



Financial Preparedness Strategies for Adaptation and Resilience

Component II, Task V

Disaster Resilient Power Systems for Odisha



Power Research and
Development Consultants
Private Limited



KPMG Advisory Services
Private Limited



TARU Leading Edge
Private Limited



Foreword



Power infrastructure and a stable electricity connection is an essential enabler of development. It supports homes, businesses, schools, hospitals, and the supply of other utilities. The introduction of smart grid technologies, bolstering renewable energy sources, and enhancing load efficiency is imperative for achieving global climate commitments.

Escalating climate risks present a challenge to this essential infrastructure and its interconnected systems. Power infrastructure in coastal regions is particularly vulnerable given the magnitude of climate intensified extreme weather events in these regions.

India has a coastline stretching over 7,500 kilometres. Its coastal areas are home to more than 260 million inhabitants. Cyclones like Fani (2019), Gaja (2018), and Hudhud (2014), which were accompanied by severe flooding, caused extensive damage to lives and livelihoods across the coastal states of Odisha, Andhra Pradesh, Tamil Nadu, and Kerala.

In response, India has become a leader in building resilience in coastal areas. Improved disaster preparedness, early warning systems, and well-executed evacuation strategies, have played a pivotal role in safeguarding vulnerable populations.

Odisha's experiences in recovering quickly from various disaster events offer compelling evidence for the development of resilient power infrastructure. The state became the first state in India to establish a disaster management authority in 1999 after the Super Cyclone, even before the establishment of the National Disaster Management Authority (NDMA) in 2005. It was also the first Indian state to create an early warning system for disseminating critical disaster-related information to the very last mile. Odisha State Disaster Management Authority has utilized the best technical expertise for building over 800 multi-purpose cyclone shelters together with evacuation roads along the state's entire coastline. Odisha's success in bringing down the casualty to double digits and putting in place robust mechanisms for risk-informed decision-making is a significant achievement.



In support of these efforts, recognizing the particular importance of power infrastructure, and to develop evidence that can be shared with other vulnerable regions, CDRI's study "Disaster Resilient Power Systems for Odisha" has aimed at strengthening the power infrastructure.

This work has identified key challenges and best practices within the Transmission and Distribution (T&D) sector at the subnational level. To understand vulnerabilities related to the T&D infrastructure system along its entire 480 km of coastline, 16 indicators were identified ranging from commissioning year to asset failure history. Recommended actions, including investment options to strengthen resilience of the T&D infrastructure, were prepared accordingly. The study serves as a vital resource for stakeholders in the power sector.

On behalf of CDRI, I express sincere gratitude to all stakeholders from the Government of Odisha, including GRIDCO Ltd, for their invaluable contributions to the report's methodology and policy recommendations for the short, medium, and long term. I would also like to extend my sincere appreciation for NDMA's support throughout the entire effort. Collaboration with Taru Leading Edge, Power Research and Development Consultants (PRDC), and KPMG - India has been instrumental in preparing this report, which serves as an indispensable tool for policymakers, practitioners, manufacturers, and other stakeholders in the power sector.

CDRI believes that the resilience of the power sector to extreme weather events is pivotal in safeguarding the lives and livelihoods of millions, particularly those in vulnerable regions. We are committed to take the lessons learned in Odisha and expand similar work to support coastal regions around the world.

A handwritten signature in blue ink, appearing to read "Amit Prothi", with a horizontal line underneath.

Amit Prothi

Director General, CDRI

New Delhi, India, June 2024



Foreword



Global energy consumption is steadily increasing annually, with an anticipated 48 percent growth over the next two decades, driven by the exponential rise in global population. In the face of escalating challenges posed by climate change, ensuring resilience in energy systems is imperative for overall development. Given the historical impact of extreme weather events on the state of Odisha, particularly the Transmission and Distribution (T&D) segment, the state has demonstrated remarkable resilience. It has rebounded and recovered by developing innovative adaptation and mitigation strategies in response to periodically changing wind speeds and the looming risk of climate change.

Understanding the socio-economic impact and losses in this regard, this study serves as an essential tool and a precursor at the sub-national, national, and global levels for coastal regions and regions with similar geographies. It provides insights into strategies that can be replicated not only for risk identification and estimation but also for capacity building, knowledge management, and financial preparedness.

This initiative aims to evaluate the climate resilience of Odisha's power infrastructure in a unique way. It will not only help in reshaping the policy landscape and risk-based governance for coastal regions but also provide valuable insights for energy sector practitioners, Original Equipment Manufacturers (OEMs), and regulators. The report details individual unit-level assets, their vulnerabilities, and offers investment options on how to build more resilient transmission and distribution assets. By setting a new standard for resilience initiatives, the study is expected to significantly influence the development of robust and adaptive energy systems, ensuring a sustainable and secure future for all.

I extend my appreciation to the Coalition for Disaster Resilient Infrastructure (CDRI) and the project stakeholders for this collaborative effort, which will help enhance the reliability and resilience of the state's power infrastructure. I strongly believe that the report will serve as a benchmark in climate-proofing of energy infrastructure in Odisha.

**Principal Secretary to Government
Energy Department,
Government of Odisha**



Preface

India is highly vulnerable to various natural hazards such as cyclones, tsunamis, earthquakes and floods, among other catastrophes. Approximately 12 percent of the nation's land area is prone to flooding and river erosion, while more than 58 percent is vulnerable to earthquakes of moderate to very high intensity (MHA, 2015). The susceptibility to cyclones and tsunamis affects approximately 76 percent of the coastline, particularly impacting the eastern coastal states of Tamil Nadu, Andhra Pradesh, Odisha and West Bengal (CEA, 2021). Climate change has increased the frequency and severity of these catastrophic events, wreaking havoc on the economy and society.

Odisha, with a 480-km coastline along the Bay of Bengal, often faces severe impacts from these disasters. Power infrastructure is one of the most severely affected sectors in the region. Large-scale damage to the state's transmission and distribution (T&D) infrastructure due to cyclones is common, leading to extended power supply outages in affected areas. Additionally, floods in Odisha are another major obstacle to the electricity infrastructure, making it impossible to operate and maintain during high rains and severe waterlogging. Between 1996 and 2018, Odisha experienced 13 years of floods and five years of cyclones (Sethi, 2019).

In light of the profound consequences that climate change and disasters have on power infrastructure, the National Disaster Management Authority (NDMA) of India convened a meeting in July 2019, inviting all stakeholders involved in developing policy and research at the national level, as well as those involved in building and operating power generation, transmission and distribution infrastructure in Odisha. The meeting discussed the power sector's damages and losses and brainstormed a road map for creating disaster- and climate-resilient power infrastructure in Odisha and, by extension, in all high-risk areas of India. The meeting also involved a thorough analysis of the cyclone's impact on the power infrastructure in Odisha, including the technical, organizational and functional factors contributing to significant damage and prolonged power restoration, which was universally acknowledged.

The following action was proposed to move forward: NDMA, in cooperation with relevant stakeholders, would conduct a comprehensive study to improve the power sector's disaster and climate resilience. Drawing from Odisha's experience, the power sector has adopted various innovative approaches to mitigate the effects of cyclones. These innovations, which have been adopted on an on-going basis over the last two decades, need to be systematically documented and disseminated so that the advances made by Odisha may benefit other cyclone-affected states in the country. The Coalition for Disaster Resilient Infrastructure (CDRI) supports NDMA in carrying out this comprehensive assessment of the resilience of power infrastructure in Odisha state.

The study on the resilience of power infrastructure in Odisha is categorized into two distinct phases. Phase I of the study relates to developing and adopting mechanisms for ensuring preparedness, preventing grid collapse, assessing losses, estimating needs and channelling adequate funds to disaster-affected areas promptly for early restoration and resilient recovery and reconstruction. It also includes aspects of community engagement.



The Phase - II study consists of two components, which yield a total of five reports. Component II focus areas include a) Risk Identification and Estimation and b) Codes, Standards, Regulations, Technology and Innovation. Component III focuses on a) Risk-based Governance and Policy Development, b) Capacity Building and Knowledge Management and c) Financial Preparedness and Adaptation.

The Phase-II reports will be a crucial instrument for policymakers to strengthen the power system's resilience, particularly in terms of T&D assets. Additionally, they will aid in evaluating and ranking investments in the power sector among similar geographical areas at every level.

The report '**Strategies for Effective Risk Identification and Estimation**' aims to differentiate the level of susceptibility and the associated risks faced by Odisha's power infrastructure due to disasters. Evaluation has meticulously considered exposure and vulnerabilities, particularly within the various components of the power infrastructure.

The report '**Codes, Standards and Technological Innovations for Infrastructure Design**', an examines various mechanisms crucial for establishing, enforcing, and regularly updating scientifically informed design standard, codes, and regulations to enhance power infrastructure resilience. This assessment factored in evolving technologies and their changing profiles to ensure efficacy. This study also considers an array of technologies and innovations available to bolster power structure resilience against diverse hazards, emphasizing the tools and technologies that could be integrated to strengthen disaster risk management.

The report '**Risk-Informed Governance and Policy Development**' reflects the need to imbibe strong institutional governance, augmented capacity building and financing for disaster resilience in the power sector. The report further recommends and provides a way forward to build a comprehensive post-disaster need assessment (PDNA) strategy and enhance the techno-regulatory capacity building of Odisha's power infrastructure. It additionally identifies the various gaps and provides plausible interventions to strengthen the resilience in both structural and non-structural aspects of the power sector in the state.

The report '**Capacity Building of Stakeholders for Better Preparedness**' addresses governance and policy structures coupled with capacity-building efforts and makes recommendations for different stakeholders of the state and Energy department. These recommendations aim to facilitate the integration of disaster and climate resilience principles into the planning, operation, maintenance and continuous improvement of power infrastructure in Odisha.

The report '**Financial Preparedness Strategies for Adaptation and Resilience**' states that financial resources are required at various stages to build further disaster-resilient infrastructure, such as disaster prevention, preparedness, response and recovery. This section of the report addresses the financial and adoption strategies.



Acknowledgements

The successful completion of the Disaster Resilient Power Systems study for coastal Odisha stands as a testament to the extensive collaborative and technical effort invested over three years.

The project encompassed thorough desk research, data collection, cleaning, analysis and calculations. The successful accomplishment of this monumental task would not have been possible without the unwavering dedication and hard work of numerous individuals and teams, to whom we express our sincere appreciation and gratitude.

We would like to express our gratitude to Shri Gagan Bihari Swain, Director (F&CA), GRIDCO and his team for their valuable guidance and coordination in collecting relevant data from different stakeholders during the study period. We also appreciate the contributions of OPTCL, TPCODL, TPNODL, TPSODL and OSDMA in providing the required information for the study.

We extend our heartfelt appreciation to our esteemed consultants, M/s Power Research and Development Consultants Private Limited-PRDC, M/s KPMG India and M/s Taru Leading Edge, for their critical contributions to the study.



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Abbreviations

ACA	Additional Central Assistance
ADB	Asian Development Bank
AfDB	African Development Bank
AIS	Air-Insulated Switchgear
CAG	Comptroller and Auditor General
CBDG-DR	Community Development Block Grant – Disaster Recovery
CDRI	Coalition for Disaster Resilient Infrastructure
CEA	Central Energy Authority
CGA	Controller General of Accounts
CHP	Combined Heat and Power
CSR	Corporate Social Responsibility
DDMA	District Disaster Management Authority
DFL	Defined Flood Level
DISCOMs	Distribution Companies
DLNA	Damage, Loss, Needs and Assessment
DM	Disaster Management
DPR	Detailed Project Report
DRC	Distribution Reforms Committee
DRR	Disaster Risk Reduction
EBRD	European Bank for Reconstruction and Development
EOI	Expression of Interest
ERB	Energy Resilience Bond
GIS	Gas-Insulated Substations
GoI	Government of India
GSDP	Gross State Domestic Product
GSS	Grid Substations
GST	Goods and Services Tax
HQ	Headquarters
HUD	Housing and Urban Development



Abbreviations

IADB	Inter-American Development Bank
JICA	Japan International Cooperation Agency
LHV	Lower Heating Value
LT Wires	Low Tension Wires
MDB	Multilateral Development Banks
MH	Major/Minor Heads
NDMA	National Disaster Management Authority
NDMF	National Disaster Mitigation Fund
NDRF	National Disaster Response Force
NDRMF	National Disaster Relief Mitigation Fund
NEA	National Electrification Administration
NJ BPU	New Jersey Board of Public Utilities
NJEDA	New Jersey Economic Development Authority
OM	Operation & Maintenance
OPSEAP	Odisha Power Sector Emergency Assistance Project
OPTCL	Odisha Power Transmission Corporation Limited
OSDMA	Odisha State Disaster Management Authority
PDNA	Post Disaster Needs Assessment
PFC	Power Finance Corporation
PRI	Panchayati Raj Institutions
PSS	Power System Stabilizers
PV	Photo Voltic
REC	Rural Electrification Corporation
SDMA	State Disaster Management Authority
SDMF	State Disaster Mitigation Fund
SDRF	State Disaster Response Force
SDRMF	State Disaster Relief Mitigation Fund
SEC	State Executive Committee
SPV	Special Purpose Vehicle



Abbreviations

SRC	Special Relief Commissioner
T&D	Transmission and Distribution
TPCODL	Tata Power Central Odisha Distribution Limited
TPL	Tonga Power Limited
TPNODL	Tata Power Northern Odisha Distribution Limited
UG Cabling	Under Ground Cabling
UNDP	United Nations Development Programme
UNDRR	United Nations Disaster Risk Reduction
USAID	United States Agency for International Development
USD	United States Dollar
WBG	World Bank Group



Executive Summary

Emphasizing the crucial role of financial preparedness in bolstering disaster resilience within the power sector, the focus of this report shifts towards tailoring strategies to fortify assets in Odisha. This imperative stems from the recurrent threat of climatic events, necessitating measures to minimize losses and damages to infrastructure and lives.

Odisha, positioned along India's east coast, faces a vulnerability rate of 17 percent to cyclones, experiencing a significant portion of these severe weather phenomena. Noteworthy cyclonic events like the Super Cyclone (1999), Phailin (2013), Hudhud (2014), Titli (2018) and Fani (2019) have left enduring impacts on the region's infrastructure and communities.

Highlighting specific high-risk districts such as Balasore, Bhadrak, Kendra Para, Jagatsinghpur, Puri and Ganjam, spanning a 480 km coastline, underscores the critical need for targeted financial strategies to safeguard power sector assets effectively.

Component – II of the study focused on Risk Identification, Estimation and Assessment of Codes and Standards for the Transmission and Distribution Sector Infrastructure in Odisha. Central to this process was the precise assessment of infrastructure risks, entailing a vulnerability evaluation to gauge existing hazards across the state.

This evaluation meticulously considered exposure and vulnerabilities, particularly within the various components of the power infrastructure. Additionally, examining diverse mechanisms was imperative to establish, enforce and regularly update scientifically informed standard designs and regulations, enhancing power infrastructure resilience. This assessment factored in evolving technologies and their changing profiles to ensure efficacy.

Exploration of various technological aspects supported this endeavour, enabling the power sector to leverage advancements to address accuracy, scale, reach and capacity limitations in constructing infrastructure systems. It underscored the array of technologies and innovations available to bolster power structure resilience against diverse hazards, emphasizing the tools and technologies that could be integrated to strengthen disaster risk management.



Financial Preparedness and Institutional Governance Mechanisms

While the previous reports primarily emphasized strengthening the power infrastructure's structural resilience, it is paramount to bolster the financial and human resource management aspects to enhance the system's overall resilience against calamities such as cyclones and floods.

Hence, Component – III reports address governance and policy structures coupled with capacity-building efforts and put forth recommendations for different stakeholders of the state and Department of Energy. These recommendations aim to facilitate the integration of disaster and climate resilience principles into the planning, operation, maintenance and continuous improvement of power infrastructure in Odisha.

A robust governance framework and comprehensive capacity-building initiatives established with a thorough assessment of vulnerability and exposure of power sector components pave the way for financial resilience and adaptation in Odisha. The adaptation focuses on withstanding cyclones, further enhancing the state's resilience, and strengthening the power sector against disasters over an extended period.

Critical infrastructure such as the power sector, hospitals and water supply must adopt robust policies and standards to improve reliability and resilience during high-impact disaster events.¹ Given the nature of its related infrastructure, such as electricity transmission lines, transformers, stations and substations, the power sector is prone to more significant damage. These require specific mitigatory action plans to increase resilience. Odisha, susceptible to recurrent episodes of cyclones/floods, suffers from massive power infrastructure losses with disruption of LT wires, electrical poles, grids and distribution transformers. Hence, huge investments are required to restore infrastructure and carry out preparedness and resilience-building activities to develop cyclone-resilient power infrastructure.²

Adverse impacts on energy infrastructure incur a considerable amount of expenses. While a significant gap exists between the amount of investment required for building resilience and trends in the deployment of funds, there are no definite and comprehensive estimates of the losses incurred.³ Uncertainty of climate events, intensities, frequency and severity make it hard to estimate the quantum and target of investment towards imparting disaster resilience.

¹<https://energy.odisha.gov.in/sites/default/files/2022-05/DIASTER%20MANAGEMENT%20PLAN%20-%20ENERGY%20DEPARTMENT%20GoO.pdf>

²<https://www.electricalindia.in/cyclone-resilient-power-infrastructure/>

³<https://www.oecd.org/environment/cc/policy-perspectives-climate-resilient-infrastructure.pdf>



Due to high frequency and high-impact cyclonic events, improper damage assessment reduces the capacity of stakeholders to respond. In Odisha, the development of resilience is further challenged due to the need for more specific fund allocation for different disaster phases, i.e., preparedness, response, recovery and reconstruction of infrastructure⁴. Hence, adherence to a standardized risk mapping framework of overall disaster management is necessary to build a resilient infrastructure.

Cost-Benefit Analysis

Another key objective of the report is to understand the benefits of developing a disaster-resilient energy infrastructure, compare them to the costs and provide a precise cost-benefit analysis for improving the energy sector's resilience. Based on the prioritization (Table 1) of the vulnerable components of power infrastructure, to build resilient infrastructure, Option 3 of investment of INR 26,992 crores should be opted, as it includes an underground cable system for distribution network in urban areas considering priority and criticality.

Assessing the losses sustained by conducting hazard scenario analysis (for 10-, 50- and 100-year return periods) is imperative to estimate the required financial investments.⁵ ***A detailed exposure dataset assessment, depending on hazard type, availability of input data and extent of analysis, provides an understanding of the criticality and vulnerability of exposed power transmission and distribution assets.*** It helps quantify the risk associated with the prioritization of assets, delivering a comprehensive overview of financial requirements. Therefore, based on the prioritization, DISCOMs have provided different options per the technical specifications for retrofitting and reconstructing new power components. While Options 1 and 2 refer to retrofitting or construction, Option 3 is recommended for logical investment, which offers an underground cable system considering priority and criticality.

Innovative Funding Mechanisms

Disaster management is a dynamic process that requires occasionally adopting global best practices and incorporating appropriate financial instruments to enhance resilience. Strengthening DRR financing strategies is additionally needed to address gaps and include comprehensive risk mapping. Incorporating risk identification with technological innovation governance and capacity building provides a way to build a resilient infrastructure.

Resilience banks must be incorporated and strengthened to increase financial resilience and adapt the mechanism of power infrastructure, resilience and catastrophe bonds, including risk layering and energy.

⁴https://forms2.rms.com/rs/729-DJX-565/images/Financial_Instruments_for_Resilient_Infrastructure_Technical_Report_October2018.pdf

⁵<http://www.charim.net/methodology/51>



Furthermore, the participation of bilateral and multi-lateral agencies should be increased to enhance the infrastructure's resilience further. Adopting various global practices taken by hazard-prone regions like New Jersey, Tonga and the Philippines to build energy-resilience banks and address the reconstruction needs further enhances the resilience of the infrastructure.

Financial resources are required at various stages to build further disaster resilient infrastructure, such as disaster prevention, preparedness, response and recovery. The funds can be divided into pre-disaster finance needs (financial needs / resources required before an event) and post-disaster finance needs (for which resources are spent after an event occurs). State and national agencies have supported the same. The disaster management financial framework helps address these blocks and fill the gaps between fund release and allocation for disaster management.

Disaster funding in India comes from national and state governments using different funds. For example, NDRF, NDMF, SDRF and SD MF. Multi and bilateral banks further aid it, and alternate sources such as reconstruction bonds, contingent credits (WBG and ADB), crowdfunding platforms, CSR, and insurance and risk pooling 2 provide scope to undertake a paradigm shift from disaster response to the holistic approach of disaster resilience and preparedness.

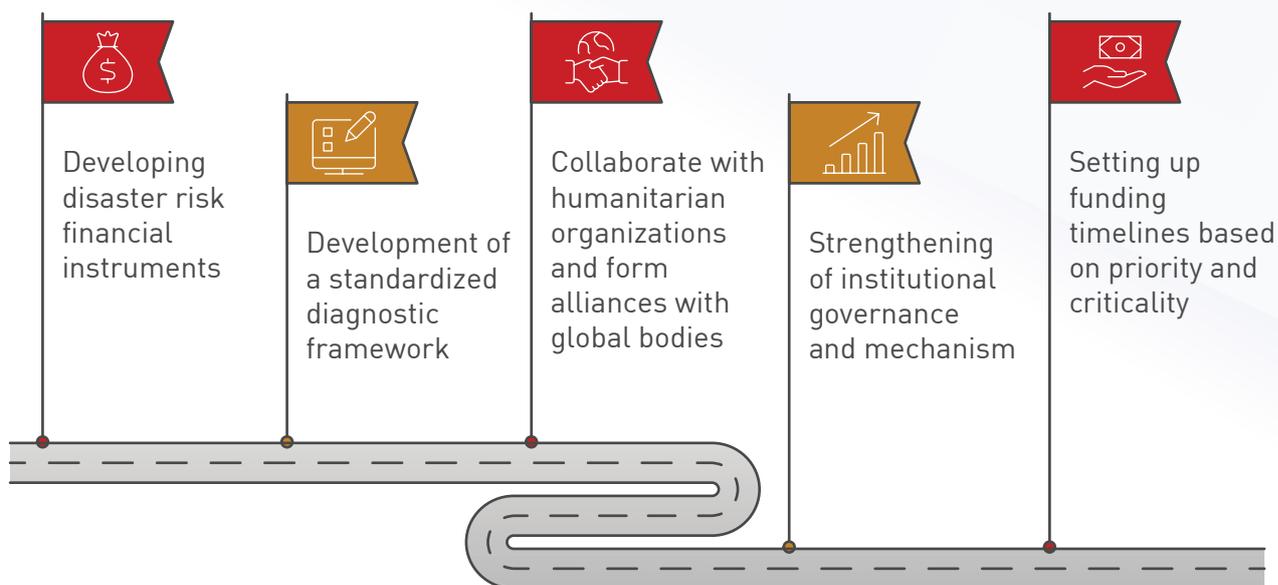
Table 1: DISCOM-wise Investment based on Priority and Criticality

DISCOM-wise Investment (in crores INR)			
DISCOMs	Option-1 (Retrofitting of Existing Lines)	Option-2 (Construction of New Lines)	Option-3 (Upgrading to Underground Cable System)
TPCODL	8610	9707	9914
TPNODL	7296	8254	8593
TPSODL	6785	7667	8486
Total	22691	25628	26992

Source: Codes, Standards and Design report, CDRI



A gap assessment regarding institutional bottlenecks in funding allocation, disbursement, or funding availability follows this. The report further reviews global best practices related to disaster infrastructure financing to identify potential financing opportunities that could be adopted in the case of Odisha to help fill the institutional gaps identified in the state. Based on the analysis, financial resilience can be further strengthened by adopting risk layering mechanisms and evaluating post-disaster finance needs. The power sector can additionally opt for the recommendations provided below to enhance the resilience of the infrastructure by building resilient financial governance.





1

Introduction





1. Introduction

The financial losses caused by disasters continue to rise, with developing countries experiencing the most significant impacts. Due to its diverse geographical terrain and climate, India is particularly vulnerable to numerous geological and hydro-meteorological hazards, such as cyclones, floods, earthquakes, landslides, droughts, extreme heat waves, lightning and wildfires. Recently, climate variability has led to an increase in the frequency, intensity and duration of weather-related disasters. These and other disasters across the country have highlighted how disasters affect the well-being of people, resulting in the loss of human lives, housing, livelihoods and infrastructure, along with several secondary impacts.

The primary responsibility for undertaking rescue, relief and rehabilitation measures during a disaster lies with the state governments. The central government assists these efforts by providing logistic and financial support. According to the Disaster Management Act, 2005, a financial mechanism has been established through the National Disaster Response Fund (NDRF) at the national level and the State Disaster Response Fund (SDRF) at the state level to meet the rescue and relief expenditure during any notified disaster. Under the notified norms, relief for repairing the damaged power sector infrastructure of an immediate nature is provided through NDRF/SDRF funds.

1.1 Need for Vulnerability Analysis and Disaster Resilient Infrastructure Investments

Statistically, there has been a cyclone every two years and a significant cyclone every four years along the coast of Odisha (see Table 1.1). As a result, coastal housing in Odisha remains highly vulnerable to cyclones and heavy rains. Additionally, the power infrastructure is completely above ground, making it particularly susceptible to disaster impacts. Disruption of the electrical system also has a cascading effect on health systems, water supply, communication, transport, etc. These services become even more critical during disasters as they help reach the most vulnerable populations.





Table 1.1 Assistance Sought Repair and Restoration of Power Infrastructure by Odisha

Cyclone	Year	Damages (in crores INR)
Phailin	2013	1,048.1
Hudhud	2014	104.3
Titli	2018	133
Fani	2019	1,068.8
Bulbul	2019	3.5
Amphan	2020	56
Yasa	2021	140.6
Total Assistance Sought		2,413.7

Source: Memorandum Phailin 2013, Hudhud 2014, Titli 2018 and Fani 2019

Hence, to estimate the associated vulnerability, it is pivotal that hazard proneness and vulnerability analysis are carried out for civil structures like buildings and power-generating infrastructure, including transmission and distribution facilities. Such research provides methods to identify quantitative risks in the power sector and evaluate effective strategies for better preparedness, immediate response and building back better. Risk analysis specifically for the power sector includes vulnerability assessment of electrical installations and equipment and hazard assessment of areas of interest. Further, it provides a financial evaluation of the losses and damages incurred (CEA 2021).

