Support for the Development of Practical Sectoral Guidance on Climate Resilient Proofing

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Rallis Kourkoulis, PhD

European Investment Bank

GRID ENGINEERS

Jaspers
Joint Assistance to Support Projects in European Regions

European Commission

SUPPORTING TOOLS

Guidance Document

- **Overview of the Climate Resilience Proofing Methodology and practical guidance**: Resources, Assessment steps, Scoring systems, Expected outputs and practical insights
- **Sectoral Climate Resilience Guidance for 3 Sectors**
  -Sensitivities of the examined systems to key climate hazards
  -Climate impacts and potential consequences (that are particular to examined sectors)
  -Detailed list of adaptation measures
  A step-by-step climate proofing example for a fictitious energy project

Climate Proofing Tool

- **Developed for small-scale projects**
- **3 instances:** Buildings, Water & Waste Projects, Urban Regeneration Projects
- Uses empirical indicators/questionnaires to describe exposure and climate sensitivities
- Automatically scores vulnerabilities/risks based on users' input
- Checks the efficiency of adaptation measures

SECTORAL GUIDANCE

ENERGY SECTOR

- **Electricity T&D Networks**
  Transformers, substations, conductors, overhead lines.
- **Wind Farms**
  Onshore/ offshore wind turbines, substations, cables, metering equipment
- **Solar Parks**
  Panels, Inverters, cables, metering equipment
- **District Heating**
  Combustion System, Boilers, Water tanks, fuel conveyor, control system
- **Green Hydrogen Electrolysers**
  Electroyser, Storage Tanks, Control system
- **Battery Energy Storage Systems**
  Batteries, Inverter, BMS, transformers

MUNICIPAL SOLID WASTE MANAGEMENT

- **Separate Waste Collection & Transport Schemes**
  Collection points, containers, vehicles, personnel, municipal roads
- **Recovery & Recycling Facility – Mechanical Separation**
  Mills, air sorters, blowers, controllers,
- **Anaerobic Digestion** (Storage/ feed equip., digester, separator, compressor, storage tanks) **Aerobic Biological Treatment** (Composting infra, sorting equip., storage facilities, filters, controllers)
- **Dumpsite Rehabilitation**
  Earthworks, geomembranes, metering equip., access roads

TRANSPORT SECTOR

- **Urban Transport**
  Vehicles, stations, bicycle routes, parking lots & equipment, depots
- **Roads**
  Pavements, Bridges, surface/subsurface drainage, earthworks
- **Railways**
  Trains, ballasts, railbeds, station buildings, waiting areas, signalling equipment.
- **Ports**
  Wharves, piers, cargo storage, handling equip., transport links

CLIMATE PROOFING FLOWCHART

PHASE 1: SCREENING

MOD. 1 — SENSITIVITY

Qualitative scoring of project sensitivities to key climate hazards.

Output: Component sensitivity rankings and project sensitivity score per hazard.

MOD. 2 — EXPOSURE

Identification and scoring of (current and future) climate hazard exposure at the project location.

Output: Project exposure score in current and future climates.

VULNERABILITY

MOD. 3

VULNERABILITY = SENSITIVITY x EXPOSURE

Output: Project vulnerability per hazard for future and current climate conditions.

Are there any significant climate vulnerabilities warranting detailed analysis?

NO → **Climate Resilience Screening Documentation**

YES → PHASE 2

PHASE 2: DETAILED ANALYSIS

MOD. 4 — LIKELIHOOD

Estimation of hazard likelihood within the project lifespan

Output: Qualitative or quantitative (i.e., probability-based) hazard likelihood.

MOD. 5 — IMPACTS

Estimation of direct, indirect & cascading hazard impacts across several risk areas.

Output: Impact scores per hazard and risk area; loss estimations

RISK

MOD. 6

RISK = LIKELIHOOD x IMPACT

Output: Project climate risk scores per hazard

MOD. 7 — **Climate Adaptation Plan**: Selection, appraisal, and implementation of suitable adaptation measures.

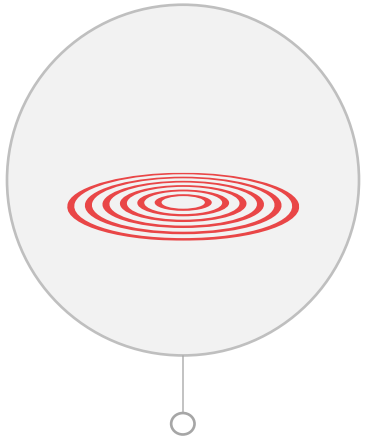
MOD. 8 — Assessment of the scope and need for a regular **Climate Monitoring Plan**.

MOD. 9 — Verification of consistency with EU, national and regional adaptation strategies, and plans.

Climate Resilience Proofing Documentation

APPRAISAL METHODS

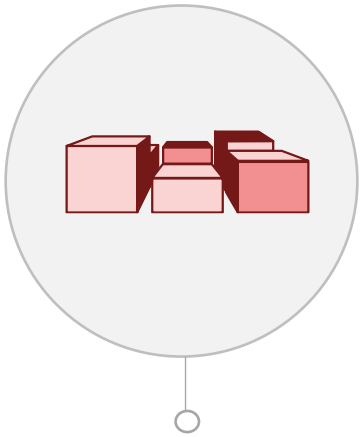
Phase 1. Screening



EXPOSURE

Assesses whether the project location lies within the **potential threat zone** of a climate hazard

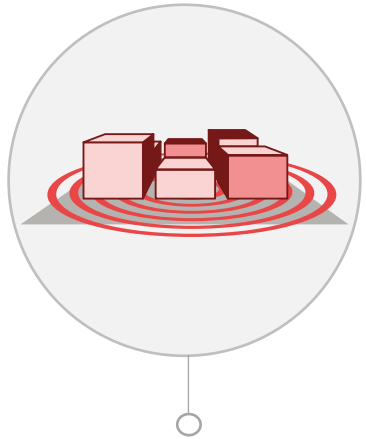
X



SENSITIVITY

Assesses the **proneness of a project to be impacted by hazard** (when exposed to it)

