
# Coalition for Disaster Resilient Infrastructure

## Mainstreaming Disaster Resilience into Infrastructure Projects- DUM 2025, Mumbai, India

# Coalition Members

CDRI
Coalition for Disaster Resilient Infrastructure

## 51 Countries

## 10 Organizations

### Africa
- CHAD
- GHANA
- GUINEA
- KENYA
- MADAGASCAR
- MAURITANIA
- MAURITIUS
- NAMIBIA
- SOUTH SUDAN

### Asia
- AFGHANISTAN
- BANGLADESH
- BHUTAN
- INDIA
- JAPAN
- MALDIVES
- MONGOLIA
- NEPAL
- SRI LANKA
- TAJIKISTAN
- VIETNAM

### Europe
- FRANCE
- GERMANY
- ITALY
- NETHERLANDS
- TURKEY
- UK

### North & Central America
- CANADA
- COSTA RICA
- GUATEMALA
- HONDURAS
- USA

### Oceania & Pacific
- AUSTRALIA
- FIJI
- NAURU
- NEW ZEALAND
- SAMOA
- TONGA

### South America
- ARGENTINA
- BRAZIL
- CHILE
- COLOMBIA
- ECUADOR
- PERU

### The Caribbean
- ANTIGUA & BARBUDA
- CUBA
- DOMINICAN REPUBLIC
- GRENADA
- HAITI
- JAMAICA
- TRINIDAD AND TOBAGO
- GUYANA

African Union · arise · ADB Asian Development Bank · CDEMA Caribbean Disaster Emergency Management Agency · European Investment Bank · ECOWAS · European Union · The World Bank IBRD • IDA · UNDP · UNDRR United Nations Office for Disaster Risk Reduction

# Disaster Impact - Community, Critical Power Infrastructure & Economy

| Resources (fuels, HR, equipment | Transport & Logistics | Generation | Transmission | Distribution | End-User |
|---|---|---|---|---|---|
| Disruption to supply chain | Disruption of logistics network & transport | Disruption to supplies and reduced efficiency due to extreme temperatures, very high winds, drought & floods | | | Changes in demand; ability to recover from extreme events |

**Cyclone Fani, India (2019)**

**Power Sector Impact- $ 1.2 billion**

**Cyclone Winston, Fiji (2017)**

**Economic Impact- $ 1.3 bn (31% GDP)**
**Power Sector Impact- $ 19 Mn**

**Hurricane Maria, Puerto Rico (2017) &Economic Impact- $ 91 billion**

**Superstorm Sandy, USA**

**Economic Impact- $ 65 billion**

Annual economic losses in Pacific SIDS- **$ 1 Bn--5%** of combined GDP- World Risk Index 2021

**40 %** ↑ no. of disasters during 2015-2030- GARR 2022

Economic Impact on developing countries-

Global Infra faces **$ 330 bn loss (Average Annual Loss)**

Energy Sector- **$ 100-110 Bn per year**

CDRI, GIRI Tool, 2023

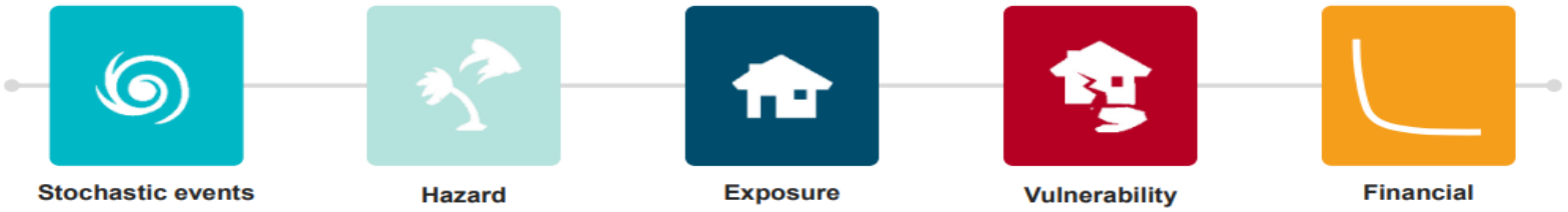
# How to Ensure Resilience

## Dynamic trends-

- **Finding the right balance-** managing energy transition risks and physical risks of extreme weather events
- Interactions across **multi-jurisdictional and subsystems critical**
- **Overcoming:** System vulnerabilities, Supply chain vulnerabilities, Resource vulnerabilities, and Market vulnerabilities
- **Integrating equity** considerations requires new questions, linkages, and supports

## Resilience consideration for the power sector -

- Where is my network at greatest risk?
- What infrastructure should be prioritized for hardening?
- How to conduct criticality analysis: Target investment where it matters most? How should it be invested?
- How much downtime can be expected for critical infrastructure?



