Risk analysis for climate change problems

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Motivation

Decision-making for climate change problems is associated with many challenges:

- Random variation in natural processes
- Uncertainty about future and unforeseen conditions
- Many types of impacts to many different social and physical systems
- Tradeoffs in costs and benefits of potential actions

Risk analysis can be a useful framework for considering these challenges

Risk is “the potential for adverse consequences”

(IPCC Sixth Assessment Report)

“Potential” → uncertainty, incomplete knowledge

“Consequences” → considers outcomes (sometimes good and bad)

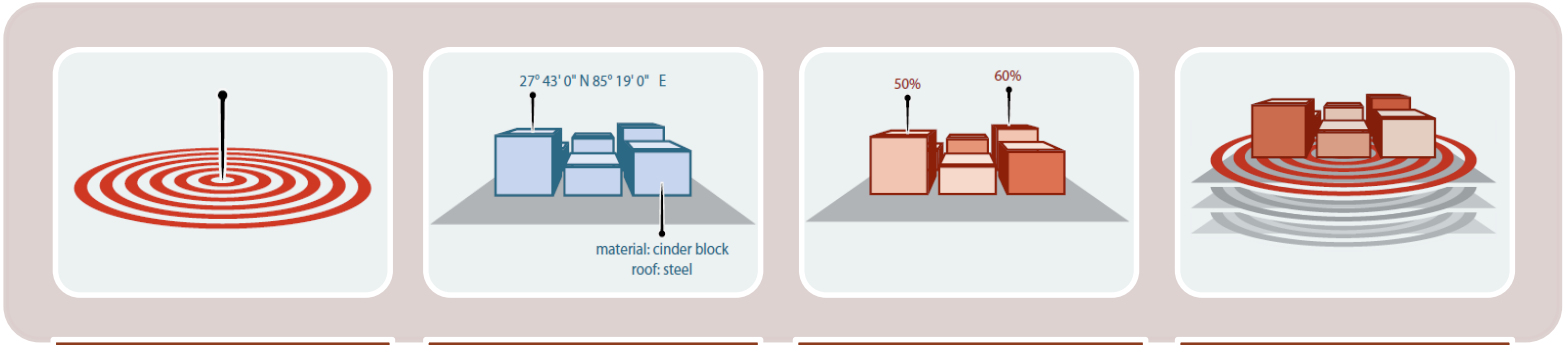
Risks can arise from potential impacts of climate change as well as human responses to climate change.

– IPCC Sixth Assessment Report

“The purpose of risk analysis and risk quantification is, always, to provide input to an underlying decision problem…”

