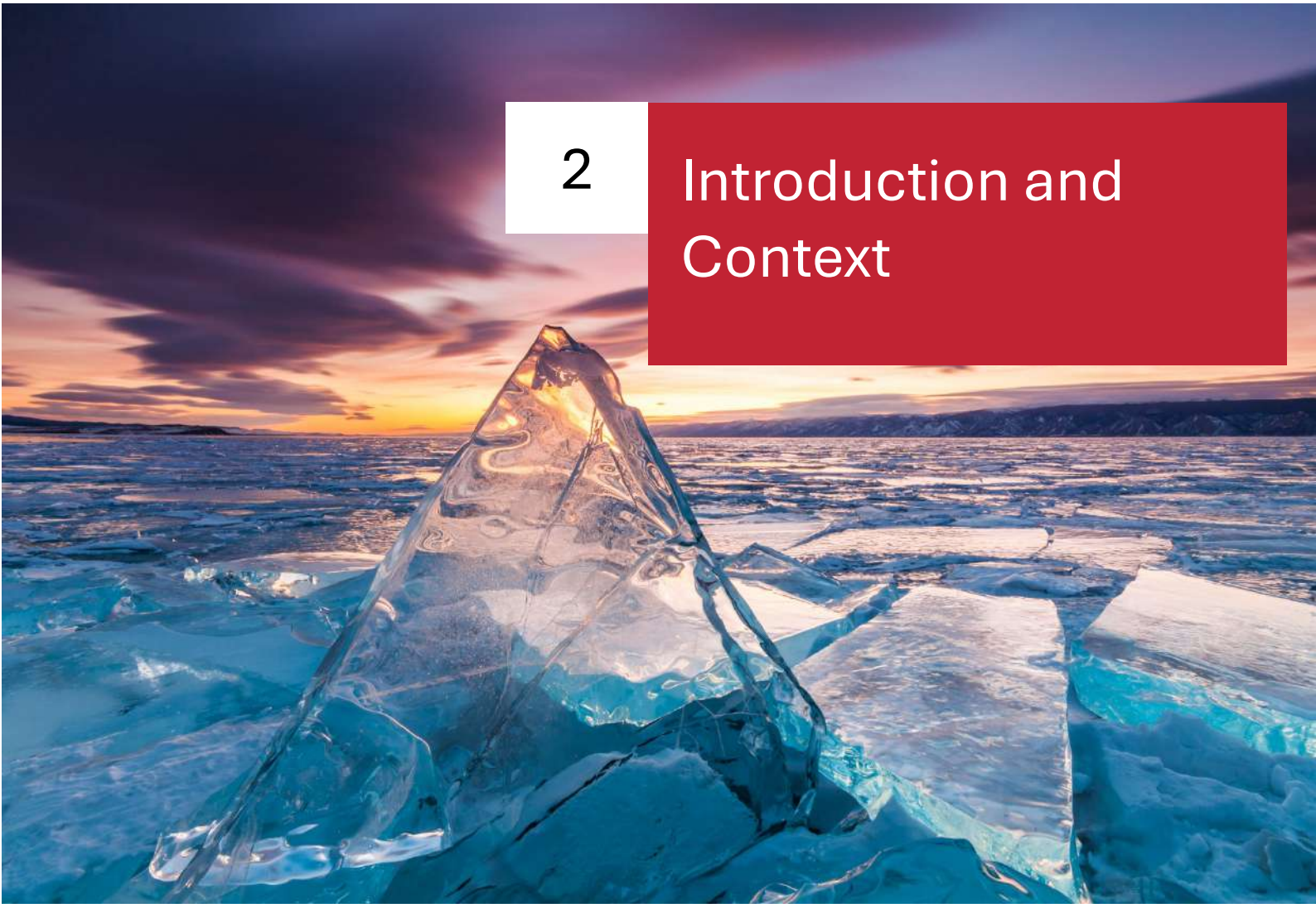
The case for resilience is no longer analytical; it is operational. Climate shocks are compounding, losses are rising, and the cost of delay is escalating. The agenda is clear. The question now is execution.

We call on leaders across government, infrastructure systems, finance, and industry to:

- Elevate resilience to a strategic priority, with board-level ownership and clear accountability.
- Shift capital decisively from recovery to prevention, backing forward-looking investments over reactive spending.
- Break institutional silos and align policy, finance, and technology with measurable risk-reduction outcomes.
- Act collectively across value chains, recognizing that systemic risk cannot be managed by individual actors alone.

Resilience is no longer a compliance exercise; it is a competitiveness imperative.

The tools exist. The capital exists. What is now needed is coordinated, measurable action to bend the loss curve and unlock resilient growth.



2 Introduction and Context

2. Introduction and Context

This section sets out why resilient infrastructure has become a central economic and financial priority, how evidence from the literature converges on the scale of the challenge and opportunity, and why this matters for capital allocation today. It then outlines the practical pathways from risk awareness to action and explains how to navigate the remainder of this working paper.

2.1 The First Global Infrastructure Resilience Report of the Coalition for Disaster Resilient Infrastructure (CDRI, 2023) — Evidence on Losses Caused by Disasters

One persistent obstacle to investing in resilient infrastructure has been the absence of public, comparable financial risk metrics. That gap is now addressed by CDRI's Global Infrastructure Risk Index (GIRI)—the first fully probabilistic global assessment tool for measuring infrastructure risk across major geo-climatic hazards and sectors. It publishes country-level metrics, such as average annual loss (AAL), which is an indicator of long-run expected losses and contingent liabilities. These metrics are accessible through an

interactive platform for visualization and querying, allowing governments and investors to turn measurement into management.

By making risk visible and comparable, GIRI allows the resilience dividend to be quantified and captured. This dividend includes avoided asset losses and service disruptions; improved quality and reliability of essential services; faster and more inclusive economic growth; and environmental co-benefits, such as reduced emissions and improved air and water quality. Explicitly articulating this dividend strengthens the economic and financial case for scaling up investment, particularly in low-income countries, where the scale of infrastructure spending remains far below needs and the choices made today will shape the development trajectory for decades.

The evidence points to a practical agenda: use risk metrics to inform national resilience policies, standards, and investment plans and mainstream nature-based infrastructure solutions along with grey assets to manage systemic risk. Build the political case by tying resilience to a service-quality promise—coverage, reliability, and affordability—which creates tangible incentives for leaders to act. On the financial side, blend public, concessional, and private capital and develop instruments that help monetize the resilience dividend (e.g., resilience-benefit certificates, insurance-linked structures, and national resilience funds) so that private capital can participate at scale.

Progress can be tracked over time using a composite resilience indicator that combines AAL with indicators of the Absorb–Respond–Recover capabilities and takes into account infrastructure gaps. This approach can also be downscaled for subnational portfolios with detailed data. This turns resilience from an abstract aspiration into a measurable performance characteristic that guides policy, finance, and operations.

2.2 What the Evidence Converges On

Geo-climatic hazard and disaster risk have become core financial issues. It is projected that disasters could cause total economic losses of approximately 16–22 percent of cumulative global GDP by 2100; combining approximately 2 percent of GDP in mitigation efforts with less than 1 percent in adaptation can materially reduce these losses (mitigation by approximately 11%–13% and adaptation by a further approximately 4%). The net cost of inaction will still come to approximately 10–15 percent of global GDP, which underscores the price of delay (World Economic Forum & Boston Consulting Group, 2025).

At the firm level, physical geo-climatic risks are already eroding earnings. If temperatures rise by approximately 3 °C, it is expected that corporate profits could fall by 5–25 percent by 2050 (Boston Consulting Group, 2024; World Economic Forum, 2025). Companies that moved first on climate have found that their action costs are approximately five times lower than the costs of inaction (Boston Consulting Group & Temasek, 2025). In other words, resilience is not a 'nice to have'; it protects profits today and positions businesses for advantage tomorrow.

Regulators and investors are accelerating this shift. Disclosure regimes (e.g., the Corporate Sustainability Reporting Directive in the EU, mandatory climate disclosure in the UK, the Securities and Exchange Commission's climate disclosure guidance rules in the US) now require large companies to assess, manage, and report climate risks and adaptation plans, while investors explicitly expect planning for multiple climate scenarios and stronger adaptation and resilience strategies.

Crucially, resilience is a value-chain activity. Vulnerability is determined both by a company's own sites and the resilience of its suppliers, logistics, and customers. Collaboration throughout the value chain (including technology and data sharing) reduces costs, improves returns, streamlines compliance, and speeds up innovation while preventing a single weak link from becoming a source of system-wide disruption.

In the past 25 years, average annual economic losses worldwide linked to geo-climatic hazards and disasters have increased more than four times, from $0.92 trillion during 1975–1999 to $3.76 trillion during 2000–2025. During these same periods, the number of reported disasters doubled, from 4,318 to 8,925, respectively (EM-DAT: The international disaster database). Additionally, in 2024 alone, natural disasters caused at least $320 billion in economic losses across global value chains, with less than half covered by

insurance (Swiss Re Institute, n.d.). It is estimated that for unprepared businesses, physical climate risks alone could put 5–25 percent of their 2050 earnings before interest, taxes, depreciation, and amortization at risk, depending on the sector and geography.

2.3 Economic Losses and Damages Caused by Disasters to Businesses

Table 4 **The impacts of disasters on businesses and infrastructure companies**

Impact of a tornado on Pfizer's warehouse in the US: In July 2023, an EF3 tornado hit Pfizer's manufacturing campus in Rocky Mount, North Carolina, ripping the roof off a key warehouse and scattering tens of thousands of medicine pallets. The facility, one of the world's largest producers of sterile injectable drugs, was severely damaged and production was temporarily halted. The company reported that at least 50,000 pallets of medicines were destroyed and 65 injectable drugs were at risk of a shortage following the disaster. The disruption threatened nearly 8% of US hospitals' injectable medication supply; full production recovery was not expected until mid-2024, prompting Pfizer and the US Food and Drug Administration to implement emergency measures to prevent a nationwide drug shortage (Reuters, 2023b).

Impact of flooding of Toyota's assembly plant in South Africa: In April 2022, severe flooding in the KwaZulu-Natal province inundated Toyota's Prospecton assembly plant in Durban. The factory was forced to shut down for cleanup and repairs, halting production of popular models for several months. Toyota lost an estimated 68,000 vehicles of output and had to scrap about 4,000 finished cars (worth ~$115 million) because of water damage. The extended shutdown disrupted export shipments and left dealers with long waitlists until the plant resumed full capacity later in 2022 (Toyota South Africa, press release, 2022).

Impact of flooding on the Deutsche Bahn rail network in Germany: In mid-July 2021, unprecedented floods across western Germany ravaged Deutsche Bahn's railway infrastructure. Torrential rain caused rivers to overflow their banks, washing out tracks, bridges, and stations, forcing major rail routes to close for repairs. Rail freight services in some areas were suspended indefinitely as crews worked to restore damaged lines. The state-owned rail operator estimated that the flooding inflicted about $1.5 billion worth of damage to its network and facilities, much of which was not insured. Recovery proved lengthy—even a year later, some 15% of the affected routes

Impact of winter storms on Samsung's chip plant in the US: In February 2021, winter storm Uri brought extreme cold and caused statewide power outages in Texas, forcing Samsung's semiconductor plant in Austin to shut down. Production was halted for about a month as electricity and water supplies were disrupted. The sudden outage ruined ongoing semiconductor batches—approximately 71,000 silicon wafers in production were scrapped, contributing to an estimated $270–$360 million loss. This outage, which came amid an existing global chip shortage, tightened supply further and delayed deliveries of critical components like smartphone display drivers (The Verge, 2021).

Impact of a glacial avalanche and flash flood on NTPC's hydropower project in India: On 7 February 2021, a glacial avalanche in the Chamoli district in Uttarakhand triggered a flash flood that devastated NTPC's Tapovan–Vishnugad hydropower project. The flooding caused an estimated $200 million worth of damage to the 520 MW plant and killed more than 200 people. The disaster washed away major portions of the under-construction dam, indefinitely delaying the project's completion (The Times of India, 2021).

Impact of Hurricane Maria on Baxter International factories: In September 2017, Category 4 Hurricane Maria devastated Puerto Rico, knocking out power and infrastructure and disrupting operations at Baxter International's pharmaceutical plants on the island. Baxter's three factories, which produce small-volume intravenous (IV) fluids and medical injection bags, initially went dark and then resumed limited production on back-up diesel generators within a week. The prolonged outage considerably reduced supplies of IV saline bags in hospitals across the US (exacerbating an existing shortage) and forced Baxter to ration distribution and import substitute products from its overseas facilities. The company anticipated a significant impact on its 2017 Q4 revenues, though it mitigated major losses by leveraging other manufacturing sites and

remained out of service, underscoring the disaster's costly operational impact (Reuters, 2021).	restoring output as quickly as possible (Reuters, 2017).

In short, extreme climate events pose a multifaceted threat to business continuity and economic stability: they directly damage assets and infrastructure, disrupt supply chains and markets, and indirectly increase operational costs and uncertainty. This new reality is forcing companies to shift from viewing climate resilience as a peripheral issue to treating it as a core business risk management priority.

2.4 The Business Case for Capital Allocation

The financing need is large and growing—$215–$387 billion per year in the Global South through 2030 and approximately $0.5–$1.3 trillion annually worldwide—but it is also investable, spanning solution providers in software, components, materials, services, and infrastructure (Boston Consulting Group & Temasek, 2025). Early movers are well positioned to capture a rapidly growing market as countries operationalize adaptation plans.

The business case extends beyond risk avoidance. Company disclosures and case study evidence indicate that the benefit-to-cost ratio typically ranges from 2:1 to 15:1, with some measures yielding significantly higher returns (e.g., 53:1 for water collection/storage), particularly in emerging markets where value at risk is high and solutions are scalable (Boston Consulting Group, Global Resilience Partnership and USAID, 2023).

2.5 From Awareness to Action

Organizations that succeed in building resilience tend to follow a consistent playbook: assess location-specific physical risks and establish baselines; prioritize interventions based on cost-effectiveness across multiple climate scenarios; and implement at scale through strategic, operational, and financial levers while disclosing progress through recognized frameworks. Technology programmes and growing investor demand are further accelerating this transition.

Achieving system-level impact requires blended capital stacks that combine public, concessional, and private finance, including risk-transfer tools and resilience-linked instruments. Channelling capital to SMEs and emerging market actors, where resilience gaps are widest and returns from avoided losses are often the highest, is particularly critical. Market scans already indicate the existence of robust pipelines across food, water, health, energy, and climate-intelligence solutions, with increasing investor participation.

The bottom line is clear: macro-level stakes are high, firm-level economics are attractive, and the mechanisms for action—collaborative value-chain strategies, credible disclosure, and investable pipelines—are increasingly being put in place. Organizations that embed resilience across their operations and supply chains, and that effectively mobilize blended finance, will be best positioned to thrive in a more volatile climate.

2.6 Why This Working Paper?

The preceding sections establish why resilience has become a central economic and financial priority and why infrastructure sits at the heart of this challenge. What remains less clear, and is the focus of this working paper, is how different actors are responding in practice, where progress is being made, and where material gaps persist.

This working paper moves beyond high-level framing to provide practical, evidence-based insights into the state of infrastructure resilience across three critical groups: large businesses, infrastructure companies, and SMEs that anchor value chains. Drawing on findings from the Global Pilot Business Survey on Infrastructure Resilience, it examines how these groups assess risk, invest in resilience, and operate across the disruption lifecycle, and where their priorities and constraints diverge.

The objective is not to prescribe a single solution but to outline patterns, benchmarks, and priorities that can inform near-term decisions by business leaders, investors, and policymakers. In doing so, this working paper aims to help translate resilience from an aspiration into an actionable agenda.

To guide readers from diagnosis to action, this working paper is structured as follows:

- The methodology section describes the survey design, scope, respondent profile, and analytical approach to lay out the survey insights.
- Subsequent sections present findings across three segments—large businesses, infrastructure companies, and SMEs—highlighting differences in exposure, preparedness, and resilience maturity.
- Insights are mapped across the infrastructure resilience lifecycle, examining how organizations absorb, respond to, and recover from disruptions.
- The analysis identifies the key levers shaping resilience outcomes, including policy, technology, finance, governance, and capacity development.
- The evidence and actions are anchored in benchmarks and case examples and conclude with clear, near-term priorities for different stakeholders.

Together, these sections are intended to equip readers with a clear understanding of where resilience stands today and what it will take to strengthen it going forward.

3 Methodology

3. Methodology

3.1 Objective of the Survey

The Pilot Global Business Survey is designed to capture diverse insights into how large businesses, infrastructure companies, and SMEs prepare for, respond to, and recover from geo-climatic risks and natural disasters. The goal is to understand resilience readiness across geographies, sectors, and organizational types by applying a globally consistent and analytically rigorous approach. In particular, the survey examines how failures in critical infrastructure services caused by disasters affect business operations, value chains, and revenues.

3.2 Country and Sector Selection

The selection of countries followed a structured three-step funnelling approach designed to identify markets with the most material infrastructure risk exposure while ensuring comparability across geographies.

Step 1: Initial screening using multi-hazard risk indicators

The analysis began with a universe of 193 countries. Each country was assessed using standardized, globally comparable risk indicators sourced from GIRI, which was developed by CDRI.

To ensure clarity for non-technical readers, the key metrics used in this screening process are as follows:

- **Multi-hazard exposure:** This refers to a country's exposure to multiple natural hazards, such as floods, cyclones, earthquakes, droughts, and extreme heat. Rather than assessing a single hazard in isolation, the index captures the combined risk across major hazard types.
- **Average annual loss (AAL):** AAL represents the expected economic loss per year from natural hazards, averaged over the long term. It does not mean that the same loss occurs every year; instead, it reflects the statistical average of losses over time, accounting for both frequent small events and rare but severe disasters. For example, if a country experiences a major disaster once every 10 years causing $10 billion in damages, the long-term AAL would be approximately $1 billion per year.
- **Relative AAL:** While AAL measures absolute expected losses in monetary terms, relative AAL expresses these losses as a percentage of a country's total infrastructure asset base, enabling comparison between large and small economies.
    - A large economy may have high absolute losses but lower risk relative to the size of its infrastructure base.
    - A small economy may have low absolute losses but higher vulnerability relative to its asset base.
- **Total asset exposure:** This represents the total estimated economic value of infrastructure assets within a country (e.g., transport networks, power systems, telecommunications infrastructure, and water systems). Countries with a large infrastructure base may face high absolute losses simply because of their scale.
- **GIRI:** GIRI is a globally standardized analytical tool that quantifies infrastructure risk by combining the following factors:
    - Hazard exposure
    - Asset exposure
    - Vulnerability
    - Expected economic losses

  It enables consistent cross-country comparison using a common methodological framework.

Using these indicators ensured that country selection was data-driven, transparent, and globally comparable.

Step 2: Shortlisting based on risk archetypes

The initial screening narrowed the sample set to approximately 50 countries, which were categorized into three archetypes to reflect different risk profiles:

1. Highly impacted countries
    - High absolute AAL
    - High relative AAL

    These countries face both large total economic losses and high vulnerability relative to their asset base.

2. Moderately impacted countries
    - Low absolute AAL
    - High relative AAL

    These countries may not experience the largest absolute losses but face proportionally high vulnerability.

3. Relatively low-impact countries
    - Low relative AAL

    These countries face comparatively lower expected infrastructure losses.

This categorization ensured balanced geographic representation while capturing diverse risk contexts—from large, advanced economies with high asset exposure to smaller, more vulnerable economies.

Step 3: Sector prioritization

Within the shortlisted countries, focus was placed on industries with the following characteristics:

- High infrastructure asset concentration
- Strong interdependencies
- Significant cascading risk potential
- High economic criticality

The primary infrastructure sectors analyzed were the following:

- Transport (roads, rail, ports, airports)
- Power and energy systems
- Telecommunications
- Water and wastewater systems

In addition, critical value-chain sectors with substantial indirect exposure to infrastructure disruption were assessed:

- Heavy industry
- Logistics and supply chains
- Consumer goods manufacturing and distribution (non-food)

These sectors were prioritized because infrastructure disruptions in these areas tend to propagate across the entire economy, amplifying economic and social impacts.

3.3 Business Segmentation

The study categorized participants into three groups:

Public and private infrastructure companies: Firms managing and operating infrastructure assets, such as power utilities, railways, and telecommunications operators.

Large businesses: Firms operating in infrastructure-dependent sectors, such as manufacturing, services, and logistics.

SMEs: Vital contributors to global economic ecosystems. Since there is no universal definition of SMEs, this survey used the following classification:

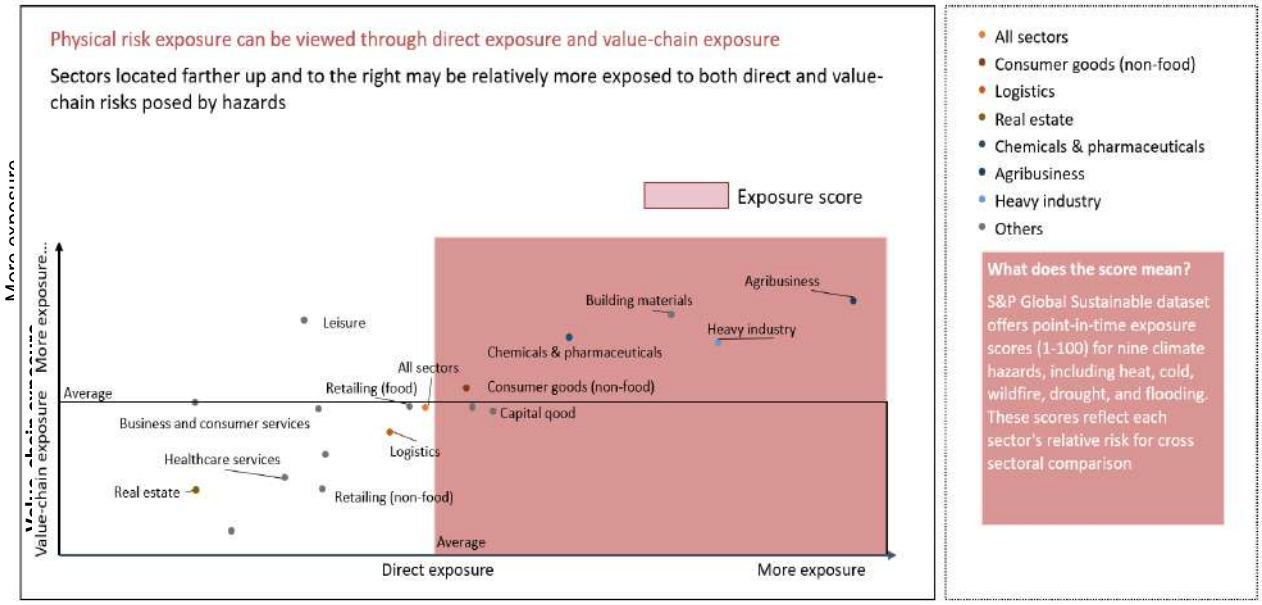
- Small enterprises: < $10 million
- Medium enterprises: $10–50 million

This segmentation enabled a comparison of resilience gaps and capacities across different organizational scales and functions.

