International Institute for Applied Systems Analysis
IIASA www.iiasa.ac.at

science for global insight

Science-policy insight for climate change and disaster risk management discourses

Reinhard Mechler

IIASA
Institute of Advanced Studies in Climate Extremes and Risk Management
Nanjing, China
October 24, 2019

Overview

1. Risk management and risk policy
2. Risk Policy Challenges
   - Challenge 1: How to further motivate investment into risk management?
   - Challenge 2: How to support acting on climate risks now, adapting over time and learning?Conclusio
   - Challenge 3: How to deal with (locally) dangerous climate change-related risks beyond adaptation?
3. Final remarks

Recap

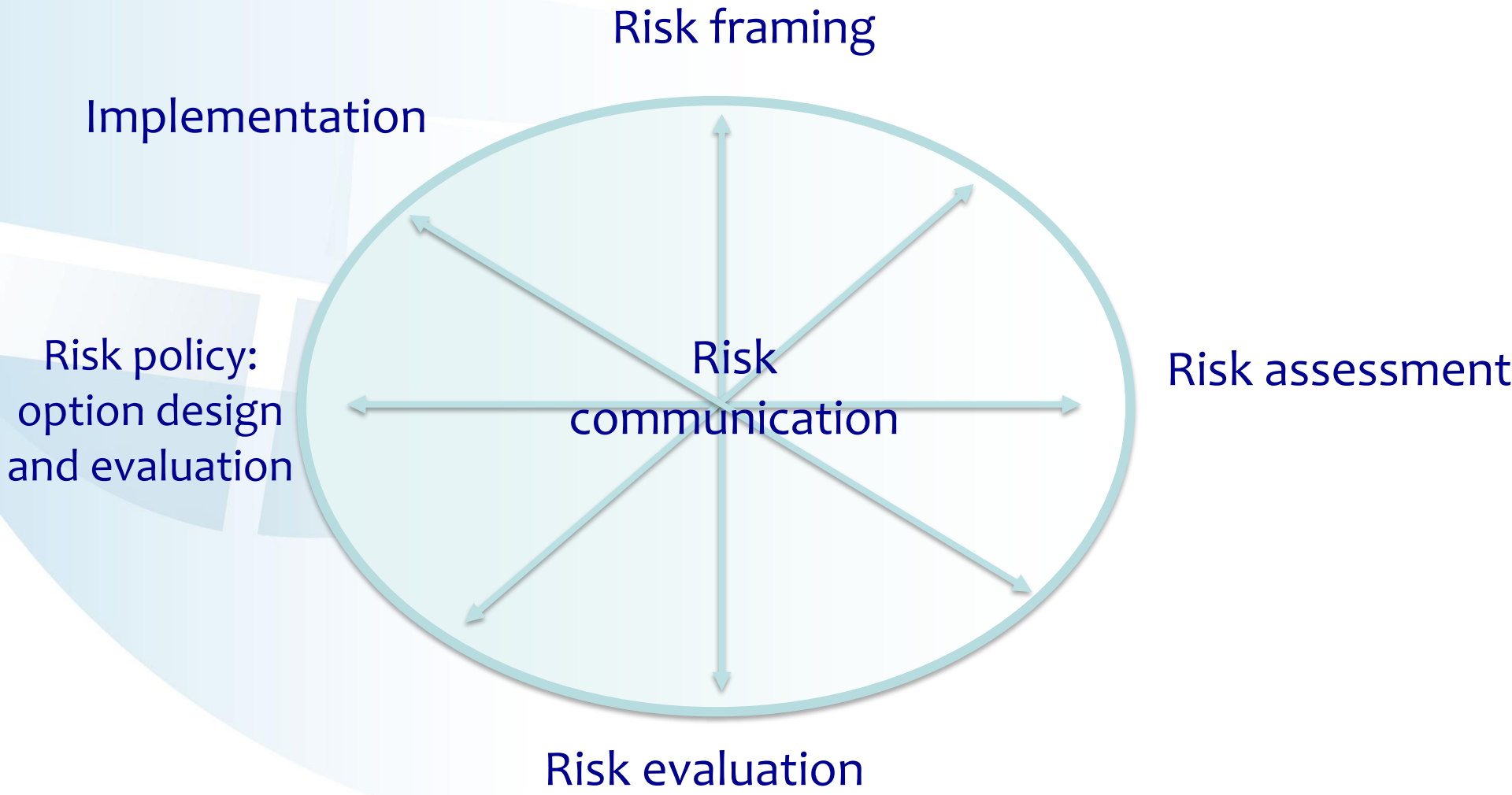
- As climate change has become real, real action required

