International Institute for Applied Systems Analysis
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science for global insight

Climate risks & extreme events

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CCCA Pre-Conference Day
Graz, 6. April 2016

Climate risk management?

Chris Field, Chair IPCC, Working Group II

"Climate change is a threat multiplier that adds new dimensions and complexity to the development challenges we're already facing.

Fundamentally, the challenge of managing climate change is a challenge of managing and reducing risk. "

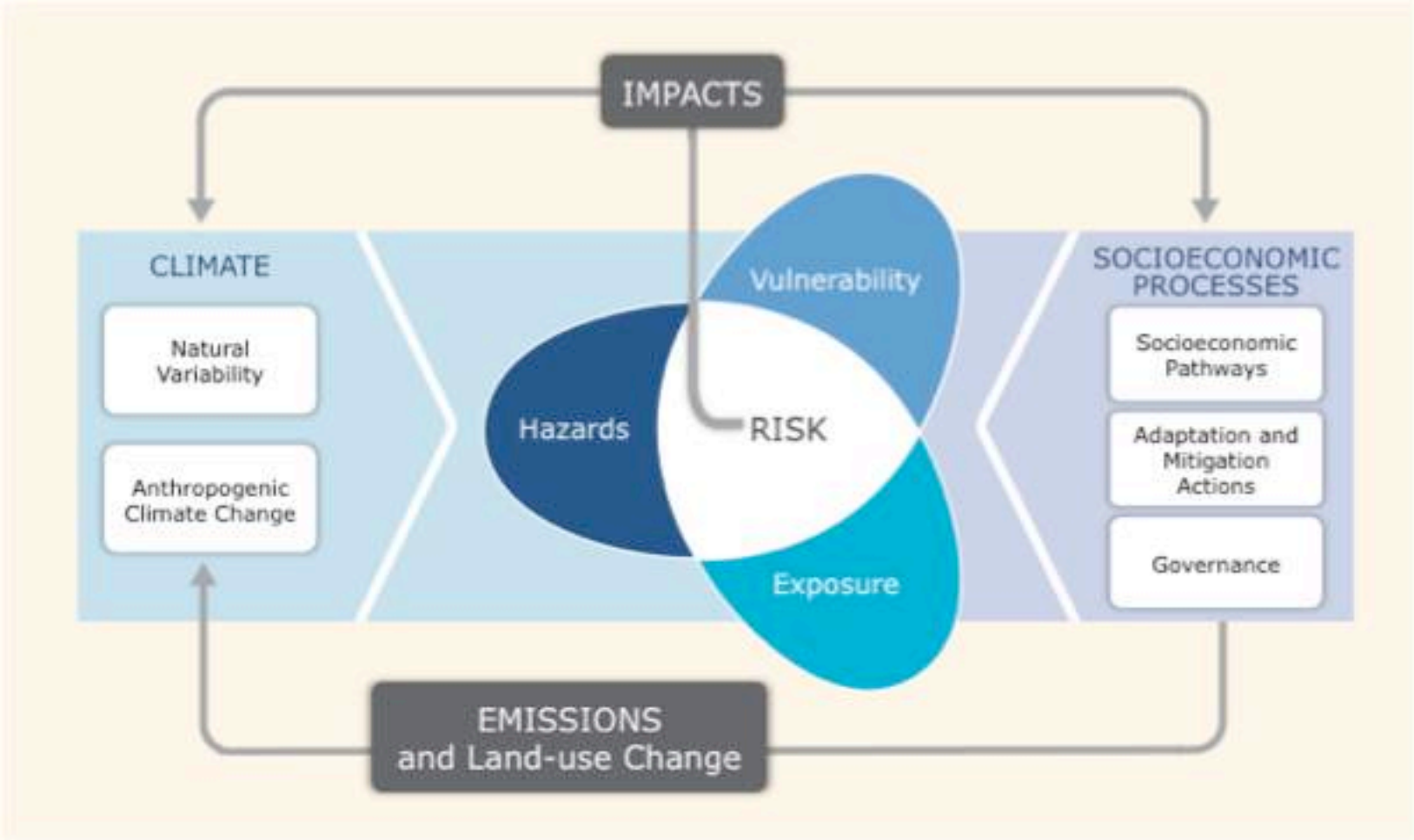
Overview

- Role of risk for responses to climate variability and climate change

- Risk analytics and management

- 3 Applications
  - Dealing with climate variability
  - Managing climate-related risk
  - Dealing with risk ‘beyond adaptation”

IPCC Working group II: Risk perspective

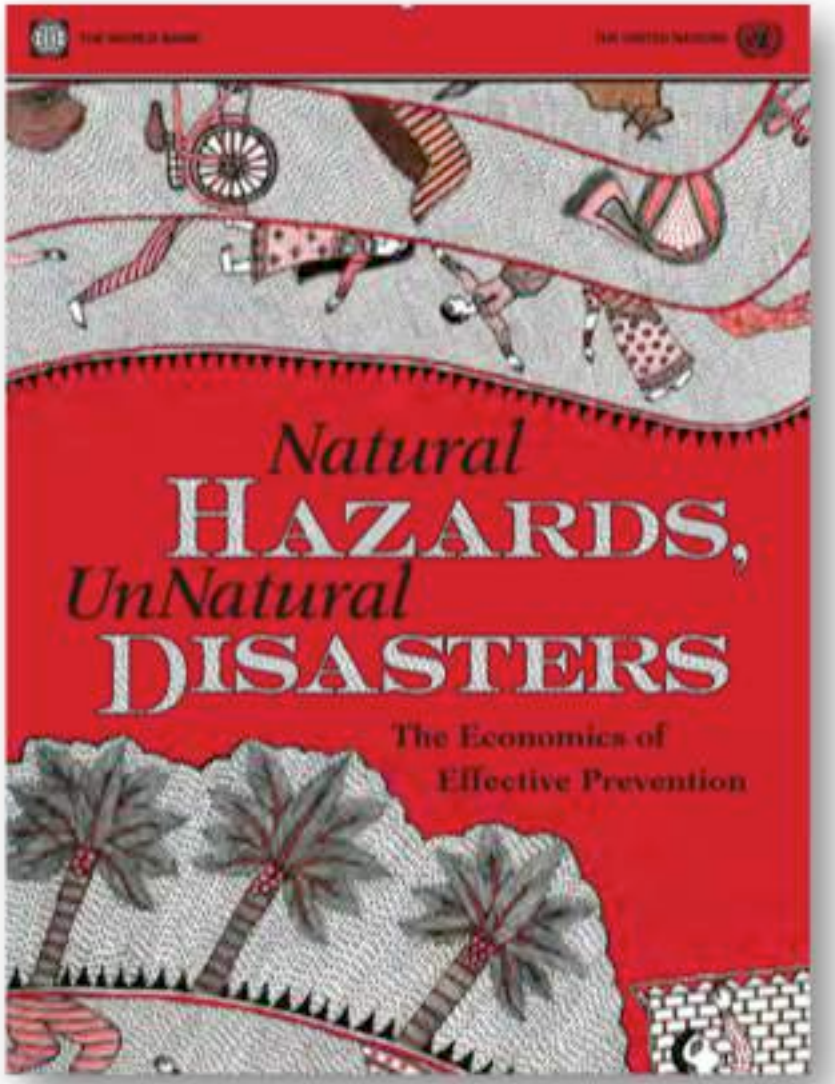


Projections: changing extremes

Increases expected in

- Warm days– *virtually certain (high confidence)*
- Heatwaves: very likely *(high confidence)*
- Heavy precipitation – *likely (high confidence)*
- Droughts– *medium confidence*
- Average tropical cyclone maximum wind speed *likely (high confidence)*
- Global frequency of tropical cyclones will either decrease or remain essentially unchanged - *likely (high confidence)*

Unnatural disasters



Weltbank and UN, 2012

Climate risk

Hazard

Intensities, duration and frequencies of some hazards changing (IPCC 2012&14)

Extreme event attribution in early stages (James et al., 2014; Trenberth et al., 2015)

Exposure

Dominating Factor - currently (IPCC, 2012&14)

Vulnerability

Key driver, knowledge gaps, significant adaptation deficit (IPCC, 2012)

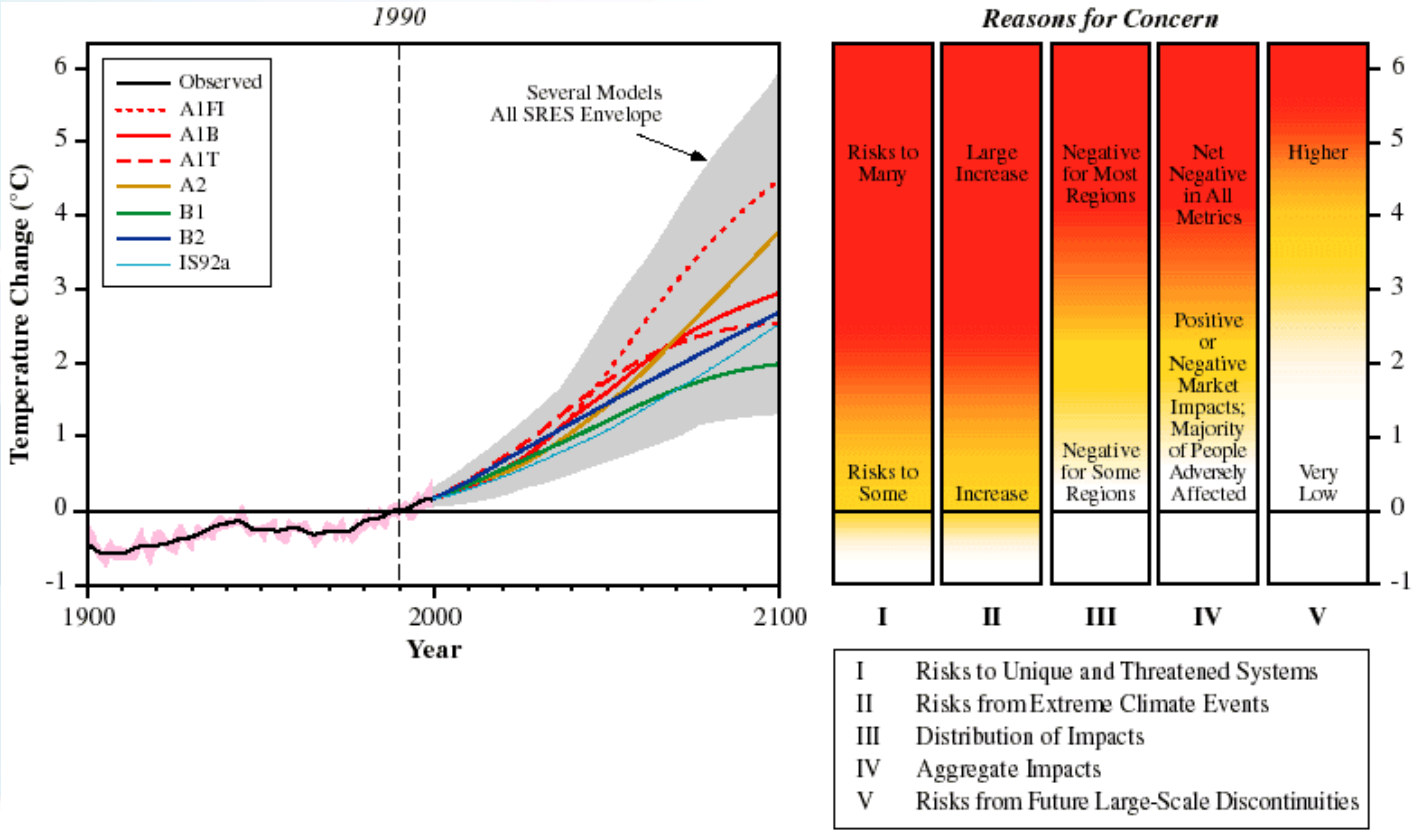
IPCC and epistemological constructions of risk

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

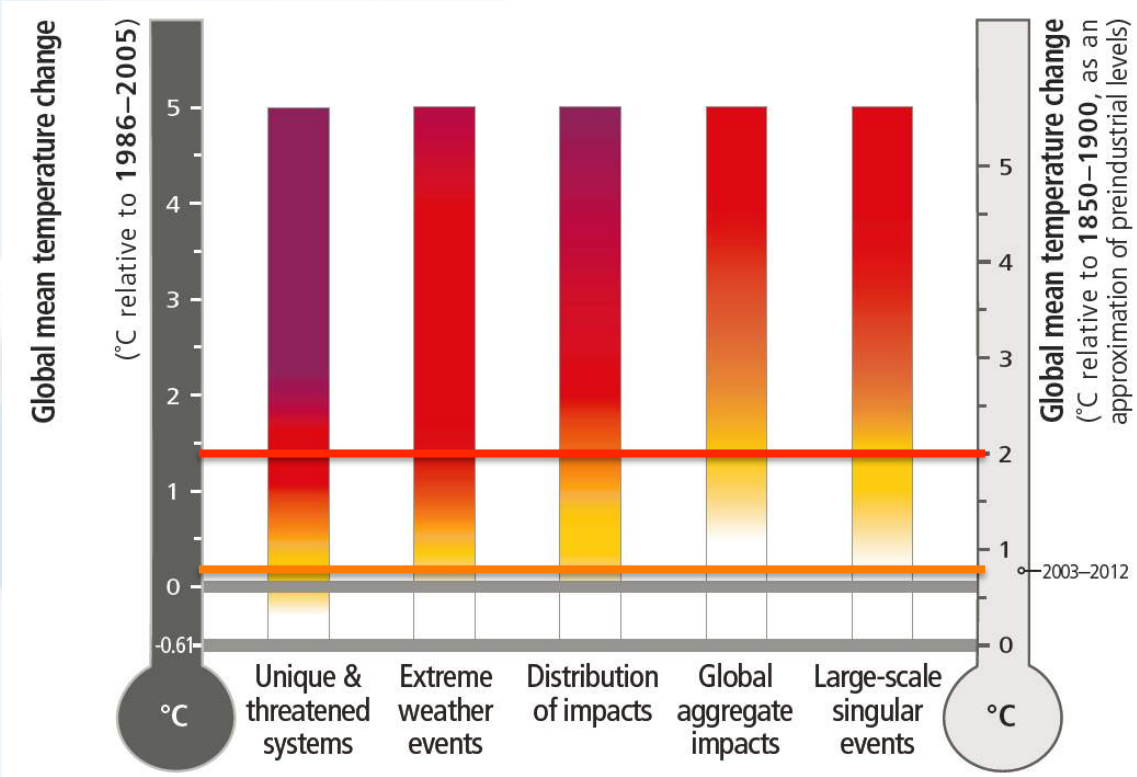
3. *Perceived risk*: the subjective judgment people make about an idealized risk
   → informing adaptation