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# Mainstreaming Disaster Resilience into Infrastructure Projects

CDRI
Coalition for Disaster Resilient Infrastructure

**Objective**: Mainstreaming disaster resilience into infrastructure projects in India

**Expected Outputs**

Cost-Benefit Analysis Tool + Appraisal of standard Contractual Agreements (MCAs) for 3-line Ministries + Disaster resilience toolkit

**Target Stakeholders**

1. Line Ministries
2. Implementing agencies Institutions
3. Potential bidders
4. Financial

**Timeline**

- **Project Initiation:** July 2023.
- **Revised Inception Report:** October 2023
- **Multi-Sectoral Consultation workshops: April & July 2024**
- **Revised Mid-term Report:** August 2024
- **Final report & Dissemination Trainings:** 2025

**Future Plans & Scalability**

CDRI aims to develop scalable framework, training, and capacity-building modules to propagate NIP work in other CDRI member countries,

# Project overview

**Objective**: Mainstreaming disaster resilience into infrastructure projects in India

## Scope

- Making a case for resilience through Cost-Benefit Analysis (CBA) for 3 sectoral projects under NIP
- Appraisal of standard agreements (MCAs), bidding documents / contractual documents, and policy documents
- Development of a toolkit for infrastructure resilience

**Tasks undertaken to identify gaps in resilience consideration**

**Literature Review** of global challenges faced by critical infrastructure due to natural hazards, global best practices incorporating resilience measures and existing resilience frameworks

**Stakeholder consultations** with line ministries, implementing agencies like Power Grid Corporation of India Limited (PGCIL), technical bodies like Indian Road Congress (IRC), National Disaster Management Authority, national financial institutions and MDBs/DFIs

**Appraisal of standard agreements** such as Revised standard EPC Agreement for NH and Centrally sponsored road works proposed to be implemented on EPC Mode, Standard EPC Tender Document for Single Stage Two Packet System and Standard Bidding Documents for procurement ISTS through TBCB process

***Mainstreaming disaster resilience in critical infrastructure***

| Resilience Cost Benefit Analysis (RCBA) Tool | Toolkit for disaster resilience | | Recommendations for incorporating resilience across key areas |
|---|---|---|---|
| *Interactive tool* | ***List 1**: List of resilience measures for biding and contractual documents* | ***Guidance Document 1**: Project identification and appraisal guidance document for line ministries* | *Policy and institution* |
| *User Guide* | | | *Infrastructure development process* |
| | ***List 2**: List of design options for asset resilience* | ***Guidance Document 2**: Project proposal preparation guidance document for potential bidders* | *Infrastructure development projects* |
| | | | *Financing* |

**Outputs of the study aimed at addressing resilience consideration gaps**

# Approach

Based on literature review & extensive consultations with Ministries, Implementing agencies, Technical Bodies and Financiers**,** Significant gaps and challenges were identified across **five key areas** of infrastructure development, & Recommendations were suggested to address them


- Project and finance level gaps addressed by the **RCBA Tool;**
- *Asset Level Resilience*

- The Resilience Toolkit guides government and private players embedding resilience in contractual agreements and Project implementation
- Addresses gaps in **standard contractual documents ;**
- *Sector & Ecosystem level resilience*

# Approach

## Target areas

1. **Processes**
2. **Ecosystem**
3. **Finances**

## Outputs of the study

### Resilience Cost-Benefit Analysis Tool

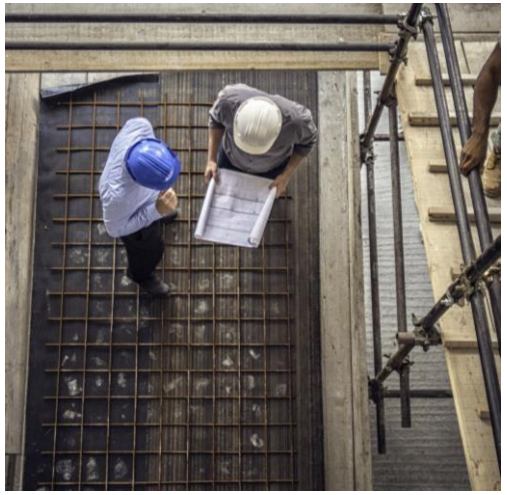
Understand the benefit of investing in resilience

*Asset level resilience*

### Toolkit for disaster resilience

Guide government and private players embedding resilience in contractual agreements and project implementation