=



VULNERABILITY

Assesses the potential of experiencing damage/failures

Phase 2. Detailed Analysis

Likelihood Analysis

Frequency/probability of occurrence

X

Impact Analysis

Estimates the severity of the impacts

=

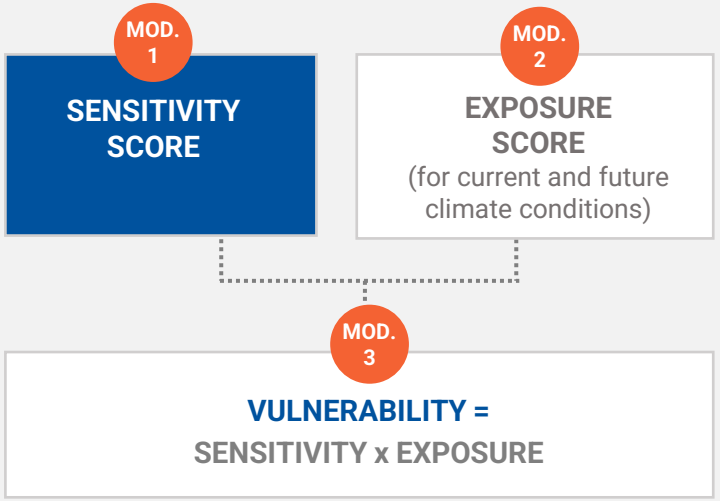
Risk Analysis

Identifies significant climate risks to the project

Climate Hazards

	Acute Hazards	Chronic Hazards
Temperature related	**Heat waves** Extreme temperature & Duration **Cold spells / frost** Extreme temperature & Duration **Wildfires** **Drought** **Fog***	**Changes in temperature patterns** e.g. Annual/ monthly/daily average temperatures **Temperature variability** e.g. Maximum and minimum daily temperatures **Permafrost thawing** **Freeze/thaw cycle***
Wind related	**Storms** including blizzards, and sand-storms **Tornados** **Cyclone, hurricane, typhoon**	**Changing wind patterns** -Maximum annual/monthly/daily wind speed -Maximum wind gust speeds per month/year
Water related	**Floods** Including coastal, fluvial, pluvial floods **Heavy rainfall & hail** Duration, total downpour **Extreme Tide and Storm Surge** **Extreme snowfall**	**Changes in precipitation patterns** Annual/Monthly precipitation **Cloudiness** **Sea level rise** **Saline intrusion** Salinity/Groundwater level
Soil related	**Subsidence** **Soil Instabilities & landslides**	**Coastal erosion** **Soil erosion**

Phase 1. Screening



Module 1 • Sensitivity Analysis

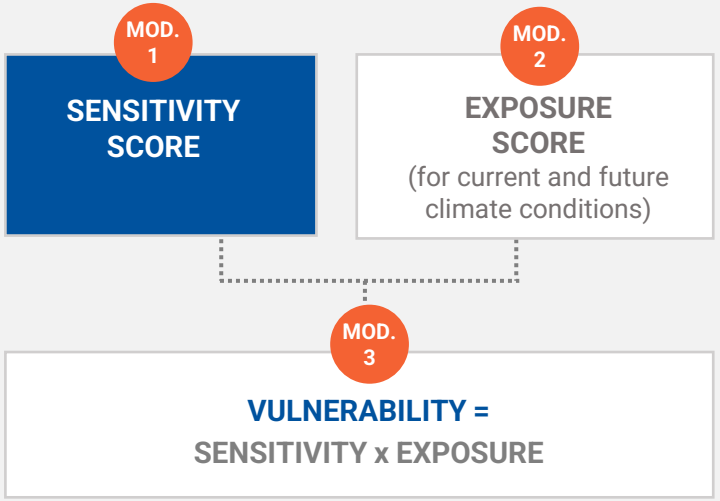
Objective: Determine the proneness of a project (or a project component) to be impacted by a hazard due to:

- Damaged assets operating at a sub-standard level
- Loss of essential input/outputs
- Unavailability of interconnected infrastructure

Qualitative description of sensitivity levels (per examined sector)

	Low	Medium	High
On-site Assets	Assets may experience minor damage	Assets may experience moderate damage	Assets including expensive assets/equipment may experience major damage or failure.
Operations	Non-critical operations may temporally be affected, but their repercussions are considered minimal.	Reduced functionality (or temporarily shutdown) of some utilities/ processes until inspections are performed.	Major equipment/facilities cannot operate and several process cannot be performed. The facility may need to completely shutdown until repairs are performed.
Input/Output	Not important effect on the energy production/ transmission/ distribution/ storage capacity.	Energy production/ transmission/ distribution/ storage capacity may temporarily decrease.	A major decrease in energy production/ transmission/ distribution/ storage may occur.
Interconnections	Insignificant/short in duration service disruptions of the supporting infrastructure	Loss of service of the supporting infrastructure affecting non-critical operations of the energy facility	Prolonged service disruptions impacting energy production

Phase 1. Screening



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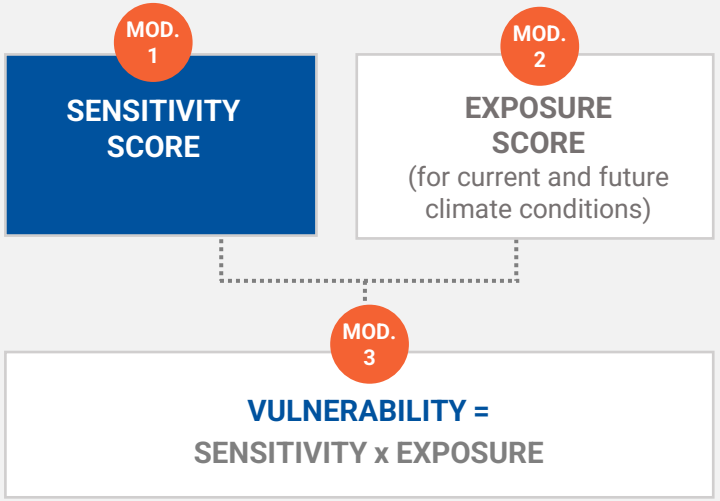
- Unavailability of interconnected infrastructure

Output: Global Sensitivity score per Hazard

Climate Hazards	Global Score	On-site assets	Input	Output	Interdependent Systems
Hazard 1	High	High	Low	Low	Medium
Hazard 2	High	High	Low	Low	Medium

Phase 1. Screening



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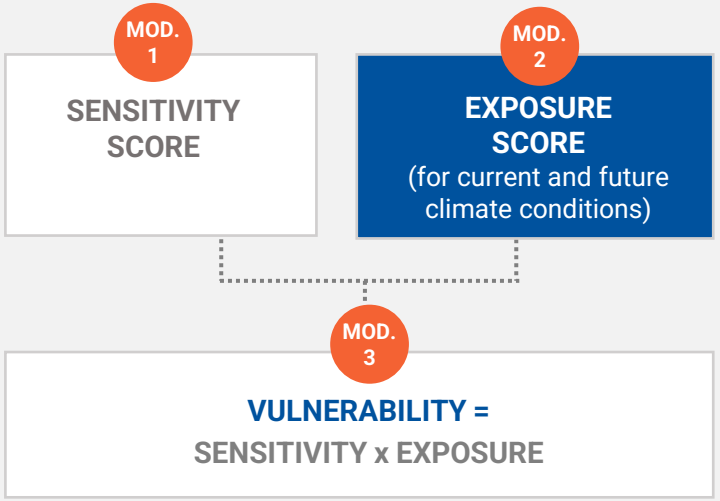
Sensitivities of Biomass Heating: Example