Dangerous Climate Change 2001
Reasons for Concern



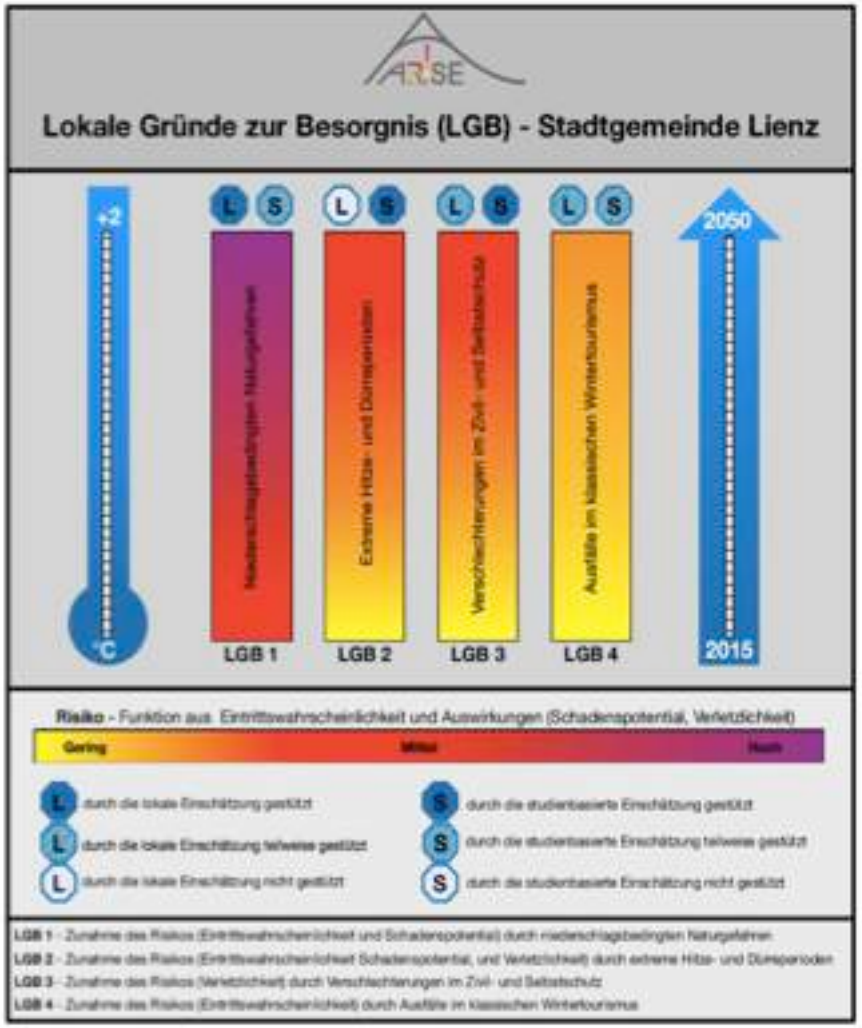
IPCC, 2001

Idealized risk
The 5 Reasons for Concern/burning embers diagram

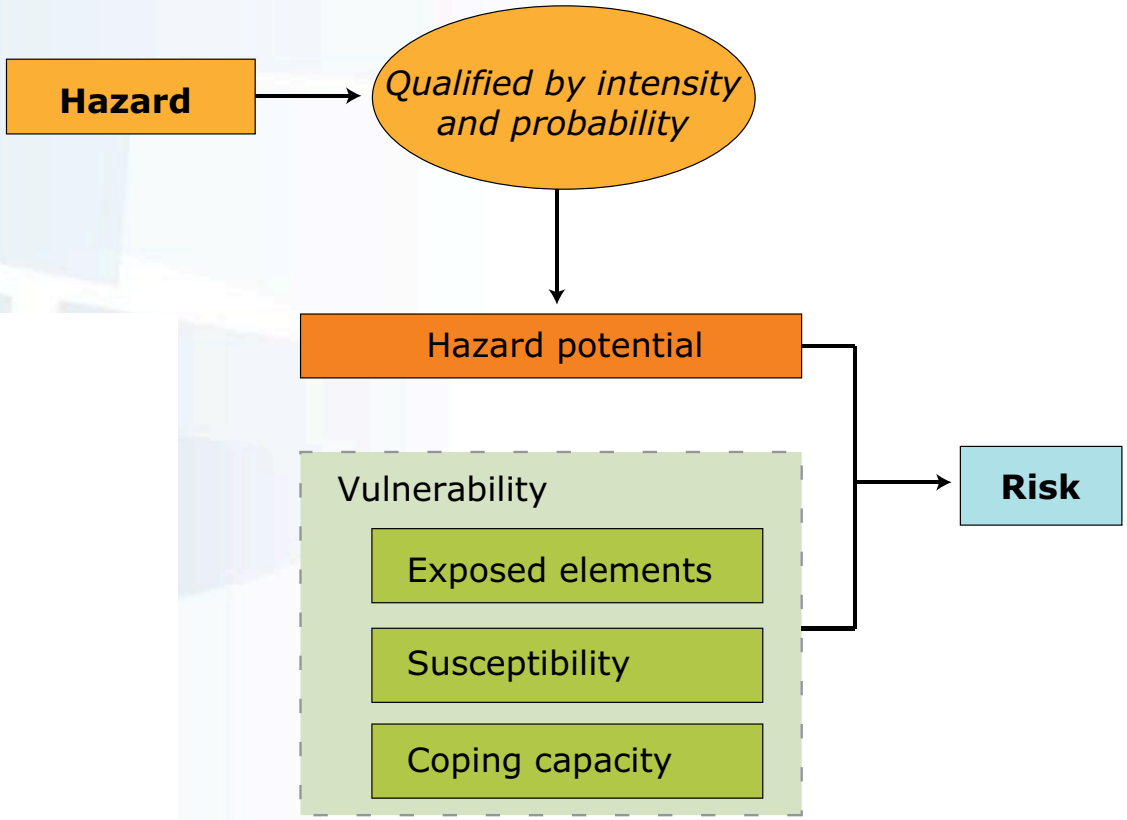


IPCC, 2014

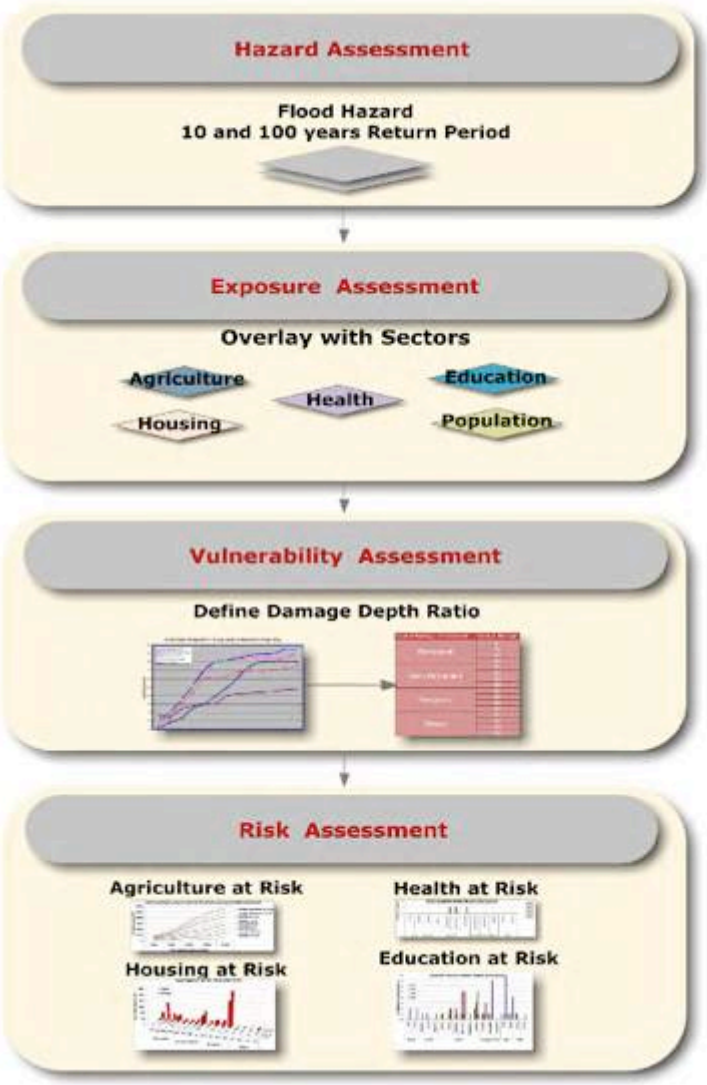
Local Reasons for Concern ARISE



Calculated risk
… to climate-related risk

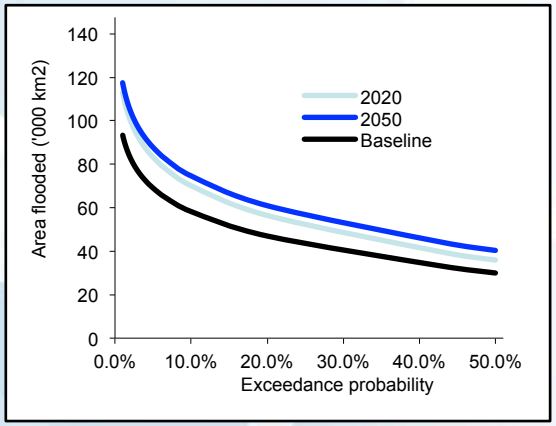


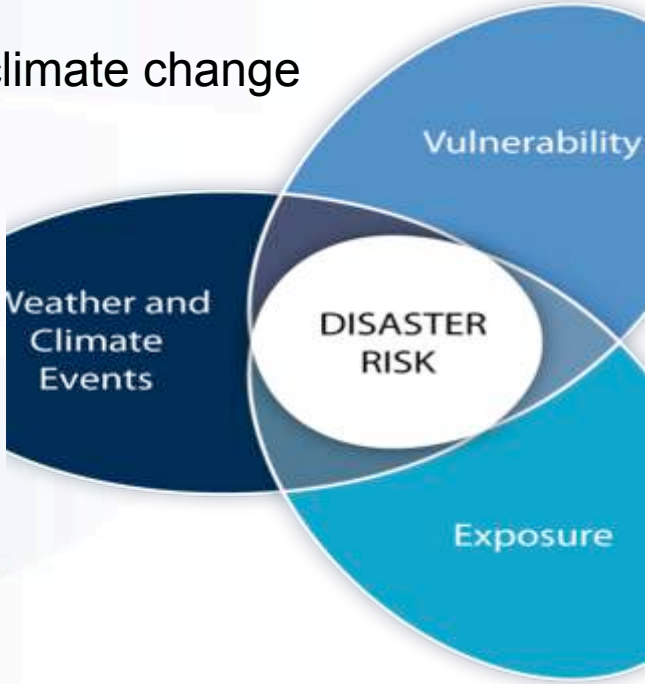
Risk assessment



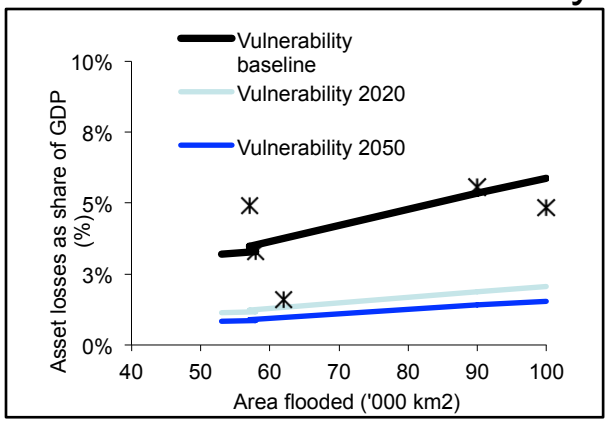
Modelling risk and trends

Hazard occurrence with climate change

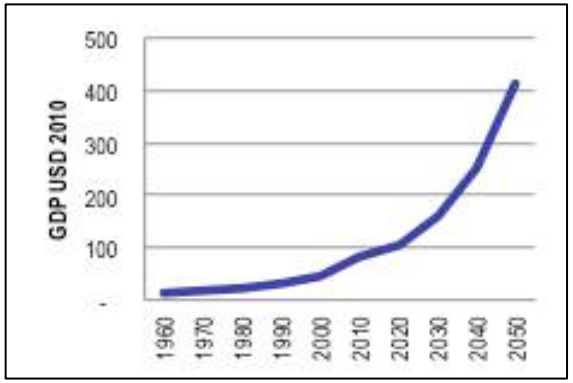




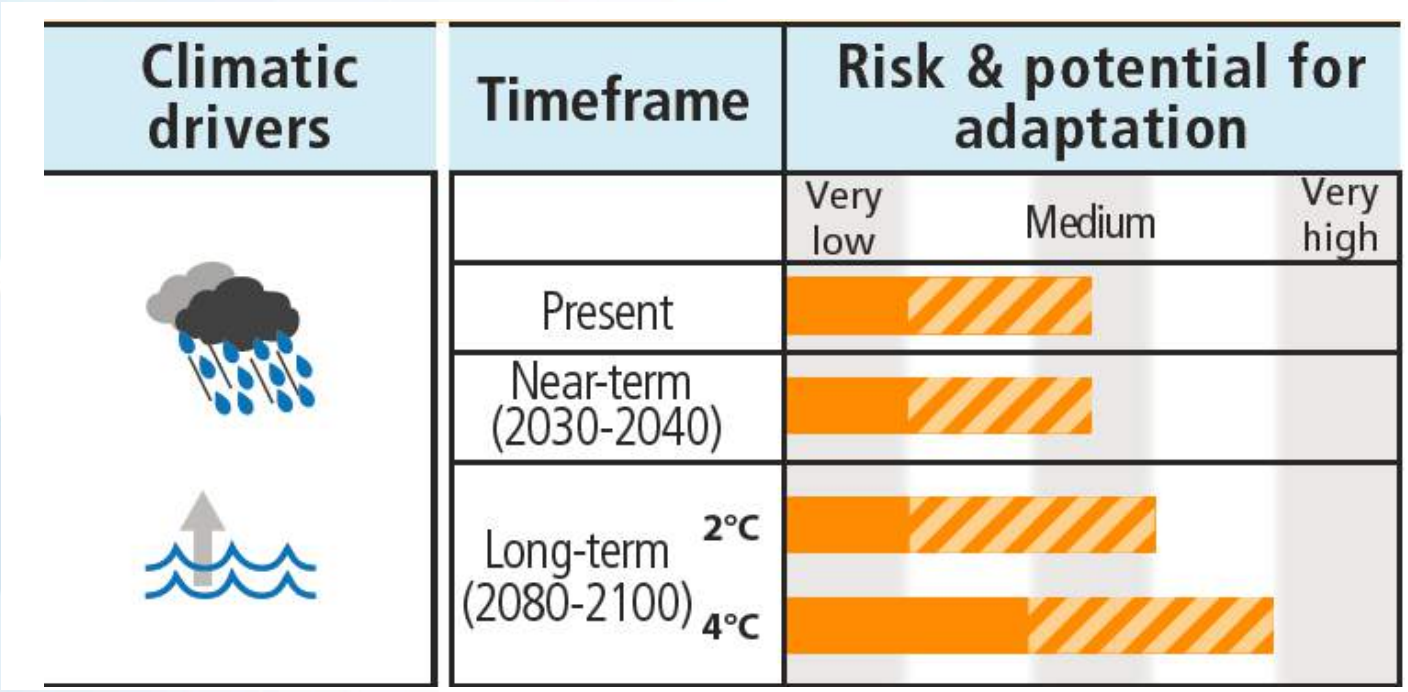
Losses for hazard intensity



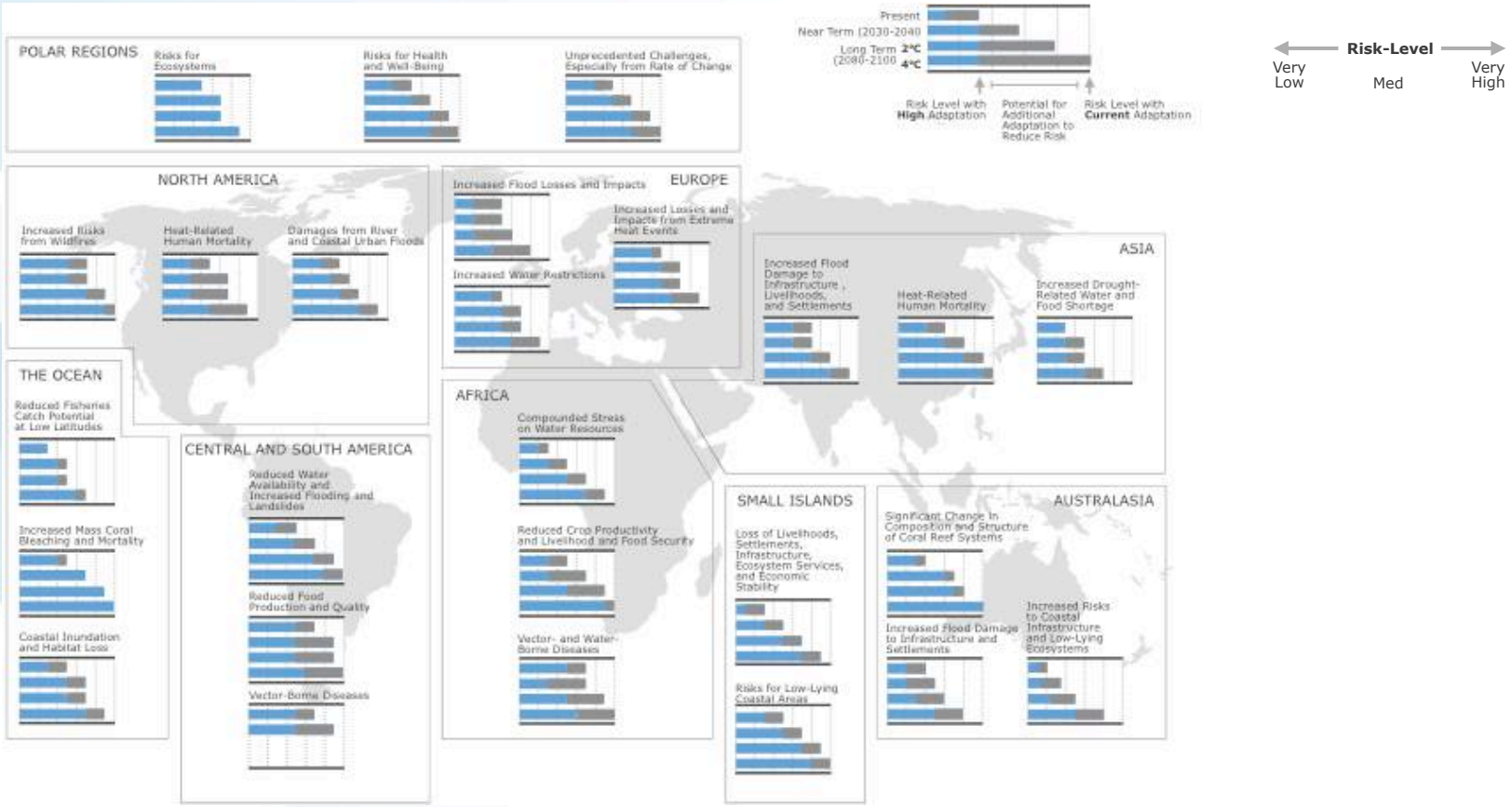
Exposure exposed to hazards



Losses from coastal and riverine flooding- Europe

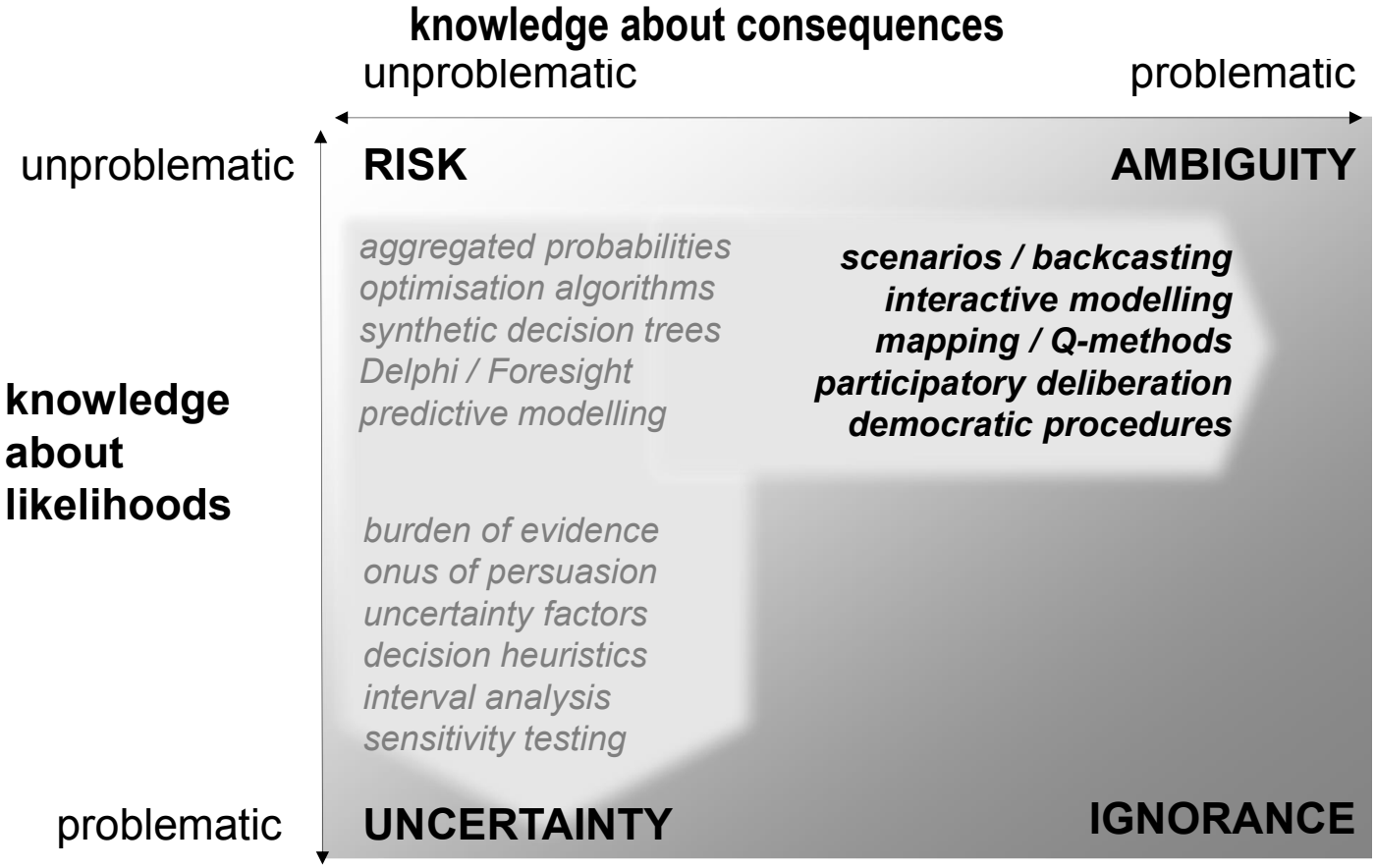


‘Calculated’ risk: regional level



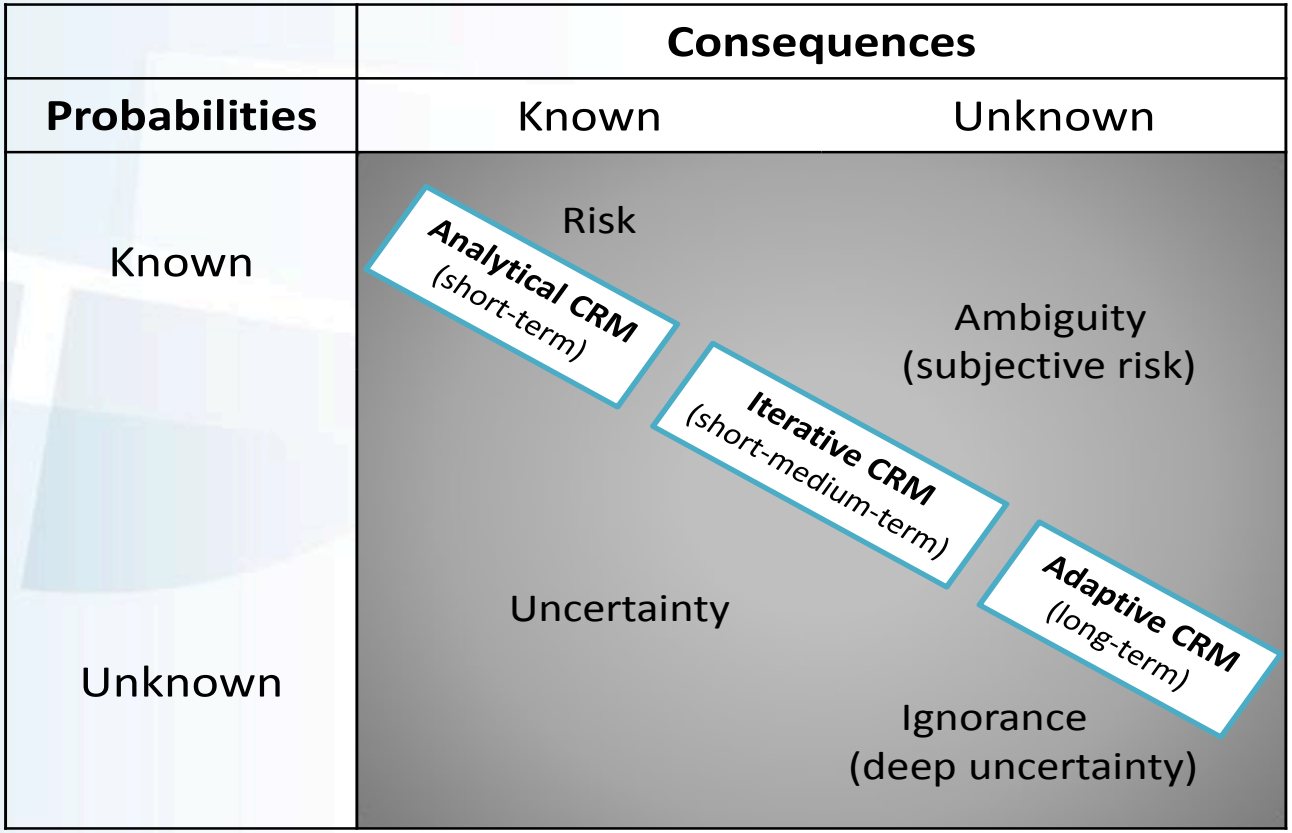
IPCC, 2014

Dealing with risk and uncertainty: Methods and Methodology



Source: Stirling, 2014

Dealing with risk and uncertainty: Methods and Methodology

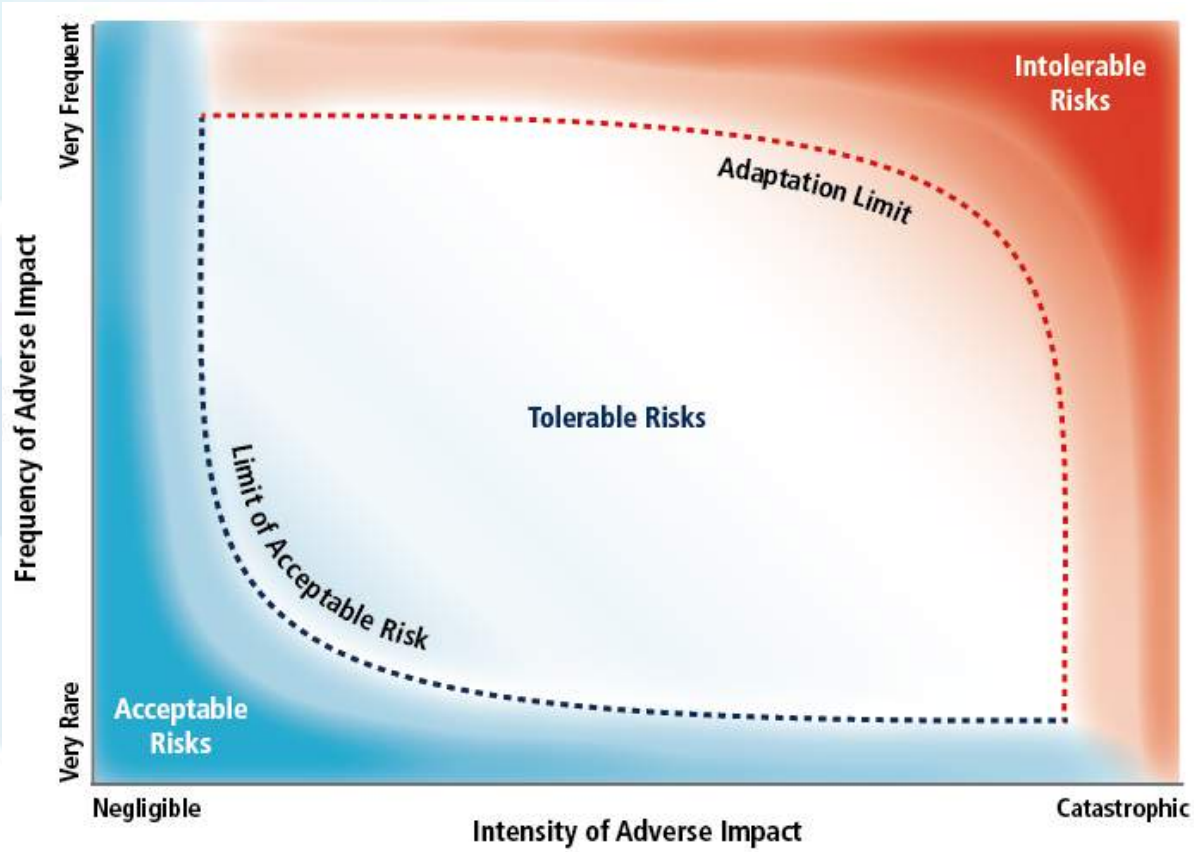


Source: Schinko et al., accepted

Suggestions/hypotheses

- Risk lense with increased relevance for responses to climate change
- Extremes as game changers
- Understanding risk tolerance key for adaptation and beyond adaptation
- Broad socio-economic methodological framework can support action on risk

Risk preference



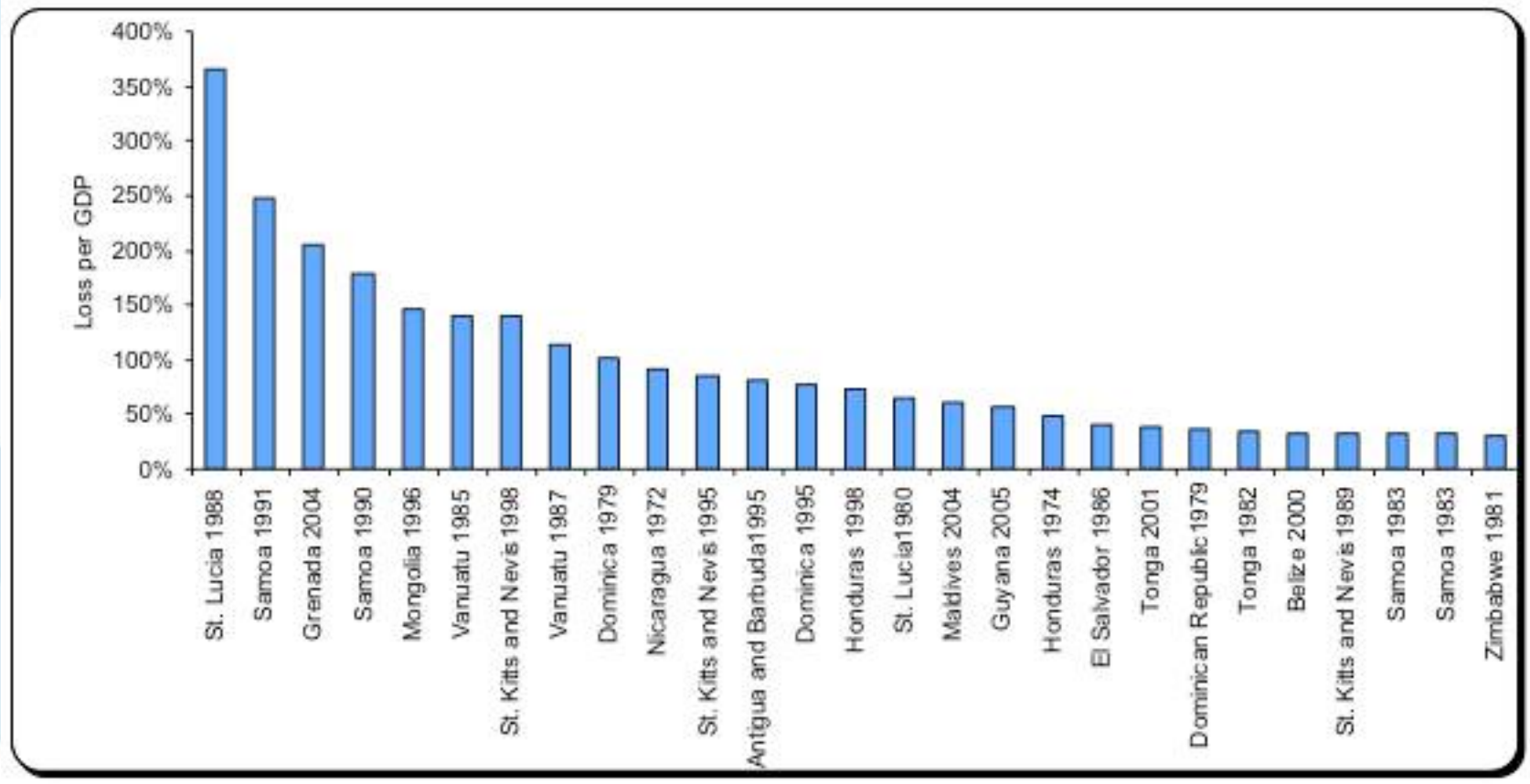
1. Dealing with climate variability: Refocusing disaster management

How to inform stronger investment in pre-disaster management?

- Leverage tight budgets
- More secure safety net
- Link to risk reduction

Linnerooth-Bayer et al 2005

Losses due to disasters, part. for climate variability, can be large



Mechler, 2009

Disaster risk in the government balance sheet

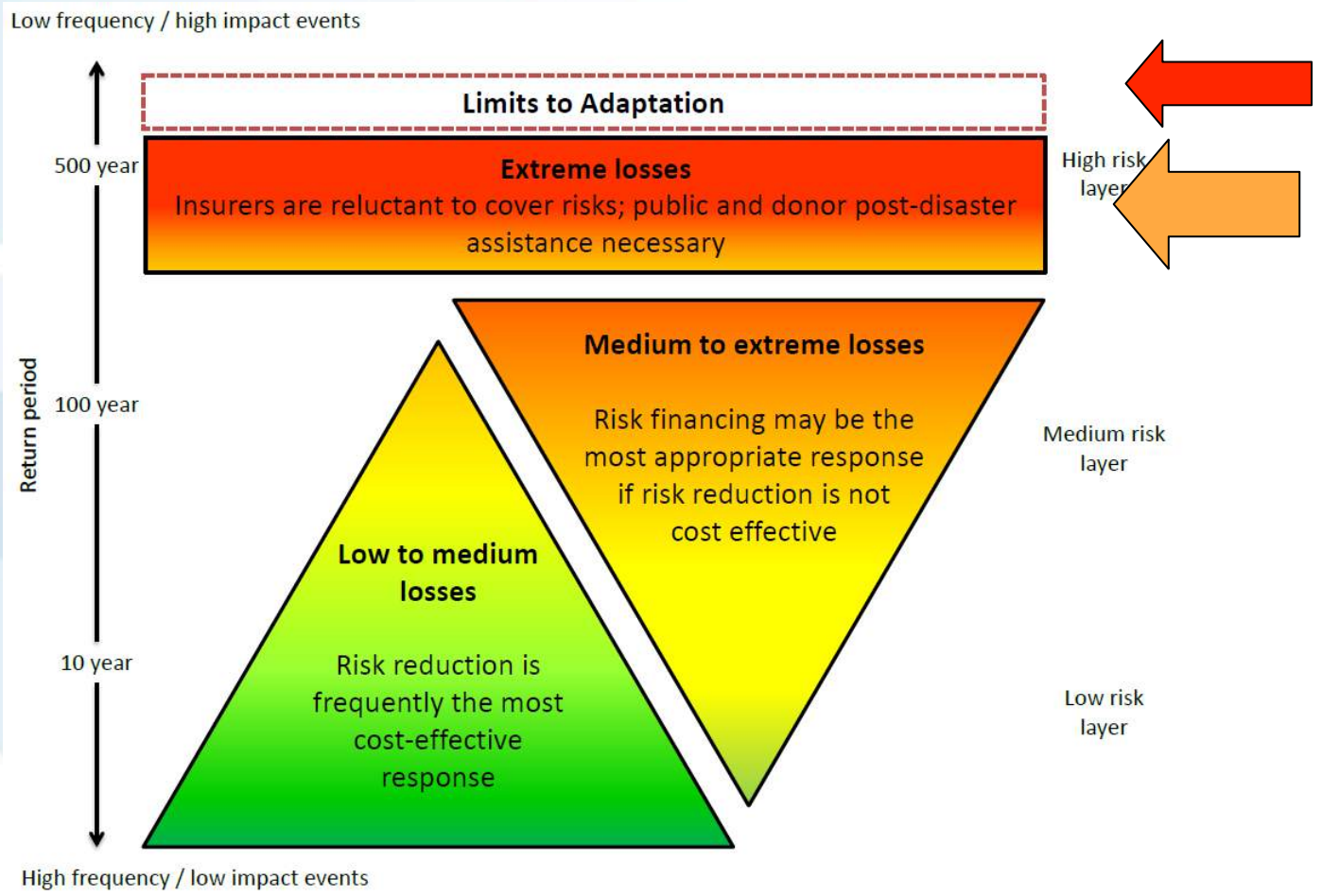
Disaster risk are unrecognised liabilities

Liabilities	**Direct:** obligation in any event	**Contingent:** obligation if a particular event occurs