– Kaplan & Garrick, 1981

Risk Components



Hazard

Likelihood and intensity of potentially destructive natural phenomena

Exposure

Location and characteristics of assets

Vulnerability

Reaction of assets when exposed to hazard event

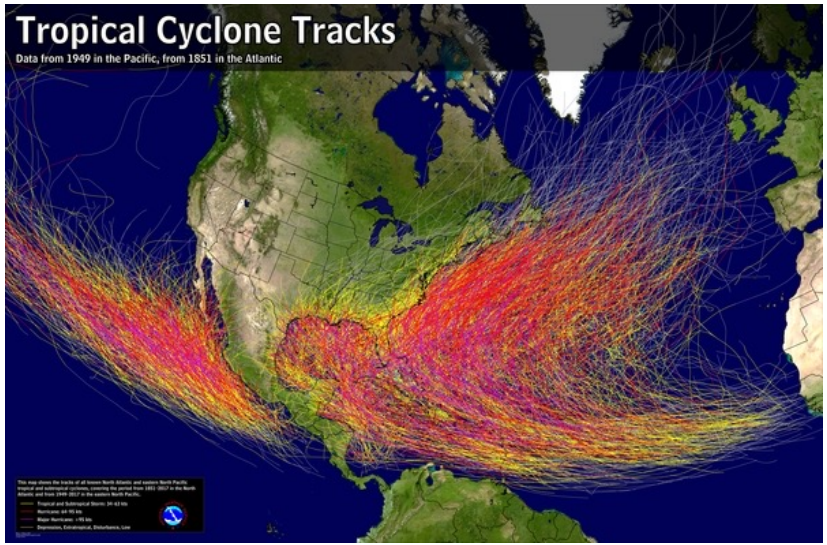
Risk

Potential for consequences

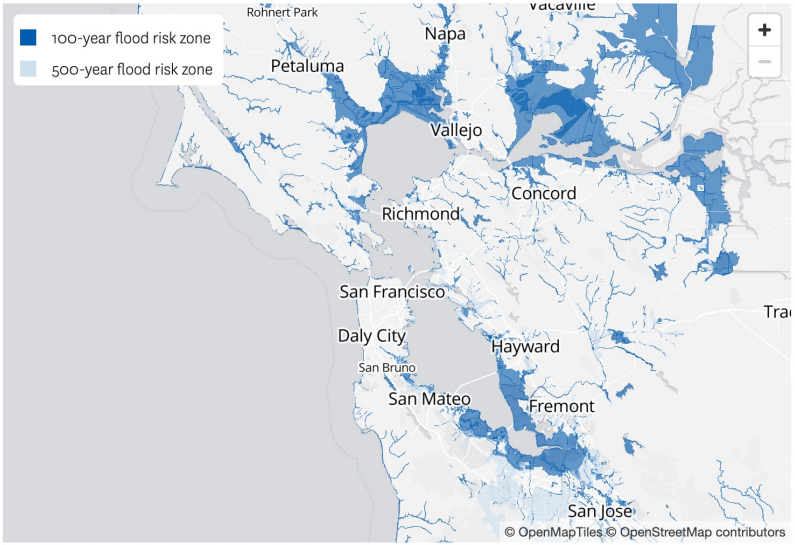
Hazard: Frequency of occurrence of a loading condition

- Flood depth
- Wind speed
- Temperature (peak, duration)
- Precipitation
- Fire intensity

Often quantified using a simulated set of events, or probability distribution of loading



www.nhc.noaa.gov/climo/

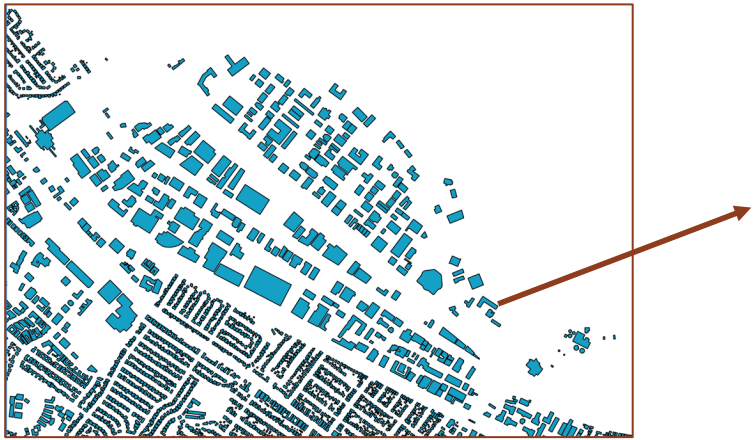


Map: Sriharsha Devulapalli / The Chronicle · Source: Metropolitan Transportation Commission

