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science for global insight

Tackling the climate challenge
A climate risk framework

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IIASA

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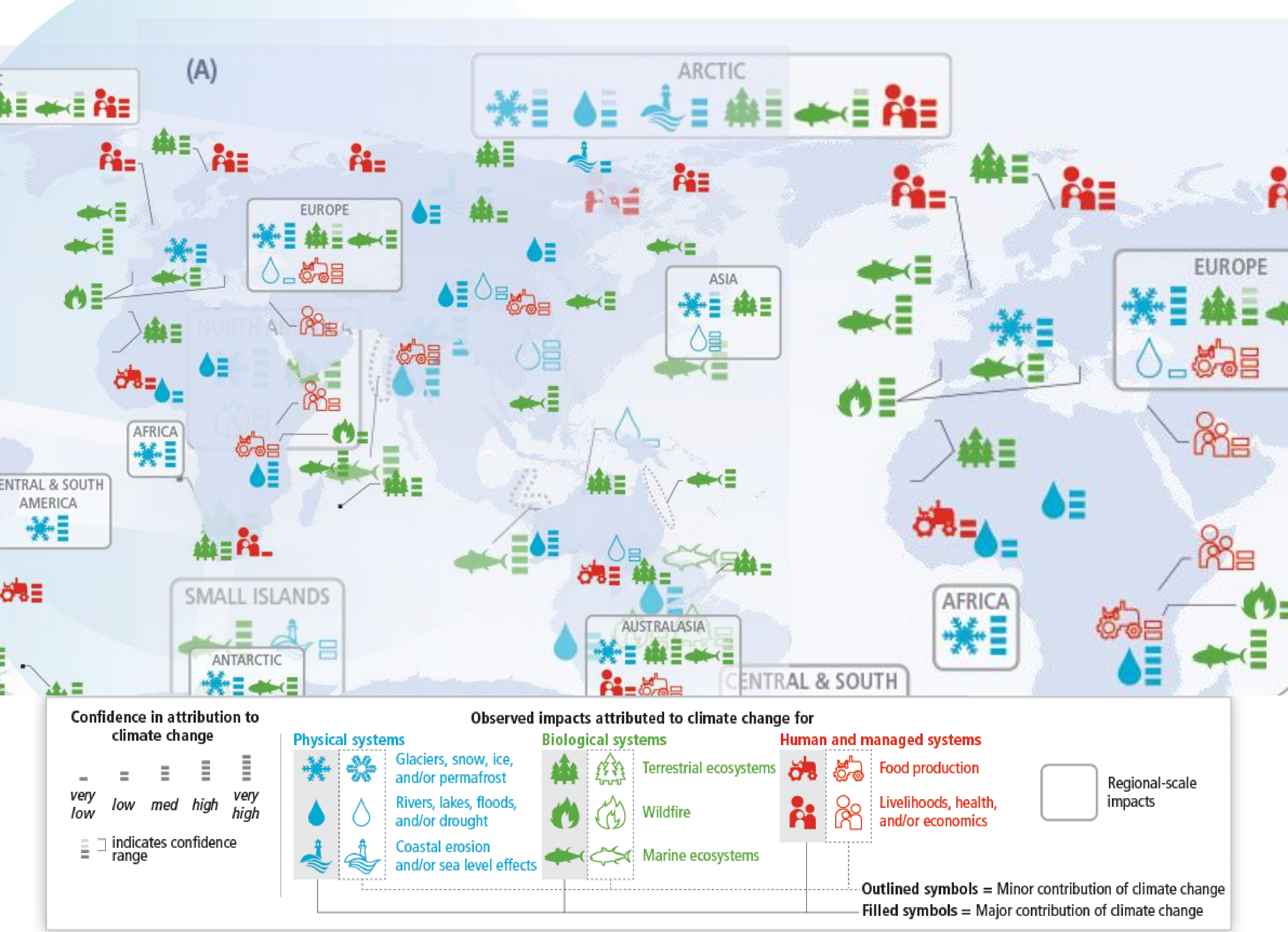
Nanjing, China
October 24, 2019

Overview

1. Climate Change challenges
2. IPCC risk framework
3. Modelling and assessing risk
4. Risk assessment: Challenges
5. Example: Bangladesh
6. Conclusions

1. Climate Change Challenges


WIDESPREAD
OBSERVED IMPACTS
A CHANGING WORLD
ipcc
INTERGOVERNMENTAL PANEL ON climate change


(A)
ARCTIC
EUROPE
ASIA
NORTH AMERICA
AFRICA
CENTRAL & SOUTH AMERICA
SMALL ISLANDS
ANTARCTIC
AUSTRALASIA
EUROPE
AFRICA
CENTRAL & SOUTH
Confidence in attribution to climate change
very low
low
med
high
very high
indicates confidence range
Observed impacts attributed to climate change for
Physical systems
Glaciers, snow, ice, and/or permafrost
Rivers, lakes, floods, and/or drought
Coastal erosion and/or sea level effects
Biological systems
Terrestrial ecosystems
Wildfire
Marine ecosystems
Human and managed systems
Food production
Livelihoods, health, and/or economics
Regional-scale impacts
Outlined symbols = Minor contribution of climate change
Filled symbols = Major contribution of climate change


ADAPTATION IS
ALREADY OCCURING
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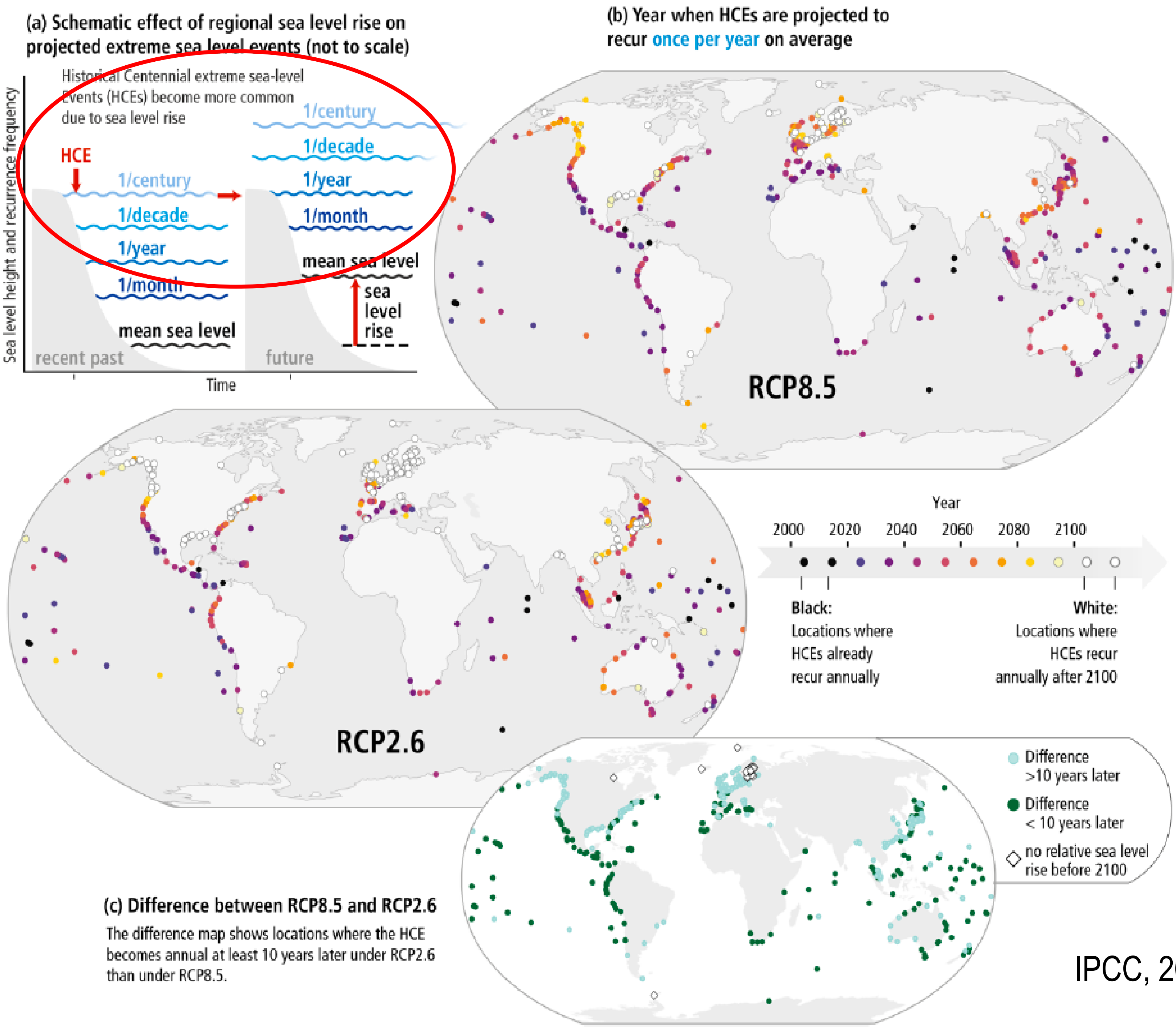
INTERGOVERNMENTAL PANEL ON climate change


RISKS OF
CLIMATE CHANGE
INCREASE
WITH CONTINUED
HIGH EMISSIONS


(a) Schematic effect of regional sea level rise on projected extreme sea level events (not to scale)
Historical Centennial extreme sea-level Events (HCEs) become more common due to sea level rise
HCE
1/century
1/decade
1/year
1/month
mean sea level
sea level rise
recent past
future
Sea level height and recurrence frequency
Time
(b) Year when HCEs are projected to recur once per year on average
RCP8.5
RCP2.6
Year
2000
2020
2040
2060
2080
2100
Black:
Locations where HCEs already recur annually
White:
Locations where HCEs recur annually after 2100
Difference >10 years later
Difference < 10 years later
no relative sea level rise before 2100
(c) Difference between RCP8.5 and RCP2.6
The difference map shows locations where the HCE becomes annual at least 10 years later under RCP2.6 than under RCP8.5.

IPCC, 2019

PLAN A
EFFECTIVE CLIMATE CHANGE MITIGATION AND CLIMATE RISK MANAGEMENT

A MORE VIBRANT WORLD

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INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

2. Perspective on risk
IPCC risk framework

Knight (1921): Uncertainty and risk

- Deep uncertainty
- Subjective uncertainty: subjective risk
- Quantified uncertainty: objective risk
- Certainty

IPCC and construction of risk

1. **Idealized risk:** the conceptual framing of the problem at hand - dangerous anthropogenic interference with the climate system as dominant framing → informing mitigation

2. **Calculated risk:** the product of a model based on a mixture of historical (observed) and theoretical information → informing adaptation

3. **Perceived risk**: the subjective judgment people make about an idealized risk
→ informing adaptation

After Jones et al., 2014
IPCC AR5, chapter 2

Constructing of risk in the IPCC

- Historically focussed on idealized and calculated risk- expert orientation

- Calculated risk: much stronger emphasis and embracing downside and upside risks

- Perceived risk: receiving more recognition also in terms of relevance for decision-making- towards more bottom-up decision-making

→ All are relevant and being taken up, integration by way of iterative risk management

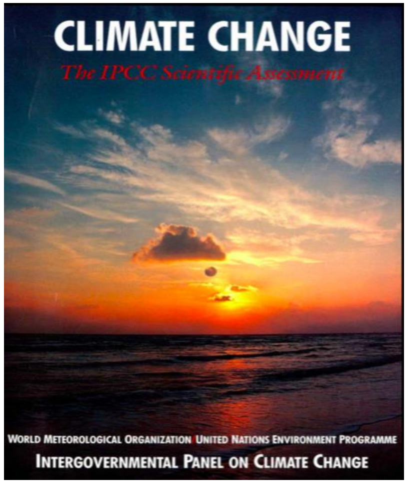
Idealized risk

Responds to UNFCCC Article 2, 1992

Art. 2: "[…] prevent **dangerous anthropogenic interference** with the climate system."

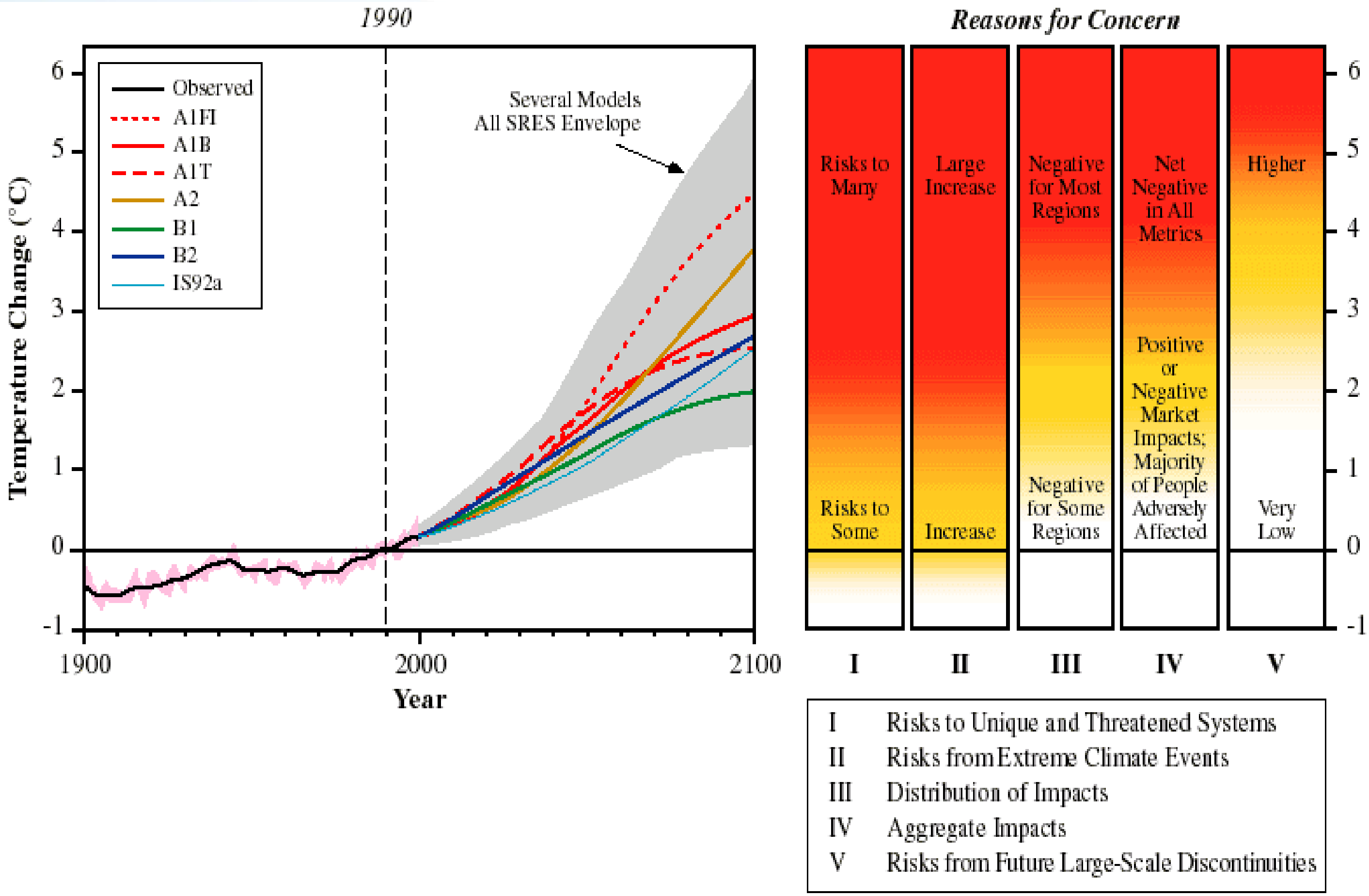
Art. 3: "[…] **specific needs and special circumstances [**…] especially those that are **particularly vulnerable** to the adverse effects of climate change [...]."

- Thresholds and tipping point perspective: 5 reasons for concern
- Also understanding of large and deep uncertainty key:
  halfway between risk-based and precautionary decision-support



IPCC, 1990

The 5 Reasons for Concern/burning embers diagram



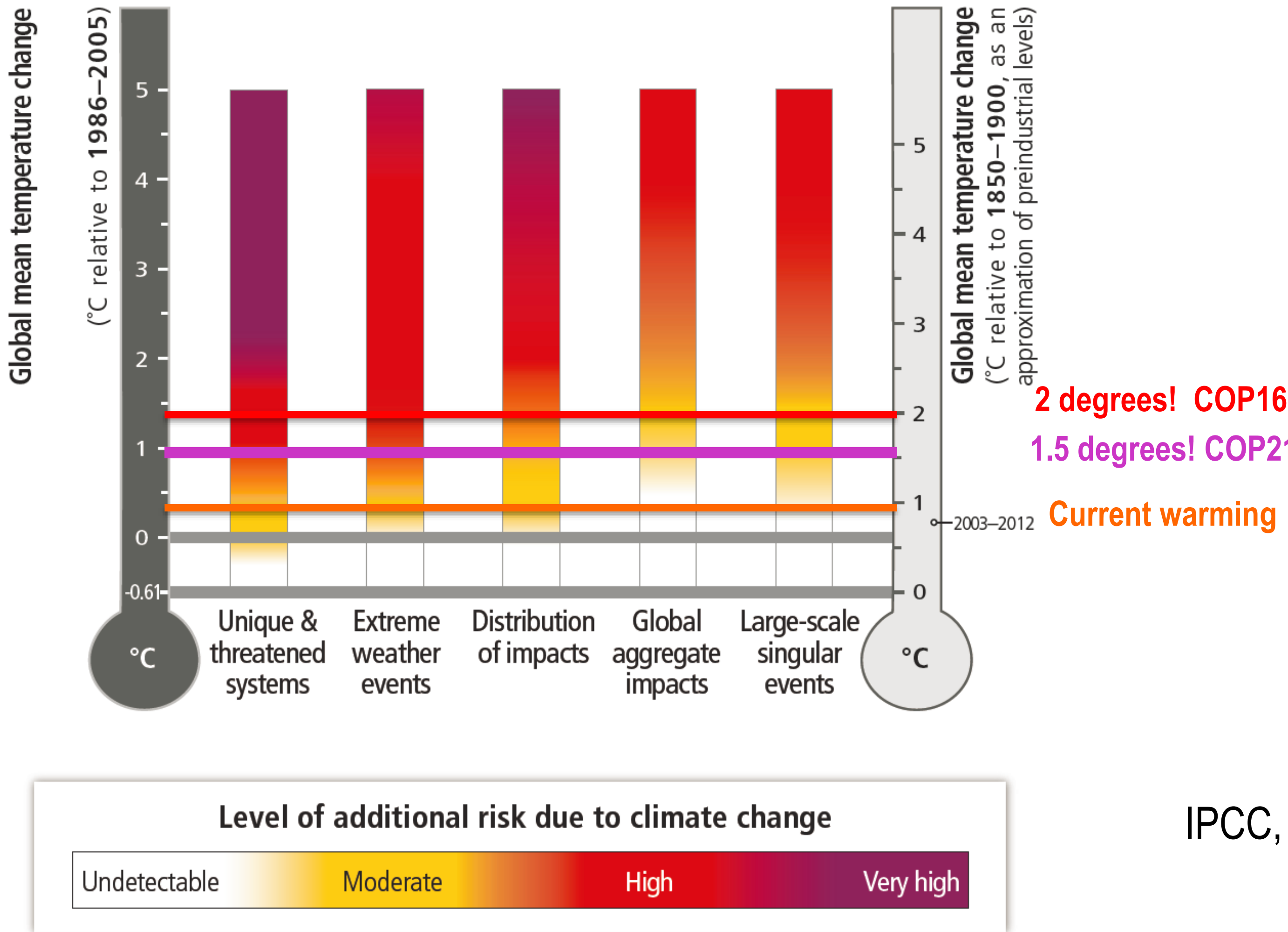
IPCC, 2001

Idealized risk
5 Reasons for Concern- the 'Burning embers'

1. ***Unique and threatened systems:*** Some unique and threatened systems, including ecosystems and cultures, are already at risk from climate change (high *confidence).* Example: coral-reef systems.
2. ***Extreme weather events:*** Climate-change-related risks from extreme events, such as heat waves, extreme precipitation, and coastal flooding, are already moderate (high *confidence)* and high with 1°C additional warming (medium *confidence)*
3. ***Distribution of impacts:*** Risks are unevenly distributed and are generally greater for disadvantaged people and communities in countries at all levels of development. Example: water availability
4. ***Global aggregate impacts:*** Risks of global aggregate impacts are moderate for additional warming between 1-2°C, reflecting impacts to both Earth's biodiversity and the overall global economy (medium *confidence).* *Example:* biodiversity loss
5. ***Large-scale singular events:*** With increasing warming some physical systems or ecosystems may be at risk of abrupt and drastic changes.