Explicit Government liability recognized by law or contract	Foreign and domestic sovereign borrowing, Expenditures by budget law and budget expenditures	State guarantees for nonsovereign borrowing and public and private sector entities, **reconstruction of public infrastructure**
Implicit A "moral" obligation of the government	Future recurrent costs of public investment projects, pension and health care expenditure	Default of subnational government and public or private entities, **disaster relief**

Extreme event risk management options

Type	EX ANTE RISK MANAGEMENT				EX POST DISASTER MANAGEMENT	
	Risk assessment	**Prevention**	**Preparedness**	**Risk sharing and financing**	**Response**	**Reconstruction and rehabilitating**
Effect	Assessing risk	Reduces risk addressing underlying factors	Reduces risk in the onset of an event	Transfers risk (reduces variability and longer term consequences)	Responding to an event	Rebuilding and rehabilitating post event
Key options						
	Vulnerability assessment (population and assets exposed)	Land-use planning and building codes	Emergency response	Alternative risk transfer	Clean-up, temporary repairs and restoration of services	Revitalization for affected sectors (tourism, agriculture, exports etc.)
	Risk assessment as a function of hazard, exposure and vulnerability	**Economic incentives for proactive risk management**	Networks of emergency responders (local/national)	National and local reserve funds	Damage assessments	Macroeconomic and budget management (stabilization, protection of social expenditures)
	Mainstreaming risk into development planning	Education, training and awareness raising about risks and prevention	Shelter facilities and evacuation plans	Calamity Funds (national or local level)	Mobilization of recovery resources (public/ multilateral/ insurance)	Incorporation of disaster mitigation components in reconstruction activities

Risk coping
Layering risk management to identify entry points

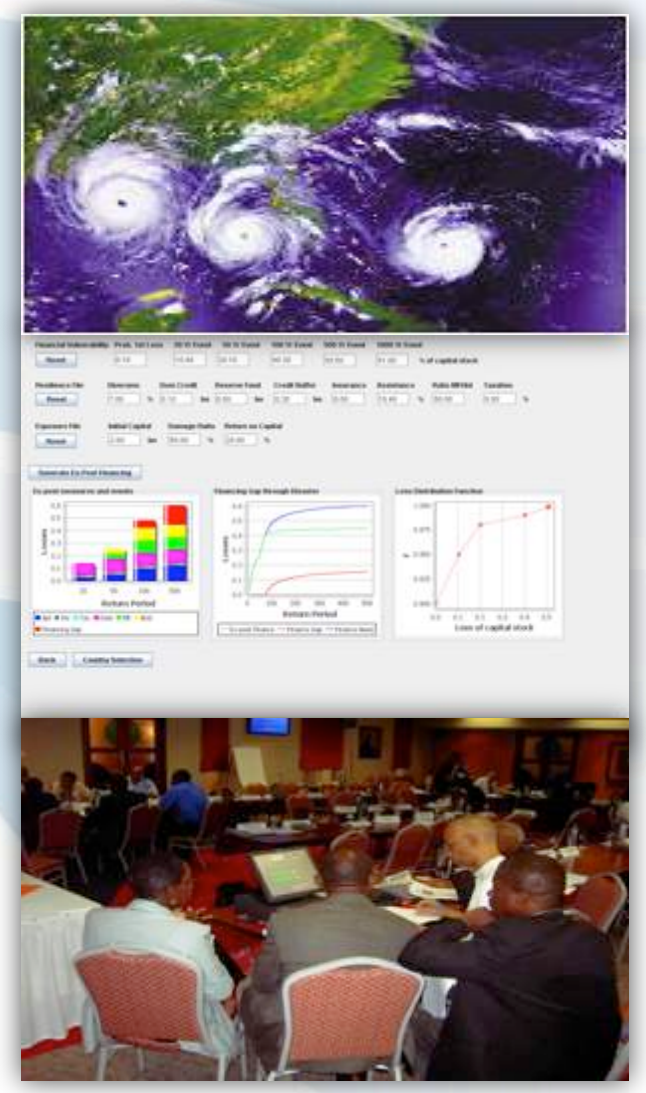


Risk beyond coping

Residual uninsurable risk

Mechler et al., 2014

CATSIM model



CATSIM informing risk management strategies of Caribbean countries, Barbados

IIASA has been a leader in the development of probabilistic models of risk management

