Nangia Group

CLIMATE RESILIENT ENERGY INFRASTRUCTURE FOR COASTLINE

Presented By:
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Executive Director - Nangia Group

Resilient Coasts, Thriving Communities:
A Sea of Solutions, 18th -19th August, 2025

Contents

Vulnerability Profiling of States and Resilient Infrastructure Development

Area of MHVM recorded at each district and their percentage with respect to the district's geographic area along the Kerala coast

District	MHVM area (sq. km)	Percentage	CVI
Alappuzha	440.37	30.29	
Ernakulam	355.72	11.42	
Kannur	171.07	5.75	
Kasaragod	79.18	3.97	
Kollam	70.99	2.78	
Kozhikode	93.11	3.94	
Malappuram	107.61	3.0	
Thiruvananthapuram	65.52	2.9	
Trissur	79.74	2.6	

Source: INCOIS and State Action Plan on Climate Change 2023 - 2030

Kerala’s Energy Landscape

THERMAL

3254.69 MW

(As of March 2025)

RENEWABLES

3853.38 MW

(Including Hydro, as of March 2025)

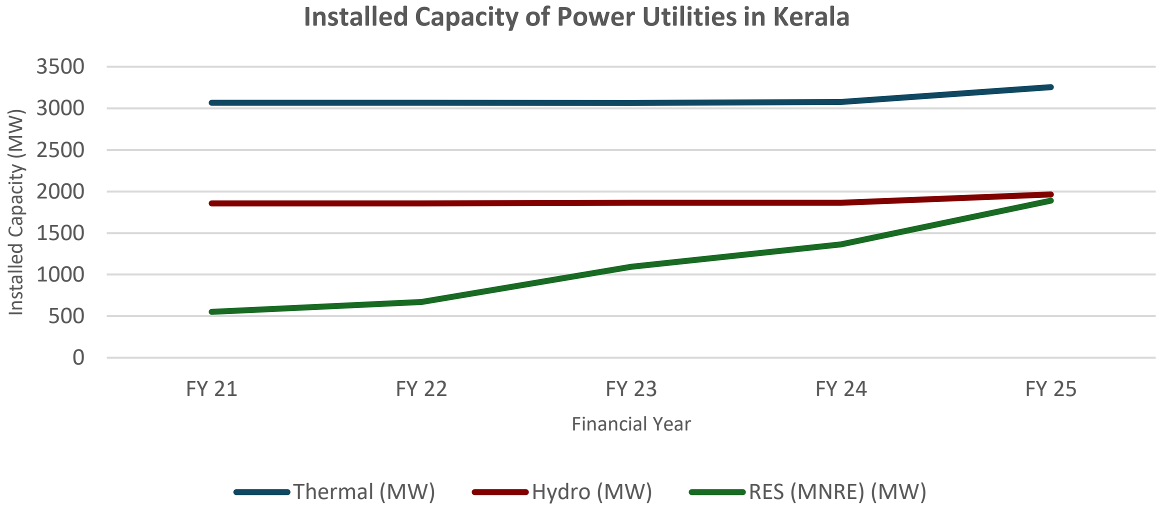
NUCLEAR

362 MW

(As of March 2025)

Kerala’s installed renewable energy capacity has increased over the years…

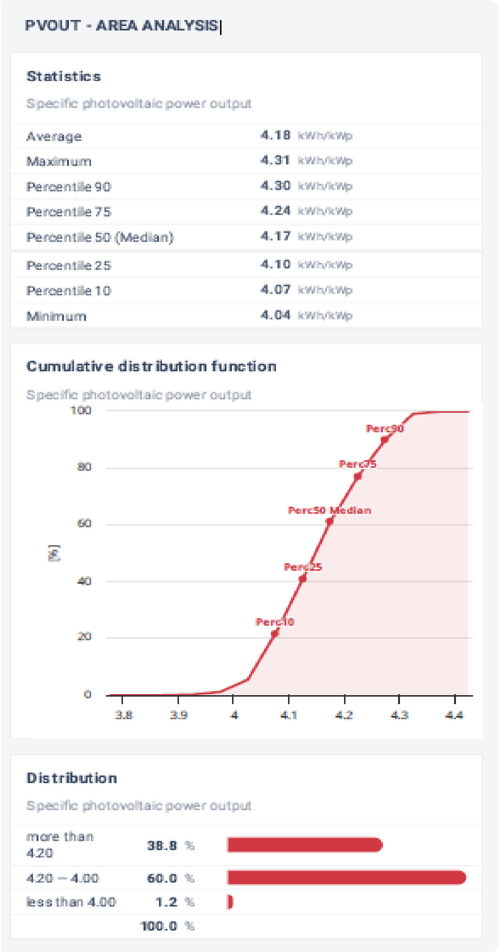
FY*	Thermal (MW)	Hydro (MW)	RES (MW)
FY 21	3066.66	1856.5	551.79
FY 22	3066.66	1856.5	670.7
FY 23	3066.74	1864.15	1092.95
FY 24	3077.67	1864.15	1365.31
FY 25	3254.69	1964.15	1889.23