Hazard	Sensitivities			
Heavy precipitation & Flooding	Short circuit or **electronic damages** when on-ground equipment gets wet.			
	Uplift failure/upheaval buckling of underground pipes creating operating issues.			
	Increased **heat-losses** in the distribution grid, due to increased moisture of the surrounding soil.			
	Increased biomass moisture (especially if stored in open space) reduces its energy value leading to **decreased energy production.**			
	Flooded biomass storages may disrupt heating/cooling operations.			
High	**On-site assets & processes**	**Inputs**	**Outputs**	**Interdependent systems**
Saline intrusion	**Chemical corrosion** of underground pipes from saline groundwater.			
	Saline groundwater may create **unfavourable buoyancy conditions for buried pipes** causing structural damages.			
	Water input for thermal energy generation may be significantly affected by saline intrusion, impacting the overall **efficiency of the system and the cost of energy.**			
High	**On-site assets & processes**	**Inputs**	**Outputs**	**Interdependent systems**

Phase 1. Screening



Module 2 • Exposure Analysis

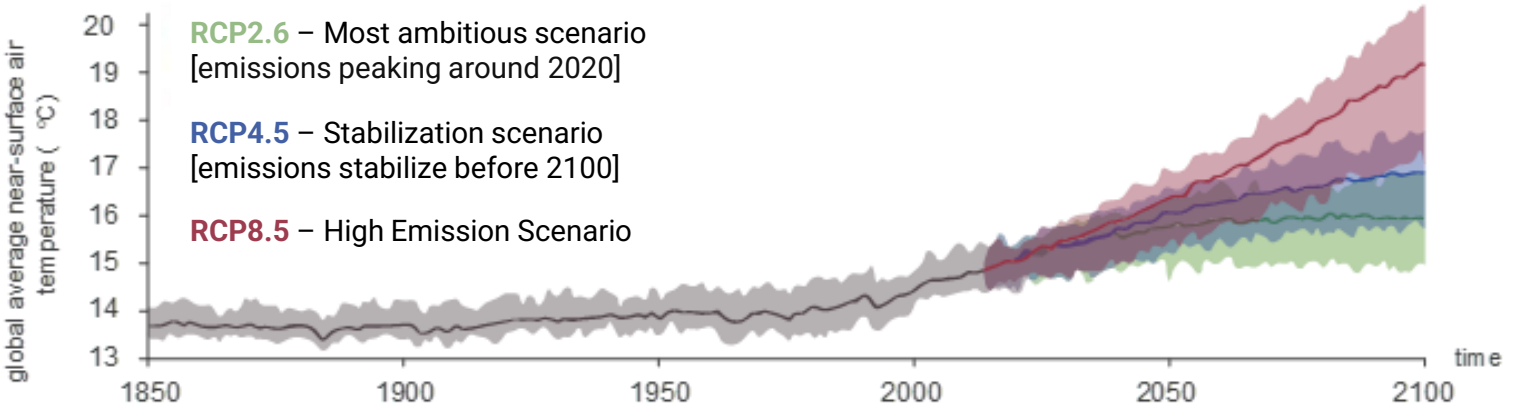
Objective: To determine the climate hazards that are present or are expected to be present in the future in the project location.

STEP. 1 Select spatial/temporal scale

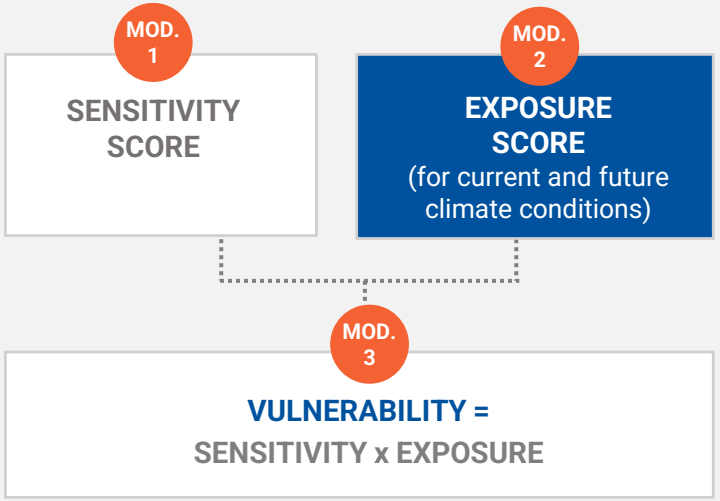
- Intended lifespan of a project
- Geographic boundaries of the assessment

STEP. 2 Select climate change scenarios

- Consider the Project's Lifespan
- Consider Recommendations of National Guidance



Phase 1. Screening



Module 2 • Exposure Analysis

Objective: To determine the climate hazards that are present or are expected to be present in the future in the project location.

STEP. 3

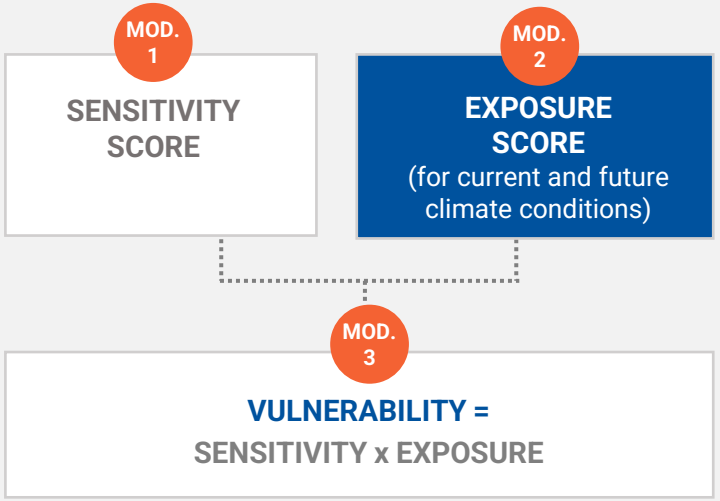
Compilation of Climate Data

- **Current Exposure:** Historic record, local knowledge and experience, consultations with climate experts
- **Future Exposure:** National Climate Portals and other Climate Datasets

Indicative Resources

Resources	Description
EEA provides an overview of the national and transnational climate atlases in Europe.	National atlases contain spatially explicit information on past and projected climate change (including for different climate variables and/or hazards).
Copernicus Climate Change Service	The Copernicus Climate Change Service (C3S) provides information on historical, current, and projected climate conditions both in Europe and globally through its Copernicus Climate Data Store (CDS).
WCRP CORDEX	The Coordinated Regional Climate Downscaling Experiment is a framework aimed at addressing climate information needs at the regional level. It produces ensemble of climate simulations based on multiple dynamical and empirical-statistical downscaling models.
Flood Risk Area Viewer (europa.eu)	Offers a tool that aims to increase awareness about flood risks. Users can observe regions of potentially significant flood risk and the varying approaches of flood protection across Member States..
The European Draught Risk Atlas	Offers a detailed exploration of drought hazards across Europe, shedding light on their impacts on agriculture, public water supply, energy, and ecosystems.
Climate Change Knowledge Portal (CCKP)	Offers global data encompassing historical and projected climate information through country profiles and watershed views.