3.4 Six Sectors Stand Out for High Total Climate Exposure

Vulnerabilities vary widely across sectors; while some sectors are directly exposed due to high concentration of physical assets, others face significant indirect risks embedded in upstream dependencies. In Figure 3 below, sectors located in the upper-right quadrant of the matrix are especially exposed, facing high climate risk both at the operational level and across their value chains. These risks are also expected to grow significantly over the next 15 years, with uneven impacts across industries.

Figure 3: Sectors facing direct and value-chain risks posed by hazards



Based on this dual lens, six priority sectors were identified for further investigation: agribusiness, chemical and pharmaceuticals, consumer goods (non-food), heavy industry, logistics and transportation, and real estate. These sectors are not only highly exposed but also foundational to economic activity, supply stability, and recovery capacity, making them strategic focal points for targeted adaptation interventions.

3.5 Survey Deployment and Coverage

The survey reached over 2,000 respondents globally, across climate, sustainability, and risk functions. It was supplemented with:

10 in-depth interviews

three focus group discussions (FGDs) with SMEs, and secondary research and expert inputs.

The data was collected between February and July 2025 in collaboration with CDRI.

The survey achieved wide regional coverage with 506 responses received, with responses distributed along the segments and sectors along with a visual map as follows:

Figure 4: Breakdown of survey participants across infrastructure, large businesses, and SMEs

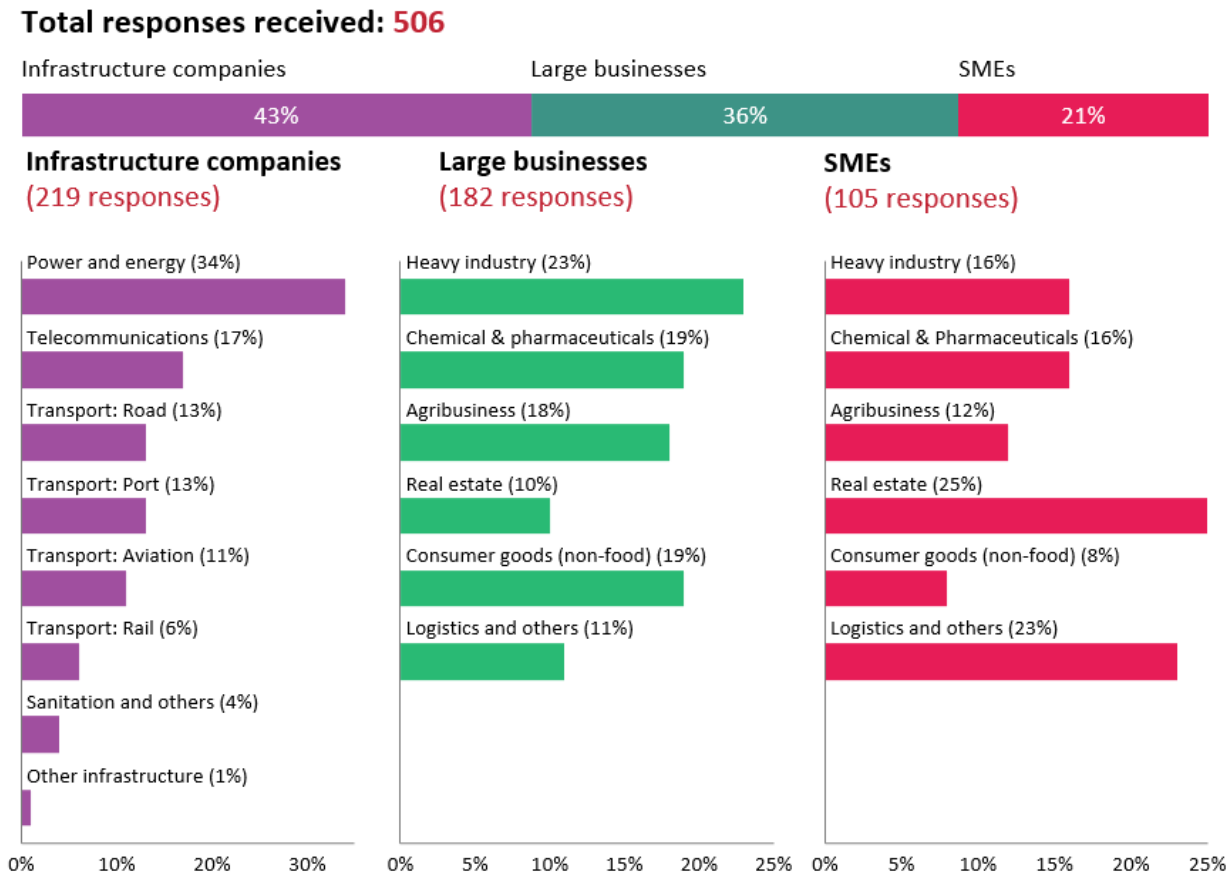
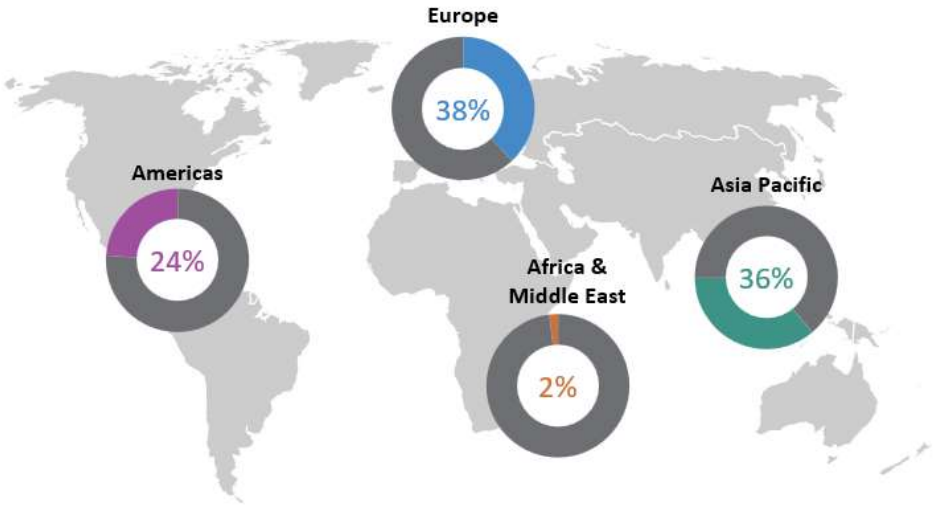


Figure 5: Geographic distribution of the Global Business Survey responses



3.6 Common Analytical Framework

The *GIR 2025 report* uses a common framework to analyze the resilience of infrastructure. This framework examines infrastructure both as a collection of individual assets and as networks of connected assets and services provided to individuals, communities, businesses, and the economy (CDRI, 2025).

The resilience of these networks and services depends on their capacity to:

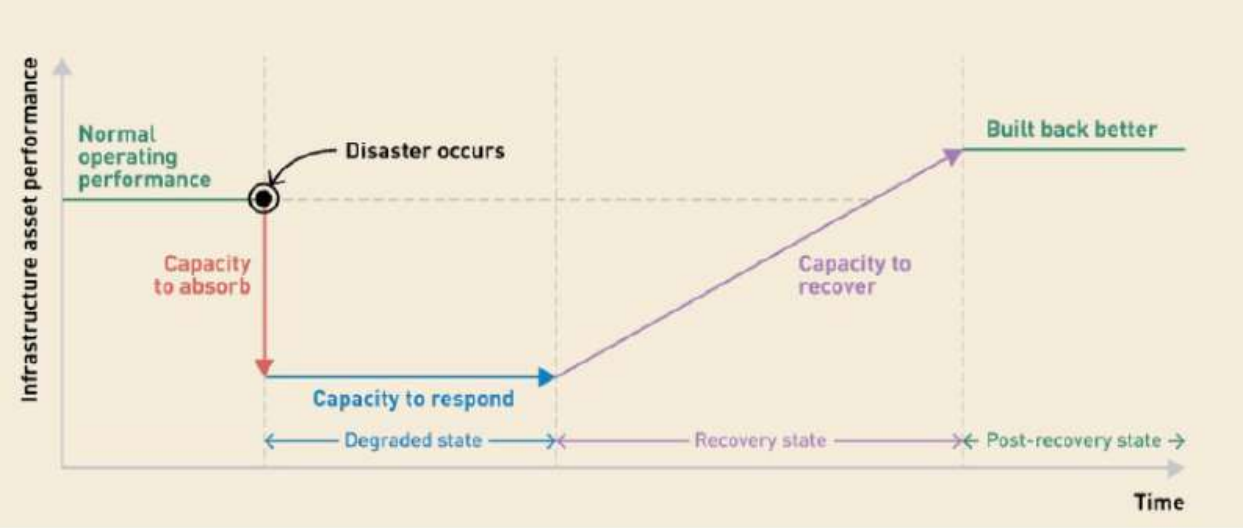
i) resist and absorb the shocks caused by disasters;
ii) respond to the damage caused by disasters and maintain basic service continuity during crises; and
iii) restore services as quickly as possible while incorporating lessons learned from the disaster and reducing future loss and damage.

It is also essential to look at the resilience of infrastructure service users, which depends on their ability to:

i) prepare effectively and leverage the information provided by early warning systems to reduce the shock of disasters;
ii) access supplementary or alternative means to replace failed infrastructure services (e.g., back-up generators for electricity or alternative modes of transport); and
iii) engage in post-disaster learning alongside infrastructure agencies, so that they are better prepared for future disasters.

At all three levels (infrastructure assets, services, and users), resilience should be seen both as the ability to absorb the next disaster and 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 6 illustrates this cycle and the three capabilities of an individual infrastructure asset.

Figure 6: The three capabilities of resilient infrastructure



Source: CDRI (2025)

Many infrastructure agencies focus primarily on strengthening the capacity to absorb shocks by enhancing standards and regulations, implementing retrofit programmes for existing assets, and improving construction supervision for new, more resilient assets. They also expand maintenance and repair programmes to make assets stronger and ready for future disasters (e.g., cyclone seasons).

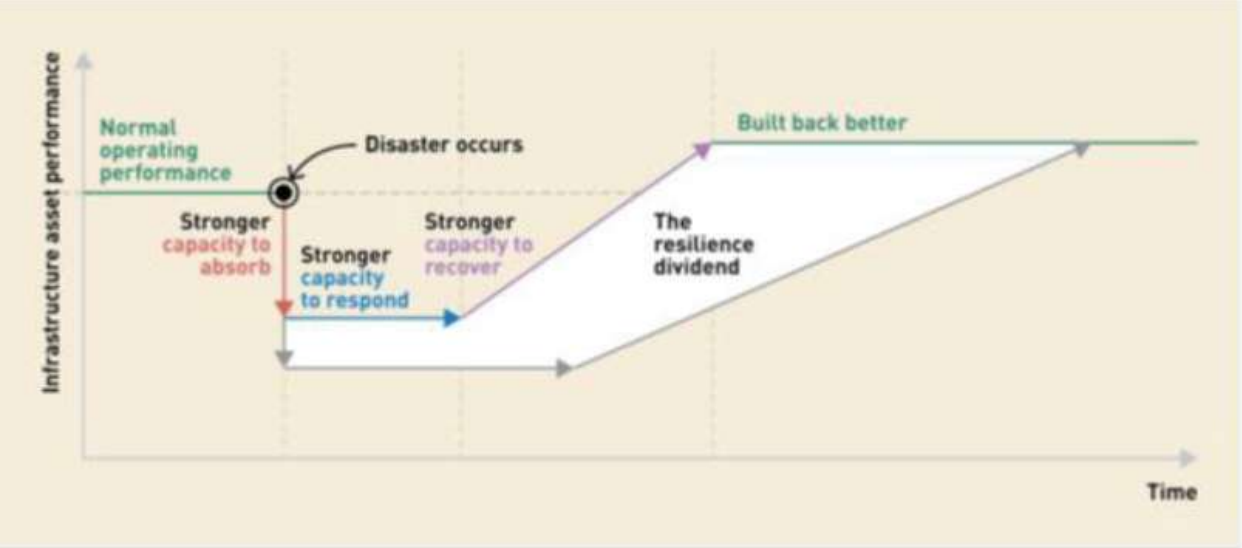
However, focusing solely on the ability to absorb is insufficient. The economic and livelihood impacts linked to interruptions in infrastructure services are directly related to the time it takes for the asset to get back to complete or enhanced operations. The longer the infrastructure asset manager takes to respond and recover, the greater the impact on households, businesses, and communities.

Figure 6 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 in the network and 'building back better' requires a network-wide analysis of vulnerabilities.

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

Building the resilience of infrastructure systems requires agencies and asset managers to strengthen the ability to absorb disasters as well as the ability to respond effectively and recover quickly. Figure 6 shows the resilience-building process that strengthens these three capabilities.

Figure 7: Strengthening the three capabilities of resilient infrastructure and the resilience dividend



Source: CDRI (2025)

An infrastructure agency or asset owner can implement several measures to strengthen the ability to absorb (represented by the short red line on the left-hand side of the graph), such as enhancing maintenance, repair, and retrofit programmes, or utilizing systems that translate early warning notices from hydrometeorological services into preparatory action to protect assets.

A greater ability to respond requires infrastructure agencies to strengthen disaster preparedness and establish robust coordination mechanisms with national disaster risk management agencies, emergency services, and interconnected infrastructure providers whose services may be disrupted during a disaster. Measures to enhance response capabilities include developing preparedness plans for debris removal, establishing standby repair service agreements, strategically positioning repair materials, and deploying new technologies (e.g., drones) for rapid damage assessment and evaluation.

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

All the efforts to strengthen the three capabilities will result in reduced damage and performance degradation, decreased response time, and more effective repair and reconstruction processes in the event of future disasters of similar magnitude. Strengthening these capabilities will also lead to faster restoration of services and lower impacts on livelihoods and the economy. The white area in the graph represents the 'resilience dividend' of such efforts. It is defined as the reduction in the value of future asset losses and damage, avoided service disruptions, broader social, economic, and environmental co-benefits, and reduced systemic risk that accrues over the lifecycle of infrastructure systems.

This framework has been consistently applied throughout this working paper.

3.7 Data Reliability Assurance

To ensure the robustness of the findings, all the survey responses were subjected to a structured quality review, including screening for response completeness, internal consistency, and response-time patterns.

Response durations were analyzed to identify instances where answers may have been selected too fast to reflect considered input (e.g., near-instant or straight-line responses across multiple questions). The

responses flagged through this process were reviewed and, where necessary, excluded from the final dataset. In total, approximately 16 responses were removed for failing quality-control checks. This quality-control process ensured that the results presented in this report are based on thoughtful, credible, and substantively completed submissions.

3.8 Framing the Resilience Imperative

The survey questionnaire was designed around a common analytical framework aligned with the infrastructure resilience lifecycle. Thirteen questions covered three lifecycle stages—Absorb, Respond, and Recover—and were further mapped to five critical levers: policy and regulation, technology, finance, governance, and capacity building. The full questionnaire, including the detailed response options, is provided in the Annexure.

Table 5 **Infrastructure resilience lifecycle framework and critical levers**

Absorb	Respond	Recover
• **Policy & regulation:** Clear resilience standards, land-use controls, and compliance incentives for climate resilient infrastructure • **Finance:** Adequate financial buffers, insurance coverage, and access to contingent finance to absorb initial shocks • **Technology:** Deployment of resilient design standards, redundancy in critical systems, and early warning and monitoring technologies • **Governance:** Strong risk ownership, clear roles, and pre-approved crisis protocols embedded in decision-making • **Capacity building:** Regular risk assessments, drills, and training to strengthen institutional readiness and workforce preparedness	• **Policy & regulation:** Fast-track approvals, emergency waivers, and coordination mechanisms to enable rapid response • **Finance:** Immediate liquidity access for repairs, emergency procurement, and continuity of essential services • **Technology:** Real-time data systems, remote operations, and digital platforms to manage disruptions and allocate resources • **Governance:** Agile decision-making, cross-agency coordination, and empowered local leadership during crises • **Capacity building:** Trained response teams, adaptive operational playbooks, and supply-chain flexibility to maintain service delivery	• **Policy & regulation:** Supportive recovery frameworks, rebuilding standards, and incentives to 'build back better' • **Finance:** Access to reconstruction finance, insurance payouts, and blended capital for resilient reinvestment • **Technology:** Use of advanced materials, automation, and data analytics to accelerate restoration and improve resilience • **Governance:** Integration of post-event learnings into planning, accountability mechanisms, and long-term resilience strategies • **Capacity building:** Institutional learning, workforce upskilling, and forward-looking recovery planning to reduce future risk

This working paper aims to address how resilience capabilities vary significantly across infrastructure providers, large businesses, and SMEs—characterized by access to capital, technical capacity, risk awareness, and policy support—and to develop a common understanding of how these business entities can better withstand, respond to, and recover from geo-climatic hazards and disasters. It also examines the roles of different stakeholders and concludes with a call to action to reduce disaster-related losses globally.

4 Large Businesses

4. Large Businesses

Large businesses sit at the centre of modern economies—anchored by fixed assets, complex operations, and deeply interconnected global value chains. As climate and disaster risks intensify, the scale and structure of large enterprises mean that disruptions rarely remain localized; instead propagating across suppliers, logistics networks, customers, and supporting infrastructure.

This chapter focuses on selected core large-business sectors where climate and disaster risks are the most consequential due to a combination of asset intensity, value-chain complexity, and systemic importance to economic activity in general.

Finally, the chapter evaluates how large businesses prepare for, respond to, and recover from disaster shocks using survey insights mapped across the Absorb–Respond–Recover lifecycle. A lever-wise analysis (policy, technology, finance, governance, and capacity building) reveals where resilience efforts are progressing and where critical gaps persist.

4.1 Regional and Sectoral Breakdown of Large Businesses That Participated in the Survey

Figure 8: Breakdown of survey participants across large businesses

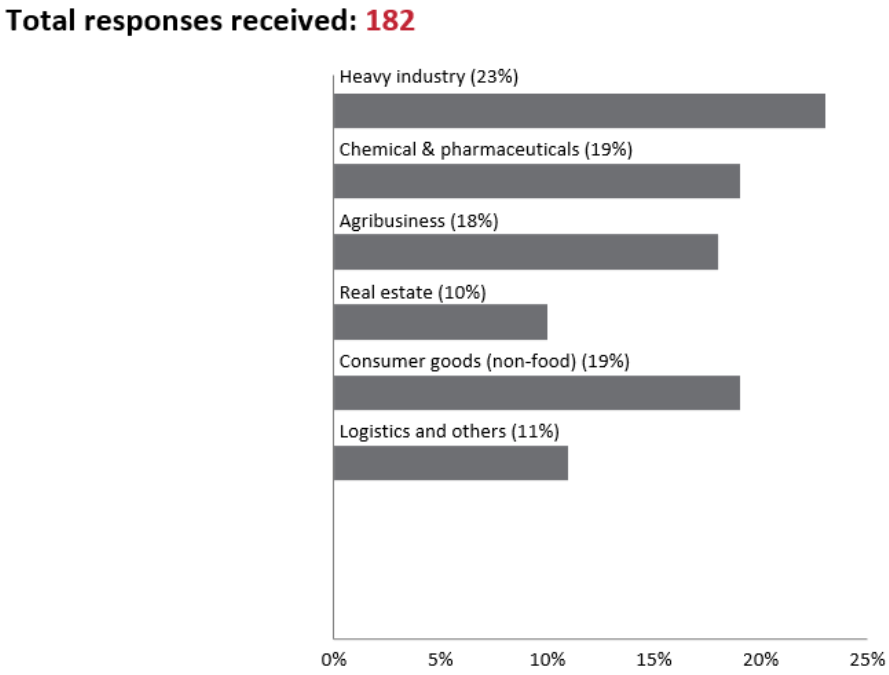
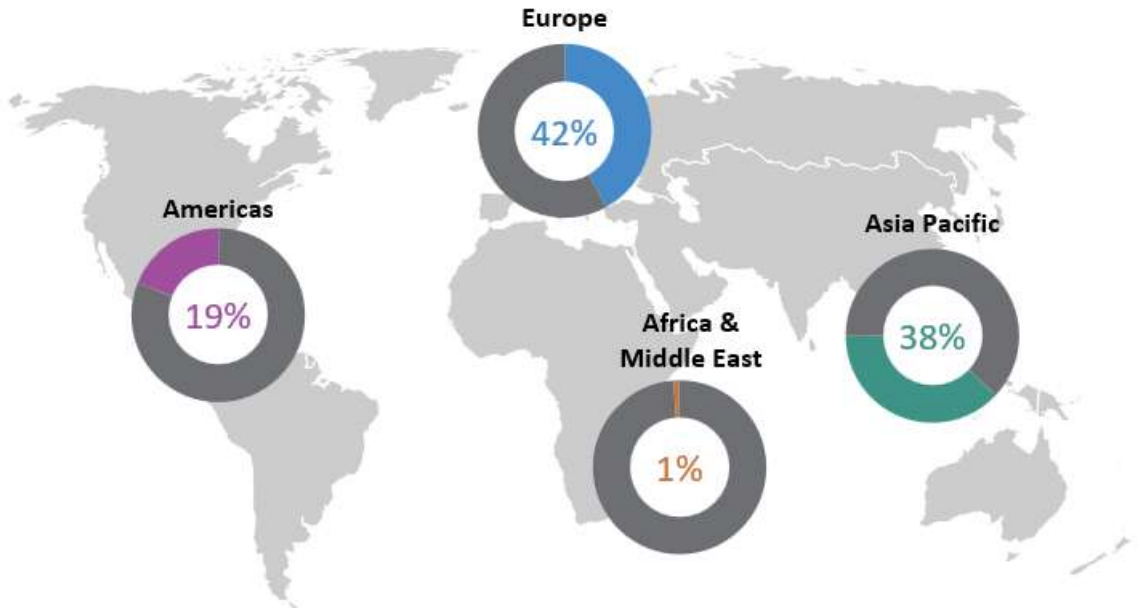


Figure 9: Geographic distribution of the Global Business Survey responses for large businesses



4.2 Geo-Climatic Hazards and Disaster Impacts Vary Considerably by Sector—Driven by Distinct Value Chains

While total exposure defines the scale of climate risk, the real disruption is determined by how specific geo-climatic hazards interact with sector-specific operations and value chains. In the six climate-critical sectors identified, the same event—whether flooding, heatwaves, or drought—results in vastly different consequences: crop loss in agribusiness, logistics disruption in consumer goods (non-food), and production halts in chemical & pharmaceuticals.