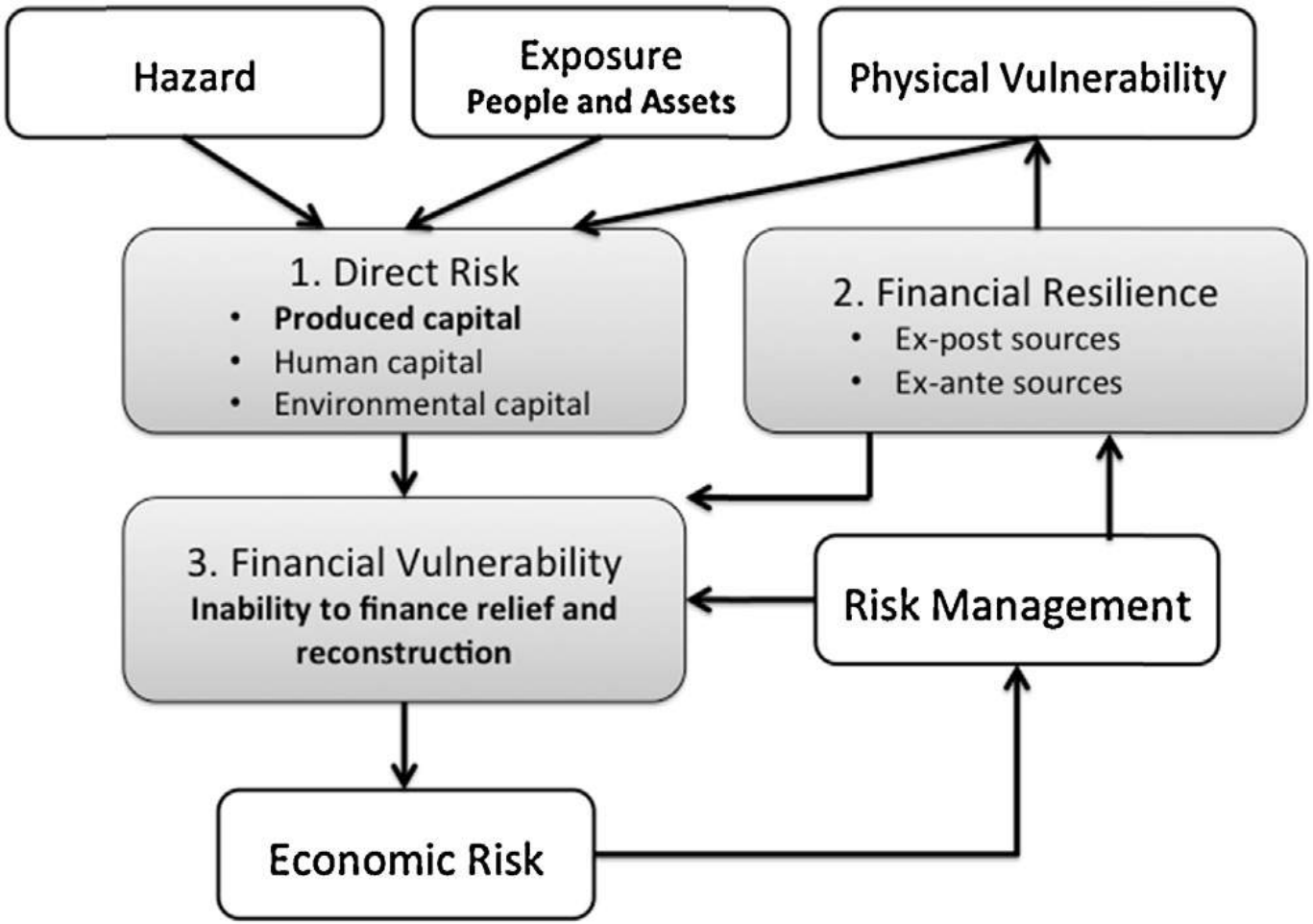
The IIASA CATSIM model assesses the economic and developmental risks of extreme events and supports risk management strategies

Bridges gaps between outcome driven risk modelling and policy-oriented methodologies respecting plural values

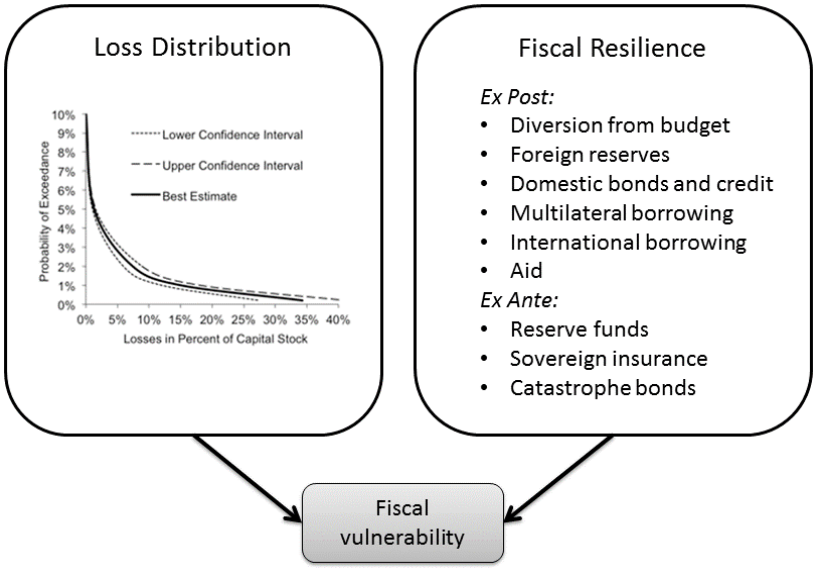
For Mexico, CATSIM provided a clear picture of the different layers of risks posed by earthquakes to the public finances and helped identify which risks could be transferred to the international market at an acceptable cost.

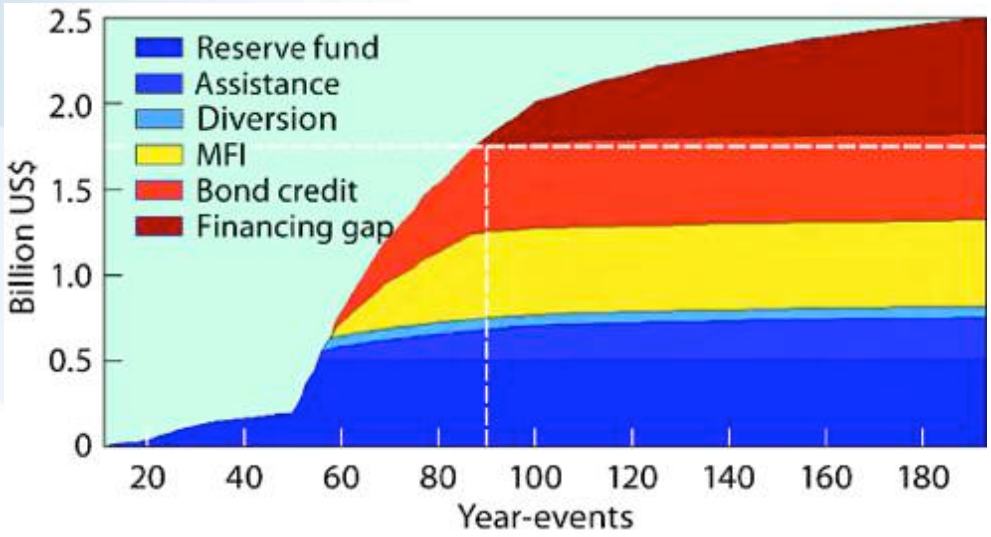
Victor Cardenas, Ministry of Finance, Mexico

CATSIM- Methodology

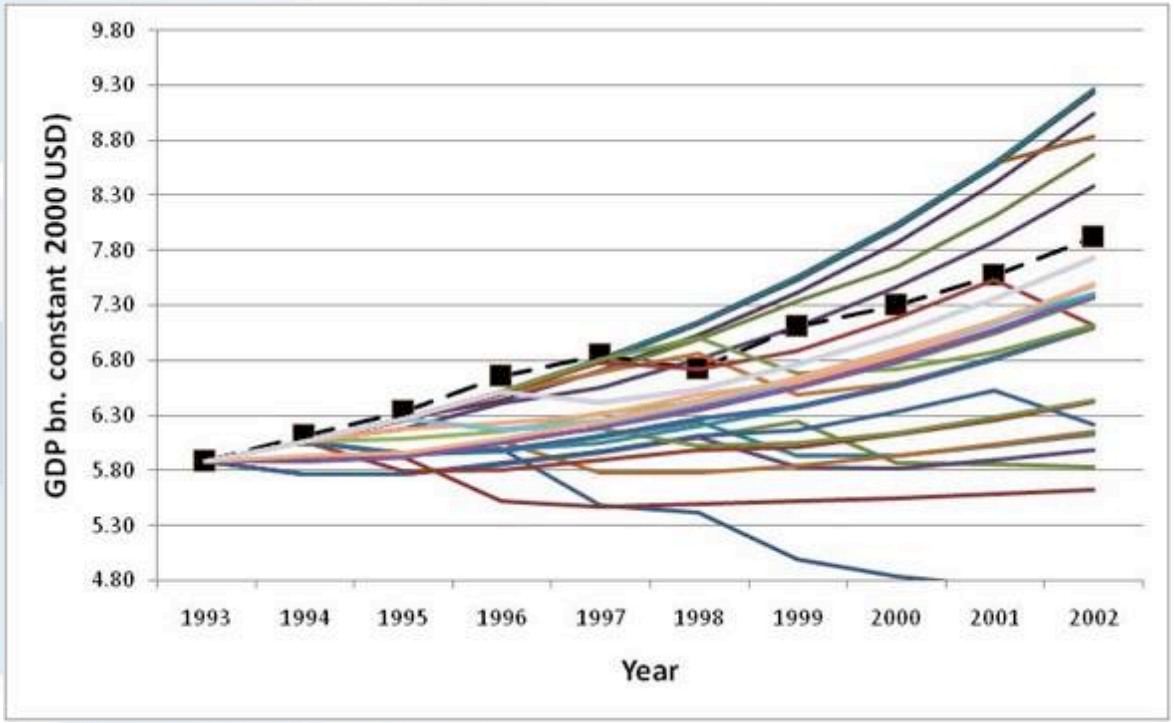


CATSIM: simulating and risk stress testing





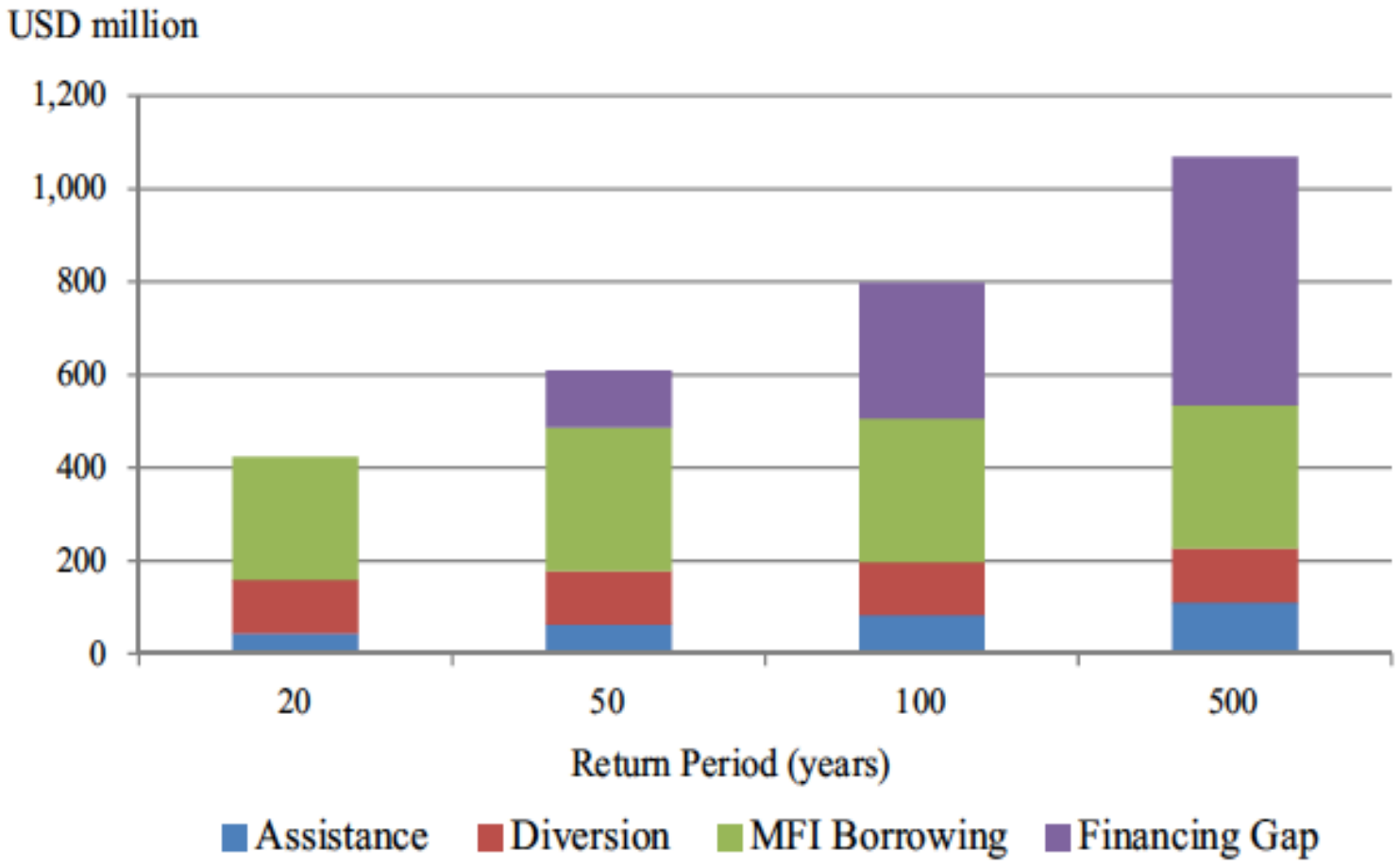
Simulation of GDP projections with and without risk GDP effects - Honduras



Hurricane Mitch
1998

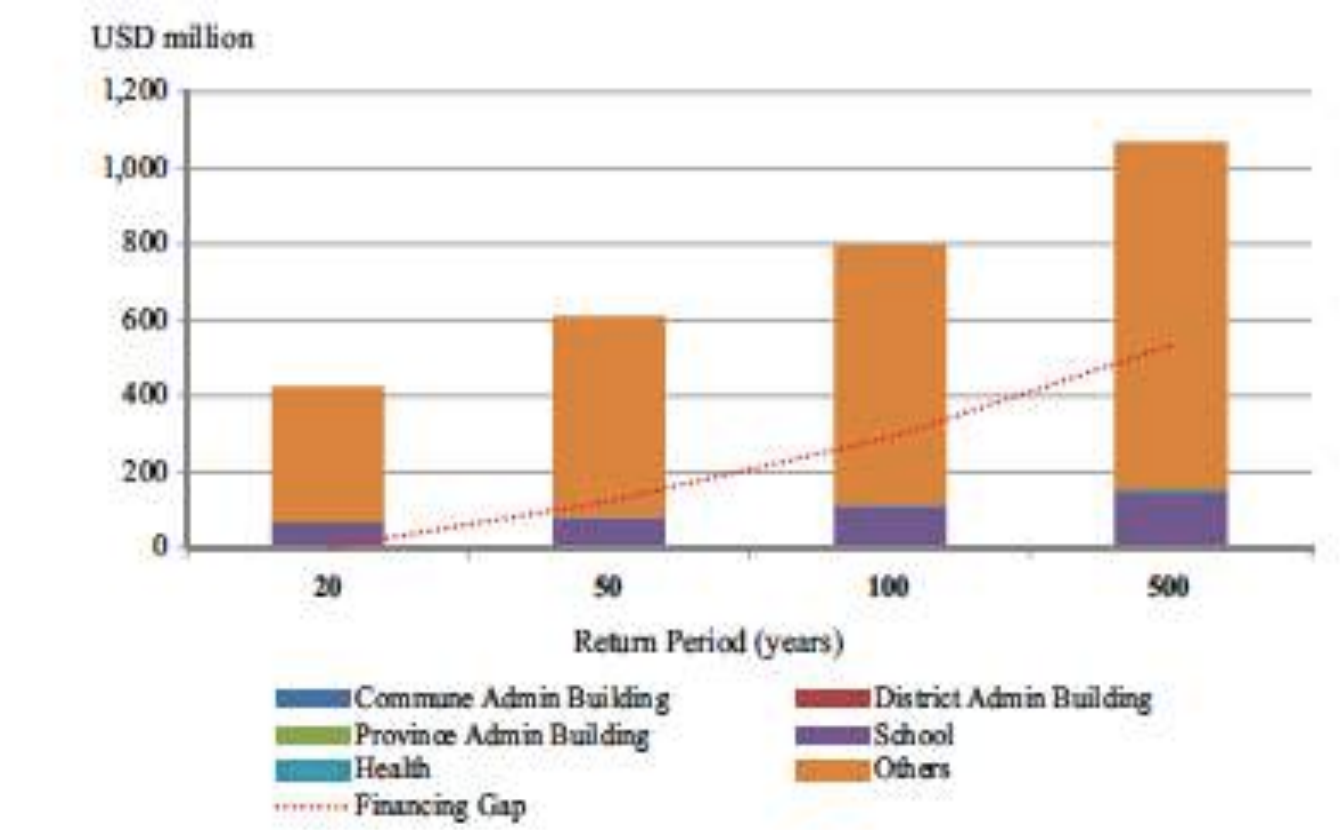
Timonina et al., 2013

Post-disaster funding USD million sources and resources gap - Cambodia



Dynamic fiscal model analysis shows that over the next 5 years, the likelihood that the Cambodian government will face a fiscal resource gap is estimated to be approximately 50 %.