*Sector & Ecosystem level resilience*



# Key Recommendations

The following recommendations have been suggested to address gaps across the **five key areas.**

| Sections | Recommendations |
|---|---|
| **Section 1:**<br>**Revision of Standard Contracts** | 1) Embed resilience clauses in contracts and concession agreements |
| **Section 2:**<br>**Resilience interventions across the project lifecycle** | 1) Incorporate resilience in asset design beyond codal minimums<br>2) Ensure real-time monitoring and resilience compliance during implementation |
| **Section 3:**<br>**Establishment of data systems & risk assessment protocols** | 1) Create a centralized Disaster Risk and Infrastructure Data platform<br>2) Mandate standardized Hazard Risk and Vulnerability Assessment (R&VA) for priority projects<br>3) Define local Hazard Thresholds and Risk Benchmarks |
| **Section 4: Capacity development** | 1) Institutionalize Resilience Expertise in Infrastructure Project Lifecycle |
| **Section 5: Financing & market-based risk solutions** | 1) Create a dedicated India Infrastructure Resilience Fund (IIRF)<br>2) Standardize definitions for 'Resilient Infrastructure Investment'<br>3) Explore the idea of a Sovereign Risk Pool<br>4) Utilize innovative products for transferring disaster risk |

# Output 1: RCBA tool - An interactive tool to guide resilience investment decisions

**Resilience Cost Benefit Analysis (RCBA) Tool – User benefits**

01 Understand project level risk
- With help of **Hazard Catalogue** for entire country

02 Identify resilience measures
-to be incorporated at initial project stage

03 Justify the cost of resilience measures
-with benefits over project lifecycle

04 Build case for upfront investment
- With ground-up approach

**Hazard catalogue –** A country level database with high resolution hazard and losses data that can integrate with GIRI 2.0

*Approach:*

*Location and Hazard*

*Hazard damages in last 10 years*

*Asset damage range*

*Reference Max. Min. & Avg. Damageability*

# RCBA tool: Making a case for resilience

## Method

- Determine vulnerability based on Location and disaster catalogue/HVRA in DPR
- Attributing cost of resilience measures

Comparison of cashflow over project lifecycle
- O&M costs
- Recovery costs in cases of disasters

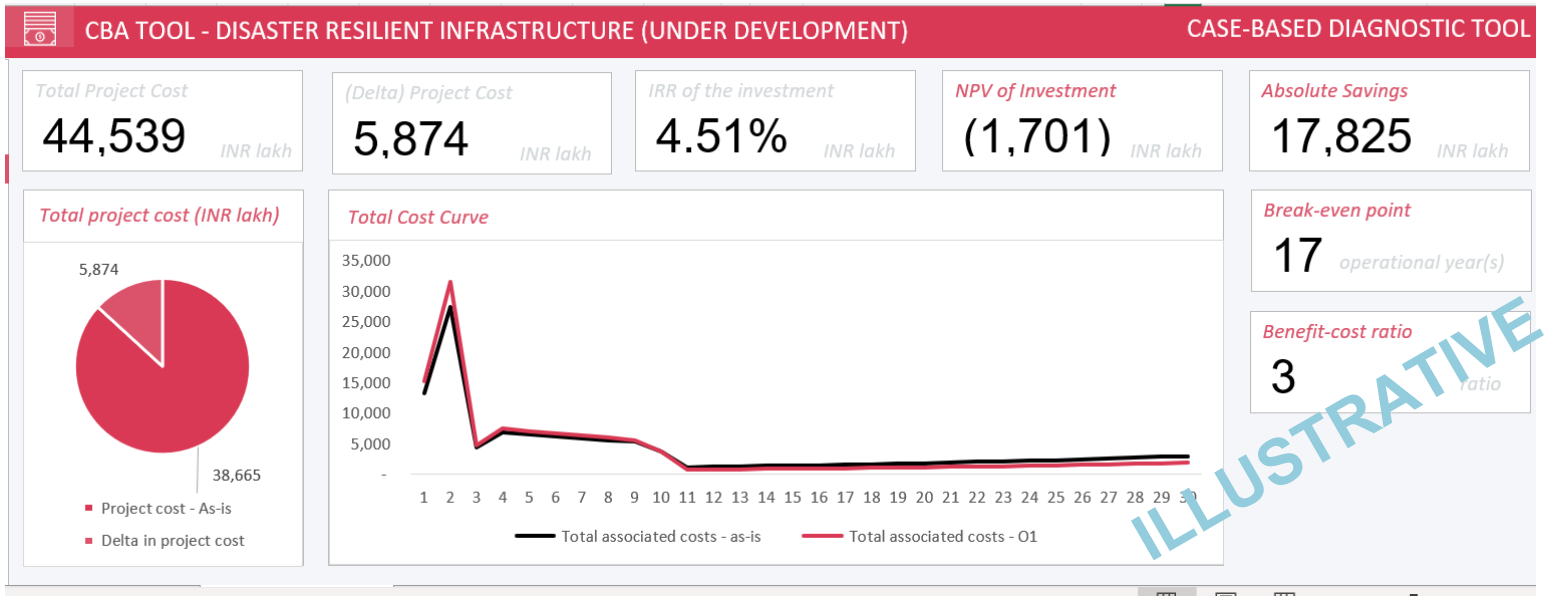
**Details of Selected Project** → **Disaster resilience options** → **Cost of alternative scenarios** → **Discounted cashflow comparison** → **NPV, Break-Even, Cost Benefit Ratio**

