Masterclass on
Climate Resilient Infrastructure Public-Private Partnerships

African Union

AFRICA ADAPTATION INITIATIVE

AFRICAN DEVELOPMENT BANK GROUP

GLOBAL CENTER ON ADAPTATION

ICSI International Coalition for Sustainable Infrastructure

Module 2 - Risk Assessment:

b) Incorporating climate resilience in the Appraisal Phase of PPPs

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Outline

Recap of Module 2a

Climate Risk Assessment: Project Appraisal Phase

Uncertainties in the Climate Risk Assessment

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Uncertainties in the Climate Risk Assessment

Recap: Project Identification Phase

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1

We should be asking: Is this a good project? Should it be procured as a PPP? And does climate change impact our answers to either question?

2

High-level screening of climate hazards identifies which hazards are significant to a project

3

Early-stage screening should look at resilience <u>of</u> infrastructure and resilience <u>through</u> infrastructure

Project Identification Phase: Climate resilience intervention points

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01 PROJECT IDENTIFICATION PHASE
- Undertake high-level climate screening

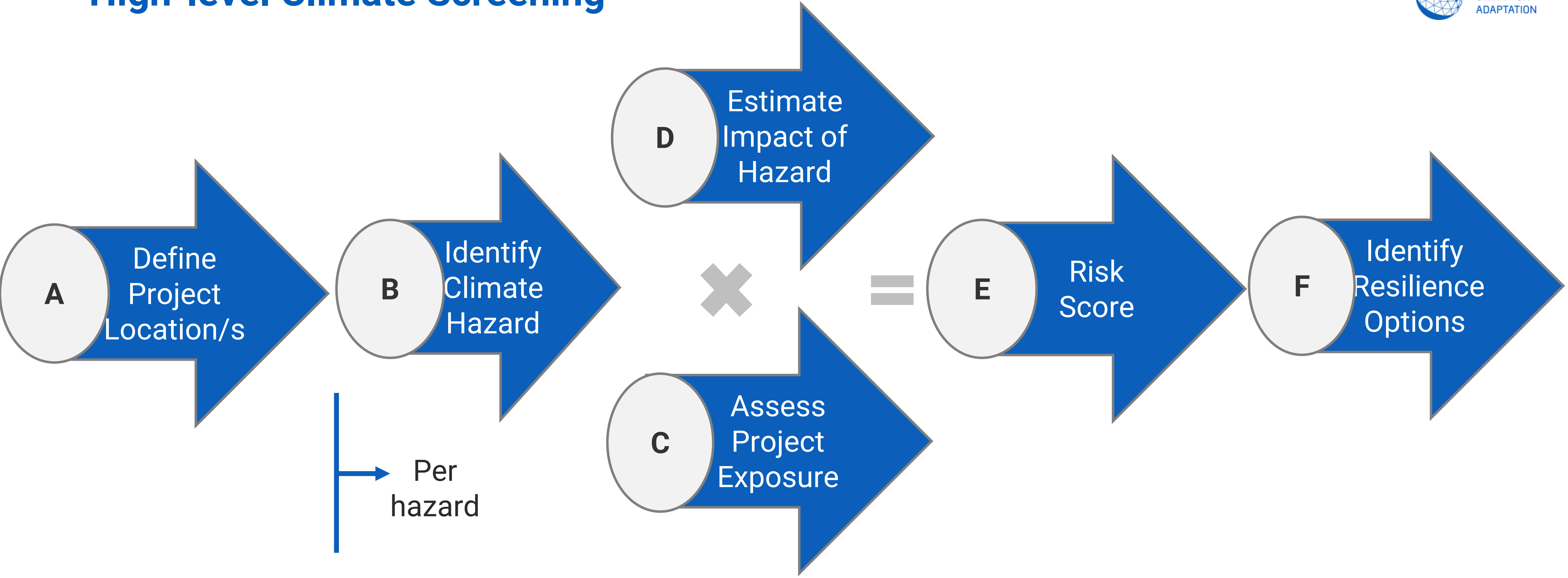
02 PROJECT APPRAISAL PHASE
- Undertake climate risk assessment
- Identify and appraise resilience options

03 TENDER AND AWARD PHASE
- Allocate climate risk
- Define climate-resilient performance requirements
- Create adjustment mechanisms for climate events
- Setting climate-related evaluation criteria
- Climate-proof project design

04 CONTRACT MANAGEMENT PHASE
- Implement resilience measures
- Climate-proof operations
- Monitor and evaluate climate-resilient performance requirements
- Deal with climate-related contractual changes
- Incorporate climate resilience in the transfer/handover process

CROSS-CUTTING TOPICS
- Decision-making under uncertainty
- Mobilising climate finance
- Stakeholder engagement
- Gender-sensitive considerations
- Nature-based solutions

High-level Climate Screening



Asset Location	Climate Hazard	Exposure	Impact (Vulnerability)	Risk Score	Resilience Options	Residual Impact
A	B	C	D	E = C X D	F	G = E-F

Project Appraisal Phase

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Recap of Module 2a

Climate Risk Assessment: Project Appraisal Stage

Uncertainties in the Climate Risk Assessment

Climate Risk Assessment

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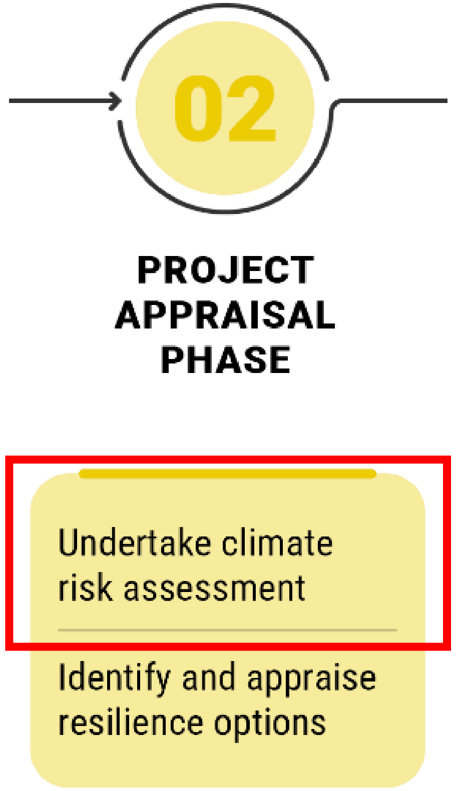
GOAL	Provide a comprehensive understanding of a project's climate risks and how they might change in the future.



1. Collect data required for the climate risk assessment
2. Assess the exposure of assets and end users across climate scenarios
3. Assess the vulnerability of assets and end users across climate scenarios

CRIO Handbook: Appraisal Phase, p29-36

Climate Risk Assessment

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GOAL	Provide a comprehensive understanding of a project's climate risks and how they might change in the future.

