GRIDCO
Empowering Odisha

CDRI
Coalition for Disaster Resilient Infrastructure

Policy Brief

Lessons from Odisha

Developing power sector resilience to extreme weather events in coastal areas

Section 1 Introduction

More than 75 percent of India's coastline is susceptible to extreme weather events like cyclones and tsunamis, the most vulnerable being the eastern coastal states of Tamil Nadu, Andhra Pradesh, Odisha and West Bengal[1]. The 1999 Super Cyclone was one of the most powerful cyclones ever documented. It resulted in the deaths of nearly 10,000 people and triggered a paradigm shift in Odisha's disaster management preparedness. Similarly, in 2019, Cyclone Fani, the strongest cyclone since Phailin in 2013, landed near the pilgrimage town of Puri in Odisha (see Figure 1). Climate change has increased the frequency and intensity of these catastrophic events. These extreme weather events severely affect critical infrastructure, including power systems, transportation networks, healthcare facilities and water supply systems. Power infrastructure in coastal regions is particularly vulnerable. The damaging impact of extreme weather events on power plants, substations and transmission lines can lead to prolonged power outages, crippling the delivery of electricity to homes, businesses, and essential services such as hospitals and emergency response units. This hampers disaster response efforts and slows down recovery and rehabilitation, exacerbating the impact on lives and livelihoods. Associated heavy rain and waterlogging degrade the ability to operate and maintain the power network. Repeated damage requires frequent repairs and upgrades, increasing maintenance costs and posing long-term challenges to energy security and resilience.

The same year, Odisha became the first state in India to establish a state disaster management authority. Today, Odisha is considered a leader in cyclone preparedness and management in the country. Within the power sector, in particular, numerous innovative strategies to manage the impact of natural hazards and enhance disaster resilience have been developed and implemented based on the state's past experience.