From sourcing raw materials to delivering finished goods to consumers, each segment faces distinct operational and financial risks. Disruptions may arise from reduced input availability, equipment breakdowns, compromised packaging, or weakened retail delivery. These touchpoints are interconnected, meaning that any weak link can trigger a system-wide failure.

Figure 10: Climate hazard impacts and vulnerabilities across the end-to-end value chain

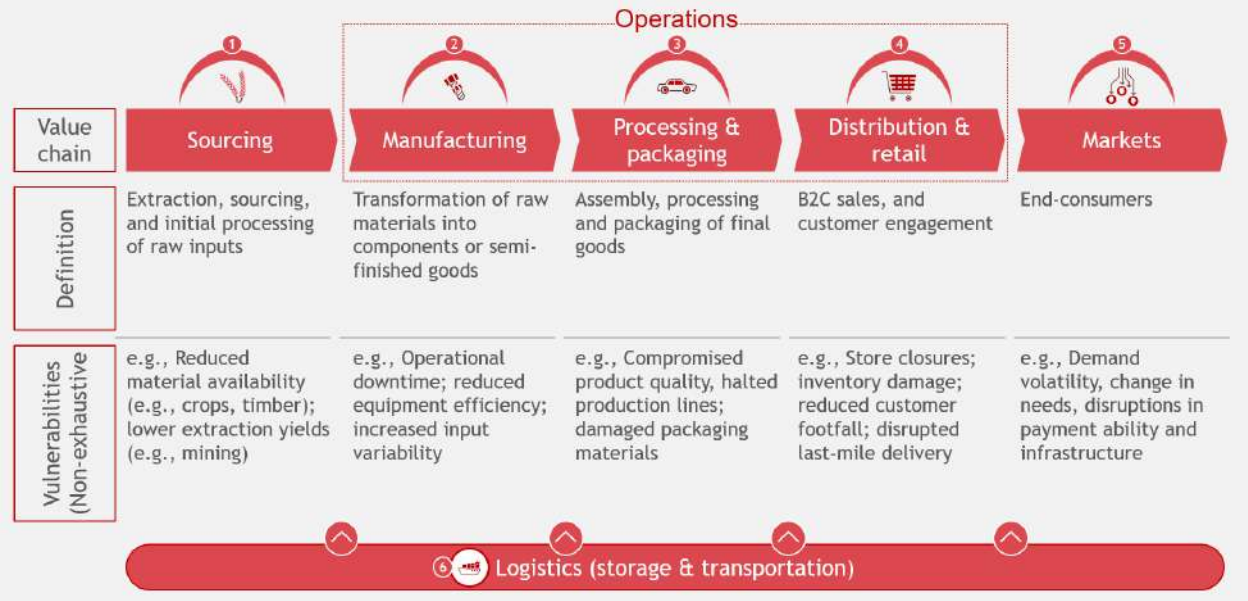


Figure 11: Logistics—a critical yet underprepared link in climate resilience

These sectoral differences are not incidental; they stem from the underlying business models, asset configurations, and supply dependencies of each industry. Understanding these fault lines across different

geo-climatic hazards is essential to identifying where and how hazards are most likely to disrupt business systems.

Table 6 **Sectoral exposure to physical climate hazards: business impacts and historical evidence**

Sector	Geo-climatic hazard	Impact on sector (non-exhaustive)	Historical events
Agribusiness	Flood & tropical cyclone	Farmland degradation, crop destruction, supply chain breakdown	Pakistan floods, 2022—4.410 million acres affected; $3.7 billion in damages (World Bank, 2022) Cyclone Idai, 2019—715,000 ha of crops lost; >$2 billion in damages (Reuters, 2019)
	Drought	Yield collapse, higher input use and costs	Droughts, 2023—caused >$21 billion in crop losses in the US (American Farm Bureau Federation, 2024)
Heavy industry (metals, mining, automotive)	Flood	Plant shutdowns, equipment damage, global parts shortages	Durban floods, 2022—Toyota predicted a 33% drop in planned vehicle production in 2022 and potential sales revenue loss of >$1.5 billion (Insurance Journal, 2025) Brazil floods, 2024—approximately $54 million in industrial losses; production suspended in >60% of the industries in Rio Grande do Sul (Brazil Reports, 2024)
	Tsunami	Disruptions in clustered production hubs, exports halt	Japan earthquake/tsunami, 2011—caused production loss of ~$1.2 billion to Toyota (The Korea Herald, 2011)
	Wildfire	Mining, smelting, and logistics corridors halted	Australia fires, 2019–20—affected 80% of the continent's population; US$1.5 billion in insured losses (Moody's, 2025)
Chemical & pharmaceuticals	Tropical cyclone	Factory damage, drug shortages	Hurricane Maria, 2017—damage to infrastructure; >500 medical product facilities affected (The Pharmaceutical Journal, 2017)
	Heatwave	Process upsets, water scarcity, product-quality risks	Experts estimated 15% production loss in May for heat-intensive industries because of heatwaves in India (Mint, 2024)
	Earthquake	Damage to concentrated manufacturing clusters	Kumamoto earthquake, 2016—multiple companies faced production interruptions (CNBC, 2016)
Consumer goods (non-food)	Flood	Factory and warehouse shutdowns, global price spikes	Thailand floods, 2011—650,000 people lost employment; prices of hard drives increased by ~20%–40% for computer hardware companies (Reuters, 2011)

Sector	Geo-climatic hazard	Impact on sector (non-exhaustive)	Historical events
	Wildfire	Damage to transport nodes, delivery delays, unemployment leads to reduced spending	California fires, 2020—increased unemployment; asset losses; multi-billion-dollar impact (The Bay Area Council Economic Institute, 2021)
Logistics	Flood	Port and rail outages, cargo delays	Europe floods, 2021—600 km of track affected; 80 stations damaged; €2 billion in damages (Railtech.com, 2021)
	Earthquake	Port and hub destruction	Tohoku quake, 2011—logistics infrastructure loss; economic impact of $210 billion (Artemis, 2011)
	Wildfire	Route closures, asset damage	Australia fires, 2019–20—tourism sector hit; >$1 billion in losses (Mongabay, 2024)
Real estate	Flood & tropical cyclone	Widespread property destruction, increased insurance costs	Hurricane Ian, 2022—149 fatalities; >$111 billion in damages (Federal Emergency Management Agency, 2024)
	Wildfire	Asset loss, premium hikes, community displacement	Hawaii fires, 2023—2,200 buildings destroyed; Hawaii's Pacific Disaster Center estimated that it will cost $5.5 billion to rebuild Lahaina (Reuters, 2023a)

While some businesses face concentrated infrastructure threats, others suffer cascading supply chain shocks. The challenge now is to shift from diagnosing risk to building resilience. Sector-specific, risk-informed, and operationally embedded resilience strategies will be essential to protect enterprise value and unlock long-term competitiveness.

4.3 Survey Insights—Large Businesses

To assess how large businesses are preparing for, responding to, and recovering from disasters and climate-related shocks, the survey evaluated their resilience strategies using a structured, lifecycle-based approach. This included analysis across three key stages—Absorb, Respond, and Recover—and performance mapping against five enabling levers: policy and regulation, technology, finance, governance, and capacity building.

The following section presents insights gained across the resilience lifecycle (Absorb–Respond–Recover). The accompanying infographic presents concise insights detailing how large businesses perform in each phase, with a focus on preparedness, operational flexibility, and post-shock restoration.

Lever-wise analysis of resilience enablers: A deep dive into the key levers reveals patterns in investment, policy adoption, digital readiness, and supply chain vulnerabilities that shape how large businesses absorb disruptions and sustain business continuity.

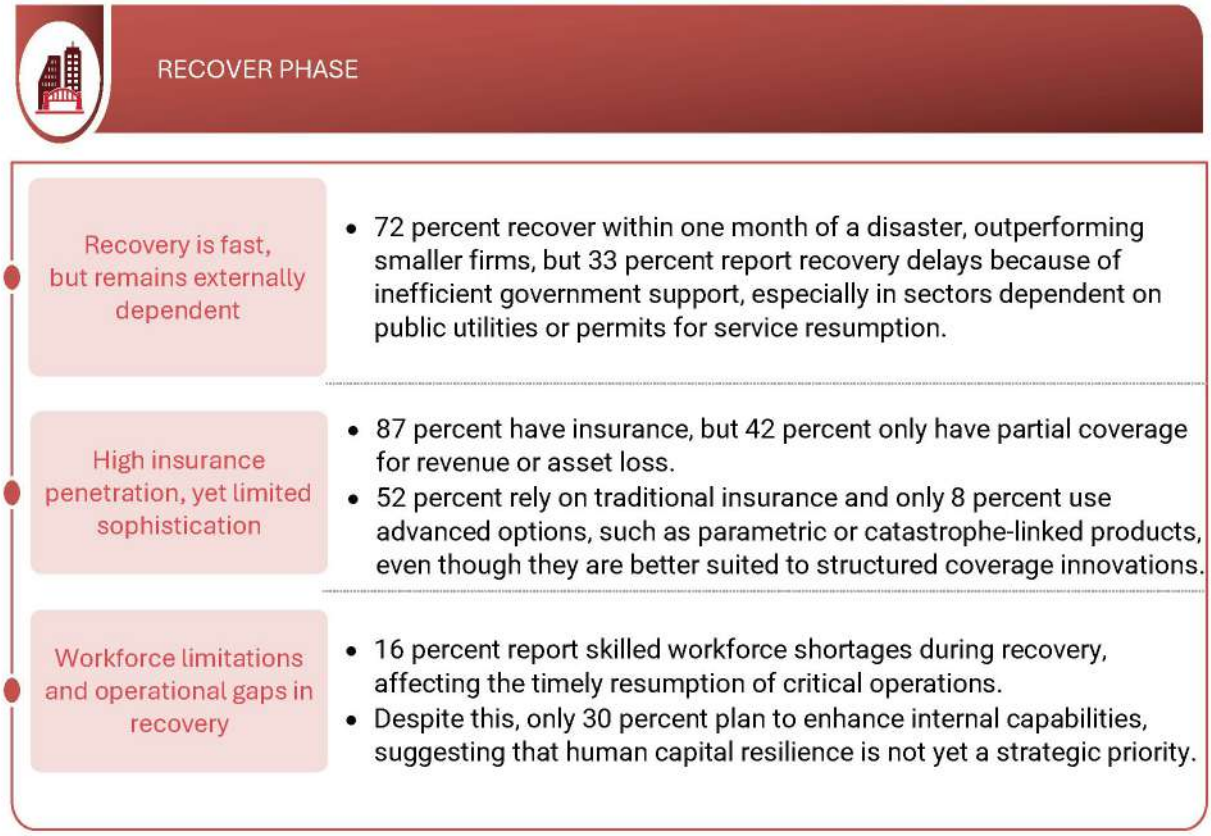
4.4 Survey Insights Across the Infrastructure Resilience Lifecycle

ABSORB PHASE

Strong risk governance exists, but execution gaps persist	• 82 percent of large businesses have a BCP but 39 percent have never tested them, which is an indication that preparedness remains theoretical. • 82 percent have a DRM policy, but 40 percent lack detailed SOPs, showing a disconnect between high-level commitment and frontline implementation.
Limited use of publicly available climate risk assessment tools despite awareness	• While 61 percent conduct risk assessments annually, 47 percent do not use publicly available climate/disaster risk assessment tools, undermining the potential value of national and global forecasting platforms. • This reflects an execution bottleneck, where knowledge exists but is not translated into structured planning or simulations.
Overconfidence in loss absorption	• Only 3 percent report losses of >10 percent, while 5 percent have not assessed their losses, suggesting that large firms may be underestimating the hidden costs of disruption or failing to track secondary impacts, such as reputational damage or workforce displacement.

RESPOND PHASE

Ad hoc crisis response persists	• 60 percent rely on ad hoc responses or underestimate the risks and 40 percent cite lack of clarity in regulation, funding, or risk data as a barrier to effective disaster response • This suggests that large companies are not systemically institutionalizing response playbooks, especially for multi-location operations.
Government policy gaps are hurting businesses	• 77 percent report that government policies are either weak or poorly enforced, indicating that external support mechanisms are not translating into on-ground resilience action.
Technologies exist, but deployment lags	• 70 percent use resilience tools, such as early warning systems and digital risk analytics, but only 37 percent have dependable access to vendors or service providers for implementation. • This infrastructure-to-execution gap limits the ability to act on alerts, despite a strong internal technology uptake.
Crisis management teams are underprepared	• 52 percent either lack a dedicated crisis management team or find them ineffective, further weakening mid-event coordination and continuity assurance across divisions.


RECOVER PHASE
Recovery is fast, but remains externally dependent
• 72 percent recover within one month of a disaster, outperforming smaller firms, but 33 percent report recovery delays because of inefficient government support, especially in sectors dependent on public utilities or permits for service resumption.
High insurance penetration, yet limited sophistication
• 87 percent have insurance, but 42 percent only have partial coverage for revenue or asset loss.
• 52 percent rely on traditional insurance and only 8 percent use advanced options, such as parametric or catastrophe-linked products, even though they are better suited to structured coverage innovations.
Workforce limitations and operational gaps in recovery
• 16 percent report skilled workforce shortages during recovery, affecting the timely resumption of critical operations.
• Despite this, only 30 percent plan to enhance internal capabilities, suggesting that human capital resilience is not yet a strategic priority.

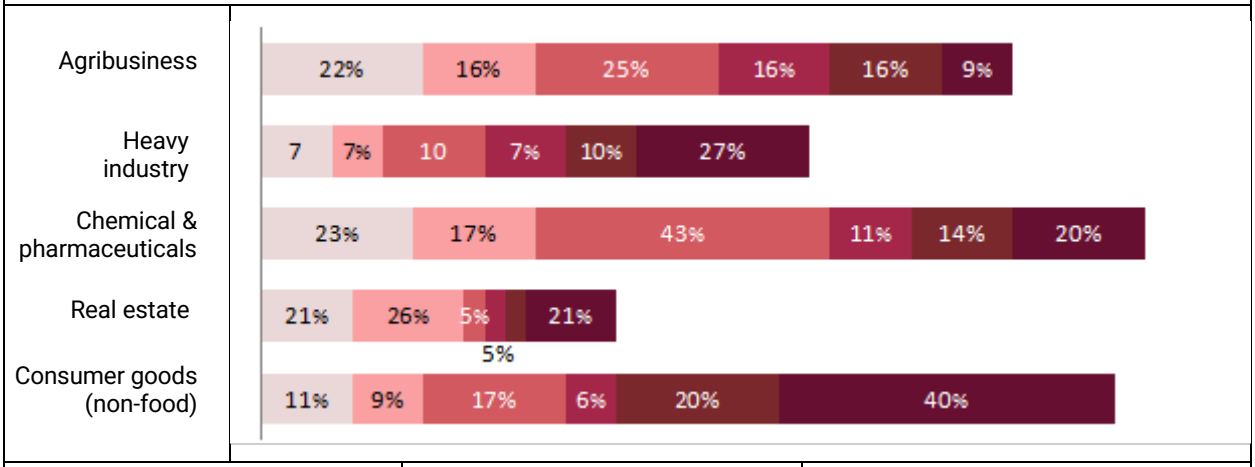
4.5 Lever-Wise Analysis of Key Resilience Pillars

POLICY AND REGULATION

Well-crafted policies create clarity and coordination, embedding climate risk into approvals, guiding procurement choices, and enabling faster recovery post-disruption. Effective regulation helps standardize best practices, reduces uncertainty, and ensures that resilience becomes a structured part of business continuity planning.

Survey insights

Incentives exist but awareness and uptake remain critically low across sectors.



Yes. Subsidies for investment in infrastructure/tech	Yes. Grants or direct financial assistance for projects	Yes. Tax incentives
Yes. Low-interest financing	No. Aware but not used	No. Not used and not aware

Limited regulatory and policy clarity

- Consumer goods (non-food) (40%), heavy industry (27%), chemical and pharmaceuticals (20%), and real estate (21%) have not utilized existing incentives.
- 77 percent of the sampled companies report policy gaps, indicating limited regulatory clarity on disaster preparedness and resilience.

Implication: Large businesses are not fully leveraging available policy incentives, which indicates a misalignment between regulatory design and enterprise needs. Persistent policy gaps may limit consistent adoption of resilience measures and reduce the effectiveness of public-private coordination in disaster preparedness.

Spotlight case: Nestlé India: Leveraging national climate programmes

Trigger

- Severe groundwater depletion in India significantly threatened Nestlé India's milk supply chains.

Interventions

- Partnered with India's National Mission for Sustainable Agriculture to implement climate-smart farming techniques, such as the System of Rice Intensification.
- Launched drought-prevention projects in Karnataka's Kabini Basin, in partnership with AgriSi, achieving a decrease in water usage and an increase in yields.
- Nestlé India's MAGGI Spice Plan was launched in partnership with farming communities.
- Nestlé India's R&D centre partnered with the Indian Institute of Millets Research in 2023 to enhance climate-resilient millet farming and supply chains to advance sustainable agriculture in key spice crops. The programme (aligned with India's priority on climate-smart agriculture) reached ~1,300 smallholder farmers in 39 villages by 2020 (2019–2022).

Key takeaways

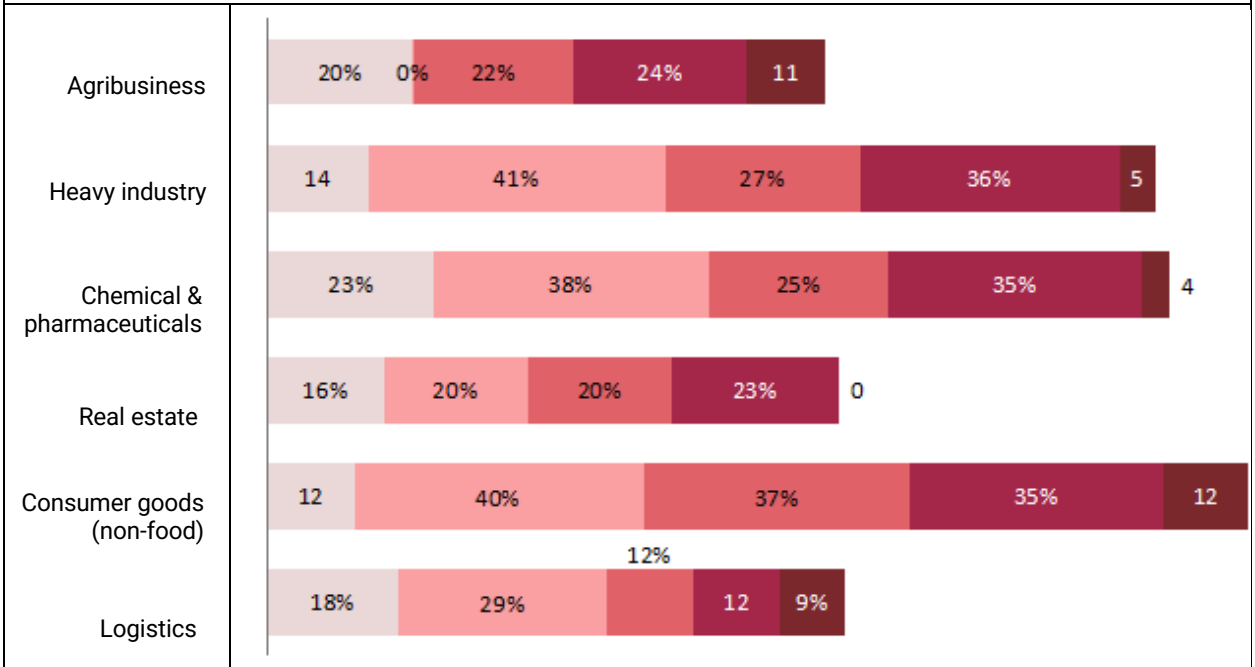
- Nestlé effectively leveraged government programmes to build robust, climate-resilient supply chains. Public-private collaborations enabled widespread adoption of sustainable practices, thereby safeguarding farmer livelihoods and ensuring business continuity amid increasing drought risk.

TECHNOLOGY

By deploying digital tools, predictive analytics, early warning systems, and adaptive infrastructure solutions, companies can anticipate disruptions, optimize operations, and reduce recovery time. From artificial intelligence–powered cooling systems to smart logistics rerouteing, technology can unlock new pathways to climate-proof assets, supply chains, and customer engagement models.

Survey insights

What types of climate- or disaster-resilient technologies/tools has your company implemented?



Physical risk reduction (e.g., flood barriers, raised platforms)	Early warning systems (e.g., automated alerts/notifications)	Traditional warning systems (e.g., local observation, manual sirens, etc.)
Digital tools (e.g., risk analytics, remote sensing)	None	

Technology adoption across sectors

- Digital tools lead adoption in chemical & pharmaceuticals and agribusiness—highlighting focus on data-driven risk management.
- Community-based practices are strong in consumer goods (non-food), indicating a hybrid tech–traditional approach.

Implication: Uneven technology adoption reflects varying levels of digital maturity across sectors, with advanced analytics enabling more proactive and systematic risk management in chemical & pharmaceuticals and agribusiness. Continued reliance on community-based or hybrid approaches in consumer goods (non-food) may support localized resilience but could limit scalability and real-time decision-making under more severe or systemic shocks.

Spotlight case: Gerding Edlen: Building climate-resilient waterfront properties using advanced technologies

Trigger

- In 2015, severe coastal flooding and infrastructure failures caused $4.3 billion in losses in East Boston, a low-lying, flood-prone region.