**Data as on 31st March of every year (Source: CEA)*
 # Includes installed as well as allocated share in joint and central sector utilities

Kerala’s Energy (RE) Challenges

Solar Energy



PVOUT - AREA ANALYSIS

Statistics

Specific photovoltaic power output

Average	4.18	kWh/kWp
Maximum	4.31	kWh/kWp
Percentile 90	4.30	kWh/kWp
Percentile 75	4.24	kWh/kWp
Percentile 50 (Median)	4.17	kWh/kWp
Percentile 25	4.10	kWh/kWp
Percentile 10	4.07	kWh/kWp
Minimum	4.04	kWh/kWp

Cumulative distribution function

Specific photovoltaic power output

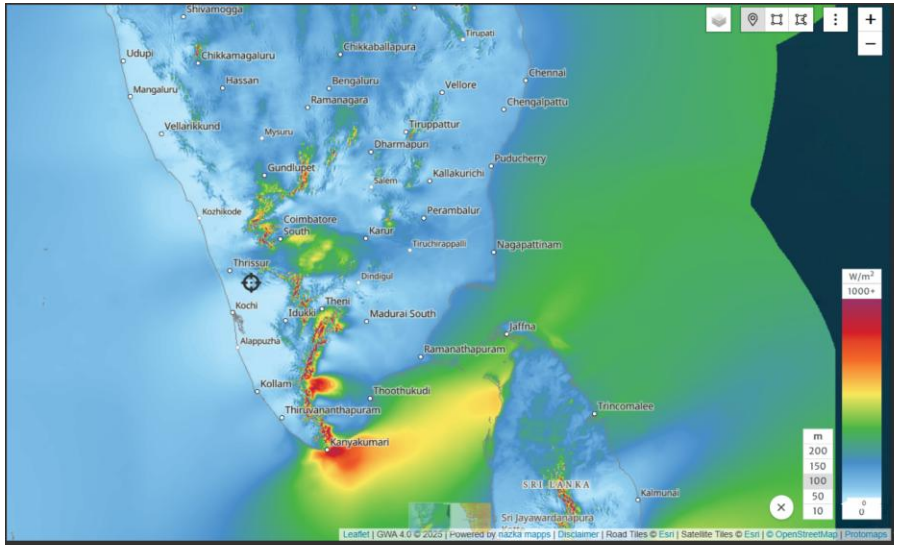
Distribution

Specific photovoltaic power output

more than 4.20	38.8	%
4.20 – 4.00	60.0	%
less than 4.00	1.2	%
	100.0	%

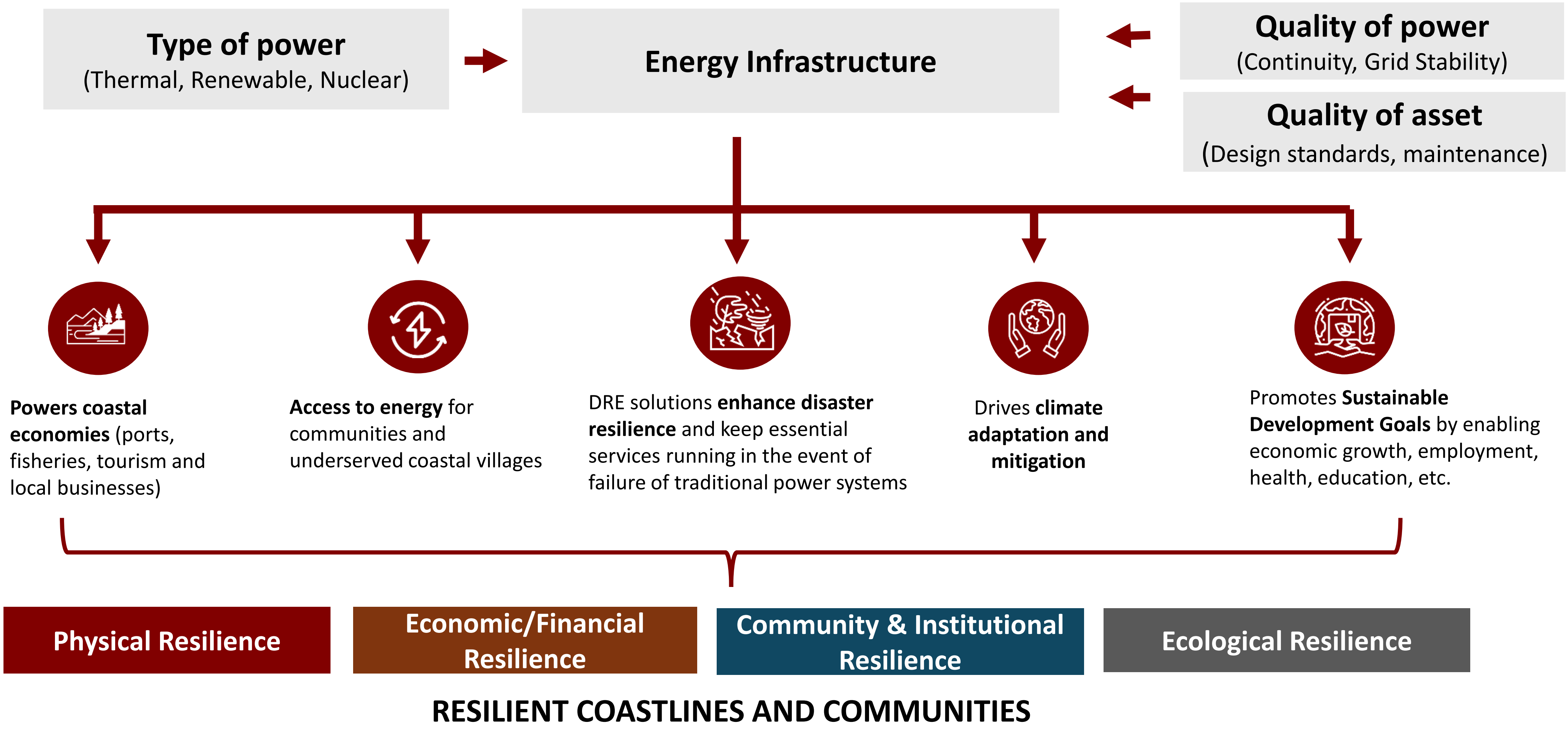
*Data as on 15th August 2025 (Source: Global Solar Atlas)

Wind Energy



*Data as on 15th August 2025 (Source: Global Wind Atlas)

Energy Infrastructure Development for Resilient Coastlines & Communities



Kerala’s energy sector faces certain risks and challenges due to climate change

Climate Change has exacerbated the vulnerability of Kerala’s energy sector by intensifying hazards and weather extremes

Changes in temperature patterns

Rise in sea level

Changes in precipitation patterns

Floods, flash floods, landslides, coastal erosion & seismic activity

Generation Facilities	Structural and operational damage to generation facilities, leading to generation failures.
Transmission and Distribution Grids	Over the Ground systems are more vulnerable to floods, landslides, and strong winds, leading to asset failures.
Fuel and maintenance supply chains	Disruption to fuel and maintenance supply chain due to port closures, damage to roads and pipelines.