Example: Wet Antarctic Iceshield

2014 version



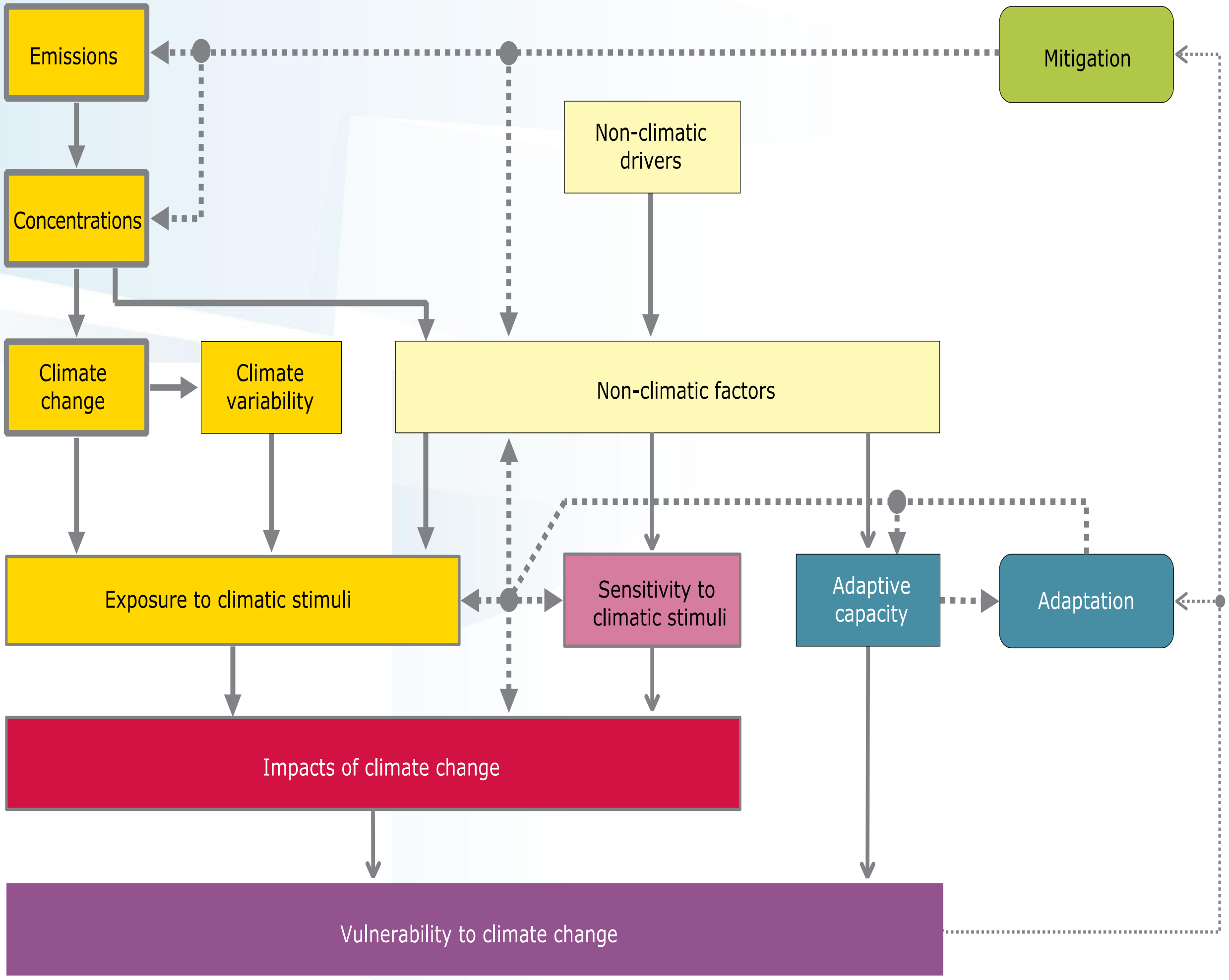
IPCC, 2014

Informing the Paris Agreement
UNFCC stocktake on long-term goal before COP21

Message 5: The 2°C limit should be seen as a defence line.
The 'guardrail' concept, in which up to 2 °C of warming is considered safe, is inadequate and would therefore be better seen as an upper limit, a **defence line that needs to be stringently defended**, while less warming would be preferable.

UNFCCC, 2015

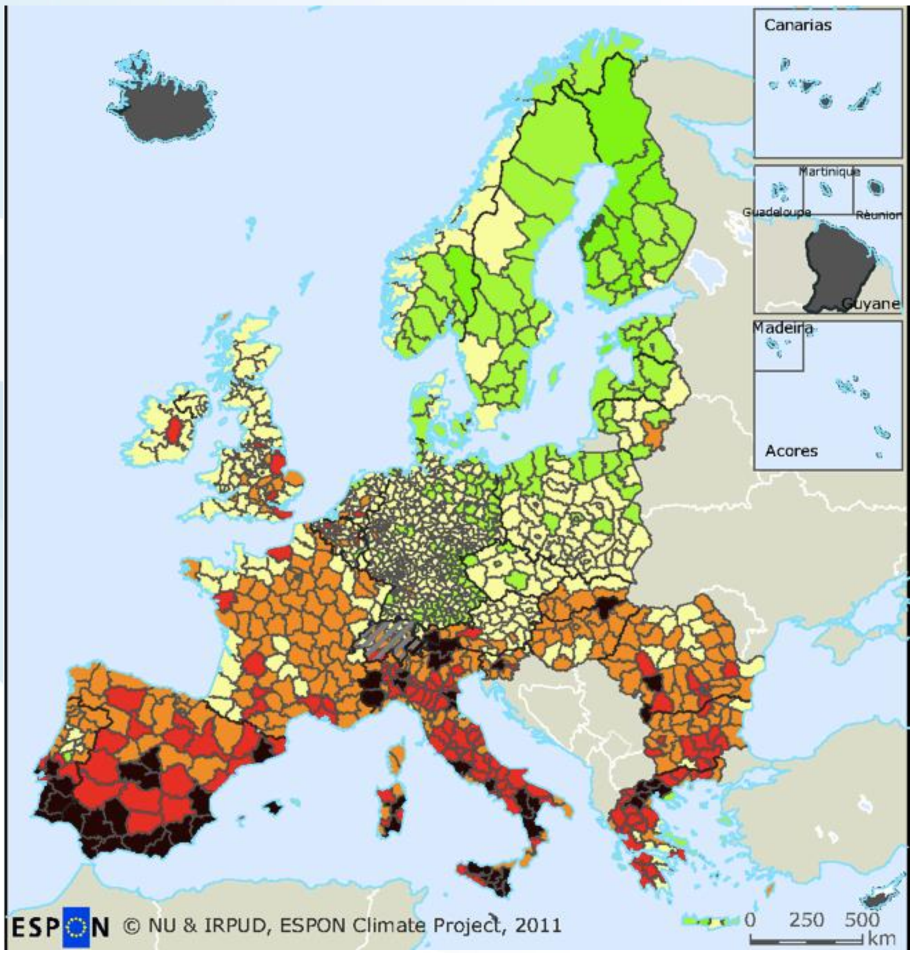
Calculated risk
From Climate Vulnerability…



Vulnerability to climate change is the degree to which geophysical, biological and socio-economic systems are susceptible to, and unable to cope with, adverse impacts of climate change

EEA, 2012

Example
Economic Climate Vulnerability in Europe



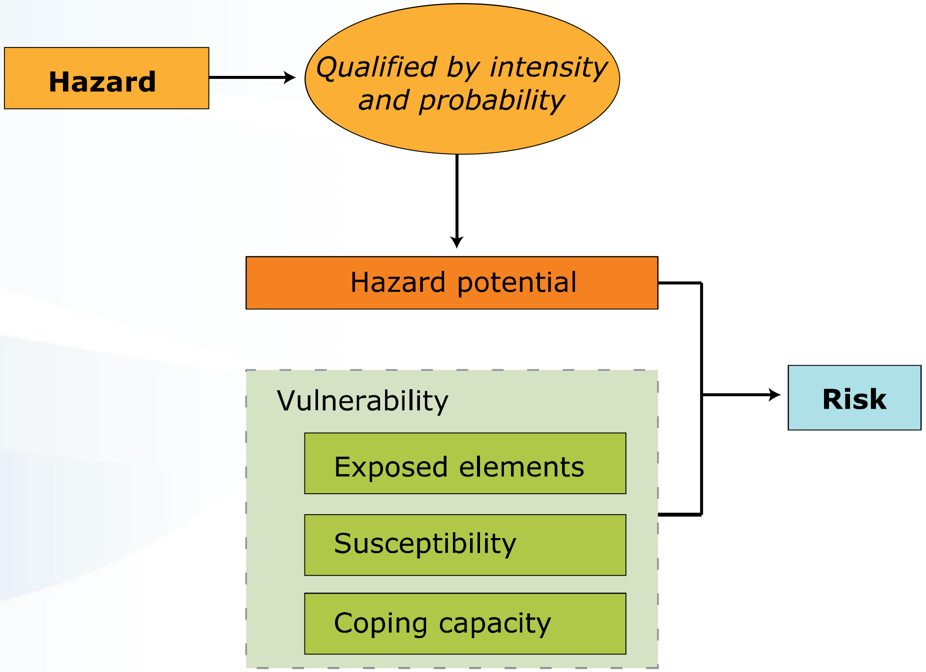
Combined potential impacts of changes in annual mean evaporation, summer days, snow cover days, frost days, changes in inundation heights of a 100 year river flood event and a sea level rise adjusted 100 year coastal storm surge event on agriculture, forestry, summer and winter tourism, energy supply and demand.

Potential economic impact of climate change

- Highest negative impact
- Medium negative impact
- Low negative impact
- No/marginal impact
- Low positive impact
- Medium positive impact
- High positive impact
- No data
- Reduced data

Source: ESPON, 2011; EEA, 2012

Calculated risk
…to Climate-related Risk



The potential for consequences where something of human value (including humans themselves) is at stake and where the outcome is uncertain.
Risk is often represented as probability of occurrence of hazardous events or trends multiplied by the consequences if these events occur (IPCC, 2014)

Impacts from weather and climate events depend on:

nature and severity of event

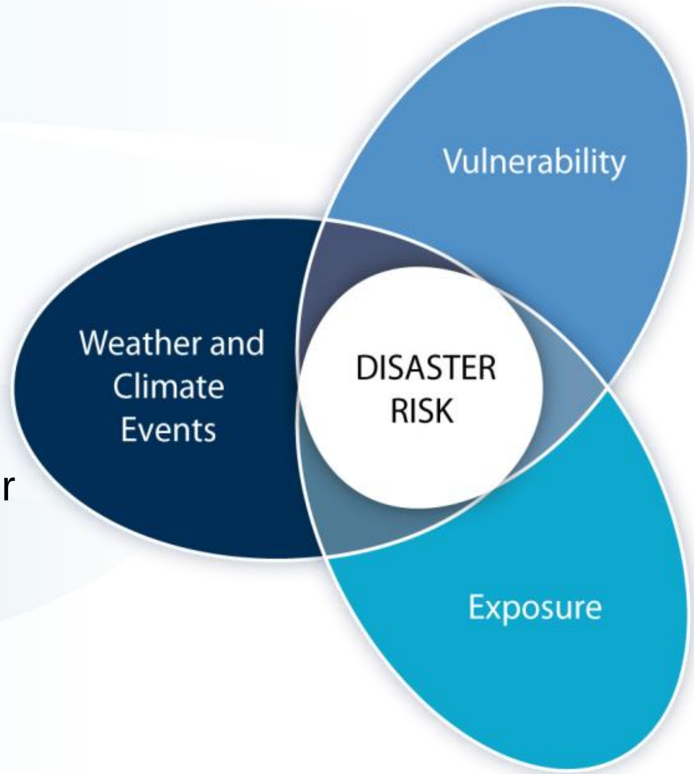
vulnerability

exposure

Socioeconomic development interacts with natural climate variations and human-caused climate change to influence risk

Disaster Risk:

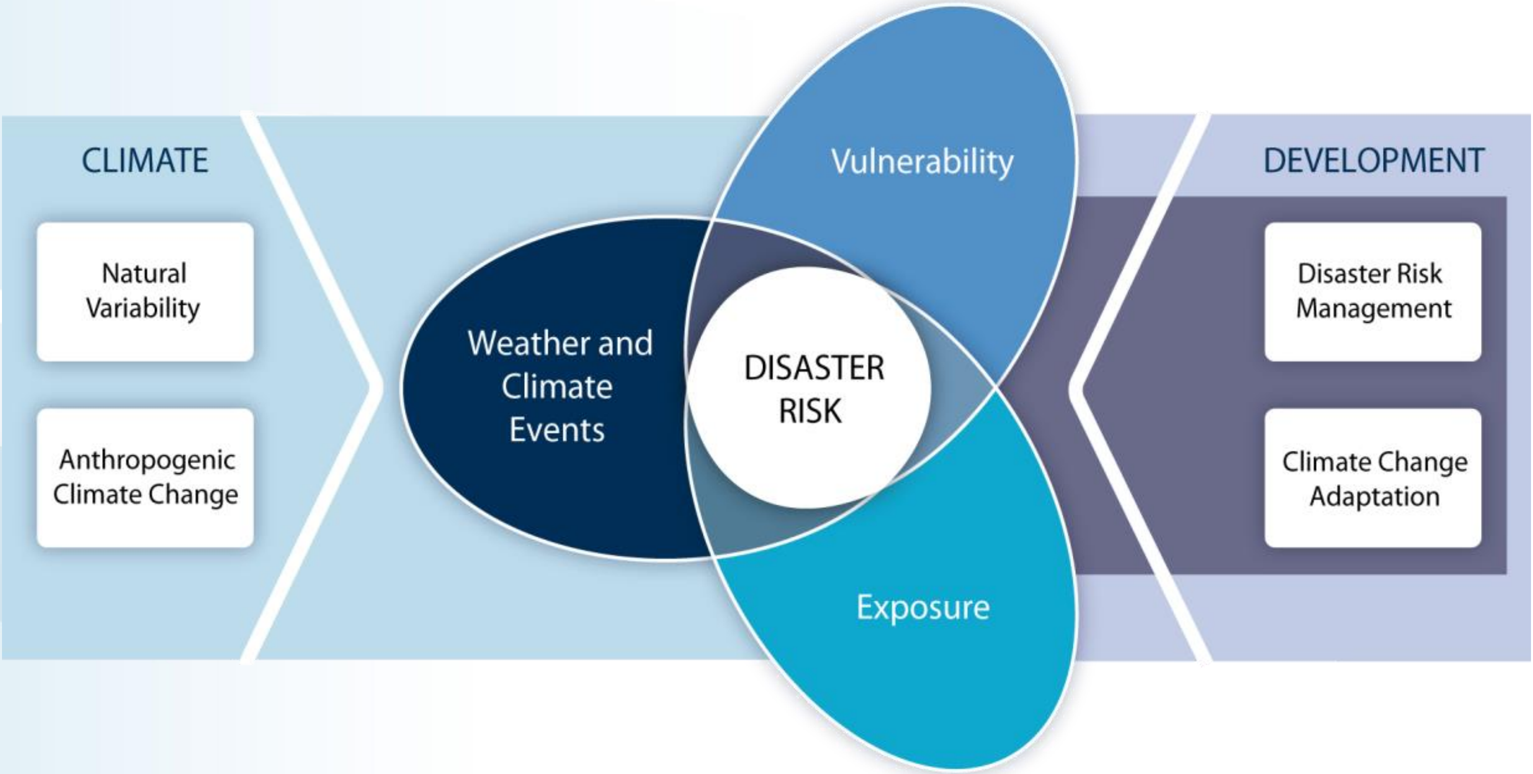
the likelihood of severe alterations in the normal functioning of a community or society due to weather or climate events interacting with vulnerable social conditions



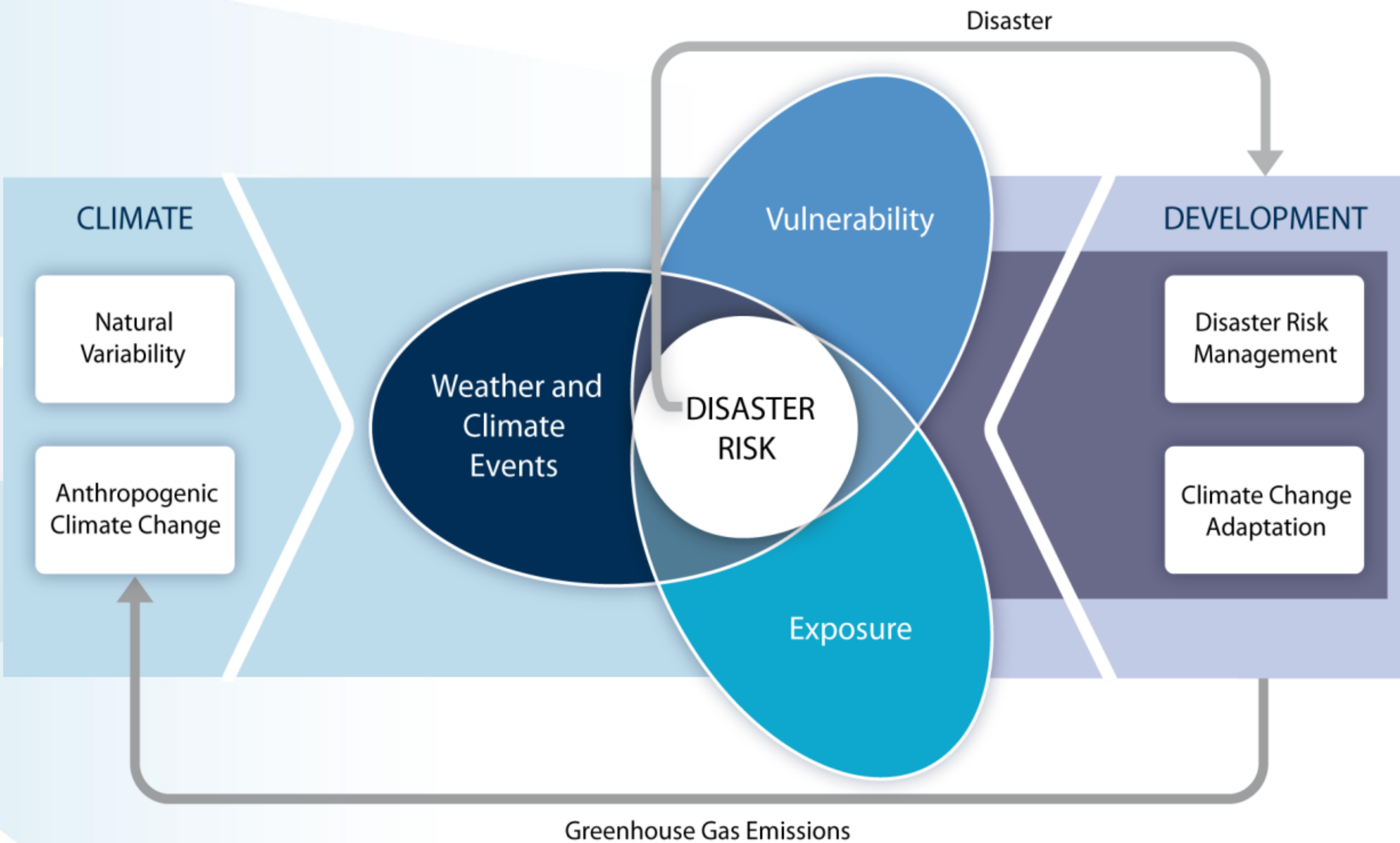
Vulnerability:

the predisposition of a person or group (exposure) to be adversely affected

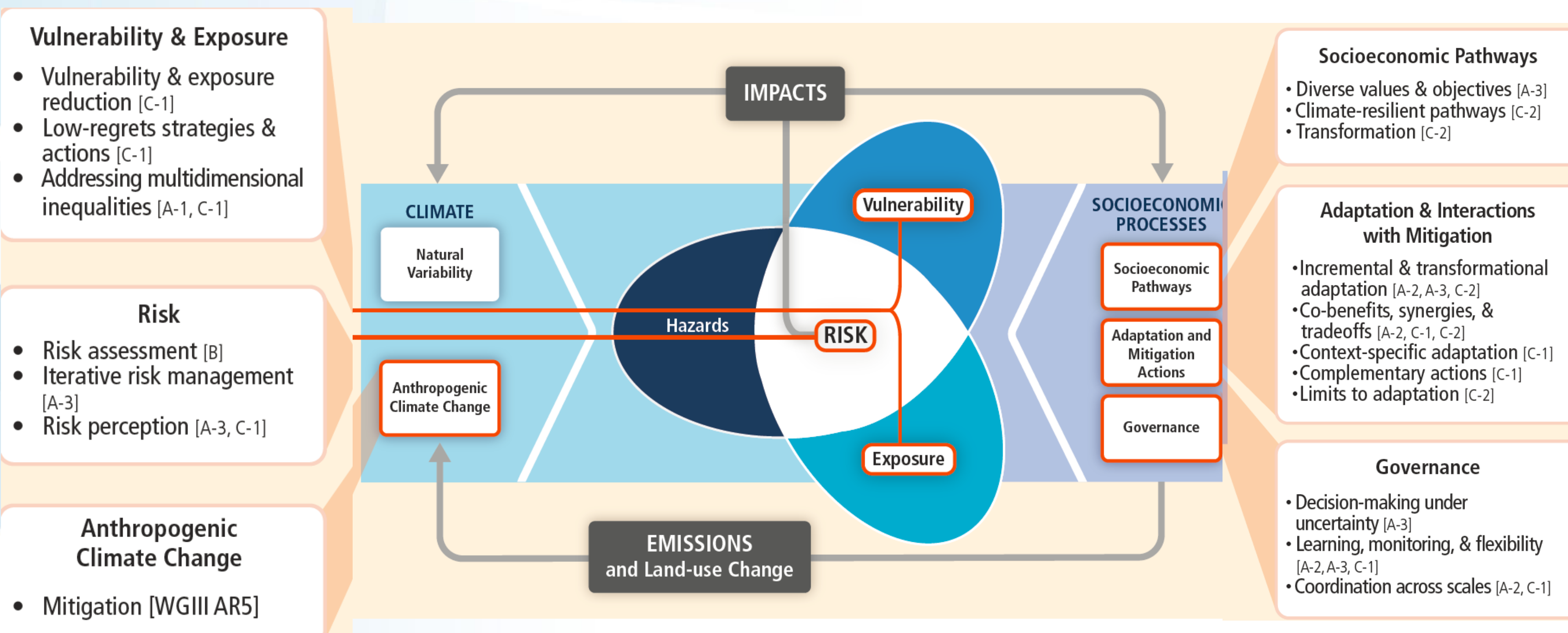
Increasing vulnerability, exposure, or severity and frequency of climate events increases risk