02

PROJECT APPRAISAL PHASE

- Undertake climate risk assessment
- Identify and appraise resilience options

1. **Collect data required for the climate risk assessment**
2. Assess the exposure of assets and end users across climate scenarios
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CRIO Handbook: Appraisal Phase, p29-36

Climate Risk Assessment: Collection of Required Data

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Climate data:

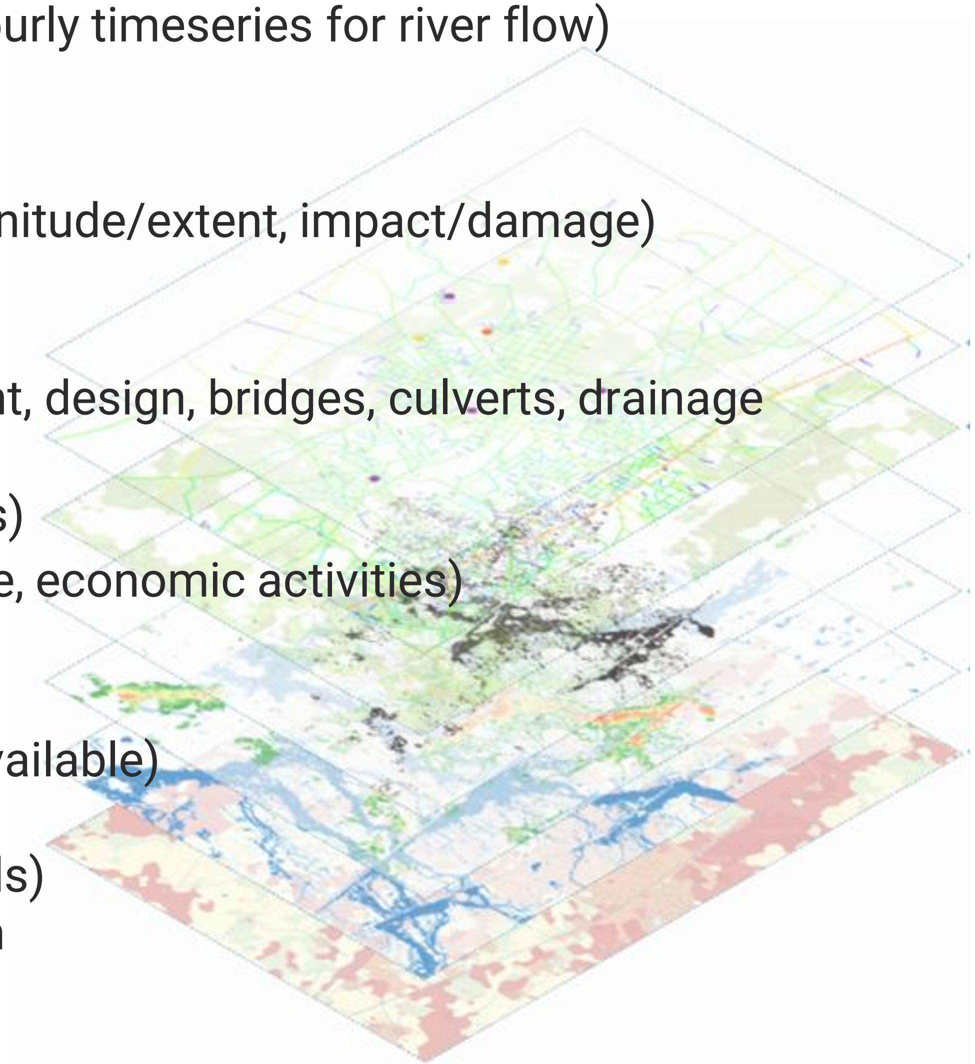
- ✓ Hydro-meteorological stations (location, type of station, hourly/daily precipitation, temperature, charts for RPs)
- ✓ Water levels and river discharge data (water depth, daily/hourly timeseries for river flow)
- ✓ Early warning systems (locations, effectiveness)
- ✓ Hazard maps and response reports (flood, landslides)
- ✓ Record of past extreme climate events (location, date, magnitude/extent, impact/damage)

Infrastructure data:

- ✓ Road database and asset specification (elevation, alignment, design, bridges, culverts, drainage infrastructure)
- ✓ Traffic data (traffic count per vehicle type, growth forecasts)
- ✓ Spatial data on critical infrastructure (education, healthcare, economic activities)

Other studies / reports:

- ✓ High-resolution DEM (30m resolution or more detailed if available)
- ✓ Land use/cover maps (incl. natural/protected areas)
- ✓ Road design and maintenance guidelines (norms, standards)
- ✓ Demographic and socioeconomic data (census, population distribution, wealth indexes)



Climate Risk Assessment: Stakeholder Engagement

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Stakeholder Group	Contribution to the Climate Risk Assessment
Local Communities	√ Local climate, environmental and social conditions, and impacts on livelihoods. √ Share gendered perspectives on how climate impacts affect women, children, and vulnerable groups. √ Offer insights into existing coping mechanisms and resilience strategies.
Project Developers	√ Identify potential climate risks during project feasibility and design. √ Engage with stakeholders to ensure gender inclusivity and diversity are incorporated into project goals and objectives.
Government Authorities and Regulators	√ Set regulatory standards requiring gender mainstreaming in CRAs. √ Enforce the inclusion of gender-responsive indicators to track socio-economic impacts on diverse groups.
Civil Society Organizations	√ Advocate for the inclusion of vulnerable groups in consultations and decision-making. √ Conduct research on gendered and socio-economic impacts of climate change, informing the risk assessment.
Private Sector and Industry Experts	√ Provide technical expertise on climate risk modeling and mitigation strategies. √ Assess financial risks from climate impacts, considering intersections with gender and socio-economic factors.
Academia and Research Institutions	√ Resources on climate projections and differential impacts of climate risks on gender. √ Offer tools and methodologies for conducting gender-sensitive CRAs.

Climate Risk Assessment

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GOAL	Provide a comprehensive understanding of a project's climate risks and how they might change in the future.

02

PROJECT APPRAISAL PHASE

Undertake climate risk assessment

Identify and appraise resilience options

1 Collect data required for the climate risk assessment

2 **Assess the exposure of assets and end users across climate scenarios**

3 Assess the vulnerability of assets and end users across climate scenarios

CRIO Handbook: Appraisal Phase, p29-36

Climate Risk Assessment: Exposure

- ✓ The railway contains the following assets:
  - ✓ Single rail track (meter-gauge) with metal sleepers constructed in the 1930s;
  - ✓ 5 bridges to cross big rivers and wetlands;
  - ✓ Culverts for drainage of precipitation and local streams passing the railway;
  - ✓ Roadway overpasses / underpasses and level crossings;
  - ✓ Wayside equipment;
  - ✓ Serviced by freight trains;
  - ✓ Train stations.

Climate Risk Assessment

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GOAL	Identify and evaluate, qualitatively and/or quantitatively, the effect of climate on the project and beneficiaries

02

PROJECT APPRAISAL PHASE

- Undertake climate risk assessment
- Identify and appraise resilience options

1. Collect data required for the climate risk assessment
2. Assess the exposure of assets and end users across climate scenarios
3. **Assess the vulnerability of assets and end users across climate scenarios**