It is imperative to create resilient infrastructure to generate long-term benefits for economic development, social well-being and community resilience. Additionally, developing a resilient structure to absorb the shocks from disastrous events and adapting to changing climatic episodes can further increase the lifespan of assets.

Hence, **building resilience in the power sector refers to the ability to anticipate, prepare for and adapt to changing conditions and withstand, respond to and recover quickly from energy sector disruptions through adaptive, holistic planning and engineering solutions.** These investments extend beyond power generation's basic needs to support a safer, more reliable and resilient energy system in the face of various threats.



2

Disaster Finance and Governance





2 Disaster Finance and Governance

2.1 Disaster Financing in India

The energy sector comprises multiple subsystems, from power generation to transmission and distribution, all of which are exposed to potential disaster risks. ***Specific risk financing strategies should be based on their unique capacities, access to capital, available resources and the ability to manage risk. Hence, offering a suitable financial incentive is crucial for guiding and facilitating the resilience of critical infrastructure like the power sector in a state like Odisha.***

As a subject and facet of Union-State relations, disaster management has evolved over the years. The initial focus was dependent on disaster relief. However, the Disaster Management Act expanded the area of concern and action of both the union and state governments to a wide range of disaster management functions. This includes relief and response, preparedness, mitigation, and recovery and reconstruction.

The 15th Finance Commission has created a hybrid funding model that addresses both response and mitigation of disaster. Instead of creating separate funds for these purposes, it recommended the inclusion of mitigation funds in already existing schemes of the National Disaster Response Fund (NDRF) and the State Disaster Response Fund (SDRF). The new converted schemes shall be known as the National Disaster Response and Mitigation Fund (NDRMF) and the State Disaster Response and Mitigation Fund (SDRMF)⁶.

In India, disaster risk concerns are integrated into the government budgets to ensure that public expenditure on risk reduction is sufficient and adequate financial arrangements are made to manage the residual risk. ***Residual risk implies a continuing need to develop and support effective capacities for emergency services, preparedness, response and recovery. Additionally, it calls for implementing socio-economic policies such as safety nets and risk transfer mechanisms, as part of a holistic approach.***

The Disaster Management Act led to the creation of a new institutional structure for disaster management, with the setting up of the National Disaster Management Authority (NDMA) and State Disaster Management Authorities (SDMAs). Additionally, the Act also mandated the role of institutions and functions influencing the gradual and incremental strengthening of financial arrangements for disaster management.

This assisted in developing a well-structured scheme of funds at both the union and state levels, which has been institutionalized and supported by guidelines that set norms for assistance. The schemes proposed were as follows:

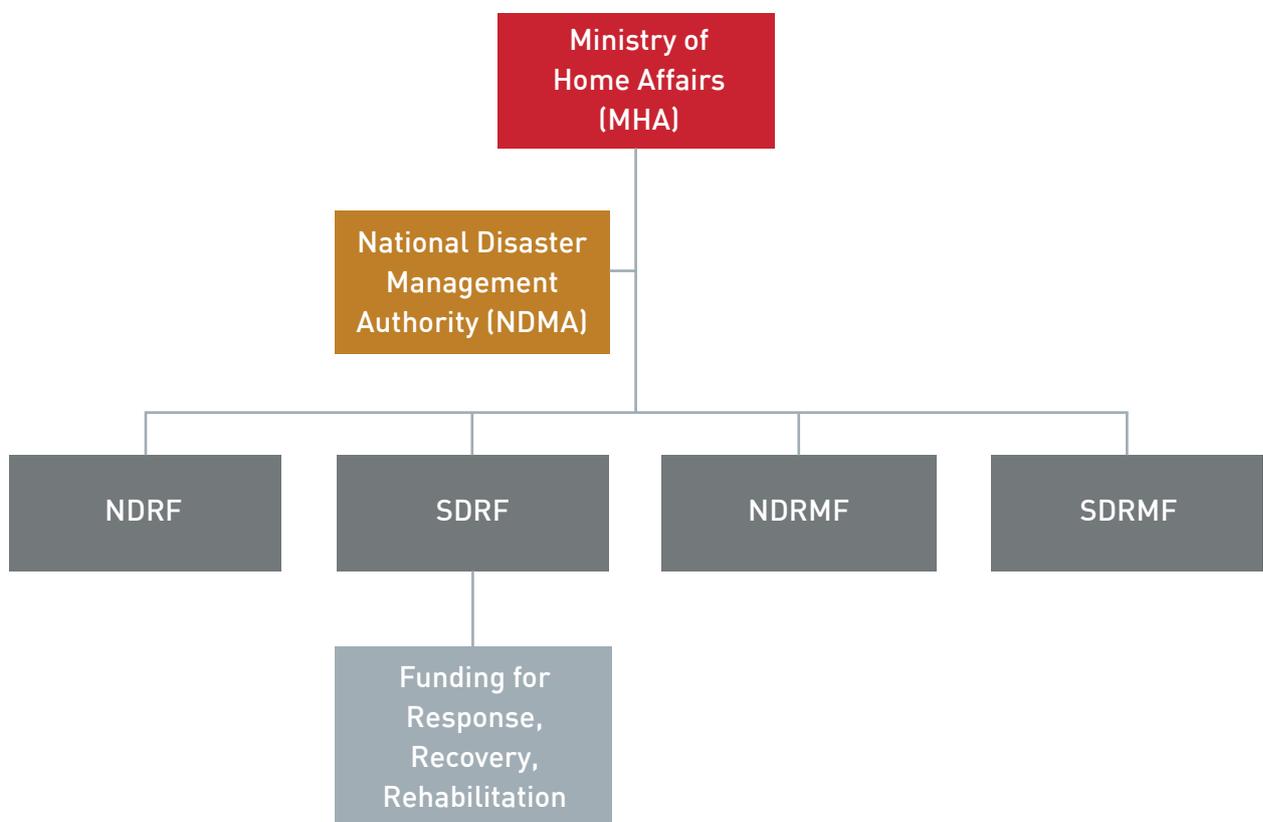
⁶Exploring Disaster Mitigation in India: A Financial Viewpoint (sagepub.com)



- » National Disaster Response Fund
- » State Disaster Response Fund
- » National Disaster Risk Management Fund / State Disaster Risk Management Fund
- » Other financial schemes and incentives under 'Mainstreaming Disaster Risk Reduction'

This funding scheme for disaster relief had been envisaged to provide state governments with a dependable source of assistance to meet their disaster response, relief, recovery and reconstruction needs. However, that has only been constituted in 2021, and the norms regarding their operationalization are still being deliberated by the Ministry of Home Affairs and NDMA (see Figure 2.1).

Figure 2.1 An overview of structured and institutionalized mobilization of funds

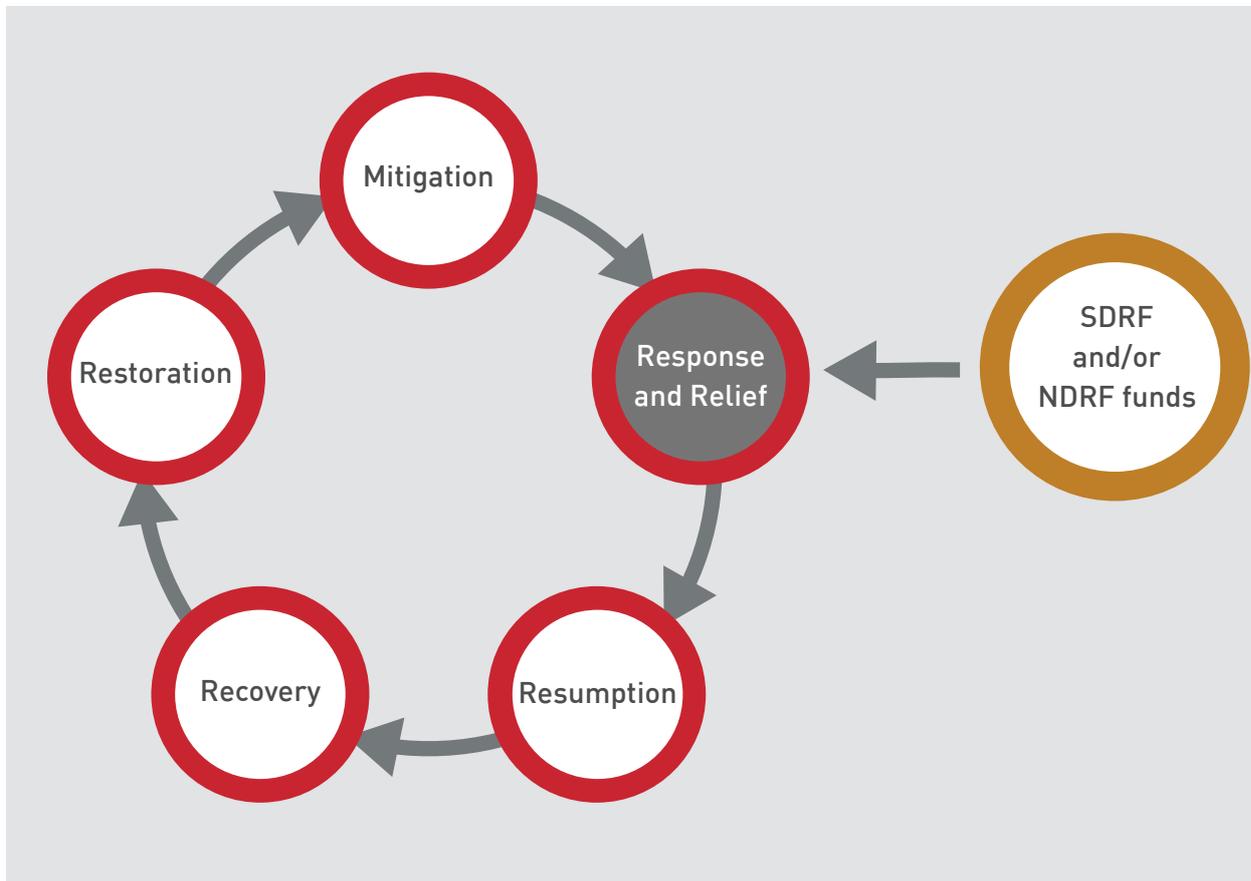


Insofar as relief under NDRF/SDRF is concerned, assistance is provided for the repair of damaged power sector infrastructure of immediate nature only. This support covers damaged conductors, poles and transformers up to 11 kV, in accordance with the assistance issued by the SDRF and NDRF from time to time (CDMP, 2022, MoP, GoI).



Instead, the disaster management focused on immediate response and relief, primarily utilizing SDRF and NDRF funds (see Figure 2.2).

Figure 2.2 Fund mechanism for response and immediate relief



Source: KPMG Internal Analysis

Furthermore, these funds could be augmented and replenished through a national disaster fund when exceptionally severe disasters of rare severity necessitate it. The guidelines and norms for assistance have been periodically revised, resulting in enhanced provisions for those affected by disasters.



2.1.1 State versus National Responsibilities

The phases of disaster management, such as response, recovery and rehabilitation, fall under the responsibility of the state government. At the same time, the union government extends secondary support by deploying the National Disaster Response Force and the armed forces at the request of state governments. The union government and its agencies provide financial and technical assistance whenever necessary. It is the state governments that incur most of the expenditures on disaster management. These expenditures are, at present, met through the SDRF.

When states exhaust their SDRF resources, they can request financial assistance through the NDRF by submitting memorandums to the union government. The NDRF, set up at the union level, replenishes and reinforces the state funds following guidelines. In addition to the assistance from the SDRF and NDRF, state governments have also been allocating funds from their budgetary resources for response and relief.

2.1.2 Role of Finance Commission

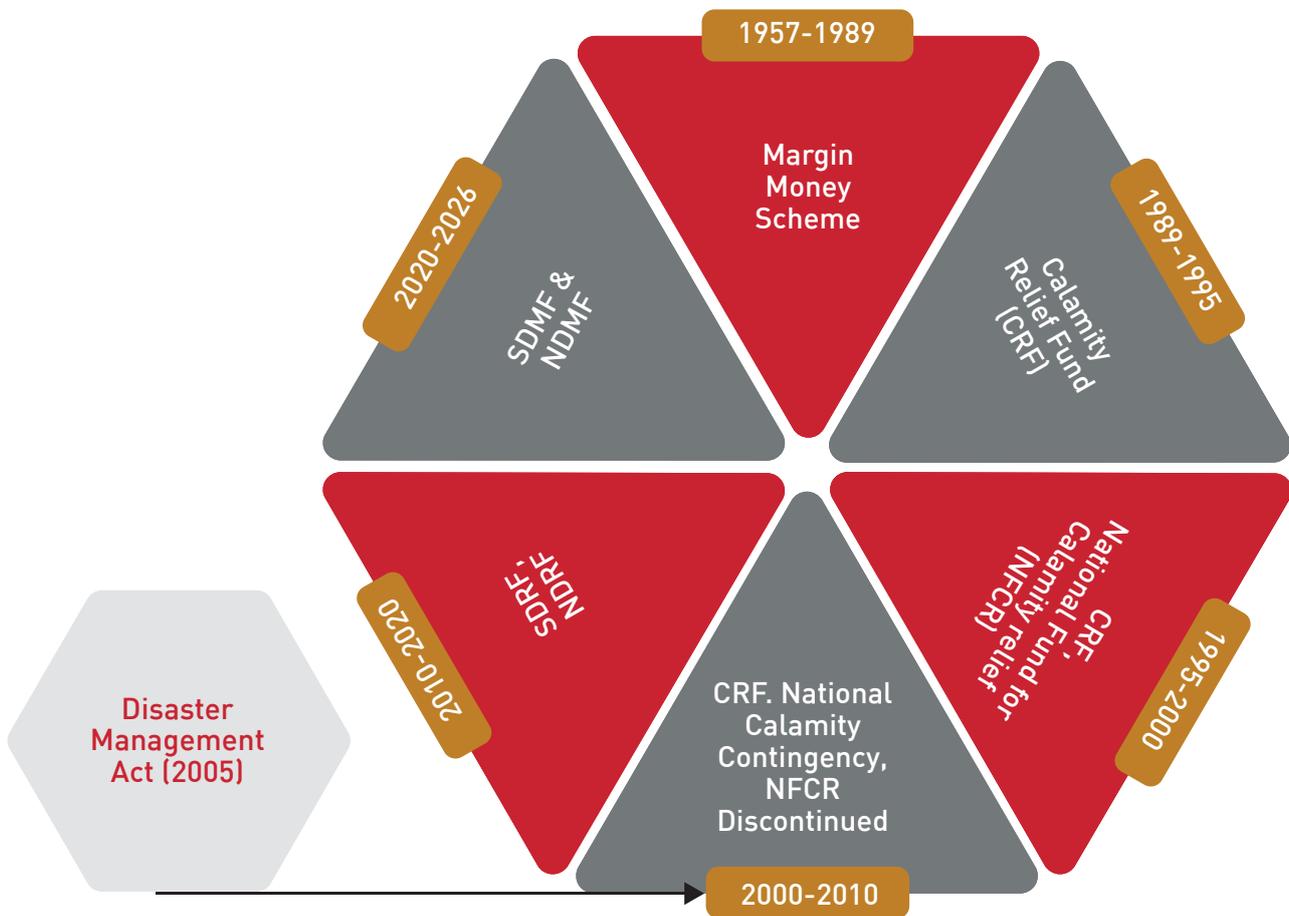
The allocation to NDRF and SDRF is determined based on the recommendations of the Finance Commission. This commission reviews these funding arrangements every five years, providing an opportunity for making interventions to introduce innovations in the funding arrangements and improve the efficiency and equity of disaster management funds.

Successive finance commissions have followed an 'expenditure-based approach' to determine the allocation of funds for disaster management to state governments. However, this approach had the limitation of only considering past expenditures made on disasters when deciding the allocation. As a result, significant factors were amiss regarding the rapidly changing risk, vulnerability and hazard scenario.

In a significant departure from the past, the report of the 15th Finance Commission for 2020/21 recommended a new methodology for determining state-wise allocation for disaster management (refer to Figure 2.3). This methodology combines three key factors: the capacity (as reflected through past expenditure), risk exposure (area and population), and hazard and vulnerability (disaster risk index).



Figure 2.3 Evolution of Disaster Risk Financing in India



Source: 15th Finance Commission Report

Infrastructure investment and resilience in disaster risk reduction (DRR) are part of the structural measures mentioned in the National Disaster Management Plan (NDMP) 2019. Infrastructure comprises various physical infrastructure and facilities required to help communities cope with disasters.

The Indian Power Sector Disaster Management Plan 2021, prepared by the Central Electricity Authority (CEA), mentions that CEA's regulations concerning safety requirement for construction, operation, and maintenance of electrical plants and electric lines. These regulations aim to avert or minimize damages that any disaster situation may cause.



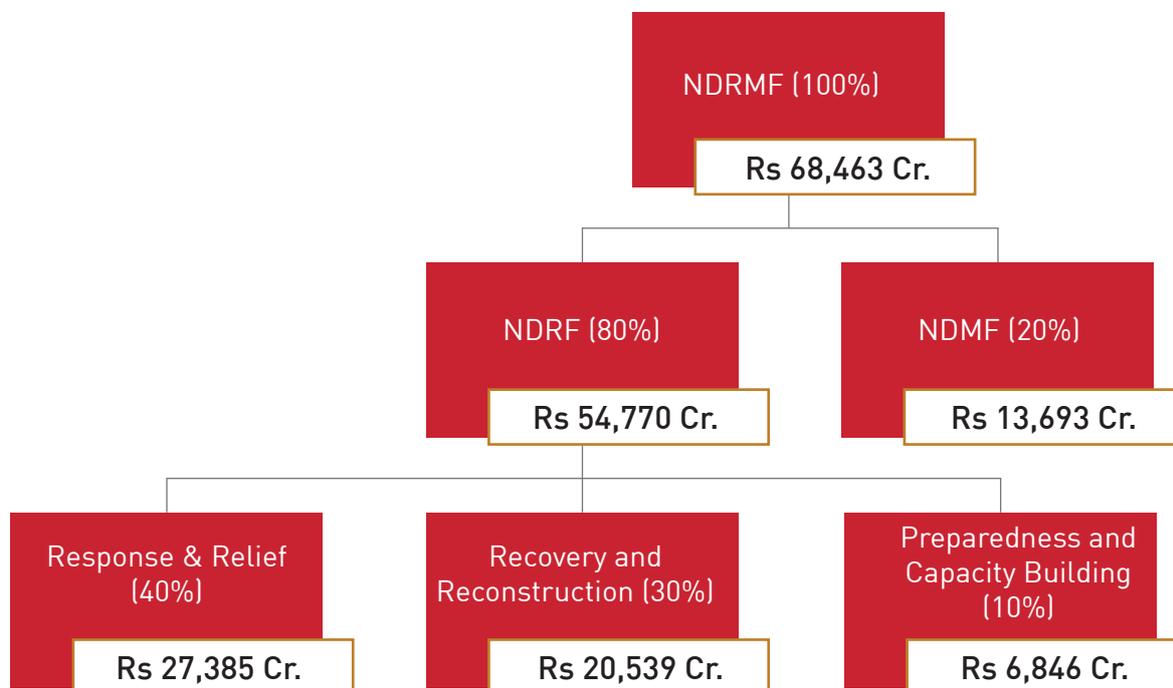
2.1.3 National Disaster Risk Management Fund/State Disaster Risk Management Fund

The Disaster Management Act stipulates two primary funding mechanisms at the national level: the NDRF and the National Disaster Mitigation Fund (NDMF). According to the recommendations of the 15th Finance Commission, the NDRMF has been established, which includes two types of funding for disaster financing: NDRF and NDMF.

The NDRMF allocation is segregated among NDRF and NDMF in an 80:20 ratio. The NDRF allocation is further divided into response and relief (40%), recovery and reconstruction (30%), and preparedness and capacity building (10%).

The 15th Finance Commission has submitted a detailed methodology for allocating funds to states for disaster management. This methodology combines factors such as capacity (as reflected through past expenditure), risk exposure (area and population), and hazard and vulnerability index. As per the 15th Finance Commission Report on Disaster Risk Methodology, Odisha has received a score of 0.90 out of 1. The Ministry of Finance, the Ministry of Home Affairs, and the NDMA may lead a review of the allocations and expenditures against indicators developed for implementing State Finance Disaster Risk Management determined by the NDMA (refer to Figure 2.4).

Figure 2.4: Earmarked funds for NDRMF as per 15th Finance Commission (2021-26)



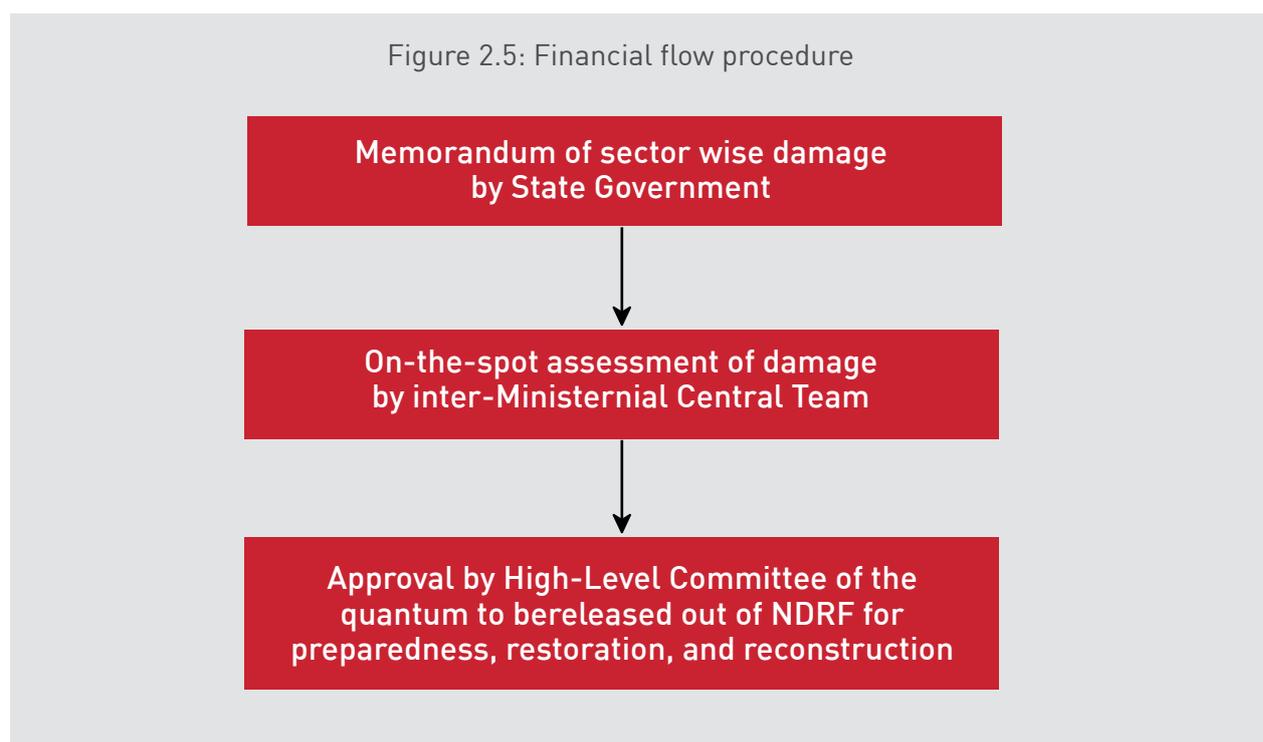


2.1.4 National Disaster Response Fund

The state government is the primary institution responsible for disaster response, recovery and rehabilitation during a disaster. During the calamity, if funds required for relief operations exceed the SDRF, additional funds can be requisitioned from the NDRF as per the procedure.

2.1.4.1 Process

As per the procedure, the state government must submit a memorandum detailing the sector-wise damage and funding requirements. Upon receiving the memorandum from the state, an inter-ministerial central team is formed and deputed for an on-the-spot assessment of damage and the condition of funds for relief operations, as per the extant items and norms of the SDRF and NDRF. After examination, a high-level committee approves only the quantum of immediate relief to be released from the NDRF to provide financial assistance for disaster relief and response (see to Figure 2.5).



Source: KPMG Internal Analysis

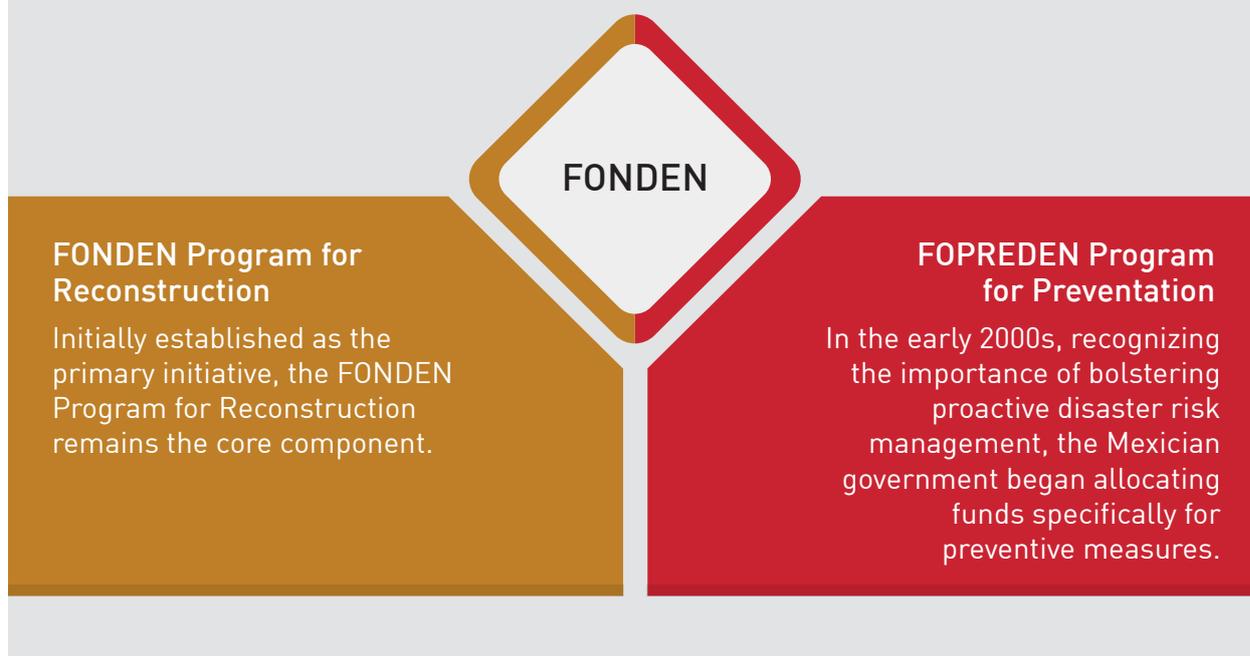


2.1.5 Addressing Disaster Risks: The Role and Operations of Mexico's FONDEN

FONDEN, Mexico's Fund for Natural Disasters, was established in the late 1990s to aid in the rapid recovery of federal and state infrastructure following adverse natural events. Initially included as a budget line in the Federal Expenditure Budget of 1996, it became operational in 1999. FONDEN's funds were allocated for the rehabilitation and reconstruction of various aspects of public infrastructure at federal, state and municipal levels. Additionally, it provides support for low-income housing and certain components of the natural environment like forestry, protected areas, rivers and lagoons (see Figure 2.6).