Exposure: Attributes of relevant assets

Define assets potentially disrupted by hazard event

Define their attributes relevant to hazard and vulnerability



- Location
- Physical and functional characteristics
- Collocation of people/housing/infrastructure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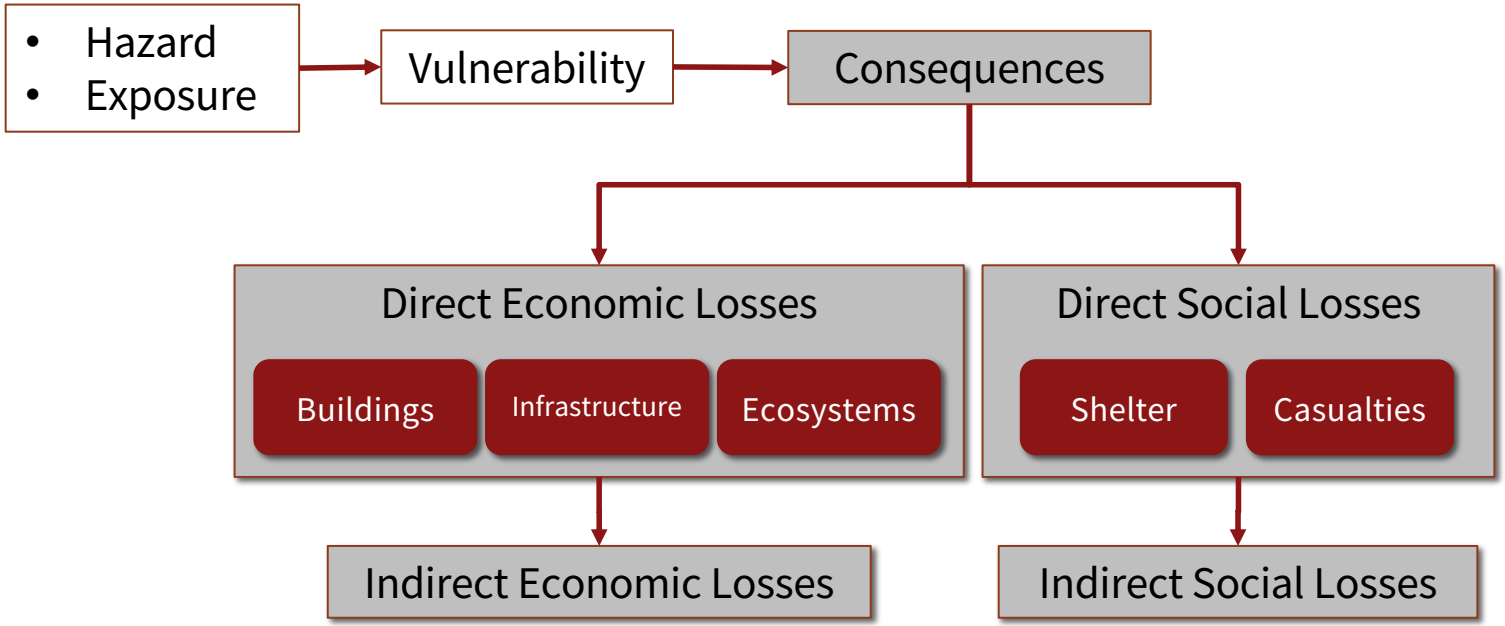
Vulnerability

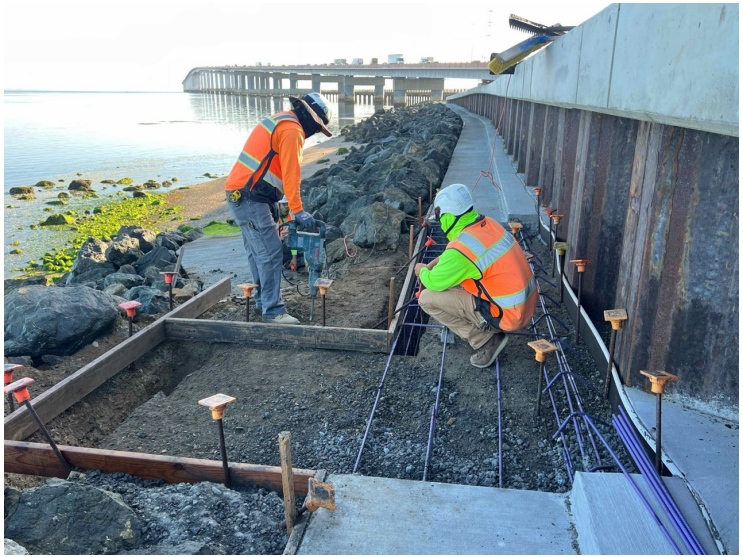
What is the response of the assets when exposed to loading?

What types of adverse outcomes are relevant?