Building Energy System Resilience

- Vulnerability assessment → development of resilience plans
- Multiple scenarios for extreme climate and geophysical events (cyclone, tsunami, etc.)
    - 100-year storm vs maximum credible event
- Adoption of emergency preparedness, response, and recovery strategies***, not just utilities***
- Lessons learned from Fukushima (2011), and Texas/ ERCOT (2021)
- Smart grids: advanced metering infrastructure, digitization and automation, drone and remote sensing for wide area monitoring applications, underground cabling, predictive maintenance of assets,
- RE and Demand forecasting considering the early weather warning system
- Power infrastructure hardening for Climate proofing, geophysical events, and maintenance (cybersecurity)
- Diversified/ distributed energy mix with flexible operation and storage throughout the system

Integrating Energy Infrastructure, Coastline, and Communities: A Case Study (1/2)

Higashi-Matsushima, a coastal city severely affected by the March 11, 2011, earthquake and Tohoku tsunami, saw widespread utilities and critical infrastructure loss and energy disruptions (about 65% of the city flooded).

The scale of damage highlighted two interlinked problems:

- the traditional, centralized electricity model and distribution network were highly vulnerable to catastrophic coastal flooding
- residents who lost homes needed to be rehoused on higher ground, requiring new communities and services that should be safe, resilient and locally sustainable

Integrating Energy Infrastructure, Coastline, and Communities: A Case Study (2/2)

Approach and Solutions

NBS into adaptation practice

Hybrid gray-green coastal defenses integrated with renewable infrastructure enrich both ecological and social resilience

Integrated Solutions (governance and funding)

the broader planning integrated these hybrid approaches to improve safety and ecosystem health

Community-centric disaster recovery

Long term energy resilience (both generation and T&D)

Community buy-in to build critical energy in emergencies

Community buy-in to build critical energy in emergencies

Large ground-mounted solar

The city converted a flood-damaged park into a ~2 MW PV plant and installed PV carports on higher ground (≈270 kW across evacuation sites) so evacuation points could also supply emergency power.

Disaster-Ready Smart Eco-Town (microgrid community)

a model community (roughly 70 detached houses + 15 apartment units, housing ~85 disaster-affected families) with integrated PV (several hundred kW total), a large battery (reported ~500 kWh), a back-up biodiesel generator (~500 kW), BEMS/EMS and private distribution lines so the district can island from the main grid and run autonomously for days

Community development

Governance: The local government worked closely with fishery cooperatives, agricultural groups, and civic associations to gain trust and ensure the rebuilding plan addressed economic and social needs

Funding: -combined government subsidies, private sector investment, and non-profit engagement.

Helped coastal protection and risk reduction through managed retreat + multi-layered protection

Financing for building resilience in the Energy Sector

LIMITED AVAILABILITY OF INFORMATION

- **Adaptation Fund:** spending on building resilience in coastal infrastructure, including generation facilities, transmission and distribution assets
- **Economic implication:** On energy infrastructure, including generation facilities, leading to curtailments/shutdowns due to floods and rising sea levels.
- **Total fund requirement** with breakup and linked related climatic and/ disaster events.
- **Financial requirement** with the future climatic scenario and events of disaster.

GAPS IN "ADDITIONAL INSURANCE"

- **Mostly traditional insurance** is present
- **Lack of understanding in** coverage types, risk management, and key factors in safeguarding renewable energy.
- **Lack of Innovative Insurance models** such as Parametric insurance product to support resilience.

GAPS IN ENERGY SECTOR RESILIENCE FINANCING

- **Lack Innovative Financing:** Innovative financial products, which include resilience bonds and green banks.
- **Lack of PPP framework** for resilience financing in building a resilient energy sector

Way Forward:

CRVA

Climate Risk and Resilience building

Climate Risk and Vulnerability Assessment to the Energy Sector for developing resilient Power sector development in Kerala Coastal area