Phase 1. Screening



Module 2 • Exposure Analysis

Objective: To determine the climate hazards that are present or are expected to be present in the future in the project location.

STEP. 4

Indicative characterization of Exposure Level (Current & Future)

Exposure Level	Acute Hazards	Chronic Hazards
Low	The project is located in an area where hazard has occurred or expected to occur **rarely**	The rate of change is low. Observable change within a time horizon exceeding the timeframe of the assessment.
Medium	The project is located in an area where hazard has occurred or expected to occur **a few times during the project's lifetime**	The rate of change is moderate. Observable change within a time horizon that may be observable during the project's lifetime
High	The project is located in an area where hazard has occurred or expected to occur **often during the project's lifetime.**	The rate of change is rapid. A significant change is expected within the project's useful life.

Phase 1. Screening

MOD. 1
SENSITIVITY SCORE

MOD. 2
EXPOSURE SCORE
(for current and future climate conditions)

MOD. 3
VULNERABILITY = SENSITIVITY x EXPOSURE

Are there any significant climate vulnerabilities warranting detailed analysis?

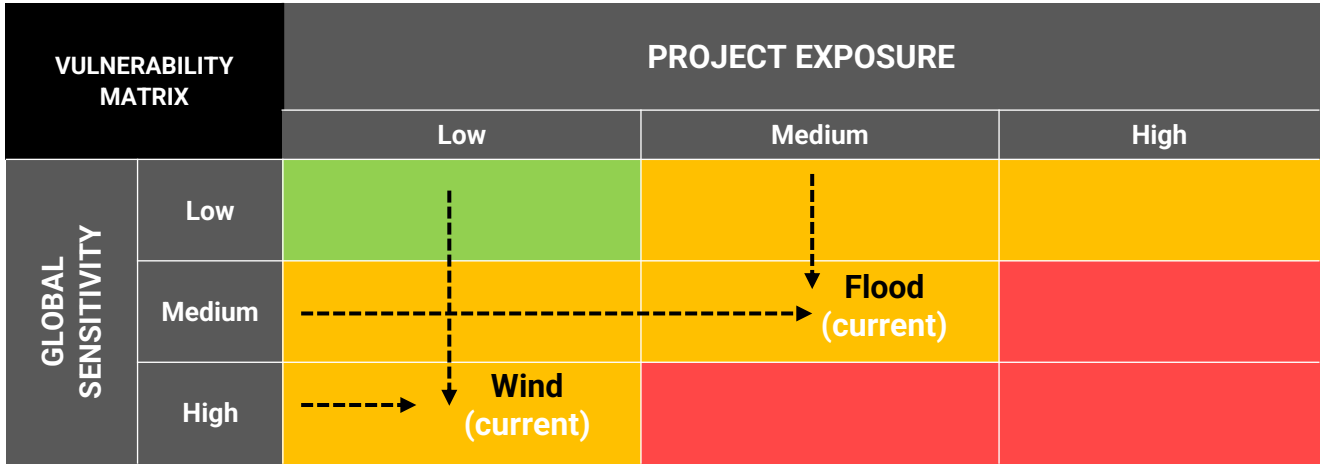
IF YES

Detailed assessment is required

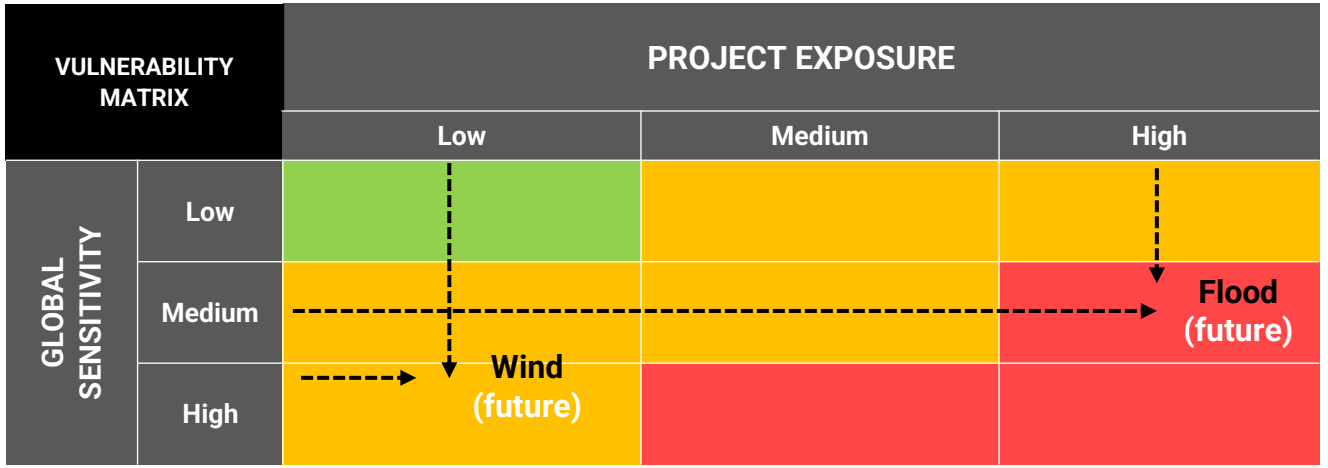
Module 3 • Vulnerability Analysis

Objective: To determine the predisposition of a project to be adversely affected by climate change-induced hazards

- For different hazards



- For different timeframes



Phase 2. Detailed Analysis

Phase 2. Detailed Analysis

Module 4 • Likelihood Analysis

Objective: To determine the probability of a hazard to occur during the lifetime of the project

Qualitative assessment

Scores the likelihood of experiencing a **potentially disruptive event** within the specified timeframe

Level	Score	Qualitative	Probability of occurrence
Rare	1	Highly unlikely	0-10 %
Unlikely	2	Unlikely	11-30 %
Moderate	3	Possible	31-60 %
Likely	4	Likely	61-90 %
Almost certain	5	Very likely	91-100 %

Quantitative assessment

- Is performed by experts
- It entails site-specific hazard analysis
- It associates climate events with a probability of occurrence
- Is recommended for significant projects

Phase 2. Detailed Analysis

How to assign likelihoods to future climate trends?