CRIO Handbook: Appraisal Phase, p29-36

Climate Risk Assessment: Analysis of Vulnerability

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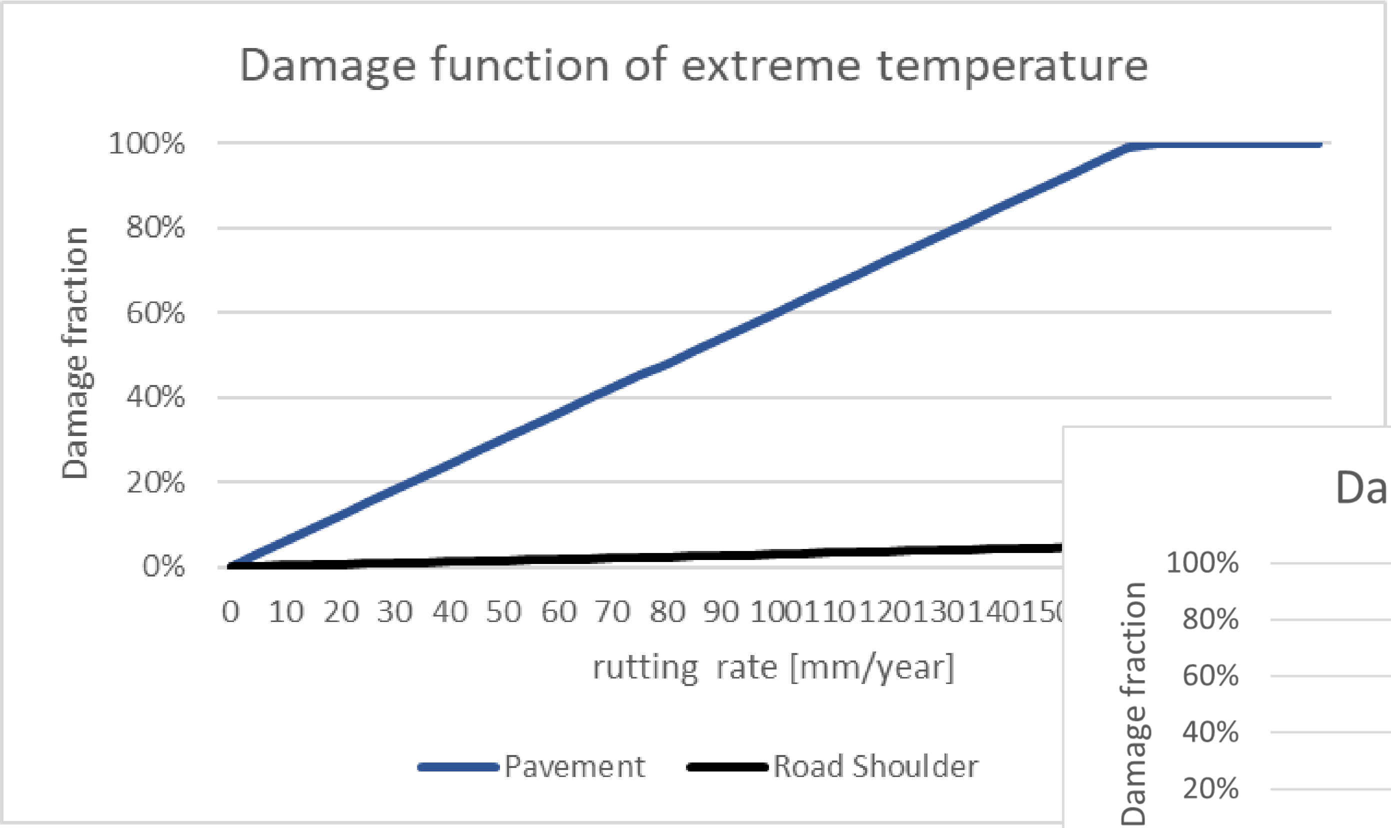
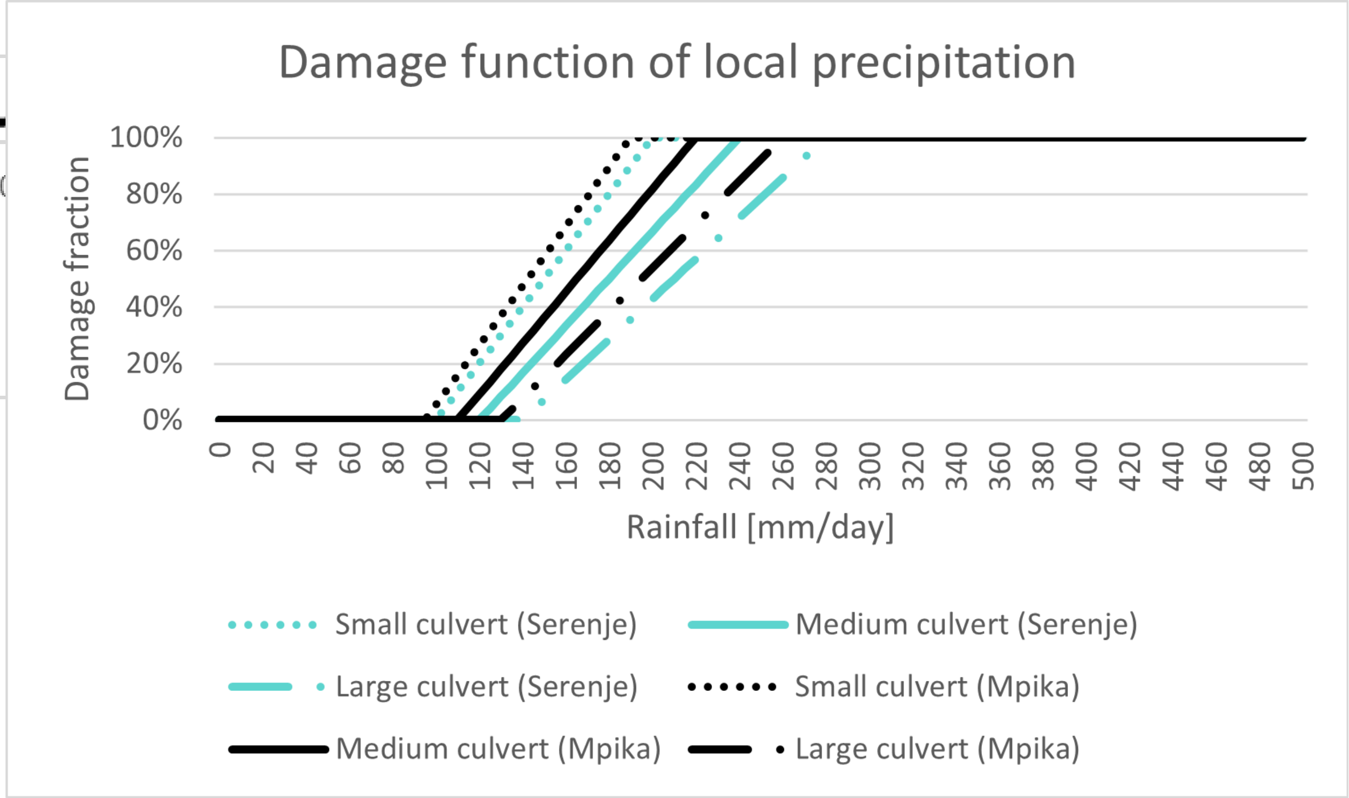
- ✓ Vulnerability functions are defined based on the **maximum damage value** and the **percentage of damage expected** due to the occurance of a certain hazard event.
- ✓ These functions are defined for all hazard/asset type combinations.

Asset type	Costs per unit	unit	Total quantity	Total value [USD million]
Foundation	USD 102	USD/m^2	$8.4 \cdot 10^6$ m^2	857
Shoulder	USD 68	USD/m^2	$2.8 \cdot 10^6$ m^2	190
Pavement	USD 68	USD/m^2	$4.9 \cdot 10^6$ m^2	333
Small culvert	USD 32,500	USD/culvert	809 culverts	20*
Medium culvert	USD 55,000	USD/culvert	26 culverts	1*
Large culvert	USD 72,500	USD/culvert	123 culverts	6*
Small Bridge	USD 50,000	USD/bridge	6 bridges	0
Medium Bridge	USD 1,000,000	USD/bridge	2 bridges	2
Large Bridge	USD 10,000,000	USD/bridge	0 bridges	0
			Total	1,409

Climate Risk Assessment: Analysis of Vulnerability





Climate Risk Assessment: Quantification of Risks

Direct Losses:

- ✓ Physical damages caused by the hazards to the assets.
- ✓ These are derived from damage curves for hazard-asset combination.
- ✓ Cost values will be derived from the repair cost, increased O&M costs, decreased lifespan of assets etc.