Resilience financing

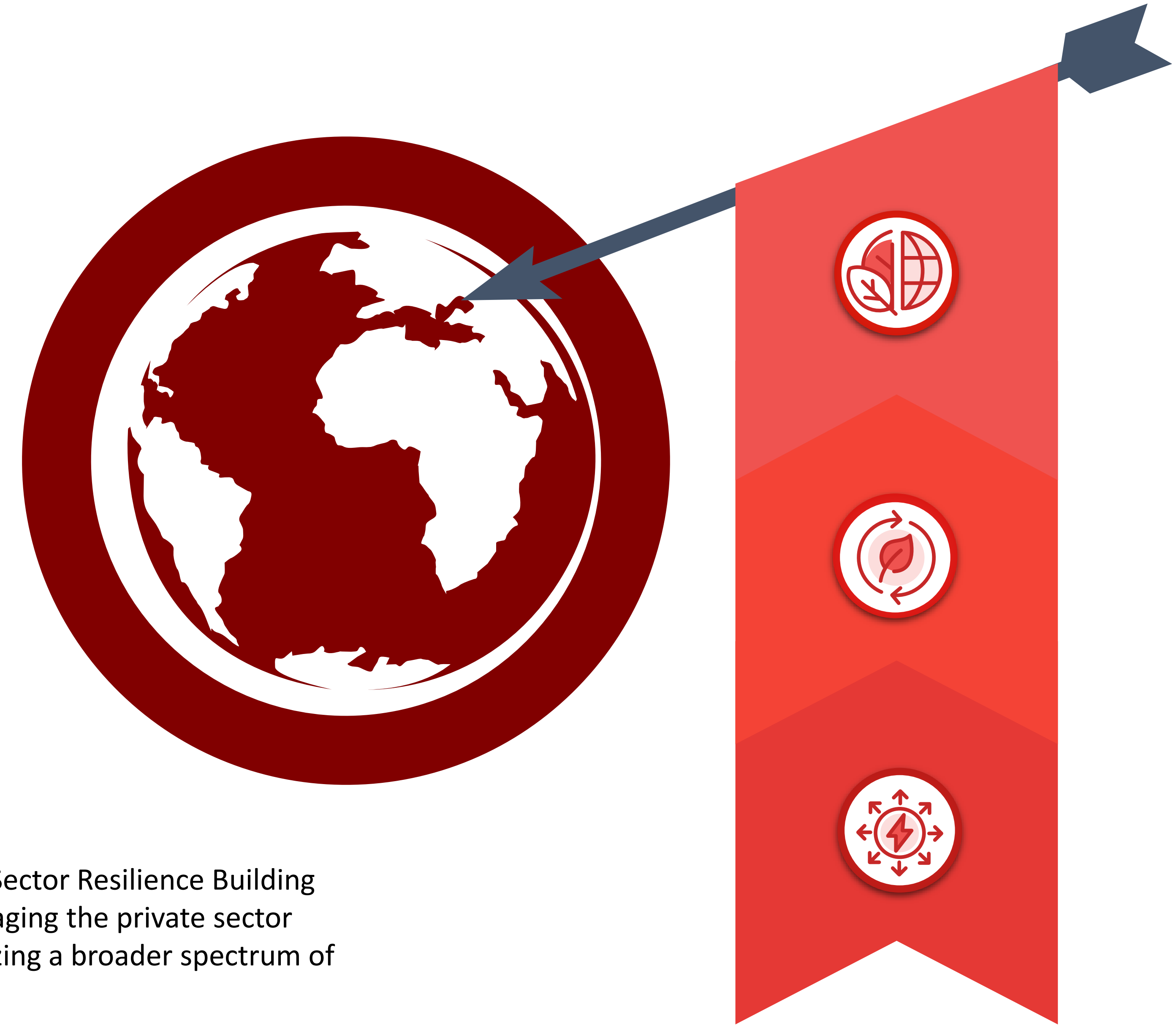
Valuing Resilience

Devise a robust framework for Resilience financing under the PPP model.

CLIMATE INSURANCE

For building Power sector resilience

- Potential De-risking Instruments for Kerala’s Energy Sector Resilience Building
- An assessment to understand the possibilities of engaging the private sector insurance industry in grid resilience and commercializing a broader spectrum of investments in climate change resilience.