Vulnerability

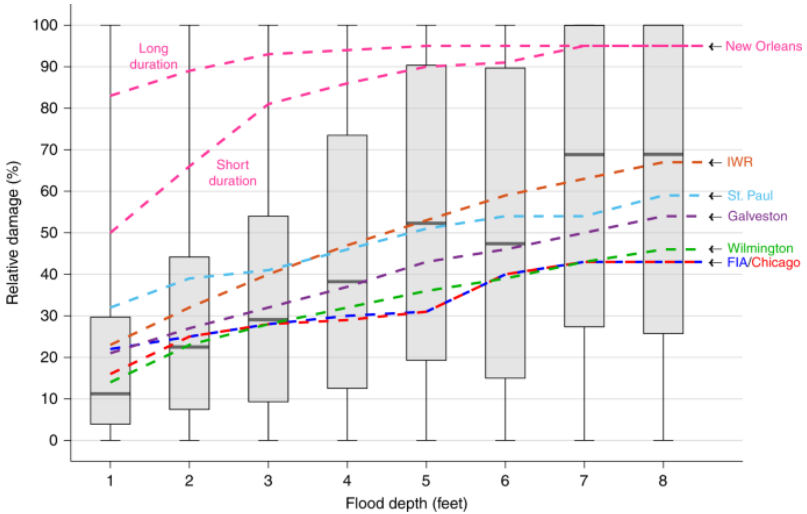
Adverse consequences include those on lives, livelihoods, health and wellbeing, economic, social and cultural assets and investments, infrastructure, services (including ecosystem services), ecosystems and species.



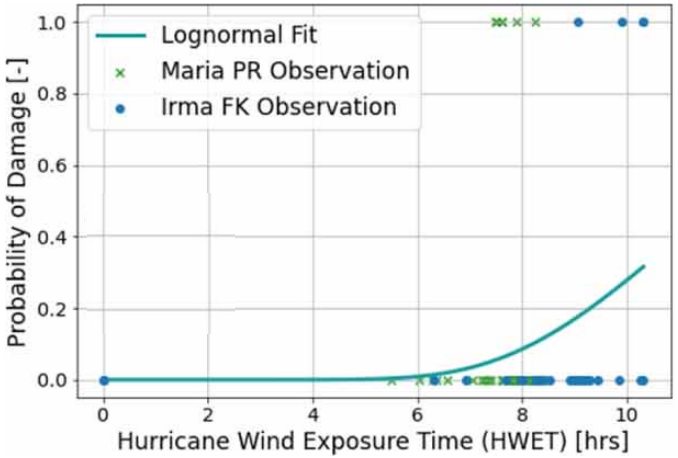
fostercitylevee.org

pexels.com/photo/flooded-town-with-residential-buildings-and-trees-6471926/

Vulnerability is often characterized using consequence predictions or fragility functions



Wing et al. (2020). "New insights into US flood vulnerability revealed from flood insurance big data." *Nature Communications*.



Madden et al. (2023). "Quantifying the fragility of the coral reefs to hurricane impacts: A case study of the Florida Keys and Puerto Rico." *Environmental Research Letters*.