- Climate projections **do not follow historic trendlines**
- How the climate will evolve depends on future policies, technological developments, international agreements and climate sensitivities, all of which are **notoriously hard to predict.**

RECOMMENDATION

- Expert judgement
- IPCC Guidance: correlates the confidence le… quantitative expression of likelihood (e.g., x%… occurring)
- **Small Projects – Climate-Change Multipliers(C…)**

Future Likelihood

=

Current Likelihood x CCM

Hazard indicator	Decreasing trend		Increasing trend	
	Low change	High change	Low change	High change
Climate Change Multiplier	0.95	0.8	1.5	2.5

Phase 2. Detailed Analysis

Module 5 • Impact Analysis

Objective: To appraise/estimate the consequences of a hazard across several Risk Areas (RA): Damage/Operations ◆ Safety & Health ◆ Environment ◆ Social ◆ Financial Impacts ◆ Reputation

Qualitative assessment

- Can be performed by non-experts
- Scores the severity of impacts based on a qualitative description of impacts

1 Insignificant	2 Minor	3 Moderate	4 Major	5 Catastrophic
Slight damages | **No consequences** to project's operations.	Consequences can be alleviated by performing **standard business continuity actions.**	The project's operations are impacted requiring the activation of **emergency protocols.**	The project's operations are severely impacted. Restoration of business continuity requires **extraordinary actions.**	Disastrous consequences incl. **permanent shut-down** and/or total loss of the project's assets

Quantitative assessment

- Is performed by experts
- Calculates Losses per event and annualized *(aggregating losses from all possible events affecting the project normalized by their probability of occurrence)*
- Converts Losses to Likelihood Scores

1 Insignificant	2 Minor	3 Moderate	4 Major	5 Catastrophic
Asset damage <5% of TRC	Asset damage 5-10% of TRC	Asset damage 10-25% of TRC	Asset damage 25-50% of TRC	Asset damage >50% of TRC
Immediate Recovery	Recovery time: few days	Recovery time: several days (e.g., 5-10days)	Recovery process is slow (e.g. 20-100 days)	Recovery time is indefinite.

Phase 2. Detailed Analysis

Module 5 • Impact Analysis

Objective: To appraise/estimate the consequences of a hazard across several Risk Areas (RA): Damage/Operations ◆ Safety & Health ◆ Environment ◆ Social ◆ Financial Impacts ◆ Reputation

RISK AREAS	1 Insignificant	2 Minor	3 Moderate	4 Major	5 Catastrophic
RA2: Safety & Health	First aid case	Minor injuries	Serious injuries or lost work	Major/multiple injuries and disabilities	Single or multiple fatalities
RA3: Environment	Impacts are localised in the source area	Impacts are localised within the site	Moderate harm with possible wider effects.	Significant harm with local effects. Long recovery.	Significant harm with widespread effect. Longer recovery > 1 year
RA4: Social	No negative social impacts	Localised temporary social impacts.	Localised, long-term social impacts.	Failure to protect vulnerable groups. Nation-wide, long-term social impacts.	Loss of social license to operate
RA5: Financial impacts	Direct and indirect costs < 2% of annual turnover.	< 2-10% of annual turnover	< 10-25% of the annual turnover	< 25-50% of annual turnover	> 50% of annual turnover.
RA6: Reputation	Local, temporary impacts on public opinion	Short-term impacts on public opinion	Negative coverage on local media	Nation-wide, short-term impacts on public opinion	Political instability
RA7: Cultural Heritage	Insignificant damage	Slight damage that can be recovered/ repaired	Serious damage with wider impact to tourism industry	Significant damage, nation-wide consequences	Permanent loss

Phase 2. Detailed Analysis

Module 5 • Impact Analysis

Objective: To appraise/estimate the consequences of a hazard across several Risk Areas (RA): Damage/Operations ◆ Safety & Health ◆ Environment ◆ Social ◆ Financial Impacts ◆ Reputation

Climate Impacts to Ports: EXAMPLE

Risk Areas	Impacts
RA1: Engineering/ Operational	**Physical Damages**: Climate extreme events can damage port infrastructure while chronic climate stress can lead to its degradation, leading to **increased maintenance and repair needs** and potential closures of docks and terminals. **Operational Disruptions**: Extreme weather conditions may halt port activities, resulting in **delays in cargo handling and disruption of shipping schedules**. er the combination of high river flows and storm surges. **Changes in the seaport tidal regime may require changes in operational time-tables**.
RA2: Safety and Health	**Worker Safety**: Harsh weather, **high winds**, and heavy precipitation pose risks to port workers' **safety during loading, unloading, and vessel manoeuvring.** **Health Impacts:** Climate-induced air and water pollution (e.g. spills of hazardous cargo) may create health incidents for workers and passengers.
RA3: Environment	**Pollution Incidents**: **Climate-induced accidental spills** can lead to pollution of water bodies, endangering marine life and affecting coastal areas. **Coastal Changes**: Intense storms and sea level rise can accelerate coastal erosion around port areas, leading to **loss of land, changes in coastal morphology, and increased sedimentation in navigational channels**.
RA4: Social	**Supply Chain Disruptions**: Port closures or limited operations due to climate events can disrupt global and regional **supply chains**, affecting trade and commerce leading to **depreciation of goods** (in case of prolonged disruptions) and increased transportation cost if **re-routing of cargo** is required. **Community Impact and Displacement**: Rising sea levels and coastal erosion may lead to **relocation of port operations** causing changes in livelihoods of **nearby communities**.
RA5: Financial impacts	**Loss of Revenue** from **reduced throughput capacity**, vessel berthing, and increased expenses for repairs **Insurance and Risk Management:** Higher insurance premiums for climate coverage.
RA6: Reputation	**Operational Reliability Perception:** Reputation damage as a result of the inability of the port to provide efficient and reliable services. **Environmental Responsibility Image:** Negative public perception arising from unmitigated climate-induced environmental impacts.

Phase 2. Detailed Analysis

Module 5 • Impact Analysis

Objective: To appraise/estimate the consequences of a hazard across several Risk Areas (RA): Damage/Operations ◆ Safety & Health ◆ Environment ◆ Social ◆ Financial Impacts ◆ Reputation

Output: Global impact score

Criticality (optional)

Although not compulsory, it is recommended that the impact analysis factors in the criticality of the project, i.e**., a hazard-agnostic property describing how fundamental the infrastructure is to the wider 'ecosystem'.**

Incorporates the following parameters (indicatively) :

- affected population in case of failures
- existence of redundancies,
- cascading effects to interconnected infrastructure components
- importance in the supply chain

Phase 2. Detailed Analysis

MOD. 4
HAZARD LIKELIHOOD
within the project lifespan

MOD. 5
IMPACTS
(across several risk areas)

MOD. 6
RISK = LIKELIHOOD x IMPACT

MOD. 7
Climate Adaptation Plan

MOD. 8
Climate Monitoring Plan.