Increasing vulnerability, exposure, or severity and frequency of climate events increases risk



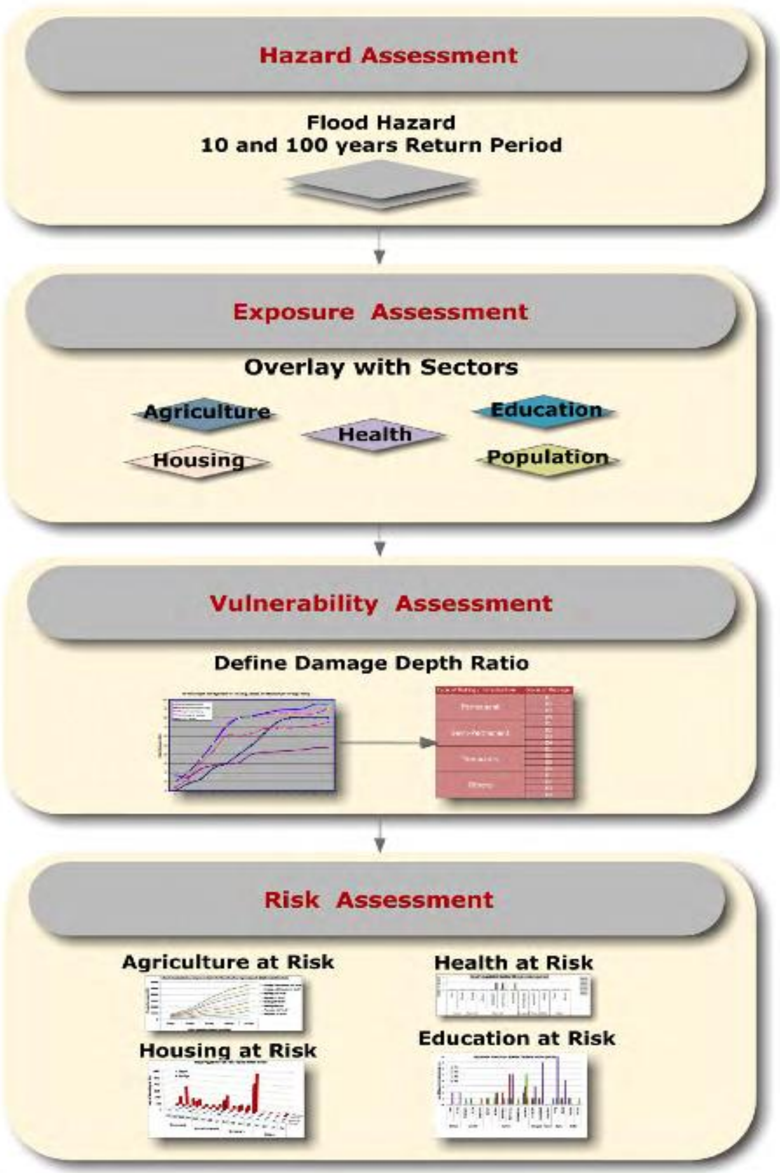
Entry points to the solution space



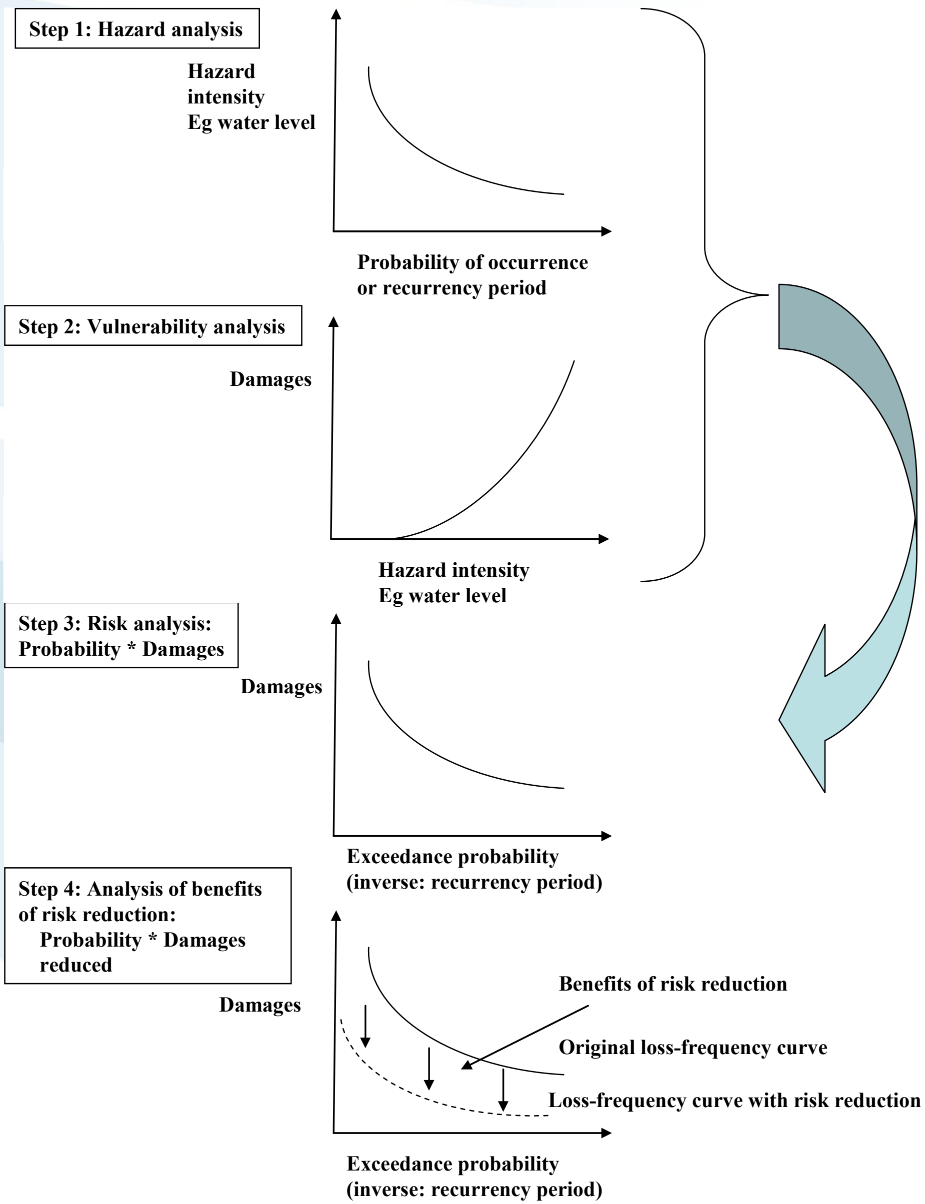
IPCC, 2014

3. Modelling and assessing risk

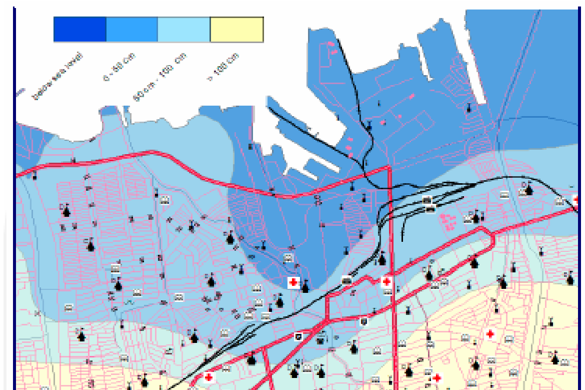
Risk appraisal



From hazard to risk

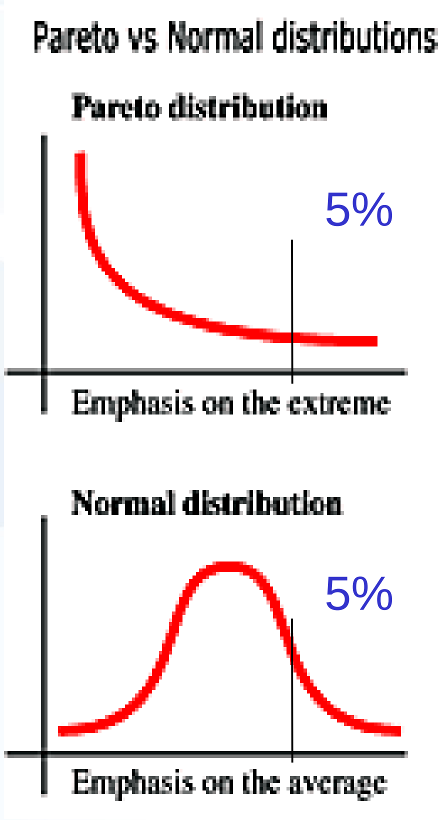


Exposure
People&Assets



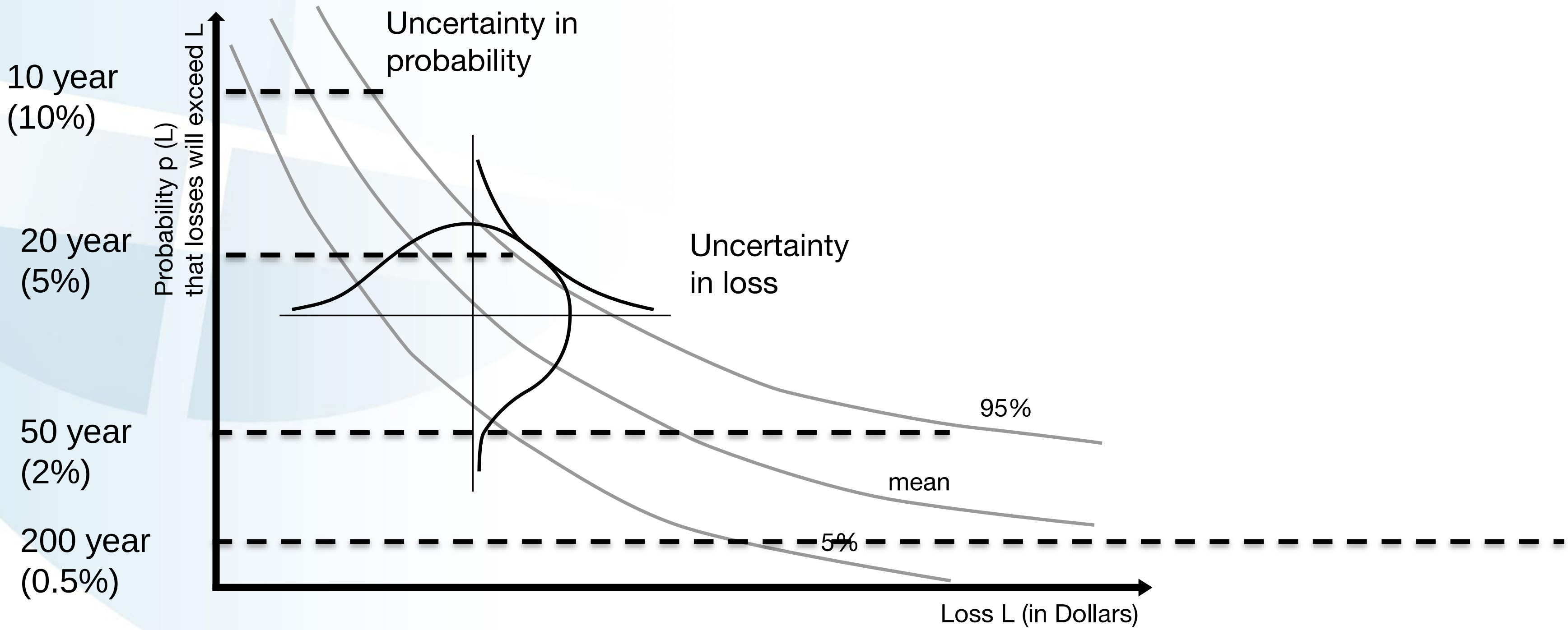
Map showing infrastructure objects (symbols and lines) intersected with subsidence projections for 2013for center of Semarang City, Central Java