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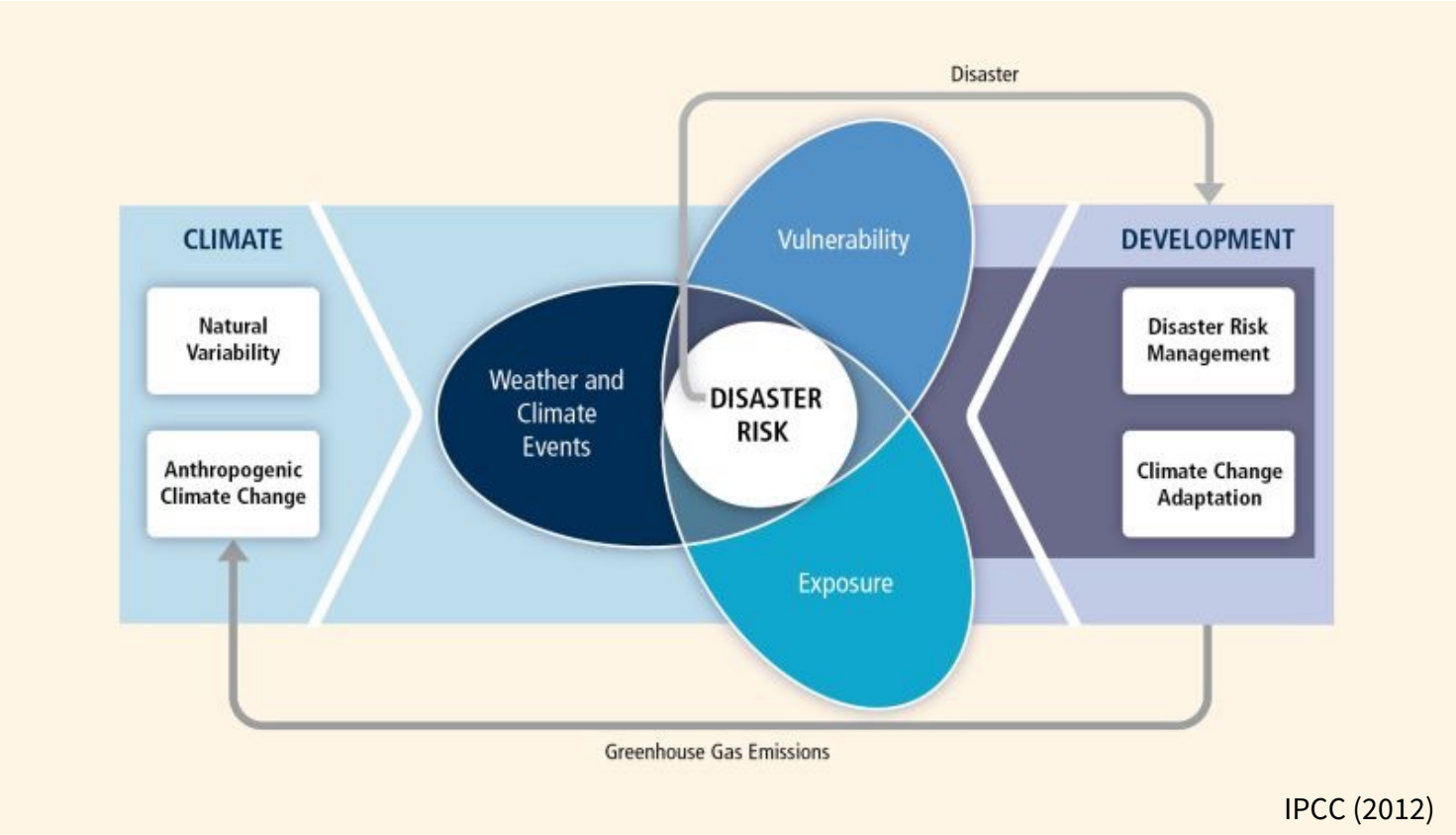
Risk analysis helps us consider mitigation and adaptation



IPCC (2012)

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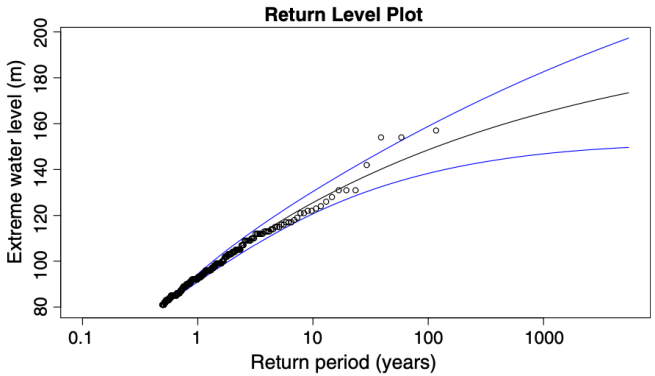
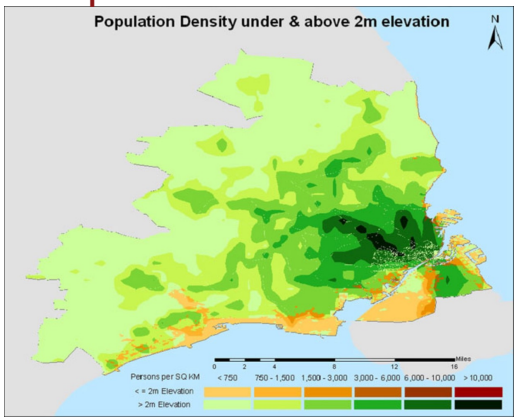
Risk analysis can be quantitative