MOD. 9
Verification of consistency

Climate Resilience Proofing Documentation

Module 6 • Climate Risk Analysis

RISK = LIKELIHOOD x IMPACT

Risk	Insignificant	Low	Medium	High	Extreme
Score	1-2	3-6	7-10	11-16	17-25
Criticality-weighted Score	1-10	11-30	31-50	51-80	81-125

RISK MONITORING RECOMMENDED

No need for adaptation measures

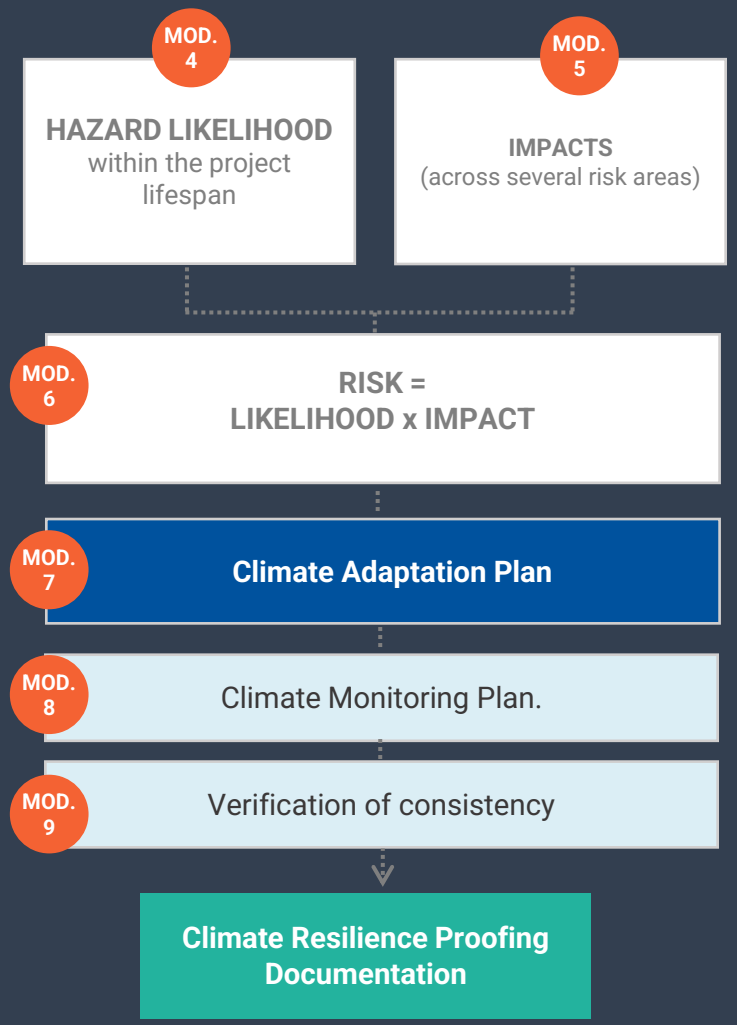
Light adaptation measures recommended

Adaptation measures may be required

Adaptation measures must be implemented

Significant adaptation are essential

Phase 2. Detailed Analysis



Module 7 • Climate Adaptation Plan

STEP. 1

Selection of Adaptation Measures

STRUCTURAL MEASURES

A physical change to the de
project re-location

NON-STRUCTURAL MEASU

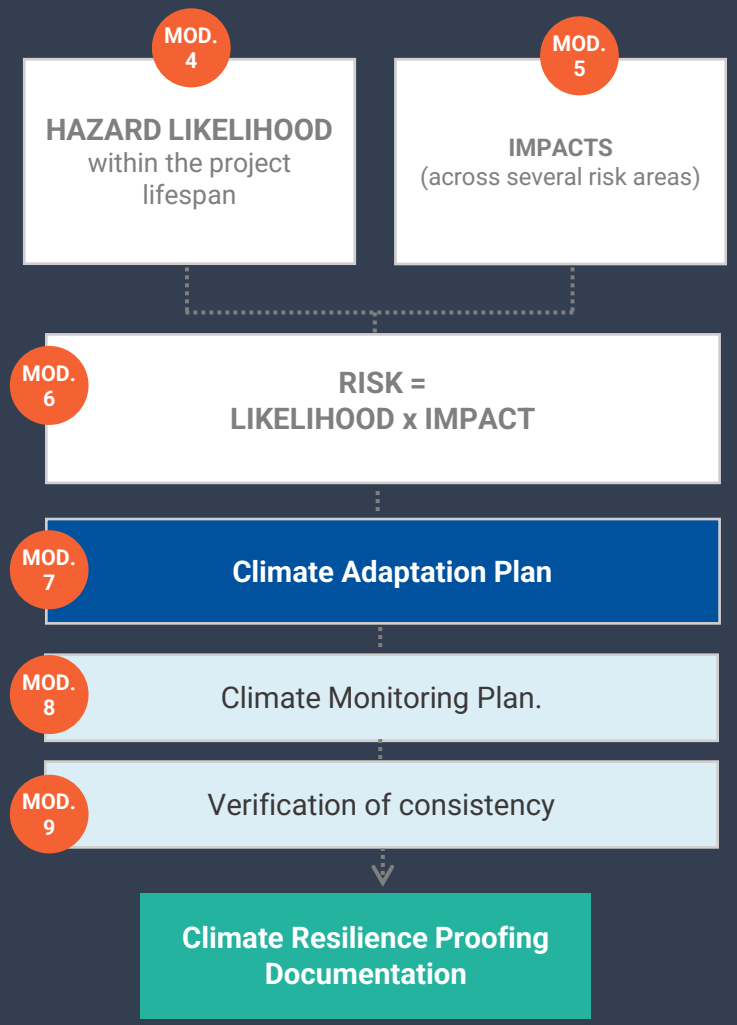
Soft-engineering measures
monitoring or early warning

OPERATIONAL MEASURES

Closing/limiting service unde
maintenance activities; back-

- Example adaptation measures for all sectors/typologies examined.
- Adaptation measures presented per hazard category /implementation phase
- Recommendations for Adaptive planning (measures implemented based on indicators monitoring)