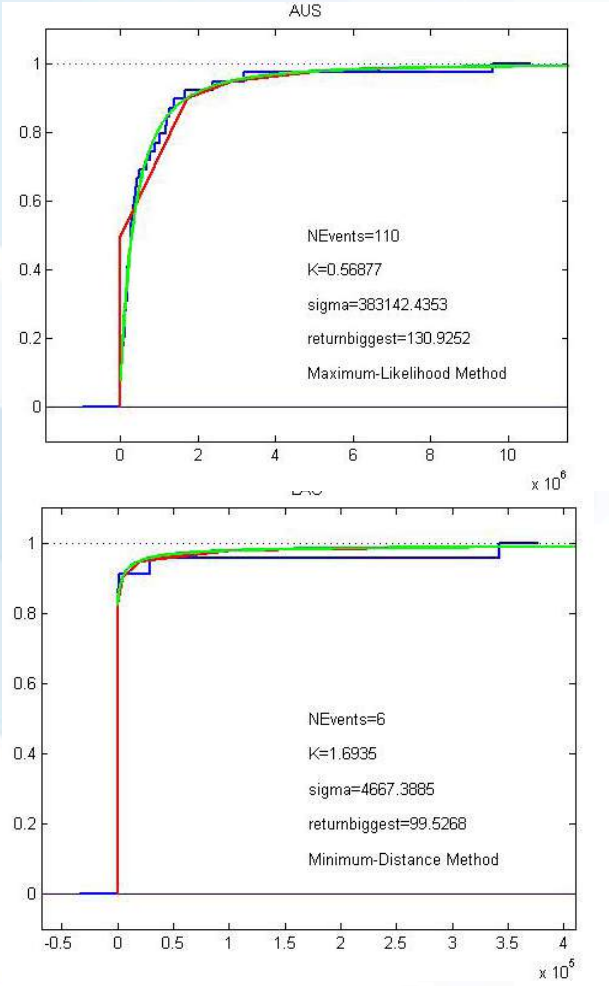
Break-down on post- USD million disaster recovery and reconstruction needs Cambodia



CATSIM has been interactively used by officials in over 20 countries

- Caribbean Catastrophe Insurance Facility (CCRIF)
- Disaster risk management pool for the Indian Ocean Council Islands

Country-level loss distributions for 172 countries



Data from Catastrophe Models

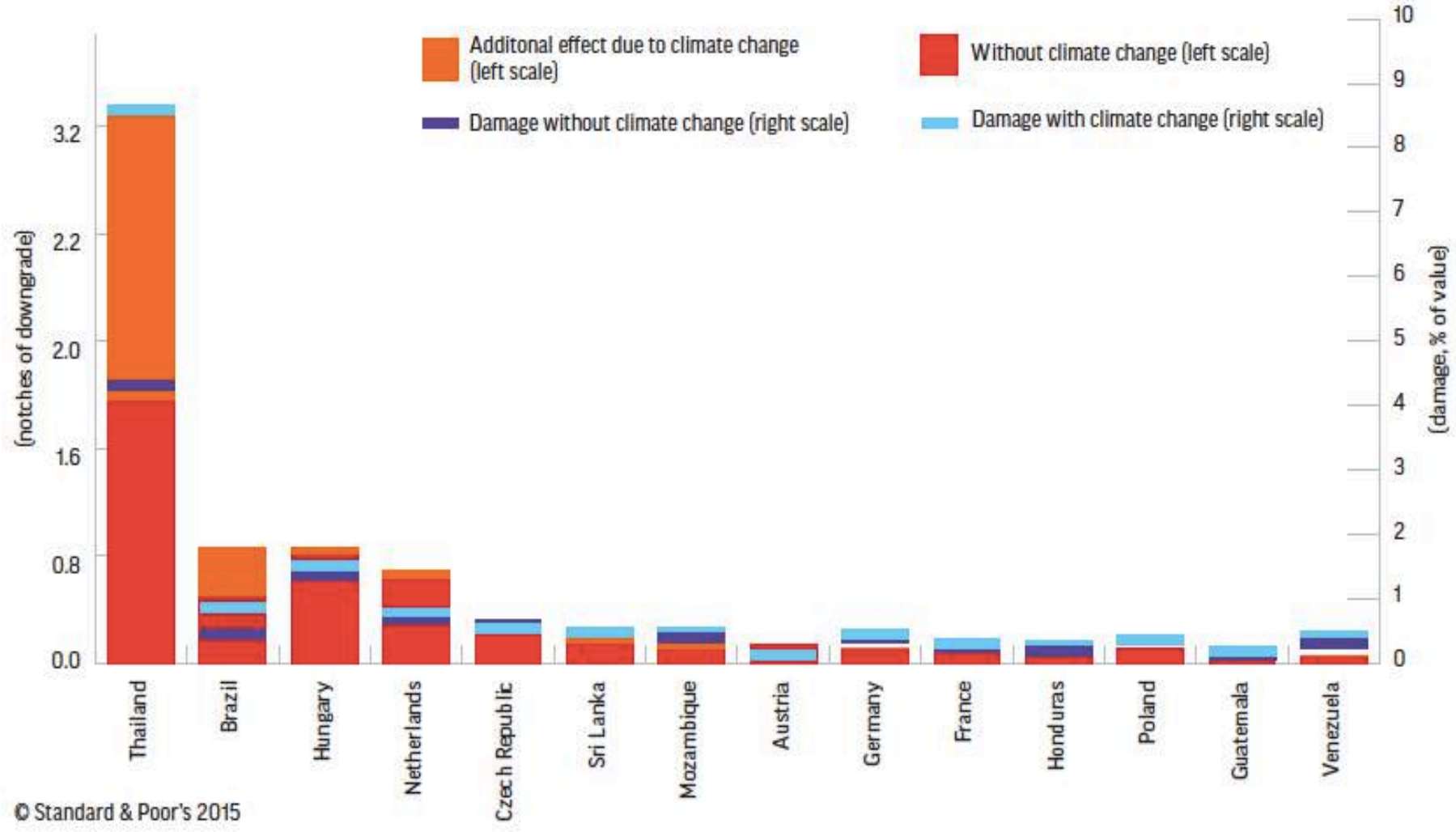
- UN GAR - Global Disaster Assessment Report
- IIASA inhouse models

Extreme Value Theory

- Statistical models
- Peak over threshold
- Block maxima
- Conditional value at risk

Risk layering and distributions

S&P rating
Rating Impact Of Floods (With And Without Climate Change)



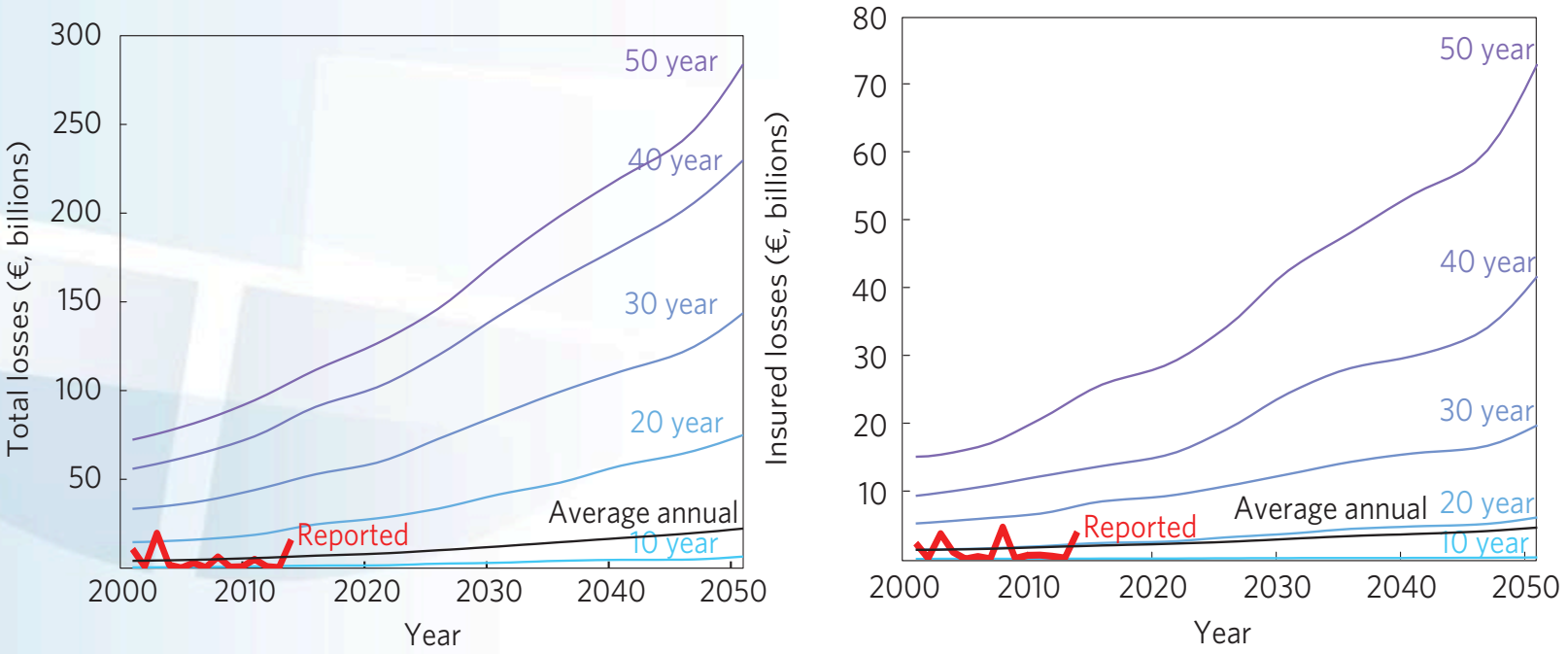
2. Managing climate extremes

IPCC 2012/14

Key messages

- A changing climate leads to changes in extreme weather and climate events
- There is evidence that anthropogenic climate change have changed these extremes
- Hazard attribution possible, risk attribution difficult

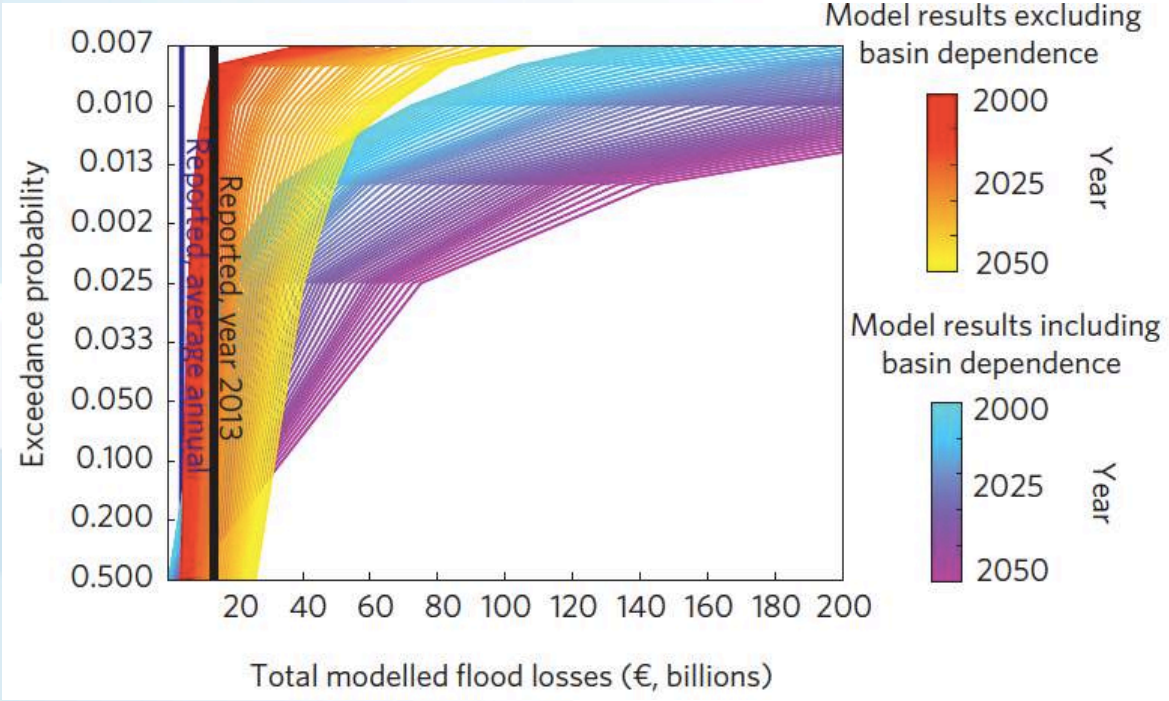
Total and insured losses



Climate scenario: SRES A1B scenario (high emissions)

Jongman et al.,2014

Methodological advances: Studying dependency



Jongman, et al, *Nature Climate Change*, 2014

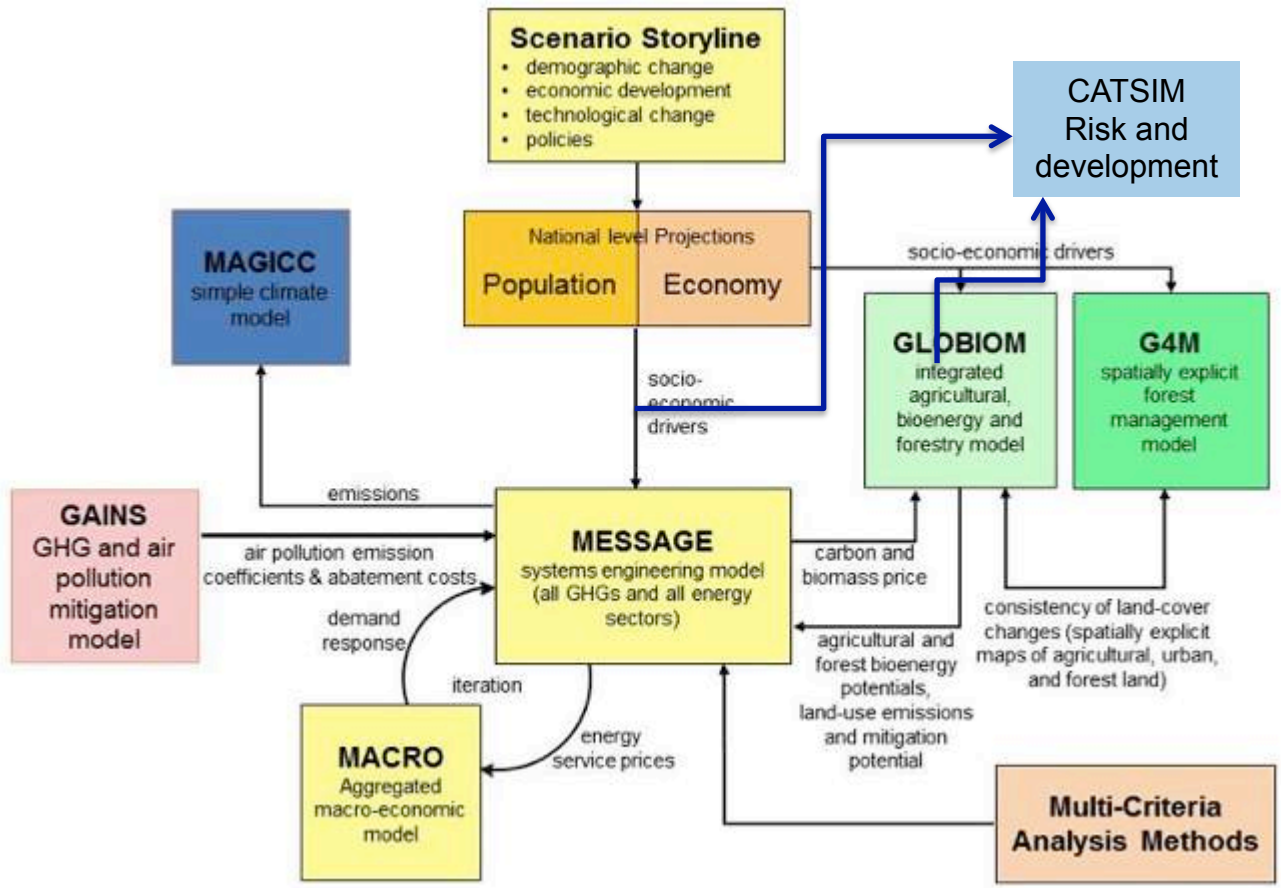
Dependency of flood risk on a pan-European scale

Managing climate risks: Risk allocation

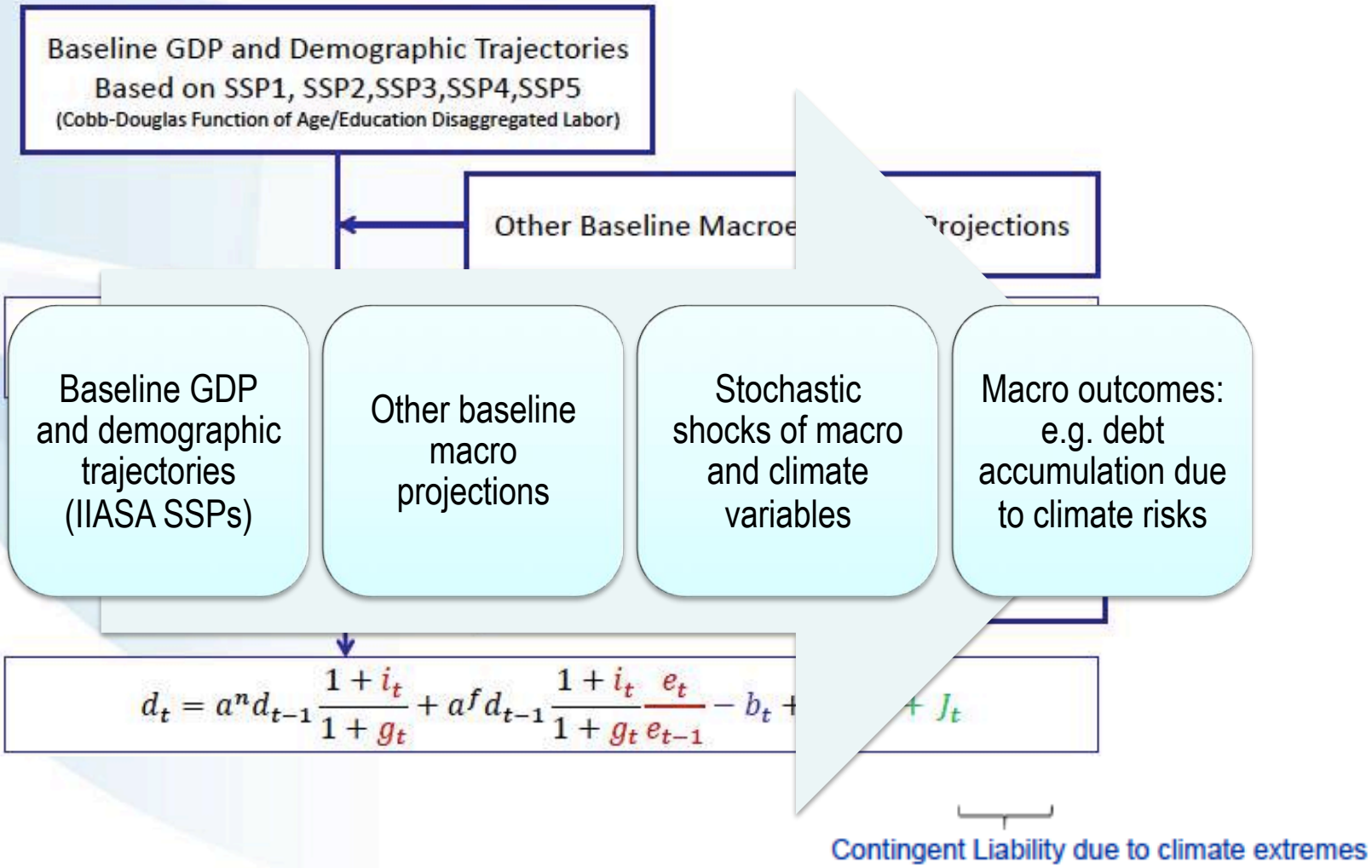
- Increasingly, roles and responsibilities of the public sector in flood risk management are receiving attention in research and policy

- How can the public sector reduce and manage risk efficiently while considering equity considerations?