Thank You

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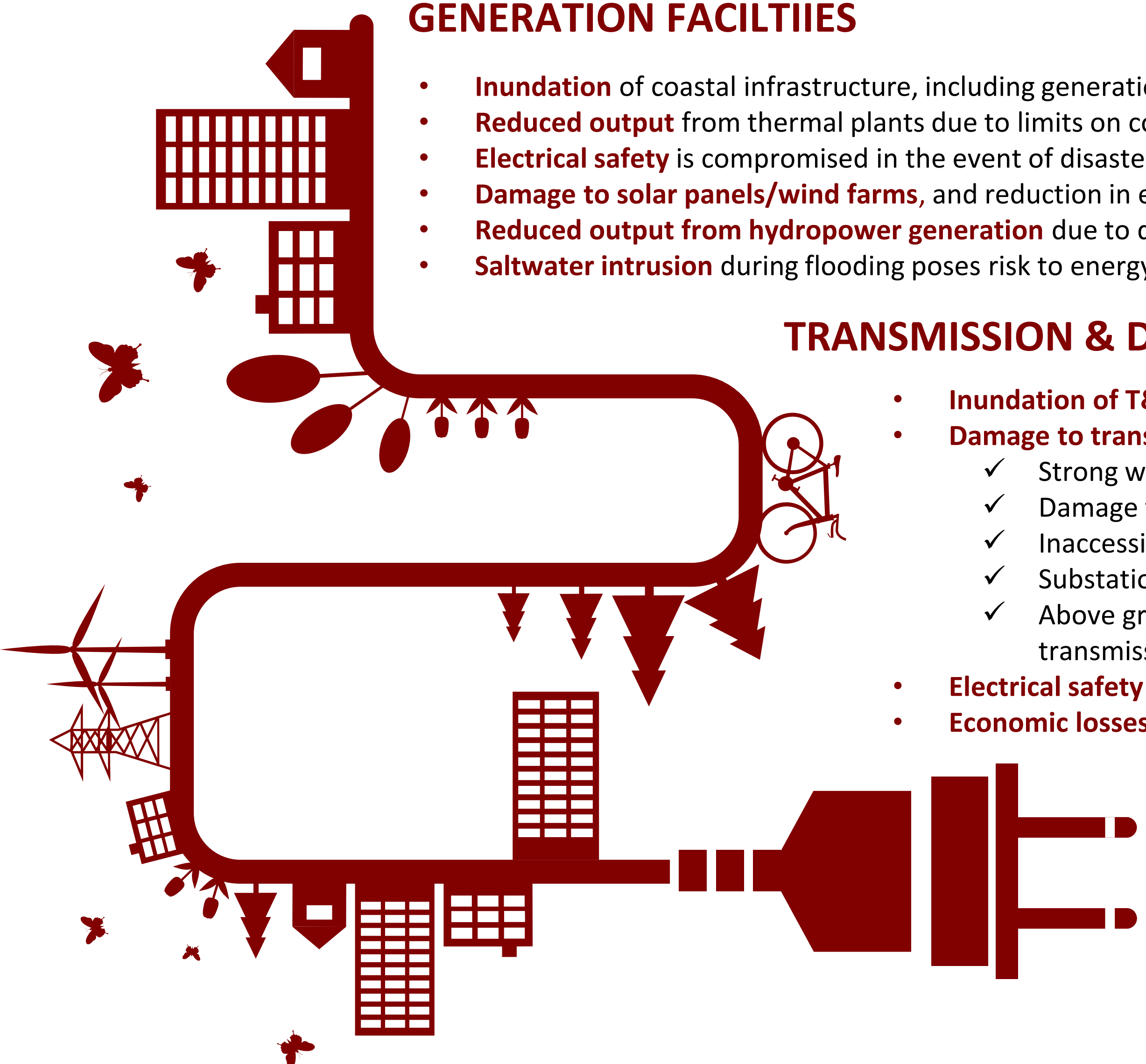


GENERATION FACILTIIES

- **Inundation** of coastal infrastructure, including generation facilities, leading to curtailments/shutdowns due to floods and rising sea levels.
- **Reduced output** from thermal plants due to limits on cooling water temperatures, triggered by temperature changes.
- **Electrical safety** is compromised in the event of disaster.
- **Damage to solar panels/wind farms**, and reduction in efficiency of these systems.
- **Reduced output from hydropower generation** due to drought conditions.
- **Saltwater intrusion** during flooding poses risk to energy assets.