Indirect Losses:

- ✓ The socio-economic damages caused by the downtime to the assets.
- ✓ Cost values can be derived from impact on food security, trade etc.
- ✓ Impacts to passenger transport and to cargo due to delay.
- ✓ Disruptions of access to services.
- ✓ Power cuts due to flooding events.

Total Annual Risks = Direct Losses + Indirect Losses

Climate Risk Assessment: Quantification of Risks

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MONETIZED LOSSES/BENEFITS

Direct Benefits:
- ✓ Avoided physical damages to road assets (bridges, culverts, pavement, drainage)
- ✓ Reduction in occurrence of events

Indirect Benefits:
- ✓ Lower downtime due to flooding, rockfall and landslides
- ✓ Reduced traffic delays, reduced cargo inventory costs, and reduced cargo deterioration

NON-MONETIZED LOSSES/BENEFITS

Direct Benefits:
- ✓ Reduced road insecurities

Indirect Benefits:
- ✓ Reduced frequency/prevention of power generation reductions and blackouts
- ✓ Reduced inaccessibility of critical services (e.g., education, medical services)
- ✓ Reduced inaccessibility of markets for selling agricultural produce
- ✓ Increased food-security

Climate Risk Assessment: Quantification of Risks Across Scenarios

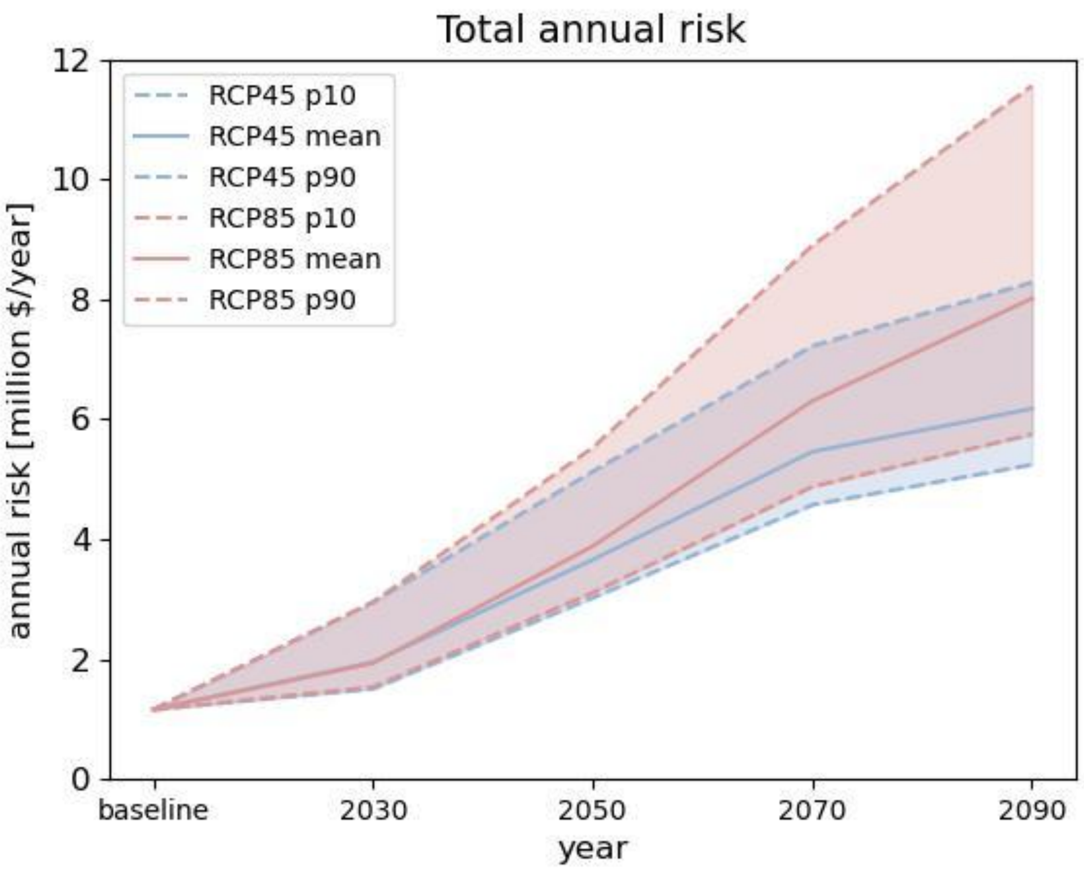
- ✓ **Annual risk (for RCP8.5):**
  - ✓ Baseline – USD 1.2 million per year
  - ✓ In 2050 – USD 3.7 million per year

- ✓ The most important climate risk is **pluvial flooding**, contributing of 98%. A gradual increase in precipitation intensities is expected over time.

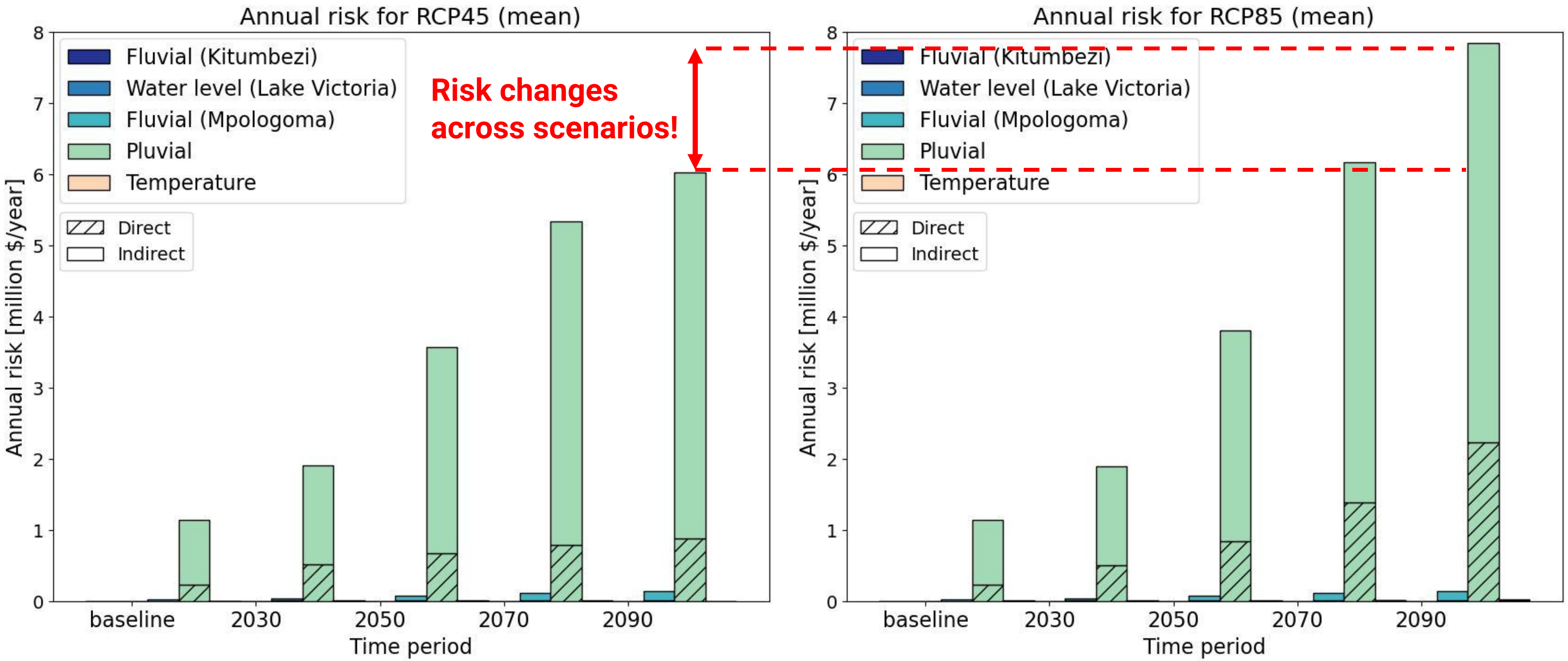
- ✓ **Fluvial risk** are emerging in the future.