Risk appraisal
Normal vs. extreme value distributions

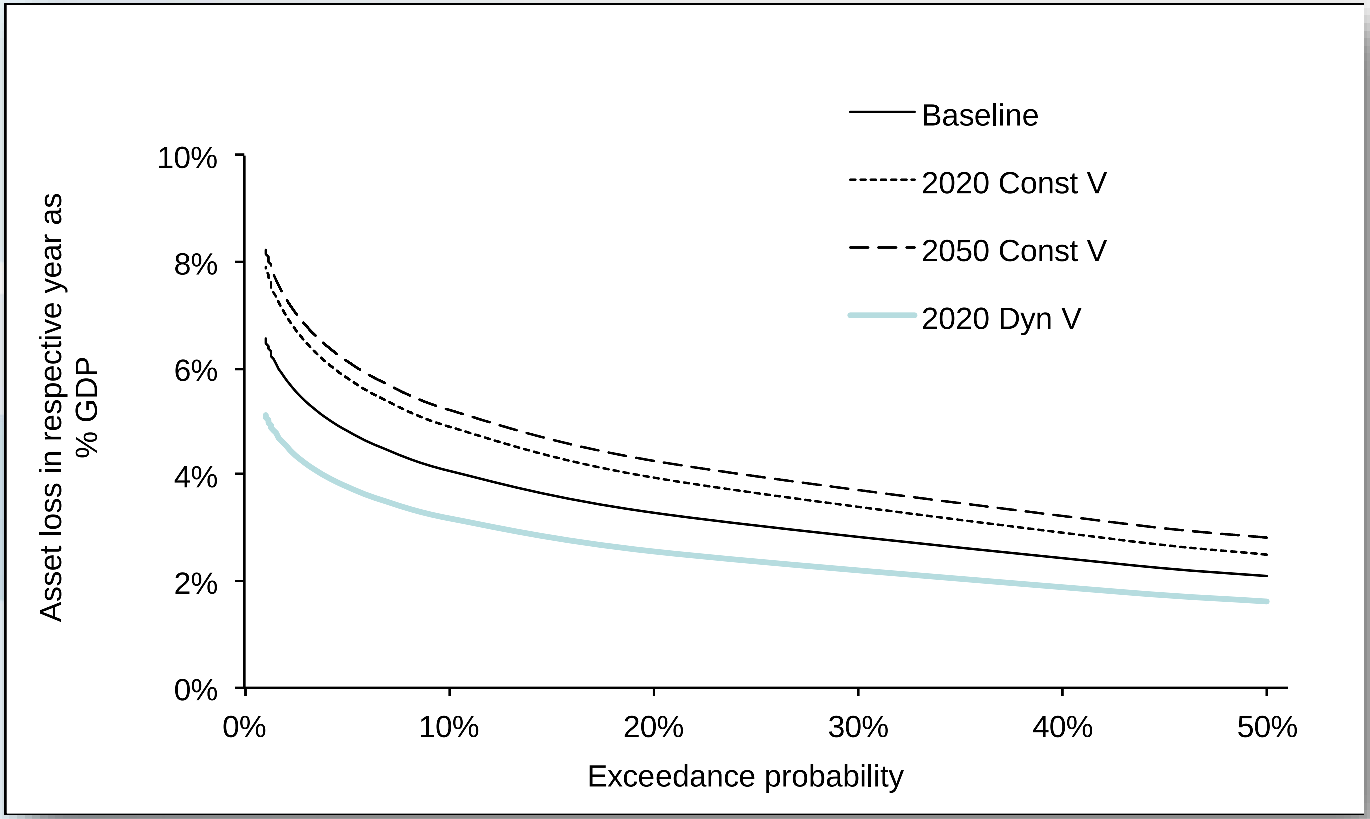


Calculated risk

Figure 3: Example of Loss Exceedance Probability Curves



Calculated risk
Projecting riverine flood risk in Bangladesh



Mechler& Bouwer, 2015

Benefits from reducing risk

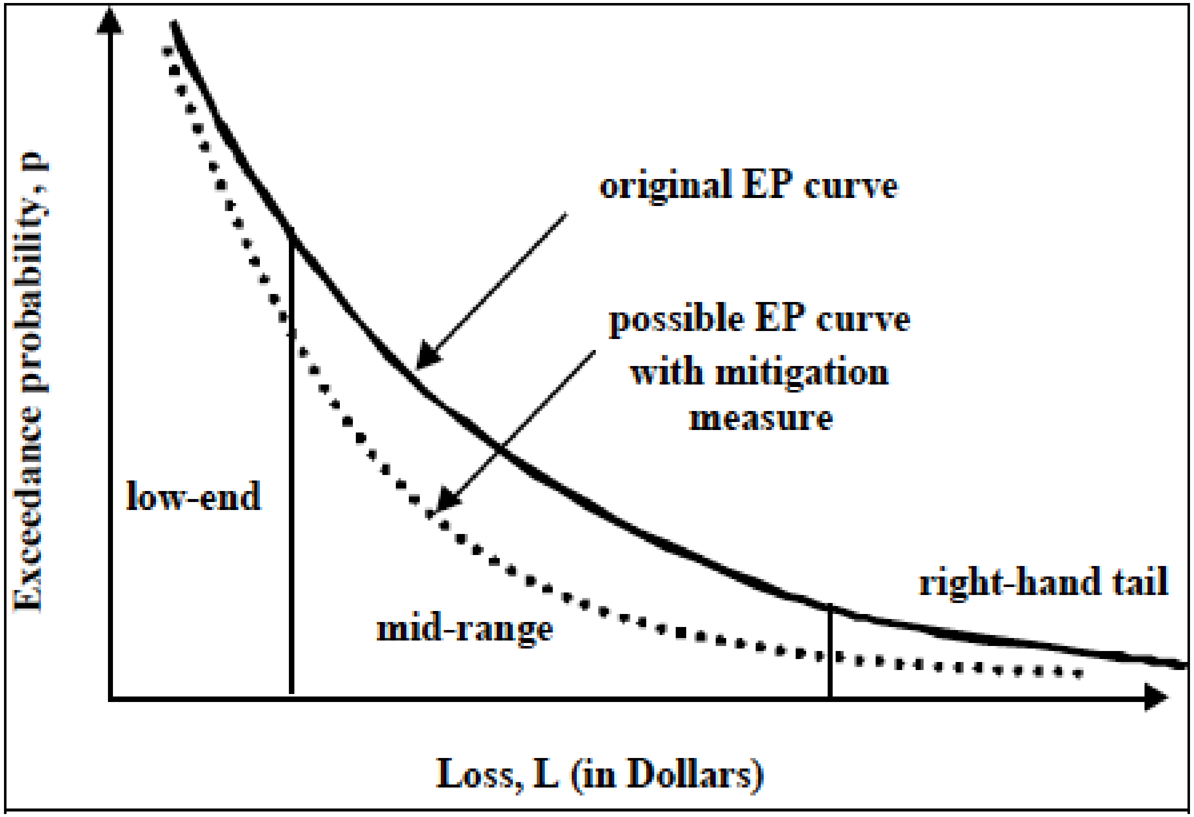
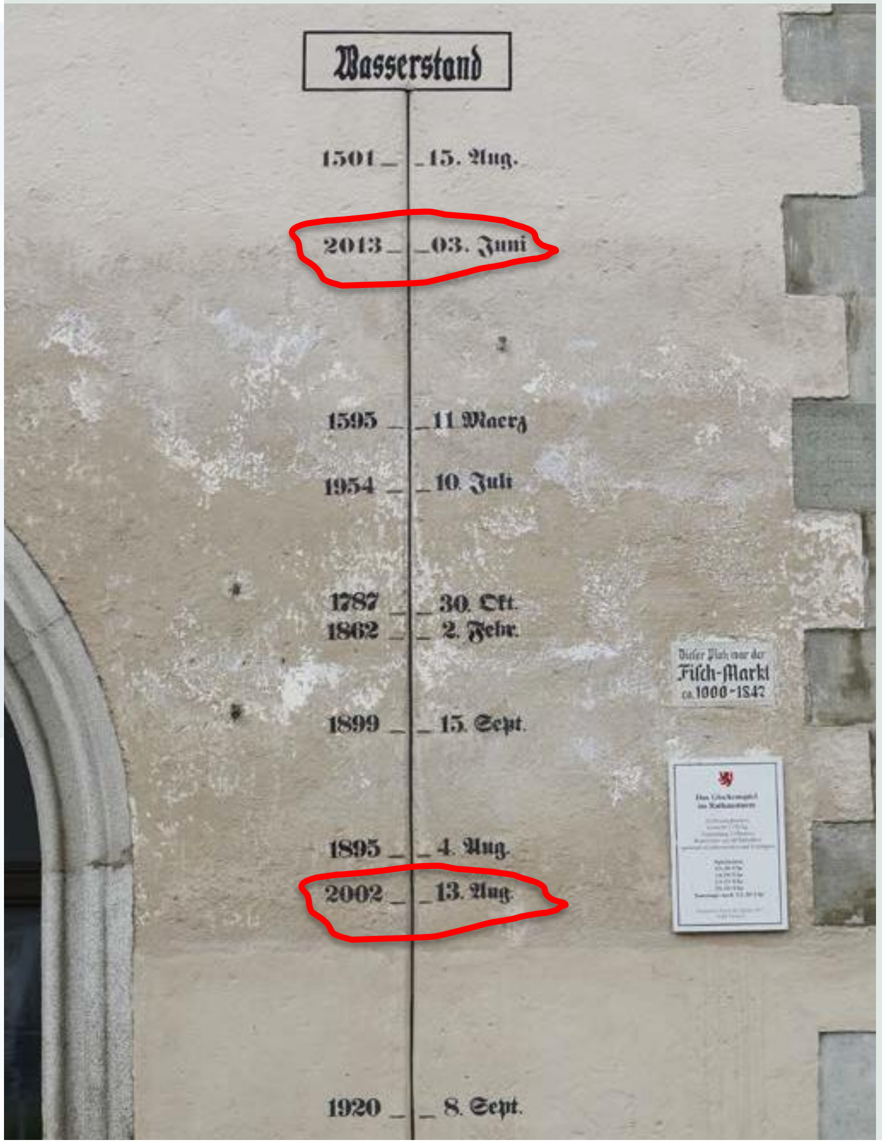


Figure 3: Exceedance probability (EP) curve showing potential benefits of disaster risk reduction.
Note: The EP curve represents the probability that losses will be a given amount, and flood risk reduction intervention shifts the EP curve to the left and therefore reduces the expected loss.

Mechler et al., 2014

Climate variability or change?
River gauge in Passau, Germany

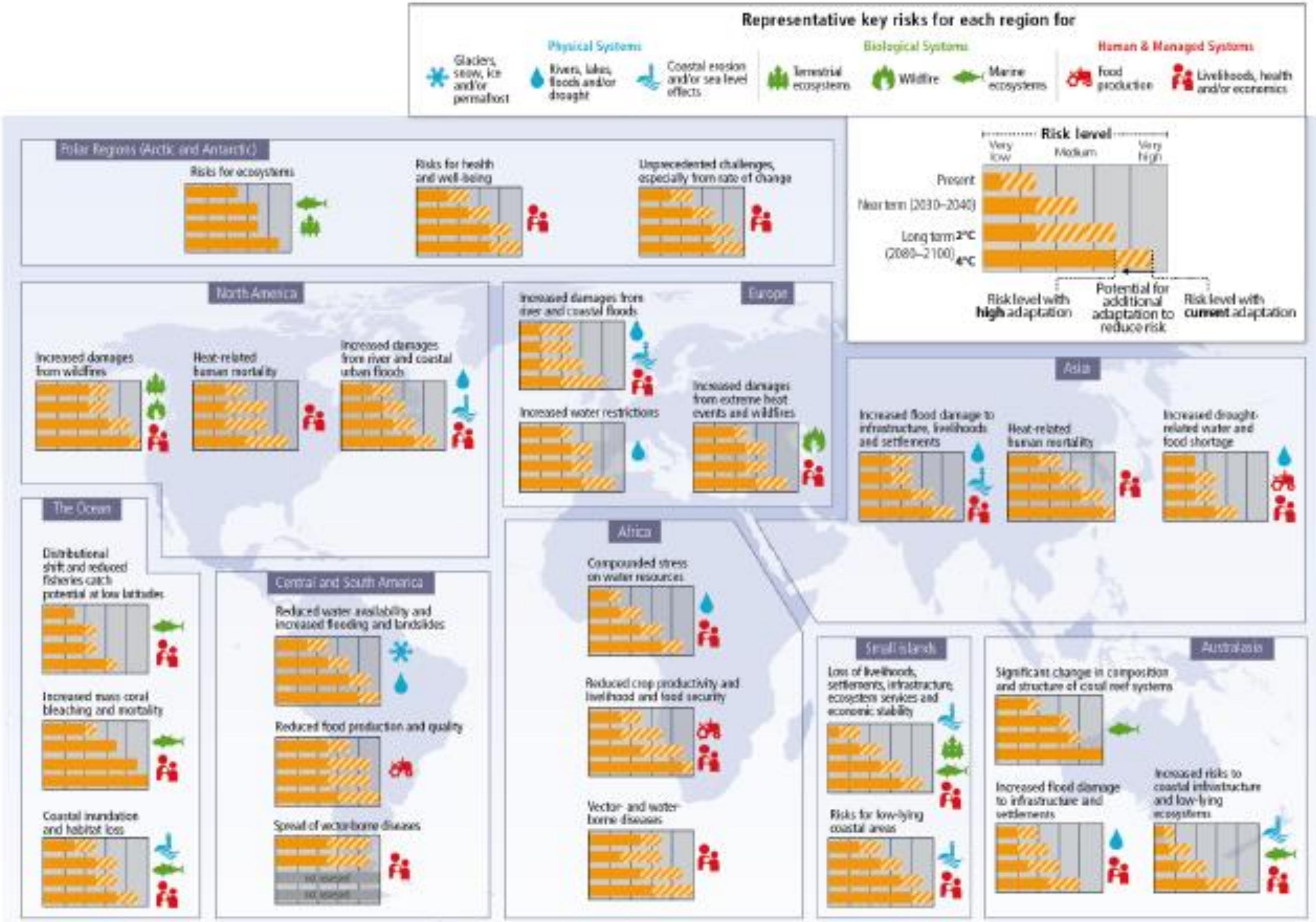


Return period:
~ 100 years

Return period:
~ 50 years

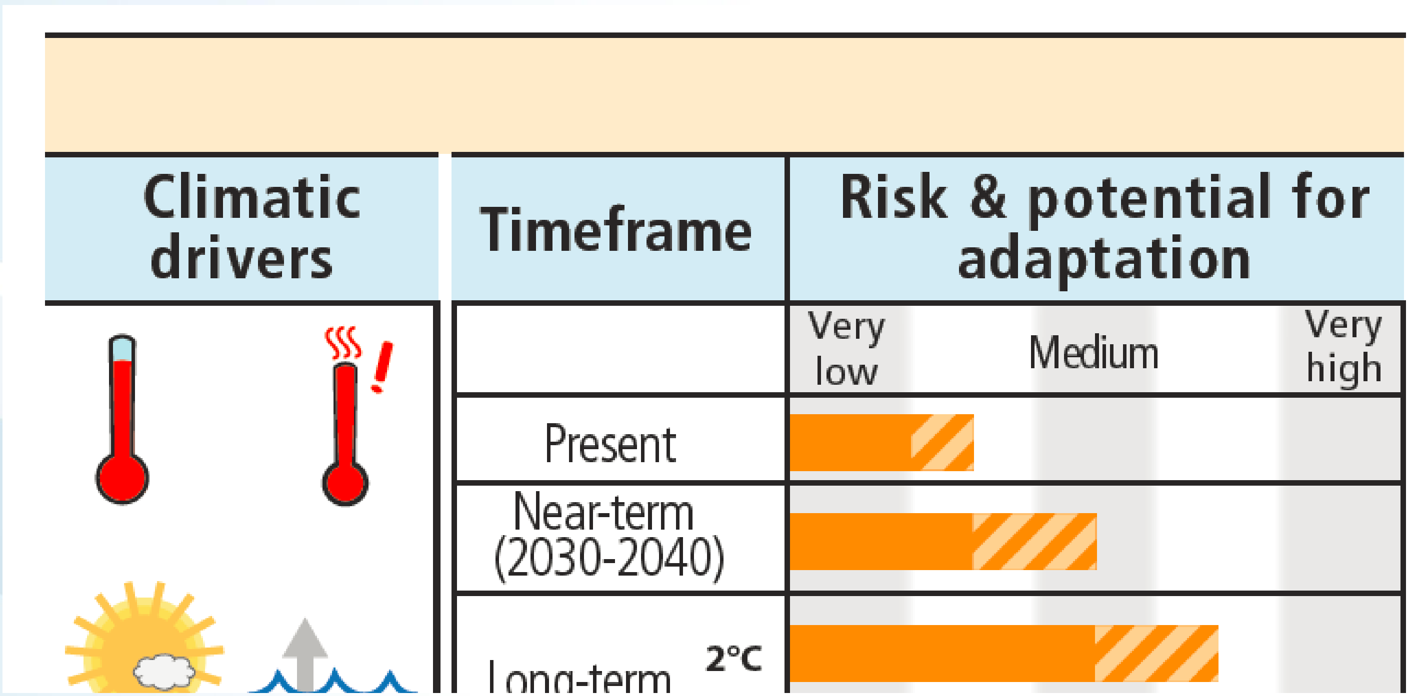
Source: Zurich, 2014

Calculated risk

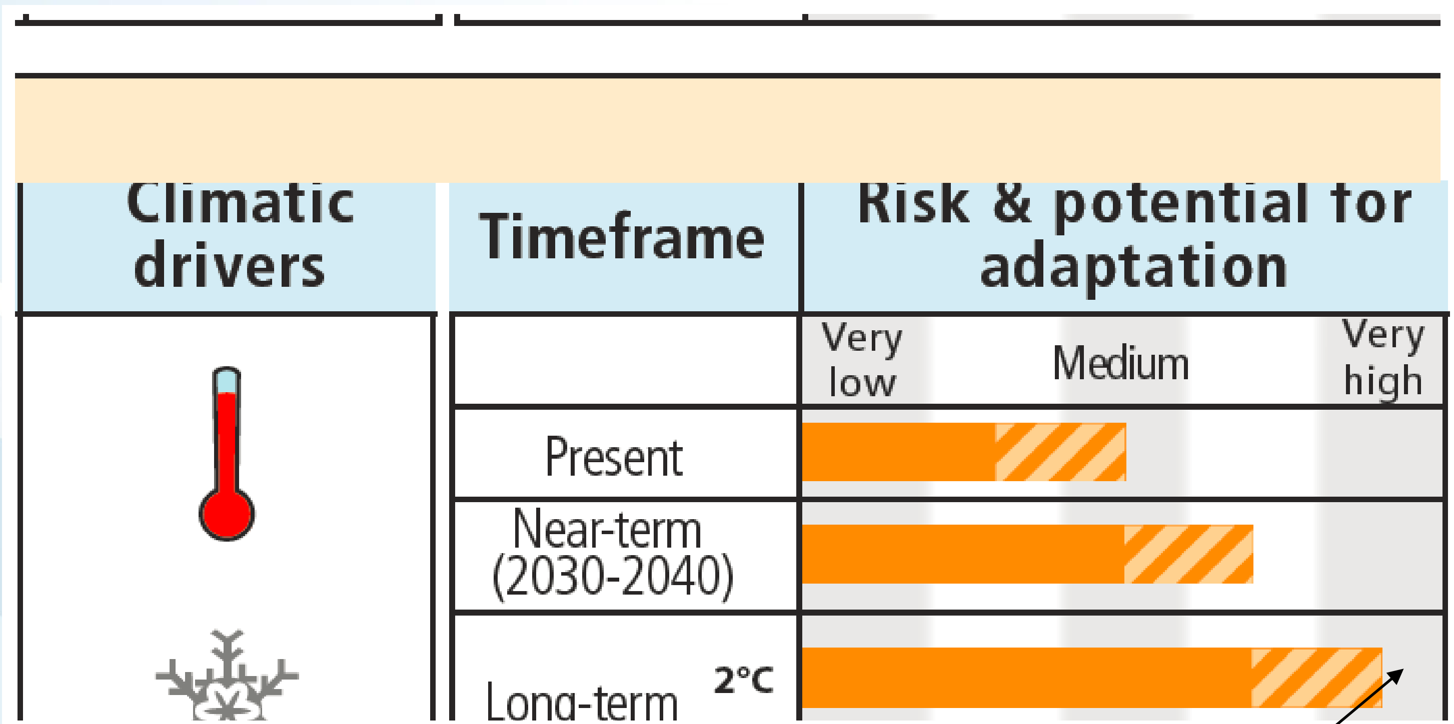


IPCC, 2014

Losses from coastal and riverine flooding-Europe



Coral reefs: Impact on biodoversity, fisheries, coastal protection

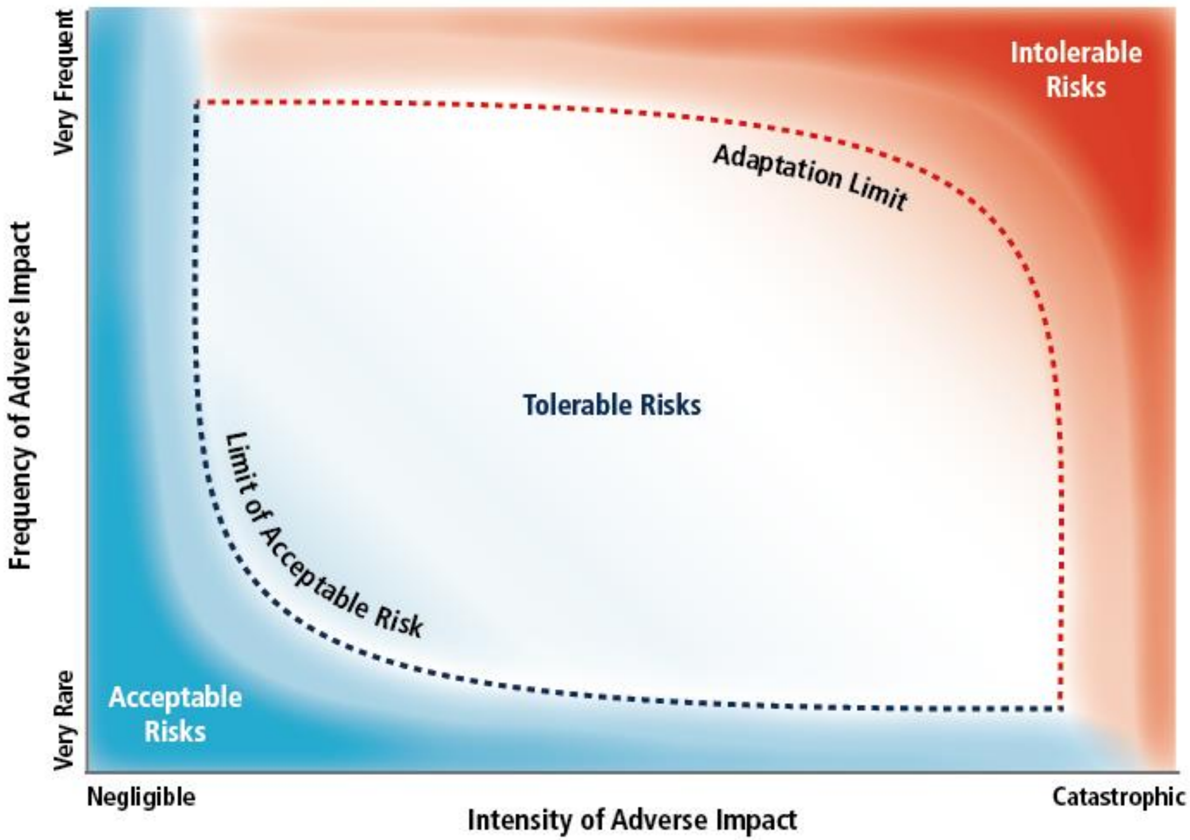


Adaptation limits

Perceived risk

- Consider actors' values, objectives, and planning horizons as they make decisions under uncertainty.
- Some risks may be routine and/or the consequences so minor that they are accepted.
- Other risks may be judged intolerable because they pose fundamental threats to actors' objectives or the sustainability of natural systems.
- A key objective of adaptation is to avoid such intolerable risks. Yet, the capacity of societal actors and natural systems to adapt is finite, and thus there are limits to adaptation

Perceived risk
Risk acceptance



4. Risk assessment: Challenges

Challenges with risk assessment

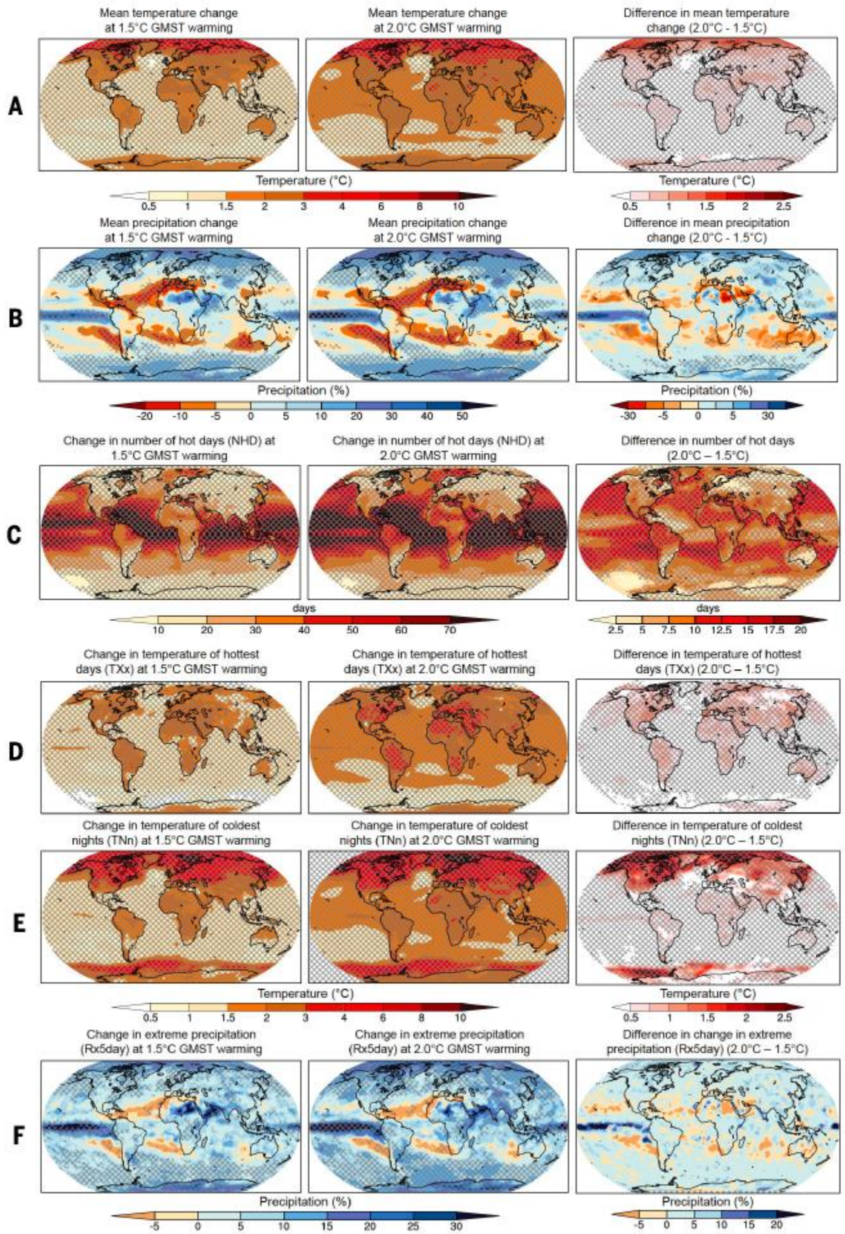
Understanding socio-economic Vulnerability