Mexico's diverse geography makes it susceptible to various geological and hydro-meteorological threats, including earthquakes, volcanoes, tsunamis, hurricanes, wildfires, floods, landslides and droughts. From 1970 to 2009, around 60 million people in Mexico were affected by natural disasters. The nation is categorized among the world's 30 most vulnerable countries to three or more types of natural hazards. Despite Mexico's economic progress, which has improved the standard of living for its inhabitants, the expansion of its asset base and population leads to heightened vulnerability to these natural calamities.

Figure 2.6: FONDEN's complementary budget accounts





Although resources allocated for prevention are notably less than those for reconstruction, the government persistently endeavours to redirect focus and funding towards proactive disaster risk management instead of reactive response measures. BANOBRAS, Mexico's state-owned development bank, holds fiduciary responsibility for managing the financial accounts.

FONDEN's funding is sourced from the Federal Expenditure Budget, as mandated by the Federal Budget Law, ensuring that no less than 0.4 percent of the annual federal budget is allocated to FONDEN, FOPREDEN and the Agricultural Fund for Natural Disasters at the beginning of each fiscal year. This allocation is adjusted based on the uncommitted funds from the previous fiscal year. Typically, this minimum allocation of 0.4 percent, amounting to approximately US\$ 800 million in 2011, is the standard budget appropriation for these programmes. If deemed insufficient, the law requires additional resources to be transferred from other programmes, such as the surplus from oil revenue.

The primary budget account of FONDEN is the 'FONDEN Program for Reconstruction', which allocates funds from the Federal Expenditure Budget to specific reconstruction initiatives. Following a disaster, funds earmarked for reconstruction are transferred to dedicated sub-accounts within the FONDEN Trust for execution. The FONDEN Trust manages these resources until reconstruction projects are underway and disburses payments for reconstruction services to implementing entities. Additionally, it oversees market-based risk transfer mechanisms, including insurance and catastrophe bonds, through BANOBRAS. Various sub-accounts, such as those for emergency relief, recovery actions and priority reconstruction activities, have been established over the years to address different post-disaster needs.

Moreover, FONDEN aims to ensure that reconstruction efforts do not perpetuate vulnerabilities. Therefore, funding can be utilized to reconstruct infrastructure to higher standards, following the 'Build Back Better' principle, and to relocate public buildings and communities to safer areas.

Collaborating closely with the Ministry of Finance and Public Credit, FONDEN has established a robust connection between its technical and financial arms for disaster management. The National Centre for Disaster Prevention (CENAPRED) is the technical arm for disaster risk reduction and collaborates closely with FONDEN. An example of this collaboration is the development and utilization of R-FONDEN, a probabilistic catastrophe risk model that calculates risk metrics for government assets and low-income housing against major perils.

In conclusion, state funds outside the US, such as Mexico's FONDEN, use CAT bonds differently than their US counterparts. Their goal is not to ensure a functioning insurance market but to provide immediate funds for disaster recovery following a disaster event⁷.

⁷<https://www.chicagofed.org/publications/chicago-fed-letter/2018/405>
https://www.gfdrr.org/sites/default/files/publication/FONDEN_paper_M4.pdf



2.2 State Disaster Risk Management Fund

In a significant departure from the earlier Finance Commissions, the 15th Finance Commission recommended two funds with the SDRMF nomenclature. SDRMF will consist of two components viz. SDRF and State Disaster Mitigation Fund (SDMF) will have 80 percent and 20 percent allocations, respectively. Together, SDRMF and NDRMF will cover the entire disaster management cycle, including prevention, preparedness, response, mitigation, recovery and reconstruction (Ministry of Home Affairs).

2.2.1 State Disaster Response Fund

SDRF is a financial resource that meets the expenses of disaster relief operations and restoration of critical infrastructure (power) for a range of specified disasters. The SDRF is constituted in each state with funding from the central and state governments. As per the 15th Finance Commission, the contribution to the SDRF is recommended as 25 percent state share and 75 percent central share until the stabilization of GST implementation. After this stabilization, the funding distribution will change to 10 percent from the state and 90 percent from the central.

2.2.1.1 Process

As per Section 20 of the Disaster Management Act, the financing of relief measures under SDRF is determined by the State Executive Committee (SEC). In the case of Odisha, the SEC is part of the Odisha State Disaster Management Authority under the Special Relief Commissioner's responsibilities.



3

Exposure Assessment for Risk Analysis in Odisha





3 Exposure Assessment for Risk Analysis in Odisha

The risk identification and estimation component evaluates the vulnerability and risk levels of power infrastructure caused by hazards, particularly cyclones and flooding. **The objectives include creating hazard zonation maps, assessing exposure, vulnerability and potential risk to power infrastructure, prioritizing critical assets, identifying gaps in data and information for building power sector resilience and providing recommendations for enhanced risk identification.** Hence, financial preparedness is required to improve resilience in both structural and non- structural measures.

The energy sector encompasses a range of subsystems from power generation to transmission and distribution. These subsystems within the energy infrastructure are vulnerable to disaster risk, which can be mitigated by implementing suitable standards and financial adaptations.

Exposure assessment is defined as a qualitative and quantitative approach to estimating the nature and extent of disaster risk. This involves analysing potential hazards and evaluating prevailing conditions of exposure and vulnerability that could harm people, infrastructure, services, livelihoods and the environment on which they depend (UNDRR).

3.1 Risks Faced by Odisha Power Sector Infrastructure

Odisha does not have a separate allocation for recovery and reconstruction. As a result, funds allocated for regular development work are redirected towards reconstruction efforts. This hampers development work and suggests that the department cannot account for how much it spends yearly on recovery and reconstruction after every disaster impact. Given its vulnerability to hazards such as cyclones and floods, Odisha frequently experiences significant structural damage, specifically in the power sector (Annexure A4), and economic loss due to infrastructure damage (Annexure A5).

The report titled ***The Damage, Loss and Needs Assessment (DLNA) for Cyclone Fani in Odisha⁸ was made possible due to the collaborative efforts of the Government of Odisha, the Odisha State*** Disaster Management Authority (OSDMA), the United Nations agencies, the World Bank and the Asian Development Bank. The report several issues observed during the reconstruction of the power network in Odisha, which could potentially increase the risks to the network in future disaster events:

- 1 Steel poles, RCC poles and transformer structures are being erected in the same or nearby locations. By implementing appropriate measures, these poles or structures can be prevented from falling again, as the soil surrounding them may have become loose or may contain existing concrete.

⁸<https://ncrmp.gov.in/wp-content/uploads/2018/09/psc/Fani2019.pdf>



- 2 The span lengths between the new poles being erected will remain the same as earlier. Without prudently deciding the new span length, a structurally weak pole will fall on a nearby pole during strong winds. This might create a domino effect, worsening the damage and impacting the entire network instead of isolating structural issues to the damaged pole only.
- 3 Base plates are not being used as per standards, potentially weakening the structure and making it vulnerable to strong winds during cyclones.
- 4 A section of the steel pole in the ground is not being coated with epoxy, which may increase the risk of rust and damage the structural integrity of the poles.
- 5 The pits/foundation requirement will be backfilled with excavated soil without concrete being poured into the foundation or the backfilled soil being compacted. In case of heavy rains, wind, or the forthcoming southwest monsoon setting in early, this could lead to the backfilled soil not being able to support the poles or equipment, which could lead to significant damage.

3.2 Vulnerability Assessment Indicators

Tropical cyclones cause significant damage to structures and result in loss of life in coastal areas of Odisha. Cyclone micro-zonation is a step forward in identifying assets at cyclone risk. Cyclone zonation was prepared for different return periods (100, 50, 25 or 5 years) (Annexure A1). Odisha, being prone to cyclones, suffers infrastructure damage from the impact of cyclonic storms, majorly in the districts of Ganjam, Puri, Khurda, Jagatsinghpur, Cuttack and Kendrapada. Not all infrastructure exposed to disasters is equally vulnerable; some have a better adaptive capacity to cope with the impacts of cyclone/flood hazards than others. To accurately assess the losses incurred and determine the financial resources required, it is essential to determine the vulnerability based on the order of risk associated. Sixteen vulnerability assessment indicators (refer to Figure 3.1) were considered to evaluate the vulnerability of power infrastructure.





Figure 3.1: Vulnerability assessment indicators

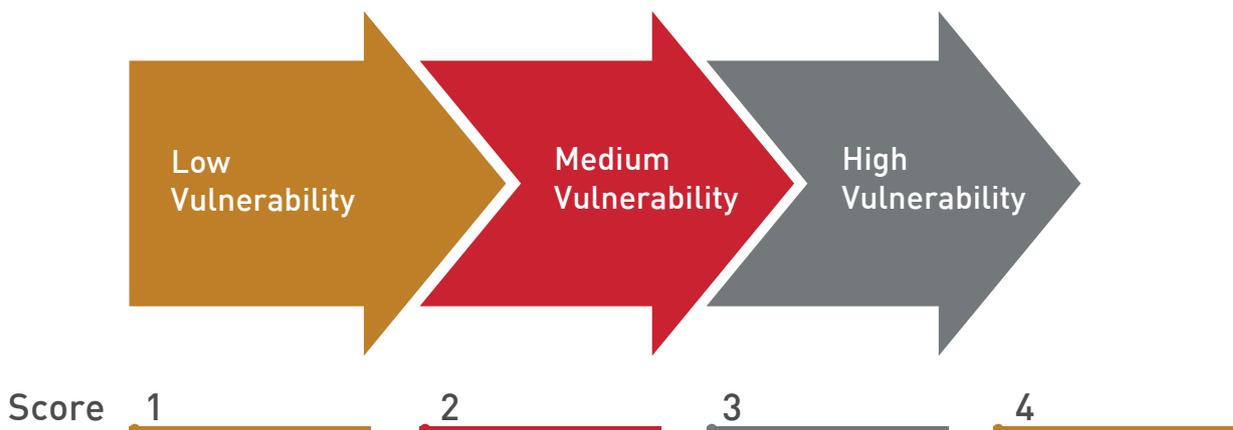
Distribution Primary sub Station (PSS)	Distribution-Lines	Transmission-Grid SS	Transmission-Lines
<ul style="list-style-type: none"> » Year of commissioning » Type of PSS » Building Standards/ codes/ Design Spec » Type of PSS power Supply Source 	<ul style="list-style-type: none"> » Year of commissioning » Type of supporting structures/poles » Span length » Failure history 	<ul style="list-style-type: none"> » Type of GSS » Year of commissioning » Failure History in past cyclones » Types of GSS power supply source 	<ul style="list-style-type: none"> » Year of commissioning » Type of circuit » Span length (m) » Failure History in past cyclones

Source: Report on Risk Identification and Estimation, CDRI

3.3 Methodology for Vulnerability Assessment

Different components, such as the composite vulnerability of distribution sub-station building standards/codes/design specifications, the type of power supply source (PSS), the type of supporting structures/poles, span length etc., were selected and assigned scores on a scale from 1 (low vulnerability) to 4 (high vulnerability) (see Figure 3.2). Based on the cumulative score, vulnerability was categorized as low, medium and high.

Figure 3.2: Vulnerability scorecard





Based on the Cyclone Zonation Map, the effect of cyclonic storms is felt mainly within the belt approximately 60 km from the coastline. Hence, infrastructure prioritization is based on the criticality/importance and vulnerability of the line/PSS, as it is not feasible to replace or renovate all the existing power components in the region owing to the significant capital investment and the potential for outages.

The criticality of the components is evaluated based on the following approaches:

- 1 Imposing power infrastructure on the developed wind and flood zonation maps (refer to Report 2: Risk Identification and Estimation)
- 2 All lines and PSS/GSS existing within 0-20 km, 20-60 km and above 60 km from the seacoast are identified from the maps (refer to Report 2: Risk Identification and Estimation).
- 3 Vulnerability level of lines and PSS.

During cyclones/floods, essential services like water supply, telecommunication service, health care service, transportation and rescue operations and district administrative buildings, are put at risk when there is a power outage. This can severely affect rescue operations. Therefore, it is essential to identify the critical power lines and respective substations feeding the power supply to these essential services. Accordingly, renovation or retrofitting is proposed per the new design and updated wind map.

Based on the components evaluated, the critical component was categorized into three categories based on PSS/GSS and critical lines:

- 1 Category 1: Feeding to essential services viz. medical, water supply pumping station, cyclone shelters (schools/colleges), food warehouse, district headquarters, police station, telecom towers, fire stations, railway stations, airport, bus stand, defence, etc.
- 2 Category 2: Based on loading (trunk lines).
- 3 Category 3: Based on the feeding arrangement of substations viz. radial or ring system (to meet N-1 contingency criteria).

Prioritization (based on vulnerability and criticality of power components) is done considering wind speed within the range of 0-20 km (high), 20-60 km (medium) and above 60 km (low) from the seacoast (see Table 3.1). It has been observed that almost 30 percent of the composite vulnerable electricity substations are located within 20 km of the seacoast.



Table 3.1 Prioritization Matrix

Prioritization Matrix			
Criticality	Vulnerability	Distance from seacoast	Priority
Yes	High	High	1
Yes	High	Medium	2
Yes	High	Low	3
Yes	Medium	High	2
Yes	Medium	Medium	3
Yes	Medium	Low	4
Yes	Low	High	3
Yes	Low	Medium	4
Yes	Low	Low	4
No	High	High	2
No	High	Medium	3
No	High	Low	4
No	Medium	High	3
No	Medium	Medium	4
No	Medium	Low	4
No	Low	High	3
No	Low	Medium	4
No	Low	Low	4

Source: Report on Risk Identification and Estimation (Table 21 Prioritization Matrix), CDRI

Prioritization (based on vulnerability and criticality of power components) is done considering wind speed within the range of 0-20 km (high), 20-60 km (medium) and above 60 km (low) from the seacoast (see Table 3.1). It has been observed that almost 30 percent of the composite vulnerable electricity substations are located within 20 km of the seacoast.



4

Power Sector: Insight to Financial Landscape





4 Power Sector: Insight to Financial Landscape

For the utilities, it has been recommended by the Disaster Management Plan for Power Sector 2021 that each power utility should create a fund to meet the requirements of the disaster management plan. The disaster management fund would be 1.5 percent of the utility's annual revenue. It is intended for immediate relief and rehabilitation, depending upon the revenue potential of the utility and will be replenished annually.

To facilitate restoration activities and post-disaster management, the power utilities can request funds from National Disaster Response Fund (NDRF) / State Disaster Response Fund (SDRF) to immediately repair damaged power infrastructure such as damaged conductors, poles and transformers up to 11 kV. ***Power utilities / state governments can mobilize funds for disaster response during/after a disaster by entering arrangements with financial institutions.*** The fund's mobilization can be made for specific activities under the Disaster Management Plan, such as project financing, disaster resilient infrastructure, upgrading technologies, etc. These efforts will assist in power infrastructure resilience during a disaster event.

4.1 Fund Mobilization: State-Level Overview

Reconstruction and rehabilitation projects following a major disaster in India are usually highly resource intensive. Most of these projects are typically financed through the state exchequer, along with funds from multilateral/bilateral funding agencies / international agencies in close coordination with the national government. Different accounting norms and standards are in place for mobilizing state and national funds (Annexure A3).

- 1 The state government, through the relevant ministry of the central government, will finalize the fund mobilization strategy. This strategy will incorporate appropriate conditions for the flow of funds, their disbursement and usage as per norms decided by the central government.
- 2 Estimation of funds required based on detailed damage assessment reports consolidated under sectoral and regional heads.
- 3 Establishing agreements with funding agencies and developing detailed operating procedures for fund flow and corresponding covenants.
- 4 The funds may be arranged from internal sources and external sources.
 - a **Domestic or internal sources:** The funding for disaster recovery typically comes from various government sources. This includes government operational and capital budgets, reallocation among the budget items to disaster-hit sectors, special levies or taxes, additional taxes or surcharges for recovery, contingency financing arrangements, issuing sovereign reconstruction or development bonds, introducing policy incentives for the private sector to share recovery costs, voluntary contributions from civil society and private philanthropies, insurance / risk transfer mechanisms, etc.

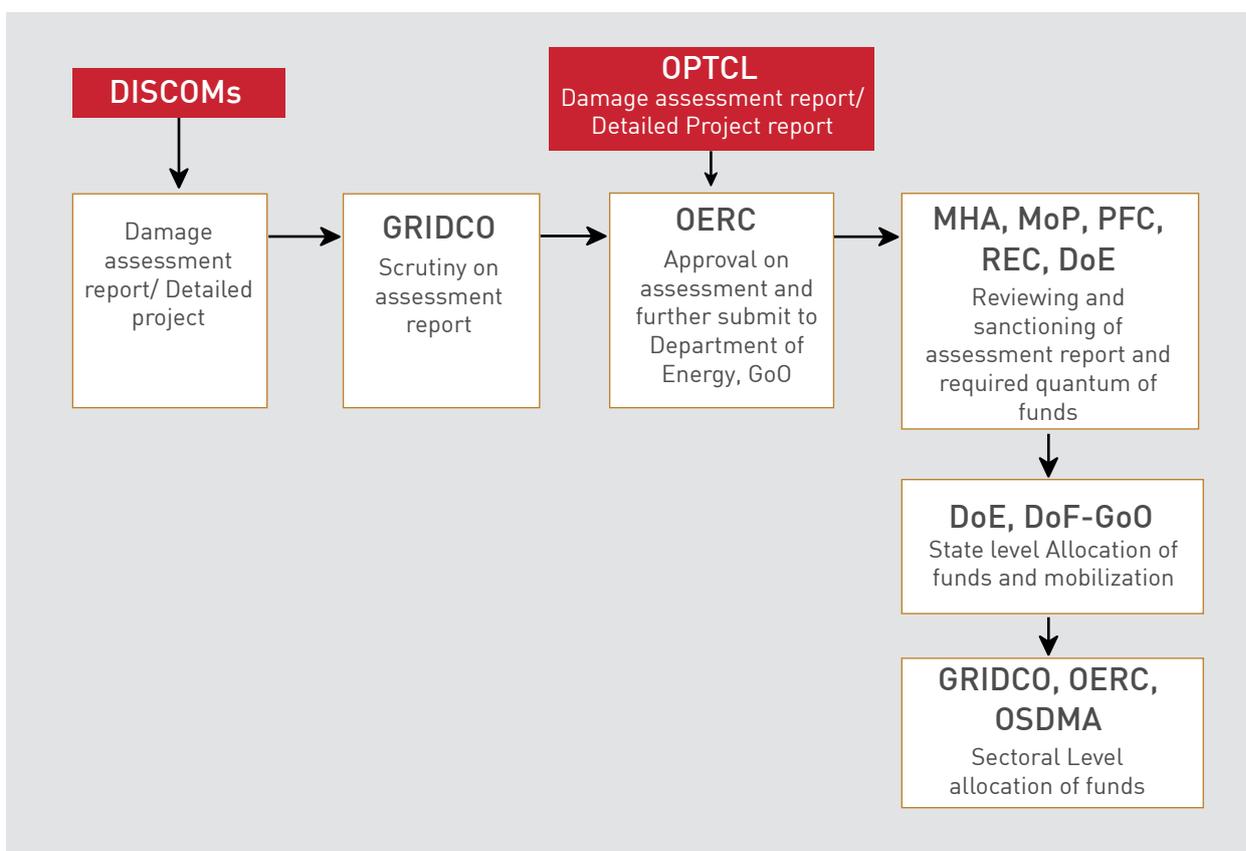


- b **External sources:** The fund for post-disaster reconstruction can also be sourced from external resources such as multilateral development banks, regional development banks, bilateral development partners and international organizations.
- c **NGOs, private philanthropies and charities, and remittances:** For the recovery of the reconstruction costs, the state government, in consultation with the relevant central government ministry, can finalize and implement select cost recovery measures. These measures may include imposing special tax/surcharge by the central government, imposing local taxes and issuing tax-free government bonds, among others.

4.2 Preview of Odisha State Finance Mechanism

During a disaster, the various heads of departments need more financial power to meet the multiple contingencies, and enhancement of financial capabilities/impressive money shall be available for the disturbance period. Arrangements should be made to secure adequate financial resources so that the restoration activities are not hampered because of a shortage of funds.

Figure 4.1: Disaster financial landscape of Odisha power sector



Source: KPMG Internal Analysis



Each power utility must establish a fund to support a disaster management plan (see Figure 4.1). The disaster management fund will be set at 1.5 percent of the utility's annual revenue. Additionally, every utility should maintain a core corpus sufficient for immediate relief and rehabilitation, which will vary based on the utility's revenue potential. This core corpus must be replenished annually (CDMP, 2022, MoP, Gol).

4.3 Resilient Infrastructure PPPs: Optimizing Disaster Risk Management and Insurance Strategies

Disaster risk financing, including insurance, is poised to become increasingly vital in the future of infrastructure public-private partnerships (PPPs). Drawing from experiences in various regions, such as Canada and Kenya, where insurance industries have addressed climate risks, underscores the importance of collaboration among financiers, governments and insurers in designing effective disaster risk financing tools.

Incentive structures can motivate private partners to respond effectively to disasters. For instance, maintaining or swiftly restoring services can lead to reduced payment deductions or additional incentivization measures. The contracting authority can enforce inspection rights and reporting obligations to ensure compliance with design requirements and disaster recovery obligations. Deductions from payments for below-specification measures can further incentivize private partners to fulfil their obligations. Additionally, lenders also emphasize the importance of satisfactory measures to meet contractual obligations.

Insurance is integral to managing climate change risks. The contracting authority should consider the availability and cost of insurance when allocating such risks to private partners. While requiring relevant insurance, if available, may increase contract costs, it could ultimately offer better value for the contracting authority. Furthermore, it may exclude costs resulting from insured events from compensation under force majeure provisions.

In Japan, previous disaster events have influenced the definition of force majeure in PPP projects. The private sector's involvement in certain events has led to faster and more efficient responses than relying solely on the public sector. This underscores the importance of disaster response planning in the private sector.

Countries with established national disaster risk management (DRM) frameworks and historical disaster data can make more informed decisions about disaster risk allocation and force majeure definitions. They can utilize probabilistic risk estimations to tailor Force majeure definitions, specify event severity thresholds, and transfer risks effectively via insurance. In contrast, countries with limited data can still identify relevant disaster risks, establish guiding principles for risk allocation and set general terms for government intervention or relief in force majeure events.



Given the uncertainties associated with climate change, PPPs may benefit from planned adjustment periods to negotiate contract adjustments in response to changing environmental conditions. This approach ensures that PPP contractual arrangements remain adaptable and effective in delivering impactful solutions for transmission and distribution (T&D) infrastructure in the power sector⁹.

Box 4.1: Odisha Power Sector Improvement Projects (OPSIP), 2014-15, Odisha Government

Due to Cyclone Phailin, southern Odisha faced significant damage to its energy infrastructure, particularly the distribution and transmission network. The destruction in the energy sector amounted to approximately INR 1,000.00 crores.

The state government developed new schemes and projects to ensure a reliable and uninterrupted power supply for consumers. This initiative involves adopting ultra-modern technology, creating new and renovating the existing infrastructure, and granting budgetary provision of INR 55.03 crores in the Plan Budget 2014-15.

This umbrella scheme aims to build up a robust energy infrastructure to combat calamities and disaster events. Several projects/sub-projects and the flexibility in fund allocation under different projects and sub-projects are anticipated as below.