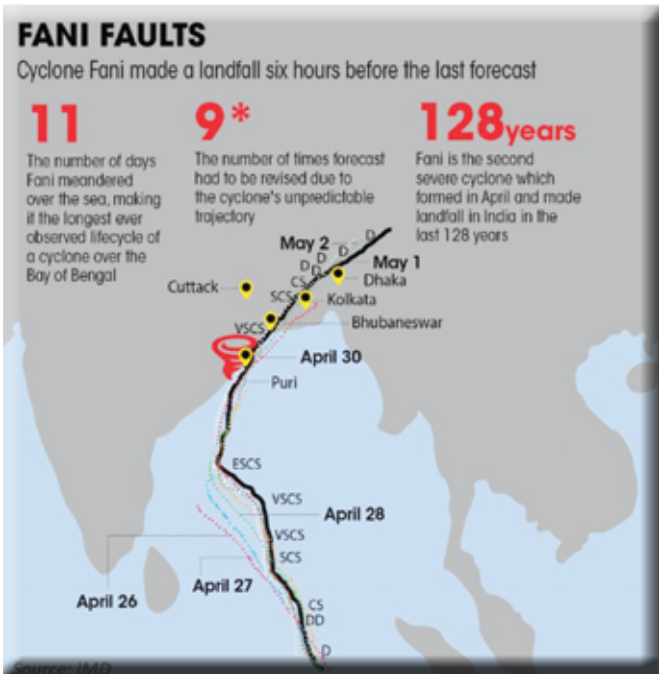
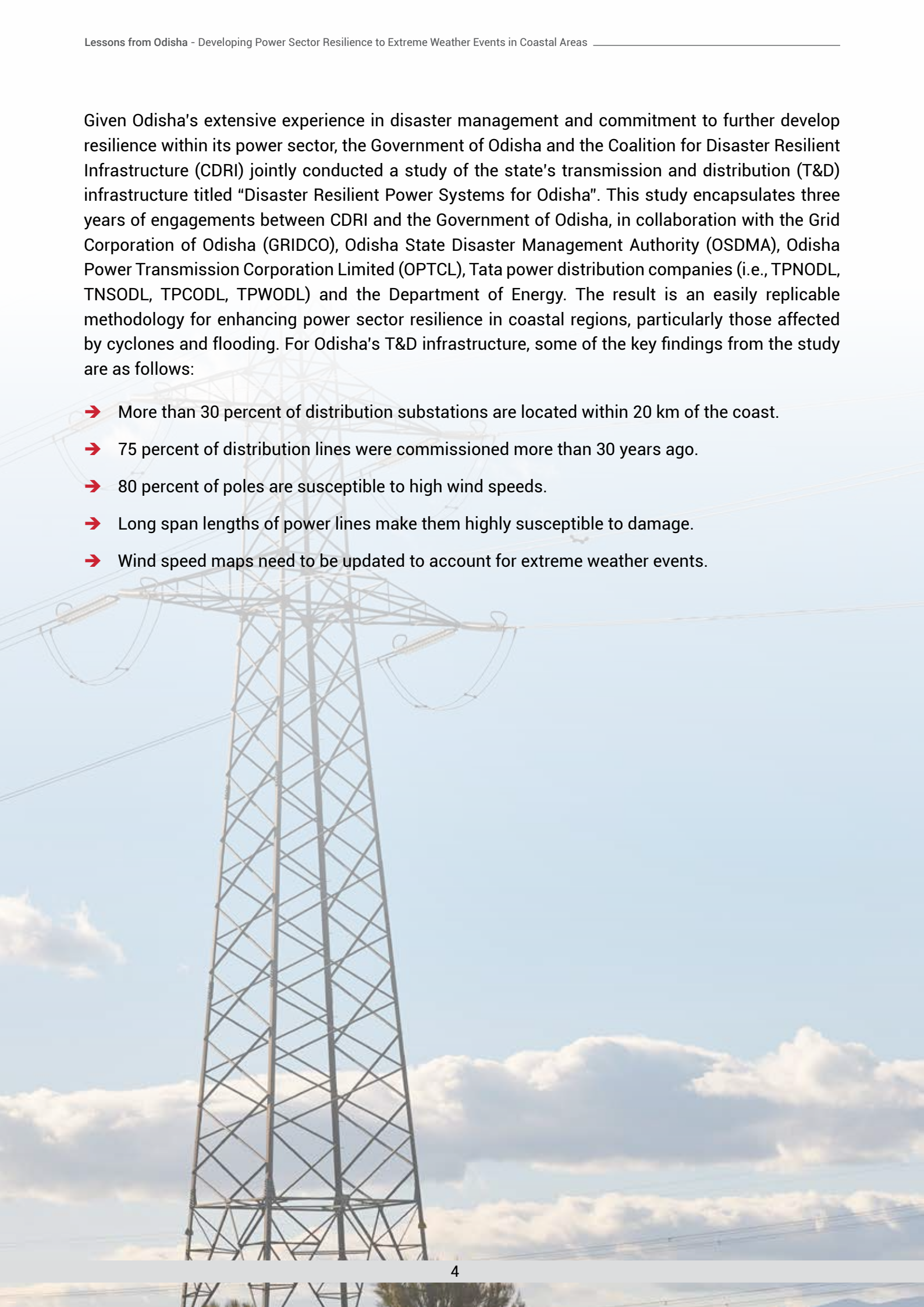


Figure 1: Cyclone Fani and its impact over the Bay of Bengal
Source: Indian Meteorological Department (IMD)

1 Central Electricity Authority, 2021

Given Odisha's extensive experience in disaster management and commitment to further develop resilience within its power sector, the Government of Odisha and the Coalition for Disaster Resilient Infrastructure (CDRI) jointly conducted a study of the state's transmission and distribution (T&D) infrastructure titled "Disaster Resilient Power Systems for Odisha". This study encapsulates three years of engagements between CDRI and the Government of Odisha, in collaboration with the Grid Corporation of Odisha (GRIDCO), Odisha State Disaster Management Authority (OSDMA), Odisha Power Transmission Corporation Limited (OPTCL), Tata power distribution companies (i.e., TPNODL, TNSODL, TPCODL, TPWODL) and the Department of Energy. The result is an easily replicable methodology for enhancing power sector resilience in coastal regions, particularly those affected by cyclones and flooding. For Odisha's T&D infrastructure, some of the key findings from the study are as follows:

- More than 30 percent of distribution substations are located within 20 km of the coast.
- 75 percent of distribution lines were commissioned more than 30 years ago.
- 80 percent of poles are susceptible to high wind speeds.
- Long span lengths of power lines make them highly susceptible to damage.
- Wind speed maps need to be updated to account for extreme weather events.



Section 2 Study Objectives and Methodology

Study Objectives

The study aimed to explore disaster resilience strategies for the power sector, specifically T&D infrastructure, against cyclones and floods, focusing on the measures undertaken by Odisha. A major objective of the study was to showcase replicable practices for coastal regions confronting comparable challenges. The study was undertaken in two phases:

1. Phase I comprised

a. Developing and implementing preparedness mechanisms; preventing grid collapse; assessing losses; estimating needs and ensuring timely funding for disaster-affected areas to facilitate early restoration and resilient recovery

b. Community engagement efforts

2. Phase II comprised:

a. Assessing risk identification and estimation, codes, standards, regulations, technology, and innovation

b. Developing risk-based governance and policy, capacity building and knowledge management, and financial preparedness and adaptation

The study examined the state's T&D infrastructure based on 16 asset-level indicators and an easy-to-adopt methodology comprising cyclone zonation, flood zonation, exposure analysis and vulnerability analysis. The study mapped and assigned vulnerability scores to the T&D assets within 60 km of Odisha's coast and developed a prioritization matrix to maximize the impact of future resilience strategies.

Study Methodology

This study's methodology is outlined in **Figure 2**.