Tackling multiple challenges
IIASA Integrated Assessment Framework

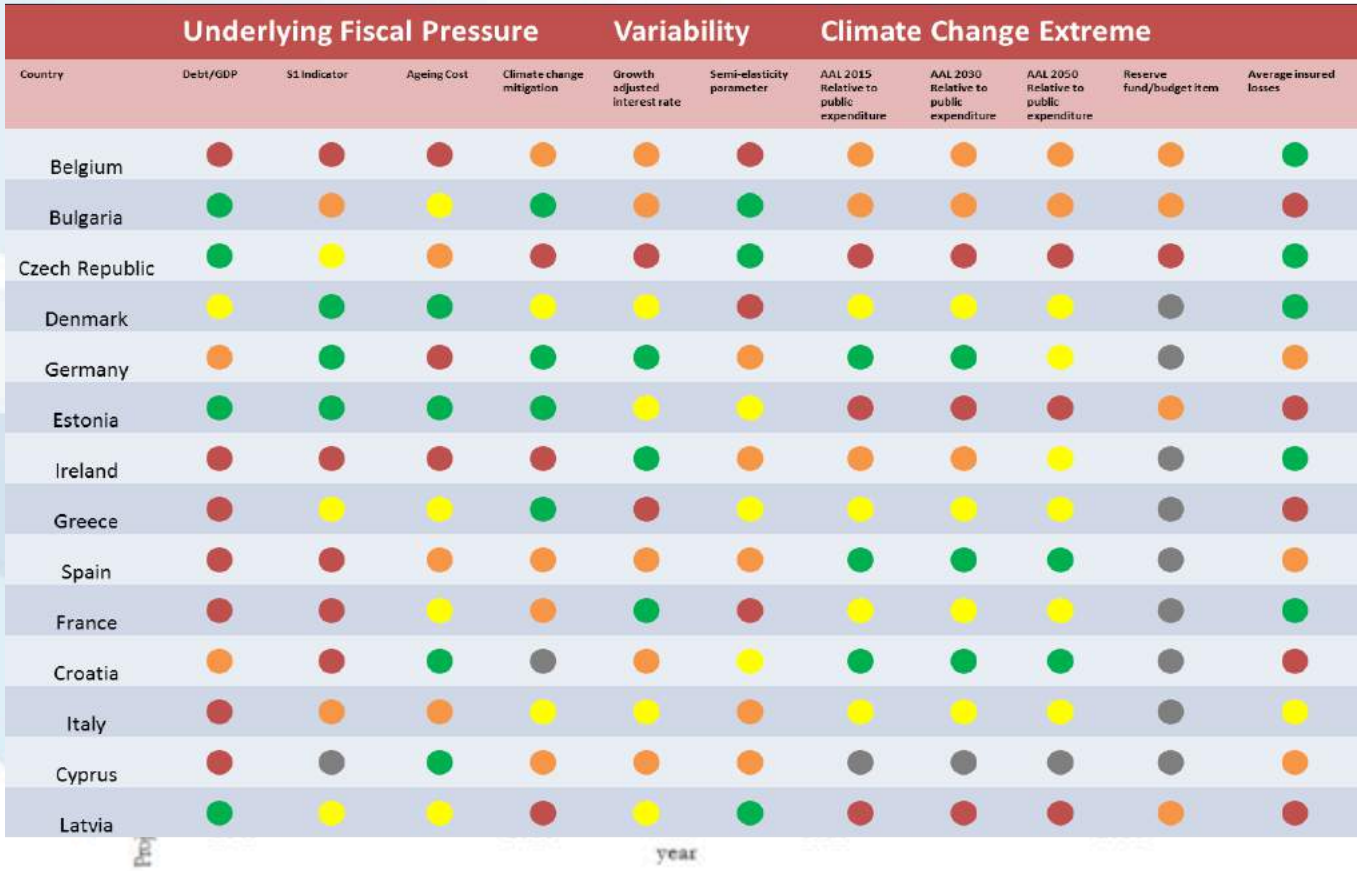


Linking risk to scenarios



Mochizuki, 2015

Fiscal Risk and Scorecard

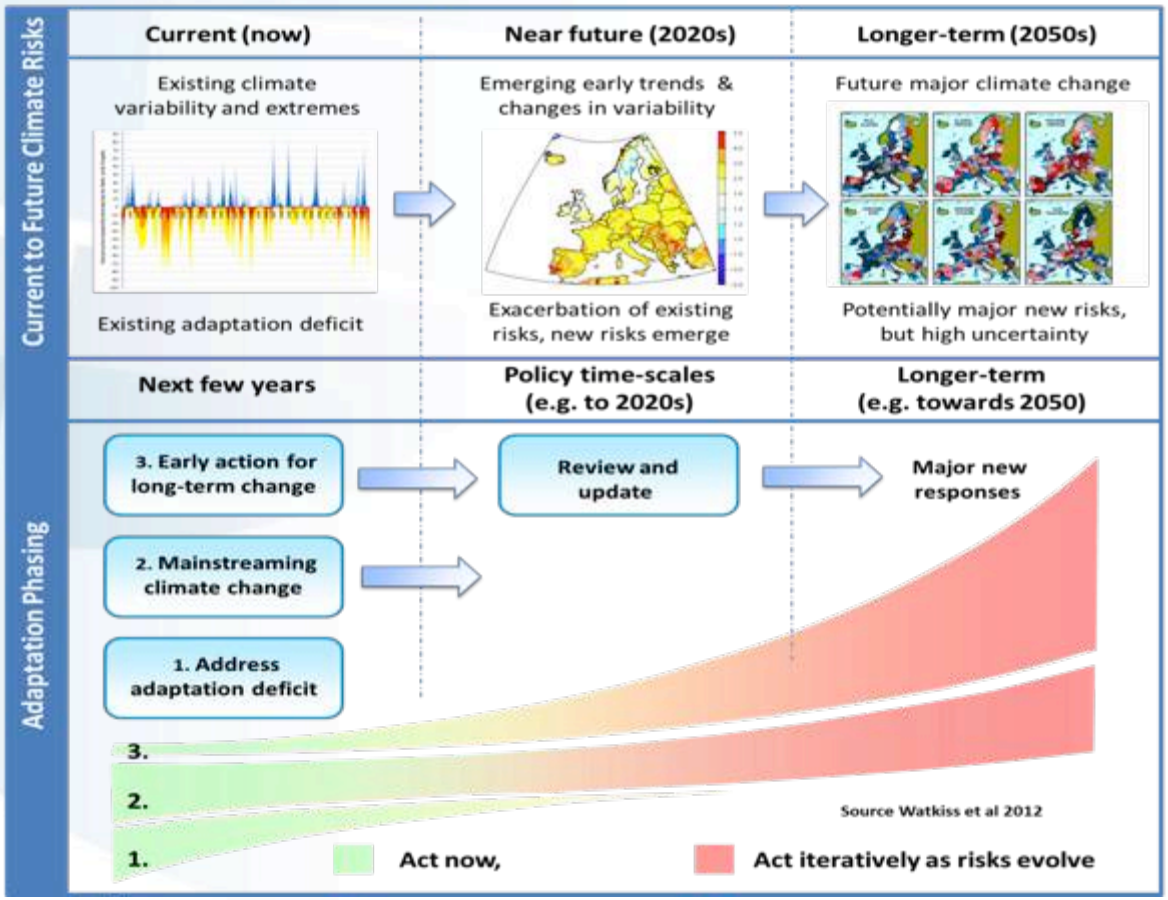


	Underlying Fiscal Pressure				Variability		Climate Change Extreme				
Country	Debt/GDP	S1 Indicator	Ageing Cost	Climate change mitigation	Growth adjusted interest rate	Semi-elasticity parameter	AAL 2015 Relative to public expenditure	AAL 2030 Relative to public expenditure	AAL 2050 Relative to public expenditure	Reserve fund/budget item	Average insured losses
Belgium											
Bulgaria											
Czech Republic											
Denmark											
Germany											
Estonia											
Ireland											
Greece											
Spain											
France											
Croatia											
Italy											
Cyprus											
Latvia											

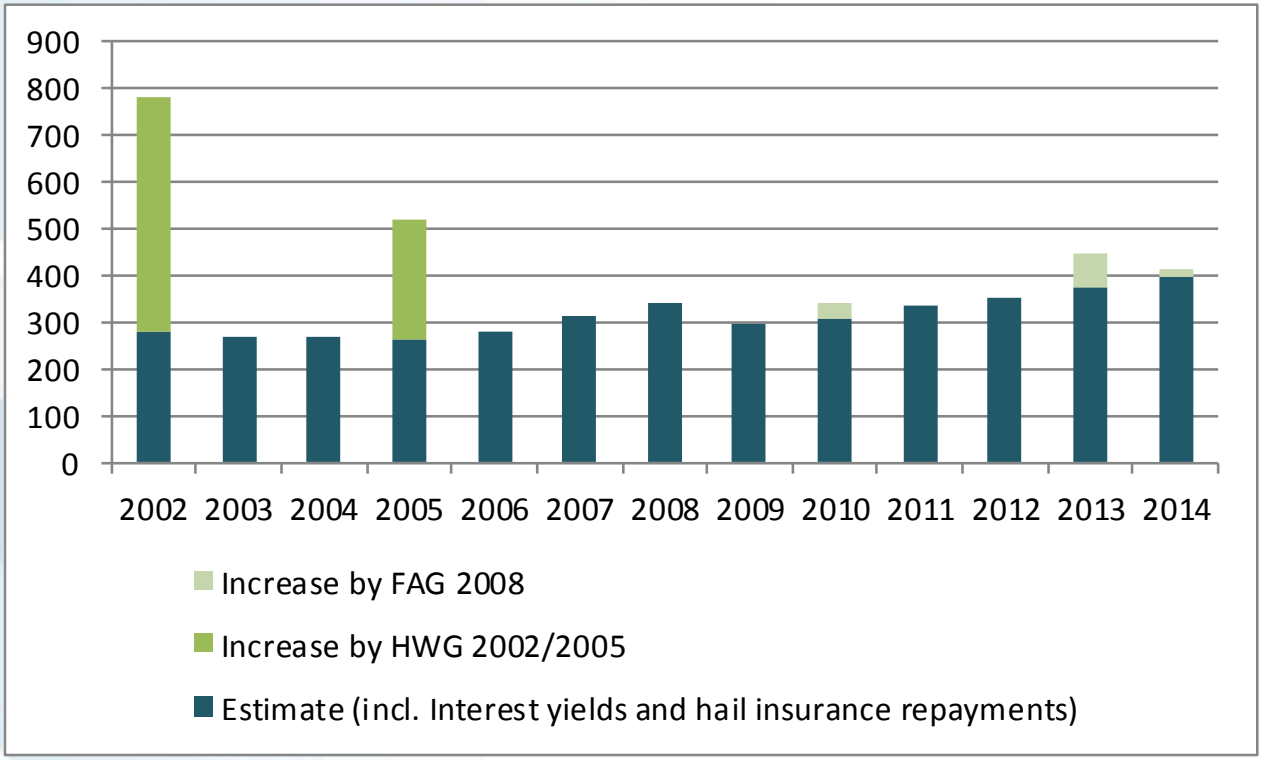
year

Mochizuki, 2016

Iterative risk management: when and how to act?