- ✓ Largest share is the **indirect risk**, caused by disruption of operations as the assets require maintenance or repairs.

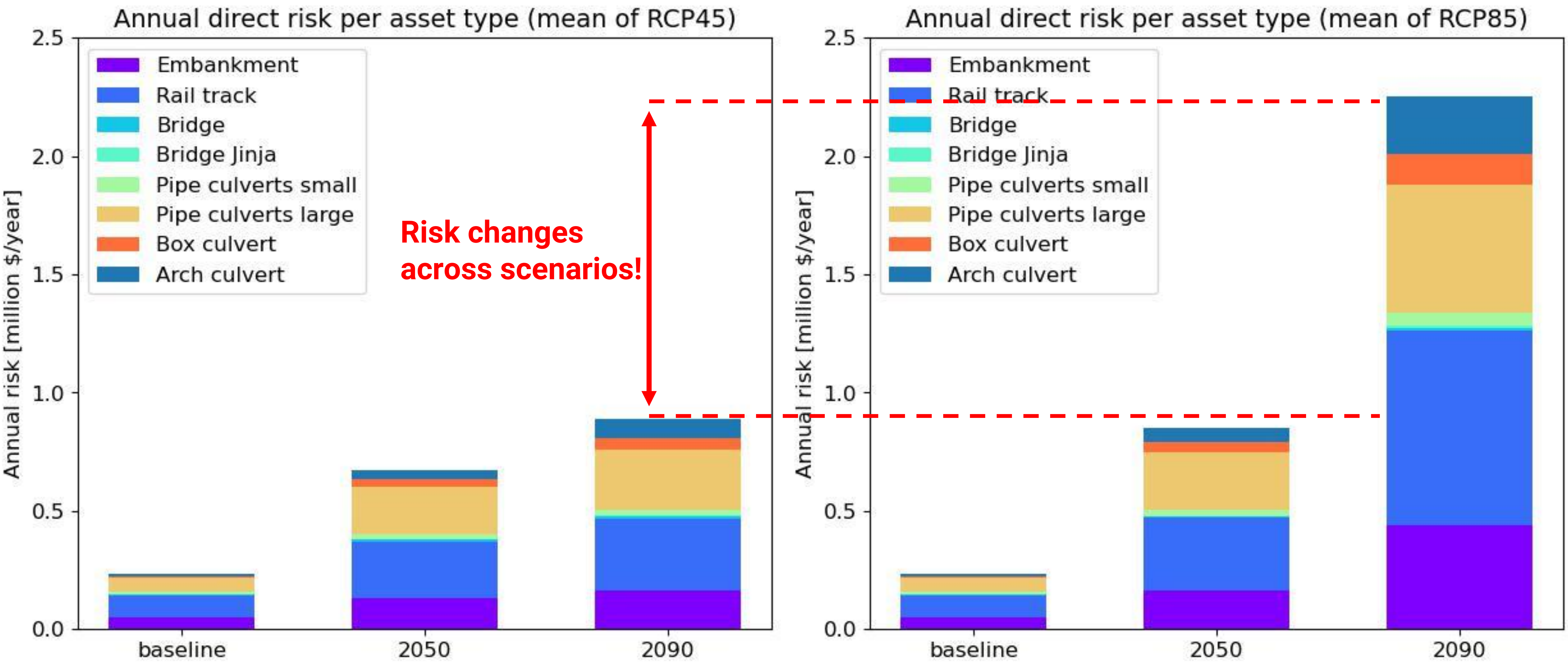
- ✓ Additionally, the expected indirect **economic benefits** from enhanced trade by rail increases the indirect risk over time.



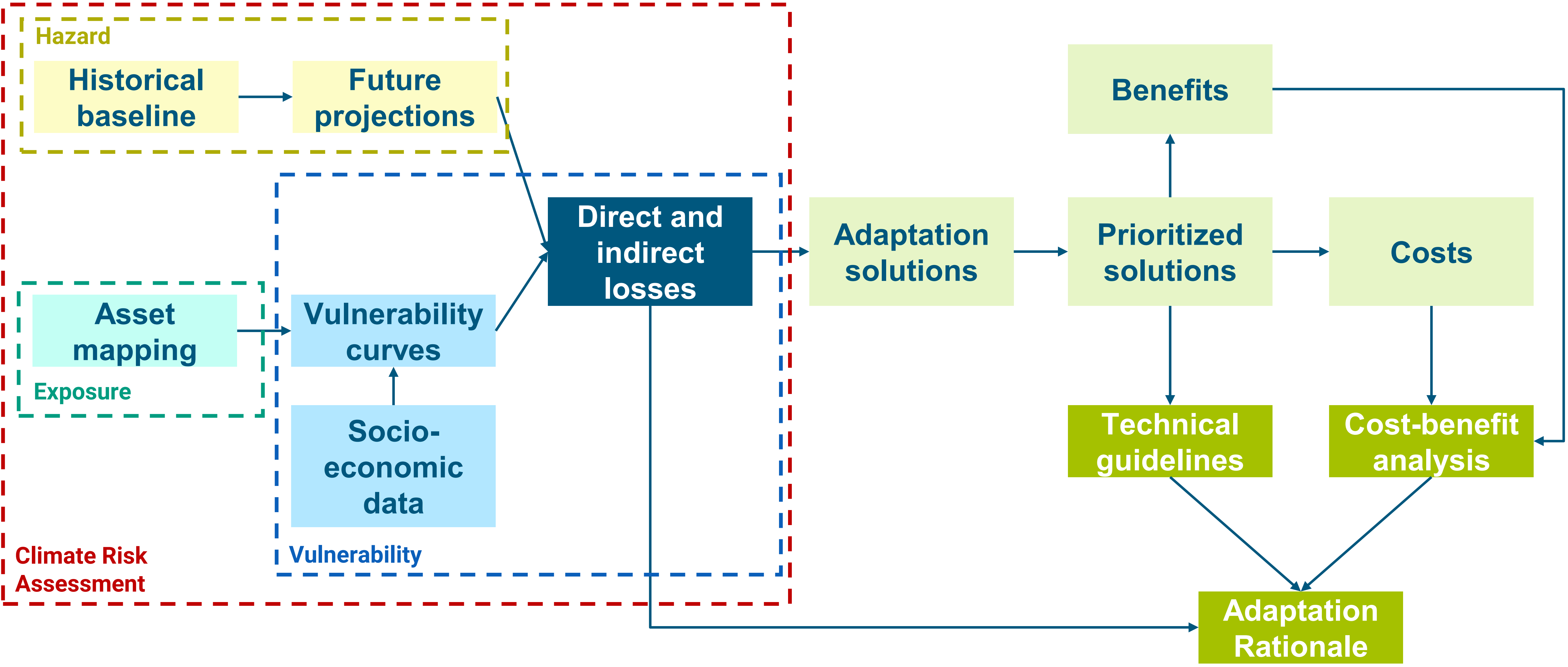
Climate Risk Assessment: Quantification of Risks Across Scenarios



Climate Risk Assessment: Quantification of Risks Across Scenarios



Climate Risk Assessment: Overview of Interlinkages



Outline

Recap of Module 2a

Climate Risk Assessment: Project Appraisal Stage

Uncertainties in the Climate Risk Assessment

What is uncertainty?