Phase 2. Detailed Analysis



Module 7 • Climate Adaptation Plan

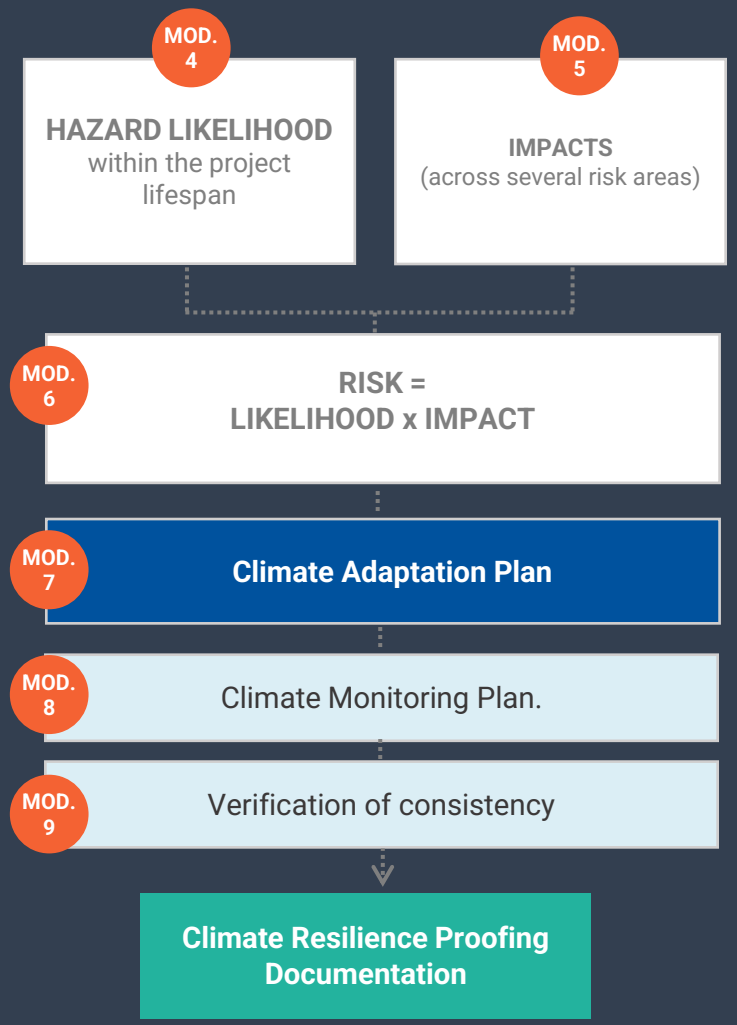
STEP. 1

Selection of Indicative Adaptation Measures

Example of Adaptation measures to Wind Parks

Climate Hazard	Plan and Feasibility	Construction	Operation & Maintenance
Extreme Winds & Cyclones	▪ Project relocation (in case the wind-park is at a tornado hot zone) ▪ Higher factors of safety / **Design beyond wind speed code thresholds**	▪ Offshore breakwaters ▪ Enhanced lightning protection and grounding ▪ Upgrade/reinforce foundations to withstand increased loading ▪ **Use of heavier or stiffer blades** ▪ Stronger pitch and yaw motors ▪ Innovative blade configurations for enhanced performance during extreme gust conditions	▪ **Weather monitoring systems** for early detection of extreme wind conditions
Cold spells	N/A	▪ **Anti-icing or de-icing techniques** (e.g., active blade heating, passive hydrophobic coating) ▪ Use materials with greater fatigue life	▪ Installation of ice detection systems
Heavy precipitation & Flooding	▪ Flood risk analysis during site selection ▪ **Redundancy measures for electrical components**	▪ **Cable Protection System (CPS) and scour protection** to withstand increased hydrodynamic loading	▪ Erosion protection measures to prevent water runoff and erosion of hillsides ▪ **Restoration of vegetation** to prevent erosion of slopes & landslides
Storm Surge & Sea level rise	▪ Provisions for subsea power cables (placement at appropriate depths) ▪ **Design for increased wave loads**	▪ Cable Protection System (CPS) ▪ **Wave-absorbing structures** for foundation protection ▪ **Anti-corrosive materials and coatings** for metal parts ▪ Insulation of submerged cables to protect from salt water	▪ **Increased maintenance frequency** ▪ Restoration of wetlands for tidal/surge protection

Phase 2. Detailed Analysis



Module 7 • Climate Adaptation Plan (possible selection process)

STEP. 1 **Selection of Adaptation Measures**

STEP. 2 **Appraisal of Adaptation Measures**

Cost-Benefit Analysis (CBA*) - requires the monetization of benefits

Costs

- **CAPEX** of the adaptation
- **O&M costs**

Benefits

- **Loss reduction**: reduced cost of repairs + reduced loss from operational disruption
- **Other Benefits**: environmental, health benefits etc

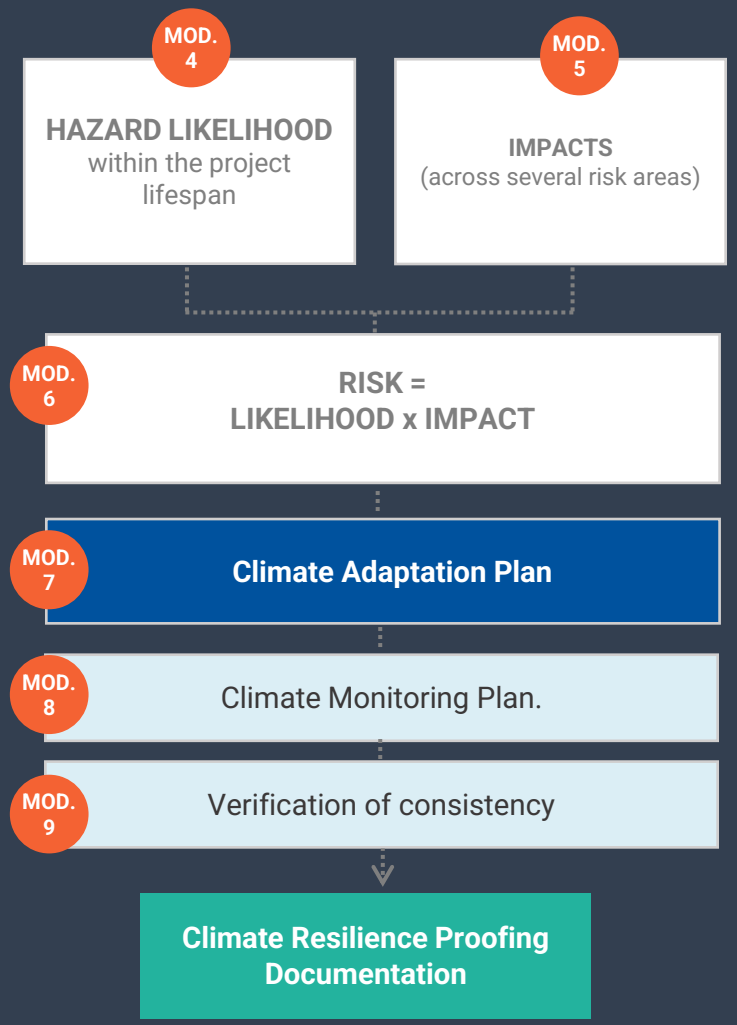
➢ Ranking based on BCR

Expert Judgement and/or Multi-Criteria Analysis (MCA) – depending on the scale and importance of the project

➢ Ranking based on weighting criteria

* Mostly applicable to large projects

Phase 2. Detailed Analysis



Module 7 • Climate Adaptation Plan (possible selection process)