- 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*

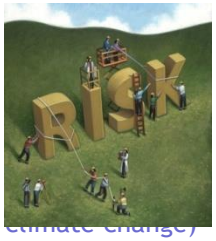
Risk management and risk policy

Risk management cycle

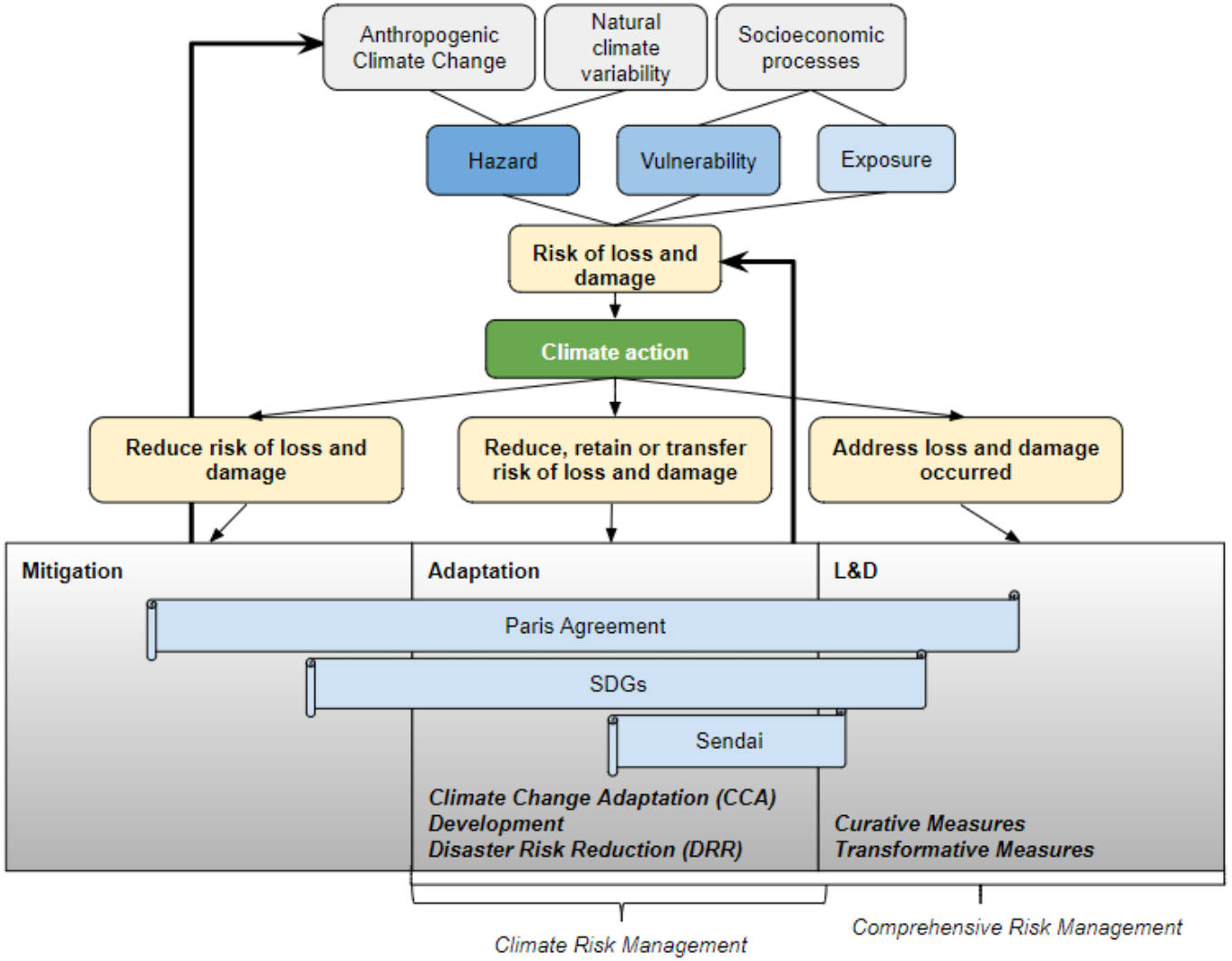