Downscaled climate projections with climate variability

Spatially explictit or aggregated population and asset information

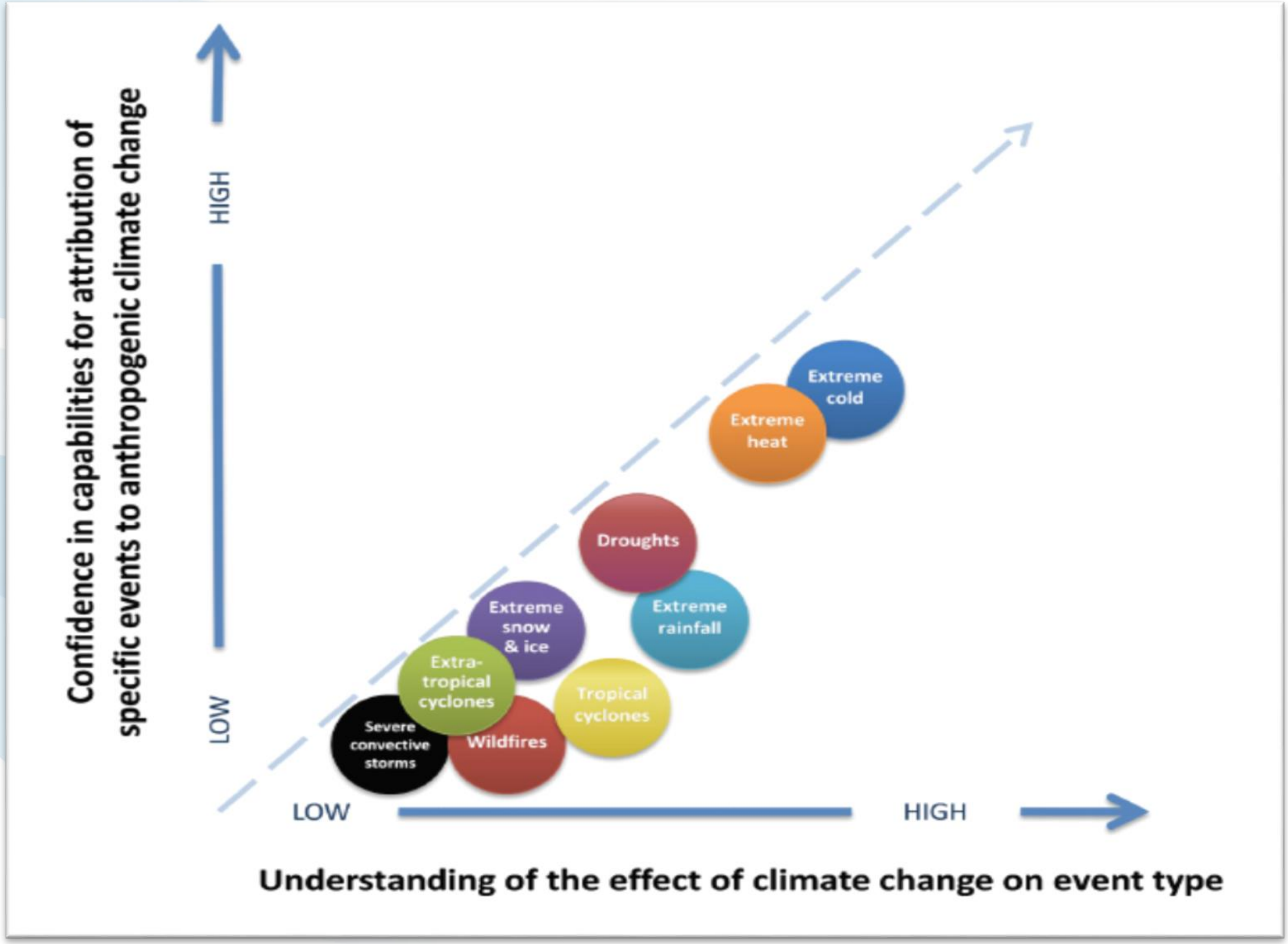
Challenges
Hazard

Projections at 1.5°C and 2°C



Guldberg et al., 2019
building on IPCC, 2018

Attribution



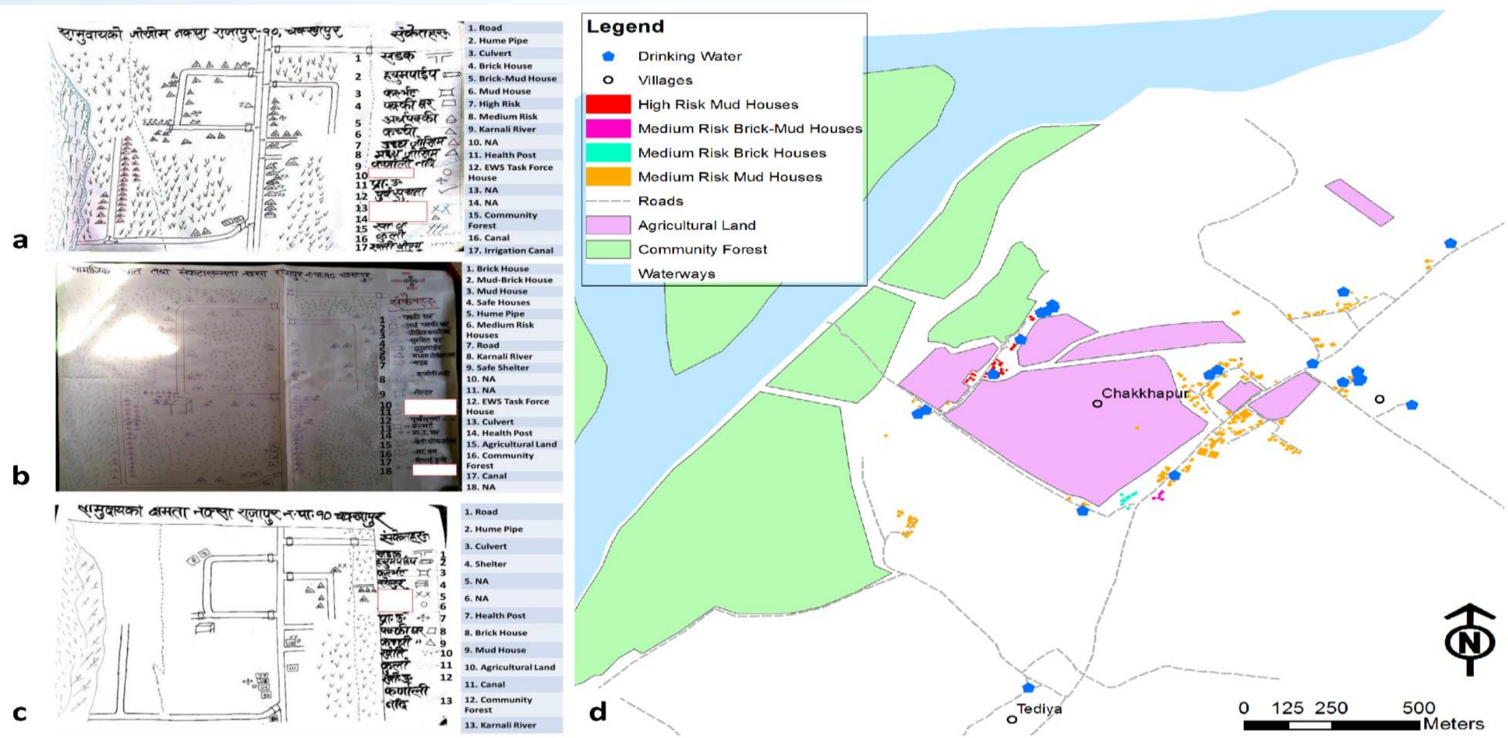
James et al., 2019

Challenges
Exposure

Exposure maps

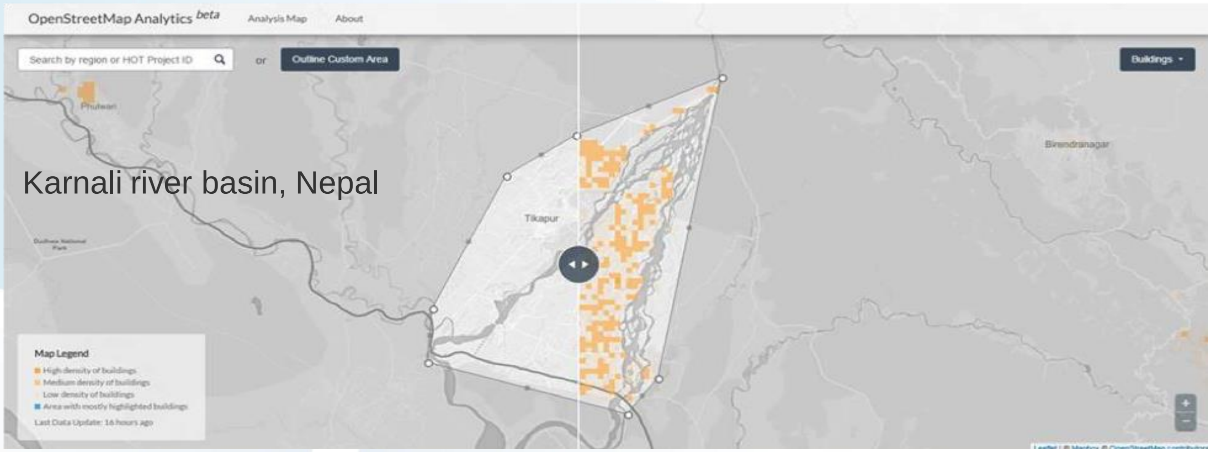
Soure: https://kartopics.com/portfolio/flood-exposure-risk-map-templates/

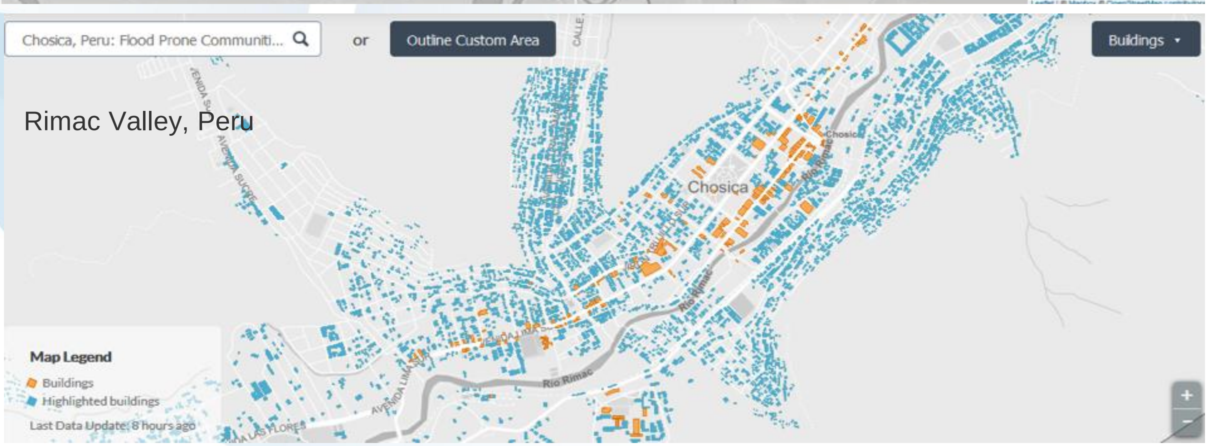
Mapping the unmapped



Liu et al., 2018

Mapping the unmapped: Mapathons





Challenges
Vulnerability

Vulnerability important

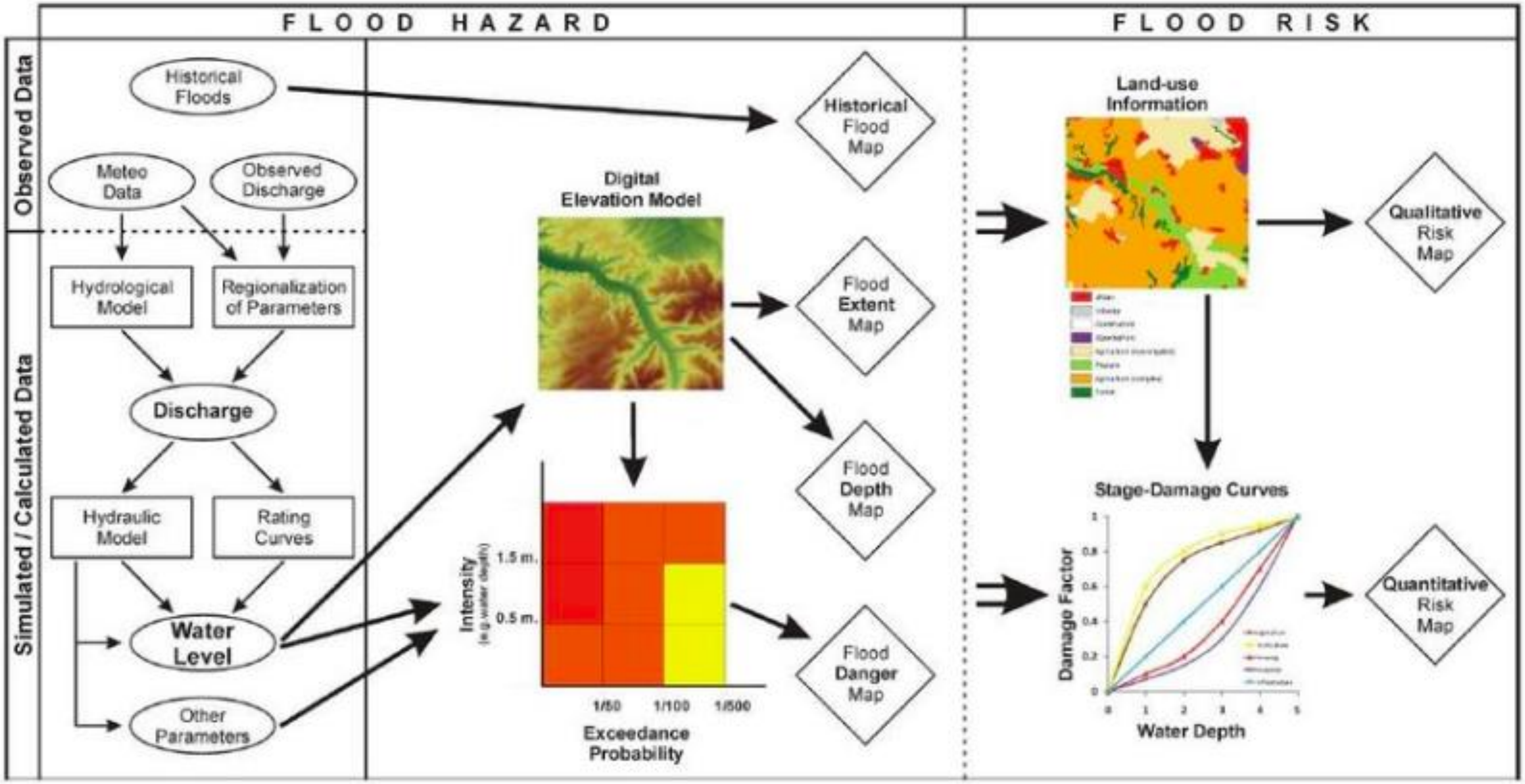
- Africa’s largest recorded cholera outbreak
- over 90,000 affected
- over 4,000 killed
- began following onset of seasonal rains
- vulnerability and exposure increased risk

IPCC, 2012

Vulnerability important

Danube flooding, June 2013

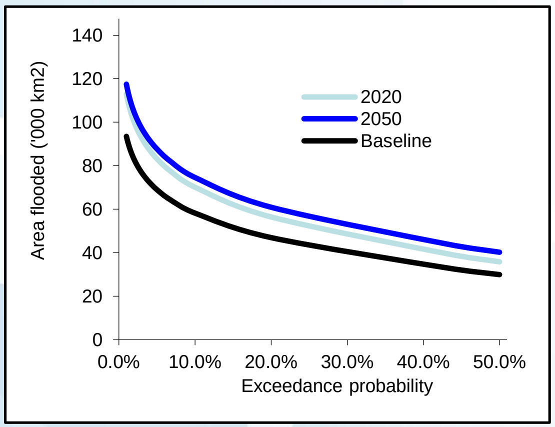
Risk Assessment (flood)

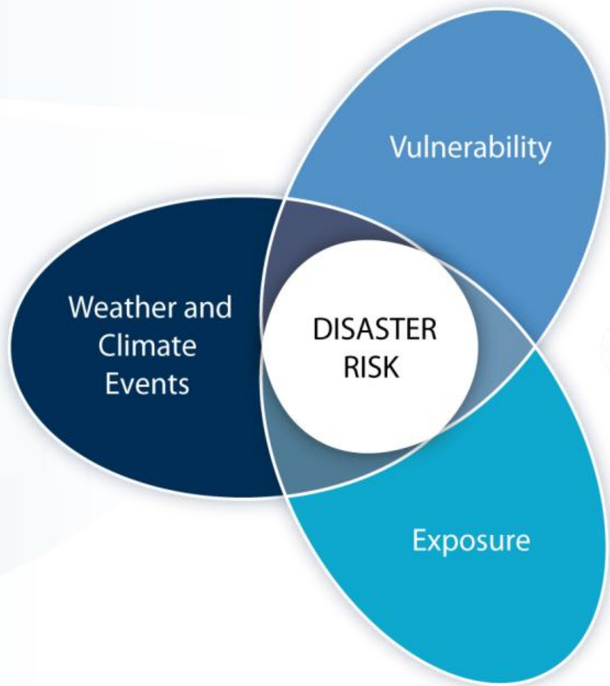


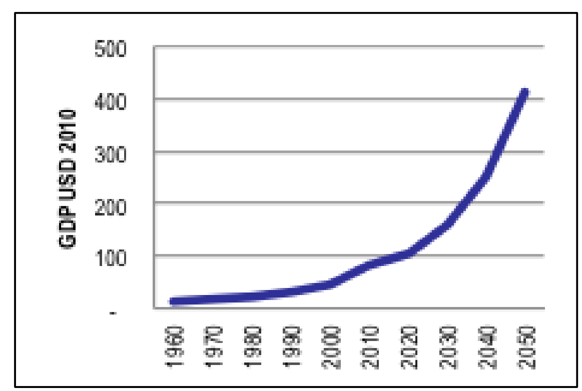
Conceptual framework for flood hazard and flood risk mapping (The matrix and curves are purely illustrative and based on a hypothetical case. In the matrix the yellow colour signifies low danger, the orange colour moderate danger and the red colour high danger)(de Moel, van Alphen and Aerts, 2009).