- 1 Radial to Ring Conversion Project
- 2 Disaster Response Centre
- 3 Disaster Resilient Power System
- 4 District Headquarter Projects

⁹https://ppp.worldbank.org/public-private-partnership/sites/ppp.worldbank.org/files/2021-03/Guidance%20on%20PPP%20Contractual%20Provisions_2019%20edition.pdf

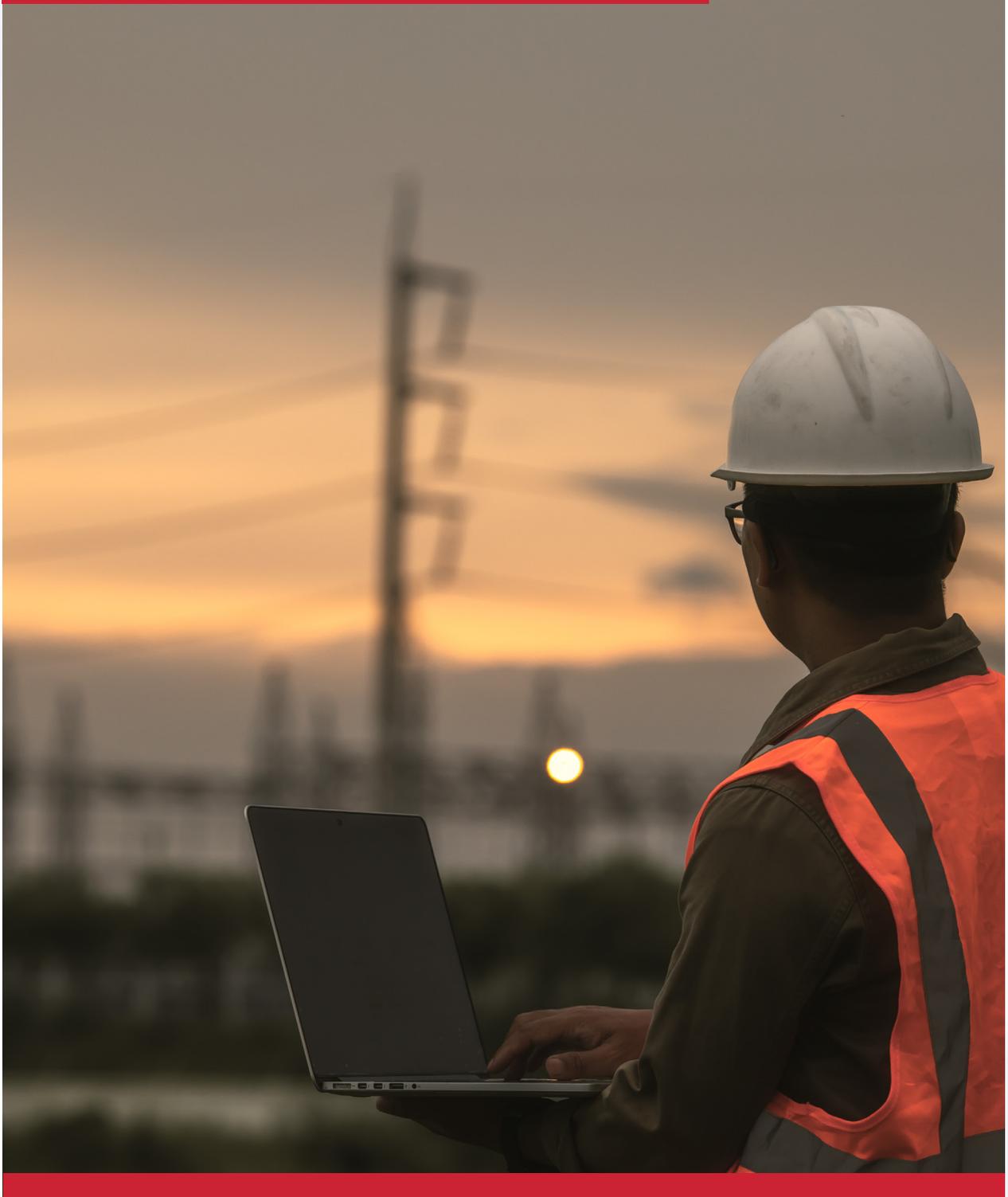
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<https://documents1.worldbank.org/curated/en/925691571416771609/pdf/Technical-Brief-on-Resilient-Infrastructure-Public-Private-Partnerships-Policy-Contracting-and-Finance.pdf>



5

Institutional Mechanism





5 Institutional Mechanism

5.1 National Level

At the national level, the Ministry of Power is supported by a plethora of organizations that handle various aspects of policymaking. This includes creating standards, design, and operation of generation and transmission and distribution (T&D) infrastructure, financing, manufacturing (private sector), research, capacity building and training, and legal and environmental protection. Each state and sector should develop risk financing strategies based on capacity, risk appetite, resources and readiness to manage risk.

Resilience depends on developing or sustaining the laws, regulations and guidelines that require utilities to apply appropriate safety standards to resilient power facilities in the installation/construction phase and during regular maintenance and operation. Hence, a proper mechanism that considers the estimated risk, various strengthening of components (structural and non-structural), governance and capacity building, and resilience financing must be developed to reduce the losses incurred.

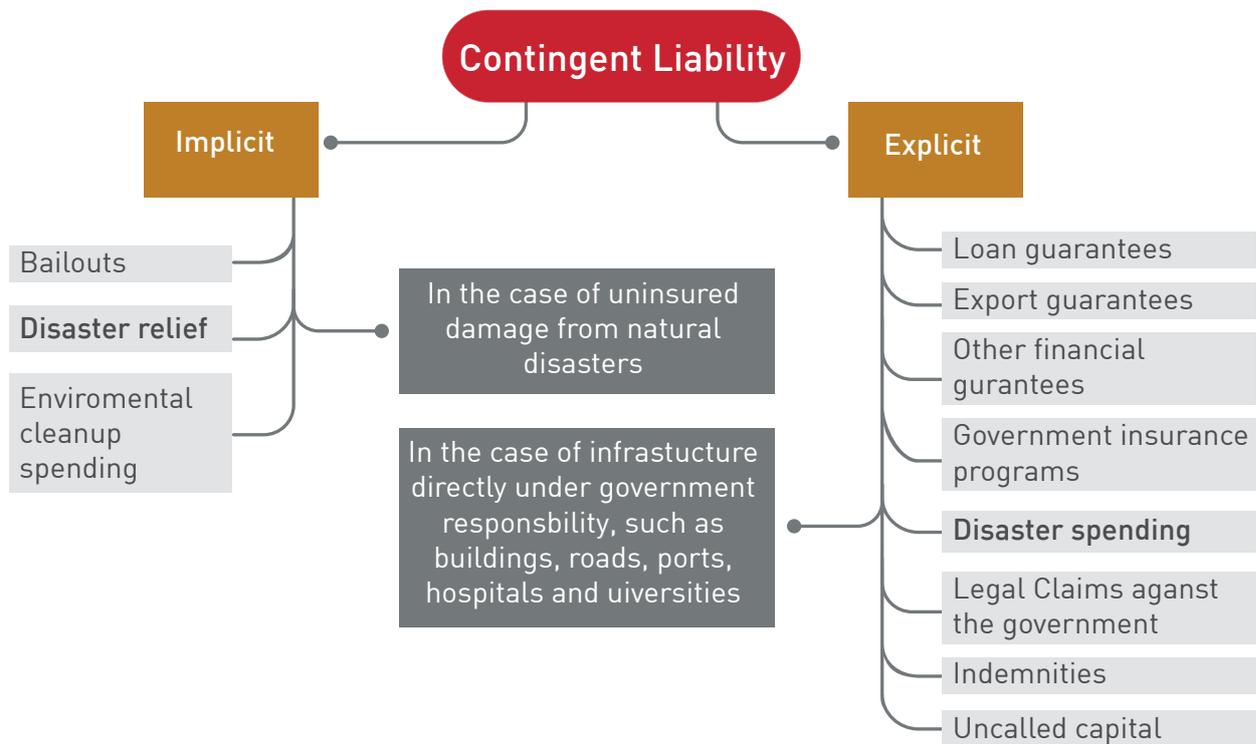
5.1.1 Disaster Resilience through Risk Allocation in Public-Private Partnerships

The recognition and management of contingent liabilities play a vital role in ensuring disaster-resilient infrastructure and financial preparedness. By examining these aspects, valuable insights and lessons can be drawn, particularly in the context of the power sector. Contingent liabilities may manifest in explicit or implicit forms (refer to Figure 5.1). Explicit contingent liabilities stem from contracts, legal obligations, or clearly defined policy commitments, typically arising from intentional decisions made by the government. On the contrary, implicit contingent liabilities arise from political or moral imperatives. These obligations often emerge from the anticipation of government intervention during crises or disasters or when the perceived cost of not intervening is deemed unacceptable.





Figure 5.1: Types of contingent liabilities



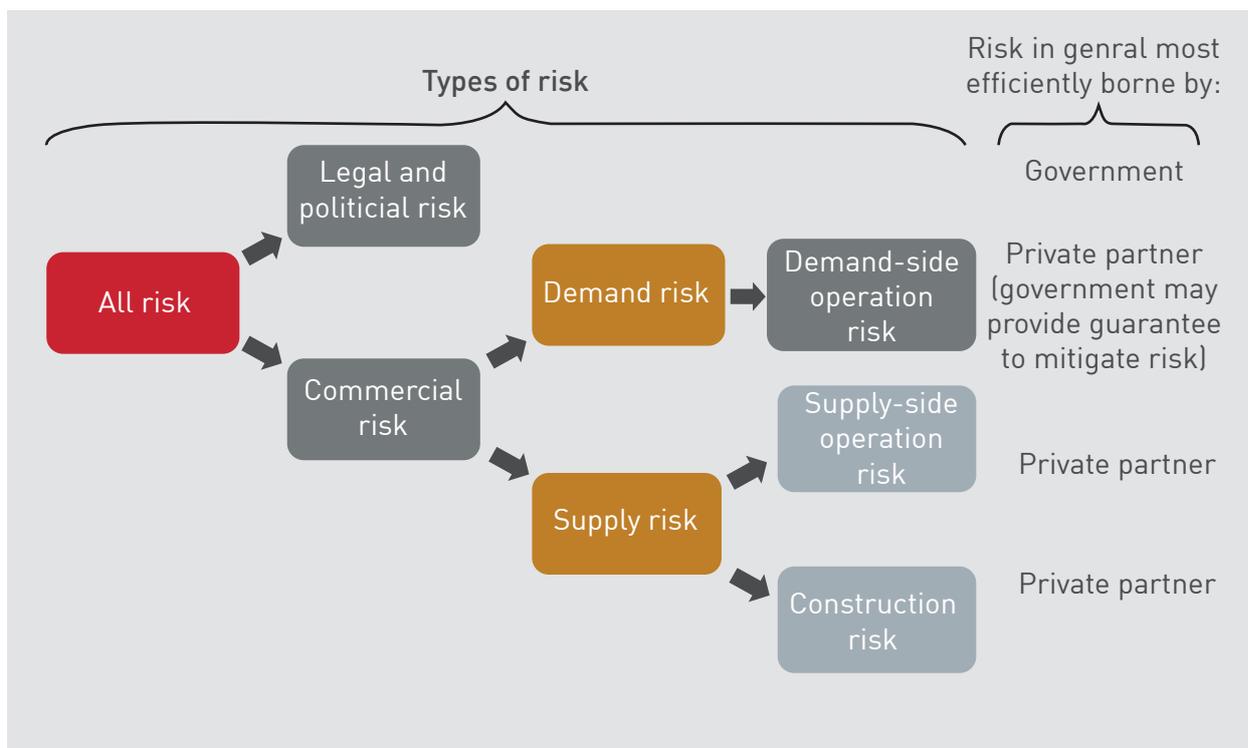
Source: IMF Working Paper, 2008

While there may be justifications for governments to undertake contingent liabilities, such actions should only be deemed appropriate if their advantages surpass the drawbacks and represent the most efficient approach towards achieving a particular objective. As with any decision involving the allocation of public funds, the decision to assume fiscal risks through contingent liabilities should be based on a thorough cost-benefit analysis

This analysis entails determining whether assuming the liability yields net benefits—both social and monetary—and whether these benefits outweigh those of alternative proposals. For instance, when contemplating the provision of state flood insurance, the costs associated with providing such insurance should be weighed against the benefits of avoiding extensive disaster relief expenditures. In situations where not all costs and benefits can be quantified monetarily, alternative assessment methods such as cost-effectiveness analysis should be employed. This approach compares the costs of various methods of achieving the same objective and selects the one with the least expense.



Figure 5.2: Hypothetical allocation of typical infrastructure PPP project risks



Source: OECD, 2008

In the realm of institutional analysis, a fundamental principle guiding risk-taking decisions is to allocate risks to those who are best equipped to manage them and for whom mitigating these risks is least burdensome. This approach aims to mitigate moral hazard by incentivizing risk-mitigation efforts among those with the capacity to do so. In the context of public-private partnerships (PPP) projects, where risk transfer is integral, this principle typically entails assigning project-specific risks—such as construction, operational and design/technical risks—to the private sector, which is often better equipped to manage them (see Figure 5.2). Conversely, governments commonly assume economy-wide risks, including force majeure, regulatory and political risks. However, risk distribution is often tailored to the unique characteristics of each project.

In situations where neither the public nor the private partner possesses a clear advantage in managing specific risks—such as demand, financing and project default risks—countries have adopted varying approaches to their allocation. Some projects have fully transferred demand risk to the private partner, leading to subsequent costly renegotiations in cases such as toll and shadow toll road concessions in Europe. In other instances, governments have retained demand risk, sometimes resulting in costly outcomes for the public sector, as seen in Colombia.

Increasingly, PPP arrangements involve shared responsibility for demand risk between the public and private sectors, as observed in countries like Chile, Colombia and South Korea.



In conclusion, PPP holds significant potential for advancing disaster-resilient infrastructure goals, particularly for transmission and distribution assets in the power sector in India¹⁰.

5.2 State Level

For a long time, Odisha has been prone to disaster events, with floods, droughts and cyclones occurring regularly in the state. In the past 50 years, Odisha has witnessed more than 17 floods and over 8 cyclones (Figure 5.3). Due to these events, the power infrastructure in Odisha has suffered considerable impacts, translating into massive damages and losses, especially in the highly vulnerable coastal belt.



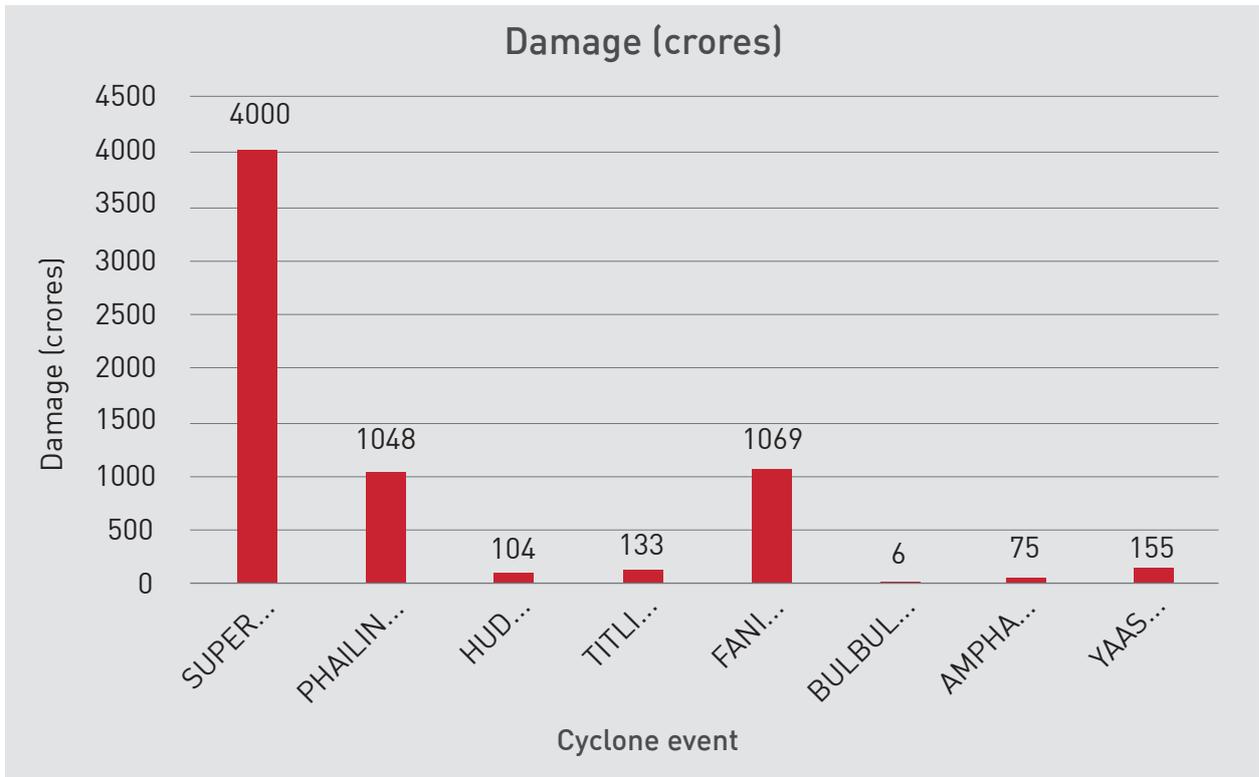
¹⁰https://ppp.worldbank.org/public-private-partnership/sites/ppp.worldbank.org/files/2021-03/Guidance%20on%20PPP%20Contractual%20Provisions_2019%20edition.pdf

<https://deliverypdf.ssrn.com/delivery.php?ID=014117064098124091067097029071006069025020066018053053081028030055097054020127015064003095066053032049102071003005108001089000093119086002072120123104103126073109096099084073081113&EXT=pdf&INDEX=TRUE>

<https://documents1.worldbank.org/curated/en/925691571416771609/pdf/Technical-Brief-on-Resilient-Infrastructure-Public-Private-Partnerships-Policy-Contracting-and-Finance.pdf>

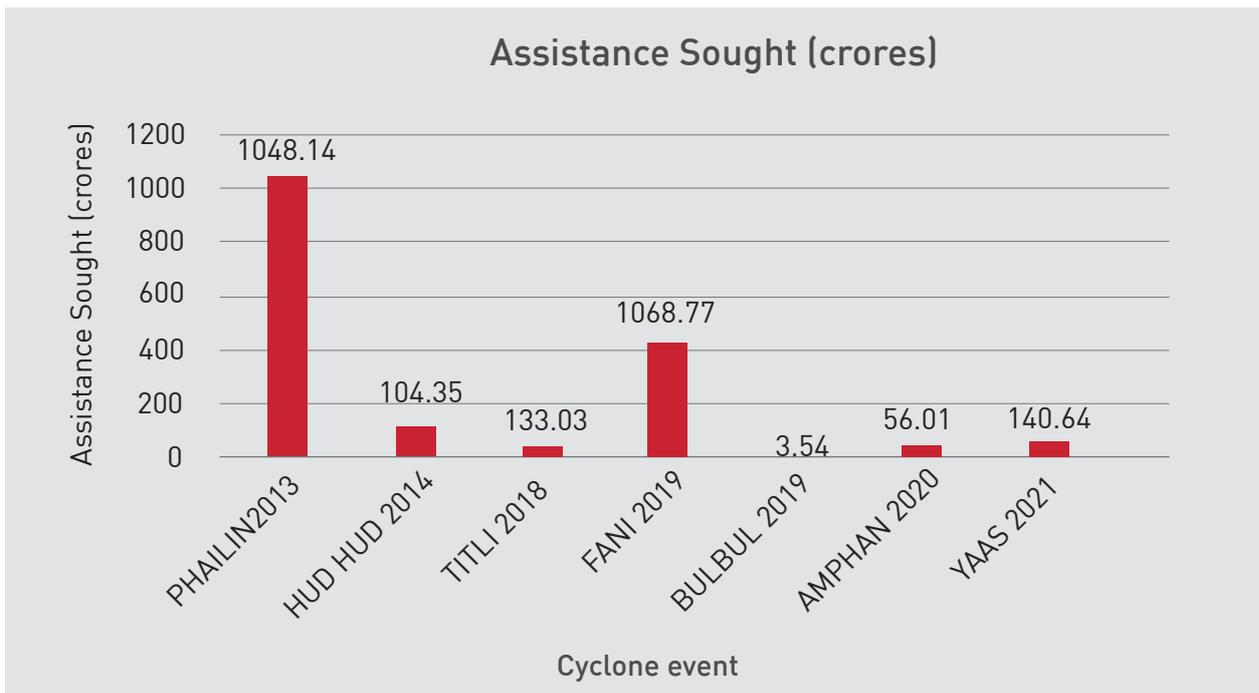


Figure 5.3: Economic damages to Odisha power sector by cyclones



To build resilient infrastructure, it is essential that specific policy, institutional, design and financial considerations are incorporated in the reconstruction plans of the Energy Department of Odisha (see Figure 5.4).

Figure 5.4: Assistance sought repair and restoration of power infrastructure





Multiple projects have been initiated in the aftermath of cyclones to assess the needs of the power sector for resilient recovery and reconstruction. One significant project was undertaken after Cyclone Fani by the Government of Odisha in collaboration with the World Bank, the Asian Development Bank and the United Nations. This project involved a detailed assessment of the damage and recovery needs in the power sector.¹¹ As part of this initiative, three recovery and reconstruction options were put forward, varying with respect to the level of design changes adopted.

Table 5.1: Recovery needs for a resilient network - Cost estimate based on analysis in the report 'The Damage, Loss and Needs Assessment (DLNA) for Cyclone Fani in Odisha'

Option 1		Option 2		Option 3	
Existing system with improved specifications and quality control		Existing system with improved specifications but with spun poles and quality control H-poles along with improved specifications and quality control		Complete system, using an underground cable network along with improved specifications and quality control	
Total cost in INR (crores)	Total cost in US\$ (millions)	Total cost in INR (crores)	Total cost in US\$ (millions)	Total cost in INR (crores)	Total cost in US\$ (millions)
9,747.7	1,392.5	11,356.8	1,622.4	25,920.2	3,702.9

Source: Cyclone Fani: Damage, Loss and Needs Assessment Report

5.2.1 Institutional Arrangement in Odisha - Reconstruction Activities

The Government of Odisha took the lead in acknowledging the need for an institutional structure to tackle the disaster-related risks faced by the state. In response, it established the Odisha State Disaster Management Authority (OSDMA) right after the Super Cyclone in 1999. Furthermore, Odisha has integrated an institutional arrangement to structure reconstruction activities in the state.

In the Odisha State Disaster Management Plan (DMP), it is stated that state government departments are responsible for carrying out relief, reconstruction and rehabilitation activities. These efforts are supervised by the Office of Special Relief Commissioner (SRC) at the state level and the collector at the district level. The SRC coordinates with districts/departments to ensure timely relief and rescue operations, as well as effective reconstruction and rehabilitation efforts. The OSDMA is mandated to take up mitigation activities, relief, restoration, reconstruction and other measures. OSDMA is responsible for facilitating coordination with the line departments involved in reconstruction. Additionally, the district administration is tasked with managing post-disaster rehabilitation and reconstruction activities by coordinating with district-level line departments. A selection of case studies can be found in Annexure A6.

¹¹<https://ncrmp.gov.in/wp-content/uploads/2018/09/psc/Fani2019.pdf>



5.2.2 Cyclone Resilient Power Infrastructure: Distribution

The Government of Odisha advised the following measures in the aftermath of Cyclone Amphan to increase the resilience of reconstruction of distribution infrastructure to cyclone¹²:

- 1 Upgrading poles and structures:** The most common practice for cyclone resilience is replacing the utility poles with poles made of galvanized steel, concrete, or composite materials. Additionally, upgrading transmission and distribution (T&D) towers to galvanized steel lattice is also common. Increasing the number of poles per kilometre of the line is another adopted measure. Such measures aim to strengthen poles, towers, or other structures to withstand windstorms, including cyclones. Structural designs of such poles and towers have been developed accordingly.
- 2 Changes in distribution system design:** The power distribution system can become more resilient with existing network changes. It may be advantageous to divide the extensive network into smaller circuits and to re-examine the circuit arrangements to enhance the speed of repair. This also improves the reliability of the supply system.
- 3 Conversion of overhead lines to underground cabling system:** Placing utility lines underground eliminates their susceptibility to lightning and wind damage. The strategy is to limit the overhead network to non-coastal areas and use underground cables in most coastal areas.
- 4 Elevating substations and control rooms:** Renovation of existing substation switchyards and making them cyclone-resilient is also one of the prime objectives. Outdoor structures need to be strengthened with resilient structures and equipment. The most prevalent cause of damage to substations is flooding from storm surges and rains; therefore, standard practice is elevating substations. This reduces the supply disruption and facilitates supply restoration immediately after the flood. A defined flood level (DFL) has been considered while providing structural designs for elevating substations.
- 5 Acquiring mobile T&D equipment, special tools and tackles:** Mobile transformers and substations can temporarily replace substation transformers damaged by a cyclone in the low and medium power range. For example, day-to-day operations at a substation are much more difficult when the entire apparatus is raised off the ground. For situations like these, risk can be mitigated by acquiring/arranging spare equipment and materials in advance so that they are prepared to make rapid repairs when a cyclone occurs.

¹²https://www.srcodisha.nic.in/calamity/Memorandum_Cyclone%20FANI_3rd%20May%202019.pdf



- 6 **SCADA/DMS:** Electric utilities rely on SCADA systems to monitor and control their T&D grid. These systems operate continuously and play a key role in cyclone response and recovery by enabling utility controllers to identify damaged assets and dispatch repair crews quickly and efficiently. Substation automation uses computer-based control and monitoring technology to create highly reliable, self-healing power systems that rapidly respond to real-time events. They can work independently or in combination with SCADA systems.
- 7 **Renewable generation:** Renewable generation in the form of solar PV power generation, when located near the load, is an attractive option, especially when these sources are scarce in the area.

5.2.3 Cyclone Resilient Power Infrastructure: Transmission

To ensure the reconstruction of resilient power systems and transmission networks capable of withstanding high wind speeds and significant variations, the recommended approaches initially proposed in the aftermath of Cyclone Amphan¹³ for recovery could be adopted:

- 1 An immediate approach to using existing design systems with proper foundations and reduced spans. This may be cost-efficient, but it might not last long.
- 2 Gradual changeover of transmission lines with the same right of way (ROW) for vulnerable disaster areas, stable towers/monopoles and smaller spans to withstand wind speeds up to 250 kmph.
- 3 The availability of materials and advanced positioning of men and materials at strategic locations resulted in a quick restoration of electricity supply to the consumers during Cyclone Amphan. From the above experience, it is clear that restoring electricity supply in the affected areas in the shortest possible time with the existing infrastructure needs an emergency stock of materials to meet future contingencies. Based on the material's experience and requirement for a quick restoration start, the estimated requirement of materials and funds are proposed.
- 4 The tentative estimate for disaster resilient transmission system (OPTCL) conversion of the old system to a resilient transmission system 132 kV and above system is given in Table 5.1.