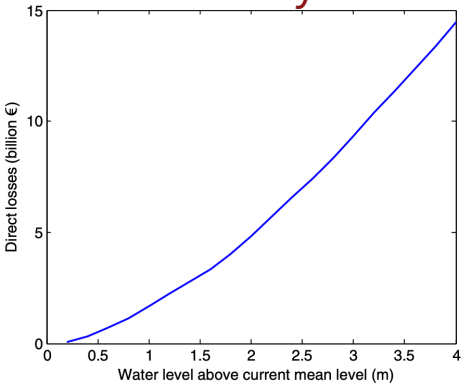
Hazard



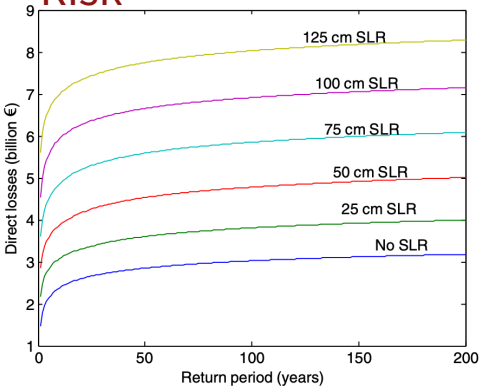
Exposure



Vulnerability



Risk



Hallegatte et al. (2011). "Assessing climate change impacts, sea level rise and storm surge risk in port cities: a case study on Copenhagen." *Climatic Change*.

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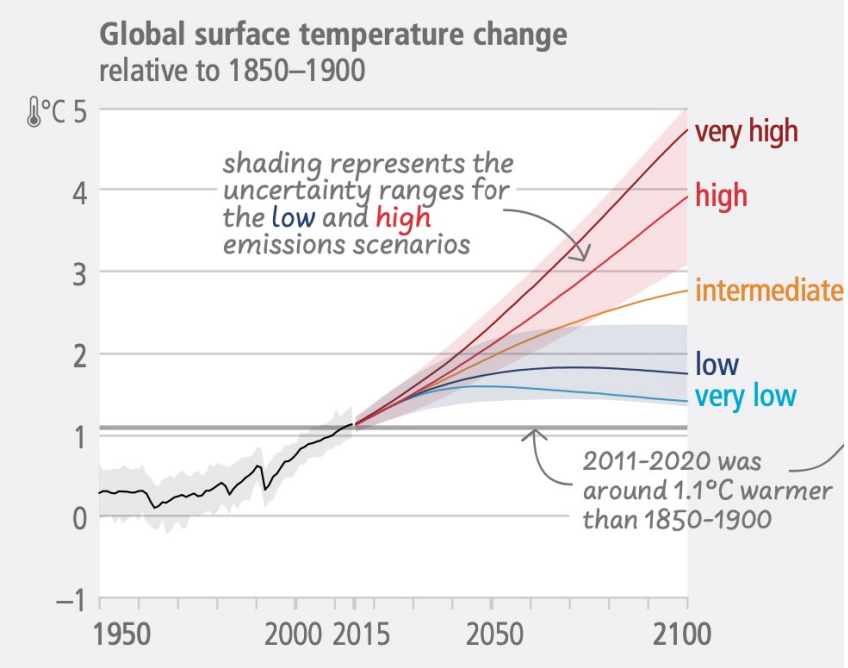
Risk analysis can be qualitative

	Qualitative Risk Assessment							
	Description of Key Risk/Cost	Timescale & Intensity Short	Medium	Long	Probability	Confidence	Intervention Potential	Perception of Risk
Wildfire	Fire Risk - Proximity to Critical Infrastructure	MED	HIGH	HIGH	LOW	MED	HIGH	HIGH
	Buffel Grass Infestation & Wildfire Risk	MED	MED	MED	MED	HIGH	HIGH	HIGH
	Fire Behavior & Changing Seasonality	LOW	MED	MED	HIGH	HIGH	LOW	LOW
	Debris Flow & Post-Fire Flooding	LOW	LOW	LOW	LOW	LOW	LOW	LOW
	Particulate Matter Concentraion - Smoke & Ash	LOW	MED	MED	LOW	LOW	LOW	LOW
Heat & Climate	Gradual Warming - Increased Peak (daily) Load/Demand	LOW	MED	HIGH	HIGH	HIGH	HIGH	LOW
	Gradual Warming - Infrastructure Wear (O&M Costs)	LOW	LOW	LOW	LOW	MED	MED	LOW
	Extreme Heat - Transmission Efficiency, Reduced Capacity Factor	LOW	LOW	MED	LOW	LOW	LOW	LOW
	Extreme Heat - Market Competition - Regional Outages	LOW	MED	MED	HIGH	HIGH	MED	MED
	Gradual Warming - Social/Community Vulnerability (quality of life)	LOW	MED	MED	MED	MED	LOW	MED
	Gradual Warming - Changing Seasonal Demand	LOW	MED	HIGH	MED	MED	HIGH	MED
	Regional Drought & CAP Water Restrictions (e.g. 1076')	LOW	MED	HIGH	LOW	MED	LOW	HIGH