Interventions

- Structures were elevated above floodwater levels, and critical equipment was safeguarded.
- Roof-mounted generators (with four-day fuel back-up).
- Wind-resistant façade (100 mph).
- Salt-tolerant landscaping.
- On-site cogeneration plant producing electricity and heat, which reduces annual energy costs by 24 percent ($150,000 in savings).

Key takeaways

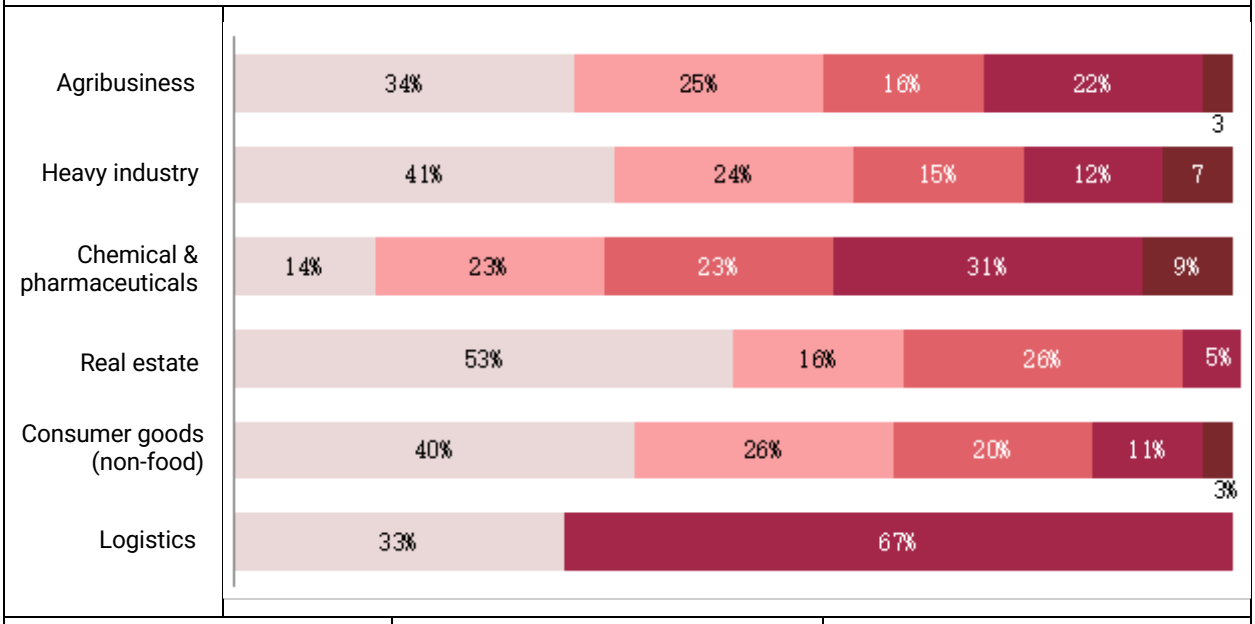
- Insurance premiums were significantly reduced (10x lower) because of enhanced resilience.
- Apartments commanded 2–18 percent higher rental rates than comparable properties because of superior climate resilience.
- Building operations resumed within three days after a major storm, compared with 60–90 days previously.

FINANCE

Finance enables businesses to move from intention to execution in building climate resilience. By mobilizing capital, leveraging risk-transfer instruments, and embedding resilience in financial planning, businesses can fund proactive adaptation instead of absorbing reactive losses. From resilience-linked insurance to dedicated budgeting for risk mitigation, financial tools help de-risk investments, unlock co-benefits, and ensure continuity under stress.

Survey insights

Does your company allocate a budget for short-term emergency response and/or long-term resilience planning for climate-/disaster-related events?



No dedicated fund. Ad hoc budget allocation	1%–5%. Limited emergency or resilience needs	5%–10%. Short-term emergency response
5%–10%. Long-term risk reduction and resilience building	>10%. For resilience building and emergency needs	

Leaders and laggards in resilience funding

- Heavy industry and real estate lag in dedicated funding, with over 40 percent relying on ad hoc or no budgeting.
- Chemical and pharmaceuticals lead in resilience funding, with 70 percent allocating more than 5 percent of their budget.

Prevalence of ad hoc or no resilience funding

- A significant number of respondents report having no dedicated budget for emergency response or long-term resilience planning—real estate (53%), heavy industry (41%), consumer goods (non-food) (40%), agribusiness (34%), and logistics (33%).

Implication: The widespread reliance on ad hoc funding suggests that resilience is not yet systematically embedded in financial planning in several sectors, potentially constraining preparedness and delaying response during climate-/disaster-related events.

Spotlight case: Parametric insurance: Safeguarding German supply chains against droughts in the Rhine River

Trigger

- Severe drought in 2018 decreased water levels in the Rhine River to 25 cm, far below the 150 cm level needed for normal navigation, resulting in financial losses for industries.

Interventions

- Implemented parametric insurance instruments triggered by specific Rhine water-level thresholds.
- Enabled immediate, automatic payouts (within days) when water levels fell below the critical point.
- Used transparent, predefined triggers to simplify claims processing.

Key takeaways

- Immediate liquidity injection mitigated drought-driven supply chain disruptions.
- Parametric insurance instruments covered non-damage business interruption gaps.
- Provided a scalable climate-risk solution for inland waterway economies.

GOVERNANCE

By embedding climate risk into enterprise governance structures, businesses can shift from ad hoc responses to institutionalized decision-making. From board-level oversight to cross-functional resilience units, governance ensures alignment across functions, timelines, and geographies. It also creates feedback loops that translate risk signals into timely action—fortifying systems, clarifying roles, and ensuring sustained resilience.

Survey insights

Do businesses have a formal and comprehensive BCP?

Yes. Fully comprehensive BCP	Yes. Have a BCP, but have not tested it
No. Currently in the process of making one	No. We do not have a BCP

Do businesses have a formal and comprehensive DRM policy?

Yes. Fully comprehensive DRM policy	Yes. Have a DRM, but do not have detailed SOPs
No. Currently in the process of making one	No. We do not have a DRM policy

Governance maturity in DRM for large businesses

- While several large businesses report having a formal BCP (43%) and DRM policy (42%) in place, many indicated that these are either untested (39% for BCP) or lack detailed SOPs (40% for DRM), pointing to gaps between policy design and execution readiness.
- Residual governance gaps remain: 17–18 percent of large businesses are either still developing or do not have a formal BCP/DRM policy, indicating incomplete governance coverage even among large, more resource-owning organizations.

Implication: Although governance frameworks for disaster and risk management are broadly established among large businesses, incomplete testing and limited operational depth may undermine their effectiveness during real events. Strengthening execution mechanisms—through testing, role clarification, and embedded decision rights—will be critical to translating formal governance into timely and coordinated resilience outcomes.

Spotlight case: Toyota: Supply chain resilience through deep supplier risk analysis and contingency planning

Trigger

- The 2011 Tohoku earthquake and tsunami severely disrupted Toyota's supply chain, shutting down plants and reducing quarterly profits by 77 percent.

Interventions

- Developed a centralized digital database mapping 650,000 supplier sites to enable rapid identification and response to disruptions.
- Instituted policies for supplier diversification, including standardization of critical components and geographically distributed manufacturing.
- Implemented new risk management protocols, including strategic inventories and dual sourcing of critical parts.

Key takeaways

2018 West Japan floods

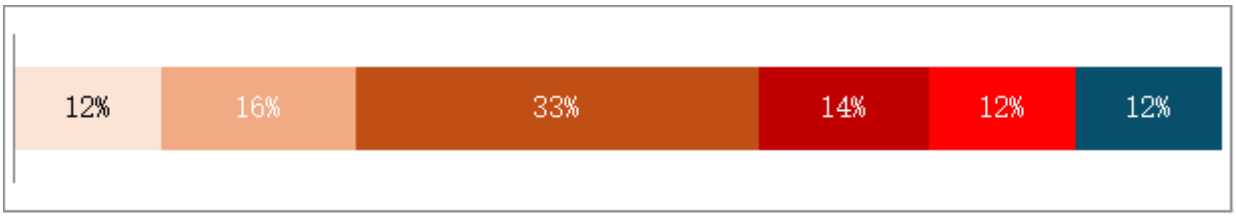
- $10 billion in losses across Japanese industries; no material impact on Toyota.
- Toyota reached out to alternate suppliers for 80,000 vehicles; four factories were restored within two to three days.
- Competitor Mazda incurred losses of $248 million; production was halted for four days and operated at reduced capacity for approximately two months.

CAPACITY DEVELOPMENT

Capacity building equips businesses with the skills and systems to act on climate risk. This includes training frontline teams, building leadership awareness, and institutionalizing know-how through guidelines, certifications, and scenario planning. A strong capacity enables faster response, better risk management, and continuity under stress—turning resilience from strategy into day-to-day operational discipline.

Survey insights

Which of the following challenges has your organization faced when restoring critical operations after a climate-/disaster-related disruption?



Lack of business continuity or recovery plan	Shortage of skilled personnel	Delays in external support
Poor internal departmental coordination	Unclear roles and responsibilities	Not experienced significant disruptions

Uneven capacity readiness across large businesses

- The most frequently cited challenges during recovery are related to operational execution—delays in external support (33%), coordination issues, and unclear roles and responsibilities (12%–14%), indicating that capacity constraints, rather than the absence of plans alone, impede effective response.
- Shortage of skilled personnel (16%) and lack of business continuity or recovery planning (12%) indicate uneven institutionalization of resilience capabilities across functions and sites, even within large organizations.

Implication: While large businesses have begun embedding resilience into strategic and governance frameworks, limited operational capacity—particularly in skills, coordination mechanisms, and external response readiness—continues to constrain effective recovery. Strengthening frontline capabilities, clarifying responsibilities, and institutionalizing training and scenario-based preparedness will be critical to translating resilience intent into consistent operational performance under stress.

Spotlight case: Walmart: Disaster preparedness through employee and community training

Trigger

- In 2005, Hurricane Katrina significantly disrupted operations, exposing Walmart's need for improved disaster preparedness and response.

Interventions

- Launched disaster preparedness training for employees, covering emergency management, communications, and business continuity.
- Regularly conducted nationwide disaster simulation drills involving thousands of associates and the broader community.
- Collaborated with federal and local emergency agencies through joint planning, resource sharing, and coordinated response exercises to strengthen community resilience.

Key takeaways

- Training significantly improved response times; during Hurricane Harvey (2017), most Walmart stores reopened within a few days.
- Efficient distribution of millions of emergency supplies to disaster-affected communities.

4.6 Embedding Resilience Across the Business Lifecycle

After analysing vulnerabilities of businesses across the value chain and different hazards, the next challenge is moving from insight to action. Building resilience requires more than isolated interventions; it demands a systemic approach that embeds adaptation at every stage of the business lifecycle, from strategy and planning through to operations and end-of-life. Achieving this at scale depends on activating five critical levers: policy and regulation, technology, finance, governance, and capacity building. It also calls for coordinated action among a wide network of stakeholders, including governments, businesses, financiers, and civil society. The framework below illustrates how these elements must work together to build business systems that are both protected and prepared.

Figure 12: Integrated framework for embedding resilience across the business lifecycle

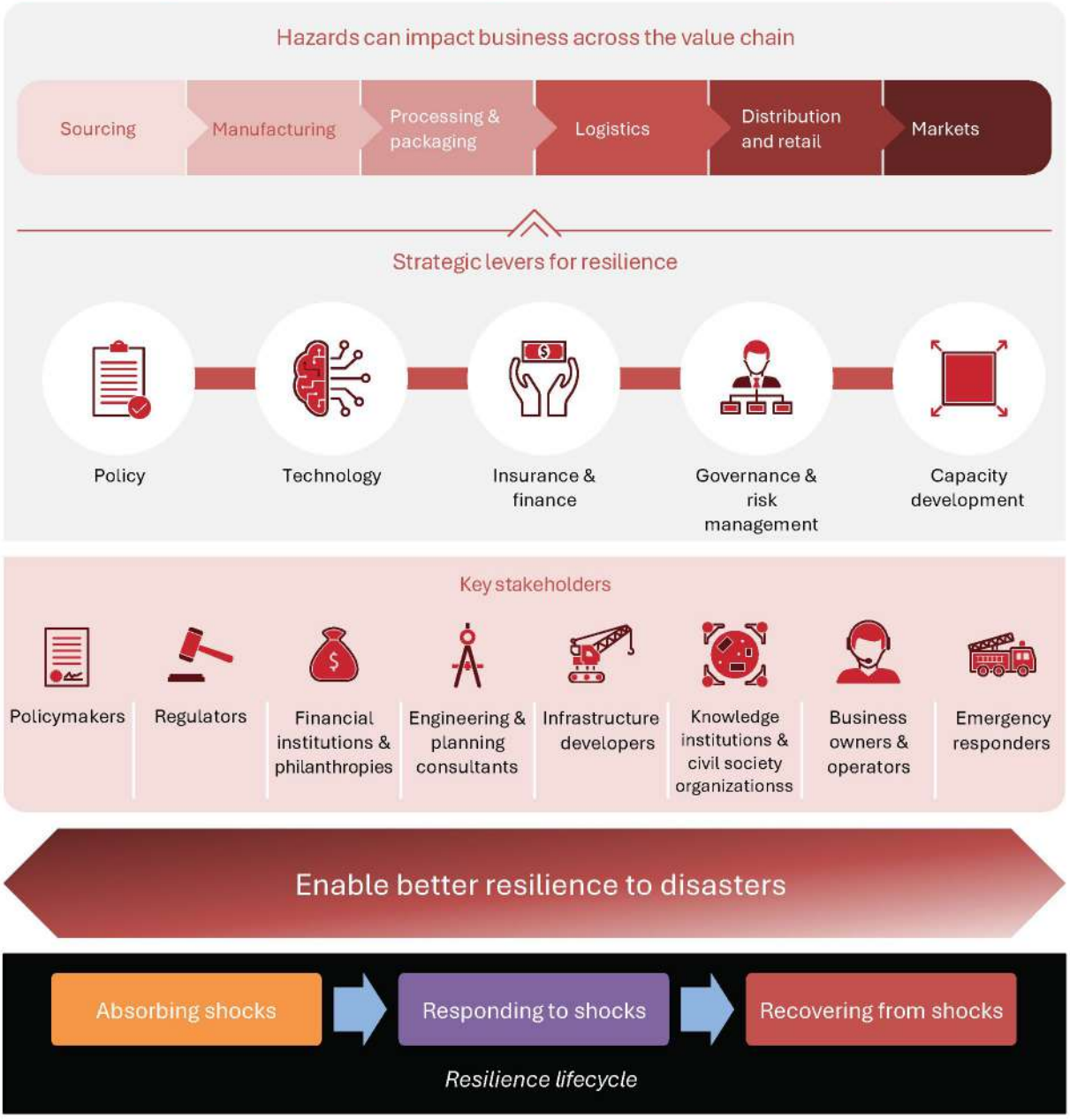


Table 7	**Business lifecycle resilience framework: key considerations and enabling levers**

Key considerations across the business lifecycle

Sourcing	Manufacturing	Processing & packaging	Logistics	Retail & distribution	Market
Identify interdependencies across suppliers	Secure internal approvals that are compliant with climate risk standards	Assess risk appetite and resilience requirements for supplier contracts	Embed resilience into logistics contracts and route planning	Stress-test delivery and distribution systems under different hazard scenarios	Assess climate impacts on consumer demand and service models
Conduct supplier-level exposure and vulnerability analysis	Integrate resilience principles into facility and process design	Define material alternatives in case of supply chain failure	Develop contingency protocols for transportation disruptions	Integrate sensors and real-time tracking for early disruption alerts	Explore strategies to repurpose, recycle, or recover post-event value
Assess the cost of inaction versus investment in resilience building					

Five enabling levers

Policy & regulation	Data & technology	Investment & financial planning
• Post-disaster financial support through public policies—soft loans, credit support, or relief packages for recovery	• Digital supply chain mapping and risk analytics to assess exposure and monitor disruptions in real time	• Index-based insurance for climate-sensitive inputs to protect suppliers from climate shocks, such as droughts or floods
• Public infrastructure insurance schemes offering quick payouts for repairing damaged roads, ports, and utilities	• AI-powered cooling and energy optimization systems that regulate facility conditions to improve climate resilience	• Catastrophe bonds for infrastructure and operations that transfer risk to investors, unlocking faster post-event funding
• Tax incentives and subsidies for resilience investments to lower the barriers to the adoption of climate-proofing measures	• Smart logistics re-routing using real-time data on congestion, weather, and infrastructure to maintain delivery timelines	• Emergency liquidity tools for employee and business continuity, ensuring rapid post-event cash flow
• Embedding resilience criteria in procurement and recovery planning to enforce minimum standards and ensure faster recovery	• Early warning systems and remote sensing technologies that automate alerts and enhance visibility across operations	• Dedicated resilience budgeting (short- and long-term) to allocate funds for both crisis response and proactive adaptation

Governance	Capacity building
• Centralized databases for supplier risk tracking to streamline visibility, disruptions, and contingency responses	• Employee disaster preparedness and recovery training, including SOPs, simulations, and drills
• ISO-aligned continuity standards and disaster simulations to stress-test preparedness and refine response plans	• Customer education on disaster readiness to strengthen community resilience and engagement
• Crisis-response protocols integrated into governance, defining clear roles and escalation pathways	• Joint training with public and emergency agencies to enhance coordination and localized response capability

This integrated framework outlines how businesses can embed climate resilience throughout their value chains in a practical and actionable way. It identifies specific interventions suited to different functions and risk profiles, thereby helping bridge persistent gaps in how businesses anticipate, withstand, and respond to climate disruptions. By linking critical business decisions to five enabling levers—policy and regulation, technology, finance, governance, and capacity building—it encourages a shift from reactive crisis management to forward-looking risk reduction. In doing so, it positions climate resilience not as a compliance exercise but as a strategic lever for agility, competitiveness, and long-term performance in an increasingly volatile operating environment.

5 Infrastructure Companies

5. Infrastructure Companies

Infrastructure companies form the backbone of economic activity, underpinning essential services, such as energy, transport, water, communications, and waste management. Characterized by long-lived, capital-intensive assets and geographically fixed networks, infrastructure systems are inherently exposed to geo-climatic hazards and disaster risks. As climate impacts intensify, disruptions in infrastructure services rarely remain contained; instead, they cascade across economies, communities, and value chains.

This chapter focuses on infrastructure operating companies that own and/or operate physical infrastructure assets. The survey sample primarily includes public/private infrastructure asset operators and developers and infrastructure asset managers with direct operational oversight.

The sectors covered include power and energy, transport (roads, rail, airports, ports), telecommunications, and water and sanitation.

This chapter focuses on critical infrastructure sectors where climate and disaster risks are the most acute, reflecting a combination of asset immobility, high replacement costs, and systemic importance to national

and regional resilience. Failures in these systems can rapidly amplify social and economic losses, affecting households, businesses, and public services simultaneously.

Finally, the chapter assesses how infrastructure companies anticipate, absorb, respond to, and recover from climate and disaster shocks. Using insights mapped across the Absorb–Respond–Recover lifecycle, the analysis examines the five key enablers—policy and regulation, technology, finance, governance, and capacity building—to highlight where resilience efforts are progressing and where structural gaps continue to constrain adaptation.

5.1 Regional and Sectoral Breakdown of Infrastructure Companies That Participated in the Survey

Figure 13: Breakdown of survey participants across infrastructure companies

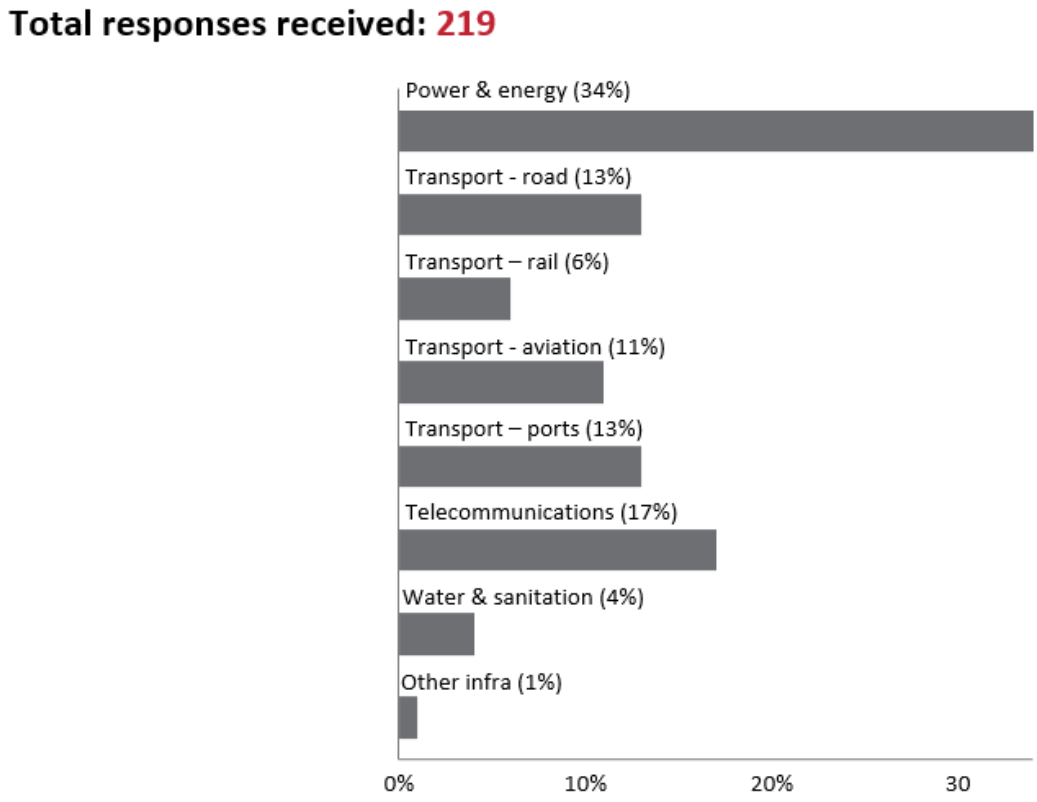
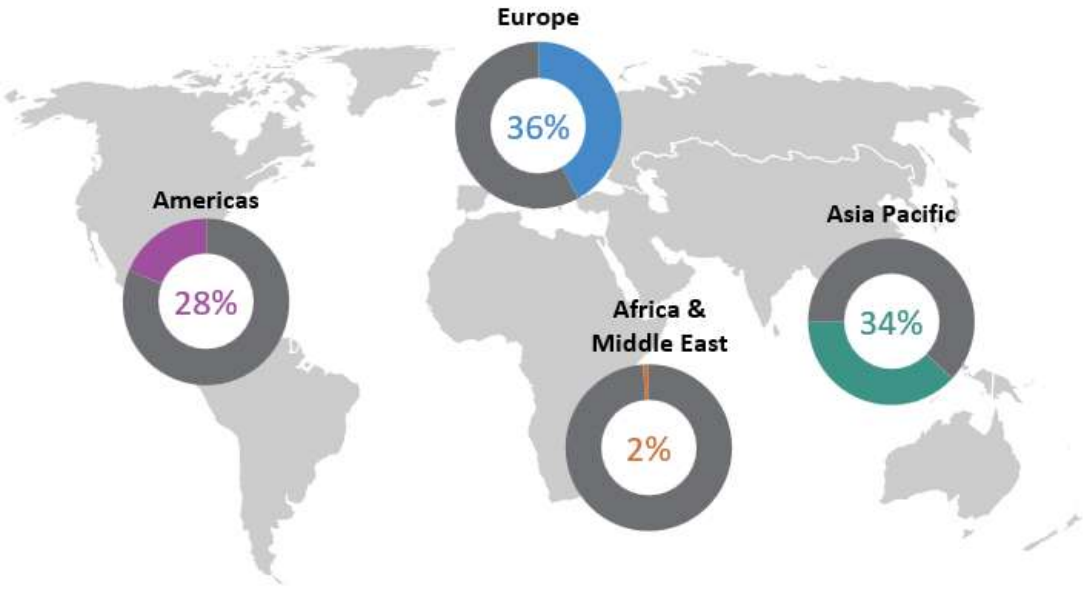


Figure 14: Geographic distribution of the Global Business Survey responses for infrastructure companies



5.2 Four Sectors Stand Out for Their High Total Climate Exposure

Figure 15: Value of assets at risk in different infrastructure sectors

Geo-climatic hazards and disaster risks are increasingly undermining critical infrastructure systems worldwide. Key sectors, including transport, water, telecommunications, and energy, are particularly exposed to hazards, such as cyclones and earthquakes, heightening risks to service continuity and economic stability (CDRI, 2023).	***All values in $ billion***			
	92,692	**54,242**	**21,508**	**13,421**
	Transport	**Power**	**Telecom**	**Water & wastewater**

These sectors not only incur direct damage from such geo-climatic hazards and disaster events, but their disruption also triggers widespread cascading impacts due to their high degree of interdependence. Interruptions in one system can lead to failures in others, amplifying socio-economic consequences and threatening the continuity of essential services.