Details from DPR of project
- Location
- Exposure to hazards
- Cost
- Design life

Comparing cost of scenarios
- with resilience measures
- without resilience measures

Key financial indicators for decision making

## Illustrative Dashboards – Highway project in vulnerable area



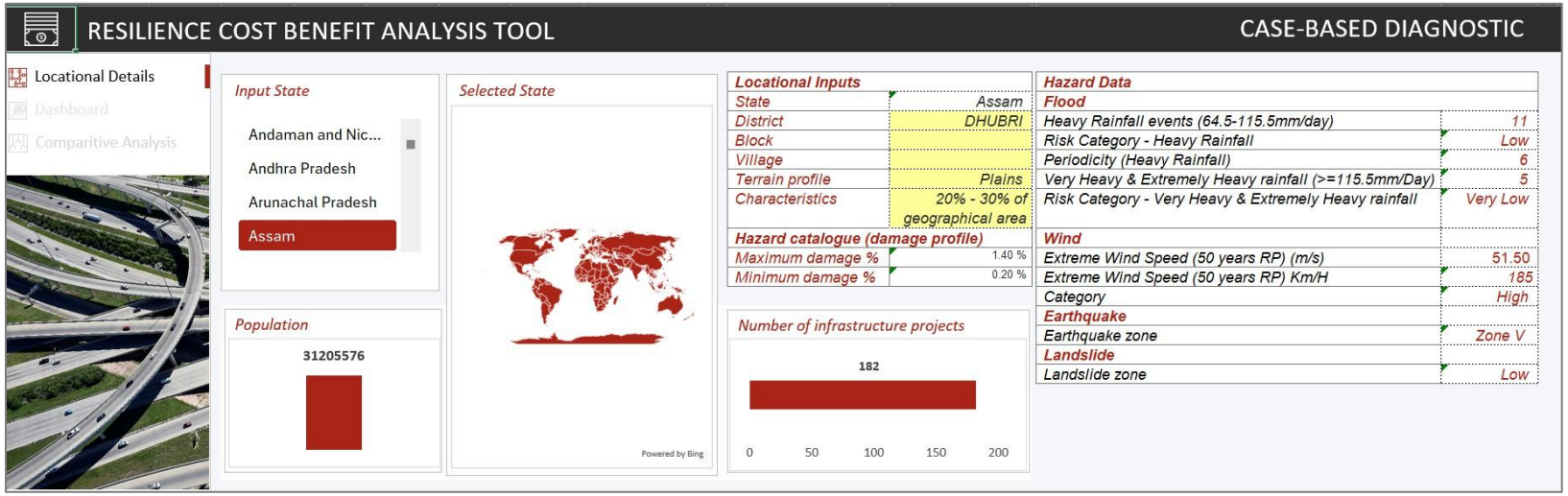

### CBA tool – Dashboard 3

**Key financial indicators** to decide incorporation of resilience measures

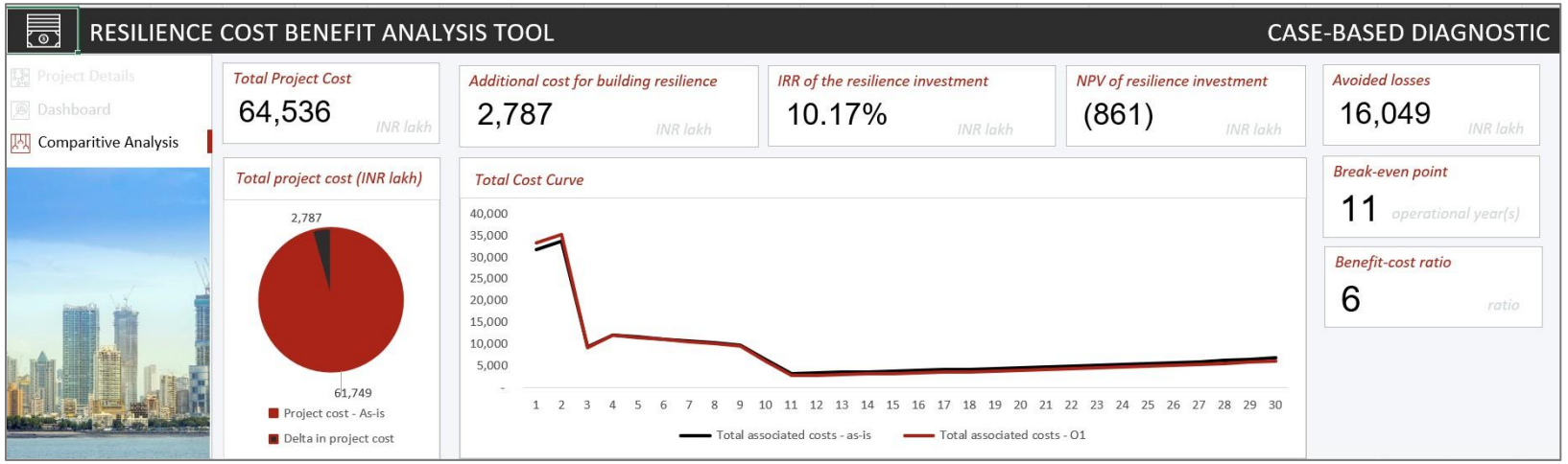
- NPV of all future cashflows
- Absolute savings on Recovery/reconstruction needs for incorporation of resilience measure
- Break-even point for the additional investment
- Benefit-cost ratio