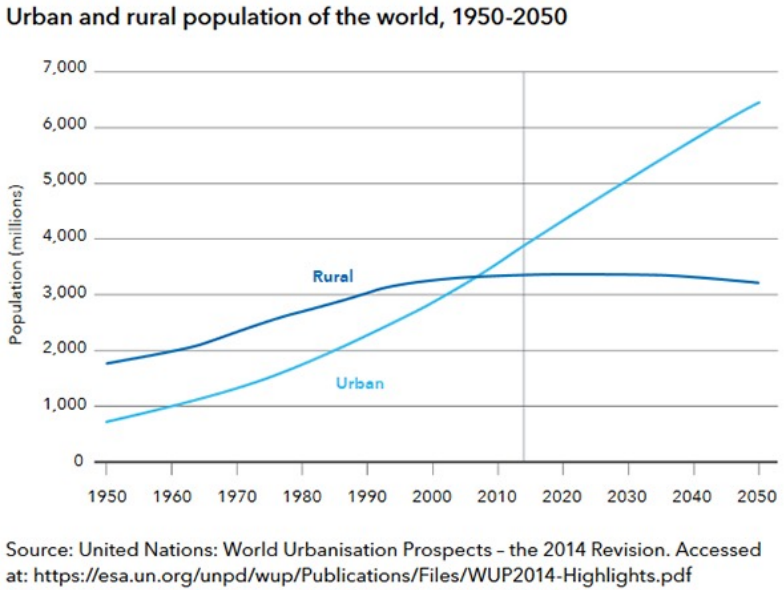
McMahan and Gerlak. "Climate risk assessment and cascading impacts: Risks and opportunities for an electrical utility in the US Southwest." *Climate risk management.*

Risk is dynamic

Hazard, exposure, and vulnerability all change over time



IPCC 2023



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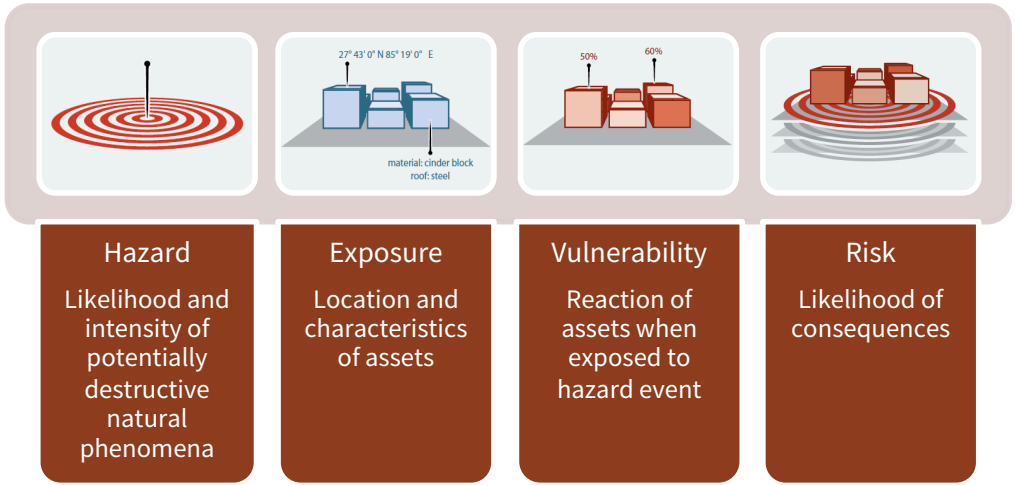
Breakout Groups: Risk analysis as a framing tool

- What are key hazards, vulnerabilities, and exposures in your project?
- What interventions are possible for each?
- What are the spatial and temporal scales of the problem and adaptation actions?
- Are there actions that reduce risks, even if they don't eliminate the problem?



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