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Definition

- ✓ The state of being unsure of something (Google)
- ✓ Uncertainty describes the unpredictability of events
  - ✓ there is neither clarity about the present situation nor the future outcome

Importance in infrastructure resilience

- ✓ To mainstream CRI it is crucial to acknowledge that uncertainty is inherent in nearly all decision-making CC presents uncertainty challenges
- ✓ To ignore it would be to undermine effective risk management

Uncertainty vs. risk

- ✓ Uncertainty is, effectively, risk that cannot be quantified
- ✓ With risk, we can estimate potential impact from the probability that it will happen and their severity if it happens. With uncertainty, we do not know

How do we deal with it?

- ✓ Climate modelling (though different modellers may have different assumptions)
- ✓ Stakeholder engagement to develop a consensus

Key principles of decision making under uncertainty

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1. No-regret strategies

- Measures that have positive benefits even in the absence of CC, e.g. reducing development in flood prone areas will yield benefits even if CC does not make flooding worse in future

2. Reversible and flexible strategies

- Measures that can be undone if future scenarios prove incorrect, e.g. early warning systems

3. Safety-margin strategies

- Measures that reduce vulnerability at no- or low-cost by including a cushion for estimates, e.g. using a worst-case estimates of drought frequency to plan farming methods and crops to plant Vs. dealing with hunger later

4. Strategies reducing decision-making time horizons

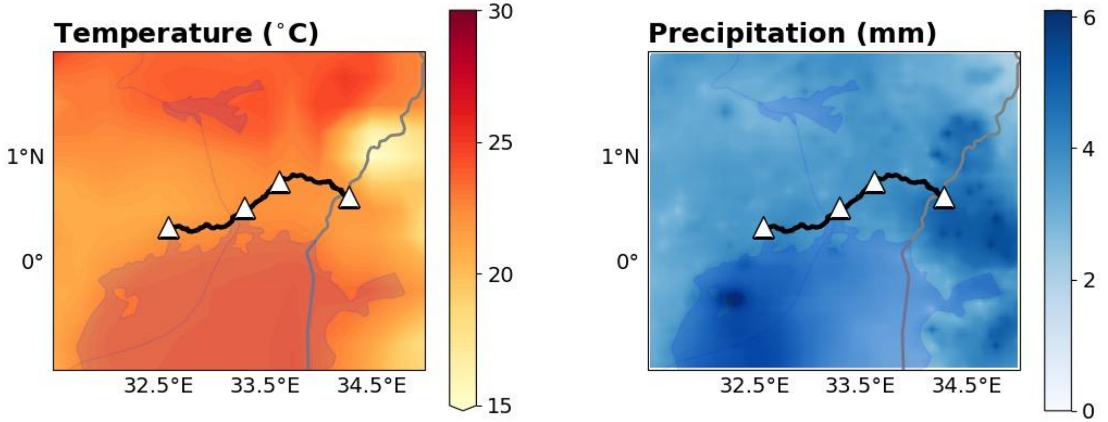
- Prioritizing measures that have shorter lifespans to avoid long-term infrastructure lock-in
- These measures can be reassessed as future states become clearer

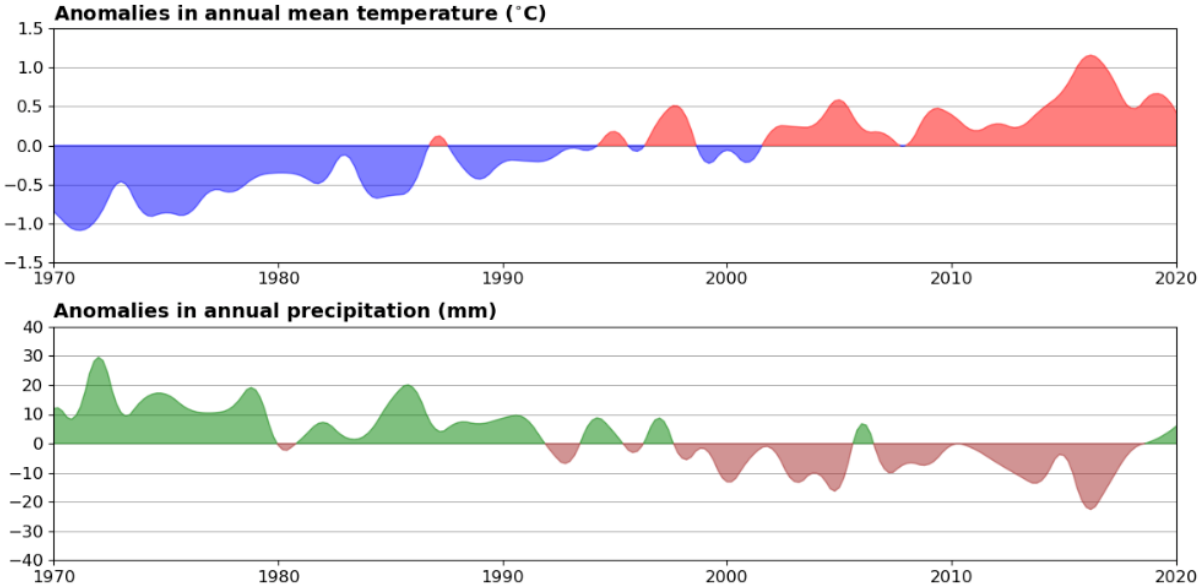
Uncertainties: Climate Baseline

A **climate baseline** serves as the benchmark against which potential impacts of climate change is measured. Generally, we look into data for the period 1981 – 2020.

The analysis of historical data helps identify **trends** in the climate variables and allows for **ground-truthing** of the results of the climate models.

Main challenge: availability of meteorological stations with sufficient and consistent measurements.





Source: GCA, 2022. Climate Hazard Assessment. Kampala-Malaba Metre Gauge Railway Project.