Table 5.2: Tentative Estimate for Disaster Resilient Transmission System

S. No	Lines	Qty	Rate (Cr)	Amount (Cr)
1	132 kV with lattice towers	900	1.3	1170
2	220 kV with lattice towers	350	1.7	595
	Total cost			1765

¹³Detailed information not available



6

Probabilistic Risk analysis





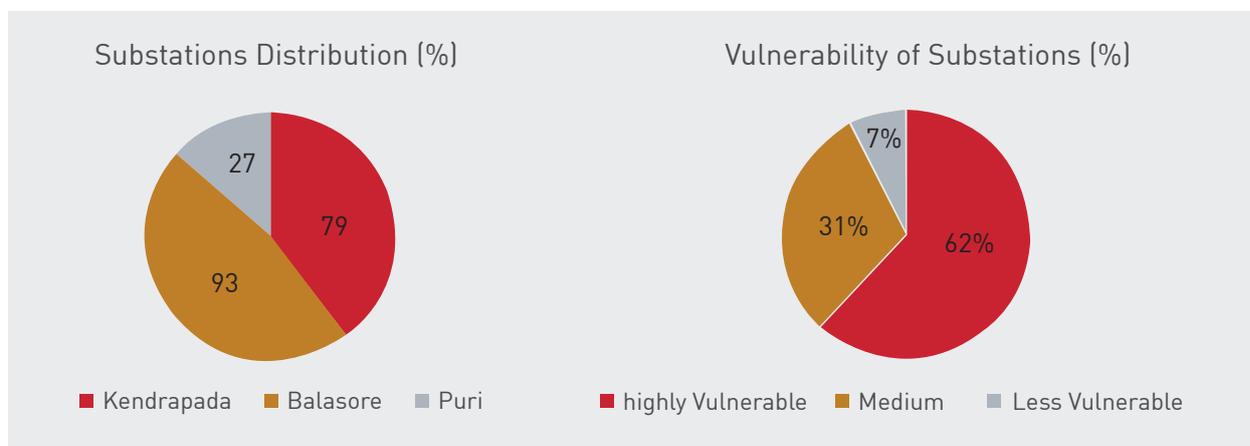
6 Probabilistic Risk analysis

6.1 Distribution Vulnerability (DISCOMs)

Among the substations located near the coast, 23 percent are classified as having a higher order of vulnerability. Specifically, the distribution substations of Kendrapada (79%), Balasore (93%) and Puri (27%) have relatively higher vulnerability than other coastal districts. Additionally, for substations located between 20 and 60 km from the coastline, 22 percent are highly vulnerable, 11 percent are moderately vulnerable and 2.6 percent are less vulnerable (Figure 6.1). Data from the three distribution companies suggests that one in three substations (34) operated by Tata Power Northern Odisha Distribution Limited (TPNODL) is highly vulnerable to cyclone winds near the coastline.

The most vulnerable substation is located in the Balasore district, while Tata Power Central Odisha Distribution Limited (TPCODL) substations in Jagatsinghpur and Kendrapada also fall into the highly vulnerable category. In general, the impact of high wind speeds is most pronounced in the coastal areas up to 0-60 km from the coastline. Hence, an assessment of prioritization for investment has been conducted, focusing on damages from cyclones occurring from 2013 to 2021, mainly due to eight cyclones.

Figure 6.1: DISCOMs vulnerability



The vulnerability of the distribution line stems from weak pole designs on which conductors and accessories are fitted. Indicators of vulnerability of distribution line included the design of the pole/tower where the distribution lines are made, span length, year of commissioning and failure history. It has been further observed that many determining factors were responsible for damage, like vintage infrastructure, type of sub-station, radial distribution system and design vulnerability of utility poles.



Table 6.1: Prioritization of investment in crores – Distribution System

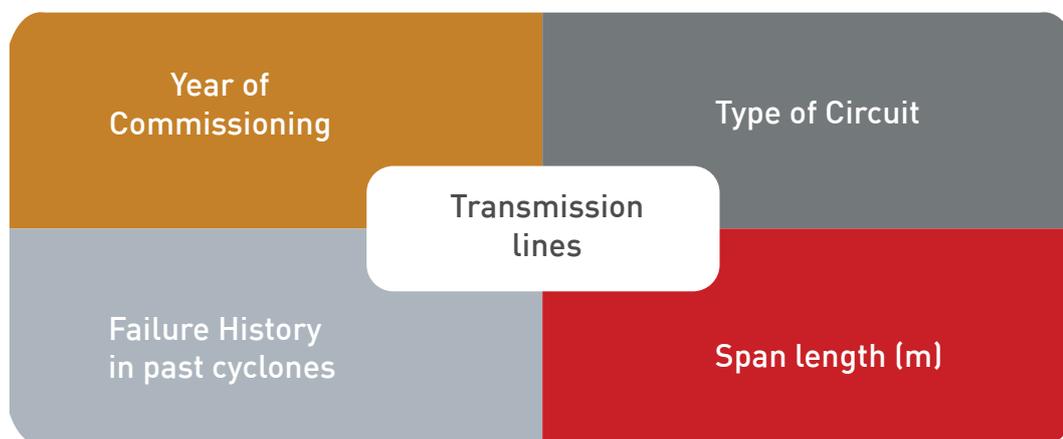
Prioritization of Investment in crores (Distribution System)				
DISCOMs	Priority 1	Priority 2	Priority 3	Total
TPCODL	3,347	4,889	1,678	9,914
TPNODL	2,769	3,793	2,031	8,593
TPSODL	2,303	3,625	2,557	8,486
Grand Total	8,419	12,307	6,266	26,992

Source: Report on Codes, Standards and Design, CDRI

6.2 Transmission Asset Vulnerability

More than half of the highly vulnerable substations are in the highest cyclone wind-speed zone (>20 km from the shoreline), indicating higher potential impact against high wind speed events. The vulnerability score for transmission lines was assigned based on the four indicators given in Figure 6.2.

Figure 6.2: Transmission line vulnerability indicators



Source: Report on Risk Identification and Estimation, CDRI



Transmission line vulnerabilities are assessed for networks within 60 km of the coastline. The circuit line vulnerability was evaluated using three indicators: Span Length, Double Circuit / Single Circuit and Age of Infrastructure (see Figure 6.3).

Figure 6.3: Indicators for vulnerability and risk assessment

Span Length
» Increased span length cause sagging that increases weight of conductors and oscillate with more wind speed hence resulting in high vulnerability.
Single / Double circuit
» Single circuits have single source making it more vulnerable while Double circuit have multiple sources making them less susceptible
Age of Infrastructure
» Infrastructures outlived their services life are more at risk.

Substations located in areas prone to high water levels are particularly vulnerable to flooding. In the event of a heavy monsoon season or a disaster in Odisha, access roads to these substations may become impassable due to surrounding water depths. Overlaying the road networks can provide insights into which road networks are likely to be inundated during a high flood event. Conventional transmission substations face flooding challenges due to their installation at or near ground level. This vulnerability necessitates the shutdown of substations during flood events, disrupting power supply and potential damage to equipment.

Hence, infrastructures located in high-risk districts should implement the recommended measures in a phased manner, prioritizing based on the order of risk associated. For flood-like events, the flood inundation maps may be used to plan and install assets, making informed decisions on expected flood levels in the identified areas. Additionally, the plinth levels of the poles and other assets can be raised according to anticipated water depths.

Different risk order assessments should be carried out to assess the risk further. See Table 6.2.



Table 6.2: Risk Categories

Risk Category	Description
First-order risk	Indicates the direct asset losses incurred by the power sector.
Second-order risk	Refers to the state's revenue loss in terms of power infrastructure, divided into two categories: the revenue loss to DISCOMs due to non-supply of power and income loss to meter readers and bill collectors (since DISCOMs outsource these activities to third parties).
Third-order risk	Refers to the impact of damages to the power sector on other critical structures like public health systems, transport, etc.

Source: Report on Codes, Standards and Design

Table 6.3: Prioritization of investment in crores (Transmission lines with interposing towers)

Prioritization of investment in crores (interposing towers)				
Voltage Rating	Prioritization of Lines (in crores)			Total
	Priority 1	Priority 2	Priority 3	
220 kV	21	0	181	202
132 kV	41	104	174	319
Grand Total	62	104	355	521

Source: Report on Codes, Standards and Design, CDRI

6.3 Assessment of base cyclone and flood risk

Odisha has faced several major cyclones and floods in the past decade (Cyclone Phailin in 2013, Cyclone Hudhud in 2014, Cyclone Titli in 2018, Cyclone Fani in 2019, Cyclone Bulbul in 2019, Cyclone Amphan in 2020, Cyclone Yass in 2021, along with floods in 2017 and 2020). The damages caused by these events have been estimated and evaluated based on the order of risk associated. Damages in cyclones from 2013 to 2021 have been ascertained, and the revenue loss and losses in the industrial and service sectors have also been estimated¹⁴ (Annexure A4).

¹⁴Detailed information not available



6.3.1 Resilience Metrics

Due to the revenue losses incurred from Cyclone Fani, it has been used as a baseline cyclone for analysis. The cost data referenced comes from the approved figures provided by the Department of Energy, Government of India and the CEA cost estimate report, with a cost escalation applied at a rate of 6 percent per annum. In instances where cost information was unavailable, the most recent market rates were utilized. Based on the vulnerability assessment and prioritization matrix, three investment proposal options are given for constructing cyclone-resilient lines under three DISCOMs. See Table 6.4.

Table 6.4: Investment options

Options	Description (Appendix)
Option 1	To retrofit existing lines with H-Pole and existing PSS: INR 22,691 crores
Option 2	Construction of new lines with H-Poles and retrofitting of existing PSS: INR 25,628 crores
Option 3	Underground cable system for distribution network in urban areas considering priority and criticality and retrofitting of existing PSS: INR 26,992 crores

Source: Report on Codes, Standards and Design, CDRI

Although retrofitting the existing distribution lines by interposing poles will not reach a 99 percent reliability level, it is an economical option and requires less right of way (RoW) for installation. On the other hand, constructing new lines with proposed structures (H-Poles in 33 and 11 kV lines and spun/H-Pole for low-tension lines) will have reliability above 99 percent. However, this option is less economical and requires more RoW for implementation.

The total tentative investment in the T&D system, when opted for all the options, amounts to an impressive INR 28,499 crores. In contrast, the projected losses (direct and indirect losses) are estimated to be INR 25,390 crores. From the above options, Option 3¹⁵ is recommended for a logical investment of INR 26,992 crores on the following priorities (Priority I, II and III) and can be planned in three stages (see Table 6.5).

The immediate focus may be given to Priority 1 with an initial investment of INR 8,419 crores in three DISCOMs.

¹⁵The damage avoided cannot be estimated due to lack of data. Hence, Option-3 is given higher importance to build a resilient infrastructure.



Table 6.5: Investment Option Merits and Demerits

Option Descriptions		Investment Options	Merits and Demerits
Option 1	Retrofitting of existing lines with H-Pole, E250 (2X150X75) mm, 36.96 kg/m for 33 kV line and H-Pole, E250 (2 X 125 X 65) mm, 28.82 kg/m for 11 kV line.	Total investment will be INR 22,691 crores	The strength of existing lines is examined by retrofitting with interposing H-poles and found suitable against the required wind speed in the region. Although retrofitting of the existing distribution lines by interposing poles will not reach a 99 percent reliability level, it is economical and requires less RoW for erection. While existing distribution lines are predominately constructed with Steel Joist poles and PSC poles, both are rectangular cross-sections. Such lines are generally weak in longitudinal directions and fail to withstand the desired wind speed during a cyclone.
Option 2	Construction of new lines with H-pole E350 (2 X 150 X 75) mm, 36.96 kg/m for 33 kV line, H-Pole E350 (2X 125 X 65) mm, 28.82 kg/m for 11 kV new line and spun poles for LT new Line in place of old lines.	Total investment will be INR 25,628 crores	Construction of new lines with proposed structures (H-Poles in 33 and 11 kV lines and Spun/H-Pole for LT lines) will have reliability above 99 percent but will not be economical and require more RoW for implementation. It further suffers from revenue loss and losses in the industrial and service sectors.
Option 3	Underground cable system for distribution network in urban areas considering priority and criticality. H-Pole for 33 kV, 11 kV new lines and Spun pole in LT new lines for rural area.	Total investment will be INR 26,992 crores	Opting for an underground cable system will enhance the resilience of the infrastructure and increase the reliability level. Based on criticality and priority, it is the suitable option, but the investment cost remains high.



Considering the vulnerability of the power sector towards cyclones and changes in climatic events, Option 3 is a reasonable investment. Although cyclones affect Odisha's entire coastal region, cyclonic storms' impact is much more severe in the Ganjam, Puri, Khurda, Jagatsinghpur, Cuttack and Kendrapada districts. Hence, the infrastructure located in the districts at high risk should implement the recommended measures in a phased manner on priority, as classified in this report. The prioritized lines and substations have been categorized into three segments for implementation to improve the resilience of T&D infrastructure.

6.4 Cost-Benefit Analysis

Odisha has faced many disasters in the last two decades, making its critical infrastructure prone to damage and loss. Although there has been a significant increase in capacity building and a reduction in fatalities in the last few years, the power sector continues to suffer heavy damage due to these catastrophic events (Table 6.6). Hence, the problem lies in assuring that this investment effectively addresses disaster preparedness and recovery needs while managing the associated cost. Such an analysis is crucial in evaluating whether the expenses incurred in disaster mitigation or recovery phase benefit and justifies the financial outlay. It further helps the decision-makers assess the gaps and risk factors and make informed choices that ensure the best allocation of resources in the face of potential disaster.

Table 6.6: Damage to the power sector by cyclones (1999-2020)

Year	Name of Cyclone	Total Districts Affected	Damage to Power Sector (in crores INR)
1999	Super Cyclone	14	INR 400.00 crores
2013	Phailin	19	INR 1,048.14 crores
2014	Hudhud	11	INR 66.00 crores
2018	Titli	17	INR 133.03 crores
2019	Fani	9	INR 8,139.00 crores
2020	Amphan	10	INR 320.00 crores

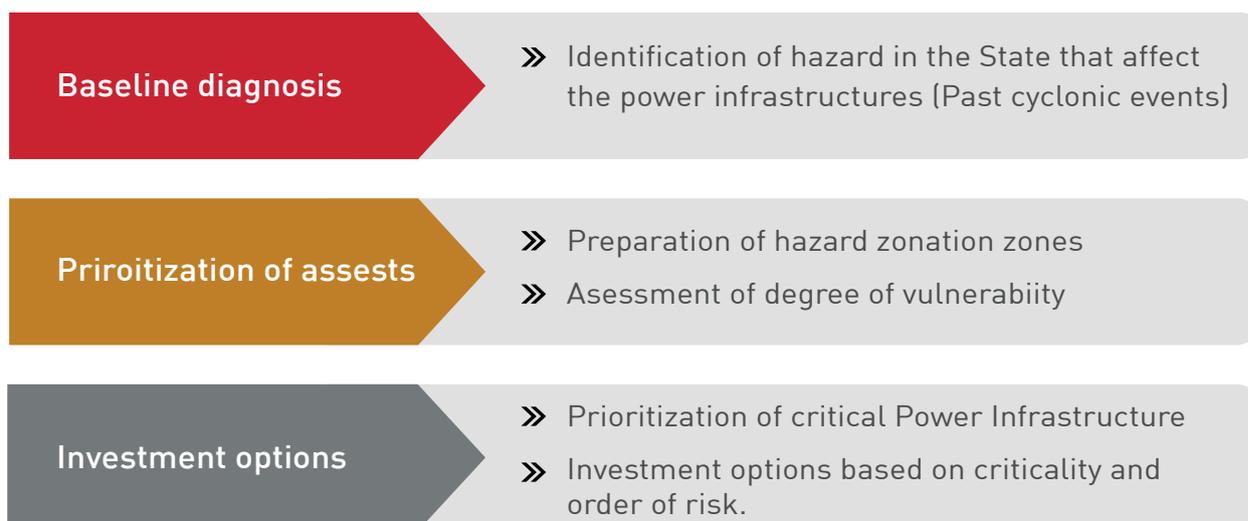
Source: Memorandum Phailin 2013, Hudhud 2014, Titli 2018 and Fani 2019



6.4.1 Methodology for CBA of Odisha's power infrastructure investment analysis

To mitigate the damages caused and to further estimate the extent of losses incurred, a cost-benefit analysis (CBA) was conducted as per Figure 6.4. The detailed methodology is elaborated in the sections following this.

Figure 6.4: Cost-benefit analysis methodology



Source: Report on Risk Identification and Estimation, CDRI

6.4.2 Identification of assets at risk

Odisha, prone to cyclones and floods, is exposed to significant damage to structures and loss of lives. It becomes necessary to identify assets at risk for each zone. Hence, cyclone micro-zonation is carried out to determine the components at structural risk, classifying more significant regions into microzones with varying wind speeds.

(Refer to report: Risk Identification and Estimation)

6.4.2.1 Preparation of zonation maps

Using the wind speed values at each grid point for different return periods, the micro-zonation maps were obtained utilizing the geographical information system (GIS) tool for inverse distancing weightage 3 (IDW). This method converts the point data to a raster image format. Cyclone zonation was prepared for different return periods (5, 10, 25, 50, 100), along with potential power assets exposed to the cyclone zone. The gust speed map with a 50-year return period is considered for analysis (Annexure A1).



6.4.2.2 Assessment of exposure and degree of vulnerability

Only some of the exposed infrastructure is equally vulnerable to cyclones and floods and may have better adaptive capacity to cope with the impact of hazards. Hence, vulnerability is a function of the degree of exposure, sensitivity and adaptive capacity. Physical indicators like transmission substations, lines, distribution lines and substations were examined to assess the vulnerability. Sixteen suitable indicators were selected with each assigned a score on a scale of 1 to 4, where higher scores indicated high vulnerability. Using equal weightage, cumulative scores were classified as low, medium and highly vulnerable.

6.4.2.3 Vulnerability assessment

Generally, the determinant of vulnerability stems from the weak design of supports of the distribution lines. A hazard vulnerability assessment is conducted to evaluate the damages caused by hazards. The severity of the vulnerability facilitates pre-disaster planning and allocation of resources.

- a) **Transmission grid substation vulnerability:** More than half of relatively highly vulnerable substations are located between 0-20 km from the shoreline, indicating exposure to probable high wind speed with varying vulnerabilities. The vulnerability score is assigned to the type of substation (GSS, GIS or AIS), the supply source (Ring or Radial type), the design standard of the control room and the year the substation was commissioned.
- b) **Transmission line vulnerability:** Transmission vulnerabilities are assessed for networks within 60 km of the coastline. The evaluation of transmission line vulnerability considered three indicators: span length, double circuit / single circuit and age of infrastructure.
- c) **Distribution substation:** Around 30 percent of vulnerable distribution substations are located along the seacoast (<20 km). Among those situated near the seacoast, 23 percent exhibit a higher order of vulnerability than other substations near the coast.
- d) **Distribution lines:** The determinant of vulnerability stems from the weak design of the supports of the distribution lines. Around 80 percent of the poles are Joist or PSC designs, particularly susceptible to intense wind speed. Ageing infrastructure compounds the impact, with nearly three-quarters of the distribution lines reportedly commissioned 30 years earlier.



6.4.2.4 Identification and prioritization of critical components

Critical lines serving essential establishments such as water supply, telecommunication service, health care service, transportation and rescue operation, and district administrative buildings need to be safeguarded during times of hazard. **Hence, based on the vulnerability and criticality analysis, lines and substations are exposed to high risk and prioritized for retrofitting/modifying their components to resist the multi-hazard risks.**

6.4.2.5 Investment options

As per the cyclone zonation map, the effect of cyclonic storms is felt mainly in a belt of approximately 60 km from the coastline. It is not feasible to replace or renovate all the existing power infrastructures in this region due to the vast capital burden and extended outages. Owing to the vulnerability of the infrastructure, resource allocation was prioritized by giving higher importance to critical and vulnerable asset infrastructure.

Hence, the infrastructure was prioritized based on the criticality/importance and vulnerability of the line/PSS. As a result, the investment options were categorized based on parameters like retrofitting, renovation, or replacement of the power components.

The selection of the investment options for different zones varied as not all exposed infrastructure was equally vulnerable. Furthermore, some of the infrastructure had better adaptive capacity to cope with the impact of cyclones and flood hazards. Hence, the infrastructure was prioritized. Priority 4 indicates no strengthening is required, and Priority 1 indicates more power infrastructure strengthening. Therefore, a cost-benefit analysis took base cyclones and calculated the first-, second- and third-order losses.

6.4.2.6 Cost-benefit analysis

To evaluate the impact of Cyclone Fani, the government-funded projects under execution at the time have been considered as these projects were delayed in capitalization. The loss due to delayed capitalization has been incorporated in the first-order loss.

Meanwhile, the second-order risk, cumulative revenue loss and project impact for cyclones from 2013 to 2021 have been assessed proportionately to the losses in Cyclone Fani, i.e., Second-order loss in other cyclones = (Second-order loss in FANI / Infrastructure damage cost in FANI) *Infrastructure damage cost in another cyclone.

For the third-order losses associated with Cyclone Fani, calculations start by considering the following:



Per capita income in 2019-20

GSDP

Population

Share of industry

Service sector and agriculture-allied sectors to GSDP

Number of days in a year

The average number of days

Number of people affected in cyclone-hit areas

Total GSDP loss, taken from Odisha Economic Survey, Odisha Budget

Annual report on NC, etc





The third-order loss for other cyclones was derived proportionately from the third-order loss in FANI (see Table 6.7).

Table 6.7: Third-order losses for cyclones

Third order loss for other cyclones							
Year	Cyclone	Direct Loss	Revenue Loss + Meter reader Loss	Project Loss	1st order +2nd order loss	3rd order loss	Total
2013	Phailin	1048.1	32.6	26.7	1107.4	326.6	1470.0
2014	Hudhud	60.0	1.9	1.5	63.4	20.8	84.2
2018	Titli	133.0	4.1	3.4	140.5	46.0	186.6
2019	Fani	8139.0	253.0	207.0	8599.0	2816.0	11415.0
2019	Bulbul	6.3	0.2	0.2	6.6	2.2	8.8
2020	Amphan	76.49	2.4	1.9	80.8	26.5	107.3
2021	Amphan	150.23	4.7	3.8	158.7	52.0	210.7
Total Loss in crore		9613.2	298.8	244.5	10156.5	3326.0	13482.5

Source: Report on Codes, Standards and Design, CDRI

The total first-order and second-order losses due to seven cyclones in eight years from 2013 to 2021 were calculated to be INR 10,156 crores, an average of INR 1,269.5 crores per year. Considering the life of the old infrastructure as 20 years, the total loss calculated in 20 years is INR 25,390 crores.

While considering the third-order losses, along with first- and second-order losses due to seven cyclones in eight years, a total loss of INR 13,482 crores, which is, on average, 1,685.25 crores per year, was incurred. Hence, considering the infrastructure lifespan as 20 years, the total loss calculated is INR 33,705 crores. Based on the losses incurred, the power sector bears consequences, such as loss and damage to assets¹⁶ and disruption of basic critical infrastructure.

¹⁶Detailed information not available



Consequences

- » Damages may extent from insignificant to minor to major based on the criticality and vulnerability of the structure.

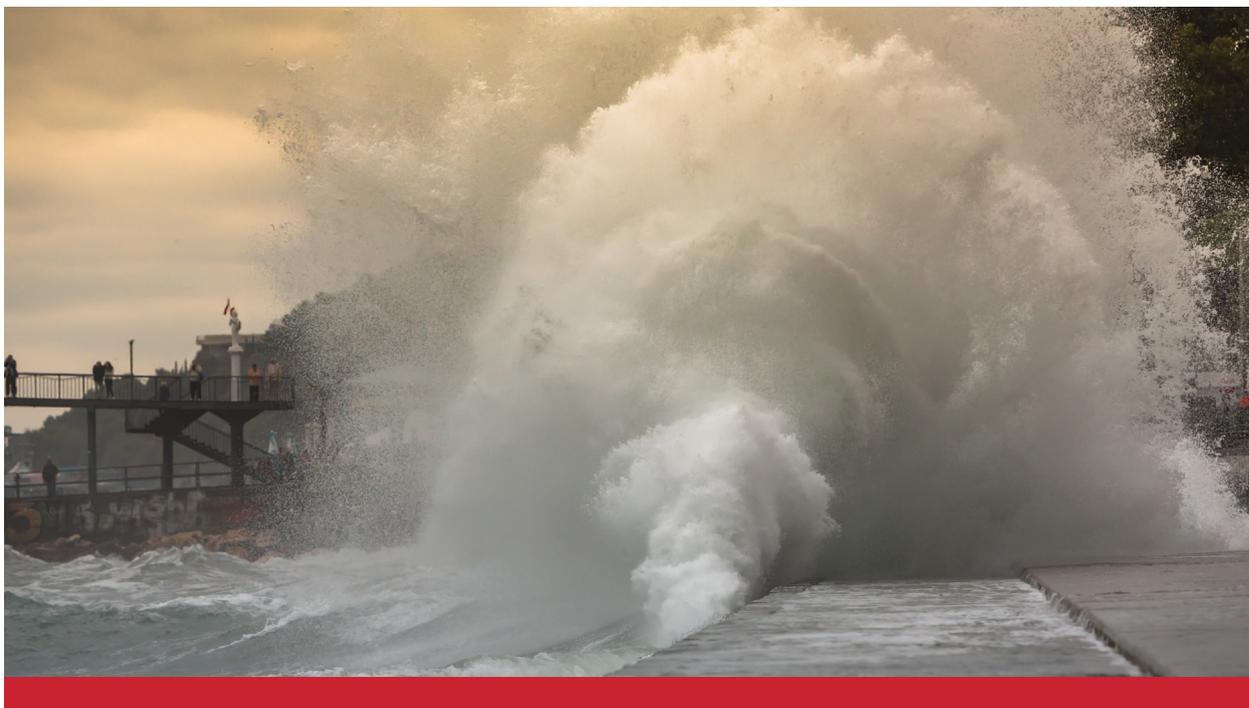
Asset damage

- » Financial and reputational risks are mainly suffered by DISCOMs and vulnerability lines

Loss of services

- » Critical services like health sector, transportation, water services and banking services are affected the most.

Utilities should prioritize work on lines and substations selected in Priority 1 based on their associated risks, criticality and vulnerability. They should implement the options in a phased manner to avoid financial implications for the authorities and stakeholders involved.





7

Major Constraints





7 Major Constraints

The Department of Energy in Odisha, like other states in the country, lacks a dedicated budget for disaster preparedness, response, recovery and reconstruction of its infrastructural system. Additionally, there is no additional funding available to incorporate disaster resilience considerations into new infrastructure projects.

The assessment process for determining union assistance through the National Disaster Response Fund (NDRF), as well as the release of these funds, should be expedited, made more efficient and transparent. The existing aid norms need to include more resources for recovery and reconstruction. Presently, the allocations are insufficient for infrastructure. Furthermore, states should receive enhanced technical assistance from national agencies to support their disaster management functions.

Investment should be envisaged for preparedness and mitigation purposes and reduce the financial burden on state governments. Additionally, adopting technical advancement requires funds; hence, allocating contingency funds to the state government should further strengthen the response mechanism.