Collectively, the transport, power, telecommunications, and water and wastewater sectors are often referred to as lifeline sectors because their continuous functioning is essential for communities and economies; when disasters strike, these systems are often the hardest hit. Estimates suggest that infrastructure sectors account for approximately 88 percent of all resilience costs globally (UNOPS, 2021). This means that strengthening infrastructure resilience in these four sectors will dominate adaptation budgets.

The distribution of geo-climatic hazards and the infrastructure sectors affected is given below. The table illustrates how different hazards disrupt transport, power, telecommunications, and water and wastewater

infrastructure—from tropical cyclones damaging power grids and ports to floods and wildfires affecting roads, railways, and communication networks. Such events underscore the worldwide exposure of critical infrastructure systems to geo-climatic hazards and disaster risks. Overall, the potential impact of climate change on infrastructure depends on the type of hazard or disaster and on its interaction with infrastructure's exposure and vulnerability (OECD, 2024).

5.3 Geo-Climatic Hazards, Impacts, and Historical Disruptions in Infrastructure Sectors

Table 8 **Geo-climatic hazards and associated impacts across infrastructure sectors**

Infrastructure type		Geo-climatic hazard	Infrastructure impacts
Transport	Land (roads, railways)	Extreme heat	Pavement softening (rutting); thermal rail expansion (buckling)
		Extreme precipitation	Washouts; flooding of roads and railways
		Storm surge & sea level rise	Inundation and destabilization of coastal roads and railway lines
		Storm, high winds	Blockage of roads and railways because of fallen trees; other damaged assets
		Permafrost melt	Buckling and destabilization of roads and railways
	Riverine	Drought	Riverine transport routes (temporarily/seasonally) becoming unnavigable
		Riverine flooding	Damage to ports, ships, and cargo; riverine transport routes temporarily becoming unnavigable
		Storm, high winds	
	Marine	Sea level rise & storm surge	Inundation and erosion of ports
		Temperature rise	Change in demand for ports; Arctic waters become navigable
		Storm, high winds	Damage to ports, ships, and cargo; certain transport routes (temporarily) becoming unsafe
		Sea level rise & storm surge	Inundation and erosion of ports
	Aviation	Storm, extreme precipitation, cold wave, wildfire (smoke)	Disruptions in flight schedules; damage to aircraft and airport infrastructure; risks to safety (e.g., accidents); need for extensive de-icing of aircraft and runways; impacts on mechanical operations; runway buckling
Energy	Hydropower	Drought	Decreased power production, with the possibility of assets getting stranded if the drop in water level persists
		Flood	Damage to hydropower plants
		Extreme heat	Increased demand for cooling; increased pressure on the power grid

Infrastructure type		Geo-climatic hazard	Infrastructure impacts
	Energy sector overall	Sea level rise, storm surge	Inundation and/or erosion of coastal power plants, cooling systems, transmission and distribution lines
		Wildfire	Damage to power production assets, transmission and distribution lines
		Riverine flooding	Disruption in energy supply because of flooding of transmission lines or power plants
		Storm, high winds	Power outages; damage to power production assets, transmission and distribution lines
Telecommunications		Extreme heat	Overheating of data centres
		Riverine flooding	Flooding and/or erosion of data centres, radio/television stations, telecommunications, and distribution lines
		Storm, high winds	Damage to telecommunications towers, distribution lines
		Wildfire	Burning of transmission cables, telecommunications towers
Water supply, waste, & stormwater infrastructure		Extreme heat	Increased evapotranspiration from reservoirs; increased need for water treatment
		Extreme precipitation	Sewage overflows; overtopping of dams, levees, and reservoirs; increased need for water storage capacity
		Riverine flooding	Contamination of water sources; overtopping of dams, levees, and reservoirs; increased need for water storage capacity
		Drought	Reduced water supply
		Sea level rise & storm surge	Salinization of water supply; inundation and/or erosion of water treatment infrastructure, including outfalls

Because transport, power, telecommunications, and water and wastewater infrastructure are so interconnected, a failure in one sector can trigger failures in others (e.g., a power blackout shuts down water pumps or mobile services). Building resilience in these sectors can significantly reduce the overall impacts, preventing systemic breakdowns. In summary, the broad geographic exposure and vulnerability to multiple hazards place these sectors at the front line of impact; accordingly, strengthening resilience across these four sectors will drive the majority of gains in global infrastructure climate risk reduction.

5.4 Survey Insights—Infrastructure Companies

To better understand how infrastructure companies prepare for, respond to, and recover from climate and disaster risks, the survey analyzed their resilience strategies using a structured, lifecycle-based framework. This approach assessed maturity across all three stages of the resilience lifecycle—Absorb, Respond, and Recover—and evaluated performance using five enabling levers: policy and regulation, technology, finance, governance, and capacity building.

The following section presents

i) A concise view of how infrastructure businesses perform at each stage of the resilience lifecycle, highlighting strengths, systemic gaps, and readiness bottlenecks.

ii) A deep dive into the five critical levers—policy, technology, finance, institutional governance, and capacity building—identifying the most urgent calls to action and opportunities for targeted intervention.

This structured approach allows a comparison of what resilience looks like at different lifecycle phases and which enabling systems support or fail that resilience. It also highlights global patterns, underlining where infrastructure firms, especially those in lifeline sectors, such as transport, energy, and telecommunications, are progressing and where coordinated support is needed.

Ultimately, this lever-wise infrastructure resilience lifecycle lens supports a more actionable, systems-level view of resilience, offering guidance to businesses, policymakers, and financiers on focusing their efforts on the most critical enablers of infrastructure continuity in the face of increasing climate and disaster risks.

Why this matters

Infrastructure companies underpin essential services and economic continuity, making their abilities to absorb, respond to, and recover from climate and disaster shocks a systemic risk issue rather than a firm-level concern. Identifying resilience gaps at different lifecycle stages and enabling systems is critical to preventing cascading failures across transport, energy, telecommunications, and other lifeline sectors as climate risks intensify.

5.5 Survey Insights Mapped Across the Infrastructure Resilience Lifecycle

ABSORB PHASE

Strong policy intent but readiness remains incomplete	• While 86 percent percent of infrastructure companies report having a BCP, 37 percent have not tested them, an indication that many plans remain unvalidated and unfit for real-time execution. • Similarly, 80 percent claim to have a DRM policy, yet 28 percent lack detailed SOPs/guidelines, weakening operational relevance.
Data awareness does not equal data use	• 63 percent conduct annual climate risk assessment but 33 percent are unaware of or do not use publicly available climate risk assessment tools, showing poor integration of risk information into the workflow. • Only 4 percent report losses >10 percent in the past 5 years, suggesting underreporting or a lack of post-event loss analysis; 5 percent have not assessed their losses.
Technology adoption is high but supplier ecosystem lags	• 78 percent use climate- or disaster-resilient tech (early warning systems, hazard modeling, etc.) but only 46 percent report reliable access to service providers, highlighting a last-mile execution gap. • This impairs their ability to translate digital insights into tangible physical risk reduction.
Finance gaps undermine preventive action	• 61 percent have allocated 1–10 percent of their budget to resilience but 24 percent have not allocated at all, indicating a clear funding shortfall that can delay critical pre-disaster investments. • The absence of earmarked budgets restricts early-stage readiness and infrastructure hardening.

RESPOND PHASE

Crisis response remains largely ad hoc	• Despite policy coverage, 57 percent of infrastructure firms still respond via ad hoc measures. 37 percent cited lack of regulatory clarity, data, or funding as key barriers. • This implies that SOPs and emergency response protocols are either absent or untested at many project sites.
Government support & policy implementation remains weak	• 71 percent state that government policies are poorly enforced or absent, limiting external triggers for business preparedness.
Early warning is under-leveraged	• While most use climate modeling or alerts, real infrastructure response (e.g., redundancy systems, workforce training) is often insufficient to act on them, which is further compounded by supplier unreliability and technical skill gaps.
Capacity gaps persist in real-time crisis teams	• 42 percent lack a dedicated crisis management team or find that existing teams are ineffective. • This is directly linked to budget constraints and fragmented SOPs, creating institutional blind spots during disruptive events.

RECOVER PHASE

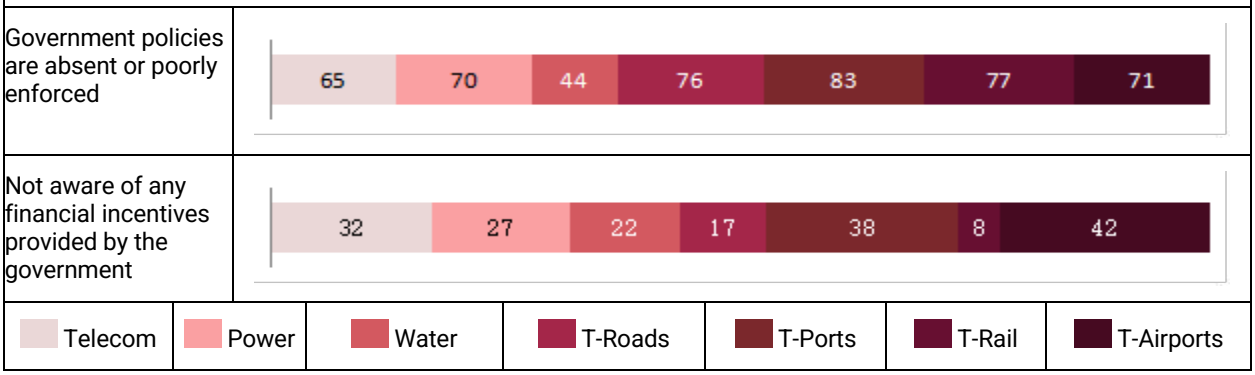
Fast recovery with pre-action but not equally across firms	• 79 percent recovered within a month post-event, showcasing high resilience for those who are prepared but likely skewed toward larger, better-funded firms. • 37 percent cited delays caused by slow external support (e.g., government aid), signaling systemic lags outside firm control.
Insurance penetration is high but depth is limited	• 90 percent have insurance but 45 percent only have partial coverage. • Furthermore, 50 percent rely solely on traditional insurance and only 13 percent use parametric or catastrophe bonds, reflecting untapped potential in modern risk transfer mechanisms.
Human resource and operational recovery is strained	• 23 percent report skilled personnel shortages during recovery, which affects the ability to restore critical operations, such as traffic, logistics, or utilities, especially in remote or resource-constrained sites.

5.6 Lever-Wise Analysis of Key Resilience Pillars

POLICY AND REGULATION

Governments play a vital role in setting rules, incentives, and mandates that guide infrastructure companies. Effective policies ensure sharing of responsibilities, reduced systemic risk, and faster adaptation. Without clear regulation and support, resilience efforts remain fragmented, leaving critical sectors vulnerable to climate and disaster shocks.

Survey insights



1. **Policy enforcement remains uneven, leaving critical gaps**

- Ports (83%), rail (77%), and roads (76%) face the greatest policy enforcement challenges, revealing critical governance gaps in essential sectors.
- Water (44%) shows the strongest policy enforcement, indicating relatively better-regulated environments for resilience planning.

Implication: Weak policy enforcement in high-impact sectors risks undermining resilience outcomes, pointing to the need for clearer accountability, greater oversight, and more consistent implementation mechanisms.

2. **Awareness of government incentives**

- Airports (42%) and ports (38%) top the list of sectors unaware of incentives, indicating limited communication or insufficiently targeted outreach efforts, while rail (8%) has the lowest unawareness.

Implication: Low awareness in airports and ports suggests gaps in policy communication, underscoring the need for more targeted outreach to improve uptake of resilience incentives.

The survey results reveal fragmented policy enforcement and uneven visibility of government incentives across infrastructure sectors. Transport sectors (airports and ports) appear to be the most vulnerable, consistently scoring high on both poor enforcement and low incentive awareness, exposing them to increased geo-climatic and disaster risks.

Spotlight case: Funding support to Pacific Gas & Electric (PG&E), one of the largest US combined natural gas and electric utility companies, during the 2017–18 California wildfires

Trigger: In 2017–18, severe wildfires in California—linked to drought—caused over 80 deaths and pushed PG&E toward bankruptcy with $30 billion in liabilities (Pacific Gas & Electric, 2020).

Interventions

- The California government established a $21 billion wildfire fund to cover future utility liabilities and stabilize the grid. Access required PG&E and others to invest $5 billion in safety upgrades and co-fund the initiative with ratepayers over 15 years. The scheme provided rapid relief while incentivizing long-term resilience.

Key takeaways

- Public-private risk sharing: The PG&E case shows how acute losses can force policy innovation, leading to risk-sharing mechanisms that blend public and private resources.

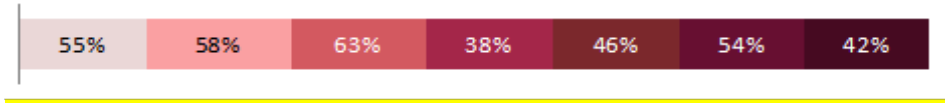
TECHNOLOGY

Infrastructure agencies often focus on reliability, safety, and compliance—adopting proven technologies through structured procurement and long-term planning. In contrast, private firms tend to be more agile, leveraging emerging digital tools to manage risks and optimize performance. While public players prioritize stability, private entities often lead in piloting innovation. Aligning both approaches is the key to scaling up resilient, tech-enabled infrastructure systems.

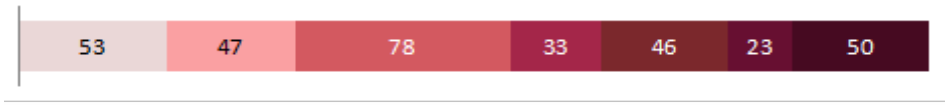
Survey insights

Digital tools are used mostly for

- Risk analysis
- Early warning systems
- Physical risk reduction measures



Easy access to tech suppliers/vendors



Telecom | Power | Water | T-Roads | T-Ports | T-Rail | T-Airports

1. **Technology adoption is widespread but unevenly distributed**

- Most infrastructure sectors report a strong uptake of digital tools (risk analysis, early warning, risk reduction)—water (63%), power (58%), and telecommunications (55%) lead.
- Roads is a clear laggard with the lowest adoption rate of 38 percent, indicating a risk gap in geo-climatic resilience.

Implication: Digital resilience is progressing unevenly; targeted interventions are needed to close the adoption gap.

2. **Access to suppliers**

- Despite a moderate level of digital tool use, rail (23%) and roads (33%) report limited access to suppliers, exposing a gap in the support ecosystem.

Implication: Supplier constraints may limit the effectiveness of resilience investments, highlighting the need to strengthen procurement and supplier ecosystems.

Resilience investments pay off when a high rate of tool adoption aligns with strong support ecosystems. The water sector exemplifies this synergy, pairing widespread digital tool use with full supplier access, and sets a benchmark for effective industry collaboration.

Spotlight case: Manual inspections were replaced with AI-driven track inspections using Light Detection and Ranging (LiDAR) technology by Network Rail, the owner and infrastructure manager of most of the railway network in the UK.

Trigger

- Since 2019, weather-related train delays have cost the UK rail system £370 million in payouts.

Interventions

- Network Rail began using Automated Intelligent Video Review (AIVR) technology to capture high-definition video and sensor data to enable remote inspections.
- Lightweight AIVR devices are mounted on the front of a train and automatically record forward-facing video during train operation.

Key takeaways

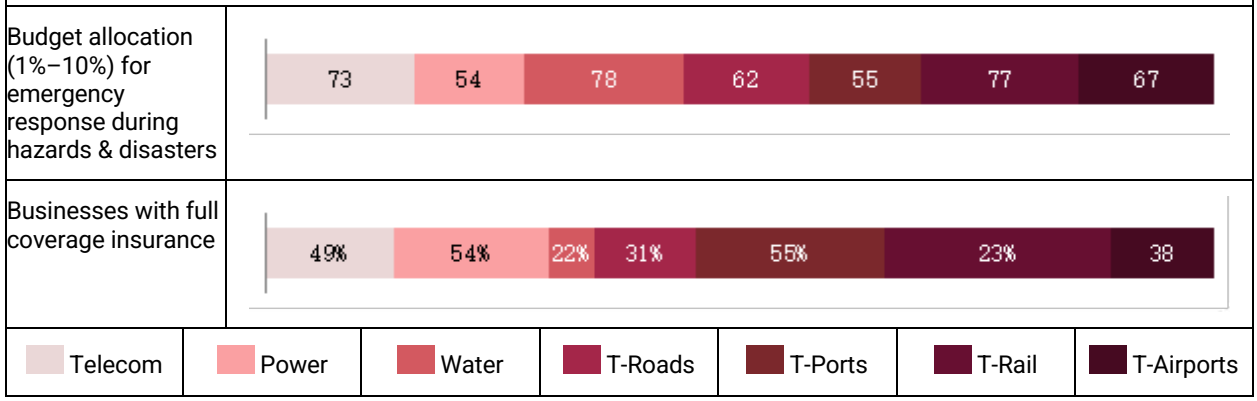
- AIVR has reduced the time taken for inspections by approximately 87.5 percent; remote monitoring has reduced the standard inspection time from 8 hours per site to 1 hour (Network Rail, 2019).
- Maintenance costs have decreased by 50–60 percent, and downtime has decreased by 50 percent.

FINANCE

Public infrastructure primarily relies on government funding, while private firms depend on investor capital and insurance to manage disaster risks.

As underinsurance is widespread, both public and private infrastructure firms face liquidity gaps after a disaster. Complementary action, i.e., public support and private capital, is essential to ensure timely recovery and resilient infrastructure.

Survey insights



1. **Budgeting and risk readiness**

- Emergency response budgets (1%–10% of total revenue): water (78%) and rail (77%) lead, with telecom (73%) and airports (67%) close behind. Roads (62%), ports (55%), and power (54%) lag.

  Implication: Networked utilities and rail earmark near-term response funding more consistently; however, ports and power need to review their contingency funding levels.

2. **Insurance adoption penetration**

- Businesses with full coverage insurance: ports (55%) and power (54%) show the highest full-coverage penetration, followed by telecom (49%). Water (22%), rail (23%), and roads (31%) exhibit a coverage gap.

  Implication: Critical public service sectors (water and rail) may recover more slowly after a shock unless insurance coverage is expanded or alternative instruments are deployed.

Rail is the most financially prepared sector, balancing budget allocation and broad insurance coverage. Other sectors show uneven preparedness, especially water and roads, which need to improve both funding commitment and insurance adoption to enhance financial resilience.

Spotlight case: The Metropolitan Transit Authority (MTA), responsible for public transportation in the New York City metropolitan area, issued catastrophe bonds to fund large-scale disaster recovery (Reuters, 2013)
Trigger • The MTA suffered a $5 billion hit to infrastructure assets and $268 million in operating losses because of Hurricane Sandy in October 2012.