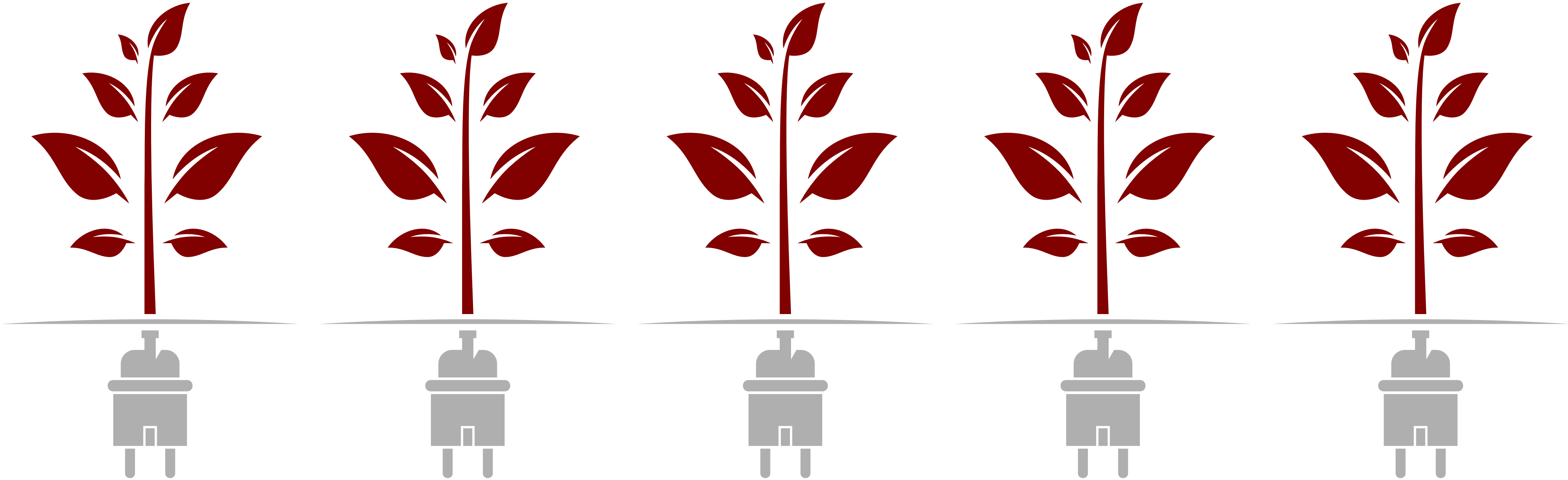
TRANSMISSION & DISTRIBUTION

- **Inundation of T&D facilities** due to floods and rising sea levels.
- **Damage to transmission and distribution substations/assets:**
  - ✓ Strong wind can topple lines and poles.
  - ✓ Damage to transmission tower foundations due to erosion and/or landslides .
  - ✓ Inaccessibility due to flooding.
  - ✓ Substations at risk of flooding.
  - ✓ Above ground systems are more vulnerable to floods, landslides, and strong winds, leading to transmission failures.
- **Electrical safety** compromised
- **Economic losses** due to power outages.