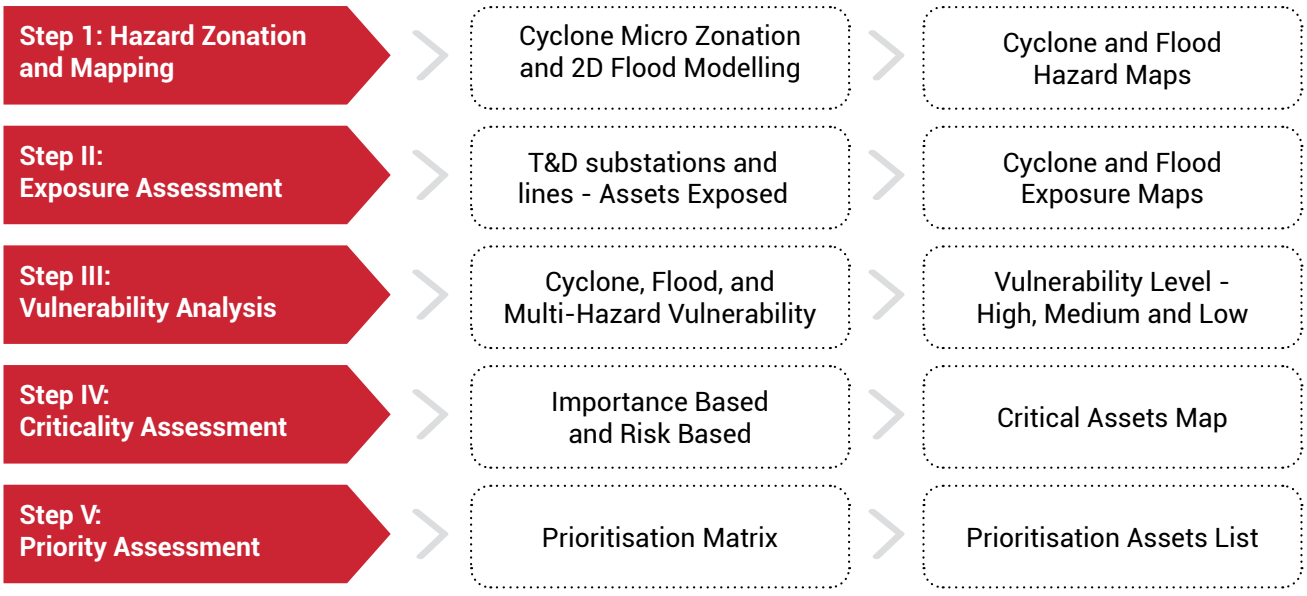


Figure 2: Study Methodology for Odisha's T&D Infrastructure

An indicator-based method was used to evaluate the risks to power infrastructure. The 16 indicators include the type of supply source, failure history during past cyclones, and building standards and design specifications **(see Figure 3)**.