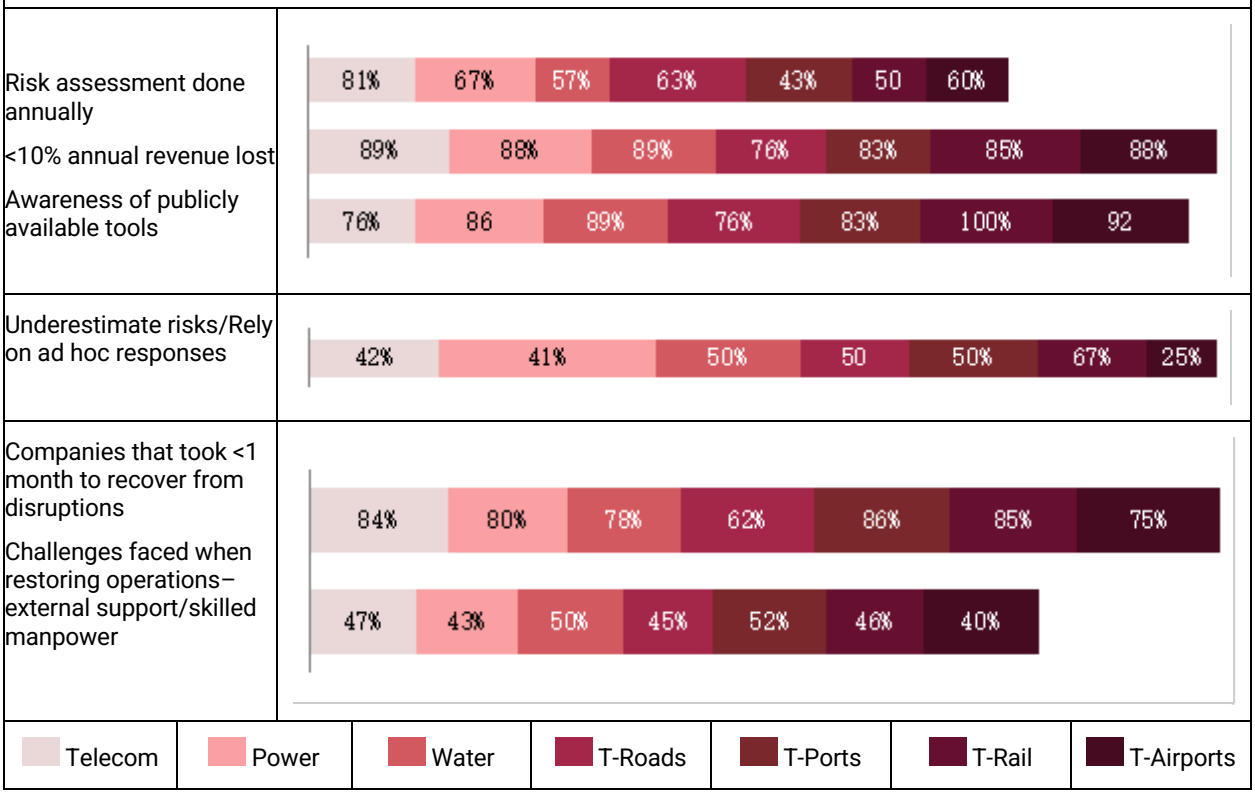
Interventions • After Hurricane Sandy, the MTA launched catastrophe bonds. • Traditional insurance proved to be inadequate or hard to obtain. • Issued $200 million of MetroCat bonds to cover storm surge risk.

Key takeaways • Transferred risk to capital markets, ensuring rapid payout after a disaster using parametric triggers. • The first-ever parametric storm surge bond issued; it is now a reference model for transit system climate resilience.

GOVERNANCE

Infrastructure companies follow standardized, mandate-driven risk protocols with a formal oversight structure to ensure service continuity and public accountability that may slow down response and recovery from disasters. Private companies are gearing themselves to embed risk awareness into operational decision-making, incentivize performance, and use data-driven tools for faster adaptation.

Survey insights



1. **Risk awareness and planning**

- Annual risk assessment: Telecommunications (81%) leads; power (67%), roads (63%), airports (60%), and water (57%) are mid-ranged, while ports (43%) and rail (50%) lag.
- Limited revenue impact (<10% lost): High across all sectors (76%–89%), indicating either effective continuity buffers or potential underestimation of financial exposure.
- Awareness of publicly available risk assessment tools: High in general; rail (100%), airports (92%), water (89%), power (86%), and ports (83%) lead, while telecommunications (76%) and roads (76%) lag.

Implication: While risk awareness and planning mechanisms are broadly in place, uneven assessment maturity and low reported revenue impacts indicate potential blind spots in financial risk estimation, particularly in ports and rail, highlighting the need for more rigorous stress testing and integration of risk insights into financial planning.

2. **Risk perception**

- Underestimation of risks/ad hoc response: Highest in rail (67%), elevated in water/roads/ports (~50%), low in telecommunications (42%) and power (41%), and the lowest in airports (25%).

  Implication: Persistent underestimation of climate risks, particularly in rail and other asset-heavy sectors, may delay proactive resilience investments, underscoring the need to strengthen risk literacy, scenario-based planning, and leadership accountability.

3. **Response efficiency and coordination**

- Recovery time <1 month: ports (86%), rail (85%), telecommunications (84%), power (80%), and water (78%) lead; solid in airports (75%), while roads (62%) lag.

  Implication: While short recovery times indicate improving response coordination across most sectors, slower recovery in roads points to structural and coordination constraints, reinforcing the need for clearer incident-response protocols and cross-agency coordination mechanisms.

Spotlight case: EVN (Vietnam Electricity), the largest state-owned power company in Vietnam, which provides electricity generation, transmission, and distribution services, established extensive resilience SOPs following catastrophic typhoons

Trigger

- Typhoons Wutip (2013) and Yagi (2024) exposed severe vulnerabilities in EVN's infrastructure.
- Massive outages in Quảng Bình (5,180 poles down; only 12% restored in 48 hours).

Interventions

- Implemented a three-part disaster readiness model: proactive prevention, timely response, and urgent recovery.
- Emergency protocols were activated before each storm season (e.g., cancel non-urgent meetings, review preparedness).

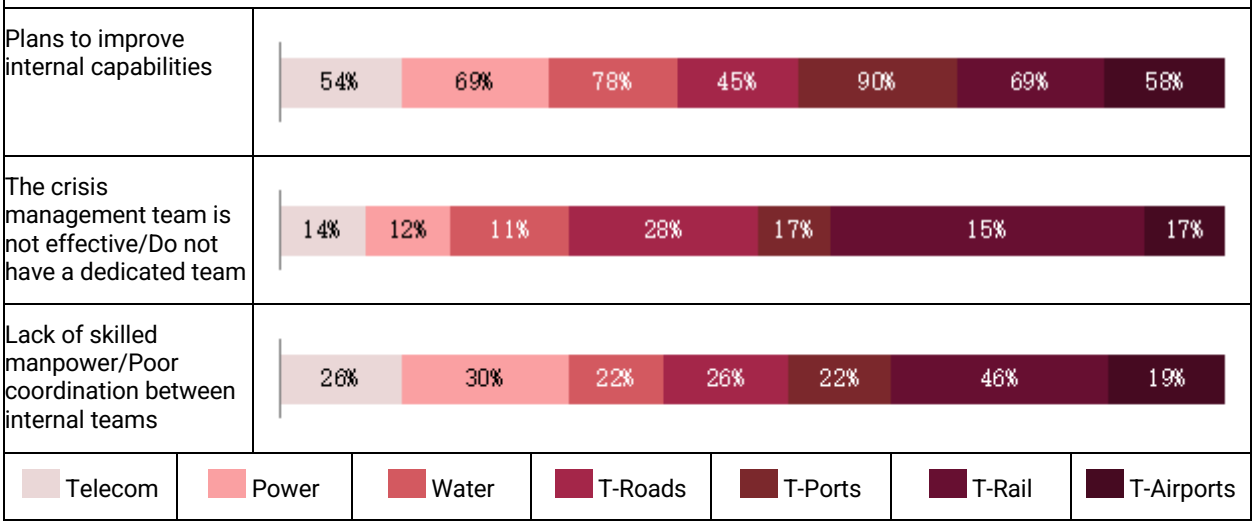
Key takeaways

- EVN restored power to 99 percent of its customers within 10 days after Typhoon Yagi affected 6.1 million users (Socialist Republic of Vietnam Government News, 2024).
- Effective risk management and business continuity proven during multiple severe weather events.

CAPACITY BUILDING

Government infrastructure companies often rely on centralized training programmes and standardized emergency protocols. Typically, they focus on maintaining continuity of essential services and ensuring compliance. Private operators are starting to provide risk-based training and, when available, invest in advanced tools, simulation drills, and partnerships to protect assets and operations.

Survey insights



1. **Investment in capacity building**

- Plans to improve internal capabilities (higher = better): While commitment to capacity building is strong in ports (90%) and water (78%), weaker intent in telecommunications (54%) and roads (45%) may limit long-term resilience, indicating a need for targeted incentives and capacity-building programmes in lagging sectors.

2. **Crisis management team**

- Shared crisis management reporting is ineffective or a dedicated team does not exist (higher = worse).
- Gaps in crisis management structures, particularly in roads (28%), could slow down response and recovery during disruptions, underscoring the need to formalize dedicated teams and strengthen preparedness in weaker sectors.

3. **Institutional coordination challenges**

- Lack of skilled manpower/Poor internal coordination (higher = worse).

Implication: Persistent coordination and capacity gaps—most acute in rail (46%)—risk weakening resilience execution, highlighting the need for workforce upskilling and clear institutional roles to improve cross-functional coordination.

Capacity building remains a weak link for most sectors. Rail is the most constrained sector, lacking structured crisis teams and skilled manpower. Greater investment in training, drills, and cross-functional readiness is critical for timely and effective disaster response.

Spotlight case: Company-wide resilience training to strengthen emergency preparedness for Anglian Water, a major water supply and wastewater services company in the UK (Anglian Water Services Limited, 2024).

Trigger

- Faced increasing disruptions caused by floods and extreme weather across the UK.
- Identified gaps in company-wide emergency readiness.

Interventions

- Trained 4,000+ staff via an internal programme that assigned secondary emergency roles to all employees.
- Conducted 40+ multi-agency drills annually with regulators and emergency services.

Key takeaways

- Embedded preparedness throughout the organization builds rapid, coordinated crisis response.
- Demonstrates how proactive training enhances operational continuity under stress.

5.7 Embedding Resilience Across the Infrastructure Project Lifecycle

To embed resilience across infrastructure systems, it is crucial to understand how different actors contribute at each phase of the infrastructure project lifecycle. Resilience is not the responsibility of a single actor; it demands coordinated action across strategy, planning, financing, implementation, and operations.

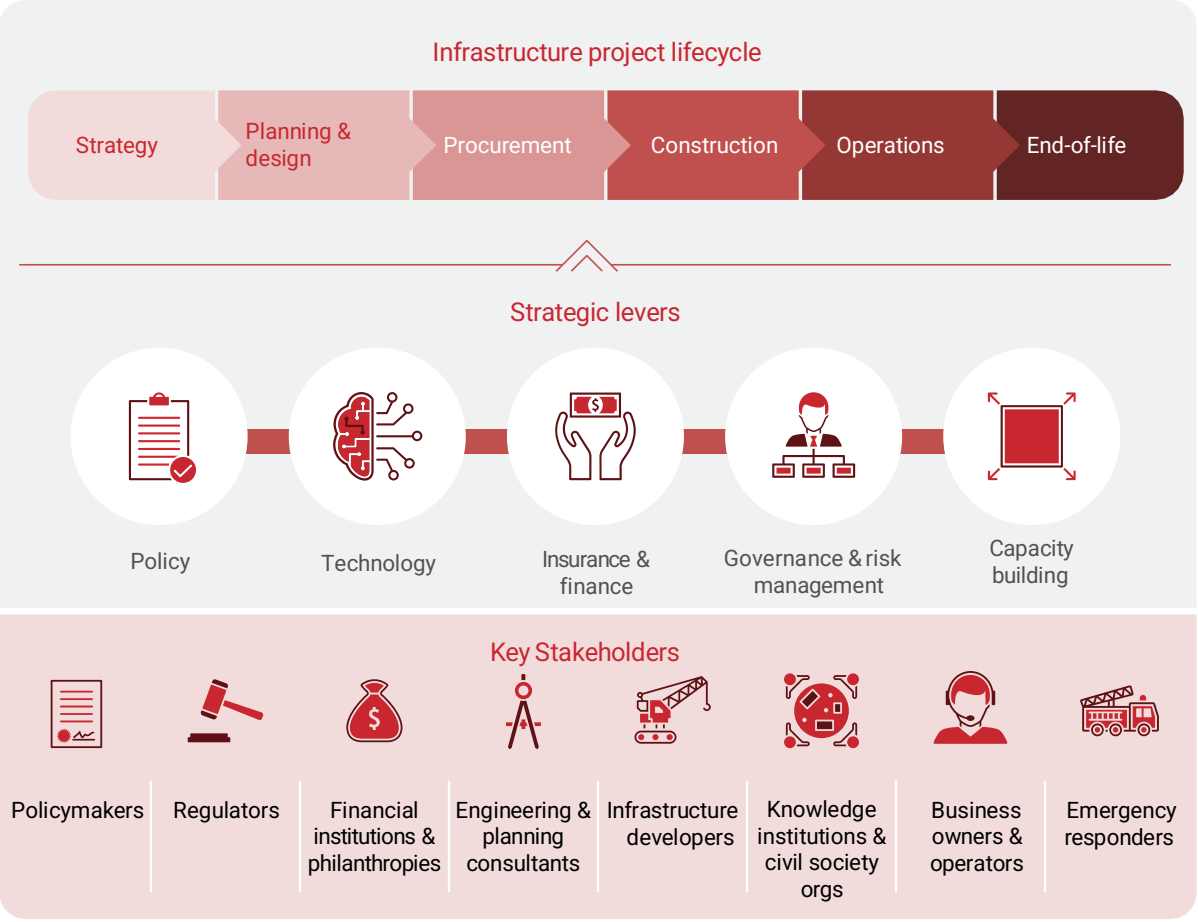
The following framework visually represents this ecosystem of collaboration:

- The stages of the infrastructure lifecycle—from strategy and planning to end of life.
- The strategic levers that enable resilience—policy and regulation, technology, finance, governance, and capacity building.
- The diverse set of stakeholders—from policymakers and engineers to financiers and emergency responders—each playing a distinct yet interconnected role.

By clarifying these intersections, the framework supports an end-to-end approach to mainstream resilience.

This section also introduces the stakeholder role matrix, which maps how various actors—from policymakers and financiers to planners, operators, and engineers—contribute to resilience building across different project phases and risk stages. In line with globally accepted norms (e.g., United Nations Office for Disaster Risk Reduction and CDRI), the matrix emphasizes that resilience must be embedded throughout infrastructure development and not treated as an isolated task.

Figure 16: Framework for embedding resilience across the infrastructure project lifecycle



	Strategy	Planning & design	Procurement	Construction	Operation & maintenance
Policymakers	Mandating robust design standards and allocating funds for risk reduction	Requiring climate and disaster risk assessment in project planning	Requiring resilience criteria in procurement and bid evaluations	Providing emergency support if disasters disrupt construction	Coordinating multi-agency crisis response and public communication
	Establishing emergency management frameworks and defining clear response roles		Activating emergency procurement rules for immediate repairs		Mobilizing recovery funds and overseeing resilient rebuilding efforts
Regulators	Developing and enforcing robust design codes and standards	Reviewing and approving project design for resilience compliance	Mandating safety and resilience criteria in procurement processes	Inspecting construction sites for compliance with resilience standards	Requiring preventive maintenance and reliability standards
	Mandating operator emergency preparedness plans	Requiring back-up systems for critical services			Providing regulatory flexibility to speed up post-disaster restoration
Infrastructure owners/operators	Identifying vulnerabilities and advising the government on resilience needs	Integrating hazard risk assessment into project design	Setting resilience performance standards for contractors and materials	Enforcing quality control so that resilience features are built to specifications	Performing regular maintenance and resilience upgrades
	Preparing business continuity and service restoration plans for disasters	Building in redundancies (e.g., back-up power) for critical operations	Stockpiling spare parts and emergency repair contracts		Deploying emergency crews for rapid repairs to minimize outages
Infrastructure developers	Proposing projects that are aligned with national resilience goals	Conducting comprehensive risk studies and integrating mitigation into designs	Selecting contractors with a strong resilience and safety record	Using adaptive construction techniques to manage site risks	
		Including business continuity features (e.g., back-up systems) in plans		Mobilizing contingency resources to quickly handle disruptions	
	Providing risk assessment and hazard scenario analyses	Designing hazard-resistant infrastructure features	Drafting resilience-focused specifications and vetting bids	Supervising construction to ensure that resilience measures are implemented	Developing maintenance and retrofit plans for long-term resilience

	Strategy	Planning & design	Procurement	Construction	Operation & maintenance
Engineers & planning consultants	Modelling disaster impacts to inform emergency preparedness plans	Incorporating fail-safe and emergency systems in designs		Adapting designs in real-time if new risks or conditions arise	Assessing damage and designing retrofits after disasters
Emergency responders	Developing coordinated disaster response plans with authorities	Advising on emergency access routes and life-safety features in infrastructure designs			Conducting regular disaster drills and training for readiness
	Contributing to high-level recovery planning for essential services				Leading emergency response operations during infrastructure failures
Financial institutions & philanthropies	Funding resilient infrastructure projects and requiring risk disclosure	Requiring thorough climate & disaster risk assessment in project design	Encouraging life-cycle cost and resilience benefits in bid evaluation	Releasing contingency funds or adjusting terms if disasters strike mid-project	Enforcing maintenance and risk monitoring covenants throughout an asset's life
	Establishing contingency funds or insurance for immediate response	Requiring project continuity plans to ensure service during crises		Providing additional financing to repair and complete projects after a disaster	Fast-tracking insurance payouts or new financing for rebuilding after events
Knowledge institutions	Advocating for resilient infrastructure investment and inclusive planning	Contributing to local hazard knowledge, community needs, and project planning	Ensuring resilience and transparency in procurement	Monitoring construction quality and flagging safety shortfalls	Participating in community maintenance and risk-reduction efforts
	Promoting community emergency preparedness and education	Lobbying for inclusion of evacuation routes and warning systems			Organizing mutual aid and first response when official help is delayed

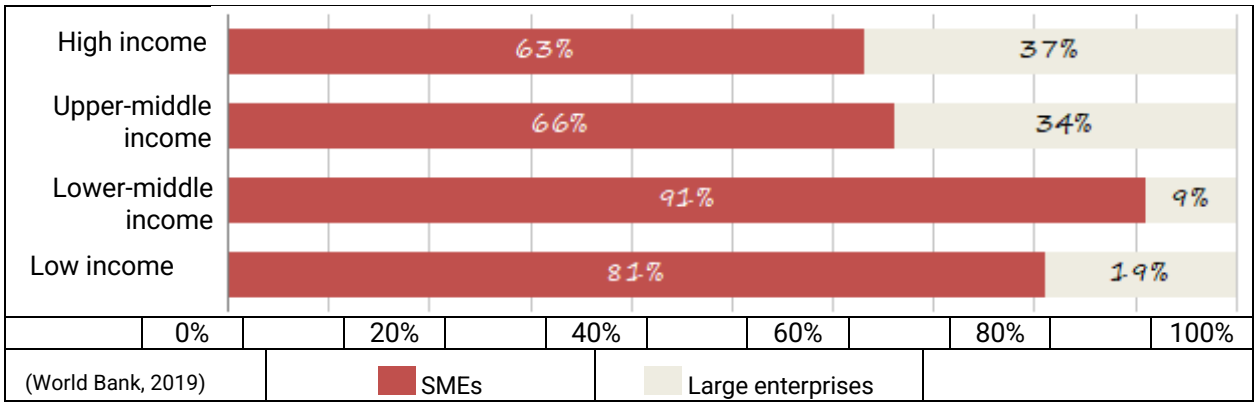
Absorb | Respond | Recover

6 Small and Medium Enterprises (SMEs)

6. Small and Medium Enterprises (SMEs)

SMEs are the economic backbone of developing countries, accounting for roughly 60 percent of global employment. This figure rises to as much as 90 percent in certain low-income regions (World Bank, 2019). In addition to employment generation, SMEs often engage low-skilled, informal, and socially vulnerable groups, including women, youth, and the previously unemployed, providing income where formal systems fall short (United Nations Development Programme [UNDP], 2013). These enterprises also form the heart of local economies, offering essential goods and services and ensuring that community infrastructure remains functional in everyday and crisis contexts. Thus, any disruption to SMEs can have serious ramifications for communities and supply chains. The 2015 Chennai floods directly affected over 8,500 SMEs, resulting in economic losses exceeding ₹17 billion, while the indirect impact affected 160,000 workers. The interruptions triggered a cascading effect across supply chains, as large industries relying on SME inputs were forced to halt operations or switch suppliers (KPMG & Confederation of Indian Industries, 2016). This underscores the critical need to build resilience in SMEs to protect livelihoods and stabilize economic systems.

Figure 17: Employment contribution by SMEs in high- to low-income countries



This chapter focuses on how geo-climatic hazards and disaster shocks affect SMEs across different income contexts, with particular emphasis on their role in sustaining livelihoods, supporting larger enterprises, and maintaining continuity of essential goods and services. Given their scale, informality, and constrained access to finance and risk management tools, disruptions in SME operations can rapidly translate into wider economic and social impacts.

Finally, the chapter examines how SMEs prepare for, respond to, and recover from climate and disaster risks across the Absorb–Respond–Recover lifecycle. Drawing on enterprise-level insights, the analysis assesses key enablers, including policy and regulation, finance, governance, and capacity building, to identify practical constraints, emerging adaptive practices, and priority areas for strengthening SME resilience.