FUEL & MAINTENANCE SUPPLY CHAIN

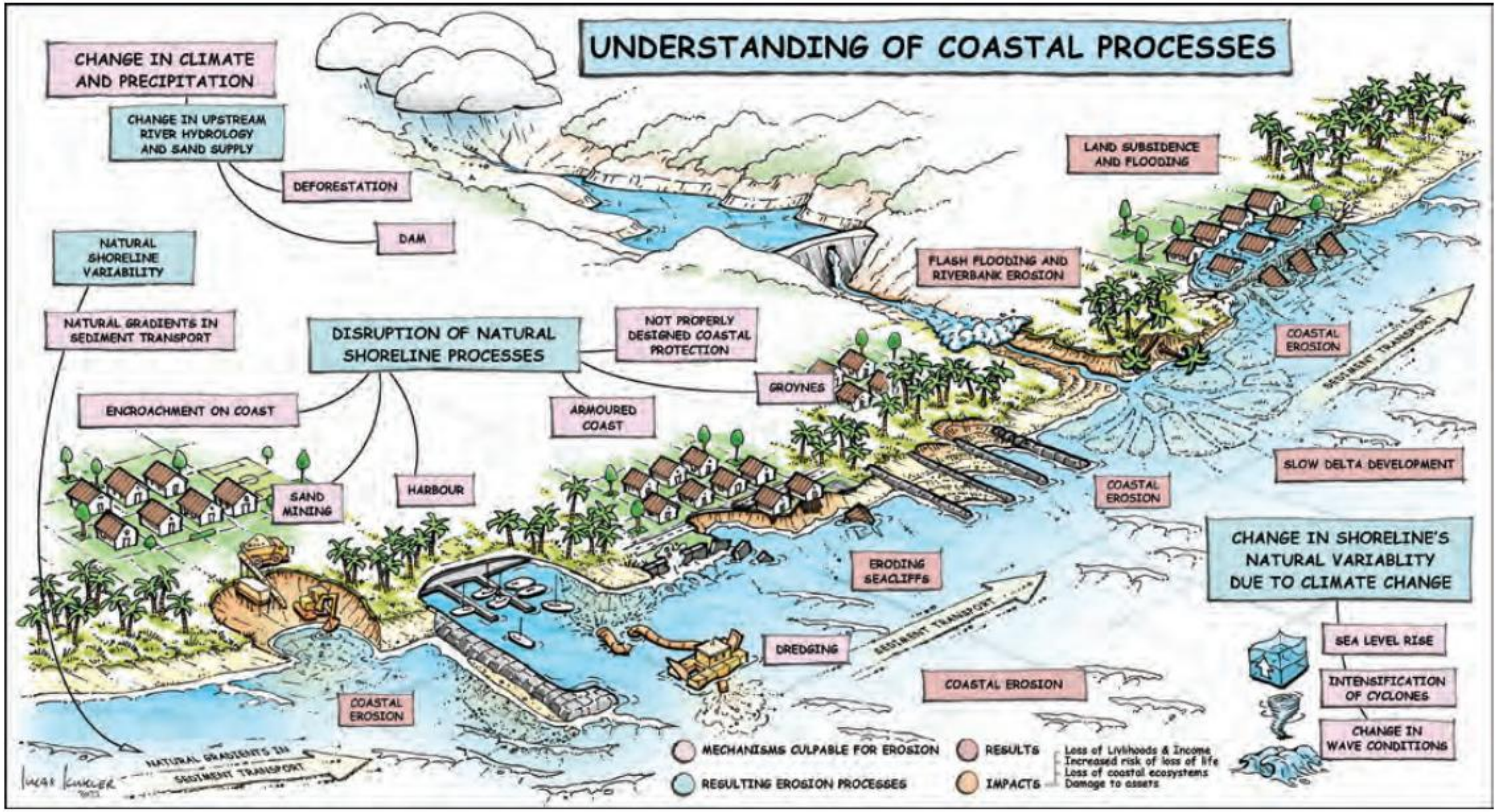
- **Disruption to fuel and maintenance supply chain** due to port closures, damage to roads and pipelines.
- **The fuel supply chain vulnerabilities of renewables** (wind, solar) are less vulnerable than traditional fuels that rely on on-demand delivery.

Necessitating the development of Climate Resilient Energy Infrastructure…



- Expansion of Decentralized Renewable Energy Systems
- Climate-smart & disaster resilient Transmission & Distribution Networks
- Investment in Energy Storage Systems (ESS) for balancing the grid
- Climate risk-informed planning, and incentives for resilient infrastructure
- Capacity building & knowledge management for key stakeholders, & communities

Coastal Erosion Mechanisms Resulting from Natural and Anthropogenic Causes and Climate Change



Source: Asian Development Bank. Illustration by Lucas Kukler.

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Disaster Financing Landscape in Kerala

Allocation of SDRF

Rs. 388 Crore

(Total Central & State share during 2024-25)

Release of Central Share of SDRF

Rs. 291.20 Crore

(Total of 1st and 2nd installment during 2024-25)

Release from NDRF

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(As of March 2025)

Allocation and Release of Disaster Financing to Kerala over the years…

Year	Allocation under SDRF (Centre and State) (Rs. Cr)	Centre's Share of SDRF Released (Rs. Cr)
2018-19	214	192.6
2019-20	225	136.65
2020-21	335.2	251.2
2021-22	335.2	251.2
2022-23	352	264