Measures incorporated to 1% of the total alignment

# Components of the tool for simplified assessment




Input Dashboards




Output Dashboard

Sample Test on tool

## Costs considered:

- Costs of resilience
- Repair and reconstruction costs
- Revenue loss
- Insurance premium

## Financial parameters for investment decisions:

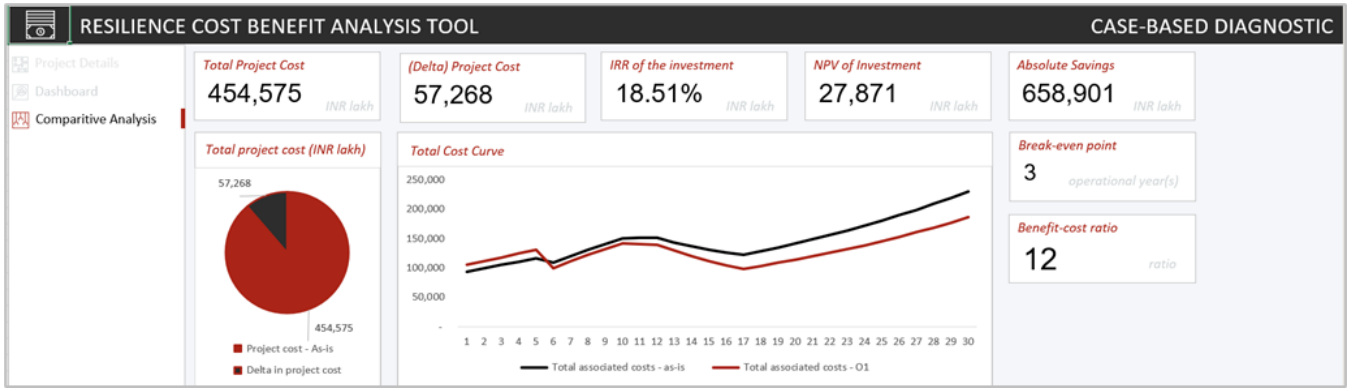
- Net Present Value (NPV)
- Internal Rate of Return (IRR)
- Benefit : Cost ratio
- Break even period

# Testing of Live Projects

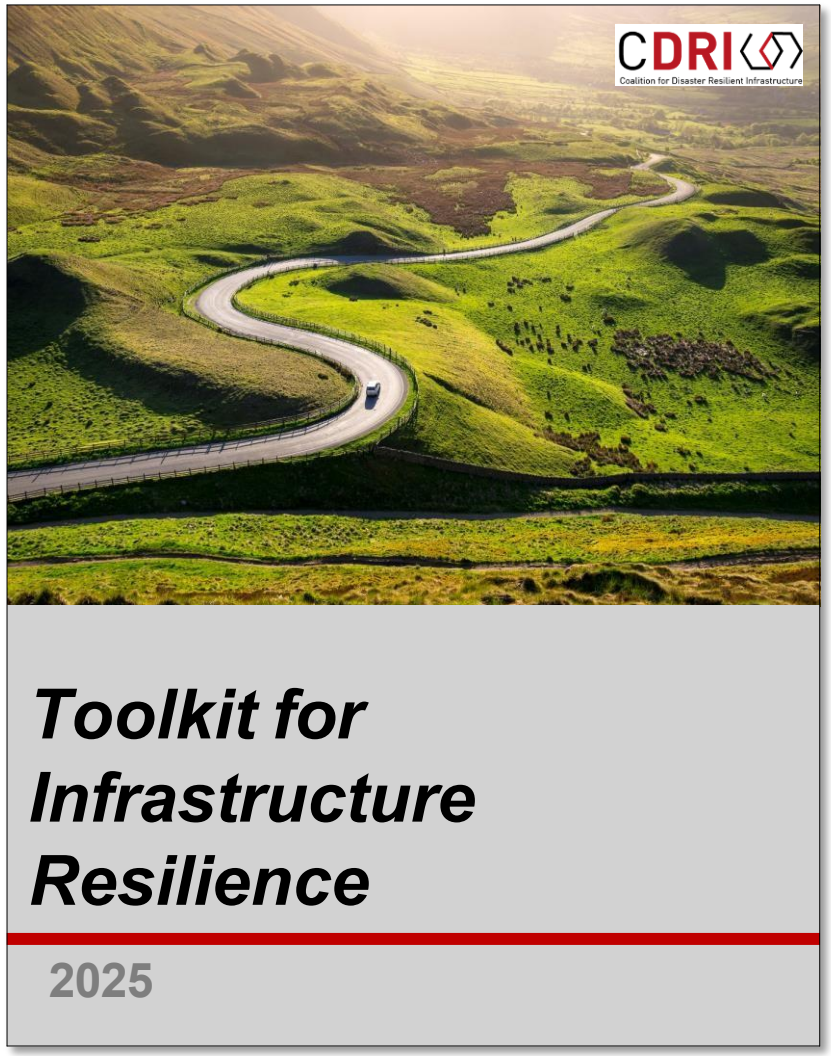
**Project 4: Transmission System for Mundra Ultra Mega Power Project**