6.1 Regional and Sectoral Breakdown of SMEs That Participated in the Survey

Figure 18: Breakdown of survey participants across SMEs

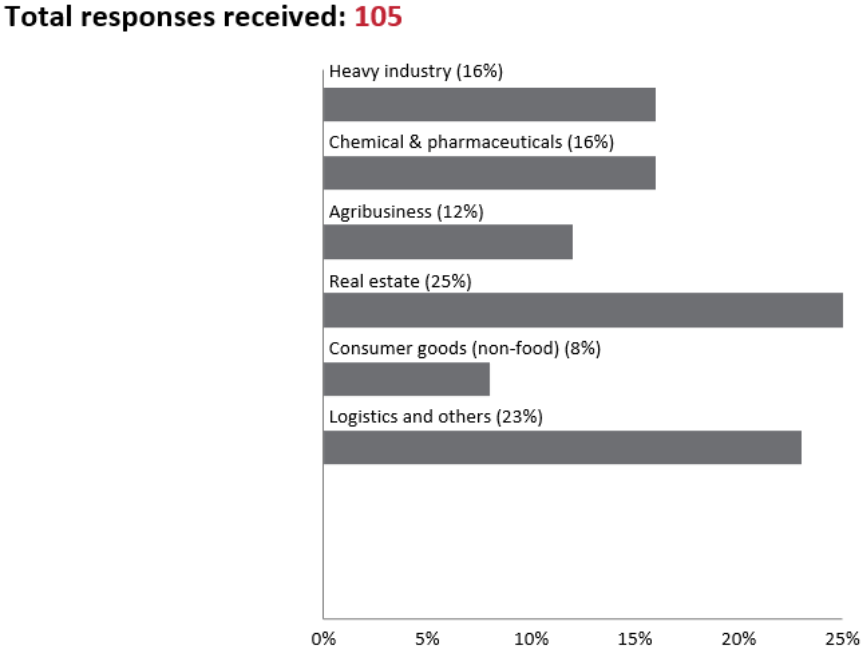
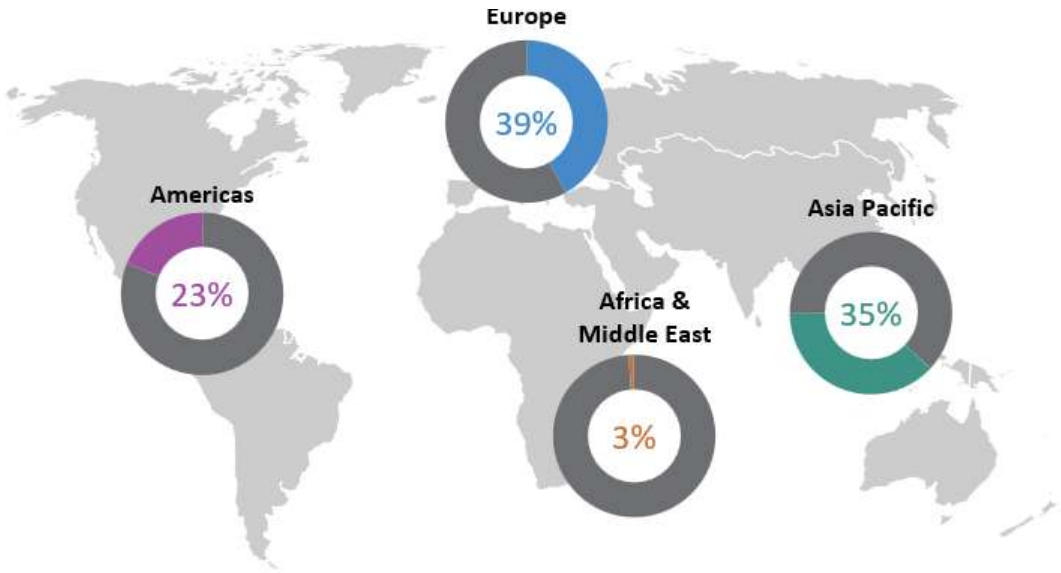


Figure 19: Geographic distribution of the Global Business Survey responses for SMEs



6.2 Survey Insights—SMEs

To better understand how SMEs navigate disaster- and climate-related risks, the survey examined their resilience strategies using a structured lifecycle-based framework. This assessment focused on three key stages—Absorb, Respond, and Recover—and five enabling levers—policy and regulation, technology, finance, governance, and capacity building.

The following section presents:

1. Insights mapped across the resilience lifecycle (Absorb–Respond–Recover)

   This view shows how SMEs perform at each stage of the resilience lifecycle, identifying critical bottlenecks in early preparedness, immediate response, and post-shock recovery.

2. Lever-wise analysis of SME resilience enablers

   A deep dive into each lever reveals SME-specific challenges, such as lack of access to affordable finance, limited insurance coverage, and low policy integration, and recommends actionable interventions to address these systemic gaps.

Why this matters

This section reveals the disproportionate vulnerability faced by SMEs to disaster and climate risks and highlights where targeted public-private interventions can significantly reduce exposure. Strengthening SMEs is not only critical for their survival but is also essential to strengthening value chains and protecting dependent industries.

6.3 Survey Insights Mapped Across the Infrastructure Resilience Lifecycle

ABSORB PHASE

Risk governance is widespread but underdeveloped	• While 67 percent of SMEs report having a BCP, nearly 1 in 3 have not tested them, indicating that risk readiness remains mostly theoretical. • 82 percent conduct annual risk assessments, but 59 percent do not use or are unaware of available risk assessment tools, reflecting a significant awareness-to-action gap.
Policy & institutional enablers remain almost non-existent	• 43 percent of SMEs cite the need for access to affordable finance, real-time climate information, and technical insurance products, underscoring foundational gaps in the support ecosystem. • 37 percent report facing business disruptions caused by climate or disaster events at least once or twice over the past 5 years, yet many have no formal prioritization of resilience, viewing it as non-essential until a crisis occurs.
Financial preparedness is concerningly low	• 59 percent of SMEs have allocated only 1–10 percent of their budgets to resilience and emergency preparedness. • Alarmingly, 37 percent of SMEs have allocated no budget at all, reflecting an overdependence on post-disaster funding, which leads to reactive rather than anticipatory behaviour.

RESPOND PHASE

Ad hoc responses dominate SME disaster response strategies	• Although 65 percent claim to have a DRM policy, 35 percent lack operational SOPs, emergency playbooks, or trained crisis teams, making their responses improvised and delayed. • Internal coordination gaps are compounded by delays in external/government support, limiting effective incident response during high-impact events.
Alert systems exist but infrastructure for action is limited	• 67 percent still rely on ad hoc measures or underestimate the risks, reflecting an attitude of short-termism and misplaced confidence in low-cost, 'quick fix' solutions. • Lack of investment in robust resilience assets, such as back-up power, flood barriers, or redundancies, shows a clear gap between signal reception and action capability.
Regulatory & funding barriers block real-time response improvements	• 33 percent of SMEs cite lack of regulatory clarity, funding access, or structured policy support as key inhibitors to the implementation of formal disaster strategies. • 77 percent report that government support mechanisms are either weakly enforced or absent, especially in emerging markets, resulting in uneven institutional response capabilities across geographies.

RECOVER PHASE

Recovery is fast but still externally dependent	• 68 percent recovered within a month of a disaster, outperforming smaller firms, but 50 percent report recovery delays caused by lack of government support, especially in sectors dependent on public utilities or permits for service resumption. • This shows that even large businesses are vulnerable to ecosystem-level friction despite internal readiness.
Incentives exist but are underutilized	• Only ~16 percent of SMEs reported benefitting from tax incentives, concessional loans, or subsidies, indicating either lack of awareness or frictions in accessing these tools. • This highlights a missed opportunity for businesses to leverage public-private recovery.
High insurance penetration but limited sophistication	• 70 percent have insurance, but 46 percent only have partial coverage for revenue or asset loss. • 50 percent rely on traditional insurance, and only 20 percent use advanced options, such as parametric or catastrophe-linked products even though they are better suited for structured coverage.
Workforce and operational gaps in recovery	• 11 percent report skilled workforce shortages during recovery, affecting timely restart of critical operations. • Despite this, only 27 percent plan to enhance internal capabilities, indicating that human capital resilience is not yet a strategic priority.

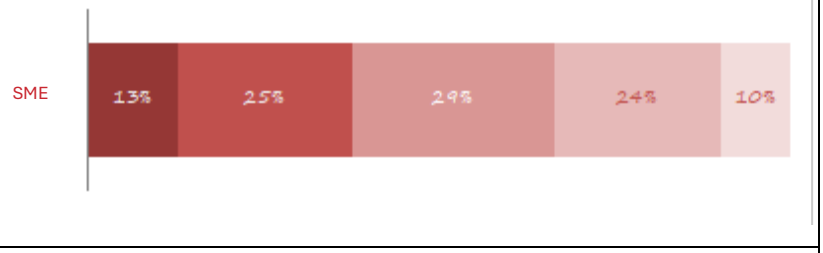
6.4 Lever-Wise Analysis of Key Resilience Pillars

POLICY AND REGULATION

Existing climate and disaster policies rarely address the needs of small, informal enterprises or provide accessible incentives. In many cases, business owners are unaware of government programmes or find them too complex or misaligned with their realities. Even when policies exist, they may lack enforcement or local delivery mechanisms. This disconnect between policy and SME engagement limits the uptake of resilience measures by SMEs.

Survey insights

Policy blind spots: SMEs left behind by inadequate and misaligned climate frameworks



- Not sure/not aware of any existing policies
- No clear or relevant national/state policies in place
- Policies exist but do not fully address our sector's specific needs
- Policies exist but not fully enforced or consistently applied
- National/state policies that adequately support our needs

- 25 percent of SMEs reported no clear or relevant national/state climate policies; another 13% were unsure of their existence; only 10% believed that current policies fully support their needs.
- Where policies do exist, they are too generic, poorly enforced, or misaligned with SME realities, especially for informal or peri-urban businesses (United Nations Development Programme & World Resources Institute, 2015).

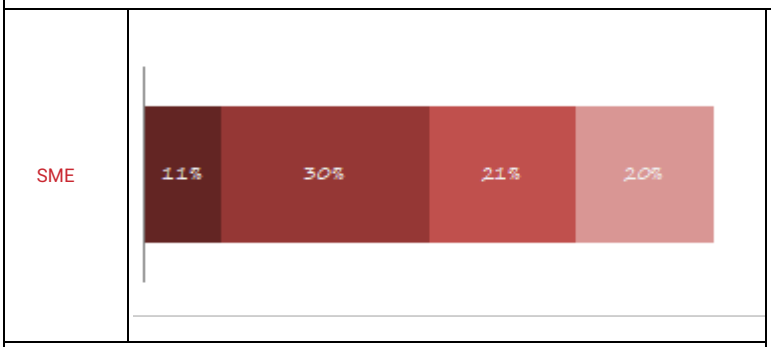
Implication: Inadequate and misaligned policy frameworks leave SMEs without clear guidance on or effective support for climate resilience, reinforcing reliance on informal and reactive coping mechanisms. Without SME-tailored policies that are actionable and enforceable, public climate frameworks will continue to bypass many at-risk enterprises.

TECHNOLOGY

Even when SMEs are aware of adaptation options, they often lack the technical capability to implement them. Skills to deploy new technologies, use resilient infrastructure, or manage climate data are limited, especially in rural or informal settings. SMEs rarely have in-house expertise or access to technical services. Without long-term technical support, most small enterprises revert to familiar, less resilient practices.

Survey insights

Do you use publicly available tools, platforms, or government-published data that support climate or disaster risk assessment?



- Only 20 percent of SMEs actively use climate risk assessment tools or platforms; 30 percent are aware but have not used them—the highest rate of non-use across sectors.
- This reflects what the UNDP describes as a critical knowledge–action gap; SMEs often lack decision-support tools to assess the practicality and affordability of and returns on adaptation options (UNDP, 2016).
- SMEs with a DRM policy are more likely to use available tools and platforms than those without, which shows that DRM adoption helps bridge the knowledge–action gap by increasing awareness of affordable, government-supported solutions.

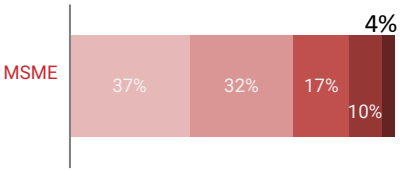
Implication: Low uptake of publicly available climate risk assessment tools reflects a persistent knowledge-to-action gap among SMEs despite a high level of awareness of their existence. Strengthening DRM adoption and improving the usability, relevance, and perceived value of government-supported tools will be critical to enable informed, cost-effective resilience decisions.

FINANCE

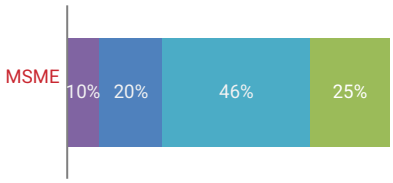
SMEs face major financial barriers to adaptation. Most operate with limited cash flow, low savings, and restricted access to loans. High upfront costs, long payback periods, and limited insurance options discourage investment in resilience. Even when financial tools exist, they are poorly tailored to the needs of small enterprises. As a result, SMEs rely on informal borrowing or personal savings, leaving them highly exposed when disasters strike.

Survey insights

Ad hoc funding and low insurance penetration leave SMEs exposed to climate shocks



- No dedicated fund – ad hoc budget allocation
- 1–5% – limited emergency or resilience needs
- 5–10% – short-term emergency response
- 5–10% – long-term risk reduction and resilience building
- >10% – for resilience building and emergency needs



- No – Not planned
- No – In progress
- Yes – Partial cover
- Yes – Full cover

- Many SMEs operate informally or lack fixed assets and formal records, making them ineligible for conventional loans and disaster recovery credit. These gaps are compounded by short investment horizons, leaving them unable to invest in long-term resilience (UNDP, 2016). The impact is clearly visible—69 percent of SMEs allocate less than 5 percent of their budget to resilience planning—revealing high dependency on ad hoc or minimal funding.
- SMEs often lack access to affordable financial products, are rarely targeted by insurers, and face increasing climate-related premiums beyond their capacity to pay. As a result, only 25 percent of

		SMEs report having full insurance, exposing them to severe recovery gaps post-disaster.

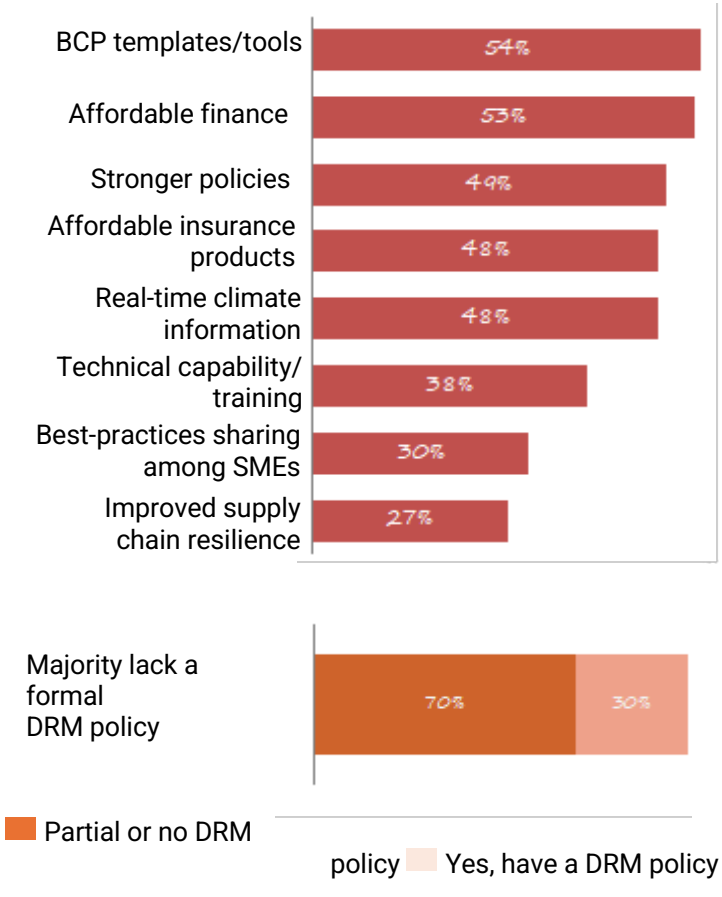
Implication: Heavy reliance on ad hoc funding and limited insurance coverage leaves SMEs highly exposed to climate and disaster shocks, constraining their ability to absorb losses and recover quickly. Without access to affordable finance and risk transfer mechanisms, SMEs remain structurally unable to invest in long-term resilience, perpetuating vulnerability cycles.

GOVERNANCE

SMEs often face weak institutional support and limited inclusion in governance frameworks. Policies, regulations, and disaster response mechanisms are frequently designed with large firms in mind, leaving SMEs with low awareness, unclear guidance, and limited access to public programmes. Fragmented coordination across national and local authorities further constrains implementation, while complex compliance requirements strain already limited managerial capacity. As a result, SMEs struggle to plan, prepare, and engage effectively in climate risk management and recovery efforts.

Survey insights

SMEs demand actionable tools, such as BCPs, affordable finance, and stronger policies, to enable resilience building



- 54 percent called for BCP tools, highlighting widespread gaps in technical preparedness, which was seen clearly during the Chennai floods when most SMEs lacked a recovery protocol.
- 53 percent have prioritized affordable finance and 48 percent affordable insurance, validating financial barriers that include poor access to credit, high collateral demands, and underdeveloped insurance markets.
- 49 percent of SMEs identified stronger policies as their top need, reflecting long-standing exclusion from DRM frameworks and lack of targeted recovery mechanisms.
- 48 percent want real-time climate data and 38 percent seek technical training, pointing to knowledge and capacity gaps faced by SMEs in understanding and acting on climate risk information.
- 70 percent still lack a formal risk management policy.

Implication: SMEs face structural barriers to resilience building; limited access to planning tools and affordable finance and insurance constrains their ability to prepare for and recover from climate and disaster shocks. Addressing these gaps will require simplified, actionable tools and targeted financial and policy support tailored to SME capabilities.

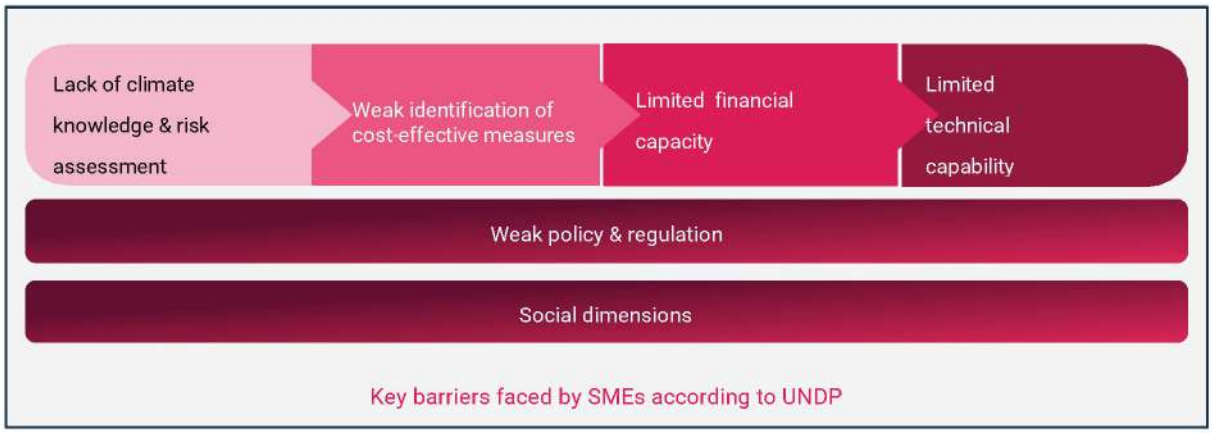
- **Banking:** Centralized procedures and a lack of customized products hinder access to disaster relief loans. Many SMEs are excluded due to inadequate credit history or formal documentation.

- **Infrastructure:** SMEs are often located in flood-prone areas with poor drainage and outdated master plans. Informal micro enterprises also lack basic social protection or training.
- **Government:** There is a lack of standardized guidelines for loss assessment. Existing industrial policies fail to support recovery and infrastructure upgrades, especially in legacy industrial estates.

UNDP identifies the following six systemic barriers that hinder SME resilience:

i) Lack of climate knowledge and risk assessment
ii) Weak identification of cost-effective adaptation measures
iii) Limited technical capability to implement adaptation
iv) Limited financial capacity and insurance access
v) Weak policy and regulatory support
vi) Social dimensions, including informality, gender gaps, and exclusion

These barriers affect SMEs in a cascading manner across their adaptation efforts and require careful examination to identify rectification strategies. They do not operate in silos; rather, they interact in ways that amplify risk, delay recovery, and limit long-term planning. A nuanced understanding of these dynamics is critical to building systemic and sustained resilience.



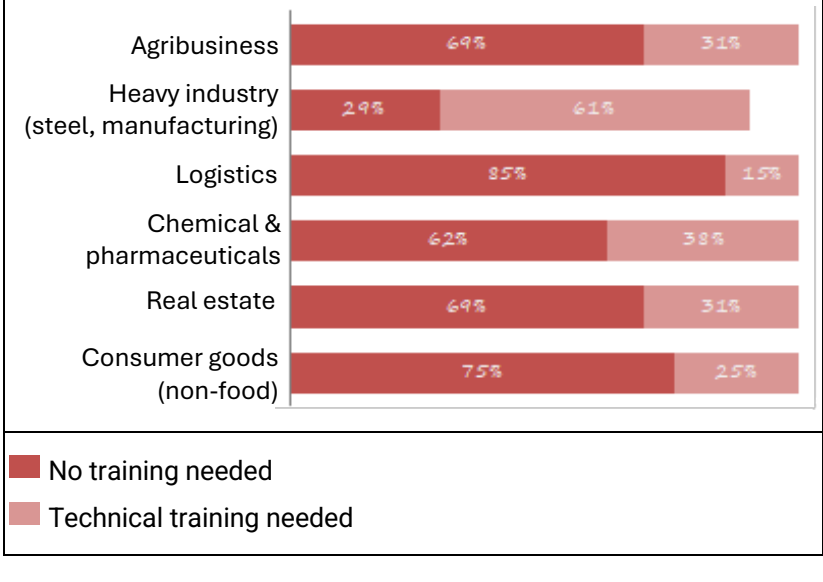
Key barriers faced by SMEs according to UNDP

CAPACITY BUILDING

SMEs often lack the technical knowledge, skills, and human resources needed to assess climate risks and implement resilience measures. Limited access to training, climate data, and advisory support constrains their ability to adopt resilient technologies, comply with evolving standards, and integrate climate considerations into business planning. High staff turnover and reliance on informal practices further weaken institutional learning, leaving SMEs underprepared to anticipate, respond to, and recover from hazards.

Survey insights

Widespread technical training gaps undermine SME resilience across key sectors



- SMEs across sectors—heavy industry, consumer goods (non-food), real estate, and logistics—indicate that they require technical training to become disaster resilient.
- Technical training gaps are a higher concern for sectors that have faster recovery times, indicating increasing importance as SMEs become more resilient.

Implication: Widespread technical training gaps across SMEs limit their ability to translate awareness of climate risk into effective preparedness and recovery actions. Targeted, sector-specific capacity building will be essential to strengthen operational resilience, particularly as faster recovery expectations place increasing pressure on SMEs to perform during disruptions.