Uncertainties: Climate Projections

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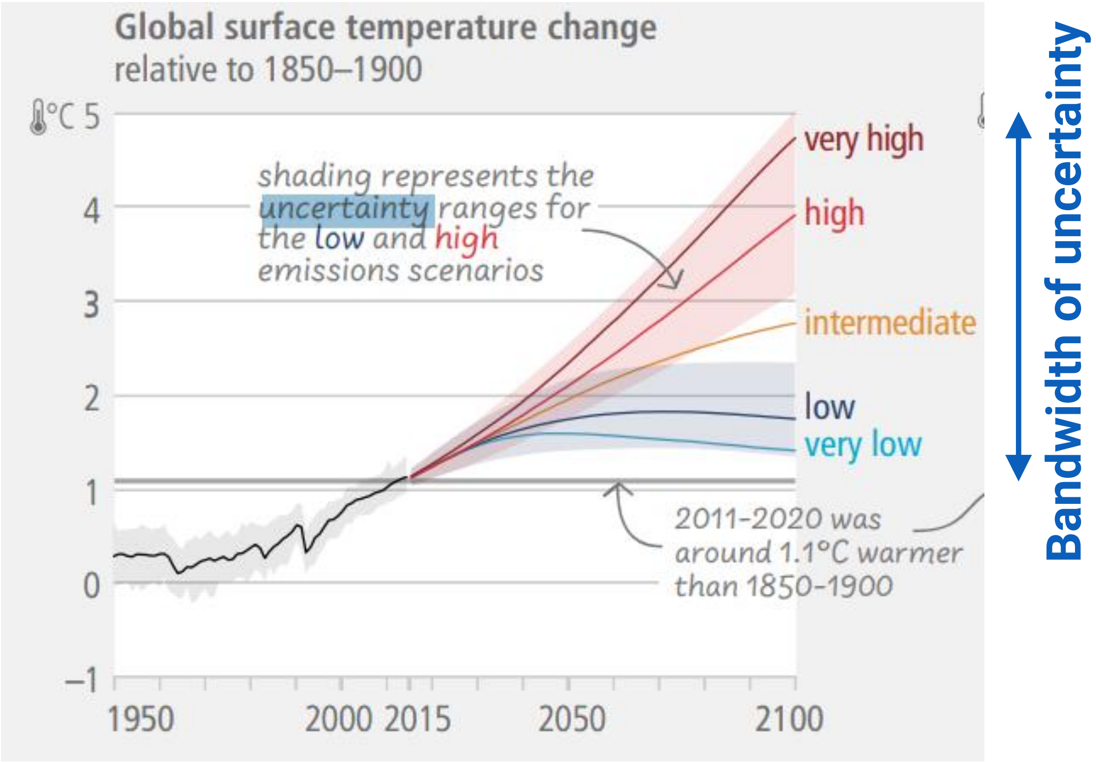
Sources of uncertainty:

- ✓ *Model errors and biases*: GCMs may not properly represent the climate in a region and may under- or overestimate.
- ✓ *Uncertainty*: a single or several GCMs may not represent the full range of potential climate changes in a region.
- ✓ *Resolution*: GCM projections are at a horizontal resolution of hundreds of kilometers and are not fine enough at the project level.

How to account for uncertainty:

- ✓ Consider a range of plausible climate futures or scenarios instead of looking into a single assumed projected climate future.
- ✓ Consider unlikely-but-plausible scenarios for significant and long-term investments.
- ✓ Adopt adaptive and flexible solutions.
- ✓ Use monitoring to inform decision-making.



Source: IPCC. 2023. Synthesis Report for the Sixth Assessment Report. [Link]

Uncertainties: Downscaling Climate Projections

Downscaling can increase both the **spatial resolution** (e.g., from hundreds to tens of kilometers) and **temporal resolution** (e.g., from monthly to daily).

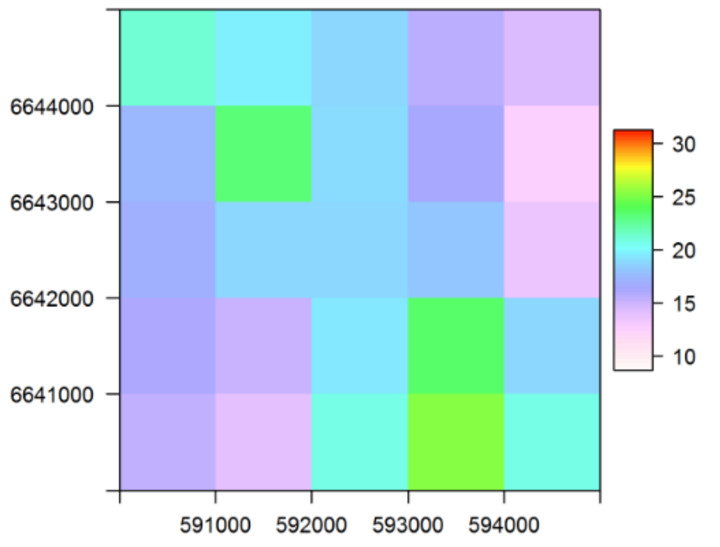
Two main approaches:

- ✓ Dynamical downscaling – using regional climate models
- ✓ Statistical downscaling – using empirical relationships

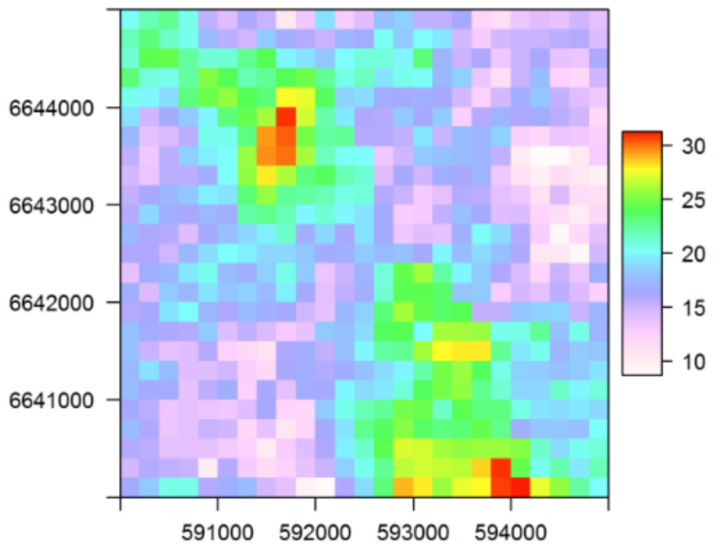
Key considerations:

- ✓ Provide a more granular assessment of climate hazards to the project location.
- ✓ The downscaling process should be bias-corrected and validated with local information.
- ✓ This analysis still has uncertainties related to the climate projections and the process to downscale data.