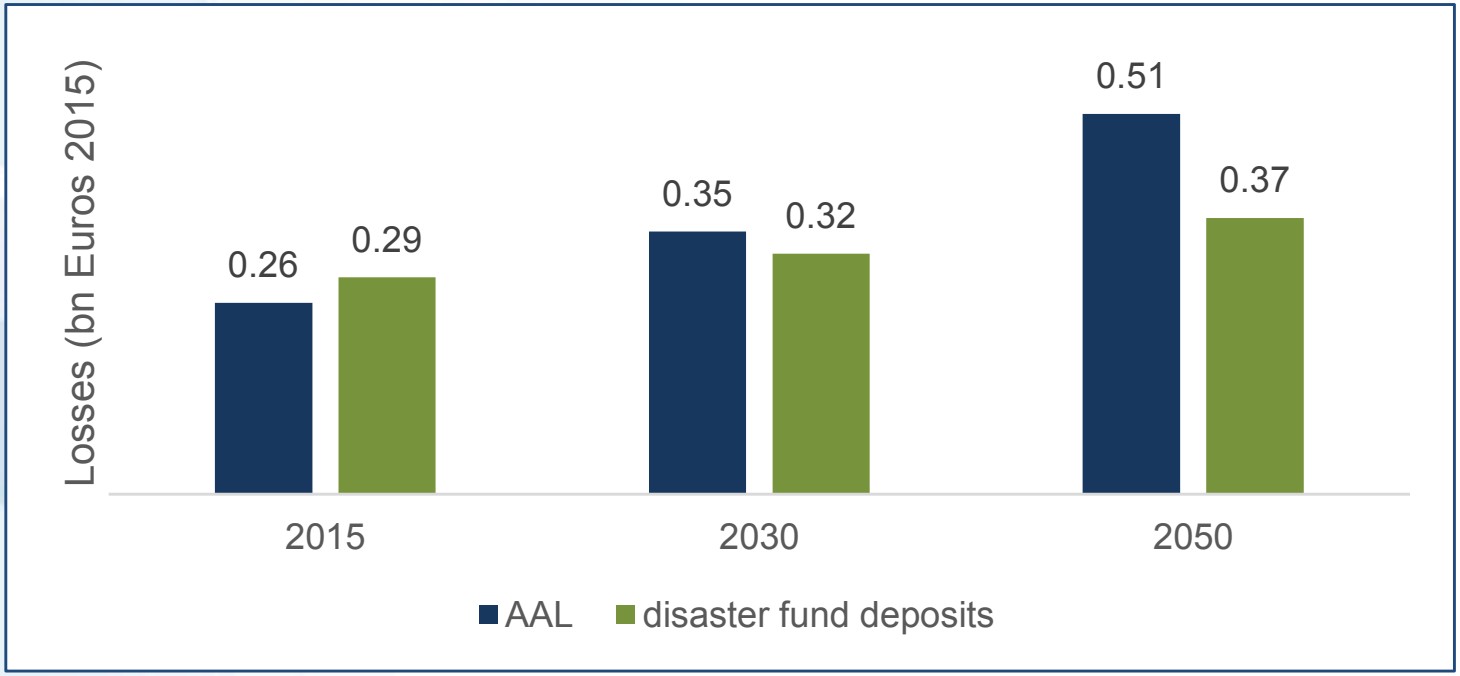


Budgetary implications of flooding



Schinko et al., 2016

Projection of flood risks and catastrophe fund reserves



Schinko et al., 2016

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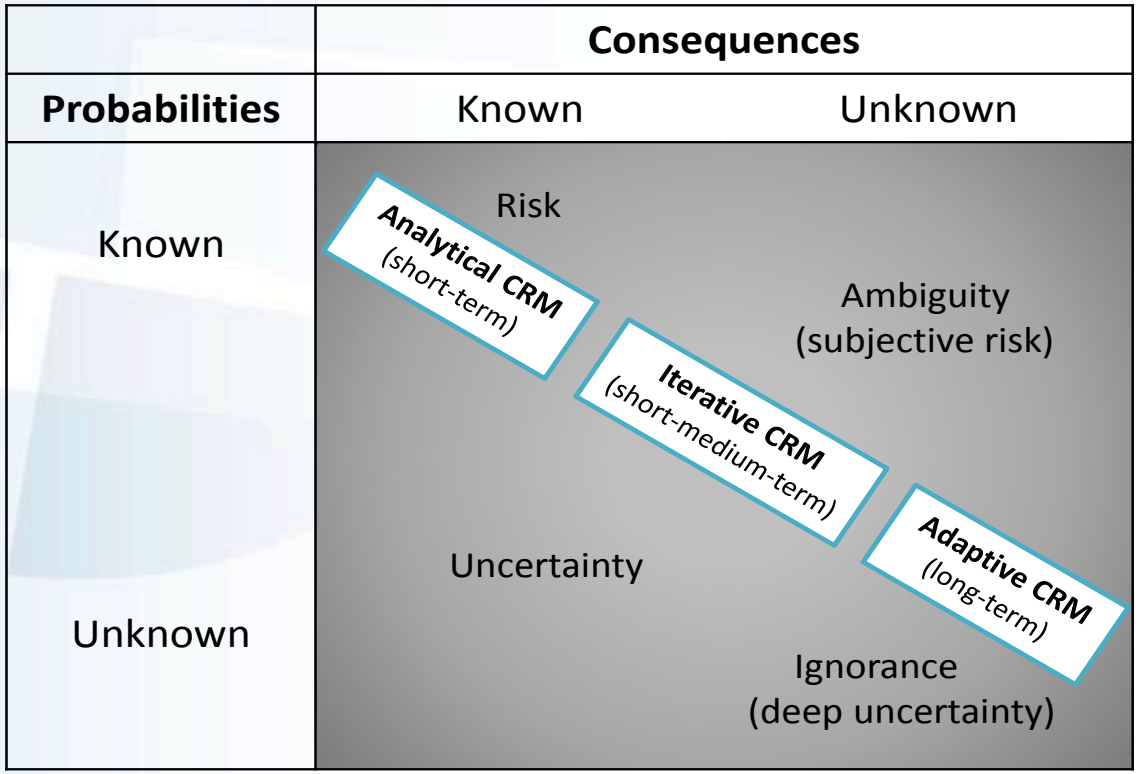
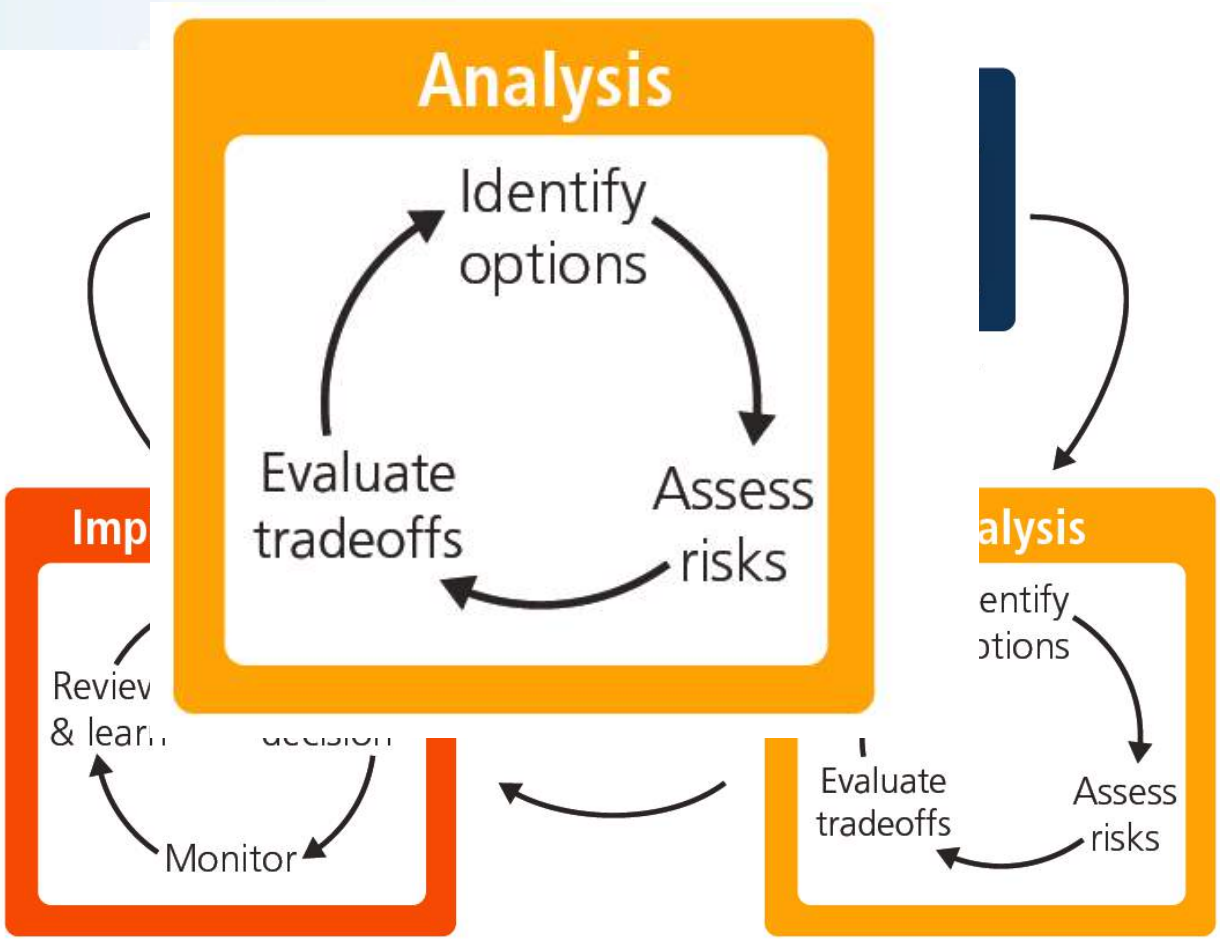


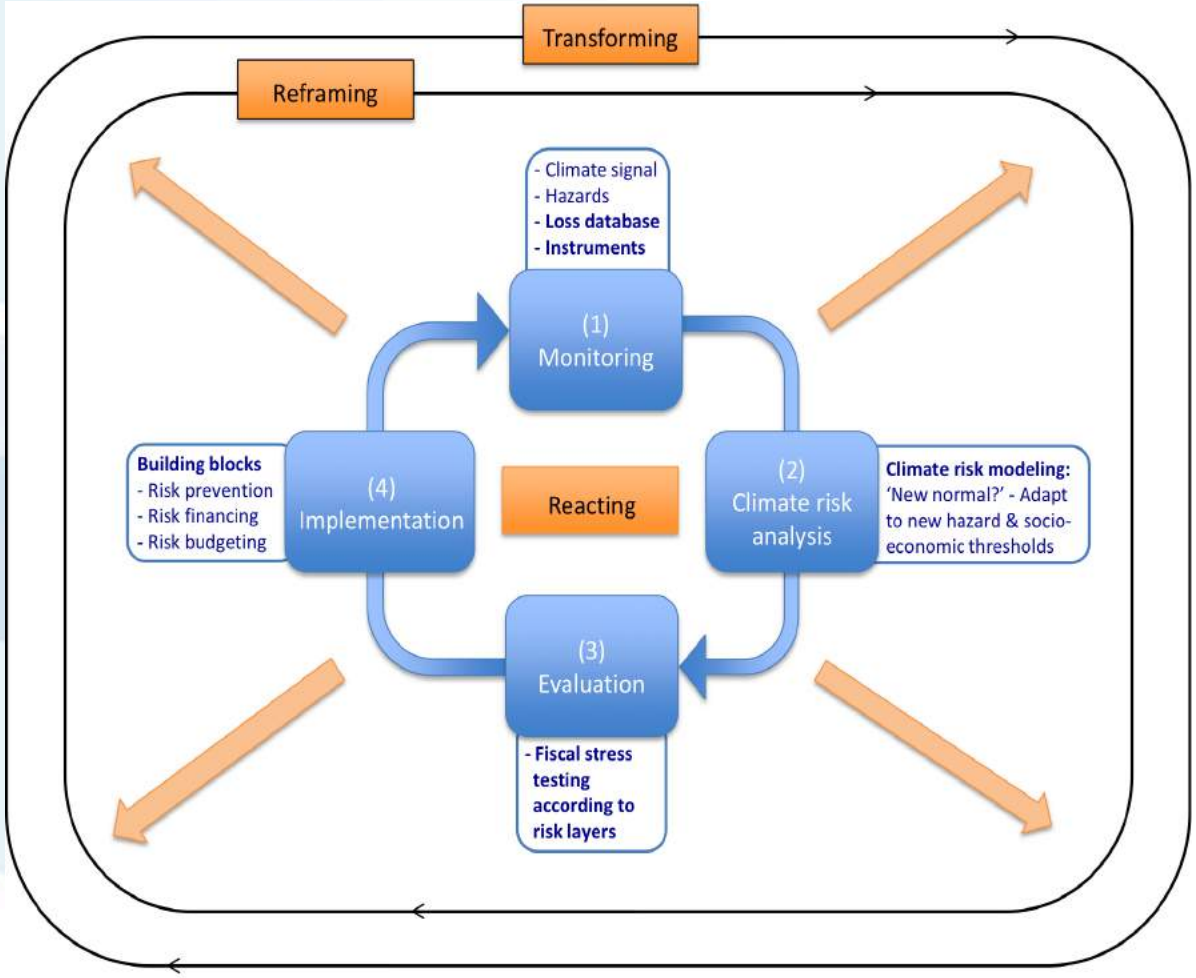
Source: Schunkjo et al., under review

Iterative climate risk management process: People and knowledge shaping the process and its outcomes



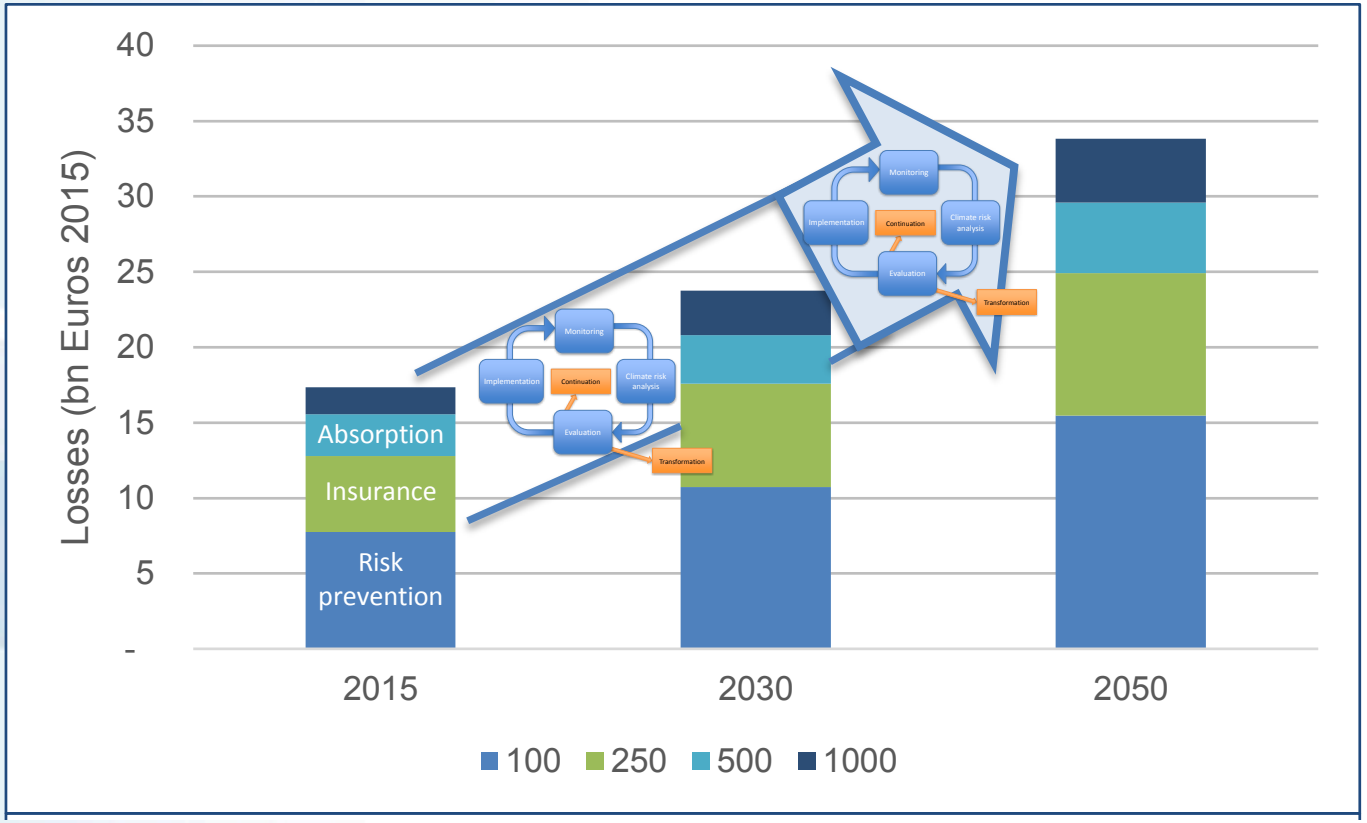
Jones et al., 2

Iterative Climate Risk Management



Schinko et al., 2016

Iterative Climate Risk Management



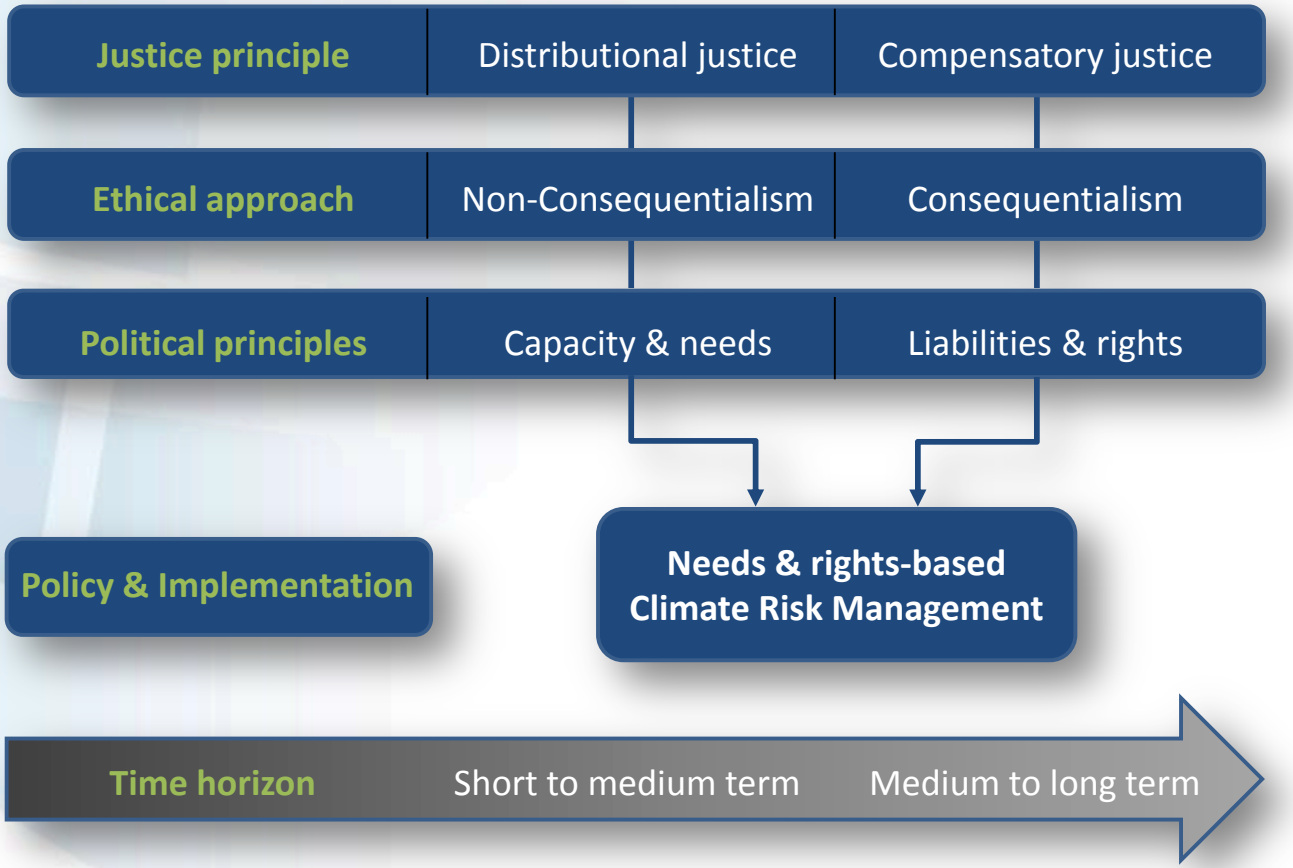
Schinko et al., 2016

3. Dealing with risks “beyond adaptation”

- 2013 Establishment of the “Warsaw international mechanism for loss and damage:”
  to deal with and provide support for **climat related damages after adaptation**

- **Contested terrain**
  - ‘Southern countries’ at risk (such as AOSIS countries) demand climate justi
  - OECD negotiators willing to support go risk management, but liability and compensation considered red lines

Positioning Loss & Damage in the climate justice debate

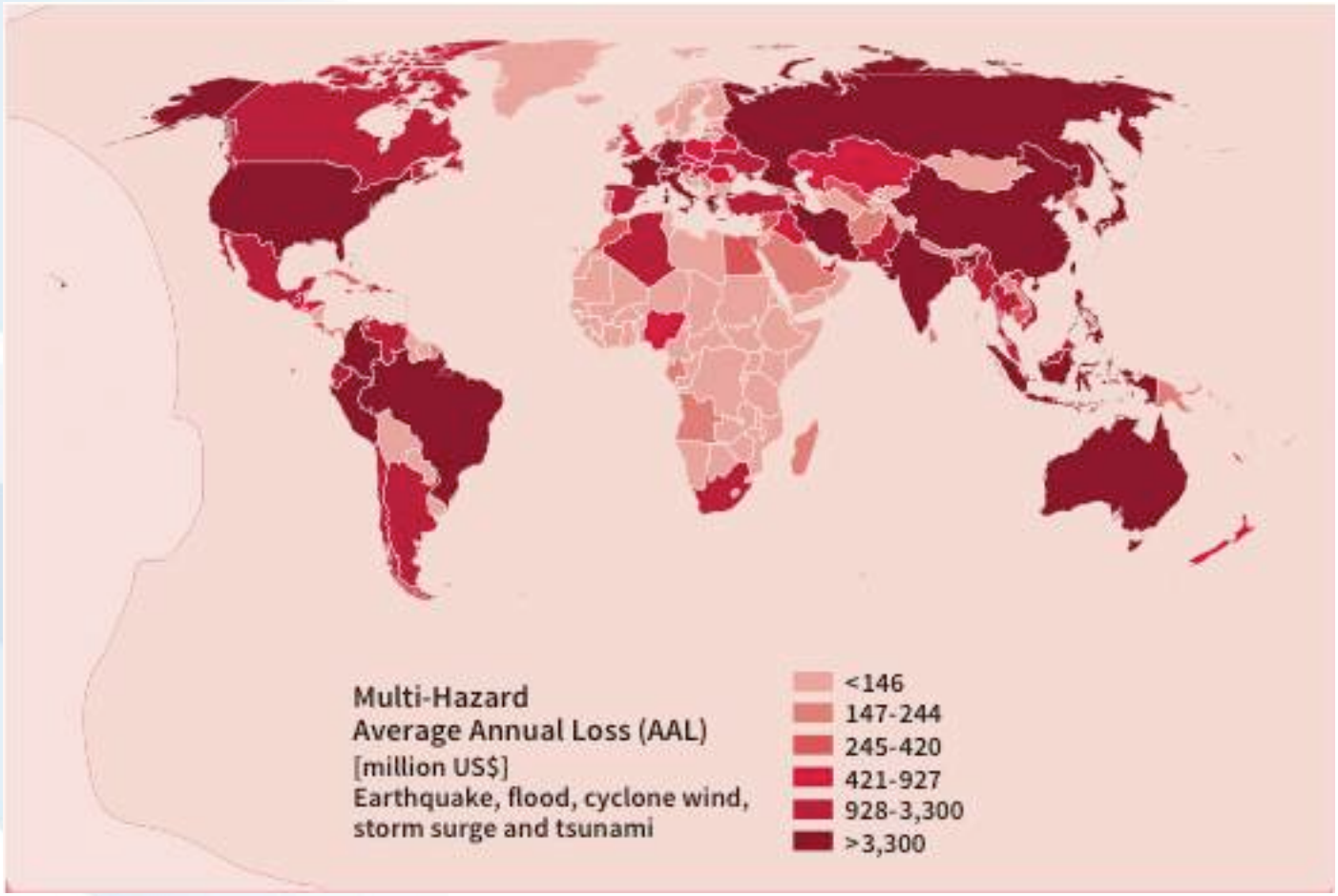


Methodological elements – needs based perspective

- Identify country-level risk
- Identify country level adaptive capacity: stress-testing
- Risk layering principle:
  - risk reduction for more frequent risks
  - Risk financing and assistance for infrequent risks
- Support from national to local