In public finance, disasters are considered contingent liability of the state. Contingents, which function as dedicated reserve funds, are the only financial mechanisms for meeting contingent liabilities. Contingent liabilities refer to (government) obligations triggered when a potential but uncertain future event occurs. The allocations made through the State Disaster Response Fund (SDRF) and the National Disaster Response Fund (NDRF) help governments meet their contingent liabilities. However, the existing approach to fulfilling the contingent liabilities has two shortfalls.

- a) It is aimed at meeting the contingent liabilities, not reducing them. Governments should invest in estimating risk exposure and taking appropriate measures to mitigate contingent liabilities by investing in disaster resilience.
- b) The SDRF and NDRF, which function as dedicated reserve funds, are the only financial mechanisms for meeting the contingent liabilities.

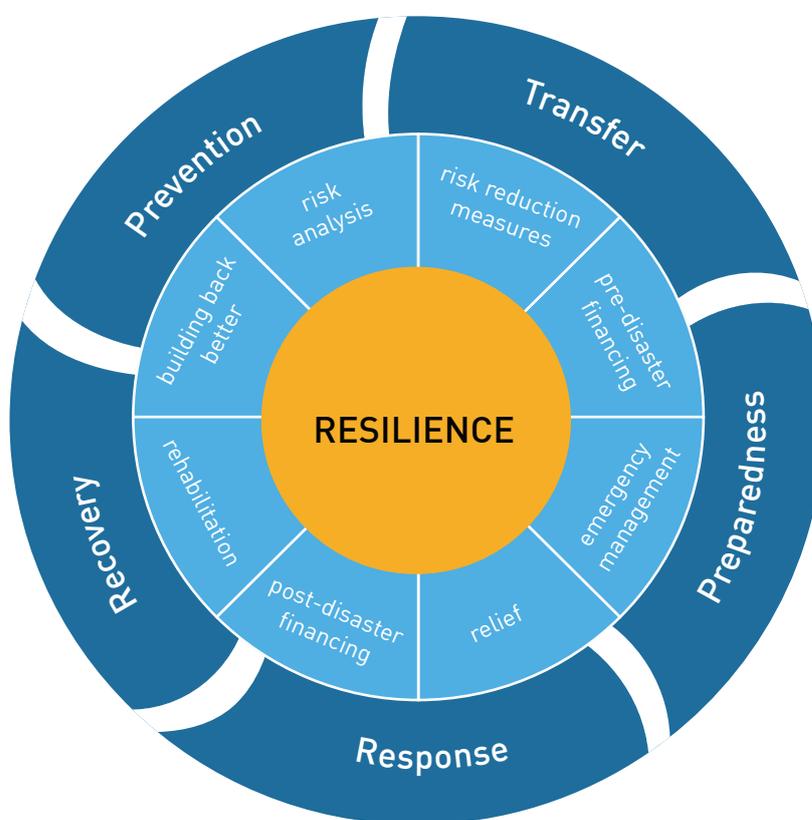
When risk exposure is high and contingent liabilities could significantly increase, it is essential to introduce multiple instruments and funding windows to meet these liabilities. Also, with rising episodes and the amplitude of extreme climatic events, disasters have increased exponentially. Evidence shows that weather-related losses in the global power and utilities industry are disproportionately higher than other operational losses, amounting to 22 percent of the total. There is a need to factor in disaster resilience measures in the design of power systems, installation, operation and maintenance.



According to the landmark Global Assessment Report on Disaster Risk Reduction Risk and Poverty in a Changing Climate, launched on 17 May 2009, exposure and vulnerability to weather and climate hazards are growing, resulting in continued rises in the numbers and costs of disasters.

Disaster risk primarily accumulates due to unplanned settlements and environmental degradation, though climate change is also beginning to show its way. Climate change will, therefore, affect disaster risks in two ways: first, it is likely to increase the frequency of weather- and climate-related hazards and lead to rising sea levels. Second, it will heighten the vulnerability of communities to these hazards due to ecosystem degradation, decreased availability of water and food, and changes to livelihoods. Hence, it becomes imperative to generate funds considering the disaster events attributed to climate change (see Figure 7.1).

Figure 7.1: Integrated climate risk management cycle



Source: Adaptation of GIZ/MCII 2017 figure

We envisage that not only should the union and state governments have adequate funds to deal with disasters, but these funds should also be sufficiently diversified to support a framework that includes all disaster management aspects.

Risks posed by hazards and disaster events have increased, and they need a more comprehensive and balanced response compared to the present approach, which focuses just on response and relief. Further, the transfer of resources on such a scale should have a clear, discernible impact on poverty and risk, which affects households and communities, particularly the poorer sections all over the country.



8

Global Good Practices and Recommendation





8 Global Good Practices and Recommendations

The global best practices for increasing disaster resilience against different disasters involve a combination of structural, non-structural and financial measures. Financial resilience refers to the ability of individuals, societies, etc., to cope better with residual risk (response, recovery, reconstruction) and includes mechanisms such as disaster response financing (DRF).

For this, various financial measures are critical as they provide the means to fund and implement structural and optional measures to withstand and increase resilience against disasters like cyclones. Measures include setting up disaster financing mechanisms, such as insurance, to cover losses in recovery costs. Additionally, governments and communities can establish contingency funds for rapid response, and incorporation from international organizations can also provide financial support for cyclone-prone regions.

- a) **Disaster risk financing:** Disaster risk financing mechanisms, including CAT bonds, multilateral development banks (MDBs), bilateral assistance, reconstruction bonds and contingent credit / stand-by facilities, are vital for addressing the financial needs of sectors like power in the aftermath of disasters.

For the power sector, these mechanisms ensure rapid access to funds for repairing damaged infrastructure, restoring services and maintaining uninterrupted power supply to affected communities. CAT bonds transfer risk to capital markets, MDBs and bilateral assistance provide financial support, reconstruction bonds focus specifically on finance infrastructure rebuilding and contingent credit facilities offer immediate access to funds for emergency expenses.

Overall, disaster risk financing is crucial for mitigating the financial impacts of disasters and enhancing the resilience of the sector.

- b) **Risk reduction financing:** Risk reduction financing, distinct from disaster risk financing, encompasses instruments such as green bonds, energy resilience banks, resilience bonds, MDBs and bilateral assistance. Unlike disaster risk financing, which primarily addresses post-disaster financial needs, risk reduction financing focuses on pre-emptive measures to enhance resilience and preparedness before disasters occur.

This proactive approach is crucial for critical infrastructure sectors like power, which serves as a lifeline for others such as health, telecom and transport. By investing in risk reduction financing, the power sector can fortify its infrastructure, improve operational resilience and mitigate the potential financial impacts of future disasters.

Thus, emphasizing risk reduction financing is essential for ensuring the financial preparedness and adaptation of critical infrastructure sectors, safeguarding their functionality and reliability even in the face of adverse events.



8.1 Innovative Funding Mechanisms for Funding Resilience from Around the World

Power utilities may also harness specific innovative financial instruments, such as catastrophe bonds and resilience bonds, and seek economic assistance from specialized funding agencies to meet any funding requirement. They may enter a financing arrangement in advance as it will reduce the response time in organizing the funds during a disaster. The power utility / state government may also arrange with financial institutions to fund specific activities under the disaster management plan (like project financing, building disaster-resilient infrastructure, strengthening existing infrastructure, etc.). This arrangement will help the utility develop infrastructure that is less prone to damage due to disaster events.

8.1.1 Energy Resilience Bank Programme

A green bank or green investment bank fortifies low-cost capital financing green projects. Energy resilience banks (ERBs) are green banks aimed explicitly at funding resilience initiatives. These banks have been used in energy resilience projects to secure gap financing or the remaining unmet needs after a project has secured traditional public and private capital. ERB financing may be sourced from grants or loans—typically forgivable, long-term, low-interest loans—or small surcharges to the bank’s customers. ERBs also seek to leverage funding from other federal, state, or private sources.

Box 8.1: New Jersey Energy Resilience Bank

New Jersey had more than 1,000 MW of installed solar capacity when Hurricane Sandy hit the Northeast United States. However, only two solar PV systems provided power in the days following the hurricane (Hotchkiss et al., 2013). At the time, a combination of interconnection policies and a lack of dynamic control transfer switches or energy storage solutions prevented the islanding of systems. In the absence of appropriate policies and codes, the installed DG capacity in New Jersey did little to aid resilience. To assist in funding new resilience-related technology, New Jersey established an Energy Resilience Bank (ERB), the first public infrastructure bank in the US to focus on energy resilience¹⁷.

The New Jersey ERB was established in 2014 with US\$ 200 million of Community Development Block Grant – Disaster Recovery (CDBG-DR) funds, which were allocated to New Jersey by the U.S. Department of Housing and Urban Development (HUD) because of Superstorm Sandy. The ERB was operated by the New Jersey Economic Development Authority (NJEDA), with support from the New Jersey Board of Public Utilities (NJ BPU) and the New Jersey Department of Treasury¹⁸. ERB funds were set aside for developing or upgrading distributed energy resource technologies, such as Combined Heat and Power (CHP), for essential facilities impacted by disasters.

¹⁷Best Practices in Resilience Planning (nrel.gov)

¹⁸Source: <https://chptap.lbl.gov/profile/281/NJEDAERBProgram-Profile.pdf>



The ERB programme was created as part of New Jersey's commitment to reduce the effects of future large-scale power outages and improve energy resilience. The following is a list of the programme's highlights:

- » CHP systems require an annual efficiency of at least 65 percent LHV (lower heating value).
- » Defining 'resilience costs' as incremental costs required to make a CHP system capable of islanding and the costs associated with hardening the facility to protect the CHP and supporting systems.
- » Developing a funding mechanism incorporating a 100 percent grant for resilience costs and a 40 percent grant for other expenses. The balance of unmet project costs was eligible for a loan with 2 percent interest and a maximum term of 20 years.

To pursue grant incentives, the potential bidders should submit a demand draft receipt of INR 5,900 at the time of submission of Expression of Interest (EOI) responses.

As a result of the ERB programme, a total of US\$ 200 million was deployed to improve the resilience of 12 critical facilities in New Jersey, including three wastewater treatment plants and nine hospitals. Nine projects included new, resilient CHP plants with infrastructure upgrades and grid islanding capabilities. The programme also funded the repowering and upgrading of existing CHP plants at one wastewater treatment plant, one hospital and one solar-plus-storage microgrid at a wastewater treatment plant¹⁹.



¹⁹Source: <https://chptap.lbl.gov/profile/281/NJEDAERBProgram-Profile.pdf>



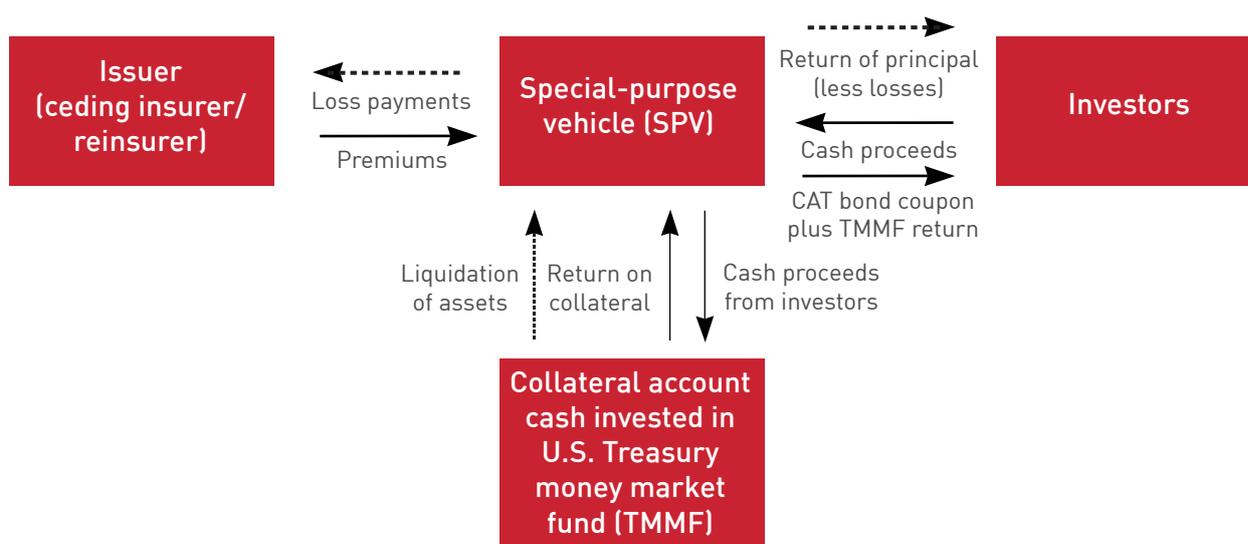
8.1.2 Catastrophe Bond

Catastrophe bonds, a type of insurance-linked securities known as Cat bonds or Capital-at-risk notes, signify financial protection in case of major disaster events, such as a hurricane or an earthquake. The issuer—governments, insurers and reinsurers—typically facilitate the transaction through a special purpose vehicle (SPV). The SPV sells the bond to investors who anticipate receiving remuneration through coupons. If a catastrophe that meets the trigger criteria does not occur, the investors receive their principal back with the coupon payments. If a catastrophe arises, the investors forgive the principal, and the insurance company pays this money to the claimants for reconstruction and rehabilitation. These bonds are inherently risky, generally carrying a BB rating and usually have less than three years of maturity. A benefit to issuers of cat bonds is that the protection is fully collateralized, significantly mitigating the issuer's credit risk²⁰.

8.1.2.1 Strengthening Disaster Resilience: The Role of the Caribbean Catastrophe Risk Insurance Facility

Governments of small island nations frequently experience severe liquidity shortages following disasters. These constraints significantly hamper their ability to mount effective disaster responses, resulting in delayed recovery efforts. Their limited fiscal resources hinder the establishment of adequate financial reserves, exacerbated by the concentrated nature of their economies, which precludes regional assistance in recovery efforts. Furthermore, high levels of debt impede their ability to secure post-disaster financing, restricting their access to catastrophe insurance due to the elevated transaction costs relative to their market share (see Figure 8.1).

Figure 8.1: Catastrophe bond structure



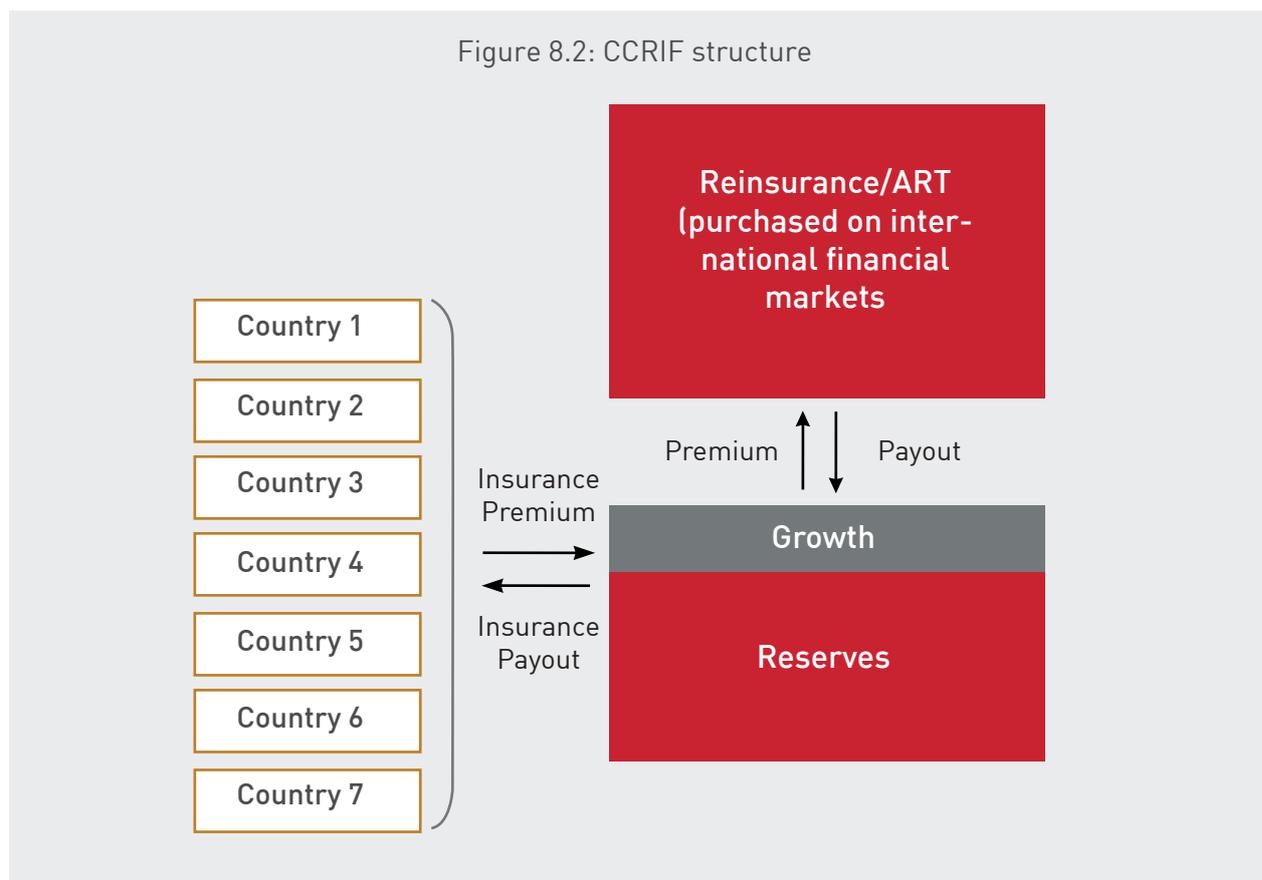
²⁰Source: <https://openknowledge.worldbank.org/bitstream/handle/10986/26382/113894-ESMAP-PUBLIC>



Securing short-term liquidity to initiate recovery efforts while maintaining essential government services is particularly acute for Caribbean governments, whose economic resilience is limited by soaring vulnerability and high levels of indebtedness. To solve this problem, the Caribbean Catastrophe Risk Insurance Facility (CCRIF) was established to provide the Caribbean Community (CARICOM) government with an insurance instrument to address this need. Similar to business interruption insurance, this instrument aims to provide short-term liquidity if a hurricane or earthquake hits them. Using CAT bonds with parametric triggers to aid member states, the CCRIF paid out a little over US\$ 20 million to Haiti and almost US\$ 1 million to Barbados within 14 days after Hurricane Matthew struck the Caribbean in the fall of 2016.

CCRIF was created with technical guidance from the World Bank and financial support from the Government of Japan. Its initial capitalization involved contributions from various entities, including the Government of Canada, the European Union, the World Bank, the United Kingdom and France governments, the Caribbean Development Bank, and the governments of Ireland and Bermuda. Additionally, participating governments contribute membership fees. See Figure 8.2 for the CCRIF structure.

Figure 8.2: CCRIF structure





Since its establishment in 2007, the CCRIF has disbursed a total of approximately US\$ 266.8 million in payouts to 17 member governments to cover damages from tropical cyclones, earthquakes and excess rainfall.

In 2014, the World Bank established a second multi-donor trust fund to aid in developing new CCRIF products and to facilitate the inclusion of Central American and additional Caribbean countries. The multi-donor trust fund receives funding from multiple donors, such as Canada (via Global Affairs Canada), the United States (via the Department of the Treasury), the European Union (via the European Commission), Germany (via the Federal Ministry for Economic Cooperation and Development and KfW), the Caribbean Development Bank (with support from Mexico), the Government of Ireland and the European Union through its Regional Resilience Building Facility managed by the Global Facility for Disaster Reduction and Recovery, and the World Bank.

An analogy to understand CCRIF is envisioning a system where multiple countries pool their emergency reserve funds. If each country were to accumulate reserves to withstand catastrophic events individually, the combined sum of these reserves would exceed the actual needs of the pooled countries in any given year. In conclusion, using CAT bonds with parametric triggers, governments can establish multiyear access to insurance protection and quickly access disaster funds when their CAT bonds are triggered. It is worth noting that parametric triggers can be determined quickly, and they do not require countries to possess the technical expertise and infrastructure to measure disaster losses²¹.

²¹<https://www.chicagofed.org/publications/chicago-fed-letter/2018/405>
https://www.ccrif.org/aboutus?language_content_entity=en#:~:~text=Since%20the%20inception%20of%20CCRIF,totalling%20approximately%20US%24266.8%20million
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiqxdXK572EAXVoe2wGHbKHAmSQFnoECBUQAQ&url=https%3A%2F%2Fwww.ipcc.ch%2Fapps%2Fnlite%2Fsrex%2Fnlite_download.php%3Fid%3D6318&usg=AOvVaw0lNjaucIkhtnwefbVZ4XuB&opi=89978449



Case Study 8.1: Tonga's Catastrophe Model by using Disaster Risk Layering Framework (World Bank)

A risk stratification approach is an important part of a comprehensive financial protection strategy that mobilizes various tools before and after a disaster to meet evolving financial needs. Risk stratification ensures that cheap funding sources are used first and the most expensive instruments are used only in exceptional cases.

Tonga's DRF approach suggests that no single financial instrument can cover all risks and that a combination of financial instruments is the most efficient and cost-effective way to protect against disasters of varying frequency and severity.

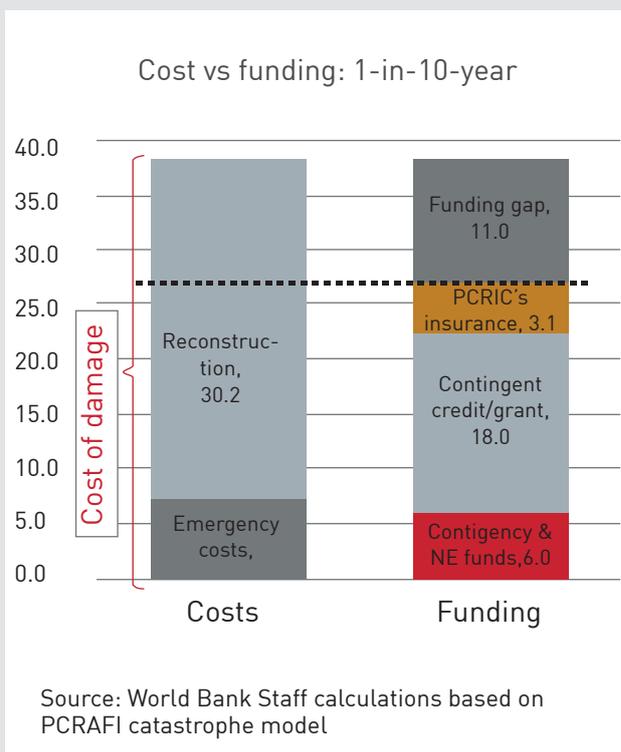
Tonga's risk layering approach includes financial instruments such as reserves, contingent financial instruments such as contingent loans, and market-based instruments such as insurance and catastrophe bonds. Tonga ensures that some of these tools are deployed before the disaster (i.e., pre-disaster tools) and others are mobilized after the disaster (i.e., post-disaster tools). In addition, Tonga considered not only the importance of having DRF measures in place, but also the timing needs of measures at its disposal, recognizing the fact that not all resources would be needed at the same time.





Response measures taken

The risk layering was considered by taking to what return period (threshold) and for what type of loss the government would want to be fully funded based on prearranged instruments before relying on ex-post instruments and risking being unable to meet costs after an event. The figure here is an example of the 1-in-10-year scenario and indicates that emergency costs are fully funded using prearranged finance, but when considering the full cost of damages (US\$ 38 million), at this return period, there is a US\$ 11 million funding gap. The blue dotted line represent the point to which there is no funding gap. Hence, the most cost-effective strategy and mix of instruments depends on the use of the prearranged finance intended for.



Tonga's Catastrophe Model: Cost vs Funding 1-10 Return Period

[Source: Curuki, Jale. (2022). The Tonga Experience Resilience Financing Pacific Resilience Program. 10.13140/RG.2.2.34731.92962.]

8.1.3 Resilience Bond

Resilience bonds are a form of cat bonds that effectively help governments raise private funding for investments in resilience projects, specifically those aimed at preventing a severe event from becoming a physical or financial disaster (RE Bound 2015). This added value is captured as a reduction in insurance premiums. This bond funds resilience-focused projects to monetize avoided losses through a rebate structure. An island community, for example, could use governmental funding from a resilience bond to invest in a battery storage system, which would have immediate resilience benefits by reducing the island's dependency on imported fuel and enabling power delivery quickly post-disaster (assuming the system was not impacted by the disaster)²².

²²Source: <https://www.nrel.gov/docs/fy20osti/74289.pdf>



Box 8.2: MultiCat Mexico, 2009 issued US\$ 290 million of 3-year bonds for emergency funding

Mexico's national government issued catastrophe bonds in 2009 and 2012 to cover earthquake and hurricane risks. The bonds were a pioneering move to help the country transfer catastrophe risk to the capital markets. The 2009 instrument, renewed in 2012, is a multi-cat programme (with a 2015 maturity). It combines risk mitigation, risk modelling, and traditional and parametric insurance to allow the government to financially prepare for disasters by transferring some of its catastrophic risks.²³ The Swiss Re Group reworked with the Mexican government and the World Bank to renew the multi-cat bond with earthquake and hurricane parametric triggers. The 2012 cat bonds totalled US\$ 290 million.²⁴ Special purpose vehicles (SPV) indirectly provide parametric insurance against earthquake risk in three regions around Mexico City and hurricanes along the Atlantic and Pacific coasts.

8.1.4 Multilateral Development Banks and bilateral assistance

MDBs such as the European Bank for Reconstruction and Development (EBRD), the World Bank and the Asian Development Bank (ADB) provide grants, loans, equity payments or guarantees for climate-related initiatives, including innovative climate resilience measures. One example of an MDB resilience fund is the Pilot Program for Climate Resilience, jointly funded by the African Development Bank (AfDB), ADB, Inter-American Development Bank (IADB), World Bank and EBRD, under the broader climate investment funds. While these funds do not have a specific focus on the power sector, they can be used for power sector resilience actions.²⁵ Also, GRIDCO would use demonstrative funds or pilot studies to increase the resilience of power infrastructure in Odisha.

Case study 8.2: Cyclone Ian, Tonga

ADB helped Tonga reconstruct the electricity network and school facilities that Cyclone Ian damaged in January 2014. The project reconstructed the leading electricity network in the Ha'apai islands to make it climate- and disaster-proof.