| Output | Project 4 |
|---|---|
| Indicators | Details |
| Asset type | Transmission |
| Name of project | *Transmission System for Mundra Ultra Mega Power Project* |
| Total Project Cost (INR Lakh) | *4,54,575* |
| State | *Gujarat* |
| Hazard type | *Cyclone* |
| Resilience measure selected | *Underground cables in vulnerable stretches* |
| Cost of selected resilience measure (INR Lakh) | *57,268* |
| Absolute savings (INR Lakh) | *6,58,901* |
| Net Present Value (INR Lakh) | *27,871* |
| Internal Rate of Return % | *18.51 %* |
| Break-even Point (Operational years) | *3* |
| Benefit Cost Ratio (BCR) | *12* |

*There is a benefit of **INR 12** for every INR invested for resilience.*



# Output 2 - A toolkit to incorporate disaster resilience in infrastructure projects




**Components of the toolkit and their purposes**

**Part 1:** List of resilience measures for bidding and contractual documents

Integrate resilience considerations into EPC/PPP contracts & SBDs

**Part 2:** List of Design Options for asset resilience

Serves as reference for project design and cost-benefit analysis.

**Part 3:** Project identification & appraisal guidance document for line ministries

**Aid line ministries** in integrating disaster risks.

**Part 4:** Project proposal guidance document for potential bidders

**Aid bidders** in incorporating resilience measures in proposals.

# Part 1: List of resilience measures for Bidding and contractual documents

Suggested modifications to bridge the resilience gaps have been compiled as a list of resilience measures for Bidding and contractual documents covering three contractual documents.

## Focus areas in the documents

Appraisal of **standard contractual documents for** resilience gaps

- Model concession agreements
- Procurement guidelines
- Service agreements

Identify gaps and provide suggestions in indicative sections for

- Incorporating **risk sharing** in **Model agreements**
- Defining **Force majeure** clauses for **EPC and PPP** modes of implementations

## Contractual documents studied

**Road Sector:**
Revised standard EPC Agreement for NH and Centrally sponsored road works proposed to be implemented on EPC Mode

**Railway Sector:**
Standard EPC Tender Document for Single Stage Two Packet System

**Power Sector:**
Revised Guidelines and Standard Bidding Documents SBDs for procurement ISTS through TBCB process

# Part 1: List of resilience measures for Bidding and contractual documents

## Structure of the list:

- Mention of ‘Clause’ in standard documents for incorporating resilience considerations.
- Existing ‘coverage’ of the clause and ‘issue’ that needs to be addressed.
- Suggestions that can be incorporated in the clause
- Reference to national/global good practice
- Stakeholders’ responsibilities

## Resilience parameters:

Detailed definition of Force Majeure
*With hazard thresholds*

Enhance expertise in resilience in the team
*Resilience experts*

Conduct Safety Audits

Action & Remedy for Non-Compliance

Resilience measures in Scope of Project

Non-inclusion of resilience measures as Event of Default

Extended Defect Liability Period

Insurance coverage for natural hazard losses

# Part 1: List of resilience measures for Bidding and contractual documents(1/2)

**Clause 17.1 – 17.5 – Defects Liability under Article 17**

**Coverage**

These clauses provide the defect liability periods that should be considered for different types of road components, their designs and details; it covers the responsibilities of the contractor maintaining the operation of the asset within the liability period including details on remedying defects, cost of remedying defects under specific conditions, contractor's failure to rectify defects and extension of defects liability period.

**Issue**

The defects liability period is flexible and not based on the project's design life. The clauses do not specify the hazard intensity considered for the design, nor do they address damages from hazards below the threshold intensity. The contractor's responsibility for remedying defects should be defined with regard to these hazard thresholds. The clause excludes force majeure events but fails to define the natural hazards and their threshold parameters.