6.5 Insights from the FGDs Conducted with SME Enterprises

Three FGDs were conducted in India and Nepal to complement secondary analysis with on-the-ground perspectives from SMEs directly experiencing geo-climatic hazards. The objective of the exercise was to capture operational realities, decision constraints, and adaptive responses that are often underrepresented in aggregated data. By engaging enterprises across sectors and geographies, the FGDs generated practical insights into how climate risks manifest throughout the Absorb–Respond–Recover lifecycle and helped identify gaps across policy and regulation, finance, governance, technology, and capacity building that shape SME resilience.

A semi-structured guide was used to probe risks and responses across the Absorb–Respond–Recover lifecycle and the enabling levers of policy and regulation, technology, finance, governance, and capacity building. The insights are directional (not statistical) and reflect the practical constraints and demands of operators.

Impacts SMEs are experiencing

- Heat, erratic monsoons, and crop/input risks: These factors are already causing quality loss and supply tightness (e.g., faster cashew maturation; approximately 25 percent of crops washed away by early rains).
- Frequent production stoppages and long recovery tails: Downtime leads to missed deliveries and red-listing by original equipment manufacturers; repairs can take 15–30 days, longer if machinery is imported.
- Spillovers across value chains: Overseas floods, warehouse losses, and domestic mass-movement events disrupt orders and logistics.
- Public infrastructure gaps amplify shocks: Poor drainage, roads, and power were cited as chronic issues undermining business continuity.
- Regulatory friction during expansion: In North India, factories face a strict PM2.5 limit during construction and compliance burdens that delay building by approximately one-third of the year.
- Worker impacts: Commutes through floodwater increase absenteeism; no specific gender-differentiated effects reported by participants.

How SMEs are coping

- Operational workarounds: Advance deliveries ahead of expected blockages (e.g., religious rallies) and active shipment tracking during extreme events.
- De-bottlenecking for continuity: Financing back-up or alternative equipment to avoid single-point failures on critical lines.
- Process innovation for water stress: Shifting to super-concentrates and investing in R&D to reduce water use while maintaining product performance.
- Basic effective environmental health and safety/BCP practices (risk analysis, drills) are in place but uneven; early warning and advisory support has been limited beyond issuing a heatwave notice recently.

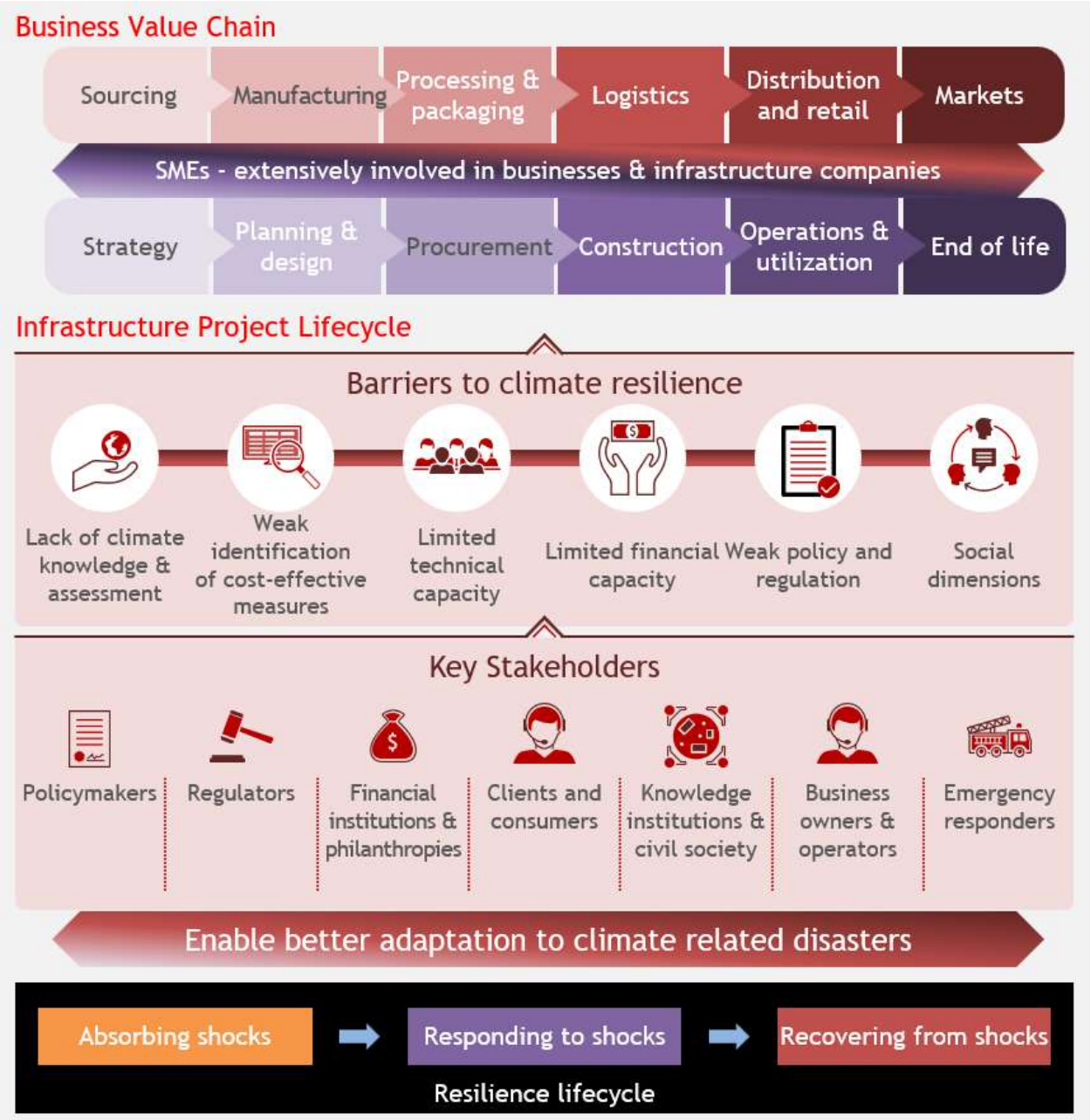
Expectations of SMEs (from buyers and government)

- Liquidity injection during shocks: Shorter payment cycles and advances ease working capital strain during disruptions.
- Move beyond audits and price pressure: Large buyers focus on price negotiations, with little ‘handholding’ on resilience planning; SMEs want co-created SOPs and supplier-development support.
- Fix the basics: Durable roads, drainage, reliable power, and clearer, faster permits; avoid shifting all compliance costs onto SMEs (e.g., genset replacements without a grid upgrade).
- Transparent land policies: Priority allotment for SMEs and curbs on speculation to keep industrial land and land near markets affordable.

6.6 Embedding Resilience Across Businesses and Infrastructure Companies Through SMEs

SMEs form the backbone of many economies, particularly in developing countries. Their extensive presence across business value chains (from sourcing to markets) and the infrastructure lifecycle (from the design stage to the end-of-life stage) makes them critical yet highly vulnerable stakeholders in the face of escalating climate risks. The framework presented here is designed to bridge systemic barriers to resilience and equip SMEs with the abilities to absorb, respond to, and recover from climate-related shocks more effectively.

Figure 20: Framework for embedding resilience across the business / SME project lifecycle



Bridging the climate resilience gap for SMEs requires more than identifying barriers: it demands coordinated action by a diverse set of stakeholders. Policymakers and regulators must lead the way by embedding SMEs into national adaptation plans, decentralizing support delivery, and designing policies that reflect the realities of informal enterprises. Financial institutions and philanthropies play a crucial role in unlocking affordable credit, insurance, and blended finance solutions tailored to SME risk profiles. Meanwhile, knowledge institutions and civil society organizations can bridge the technical divide by providing hands-on training, localized climate data, and user-friendly decision-support tools. Clients, consumers, and off-takers can incentivize resilient practices by prioritizing SMEs that disclose climate risks or adopt sustainable standards. Lastly, SME associations and emergency responders are essential for last-mile delivery of early warnings, recovery planning, and ensuring that gender, social, and geographic vulnerabilities are not overlooked. Large businesses need to support and guide the SMEs they rely on.

Table 9 **Barriers to climate resilience for SMEs and recommended interventions across key stakeholders**

Barrier	Key challenges	Interventions (non-exhaustive)	Key influencers
1. Lack of climate knowledge & risk assessment	• Limited awareness of climate risks; climate data not localized or accessible • Difficulty applying forecasts to business plans • Limited early warning system reach	• Develop localized climate portals • Disseminate data via local networks • Translate risks into business terms; include SMEs in climate info	Policymakers, SME sector associations, large businesses
2. Weak identification of cost-effective measures	• No cost-benefit tools for SMEs • Uncertainty over economic returns • Dependence on traditional methods	• Publish tested adaptation options • Peer-learning through cluster pilots • Co-develop decision tools with SMEs • Promote evidence-backed options	SME sector associations, customers/off-takers
3. Limited technical capability	• Lack of access to adaptation know-how • Absence of trained local coaches • Few SME-specific training materials • Weak link to service providers	• Build adaptation coach networks • Develop SME-oriented toolkits • Fund local skill-building centres • Use radio & mobile for training delivery	SME sector associations, large businesses, customers/off-takers
4. Limited financial capacity	• High cost of adaptation investments • No collateral or formal credit access • Limited insurance options • Low or no awareness of financial tools	• Bundle insurance with credit • Promote emergency SME funds • Design flexible lending tools • Link SMEs to climate investors	Financial institutions, philanthropies, policymakers, large businesses
5. Weak policy & regulation	• SMEs excluded from DRM planning • Policies not tailored to small businesses	• Include SMEs in DRM policy design • Create local policy delivery systems	Policymakers, regulators

	• Weak implementation at the local level • Disaster aid favours formal firms	• Monitor equity in aid access • Provide SME-specific incentives	
6. Social dimensions	• Informal enterprises left out of recovery planning • Gendered roles limit access to support • Poor representation in planning • Disparities in access to aid and resources	• Gender-sensitive recovery planning • Tailored messaging for vulnerable groups	SME sector associations

Spotlight case: Ngorongo Tea Factory's resilience journey

Trigger

- Faced with growing threats from climate change, Ngorongo Tea Factory in Kenya undertook a structured approach to enhance resilience.
- The region is experiencing increasingly erratic weather patterns, including prolonged droughts, unpredictable and heavy rainfall, frost, and rising temperatures.
- These changes have damaged infrastructure, reduced tea yield, increased production costs, and introduced new pests and diseases.

Interventions

- Ngorongo partnered with the International Trade Centre (ITC) through the Strengthening Competitiveness Through Climate Resilience in International Value Chains project.
- The company developed a resilience plan in collaboration with climate experts, introduced drought- and frost-resistant cultivars, and implemented sustainable energy and water conservation solutions.
- Staff received customized training, and partnerships were formed with the Tea Research Institute and Swedish solar company Absolicon, resulting in improved product quality, operational efficiency, and long-term adaptive capability.

Key takeaways

- Partnerships with ITC and climate experts enabled Ngorongo to develop a tailored adaptation plan to address drought, frost, and erratic rainfall.
- Investments in solar energy, firewood sheds, and vehicle covers improved energy efficiency and product quality.
- Customized staff training helped integrate resilience practices across farming, processing, and logistics operations.

7 Conclusion

7. Conclusion: From Awareness to Execution—An Agenda for Resilient Growth

The evidence is unambiguous: between 1975 and 1999, the frequency of disasters doubled while economic losses have quadrupled, with lifeline sectors—transport, power, water, and telecommunications—bearing the maximum brunt and transmitting shocks across value chains and into SMEs that anchor jobs and local markets. This pilot survey reveals a similar pattern in business operations worldwide: high exposure, uneven preparedness, and cascading vulnerabilities that turn local hazards into system-wide disruptions. Where infrastructure systems are fragile, even well-prepared firms face downtime, supply interruptions, and lost demand. Conversely, resilient infrastructure multiplies returns on firm-level preparedness across entire economies.

The economics favour action. Across firms and sectors, implementing resilience measures has repeatedly shown a high benefit-to-cost ratio; delaying investment leads to a high 'cost of inaction'. Capital is available if blended intelligently—combining public, concessional, and private finance with risk-transfer tools—to move from isolated projects to portfolio-level risk reduction, especially in emerging markets and developing economies where avoided losses scale most rapidly.

What works is consistent and practical measures: embedding resilience throughout the lifecycle (Absorb–Respond–Recover); hardwiring governance (tested BCPs/DRM policies with clear SOPs); mobilizing technology (risk analytics, early warning systems, adaptive assets); mainstreaming fit-for-purpose finance (from reserves to parametric covers and resilience-linked loans); and, critically, extending action beyond owned assets to suppliers, logistics, customers, and especially SMEs. Resilience is now a value-chain activity.

Six near-term calls to action

1. **Institutionalize preparedness and accountability (policy, governance)**: Mandate annual testing of BCPs/DRM policies, including site-level simulations and board-level oversight, to embed resilience accountability and ensure readiness in critical operations.
2. **Strengthen value chain resilience standards (policy, governance)**: Map climate risk across priority value chains and enforce minimum supplier resilience requirements (redundancy, continuity planning, location screening) to reduce cascading disruptions.
3. **Secure dedicated resilience financing (finance)**: Ring-fence budgets for both emergency response and forward-looking risk reduction, reducing overreliance on post-disaster funding and indemnity-based insurance.
4. **Modernize risk transfer and financial protection (finance)**: Pilot parametric insurance, catastrophe bonds, and pooled risk mechanisms for high-exposure hazards and critical chokepoints to enable faster liquidity during shocks.
5. **Digitize risk management and response (technology)**: Integrate digital risk analytics, early warning systems, and real-time monitoring into operations, linking alerts directly to automated SOPs and decision workflows.
6. **Mobilize partnerships to scale up SME resilience (finance, capacity building, governance)**: Leverage public-private partnerships to expand SME access to working capital, insurance, technology, and advisory support for resilience upgrades and business continuity.

Bottom line: By acting together, governments, infrastructure operators, financiers, large firms, and SMEs can bend the loss curve and unlock competitive advantage. The tools, capital, and know-how exist; what is needed now is coordinated, measurable execution.

Annexure

1. Questionnaire

A. Industry/Sector profile, governance, and risk assessment

1) Does your company have an established BCP to ensure the continuity of critical operations during disruptions?

- Yes, we have a fully documented and tested BCP that includes detailed procedures for all essential operations
- Yes, we have a BCP but it is not fully tested or lacks detailed plans for some critical operations
- No, we are currently in the process of creating a BCP
- No, we do not have a BCP in place

2) Does your company have a formal climate/disaster risk management policy along with standard operating procedures (SOPs) or guidelines in place? *(Single choice)*

- Yes, we have a comprehensive policy along with SOPs or guidelines that address multiple hazards and define clear response protocols
- Yes, we have a risk management policy but do not yet have detailed SOPs or guidelines to operationalize it
- No, but we are in the process of developing a formal policy and/or SOPs
- No, we do not have a disaster risk management policy in place

If option a or b is chosen in Q2, please answer the following question:

- How frequently is climate/disaster risk assessment done?
  - Annually
  - Every 3–5 years
  - Only when a major project requires it
  - Never

If option c or d is chosen in Q2, please answer the following question:

- What are the key barriers preventing your company from implementing a formal climate/disaster risk management policy? *(Select up to 2)*
  - Limited financial resources
  - Low perceived risk or priority within the organization
  - Absence of regulatory requirements or external mandates
  - Lack of access to relevant tools, data, or frameworks
  - Reliance on informal or ad hoc response mechanisms
  - Other (please specify) _____

3) Are you aware of, or does your company make use of, any publicly available tools, platforms, or government-published data that support climate or disaster risk assessments? *(Single choice)*

- Yes, we actively use government-provided tools or platforms (e.g., hazard maps, risk models, climate projections) to inform our internal risk assessments.
- Yes, we are aware of such resources, but we have not yet integrated them into our risk assessment processes.
- We rely on publicly available datasets, such as meteorological data, environmental risk indices, or regional hazard forecasts but not structured tools or platforms.

- We are not aware of any public tools, platforms, or datasets made available by the government or other public agencies.
- We primarily rely on internal tools or private providers for risk assessments, not public/government resources.
- Other (please specify) _____

4) **In the past 5 years, what percentage of your company's annual revenue was lost because of climate-related hazards or disasters, including direct (e.g., asset damage) and indirect losses (e.g., service disruptions or vendor/supplier delivery failures)?** *(Single choice)*

- Less than 1%: Minimal financial impact
- 1%–10%: Moderate financial strain requiring adjustments in business strategy
- More than 10%: Significant financial impact affecting long-term operations
- No financial loss incurred
- Not assessed/No data available

5) **Within the past 5 years, how frequently has your company experienced interruptions in critical operations because of climate/disaster-related events?** *(Single choice)*

- 1–2 times
- 3–5 times
- More than 5 times
- Not assessed/No data available
- No impact faced

6) **Since the last climate/disaster-related event, what was the typical timeframe for your company to resume full operations?** *(Single choice)*

- Less than a week (Minimal disruption, immediate recovery)
- Less than a month (Moderate disruption, manageable delays)
- Less than a year (Severe disruption requiring significant restoration efforts)
- More than a year (Adverse impact with prolonged recovery time)
- Not assessed/No data available
- No impact faced

7) **How would you rate the effectiveness of your organization's dedicated crisis management team in responding to past climate/disaster-related hazards or events?** *(Single choice)*

- Not applicable, we do not have a dedicated crisis management team
- Not effective, major delays or poor coordination
- Somewhat effective, partial response with several gaps
- Effective, timely, and coordinated response with minor issues
- Highly effective, proactive, well-coordinated, and timely response

8) **Which of the following challenges has your organization faced when restoring critical operations after a climate/disaster-related disruption?** *(Select up to two)*

- Lack of a predefined business continuity or recovery plan
- Shortage of skilled personnel during the recovery phase
- Delays in external support (e.g., vendors, government agencies)
- Poor coordination among internal departments or teams
- Unclear roles and responsibilities during recovery

- Other (please specify) _____
- Not applicable—we have not experienced any significant disruptions

B. Policy and regulation

9) Are there clear, well-defined national or state regulations/policies to support your company or sector in preparing for climate-/disaster-related risks and resilience?

- Yes, there are comprehensive national/state policies that adequately support our sector's resilience needs
- Yes, some national/state policies exist, but they are not fully enforced or consistently applied
- Partially, some policies exist, but they do not fully address our sector's specific needs
- No, there are no clear or relevant national/state policies in place
- Not sure/Not aware of any existing policies

If option a, b, or c is chosen in Q9, please answer the following question:

- Has your company benefitted from or are you aware of any government-provided incentives aimed at enhancing climate resilience or disaster preparedness (e.g., financial support, tax breaks, technical assistance, capacity building, or access to technology/funding)? (*Select all that apply*)
  - Subsidies for investment in resilient infrastructure or technology (e.g., energy-efficient equipment, flood proofing)
  - Grants or direct financial assistance for climate- or disaster-resilience projects
  - Tax incentives or relief measures, such as deductions or exemptions on climate- or disaster-resilience investments
  - Concessional loans or low-interest financing for implementing climate- or disaster-resilience initiatives
  - Other financial incentives (please specify) _____
  - Aware of such incentives but have not accessed any
  - No, we have not received nor are we aware of any such financial incentives

C. Technology and innovation

10) What types of climate- or disaster-resilient technologies/tools has your company implemented? *(Select all that apply)*

- Digital tools for climate risk analysis and monitoring (e.g., AI-driven risk analytics, remote sensing, GIS, sensor-based systems)
- Early warning and emergency response systems (e.g., automated alerts, disaster notification platforms)
- Physical risk-reduction measures (e.g., flood barriers, raised platforms)
- Community-based or traditional early warning practices (e.g., local observation, manual sirens, communication via community networks)
- Other (please specify) _____
- None

If option a, b, c, d, or e is chosen in Q10, please answer the following question:

- Do you have easy access to suppliers or service providers for the climate/disaster resilient technologies and tools listed above?
  - Yes, we have easy and reliable access to suppliers
  - No, we face challenges in accessing reliable suppliers
  - Somewhat, there are occasional challenges or delays

If facing challenges, please specify the main barriers

- Limited local supplier availability
- High cost of technologies/services
- Quality and reliability concerns
- Other (please specify) _____

D. Finance and investment

11) Does your company allocate budget for short-term emergency response and/or long-term resilience planning for climate-/disaster-related events? *(Single choice)*

- Well-funded for both: We allocate a substantial budget (>10%) for both immediate emergency needs and long-term resilience planning
- Emergency-focused: We have a defined fund (5%–10%) primarily for short-term emergency response
- Resilience-focused: We allocate a budget (5%–10%) primarily for long-term risk reduction and resilience-building
- Limited funding: A small portion (1%–5%) is reserved for emergency or resilience needs
- No dedicated funding: We rely on ad hoc budget reallocations as needed

12) Does your business currently have insurance coverage for climate-related disruptions or disasters, including coverage for either physical asset losses or business interruptions (e.g., revenue loss)? *(Single choice)*

- Yes, we are fully covered for both physical damage and revenue losses/business interruptions
- Yes, but only partially covered—either physical asset loss or revenue loss but not both
- No, but we are currently evaluating insurance options
- No, and we do not plan to obtain such coverage

If option a or b is chosen in Q12, please answer the following question:

- What type of insurance product has your business adopted for climate-related disruptions/disasters? *(Select all that apply)*
  - Traditional property and casualty insurance—covers physical damage to assets from extreme weather (e.g., storms, floods, fires)
  - Business interruption insurance—covers revenue loss caused by operational downtime or service disruption caused by a disaster
  - Parametric insurance—payouts are based on predefined event parameters (e.g., rainfall level, temperature, wind speed), not on actual loss assessment
  - Catastrophe bonds or alternative risk transfer products—transfers risk to capital markets rather than traditional insurers
  - Other (please specify) _____

E. Capacity building

13) Which of the following measures are you planning to adopt in the next 5 years for climate/disaster resilience? *(Select up to 2)*

- Investing in resilient infrastructure and technologies (e.g., flood barriers, smart sensors, energy-efficient systems, early warning tools)
- Strengthening collaboration with governments and industry stakeholders (e.g., policy advocacy, public-private partnerships, regulatory alignment)
- Improving internal capabilities and awareness of climate risks (e.g., workforce preparedness, leadership training, business continuity planning)

- Securing financial resources for resilience investments (e.g., insurance, climate bonds, dedicated resilience funding)
- Developing or updating formal disaster risk management policies (e.g., comprehensive risk assessments, response protocols, recovery plans)
- No specific plans for climate/disaster resilience at this time
- Other (please specify) _____

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