More than 90 percent of Ha'apai's electricity network was damaged, and fixing and upgrading it required considerable investment. Immediately after Cyclone Ian, the Government of New Zealand provided separate bilateral assistance of US\$ 1.4 million to restore power lines and connection to priority consumers temporarily. This bought time for Tonga Power Limited (TPL) to prepare a detailed plan and cost estimates for permanent repairs and climate-proofing of the affected network. At project completion, the project had the following:²⁶

²³National Symposium on Risk & Disasters Lessons from Hurricane Katrina for American Life Rebuilding the Gulf: Case Study for the Future (oecd.org)

²⁴Source: <https://openknowledge.worldbank.org/bitstream/handle/10986/26382/113894-ESMAP-PUBLIC>

²⁵Source: <https://www.nrel.gov/docs/fy20osti/74289.pdf>

²⁶Source: <https://www.adb.org/sites/default/files/project-documents/48192/48192-001-pcr-en.pdf>



- » Reconstructed the distribution network and upgraded its capacity from 6.6 kV to 11 kV
- » Reconstructed 15.2 km of high-voltage overhead bundle lines
- » Constructed 34.7 km of low-voltage overhead lines
- » Reconnected underground cables to 1,010 households and 27 commercial and government consumers

A 1.5 km high-voltage underground cable was constructed to service the new Ha'apai hospital. The project also supported the installation of 400 new streetlights and the purchasing and distributing of temporary solar lanterns and community solar chargers to 610 households on the outer islands of Ha'apai.

8.2 Alternative Source of Funding Based on the 15th Finance Commission Report

8.2.1 Reconstruction Bonds

In a post-disaster situation, state governments can issue reconstruction bonds, with a maturity of three to five years, with the approval of the union government. The resources raised by these bonds should largely be spent on constructing productive and social assets. The state government can issue the bonds with a lower yield.

8.2.2 Contingent Credit / Stand-by Facility with International Financial Institutions

The state government can request loans from international financial institutions like the World Bank, ADB and JICA to support recovery and reconstruction efforts after a disaster. These requests must be approved by the related institutions. Approvals may be based on several factors, including the cost of borrowing, knowledge transfer and organizational help.



Box 8.3: Japan International Cooperation Agency

The Japan International Cooperation Agency (JICA) is a major source of financing in India's energy sector. JICA has funded thermal and hydrogeneration capacity additions totalling 9,300 MW and transmission and urban distribution system upgrades in the states of Andhra Pradesh, Haryana, Madhya Pradesh, Maharashtra, Odisha, Tamil Nadu and West Bengal, and in the cities of Bangalore and Hyderabad.

(Source: Uttar Pradesh Power Distribution Network Rehabilitation Project: Development Coordination (adb.org))

8.2.3 Insurance and Risk Pool for Infrastructure Protection and Recovery

The government is currently viewed as the ultimate insurer, prohibiting insurance coverage for infrastructure assets vulnerable to disaster risks and may cause massive damage and loss. The restoration and reconstruction of the infrastructure following a disaster event is funded by the central and state governments, and this process needs to be improved.

To enhance the protection of infrastructure assets, a national risk pool should be established in partnership with an insurance company. This initiative would offer insurance protection to infrastructure companies in areas such as disaster risk protection, improved standards and regulations for disaster resilience, evaluation of damage and loss during a post-disaster event, and a risk pool for fund accessibility for recovery and reconstruction. The Coalition for Disaster Resilient Infrastructure (CDRI) can support these risk transfer solutions by utilizing cost-effective market mechanisms.

8.2.4 Private Sector Participation in Insurance and Reinsurance for Disaster Risk Funding in the Power Sector

Infrastructure assets are vulnerable to hazards, resulting in significant damage and loss during disasters. As governments are often viewed as the ultimate insurer, infrastructure protection typically lacks insurance coverage. When disasters occur, the union and state governments provide assistance for infrastructure restoration. However, the resources available are often insufficient for comprehensive restoration and reconstruction efforts.

India's growing infrastructure demands significant resource commitments for protection. One effective approach could be establishing a national risk pool for infrastructure in collaboration with an insurance company / private sector. Infrastructure companies nationwide could be encouraged to participate in the risk pool, providing insurance protection against risks and incentivizing investment in improved standards.



The 15th Finance Commission recommends exploring an additional layer of protection against hazard events through the international reinsurance market. This form of protection would feature a parametric structure, targeting low-frequency but high-intensity disaster events, and would offer an additional layer of security through a global risk pool. The index for such disasters could be defined based on parameters such as magnitude and severity. For instance, a significant earthquake of magnitude 8 MW or a super-cyclone could trigger insurance payouts.

Procuring such insurance protection would require obtaining market quotes. Given the infrequency of disasters and the availability of a global reinsurance pool, the premium for parametric risk protection could be cost-effective. International reinsurance companies would bid for protection based on the magnitude of the hazard and the payout. This insurance protection must remain cost-effective and cheaper than alternative forms of protection.

The union government is overseeing the implementation of the National Adaptation Fund for Climate Change to bolster the adaptation efforts of states and union territories vulnerable to the adverse impacts of climate change. As the disaster financing system evolves, there is a recognized need to diversify financial services and instruments for disaster management. While public funds play a crucial role in providing consistent support to states, it was observed that they often lag behind in availability. Hence, recognizing the significance of alternative funding sources and the potential role of market instruments in risk management is constantly emphasized.

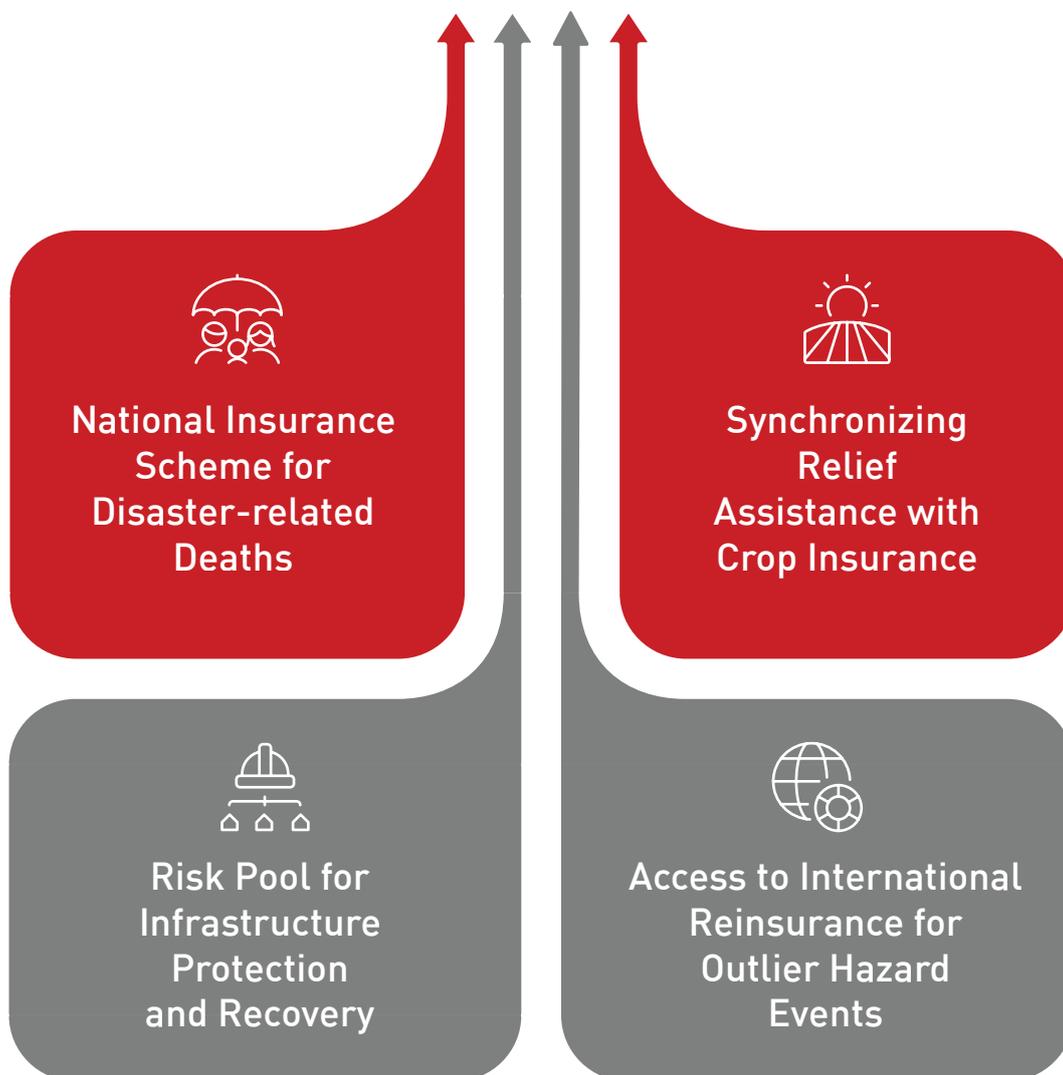
While the previous Finance Commissions in India have maintained their stance against extending insurance coverage for disasters to the entire population, the 15th Finance Commission of India argues that there is a strong case for introducing insurance and risk pooling in specific areas where market-based risk management instruments can be effectively utilized. Insurance becomes feasible and practical when there are large risk pools, adequate data on damage and loss, and the ability to estimate payouts with reasonable accuracy. The feasibility of insurance services is enhanced by an expanded risk pool, which could operate on a national or global scale, along with the ability to quantify risks through a comprehensive long-term database.

Moreover, insurance instruments are most efficient for infrequent disaster events but carry a high potential impact. The cost of response and recovery for frequently occurring disasters, happening once every five to ten years, depending on the peril, is best absorbed by public funds such as the State Disaster Response Fund and the National Disaster Response Fund. However, severe hazards occurring every ten to hundred years are more suited to be covered by insurance policies or catastrophe bonds.

In line with these principles, four insurance interventions are proposed according to the 15th Finance Commission of India, which require further feasibility examination by the National Disaster Management Authority and relevant ministries. These insurance interventions would provide an additional layer of protection to the population. They are not intended to replace existing public fund mechanisms but to supplement and reinforce them, ensuring enhanced protection for the people.



As per the 15th Finance Commission report, the four proposed insurance mechanisms are as follows:



Leveraging the insurance sector can substantially alleviate the financial burden of disaster management on households, particularly those with higher socio-economic status. The insurance industry has witnessed significant growth over the past decade, particularly following the 2015-16 increase in the limit on foreign direct investment in the sector to 49 percent under the automatic route. Major global insurance firms have established operations in India through partnerships with domestic players, introducing a wide array of life and non-life insurance services and products to the market. As household incomes rise, the Indian insurance sector is poised for robust expansion fuelled by product innovation, competitive premiums, improved claims management and enhanced regulatory oversight. Following thorough due diligence, insurance mechanisms that serve as a social safety net and complement existing financial mechanisms should be introduced in collaboration with insurance companies / private sector²⁷.

²⁷ 1) 15th Finance Commission Report, Government of India (<https://fincomindia.nic.in/commission-reports-fifteenth>)



9

Gaps and Recommendations





9 Gaps and Recommendation

9.1 Our Recommendations for Financing Resilient Recovery of Power Infrastructure in Odisha

9.1.1 Guidelines for Resilient Recovery

In India, the optimal combination of regulation and incentives (both financial and non-financial) stimulates a resilient recovery. Depending on each region's infrastructure and private sector capacity characteristics, effective government incentives can be localized.

The plans for reconstruction in highly disaster-prone areas are drawn out during normalcy. Central ministries/departments concerned, the state governments and power utility companies should create dedicated project teams to speed up the reconstruction process.

9.1.2 Disaster Risk Finance 2.0

Damage to infrastructure like buildings and plants can directly impact households and businesses, hampering economic well-being and ultimately reducing government revenue. Owing to different exposed risks, the sources of government liabilities in the aftermath of disasters vary, including fiscal transfer to subnational governments, rehabilitation of damaged assets, immediate relief and livelihood support, assistance to uninsured households, assistance to small enterprises and stabilization of the private sector. Inadequate government funds and increased expenditure result in economic disruptions, leading to increased public debt. Hence, disaster risk management must be focused.

Case Study 9.1: Adoption of the triple dividend: A comprehensive business case for resilience

The adverse impacts of climate change and extreme weather events severely threaten livelihoods and hold back growth and sustainable development. Effective disaster risk management policies and actions are often measured by their ability to save lives and reduce the number of people affected by disasters. DRM investments have been critical in reducing disaster losses in infrastructure, early warning systems and planning. Infrastructure losses often go well beyond physical damage. Business losses can result from 'ripple effects' as the impact of shocks propagates upstream (backwards) from clients to suppliers and downstream (forward) from suppliers to clients. Hence, **the investment of DRM in three dividends can help reduce the losses incurred (tangible or intangible).**

The process of **disaster risk management** includes the following:



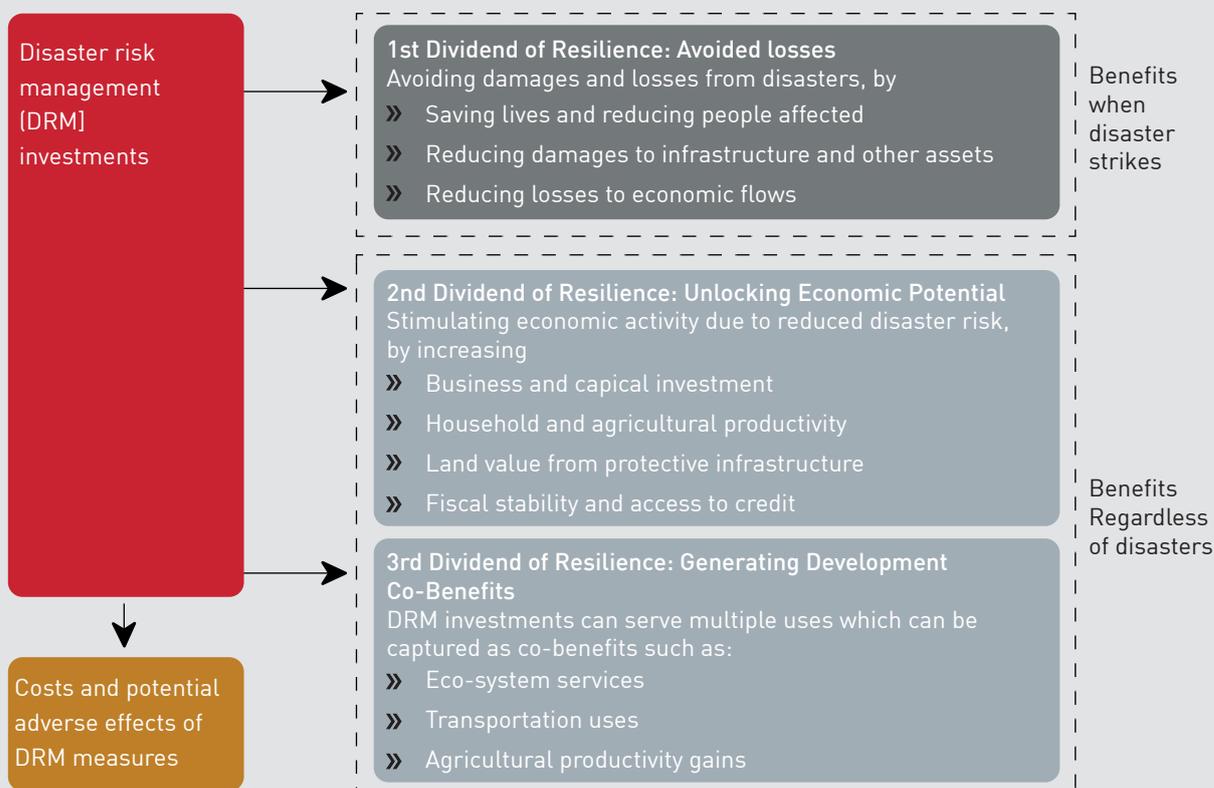
- (i) risk identification, which informs the design of other risk management actions
- (ii) reducing risk by avoiding the creation of new threats and reducing existing risks; preparing for the residual risk, either
 - a) physically (preparedness), or
 - b) financially (financial protection); and
- (iii) resilient recovery and reconstruction by building back better after a disaster.

Hence, to mitigate the implications posed by disaster risk, adoption of a triple dividend: **investing in resilience** can aid by yielding results:

1. Avoiding losses when disasters strike
2. Stimulating economic activity thanks to reduced disaster risk
3. Development co-benefits

The First Dividend (avoided losses): Investing in DRM strategies takes the form of reduced losses and damages in the event of a disaster. These losses and damages can be direct and indirect, leading to immediate and long-term effects. This corresponds to the conventional export, loss-centric view and is likely to underestimate the benefits of DRM measures.

Investing in resilience reduces losses and damages in the case of a disaster. However, it can also yield development benefits regardless of disasters. Typically, standard disaster risk management investment appraisals fail to account for the 2nd and 3rd dividends of resilience.





The Second Dividend (unlocking economic potential)

Even the possibility of a future disaster impacts present-day economic growth, particularly in regions or localities where disaster risks are perceived to be high. DRM measures help to manage this ever-present background risk of potential future disasters. Increased resilience can catalyze innovation, entrepreneurship and investment in productive assets—even if disasters do not occur long. Disaster insurance can encourage the kind of ‘positive risk-taking’ that is arguably fundamental to the development process, making investments more secure and fostering business innovation and growth.

The Third Dividend (generating development co-benefits)

DRM investments are typically associated with economic, social and environmental uses, or ‘co-benefits’. For instance, ecosystem co-benefits, social co-benefits and economic co-benefits.

Table 3: The range of co-benefits associated with DRM measures

DRM ACTIVITY	POSSIBLE CO-BENEFITS
Flood protection structures	Provision of irrigation or potable water and hydro-electric power. Dual-purpose road infrastructure
Strengthening DRM capacity of civil society	Improved governance, more organised social structures
Eco-system based DRM approaches	Environmental conservation, improved air quality, climate change mitigation
Shelters	Community facilities (e.g. clinics or schools) in non-disaster periods
Improving water supply systems in rural areas	Water supply systems improved regardless of a disaster occurring
Construction and use of drainage pipes, canals and water retention basins	Improved irrigation practices, possibly improved agricultural practices. Dual purpose road tunnel or parking lot infrastructure
Community-based disaster preparedness	Improved women's involvement in community level activities



Installing more resilient wireless communications	Enhanced access to telephony and electronic data services
Training farmers to diversify the use of crops	Reduced vulnerability to poverty
Better monitoring of food supplies	Improvement to the food supply chain, possibly making it more cost-effective

Source: Adapted from Environmental Resources Management and Department for International Development (ERM), 2005

Realizing the triple dividend of resilience involves a strategic shift, offering a different perspective on how investments can support policies and objectives beyond DRM. The approach provides an enhanced understanding of the broader economic, social and environmental implications of investing in DRM activities.

DRM is not seen as an objective in its own right-it is considered an essential lever for strategic risk management of overall development progress that reduces avoided losses and yields benefits from taking risks.

Source: https://www.gfdr.org/sites/default/files/publication/The_Triple_Dividend_of_Resilience.pdf

Hence, the same can be combated by developing financial protection strategies-a suite of policies and financial instruments-to secure access to financing before shocks and protect the fiscal balance and budget when disasters strike. Making funds more predictable ensures timely and sufficient access to funds and further improves the resilience of national and subnational governments and businesses.

The associated risk and potential disaster costs can be further mitigated by investing in structural measures such as physical construction and enhanced engineering technology and non-structural measures such as early warning and business, continuity planning, proper policy and governance.

To decrease the remedial costs associated, a coherent approach of all the three resilience must be developed (Figure 9.1):

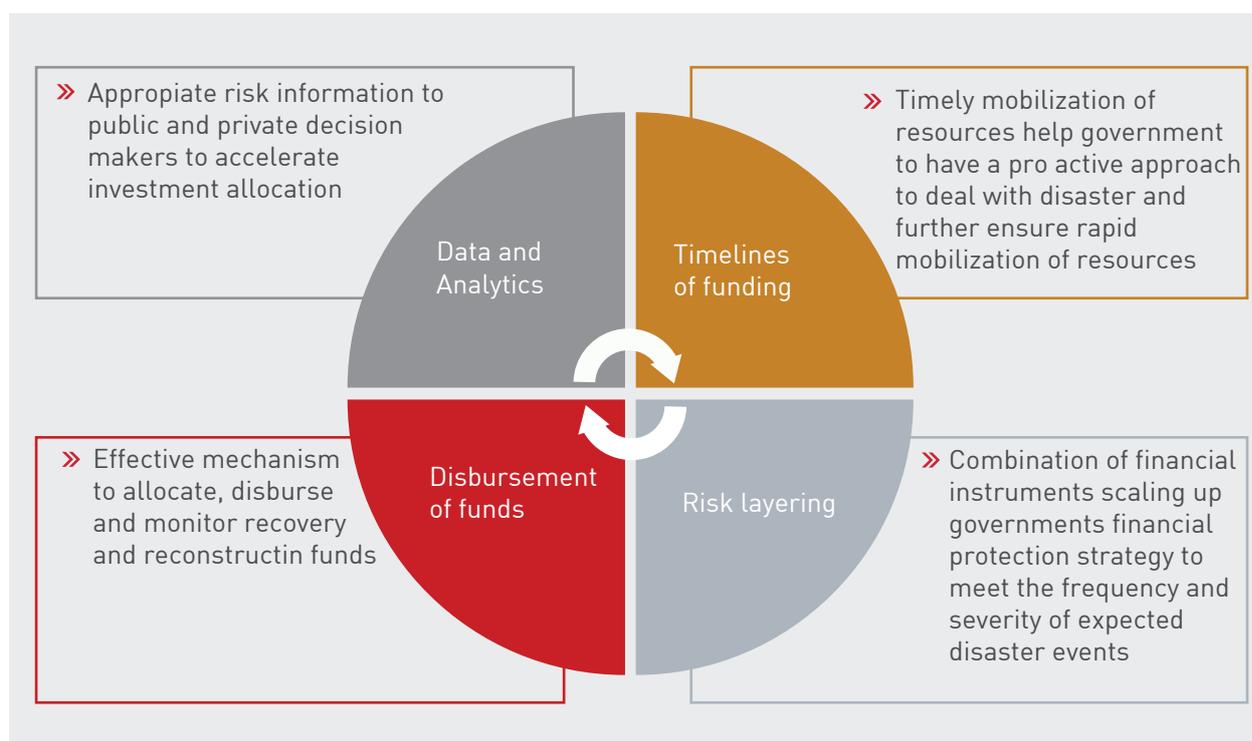
Figure 9.1: Types of resilience





Better management regarding disaster-related expenditures becomes a pre-requisite to be better prepared for disaster-related response. Integrating disaster shocks in budget planning and risk management, pre-arranging or quickly mobilizing the required resources and effectively executing these funds help mitigate the long-term financial impacts on the public budget. Efficient risk management by countries starts with efforts to strengthen the management of budgetary resources through strong public financial management processes further complemented with support from international partners and financial instruments such as insurance and financial protection strategies against disaster in place (see Figure 9.2).

Figure 9.2: Financial protection strategies against disasters



The recovery and reconstruction are often delayed due to the late mobilization of resources and funds, further negatively impacting economic activities, raising public debt, lowering sovereign ratings and potentially increasing interest expenses. Hence, to avoid disaster shocks, the government could rely on post-disaster financing instruments, including budget reallocation, borrowing, taxation and international aid. Pre-arranged risk financing instruments provide governments with immediate access to funds and mitigate the negative impact of disasters on economic activities and future fiscal costs²⁸.

²⁸World Bank Document



In Odisha, the density of the electricity network is higher in the coastal belt and industrial areas. As a result, the chance of disruption is higher in the coastal zone. The low tension (voltage) lines and DTRs (distribution transformers) and substations (11 kV, 33 kV, 33 kV/11kV) within up to 80 km of the coastal zone are at higher risk.

Four districts affected by Cyclone Amphan were within that range from the seacoast. Due to their height, the transmission lines are highly vulnerable to cyclones. These lines are vulnerable to falling trees in forest areas. In addition, low-laying substations are prone to flooding following a cyclone. Moreover, the quick supply of towers and accessibility to remote locations remain challenging for T&D organizations. Hence, it is essential to build resilient power infrastructure to avoid or minimize the chances of failure and disruptions in people's lives and to maintain emergency services.





Thematic Areas	Gaps	Recommendations
Funding Mechanisms	Inadequate funds for preparedness, mitigation and resilience building	<p>To develop ex-ante vs. ex-post disaster risk finance instruments.</p> <p>Ex ante: Ex-ante instruments are arranged before an event and can be mobilized for better preparedness and capacity building.</p>
	Post-Disaster Finance Needs	<p>Ex-post instruments are arranged after an event.</p> <p>The two should be combined to provide an effective package of instruments. Generally, there will be some scope for budget reallocations following a disaster, as planned investments in disaster-affected areas have to be postponed.</p> <p>Depending on market access and existing levels of domestic and external debt, there may also be scope for borrowing.</p>
Disaster Finance and Governance	No standardized diagnostic framework	<p>Diagnostic framework to be incorporated into the development of disaster risk finance strategies, which set out policy priorities to strategically meet post-disaster financing needs.</p> <ol style="list-style-type: none"> 1. It gives a current overview of available financial windows along with policies and institutional mechanisms for financial protection. 2. Helps identify gaps and set priorities by strengthening financing instruments of central and state governments.
Funding sources	Lack of partnership and alliance for fund mobilization specific to the power sector at the national and global level	With an alliance of global bodies, foreign aid and humanitarian organizations at the national level can generate funds specifically pertaining to the power sector.