**Suggestion**

Extending the Defects Liability Period (DLP) in contractual agreements in general (e.g. 5 years to 15 years), can significantly enhance the project's long-term effectiveness and ensure resilience. Within the defect liability period it is crucial to define the accountability and responsibility of the concerned stakeholder in case of damage due to a natural hazard while clearly specifying the hazard thresholds.

**Reference good practice - International**

**Type of Document:** Defect Liability Period and Statutory Liability Period. Heliz Law, Specialist Litigation Solicitors, 2023

**Reference clause:** The Limitation Act 1980

Under the Limitation Act 1980, specific statuary liability limitation period was introduced for construction contracts and law. While Defects Liability Period (DLP) ranged between 6 months to 2 years as per construction contract, statutory liability for defects was extended beyond DLP which lasts for 6 years for standard contracts and 12 years for deeds. In some contracts specific 12-month defect liability period is also present to address post-completion issues.

## Checklist of resilience measures

**Parameters covered:**

1. Force Majeure
2. Obligations of contractor
3. Role of safety consultant
4. Payment reduction on non-performance of maintenance obligations
5. Daily reporting by contractors on safety & security incidents
6. Submission of periodic compliance reports by authority engineer on safety consultant's recommendations.
7. Safety related schedule
8. Event of Default
9. Change in Scope - Authority require modifications before issuing the Completion Certificate.
10. User safety

# Part 2: List of resilience measures for Bidding and contractual documents(2/2)

**Clause 21.1 – Force Majeure under Article 21**

**Coverage**

The clause covers 'The expression "Force Majeure" or "Force Majeure Event" shall mean occurrence in India of any or all of Non-Political Event, Indirect Political Event and Political Event, as defined in Clauses 21.2, 21.3 and 21.4 respectively, if it affects the performance by the Party claiming the benefit of Force Majeure (the "Affected Party") of its obligations under this Agreement and which act or event (i) is beyond the reasonable control of the Affected Party, and (ii) the Affected Party could not have prevented or overcome by exercise of due diligence and following Good Industry Practice, and (iii) has Material Adverse Effect on the Affected Party'.

**Issue**

Currently the force majeure clauses in the agreement considers natural hazards as acts of God whereas the assets are designed to withstand a particular degree of natural hazard.

**Suggestion**

To determine damage liabilities, there should be a provision for including natural hazards under force majeure with clearly defined hazard types and threshold parameters such as intensity, frequency, duration, and spatial extent, among others. This can also be used to define and estimate the contingent liabilities of the authority and the party responsible for the design. Each project's thresholds must be specific based on asset type and site location.

**Reference Good Practice - International (Japan)**

In Japan's Aichi Toll Road Concession Project, the government bears costs only for unforeseeable force majeure events if the concessionaire cannot prevent them.

| Disaster type | Events for which the public sector bears additional costs |
|---|---|
| Earthquake | Damage based on normal social conventions |
| Heavy rain | Maximum rainfall of 80mm or more in 24 hours.<br><br>Even if rainfall is below the above standard, it is considered heavy rain if hourly rainfall is significant (20 mm or more), provided that the hourly rainfall is observed at the nearest weather observation station (managed by the public corporation) from the damaged place. |
| Storm | Maximum wind speed of 15 m per second or more (average in 10 min) |
| High tide, storm surge, tsunami | Extraordinarily high tide, storm surge, or tsunami caused by a storm or its aftermath with relatively non-minor damage |

## Checklist of resilience measures

**Parameters covered:**

1. Force Majeure
2. Obligations of contractor
3. Role of safety consultant
4. Payment reduction on non-performance of maintenance obligations
5. Daily reporting by contractors on safety & security incidents
6. Submission of periodic compliance reports by authority engineer on safety consultant's recommendations.
7. Safety related schedule
8. Event of Default
9. Change in Scope - Authority require modifications before issuing the Completion Certificate.
10. User safety

# Part 2 - List of design options for asset resilience

Includes a list of design options **(engineering interventions)** to enhance asset resilience and serves as reference for **project design** and **cost-benefit analysis**.

## Who uses it?

- Implementing Authority
- DPR consultant
- Contractors

## At what stage?

- Planning
- Design
- Implementation

## How will it help?

- Select suitable resilience design options for asset and hazard type.
- Use in RCBA tool to check viable options.