STEP. 1 **Selection of Adaptation Measures**

STEP. 2 **Appraisal of Adaptation Measures**

STEP. 3 **Implementation Plan**

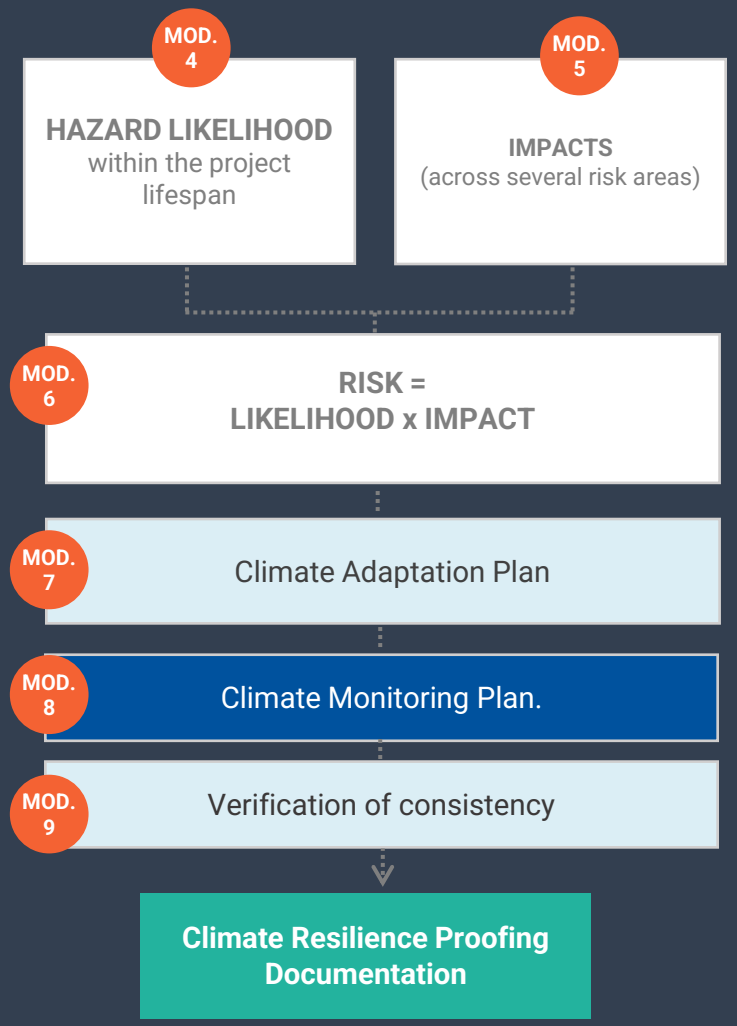
Immediate Adaptation (performed at the project outset)

- Risk of maladaptation

Adaptive (phased) Adaptation –Monitor the situation and only implement physical measures when the situation reaches a critical threshold

- Robust monitoring plan; Trigger-Action Plan; Continuous re-assessments

Phase 2. Detailed Analysis



Module 8 • Monitoring Plans

Asset Management
A platform for storing, organizing, managing and reviewing data

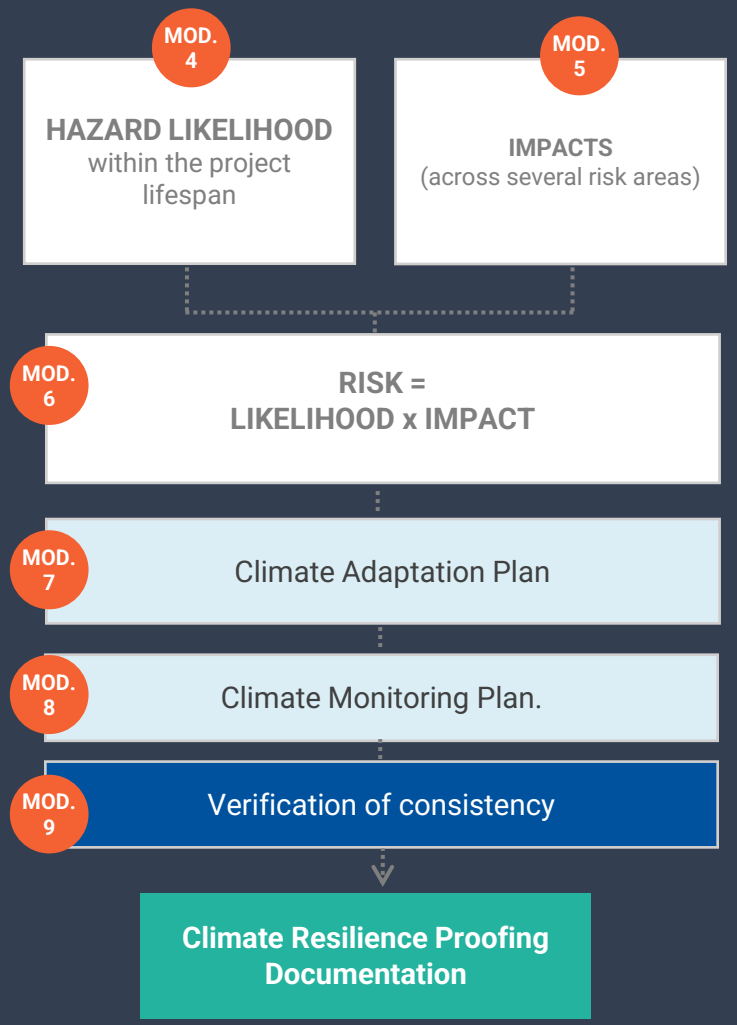
Preventive Module
Monitors the live asset condition and applies advanced analytics to predict response in future climate events enabling preventive maintenance actions.

Early Warning System
Gathers real-time hazard data, provides rapid damage diagnosis, and informs evacuation plans

Climate Registry
- Dataset of climate incidents (climate data; repair costs, performance logs)
- Climate Sensor indicators & thresholds allowing the classification of events using a standardized procedure

Climate Auditing
Measures the accomplishment of climate-proofing targets using mutually agreed/objective KPIs

Phase 2. Detailed Analysis



Module 9 • Verification of Consistency

Objective: To verify the project's compatibility with the country's resilient development pathway

Project Scope

The project aligns with the climate adaptation strategy outlined in NAPs (https://climate-adapt.eea.europa.eu/en), and relevant regional or local adaptation plans and strategies (as applicable)

Outcome

the project complies with the prescribed sector-specific criteria, addresses climate risks and has taken the necessary measures to avoid cases of maladaptation.

Thank you !

For info on this webinar and details on the activities of the JASPERS Networking Platform please visit the following websites::

https://jaspers.eib.org/knowledge/index

http://jaspers.eib.org/

Or write us at jaspersnetwork@eib.org