Risk assessment… in practice

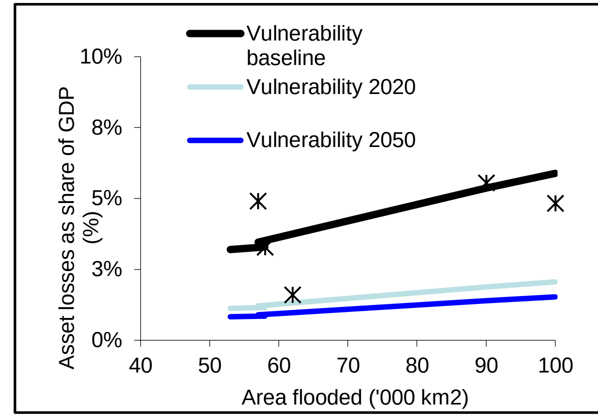
X

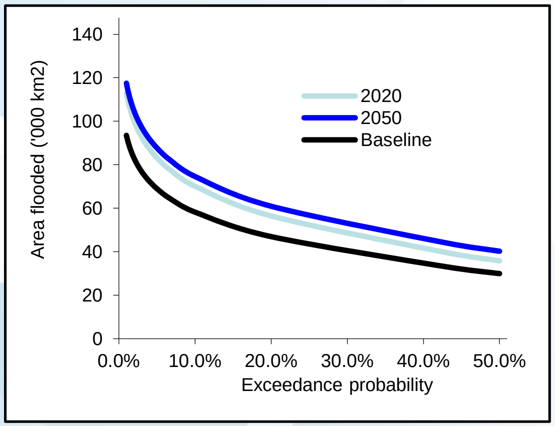


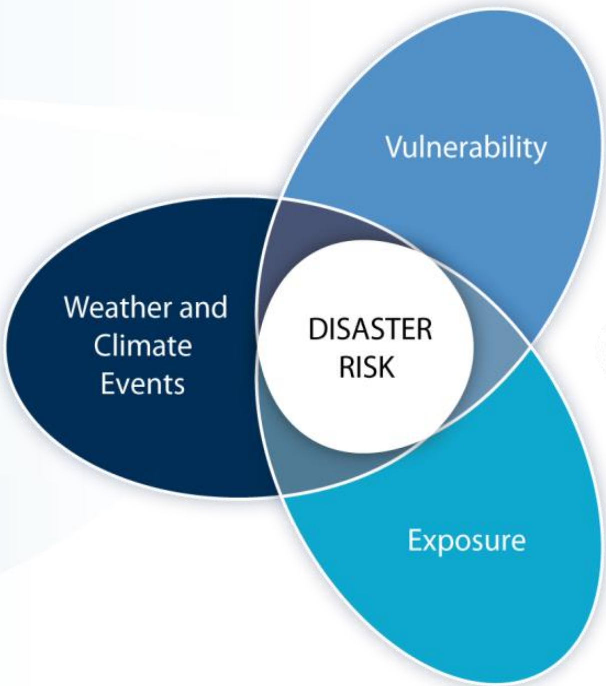


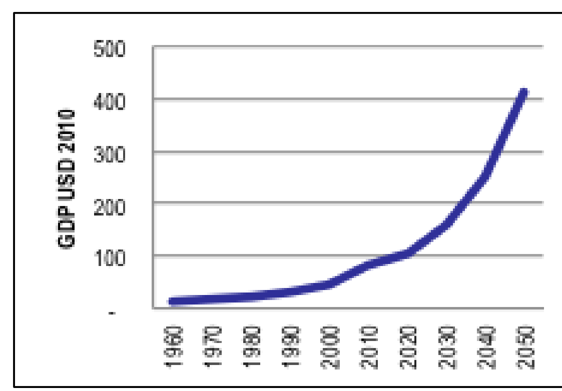


Understanding risk and trends









Case study Bangladesh

Climatic Change
DOI 10.1007/s10584-014-1141-0

Understanding trends and projections of disaster losses and climate change: is vulnerability the missing link?

Reinhard Mechler · Laurens M. Bouwer

Received: 22 April 2013 / Accepted: 27 April 2014

Abstract The recent IPCC-SREX report demonstrated for the first time comprehensively that anthropogenic climate change is modifying weather and climate extremes. The report also documents, what has been long known, that losses from natural disasters, including those linked to weather, have increased strongly over the last decades. Responding to the debate regarding a contribution of anthropogenic climate change to the increased burden from weather-related disasters, the IPCC-SREX finds that such a link cannot be made today, and identifies the key driver behind increases in losses as exposure changes in terms of rising

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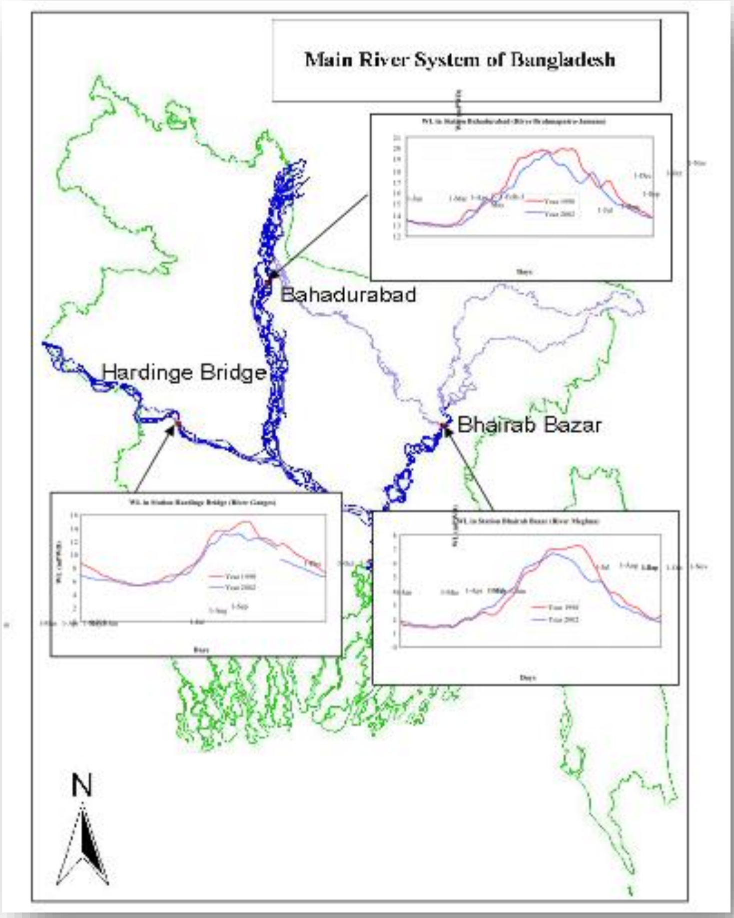
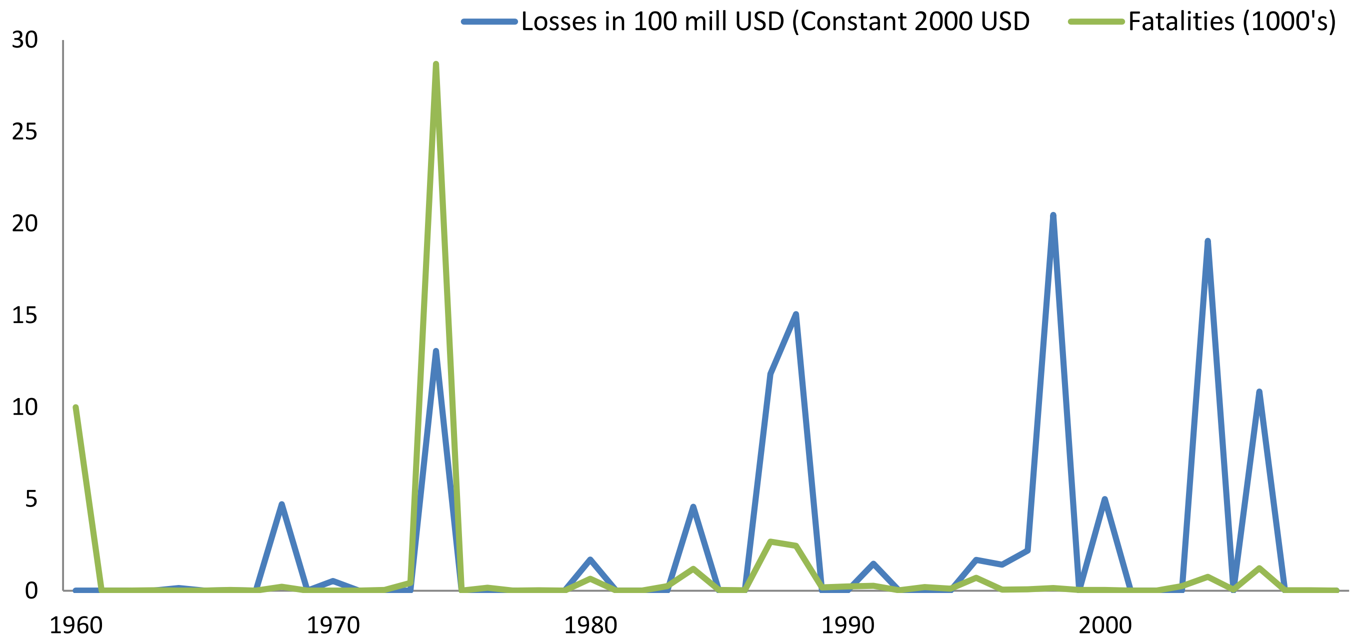
Case study Bangladesh

- Hotspot: Riverine flood risk dominating-1 large riverbasin
- Good probabilistic data
- Good experience in reducing risk
- What can be said about dynamic risk at country levels-macro analysis?
- How to capture vulnerability?

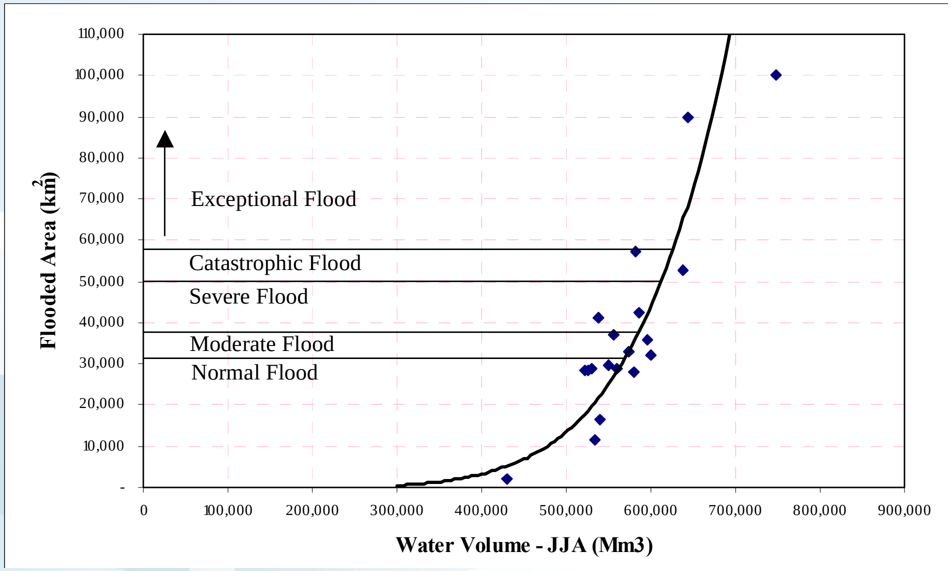


Tanner et al., 2007

Case study Bangladesh- impacts from riverine flooding



Case study Bangladesh- impacts from major riverine flooding



Tanner et al., 2007

Year	Probability	Flooded area (000 sq km)	Fatalities	Losses (million current $)
1998	1%	100	1,050	2,128
1988	2%	90	2,440	1,424
2007	7%	62	405	1,100
1987	8%	57	2,280	1,167
2004	9%	58	761	1,860
1974	11%	53	28,700	936
1984	53%	28	1,200	378

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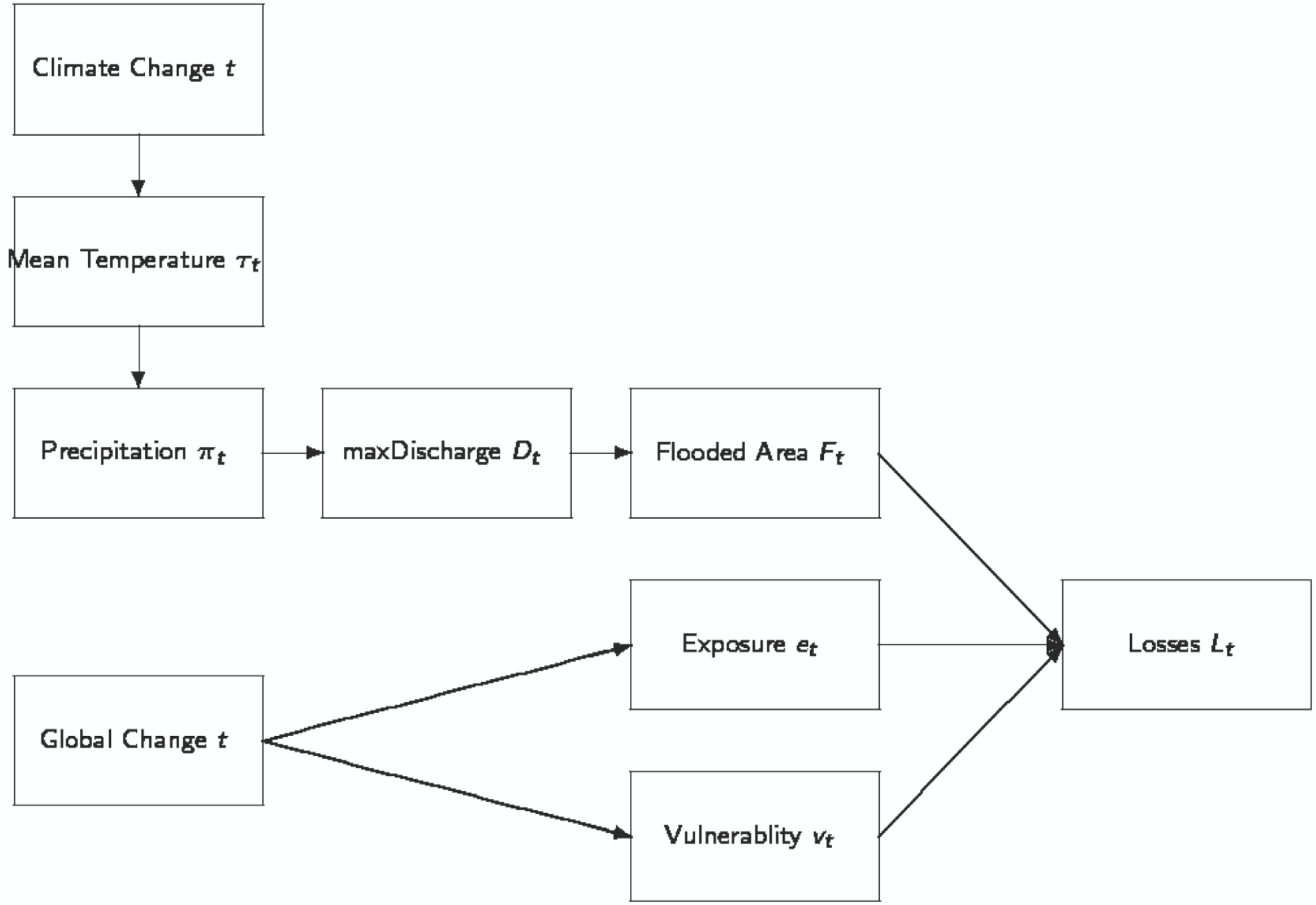
Bangladesh- modelling risks from riverine flooding



Bangladesh- modelling risks from riverine flooding

Module	Functional relationship or drivers	Source
Precipitation	Function of mean temperature change	PRECIS RCM for A2 and B1 (Data taken from Tanner et al. 2007)
Maximum discharge	Function of precipitation	Based on Conway et al. 2007
Flooded area	Function of max discharge	Statistical model (based on Mirza 2002)
Economic Vulnerability	Observed losses and vulnerability	Bangladesh statistics (Based on CRED 2010-1)
Exposure	GDP, assets	World Bank, 2012, SRES
Risk	Function of hazard, exposure and vulnerability	

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Bangladesh- modelling risks from riverine flooding

$$DMax\_G = 603.48\Delta P + 52623 \quad (1)$$

$$DMax\_B = 535.59\Delta P + 65271 \quad (1')$$

$$DMax\_M = 227.73\Delta P + 14084 \quad (1'')$$

$$D_t = DMax\_G + DMax\_B + DMax\_M \quad (1''')$$

$$F(x) = \exp(-\exp(-x)) \quad (2)$$

$$F_{\mu,\sigma}(x) = \exp(-\exp(-\left(\frac{x-\mu}{\sigma} + \gamma\right)\pi / \sqrt{6})) \quad (2')$$

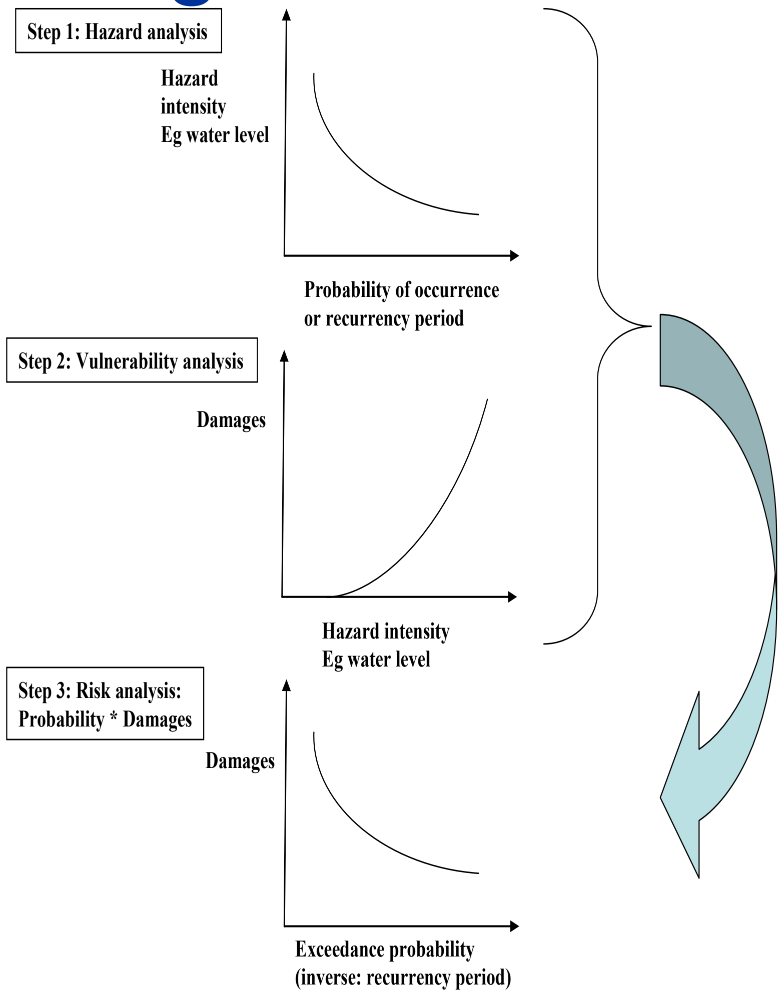
$$\text{with } \gamma = \lim_n \left[\sum_k \frac{1}{k} - \log n\right] = 0.5772$$

$$F(t) = 1.2621\left(\frac{D_t}{10000}\right)^{3.778} \quad (2'')$$

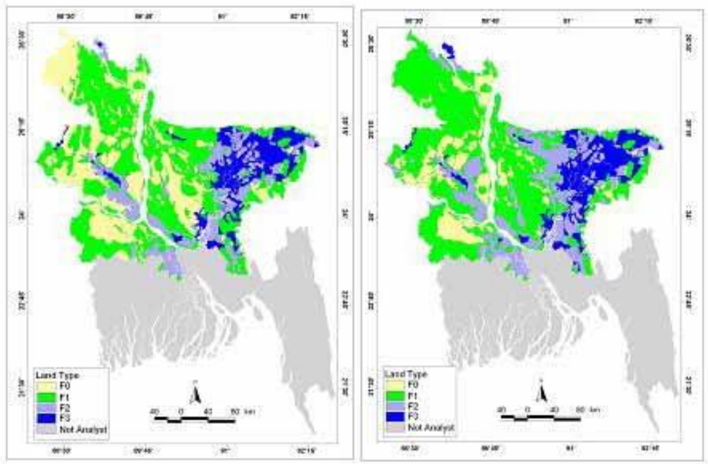
$$V(F_t) = v_0 * F_t * Vi_t$$

$$Vi(t) = 5E + 25*e^{(-0.0308*t)} \quad (3)$$

$$L(t) = V_t * E_t \quad (4)$$

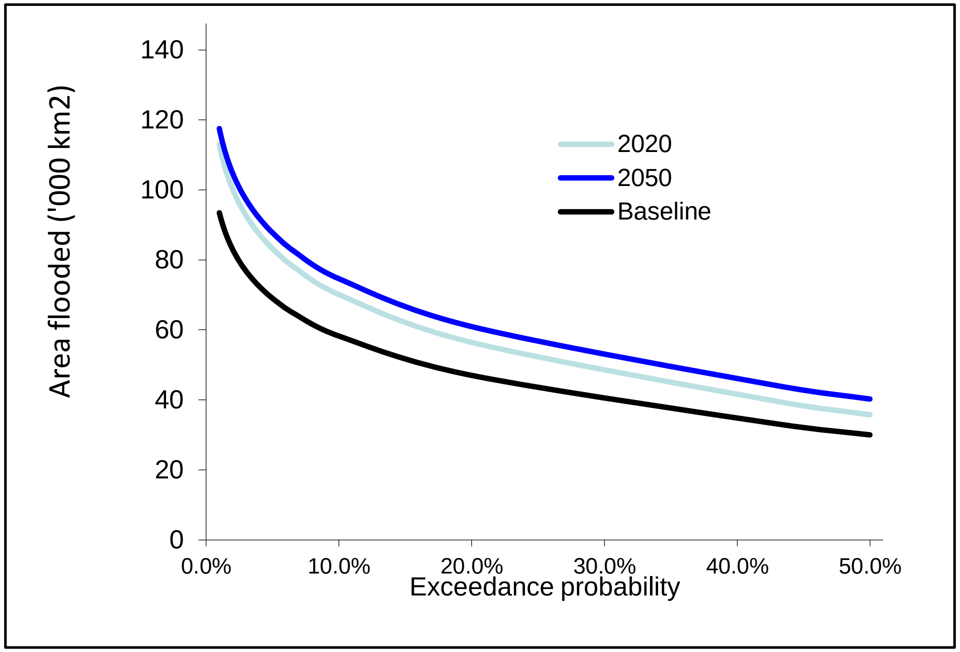


Projecting flooding
Change in frequency of area flooded



(a) SERS A2 (2020s) (b) SERS A2 (2050s)