## Asset type and hazards coverage:

**Roads:** Landslide, Flood, Heatwave and Earthquake

**Railway tracks:** Flood, Earthquake, Wind and Fire

**Transmission Infrastructure:** Wind, Cyclone and Flood

| Power asset | Existing measures | Future (Measures that can be proposed) | Reference |
|---|---|---|---|
| **Transmission Lines** | **(i) Reconstruction of damaged infrastructure and strengthening of existing Transmission line towers** Many transmission lines in cyclone-prone regions still follow outdated codes (IS 802: 1977/1995). IS 802 was revised in 2015, and wind speeds have increased per the 2018 SERC wind map, included in the 2016 NBC. Redesigning all towers to meet new standards (IS 802-2015) and the revised wind map is impractical due to potential power outages. Instead, modification/strengthening should be based on failure history. Network owners must assess the risk and plan upgrades accordingly. Rapid | **Change in Design Loads: Challenge-** Wind challenges transmission lines, causing most tower failures. Cyclonic winds of 60-75 m/s account for 80-85% of cases. Lattice structures are designed per IS 802, incorporating changes in wind zones, probabilistic design, peak gust velocity, and wind load factors. Coastal regions in eastern India are in Wind Zone 5, with a design speed of 50 m/s. **Cyclones sometimes exceed this, reaching up to 69 m/s.** Measures to address high wind loads and strengthen towers include: | https://cea.nic.in/wp-content/uploads/pse td/2021/11/Task _force.pdf<br><br>https://cea.nic.in/wp-content/uploads/regulations_cpt/2023/01/CEA_Technical_Standards_for_Construction_of_Electrical_Plants_Lines_Regulations_2022-3.pdf<br><br>https://technicalcivil.com/wp-content/uploads/2019/04/IS-875-part-3-2015.pdf?x57228 |

Illustrative

# Part 3 - Project identification and appraisal guidance document for line ministries

**Support the line ministries** on **incorporating disaster risk considerations** during **project identification** and **appraisal phases.**

## Who uses it?

- Line ministries
- Implementing authority

## At what stage?

- Planning
- Design
- Implementation

## How will it help?

- Incorporate resilience aspects in contractual clauses.
- Ensure informed and risk-aware decision making.

## The document includes:

- Introduction and its applicability
- Basics on understanding disaster resilience
- User journey to navigate resilience checklist
- Sector specific questions to ensure disaster resilience integration (project phase wise).

| Project phase | Checklist | ✓ / × | Reference guidance document/clause |
|---|---|---|---|
| Conceptualization & planning | 1. Have you conducted a comprehensive hazard, risk and vulnerability assessment for the project site?<br>*A comprehensive hazard, risk, and vulnerability assessment for the project site involves systematically identifying potential hazards, analyzing the site's vulnerability to these risks and evaluating the risks. This process should include data collection, stakeholder consultation, and the development of mitigation strategies to minimize potential impacts.* | | |
| | 2. Have you ensured that the proposed alignment is stable and not prone to landslide hazards or other adverse climatic conditions? | | |
| | 3. Have you considered climate hazards during the micro-site assessment? | | |
| | 4. Have you assessed the climate risks within the site is/may be susceptible to?<br>*Mention the method used to assess climate risks including but not limited to:*<br>- *Historical data: Analyze historical weather and climate data to identify patterns of extreme weather events, such as floods, droughts, and storms; refer to local and regional climate reports.*<br>- *Stakeholder engagement and participatory approaches: Conduct focus group discussions with local communities, experts, and stakeholders to gather insights and validate findings; use surveys and interviews to collect qualitative data on local knowledge, perceptions, and experiences related to climate risks.*<br>- *Scenario Analysis: It includes developing and analyzing multiple future scenarios based on different climate projections and socio-economic pathways.*<br>- *Climate Modeling and Projections: Utilizing global and regional climate models to project future climate conditions and assess potential.* | | |

Illustrative

# Part 4 - Project proposal preparation guidance document for potential bidders

**Support potential bidders** in the **development of project proposals** that effectively integrate disaster resilience goals.

## Who uses it?

- Implementing authority
- Developers & contractors

## At what stage?

- Design
- Implementation
- O&M

## How will it help?

- Build resilience considerations into bid proposals and before entering into contract.

## The document includes:

- Introduction and its applicability
- Basics on understanding disaster resilience
- User journey to navigate resilience checklist
- Sector agnostic questions to be considered for drafting proposals (project phase wise).

| Project phase | Checklist | ✓ / × | Reference guidance document / clause |
|---|---|---|---|
| Design | 1. Are you aware of and do you understand the local hazard profile of the project site? | | |
| | 2. Are you aware about the climate risks that the site is prone to? | | |
| | 3. Have you developed designs and drawings in accordance with the specifications and standards outlined in the Agreement considering:<br>a) Local hazard profile …….<br>b) Disaster resilience aspects……..<br>c) Hazard threshold parameters…….. | | |
| | 4. Have you referred to the list of design options for resilience while finalizing the design? | | Checklist of resilience measures-2 > Engineering design options list for asset resilience |
| | 5. Have you consulted with infrastructure resilience experts and engineers to validate the design? | | Checklist of resilience measures-1 > Bidding and contracts checklist for resilience measures > (3.3.) Checklist of resilience considerations in power sector > Theme: Design, Safety and Scope aspects > Clause 5.1 of TSA – Construction responsibility |

Illustrative