Input: GCM simulation



Output: Downscaled result



Uncertainties: Vulnerability

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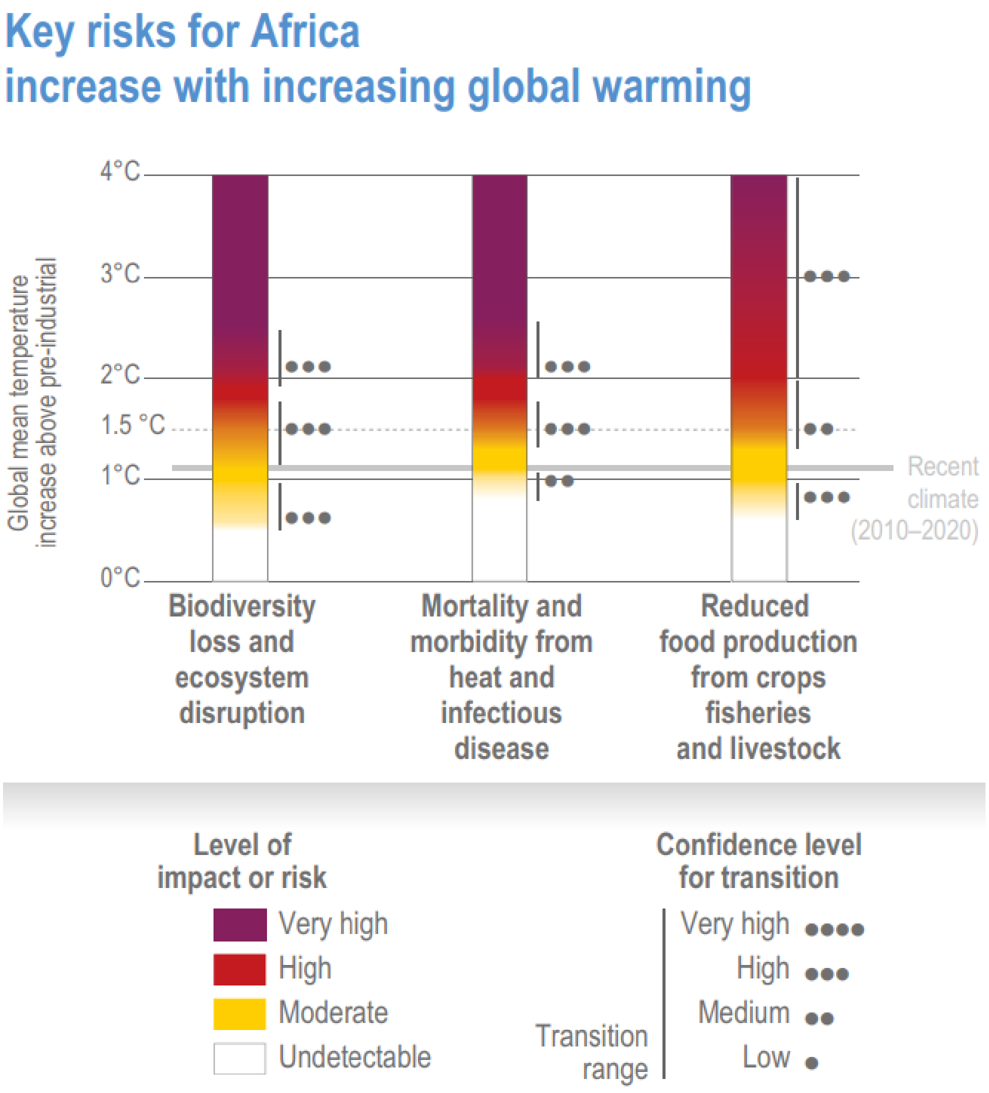
The degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes.

Depends on conditions specific to the project location:

- ✓ Observable information from **local experiences**.
- ✓ **Socio-ecological drivers** such as income level, settlement patterns, infrastructure, ecosystem and human health, gender, political participation, and individual behavior.
- ✓ **Biophysical drivers** such as poor land management, deforestation, geophysical instabilities. Some ecosystems are more exposed to risks, such as low-lying coastal areas and permafrost areas.



Source: AR6 Work Group II , 2022. (https://report.ipcc.ch/ar6/wg2/IPCC_AR6_WGII_FullReport.pdf)

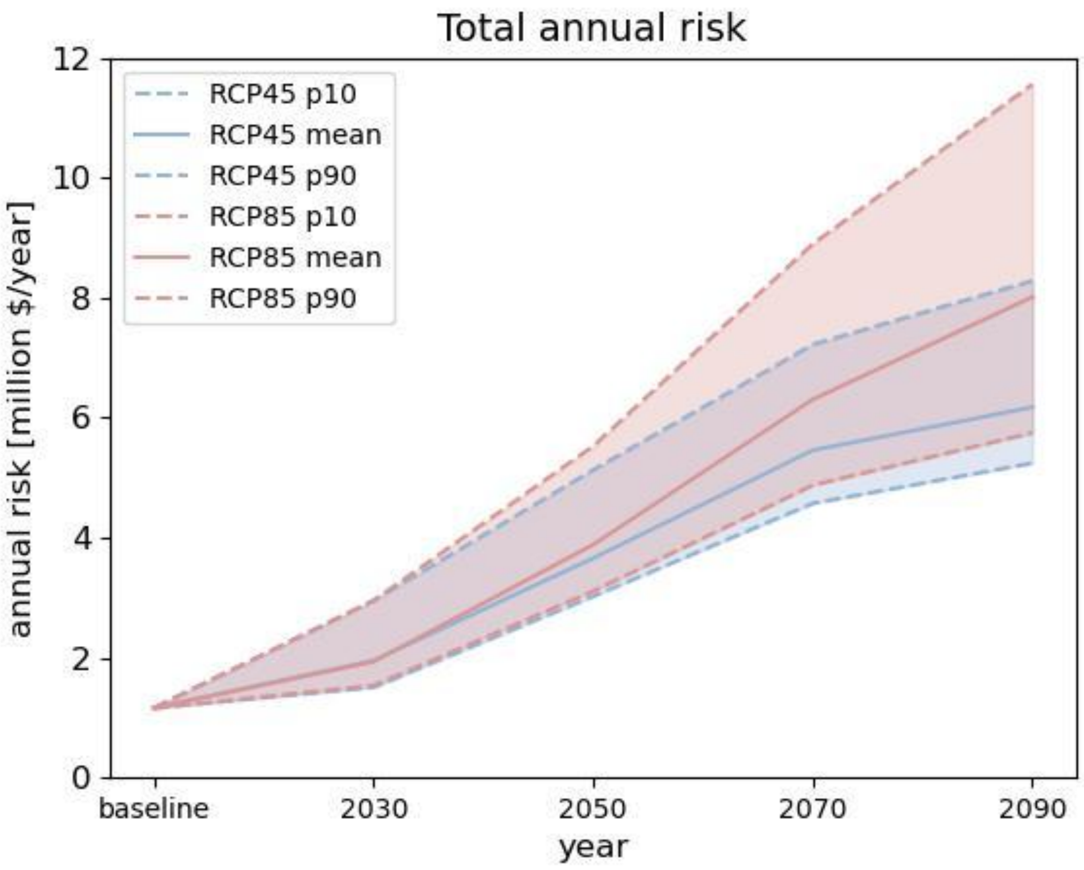
Uncertainties: Climate Risk

The quantification of climate risks carries an **inherent uncertainty** due to the uncertainties in hazard, exposure and vulnerability.

Key considerations:

- ✓ Understanding how the results of total climate risk might change across climate scenarios and return periods is important for making investment decisions.

- ✓ Being able to visualize and to communicate clearly about these uncertainties will support the definition of the level of risk that is acceptable.



Uncertainties: Adaptation Solutions

- Costs of adaptation options can vary and this might affect the economic analysis results.
- The result is that adaptation options can be often more or less economically feasible.

Adaptation Package	NPV		BCR		IRR	
	RCP4.5	RCP8.5	RCP4.5	RCP8.5	RCP4.5	RCP8.5
Package 0: Basic Design	2,483,000 EUR	2,589,000 EUR	1.74	1.77	16.57%	16.78%
Package 1: Empowering Local Communities	1,132,000 EUR	1,259,000 EUR	3.06	3.29	39.94%	41.37%
Package 2: Future Design Boundary Conditions	563,000 EUR	683,000 EUR	1.23	1.28	12.96%	13.48%
Package 3: Enhanced Resilience	558,000 EUR	678,000 EUR	1.23	1.28	12.93%	13.45%

Discussion questions

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- How have you handled decision-making in uncertain circumstances?
- How have you prioritized resilience options under conditions of uncertainty?

Recap: Appraisal Phase – Climate Risk Assessment

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1

Collect detailed data (on climate and infrastructure) is a key part of developing a climate risk assessment.

2

Total risks can change across climate scenarios, that needs to be well understood to inform investment decisions.

3

Uncertainties are inherent in the process of a climate risk assessment. We need to integrate that in each step of the process.

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