Thematic Areas	Gaps	Recommendations
Institutional mechanisms and governance	Inadequate policies and governance	<p>Public expenditure and financial accountability assessments and public expenditure reviews are to be checked as follows:</p> <ol style="list-style-type: none"> 1. The higher the public investment management, the higher the capacity of the government to execute reconstruction projects. 2. The efficiency of social welfare expenditure and delivery mechanisms, as this relates to the government's capacity to channel relief payments through existing systems. 3. The expenditure efficiency of the various sectors through which emergency funds might be channelled.
Inclusion of new funding opportunities	Inadequate inclusion of international frameworks in risk reduction	<p>Risk Layering: Combining different instruments to protect against events of frequency and severity. Financing mechanisms can be grouped into two main categories:</p> <ol style="list-style-type: none"> 1. Retention: The government assumes and manages disaster losses through budgetary resources—e.g., budgetary reserves, post-disaster budget reallocations, or borrowing. 2. Transfer: The government transfers potential future disaster losses to financial or insurance markets by paying a premium—e.g., through traditional insurance/ reinsurance. <p>A bottom-up approach is recommended: the government first secures funds for recurring disaster events and then increases its post-disaster financial capacity to finance less frequent but more severe events.</p>



Thematic Areas	Gaps	Recommendations
Funding required	Inefficient method for estimating damages	<p>The funding gap can be derived by subtracting available disaster risk funds from the costs associated with each scenario.</p> <p>Two metrics are discussed below:</p> <ol style="list-style-type: none"> 1. A short-term funding gap analysis to assess the government's readiness to finance immediate and near-term emergency relief and early recovery costs and 2. A longer-term funding gap analysis to assess a country's ability to finance potential reconstruction needs.
Funding timelines	Undefined time horizons/periods	<p>Two aspects of timeliness are critical for financial resilience. The instrument's speed (how long it takes funds to be made available) and the instrument's timing (when those funds will be needed in the response, depending on whether they are for relief and emergency response, recovery, or longer-term reconstruction).</p> <p>To develop a plan/framework for building resilient structures based on short-term, mid-term and long-term time horizons.</p> <ol style="list-style-type: none"> 1. Short term (0-5 years) 2. Mid term (5-10 years) 3. Long term (10-20 years)
Disbursal mechanisms	Transparent and effective distribution of funds	<p>To increase accountability and transparency for public funds. Also, clear, ex-ante disbursement is needed to describe how and when funds will flow from the government to the responsible DRM, response, recovery and reconstruction ministries.</p>

Source: assessing-financial-protection-against-disasters.pdf (adb.org)

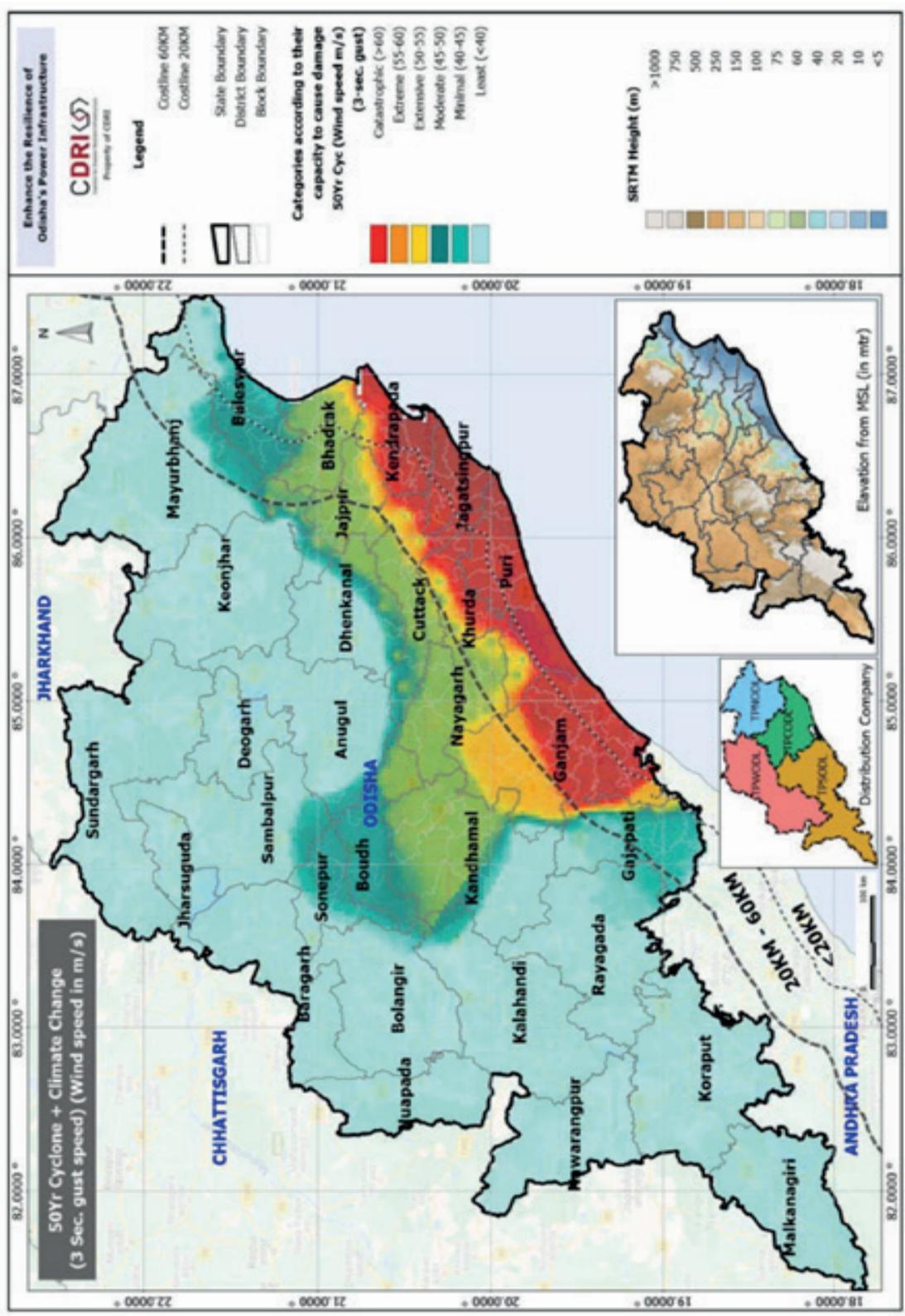
Climate and Disaster Risk Financing Instruments - UN Capital Development Fund (UNCDF)



Annexure

Annexure 1

Annexure A1: Cyclone Zonation Maps (with 50-year and 100-year return periods)





Annexure A2: Data Requested from Stakeholders

Data points requested

1. **For Task 1 Exposure assessment:** Develop an exposure dataset describing the power transmission and distribution assets for the modelling. This part would primarily come from CII.1 – Risk Assessment. From the Risk Identification and Estimation report, we need the detailed methodology part to lay down detailed asset prioritization criteria. We would be required to discuss the dataset we would take for modelling in the replacement scenarios. For example, if we take priority category 1 based on criticality and vulnerability, we must justify that in the form of proper methodology and explanation of the dataset.
2. **For Task 2, Conduct Probabilistic Risk Analysis:** We need to assess the 'Base' cyclone and flood risk - risk analysis of the 'base' exposure dataset of power transmission and distribution assets by PRDC. The impact for the base year projected for a timespan should be put forward regarding the quantum of infrastructure to be plausibly damaged.
3. **In addition, we would need the schedule of rates for damage assessment of the base risk and the replacement technology for disaster resilience type and cost.**

Information required from GRIDCO

1. How is the allocation by ministries and departments under Section 49 of the Disaster Management Act for disaster management activities? Funds released under SRC are disbursed to power infrastructure projects and stakeholders in Odisha.
2. What is the role of SDMA and OSDMA in the financial disbursement to the power sector in Odisha?
3. What is the role of GRIDCO and OERC in the financial allocation for disaster management via the state funds to DISCOMs/OPTCL?
4. Can you please list the expenditure GRIDCO has approved on the lines of the categories listed below as part of their approved expenditure for the last three financial years? *
 - i. Mitigation (structural and non-structural components)
 - ii. Capacity building (training programmes, mock drills, and IEC material)
 - iii. Procurement (materials and resources)
 - iv. Total expenditure allocation (as % of annual budget)



5. Can you please shed light on some of the recent recommendations GRIDCO has put forward as the steps needed to infuse disaster resilience into the ministry?
6. GRIDCO is engaged in bulk purchasing and selling power to the four distribution companies inside the state and trading surplus power through traders to promote power exchange with neighbouring states. Does it have any role to play in situations of restoration of power supply in cases of disaster by coordinating with other states?

Annexure A3: Accounting Norms and Standards for Central and State Disaster Funds

1. It is mandated that the state transfer its share towards SDRF and SDRMF along with the Union's share received by them promptly into the public account. Any lapse in timely transfer results in inadequate funds available to the state and affects the mobilization of funds during Additional Central Assistance (ACA) from NDRF to undertake disaster response and reconstruction during a post-disaster activity.
2. The Ministry of Home Affairs, in consultation with the Department of Expenditure in the Ministry of Finance, will open new accounting heads with operational guidelines and norms for the SDRMF and NDRMF. Some of the heads are as follows:
 - i. MH 1601 – Grants in Aid to State Government
 - ii. MH 2245 – Relief on Account of Natural Calamities
 - iii. MH 3601 – Grants in Aid to State Government
 - iv. MH – 8121 – General and other Reserve Funds under Reserve Funds Not Bearing Interest should be opened before the first instalment of 2021-22 for SDRMF and NDRMF is released.
 - v. The CGA and Dept of Expenditure ensure that these accounting norms are adhered to, and the CAG can appropriately review the adherence to prescribed accounting practices.
3. The Ministry of Home Affairs, Disaster Management Division
 - A. DM-1 Section handles the information related to
 - i. Resource Mobilization for Response and Relief for Natural Disasters
 - ii. Matter relating to the State Disaster Response Fund
 - iii. Matter pertaining to the National Disaster Response Fund



- B. DM-3 Section handles the information related to
 - i. Disaster mitigation programmes and projects,
 - ii. Gol – UNDP and Gol – USAID programme on disaster risk management
 - iii. Post-disaster / long-term rehabilitation and reconstruction measures
 - iv. International cooperation / matters relating to disaster mitigation and reconstruction, including foreign deputation cases
 - v. Capacity building of communities in disaster management under different central sector schemes

- 4. As per the current practice, 50 percent of the available balance under SDRF as of April 1 of a financial year, as reported by the Accountant General of the State, is adjusted while calculating the requirement of ACA from the NDRF during severe calamities.

- 5. While calculating ACA under NDRF, the first charge should be on the SDRF during a severe disaster.

- 6. The ratio of contribution by Union and States to the state-level allocation for disaster management; as such, Odisha is to contribute 25 percent of funds of SDRF and SDMF, while the rest are to be provided by the union government.

- 7. All the central assistance through the NDRF and NDMF is provided on a graded cost-sharing basis; States should contribute 10 percent for aid up to INR 250 crores, 20 percent for assistance up to INR 500 crores and 25 percent for all assistance exceeding INR 500 crores

- 8. The access of central assistance to the states is based on a two-stage assessment.
 - A. Humanitarian needs assessment for response and relief assistance.
 - B. Post-disaster needs assessment (PDNA) for recovery and reconstruction needs

- 9. For the power sector, as per the Power Finance Corporation Guidelines,
 - A. The disaster resilient infrastructure works as specified in the disaster management plan for the power sector issued by Central Electricity Authority in January 2021 and its future amendments, if any and the disaster resilient works specified by the National Disaster Management Authority (NDMA) allowed for financial assistance.



- B. The DISCOMs can submit the disaster resilient works as a separate component in the Detailed Project Report (DPR) for consideration of sanction along with DPR for loss reduction or with DPR for modernization and system augmentation.
- C. The national nodal agencies are REC and PFC for the fund mobilization, guidelines, appraisal, evaluation, loan administration and project implementation under the overall guidance of the monitoring committees with power as per OM No 20/9/2019-IPDS dt.20.7.21.
- D. The state government cabinet approves the action plan under the loan scheme at the state level. It furnishes a guarantee for the loan component in case DISCOMs cannot provide any other mode of security.
- E. At the state level, the Distribution Reforms Committee (DRC) is chaired by the Chief Secretary, Secretary in charge of the Energy/Power Dept of the State Convener with the committee members like the Secretary of Finance, Secretary of Land Revenue, and Secretary of Forest and Environment, with responsibilities,
 - i. Recommends the action plan for approval of the state cabinet
 - ii. Recommends the DPRs for approval of the monitoring committee
 - iii. Monitors the implementation of the action plan and physical and financial progress, including the quality of the projects



Annexure A4: Infrastructure Damages to Power Sector

Power Infrastructure	Cyclone					
	Phailin (2013)	Hudhud (2014)	Titli (2018)	Fani (2019)	Bulbul (2019)	Amphan (2020)
Feeders (no)	1756	-	-	-	-	-
Sub Station (no)	38997	-	-	-	-	-
LT line (in km)	36133.9	1088.75	1968.5	-	-	-
EHT Line (in km)	4074	-	-	-	-	-
Electrical Poles (no)	211014	-	-	-	-	-
EHT Towers (no)	93	-	-	-	-	-
33 kV lines (in km)	-	239.95	176.7	6078	-	-
11 kV lines (in km)	-	2155.99	903.46	-	-	-
Distribution transformers (no)	-	1754	2598	12042	126	1119
Power transformers (no)	-	8	-	26	1	-
LT line poles (no)	-	-	10415	-	-	17694
Conductor up to 11 kV (in km)	-	-	-	107132	-	-
33 kV line poles (no)	-	-	1077	16715	-	2016
11 kV line poles (no)	-	-	7462	202690	1523	13800
220 kV/132 kV tower and lines	-	-	-	-	-	-
VCB, insulators, switches, lightning arrestors, etc.	-	-	-	-	-	-
Conductor (HT/LT) (in km)	-	-	-	-	336	-
Feed Transformer (no)	-	-	-	-	-	4
33 kV conductor (in km)	-	-	-	-	-	388.02
33 kV VCB (no)	-	-	-	-	-	26
11 kV conductor (in km)	-	-	-	-	-	3624.443
11 kV VCB (no)	-	-	-	-	-	68
LT line conductor (in km)	-	-	-	-	-	2821



Annexure A5: Economic loss due to infrastructure damage to Odisha power sector

Power Infrastructure	Cyclone								
	Phailin (2013)	Hudhud (2014)	Titli (2018)	Fani (2019)	Bulbul (2019)	Amphan (2020)			
Feeders	Individual costing is not available. Consolidated costing: INR 104814 lakhs	Individual costing is not available. Consolidated costing: INR 10435 lakhs	Individual costing is not available. Consolidated costing: INR 13303.18 lakhs	-	-	-			
Substation				-	-	-			
LT Line				-	-	-			
EHT Line				-	-	-			
Electrical Poles				-	-	-			
EHT Towers				-	-	-			
33 kV Lines				104814	10435	13303.18	2450	-	-
11 kV Lines				lakhs	lakhs	lakhs	-	-	-
Distribution Transformers							12042	135.62	1119
Power Transformers							1777.36	65.33	-
LT Line Poles							-	-	707.76
Conductor up to 11 kV							53565.51	-	-
33 kV Line Poles							668.6	-	80.64
11 kV Line Poles							8107.6	86.36	552
220 kV/132 kV Tower and Lines							9100	-	-
VCB, Insulators, Switches, Lightning Arrestors, etc.							28266	-	986.93
Conductor (HT/LT)							-	338.75	-
Feed Transformer							-	-	273.44
33 kV conductor							-	-	194.01
33 kV VCB							-	-	153.4
11 kV conductor				-	-	1812.22			
11 kV VCB				-	-	224.4			
LT Line conductor				-	-	1410.5			
Total in Lakhs	104814	10435	13303.18	115977.07	626.05	7514.3			



Annexure A6: Case Studies

Enhancing the Resilience in Power Infrastructure - Reconstruction Projects, Odisha Government

A. Odisha Power System Emergency Assistance Project (OPSEAP)

This project was formulated based on the Joint Rapid Damage and Needs Assessment (JRDNA) undertaken by the Asian Development Bank (ADB) and the World Bank²⁹ in the aftermath of Cyclone Phailin. The scope under OPSEAP³⁰ initially included repairs, strengthening and rehabilitation of substations, transmission and distribution lines, replacement of other associated damaged equipment or their augmentation and supplementary works in the power infrastructure for areas in and around Brahmapur, Chhatrapur and Gopalpur of the Ganjam district. Consequently, the scope of the project was broadened, with the main objectives of the project being as follows:

- i. To build a power supply distribution network resilient to the Super cyclone with a wind speed of 350 kmph, with a design distribution network infrastructure adequate to take care of load growth for the next 10 years and create the same for catering load growth of 5 years.
- ii. The objective further aimed to elevate the outdoor infrastructure above the defined flood levels and additionally carry out the deployment of modern techniques in power distribution such as GIS, Compact Substations, Intelligent Remote Monitoring tools/technology, etc. and SCADA implementation. To further implement the town-specific implementation of essential installations and create restoration cells.
- iii. As per the Government of Odisha's decision, the project and transmission system upgrade would have been primarily funded by the Asian Development Bank (ADB) through OPSEAP, and the state government would finance the rest. The total project cost was slated to be INR 1,000 crores. (Transmission system – INR 414.55 crores and Distribution system - INR 585.45 crores).
- iv. The loan assistance from ADB was limited to US\$ 100 million, i.e., INR 615 crores of INR 61.5 (per dollar) inclusive of transmission upgradation cost, and the balance amount of INR 385 crores was to be funded by the state government. However, the ADB loan would not be available for the smart grid and solar PV projects, which the state government would fund. The state has kept a budgetary provision of INR 250

²⁹<https://ncrmp.gov.in/wp-content/uploads/2014/03/Odisha-Phailin-report-Final.pdf>

³⁰<https://www.adb.org/sites/default/files/project-document/80285/47379-001-earf.pdf>



Enhancing the Resilience in Power Infrastructure - Reconstruction Projects, Odisha Government

The project was proposed by the Government of Odisha for the reconstruction of power sector infrastructure following Cyclone Amphan. This initiative is part of broader mitigation measures that include various activities³¹:

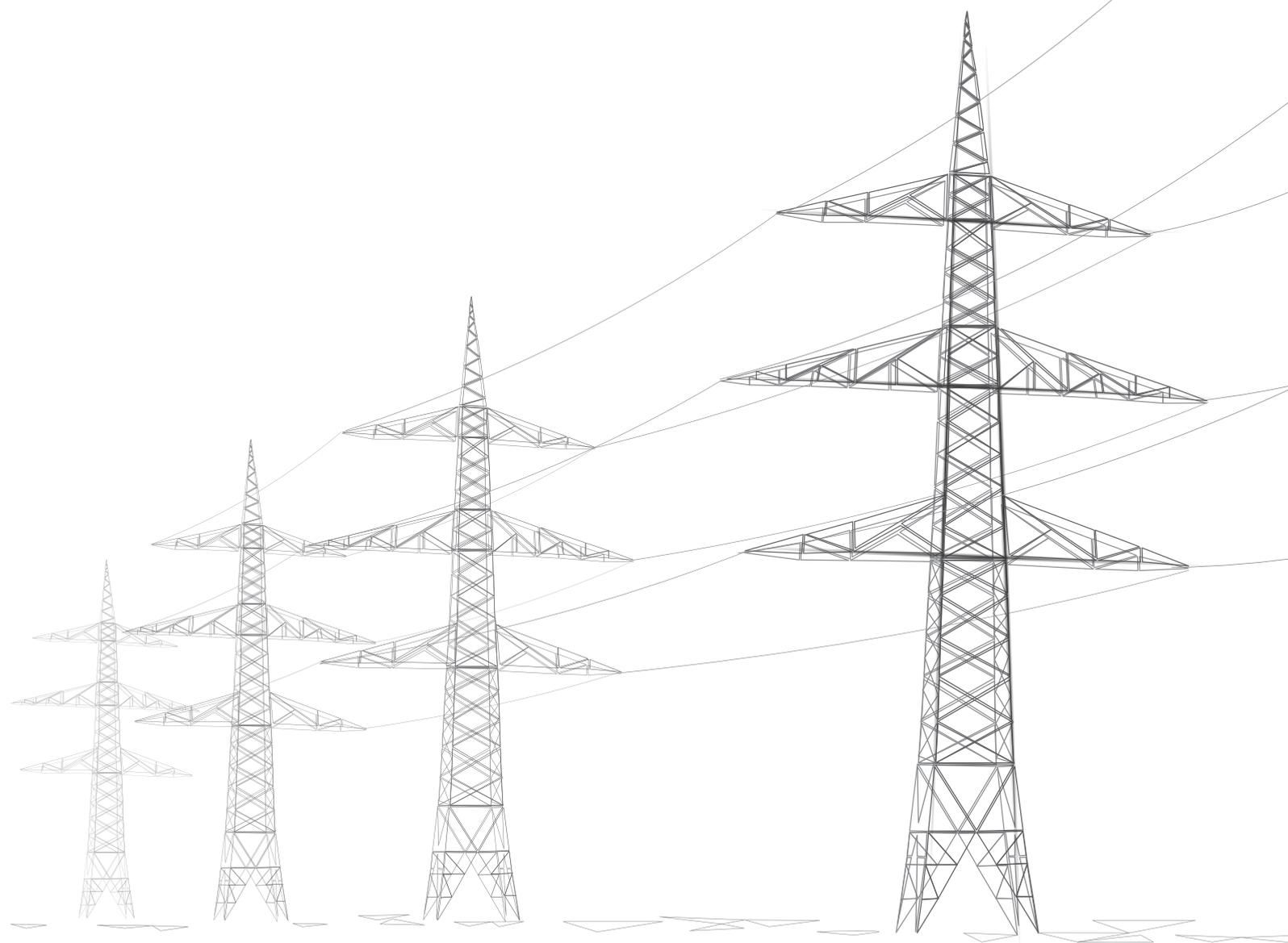
- i. Renovation/reconstruction/conversion of 33 kV lines with NBLs/H-Type GI poles. Further conversion of 33 kV, 11 kV and LT overhead lines to UG cabling system in urban areas with 11 kV RMUs and CSS in UG cabling system.
- ii. It aimed to develop material banks for preparedness during cyclones and disaster response equipment. The proposed network design is being implemented nationwide and is a proven technology. This has many advantages over the conventional design apart from cyclone resilience, like ensuring power supply restoration within very little time immediately after such a disaster in the future. The designed infrastructures are fully robust and highly resilient to any extreme climate and wind pressure during cyclones.
- iii. Since the equipment will be installed near the coastal region, deterioration due to the saline effect is a prime concern. This is taken care of while designing the equipment specifications.
- iv. The proposed network ensures reliability during exigencies and will meet demand growth over the next ten years, resulting in negligible loss of public property after this one-time investment. This T&D loss will be reduced, improving the quality of power in the region and ensuring the safety of life and property and zero accidents
- v. Urban areas will become wireless, improving public conveniences and reducing disruption besides aesthetic values. The overall improvement in electricity supply reliability will enable the continuity of other emergency services during or in immediate post-disaster situations.

³¹https://www.srcodisha.nic.in/calamity/Memorandum_Cyclone%20FANI_3rd%20May%202019.pdf



Table A1: Abstract of estimate (In crores INR)

Scope of Work	NESCO	TPCODL	OPTCL	Total (Cr)
33 kV and 11 kV lines and DT material bank	3997.36	2609.35	0.00	6606.71
UG cabling substation renovation	75.03	85.20	79.39	239.62
	1523.00	633.00		2156.00
	118.00	74.00		192.00
132 kV and 220 kV lines	0.00	0.00	1765.00	1765.00
Disaster response equipment	0.00	0.00		154.35
Grand Total	5713.39	3401.55	1844.39	11,113.68





Case study: Reconstruction Needs Assessment and Funds (The Philippines)

Financial assessment of reconstruction is generally for the long term (3 years and more) and intended to build a resilient structure. Reconstruction activity includes short-term credit for the reconstruction of affected structures, machinery procurement, structural retrofitting, equipment replacement and relocation of the plant to safe areas.

Table A2: Summary of recovery and reconstruction needs in the power sector³²

S. No	Needs	Type and Amount of Assistance Needed (PhP)				Total Needs (PhP)	Annual Needed Amount of Assistance (PhP)				Total Needs (PhP)	Proposed Source of Funds
		Grant		Credit			Disaster Year	Year 1	Year 1	Year 3 and beyond		
		Public	Private	Public	Private							
	Recovery Needs											
1	Urgent repair or replacement of equipment and machinery											
2	Interconnection											
3	Procurement of vital supplies											
4	Cleaning operations											
5	Others (Specify)											
	Total Reconstruction Needs											
1	Replacement or reconstruction of affected structures											
2	Procurement of equipment and machinery											

³²<https://ipdnaph.com/index.php/guidance-notes/90-guidance-notes-x-power-sector>



3	Technical assistance																			
4	Relocation																			
5	Others (Specify)																			
Total																				
Grand Total																				

- » The reconstruction needs under the ‘credit’ column commonly refer to the assistance extended to damaged facilities owned by the private sector and are expected to be repaid over time. If the government extends assistance to the private sector without repayment required, the amount of the aid should be under the ‘grant’ column.
- » Government-owned facilities are assumed to be financed by the government without repayment. As such, the amount should be under the ‘grant’ column. However, if the government will fund the needs of profit-earning firms through credit, the amount should be placed in the credit column.
- » Fund Sources – Calamity loan, Quick Response Fund, National DRRM Fund, existing funds that can be re-directed to the present needs, grants from international development partners, private sector donations, and additional government budgets and/or foreign loans.

Subsidies from the national government and NEA calamity loans could be considered as financing sources to procure necessary funds for the recovery work of disaster-damaged ECs. To receive subsidies from the national government, damaged ECs must submit calamity grant requests. NEA is intermediating the subsidy request procedure by, for example, verifying that the amounts that ECs apply for in their damage reports are consistent with their actual needs. On the other hand, NEA has a loan programme, ‘Calamity Loan’, for calamity-affected ECs, supporting them via financial assistance for their service restoration and doing so with concessional lending terms, such as lower interest rates. The overview of the calamity loan is shown in Table A3³³.

³³<https://openjicareport.jica.go.jp/pdf/12247862.pdf>



Table A3: Overview of NEA'S Calamity Loan³⁴

Objective	For the repair of distribution lines and restoration of power in the coverage areas damaged by typhoons and other calamities
Amount	Evaluated cost, subject to availability of funds
Terms	<p>(Subsidy funded)</p> <ul style="list-style-type: none">• Interest rate: 3% per annum• Payable in 10 years• Grace period: Maximum 1 year <p>(IGF funded)</p> <ul style="list-style-type: none">• Interest rate: Lower by 50% of the prevailing NEA lending rate (3.25% as of this study's implementation)• Payable in 10 years• Grace period: Maximum 1 year
Requirements	<p>Board resolution</p> <ul style="list-style-type: none">• Budget request• Bill of materials• Information on cost of repairs• Damage report / restoration report• Photo

³⁴<https://openjicareport.jica.go.jp/pdf/12247862.pdf>



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