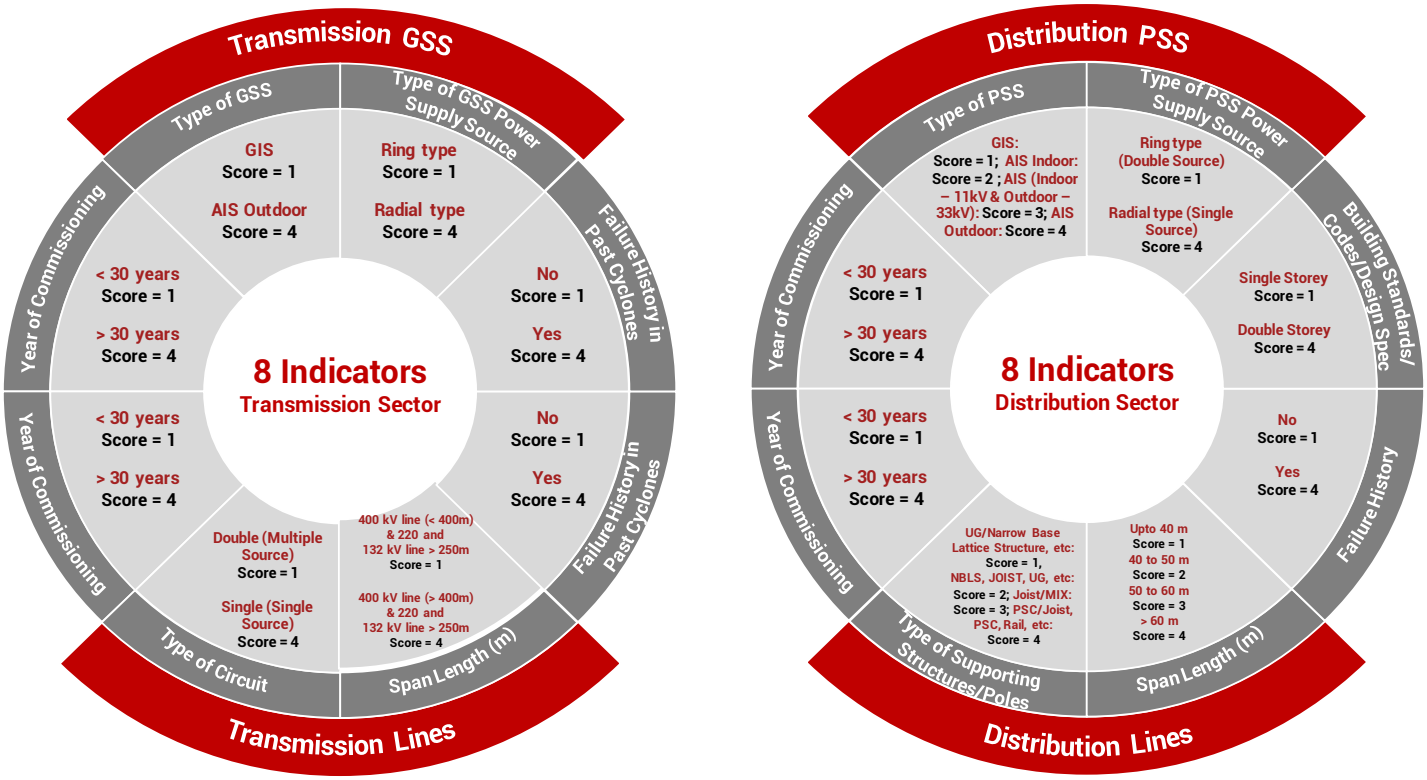


Figure 3: Asset-level Indicators for Odisha's T&D Infrastructure

Having identified which infrastructure assets were most at risk, a prioritisation of the T&D assets was carried out **(see Table 1)**. This approach is useful for cyclone- and flood-prone coastal geographies, helping identify a broad range of disaster risks and aiding governments and policymakers in determining the necessary steps for investments, risk-based governance and capacity building.

DISOM		TPCODL	TPNODL	TPSODL
Priority 1	33 kV	52	71	34
	11kV	138	144	146
	PSS	18	5	2
Priority 2	33 kV	62	59	59
	11kV	333	133	137
	PSS	59	62	46
Priority 3	33 kV	45	34	26
	11kV	91	101	92
	PSS	74	44	39
Priority 4	33 kV	199	62	13
	11kV	0	0	24
	PSS	171	115	20

Section 3 Policy Recommendations

Part A
Resilience in Numbers: Climate-Risk Data, Codes and Standards

This section outlines the necessary frameworks and tools to collect and manage climate-risk data to ensure that building standards and codes account for moderate and extreme climate change scenarios. Data is essential to understanding risk and enhancing the resilience of any system and is crucial for wind zonation maps, regulations and policies, and cross-sectoral data frameworks. In cyclone-prone coastal regions, high-intensity winds lead to failures in transmission lines and towers, requiring robust design frameworks.

Most recently, the 2022 Central Electricity Authority (CEA) Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations included recommendations such as using the updated wind zone map of the Bureau of Indian Standards (BIS) National Building Code SP 7 2016, introducing the K4 factor and modification, and changing the reliability level and drag coefficient. Reports from CEA expert committees and task forces highlighted the significance of considering wind factors in design, especially in cyclone-prone areas.

Recommendation 1: Enhance Codes and Standards for Wind Zonation in Odisha

➔ **Update Building Codes and Standards for T&D Infrastructure:** There is a need to update building codes and standards that are crucial for constructing new infrastructure and renovating existing ones to account for changes in wind speeds and other moderate and extreme climate change scenarios.

- Current codes and standards that do not reflect current and projected climate conditions can lead to ineffective designs in cyclone- and flood-prone coastal regions. Ensuring that materials, design, installation and maintenance of T&D infrastructure adhere to the latest standards, such as those outlined by the BIS and CEA, is essential for maintaining the integrity and reliability of power infrastructure.

➔ **Update Wind Zonation Maps and Install Anemometers at Substations:** This will ensure the regular updating of wind zonation maps to reflect the most recent and localized meteorological data.

- It is suggested that the installation of anemometers at substations is made mandatory to collect real-time wind speed data, enhancing the accuracy of wind maps. This data is recommended to be integrated with the IMD post-1990 data to provide a comprehensive understanding of localized wind conditions during cyclones. By updating wind zonation maps and utilizing real-time data, infrastructure design parameters can be significantly improved, ensuring that the power infrastructure is built to withstand the impact of extreme weather events.

Recommendation 2: Improve Forecasting through Data Access Platforms

- ➔ **Track Historic Data for Enhanced Systemic Resilience:** Tracking historical disaster occurrences over the past two decades will help identify trends, patterns and vulnerabilities, enabling policymakers to allocate resources more effectively and develop informed disaster risk reduction policies.
- ➔ **Create Data Access Platforms for Physical Climate Risks:** Such platforms would facilitate clear communication and collaboration with disaster management authorities and regulators, providing diverse and standardized physical climate-risk data sets for impact-based forecasting. This approach would play a pivotal role in supporting decision-makers, especially in formulating informed post-disaster needs assessments, recovery, and reconstruction plans, and ensuring the power infrastructure can withstand extreme weather events.