(c) SERS B1 (2020s) (d) SERS B1 (2050s)



Tanner et al., 2007

Measuring economic vulnerability concept of stage-damage curves

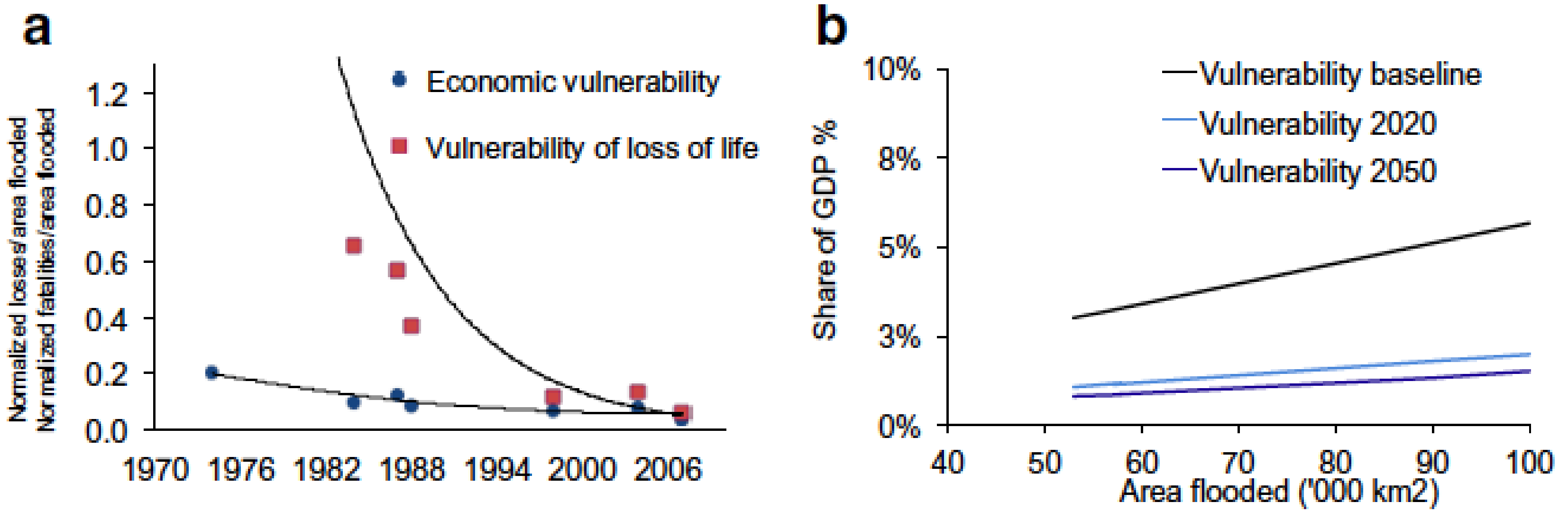
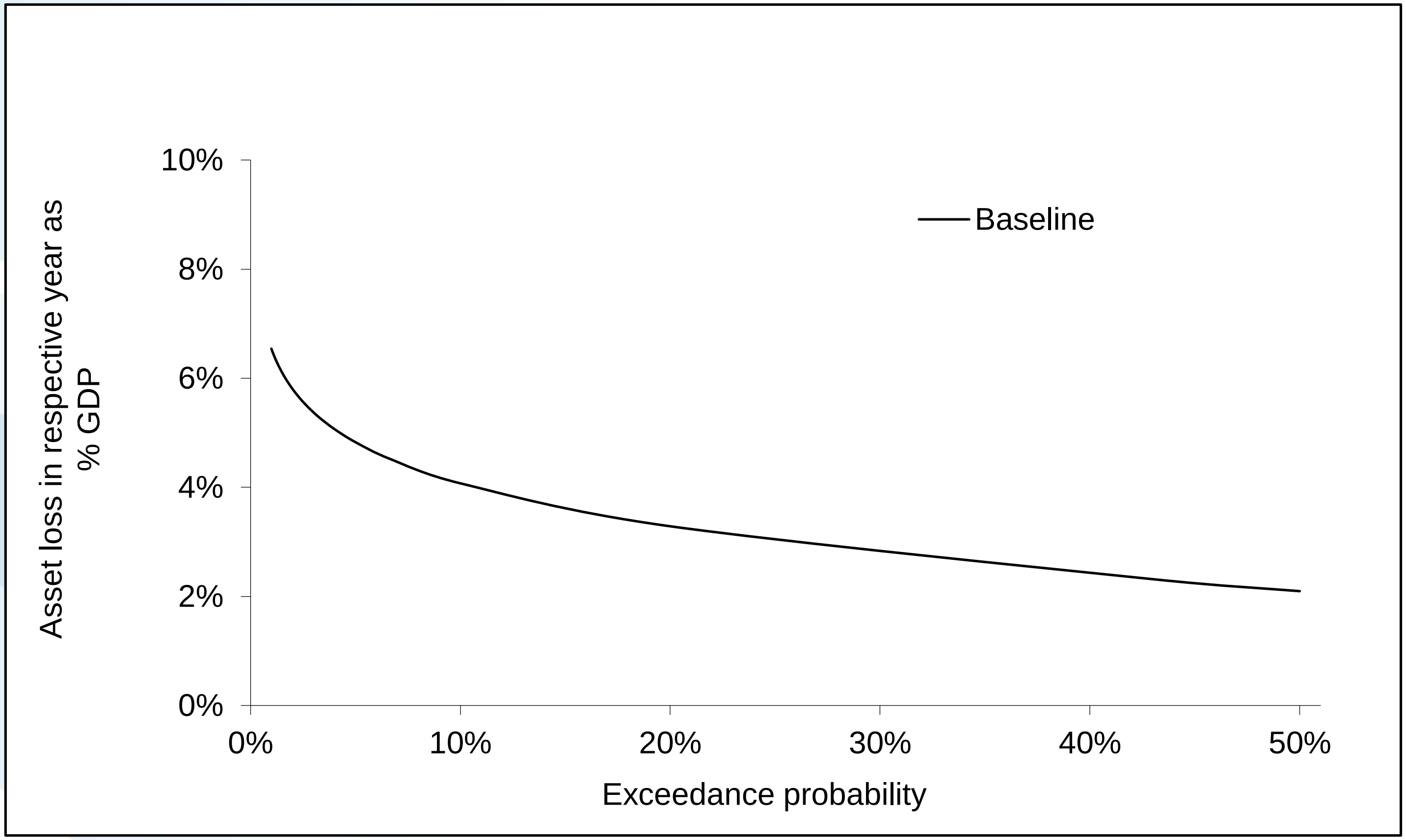


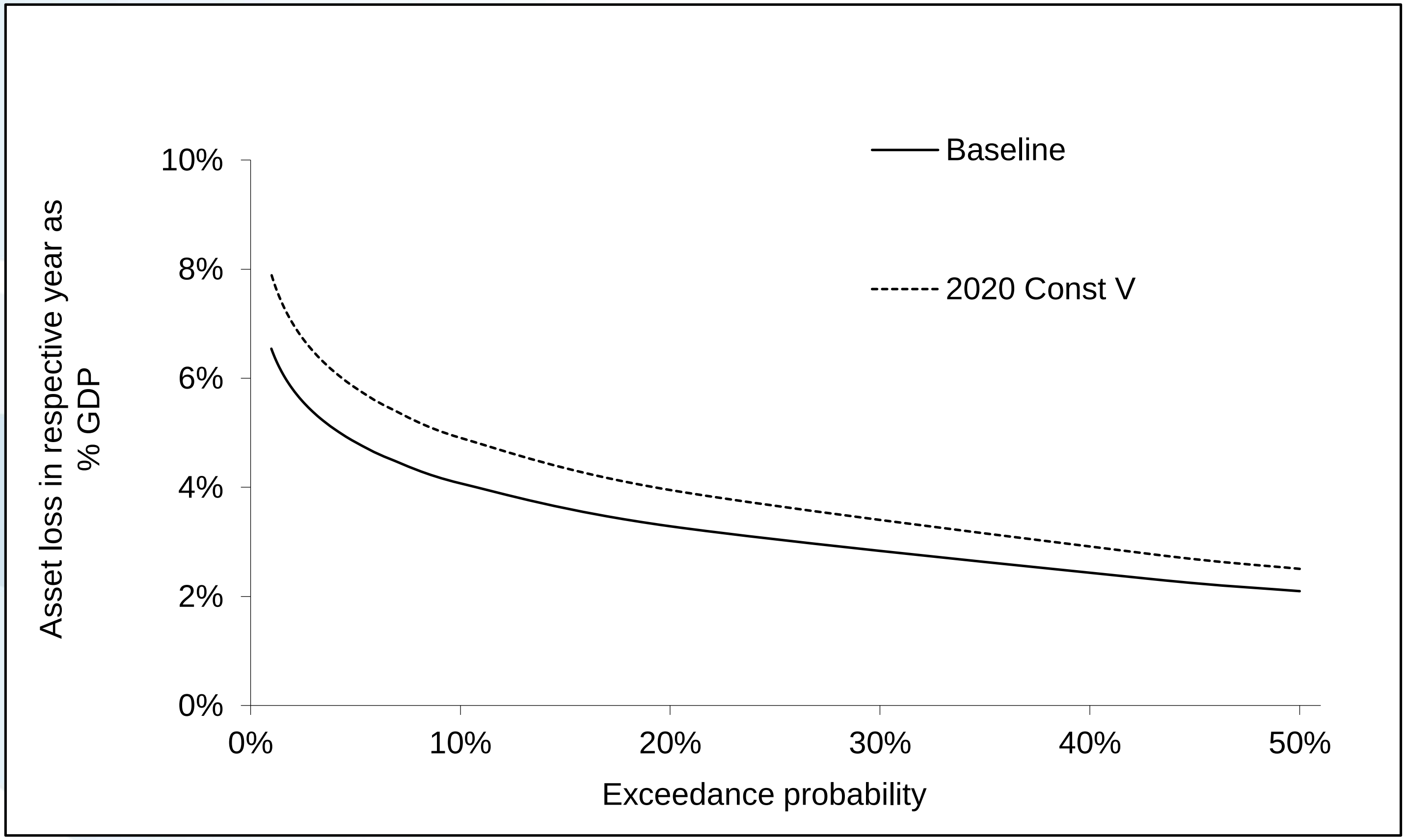
Fig. 2 a,b: Observed changes in economic vulnerability and vulnerability of loss of life (left panel), and derived economic vulnerability functions (right panel) for riverine flooding in Bangladesh. Source: Extended from Tanner et al. 2007

Mechler and Bouwer, 2015

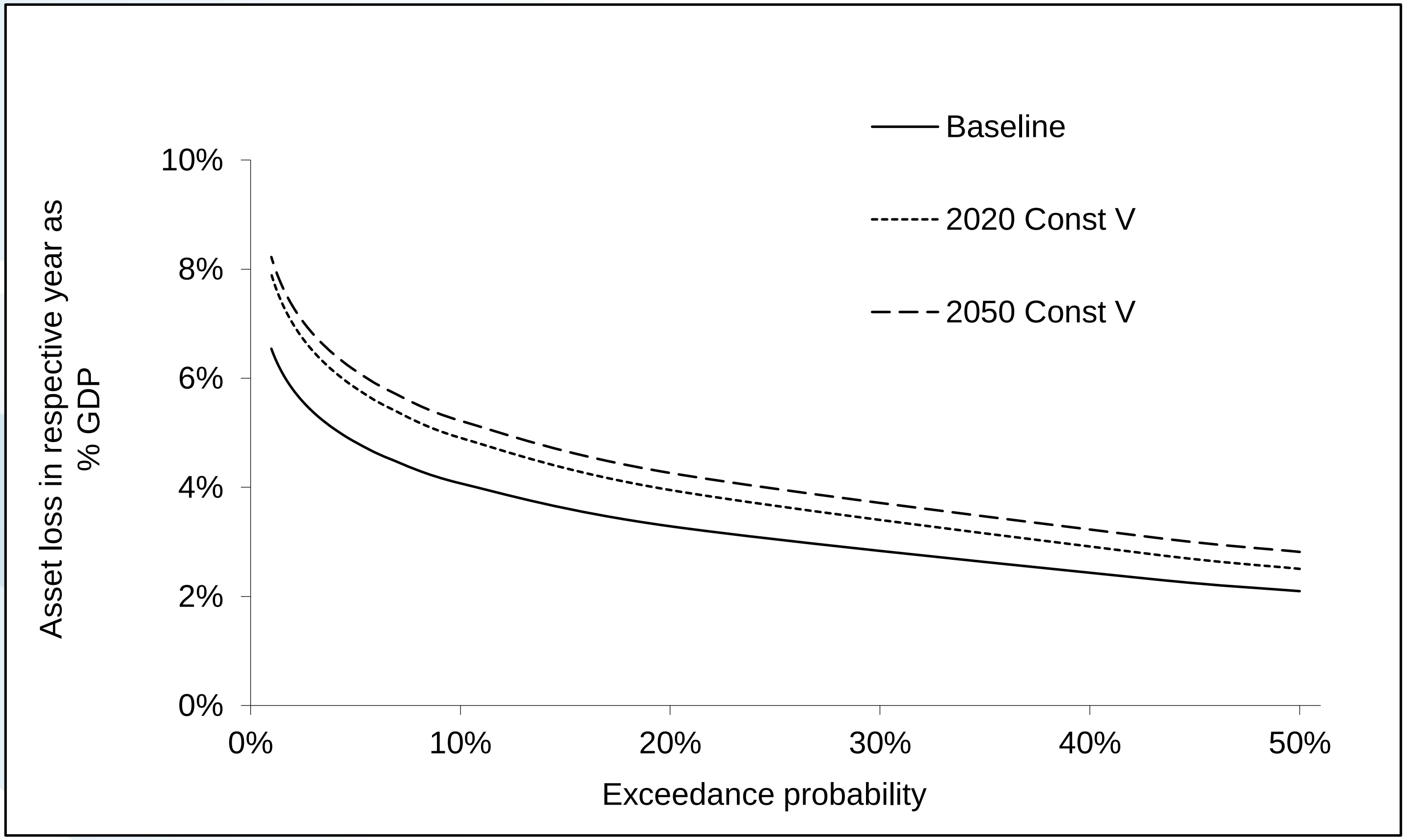
Projecting riverine flood risk in Bangladesh



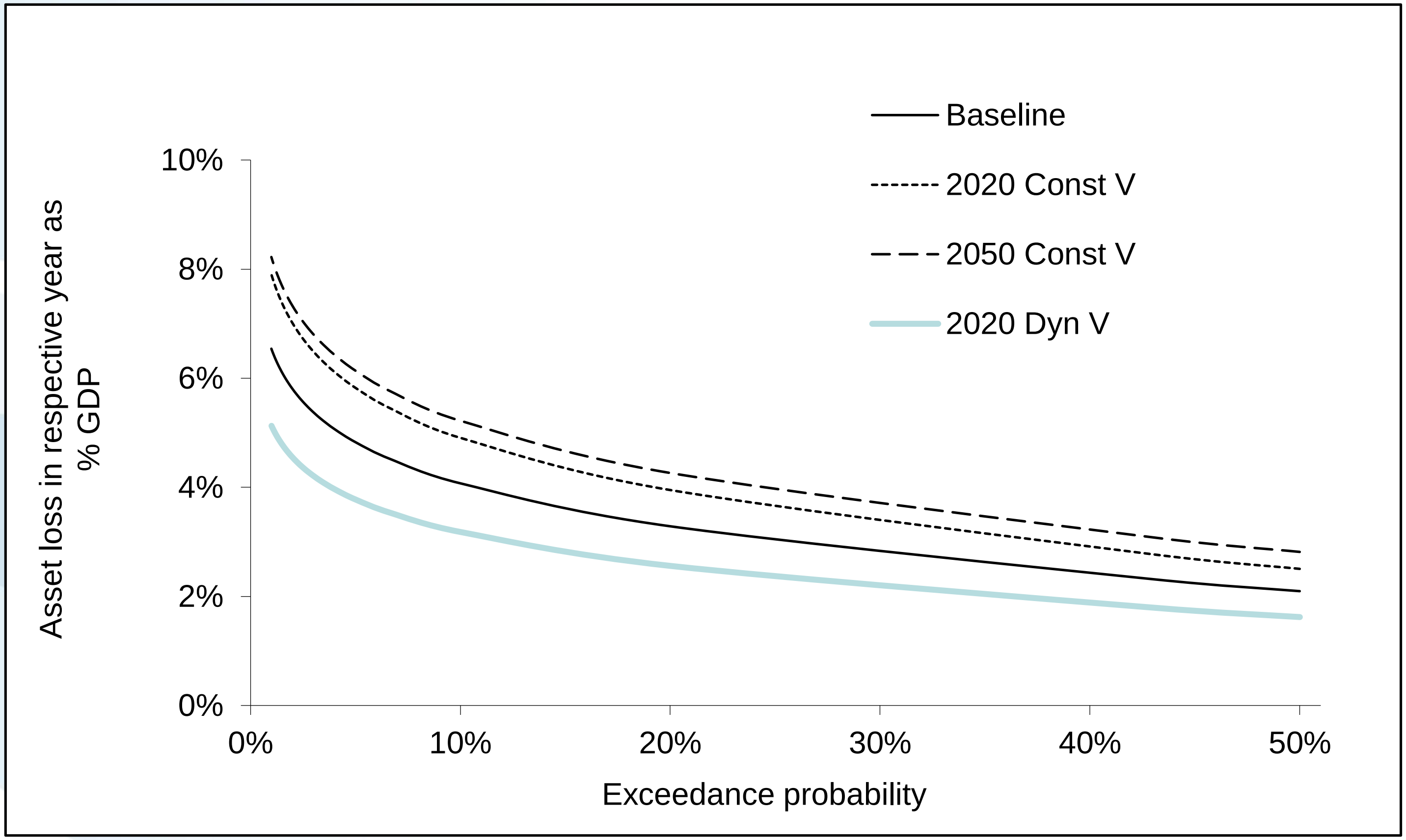
Projecting riverine flood risk in Bangladesh