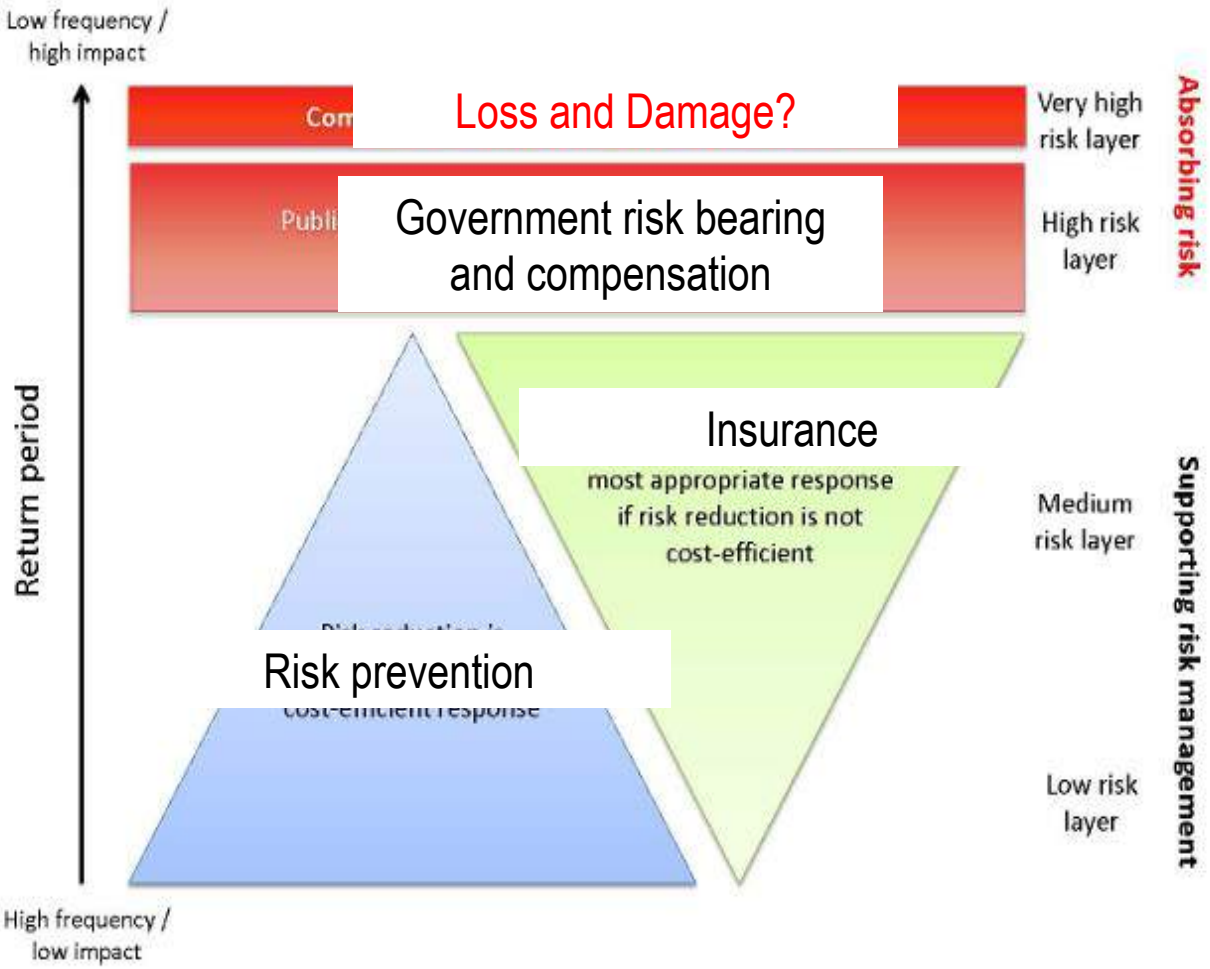
Distributional justice needs based perspective

GAR
Global Assessment Report on Disaster Risk Reduction
2015



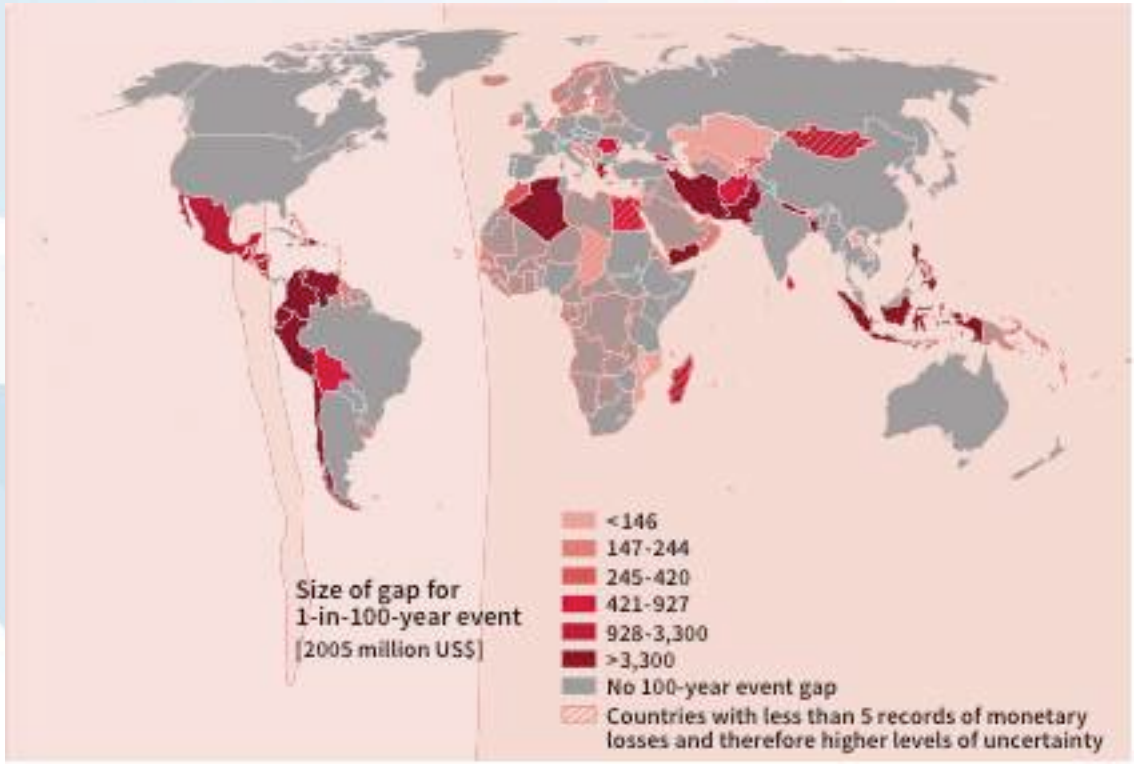
Global disaster risk today

Portfolios: Layering risk management



Mechler et al., *Nature Climate Change* 2014

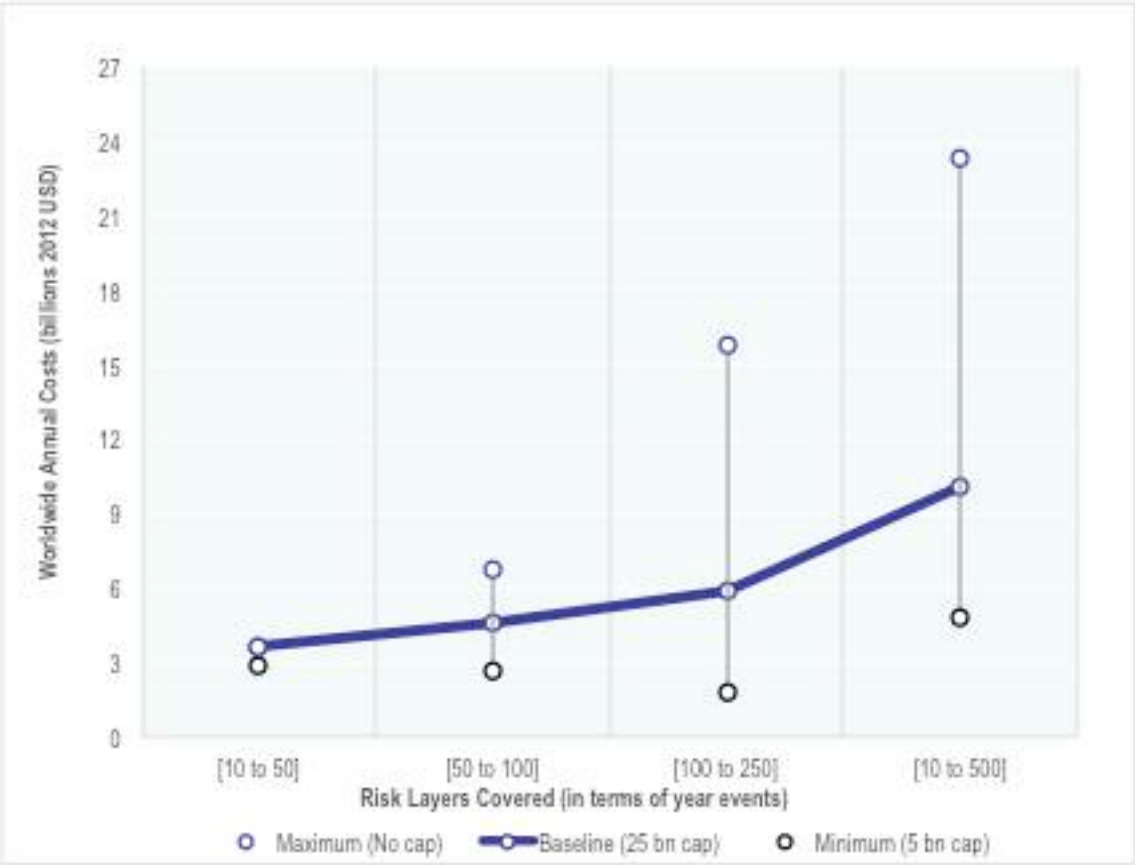
Distributional justice Capacity & Needs



- Compensating all countries for loss and damage beyond their coping capacity
- ~ USD 10 billion annually
- Increasing over time
- Signal for mitigation challenge

IIASA for GAR, 2015
Hochrainer-Stigler et al., *Global Environmental Change*, 2014

Global costs to cover gaps



For example:
50-100 year layer:
$ 4.5 billion [2.7-6.7] /a
ecessary for absorbing
risk beyond adaptive
capacity

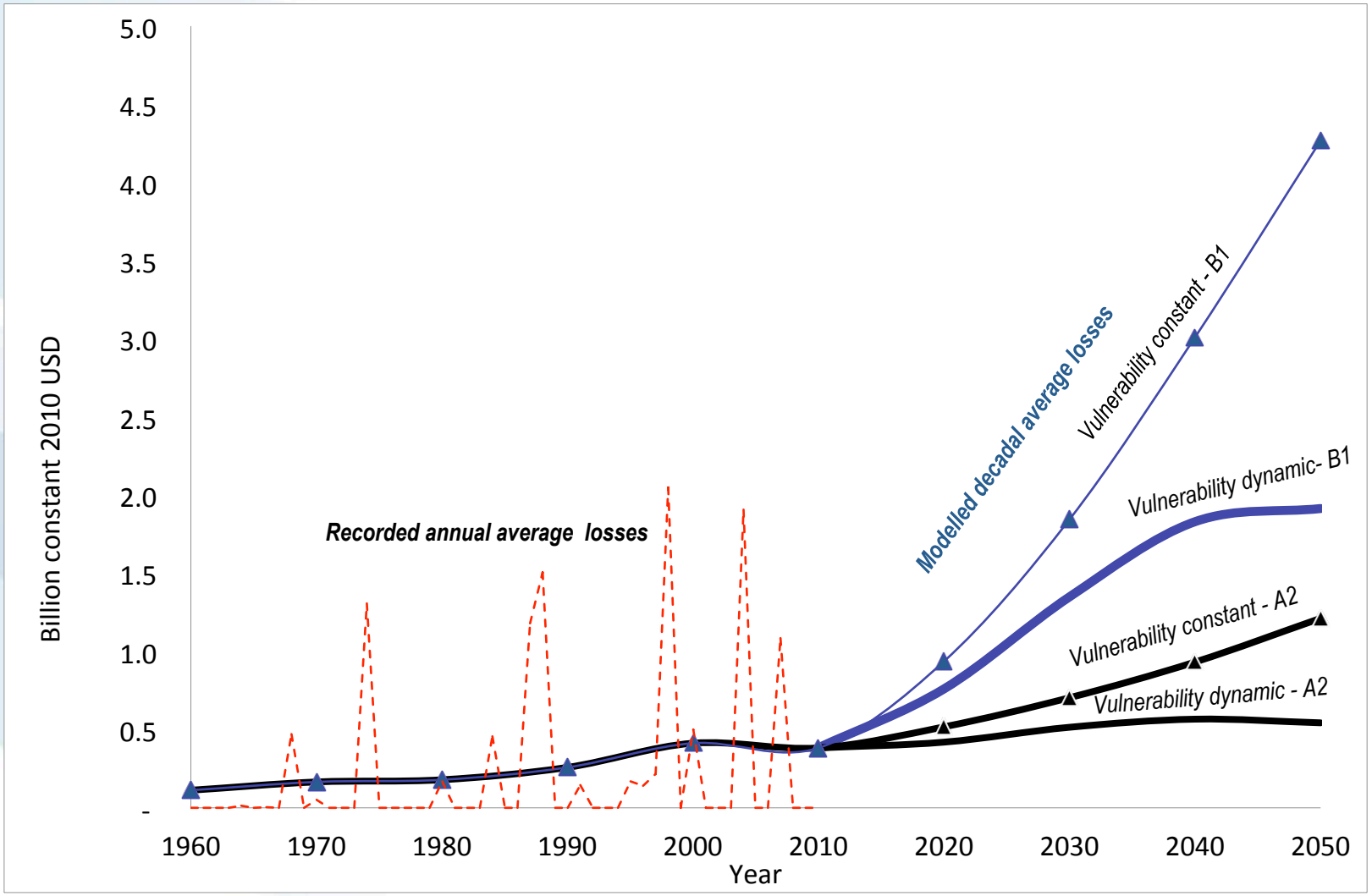
Option space?

- Regional and national: Risk pooling and financing- Sovereign insurance and regional pools:
  → Caribbean, Pacific, Africa

- National to community level: Public-private partnerships for risk reduction

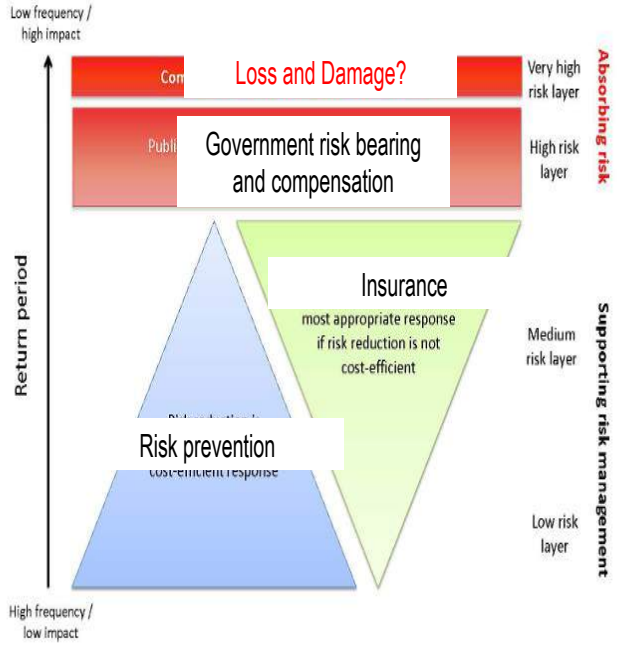
- National funds to bolster community-level risk management partnerships (Peru)

Projecting risks: Bangladesh

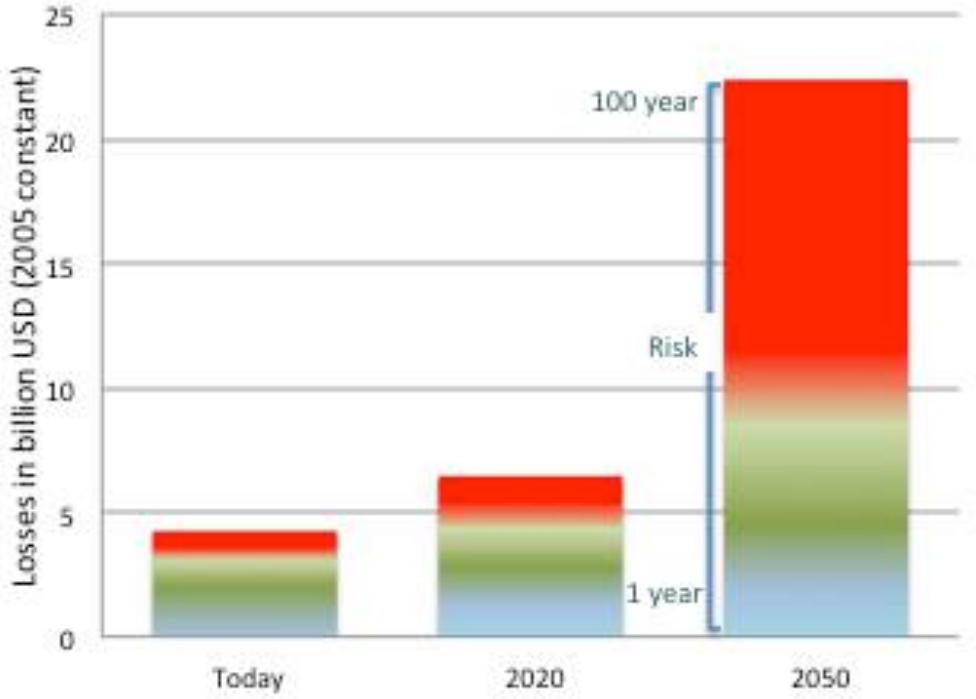


Mechler and Bouwer, *Climatic Change*, 2015
Hochrainer et al., 2013

Climate risk layering
Example Bangladesh



Layering risk management



Risk layers with climate change (B1 scenario and no additional risk reduction)

Based on Mechler and Bouwer, *Climatic Change* 2015

Bangladesh- modelling risks from riverine flooding

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

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

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

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

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

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

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

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

$$V(F_t) = v_0 * F_t * Vi_t$$
$$Vi(t) = 5E + 25 * e^{(-0.0308*t)} \quad (3)$$

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

Final remarks

- As climate change has become real, real action required
- Risk perspective useful to inform decisions on
  - short-medium term adaptation,
  - iterative risk management
  - long term transformation,
  - Mitigation
- Efficiency and responsibility as two linked dimensions (e.g., see Loss and Damage)

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