Part B
Strategic Resilience: Risk-Informed Governance for the Power Sector

These recommendations focus on risk-based governance and policy development, emphasizing the need for cross-sector and inter-agency collaboration to integrate resilience into planning and partnerships. It is suggested that physical climate risk-based policy measures be developed to bolster disaster resilience in the power sector, specifically for T&D assets in coastal regions. These measures would entail informed decision-making based on a top-down policy approach to ensure effective operations and maintenance.

Recommendation 3: Include "Resilience" Component: Policy-focused Strategies for Disaster-Resilient T&D Infrastructure

- ➔ **Incorporate "Resilience" Component across Policy Frameworks, including Non-Structural Measures:** The "resilience" component is suggested be mandatorily integrated into policy frameworks across all sectors, including financing mechanisms, data management departments, standard-setting bodies, and training and capacity-building institutions. The non-structural measures are recommended to include recovery measures to address the lack of financing mechanisms for disaster resilient infrastructure.

Recommendation 4: Develop a Cross-Sectoral Framework for Stakeholder Collaboration

- ➔ **Develop Cross-Sectoral Framework for Enhanced Stakeholder Collaboration:** The study highlights the necessity of bringing together regulators, Original Equipment Manufacturers and other power sector practitioners to actively participate in the policymaking process alongside standard-setting bodies and disaster management authorities.

Recommendation 5: Leverage Partnerships for Development

- ➔ **Leverage Partnerships across Similar Geographies:** The study methodology can serve as a global model, enabling regions to collaborate effectively and secure disaster-resilient power infrastructure together. Therefore, it is recommended to leverage partnerships among coastal regions facing similar challenges to the power infrastructure.

Recommendation 6: Partnering for Training and Capacity Building Initiatives

- ➔ **Develop Distinct Training Modules with Hands-On Training Sessions:** Training and capacity building, along with knowledge management, form a crucial part of the preparedness strategy in the face of extreme weather events. Therefore, developing distinct training modules with instructional content for hands-on training sessions is necessary to educate trainers in disaster management and risk reduction, equipping them with the necessary knowledge and skills.
- ➔ **Implement Training Programmes for Effective Disaster Preparedness:** Establishing clear guidelines for disaster management training and separating overarching policies from practical training modules ensures clarity and effectiveness in training initiatives. Therefore, implementing training programmes conducted by master trainers, targeting government officials, executives and relevant stakeholders, ensures that key decision-makers have the necessary knowledge and skills for effective disaster preparedness and response.

Part C
Enhancing Resilience: Innovative Financing Solutions for Adaptive Preparedness

These recommendations focus on financial preparedness and adaptation, advocating for investment mechanisms to fund disaster resilience and preparedness within the power sector. Introducing a grant component into the existing financial landscape would address emerging needs and bolster financial readiness for extreme weather events at the state level. Partnerships with the private sector could establish grant components focusing on disaster risk financing and reduction. These collaborations, including insurance, reinsurance, and catastrophe (CAT) bonds, offer innovative funding mechanisms, ensuring community recovery and supporting critical infrastructure development.

Recommendation 7: Integrate Risk Assessments into Financial Planning

- ➔ **Leverage Innovative Insurance Mechanisms:** Insurance firms have introduced a wide array of life and non-life insurance services and products to the market in India. With rising household income, the Indian insurance sector is poised for robust expansion fueled by product innovation, competitive premiums, improved claims management and enhanced regulatory oversight. To capitalize on this potential, thorough due diligence can be conducted and insurance mechanisms that serve as a social safety net and complement existing financial mechanisms is suggested to be introduced in collaboration with insurance companies/ private sector stakeholders.
- ➔ **Balance Force Majeure Clause Implications:** Force majeure typically refers to unforeseeable circumstances that prevent parties from fulfilling contractual obligations. In the context of disasters, force majeure clauses often relieve parties from liability when events beyond their control, such as natural hazards and disasters, occur. However, these clauses can disproportionately burden the government, as it frequently bears the costs and liabilities associated with disaster response and recovery. To address this imbalance and promote public-private partnerships, contracts are recommended to be revised to ensure that the private sector also shares the burden in such circumstances.