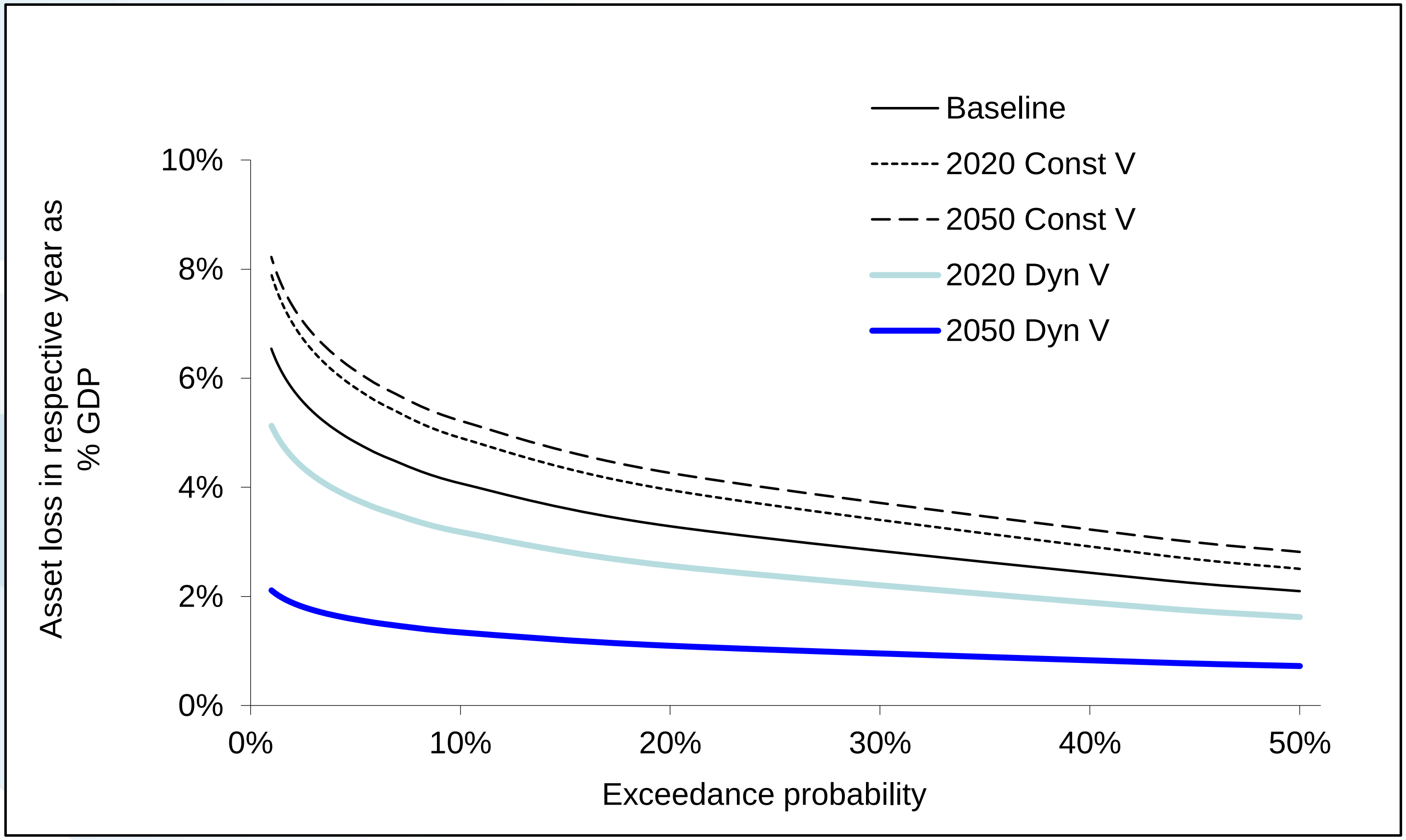
Projecting riverine flood risk in Bangladesh



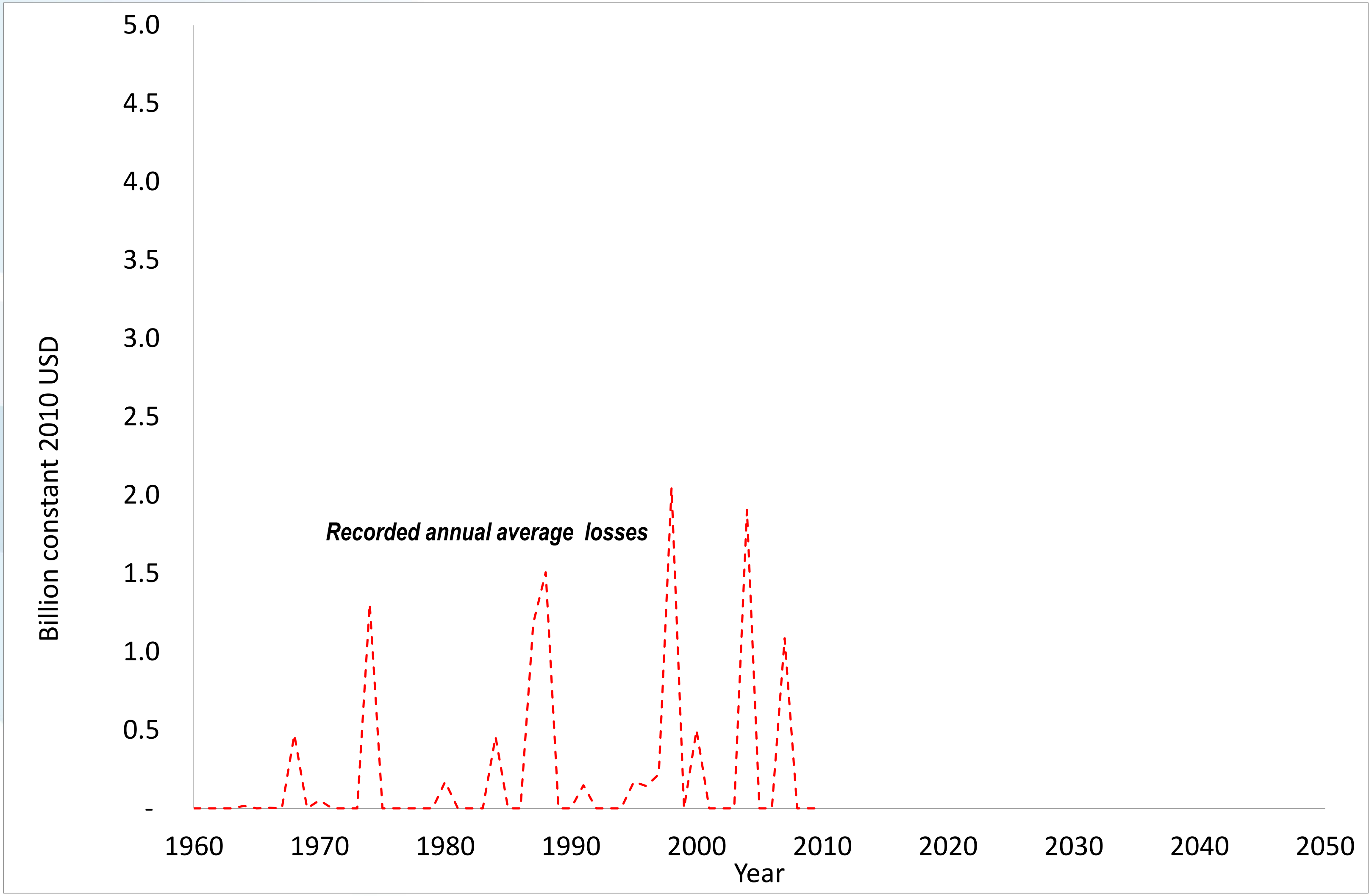
Projecting riverine flood risk in Bangladesh



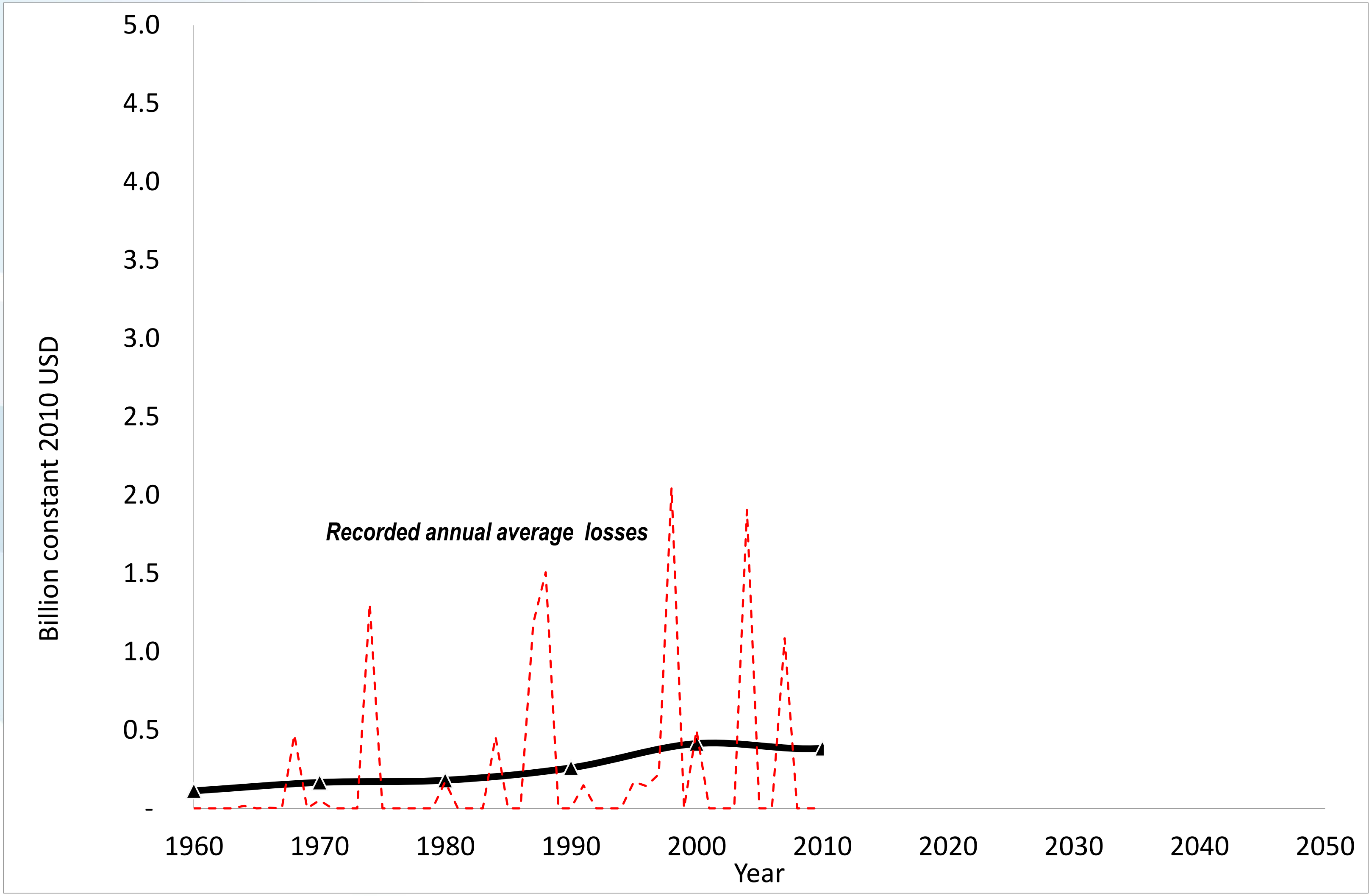
Projecting riverine flood risk in Bangladesh



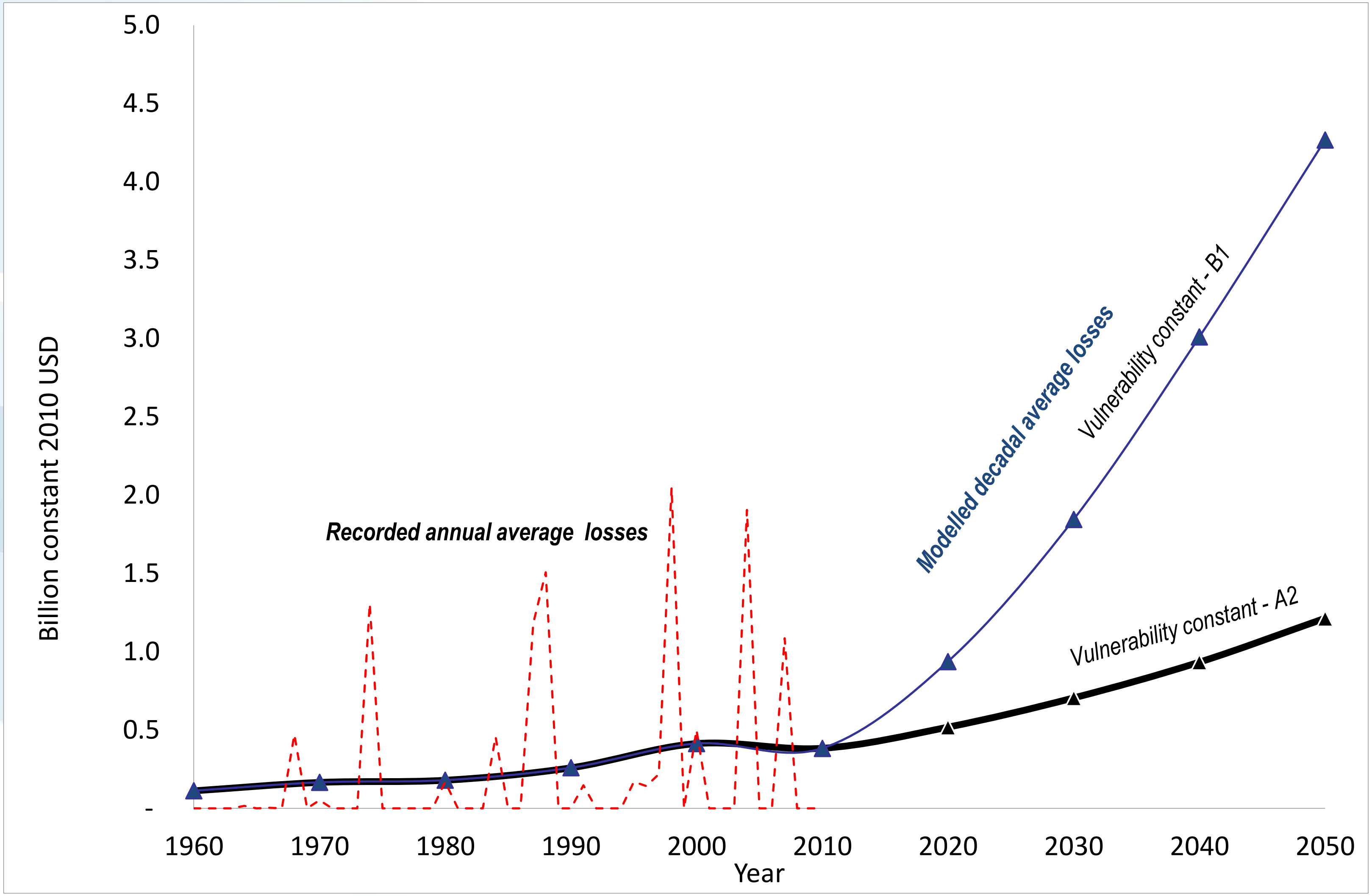
Projections: average losses



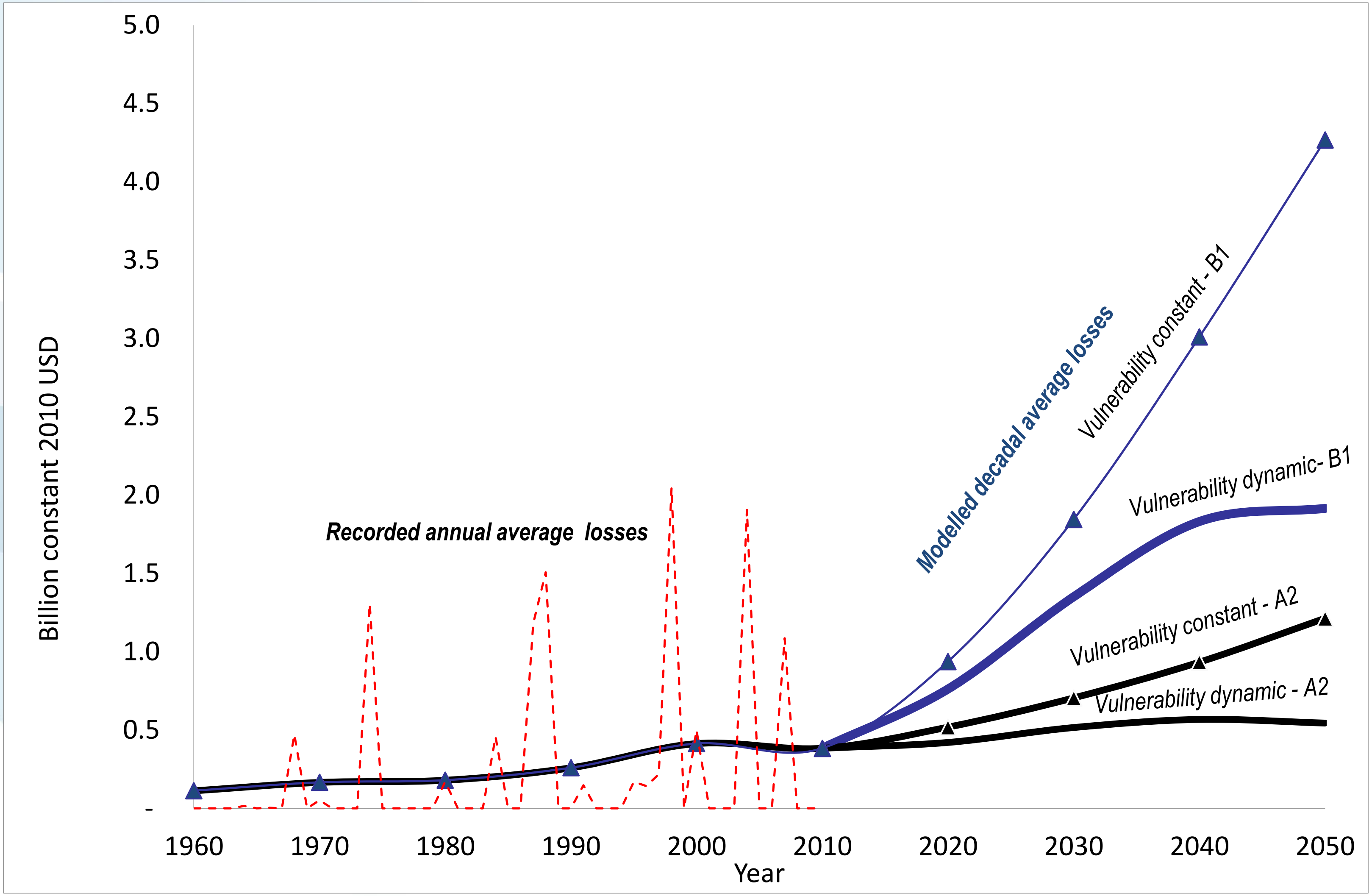
Projections: average losses



Projections: average losses



Projections: average losses



Putting things into perspective… Observed vulnerability, exposure and risk

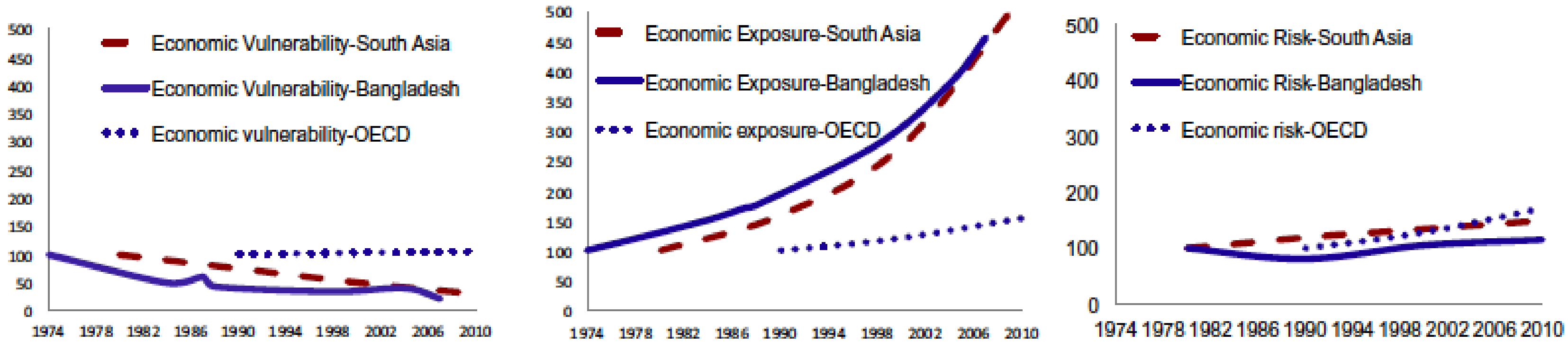


Fig. 4 Observed changes in economic vulnerability, exposure and risk for disaster risk in Bangladesh, South Asia, and the OECD (normalized to different years). Note: Hazard for Bangladesh and the OECD is flooding (marked in blue); for South Asia tropical cyclones (marked in red). Data sources: Tanner et al. 2007; UNISDR 2011

Mechler and Bouwer, 2015

Implications

- Absent quantifications of vulnerability, studies on future losses under climatic change are not robust
  –> important for risk planning questions

- Analysis suggests substantial benefits to supporting vulnerability-reducing measures
  --> important for tailoring support for risk management

- Need for taking a truly risk-based perspective on modelling extremes: Drivers and outcomes

Conclusions

- As climate change has become real, real action required
- Risk perspective useful to consider
  - Question of ‘danger’: idealized risk
  - Calculated risk: actionable metric
  - Perceived risk: perceptions of those at risk
- IPCC impactful with climate risk analytics: *Reasons for Concern* and *Key Risks*

Conclusions

- Climate risk assessment with challenges
- Hazard: projections and attribution
- Exposure: what about the unmapped
- Vulnerability: how to operationalize at relevant scale (as input to risk)?