➔ **Revisit Contingent Liability and Other Contractual Obligations:** Contingent liabilities may arise explicitly from contracts, legal obligations or policy commitments, or implicitly from political or moral imperatives. While governments may have justifications for assuming contingent liabilities, such actions are recommended to be deemed appropriate only if their advantages outweigh the drawbacks and represent the most efficient approach toward achieving specific objectives. Therefore, decisions involving contingent liabilities is recommended to be based on a thorough cost-benefit analysis, considering both social and monetary benefits. Moreover, alternative assessment methods such as cost-effectiveness analysis could be employed when not all costs and benefits can be quantified monetarily.

Recommendation 8: Create Grants and Funds Tailored for Power Utilities

➔ **Creation of "Grant" Component for Power Utilities:** It is recommended to devise a robust strategy at the state-level including a grant component to address emergent needs and augment financial preparedness for extreme weather events.

- For example, akin to the Department of Energy grants in the United States, a grant component focusing on non-structural measures related to disaster risk financing or risk reduction financing for T&D utilities could be established.

➔ **Establish Power-Utility-focused Funds:** Implementing power utility-focused funds is essential to address the risks and vulnerabilities of T&D infrastructure in the face of extreme weather events.

Path to Progress: Translating Policy into Action

To develop disaster-resilient power systems in coastal regions globally, it is imperative to employ a comprehensive strategy that integrates robust data collection, innovative funding mechanisms, and governance frameworks. Through concerted efforts and pooled resources, power infrastructure in similar geographies can attain resilience, particularly in adapting to extreme weather events. Strategies arising from the following steps are pivotal in this endeavour **(see Table 2)**:

Leverage Collaborative Efforts for Climate Data Advancements in Coastal Regions

Coastal regions face unique climate challenges that demand collective action for power infrastructure resilience. By leveraging collaborative efforts, such as those outlined in this study, public and private sector stakeholders can come together to update critical climate data like wind zonation maps and integrate real-time information, laying the groundwork for future resilience strategies informed by shared knowledge and expertise.

Promote Unified Governance Mechanisms for Power Infrastructure Resilience

Building resilient power infrastructure in coastal regions requires robust governance networks fostered through collaborative efforts. Utilizing the methodologies elucidated in this study, regions can formulate cross-border frameworks, delineate responsibilities effectively, and consolidate resources for targeted renovation and retrofitting of T&D assets.

Co-create Emergency Response and Financial Plans for Coastal Regions

Collaborative inter-governmental planning sessions, informed by this study's findings for Odisha, are instrumental in crafting tailored emergency response and financial plans for coastal regions. By integrating financial strategies collectively, coastal regions can ensure equitable access to funds, with a key focus on fostering partnerships among governments, industries, and financial institutions.

Table 2: Way Forward for Disaster Resilient Power Infrastructure in Coastal Regions

Parameter	Collective Action (s)
Collaborative Climate Data Advancements	**Update** wind zonation maps
	Integrate real-time climate data
Strong Governance Networks	**Establish** cross-border governance frameworks
	Pool resources for targeted upgrades for power infrastructure
	Reinforce a culture of shared accountability
Co-creation of Emergency Response and Financial Plans	**Develop** comprehensive emergency response plans
	Devise innovative funding mechanisms for infrastructure resilience
	Foster partnerships between governments, industries, and financial institutions

By jointly undertaking these steps, coastal regions can combine their efforts and enhance their collective disaster resilience in the power sector. This collaborative approach will contribute to a dependable power supply even in the face of extreme weather events, foster sustainable development, and encourage cross-border collaboration at all levels.

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