Based on IRGC, 2005

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

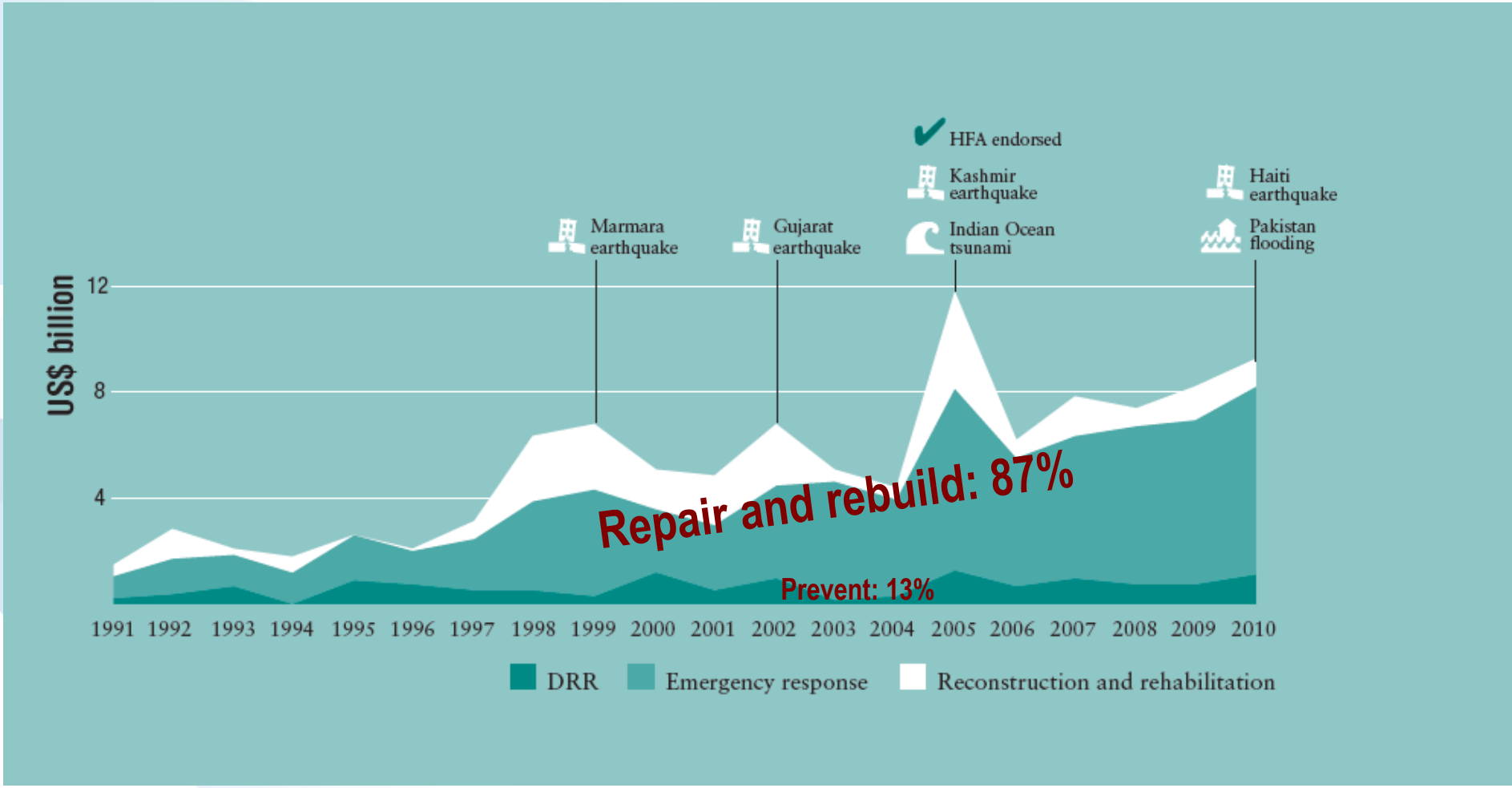
Policy Arenas



Van Homberg and McQuistan, 2019

Risk Policy Challenges

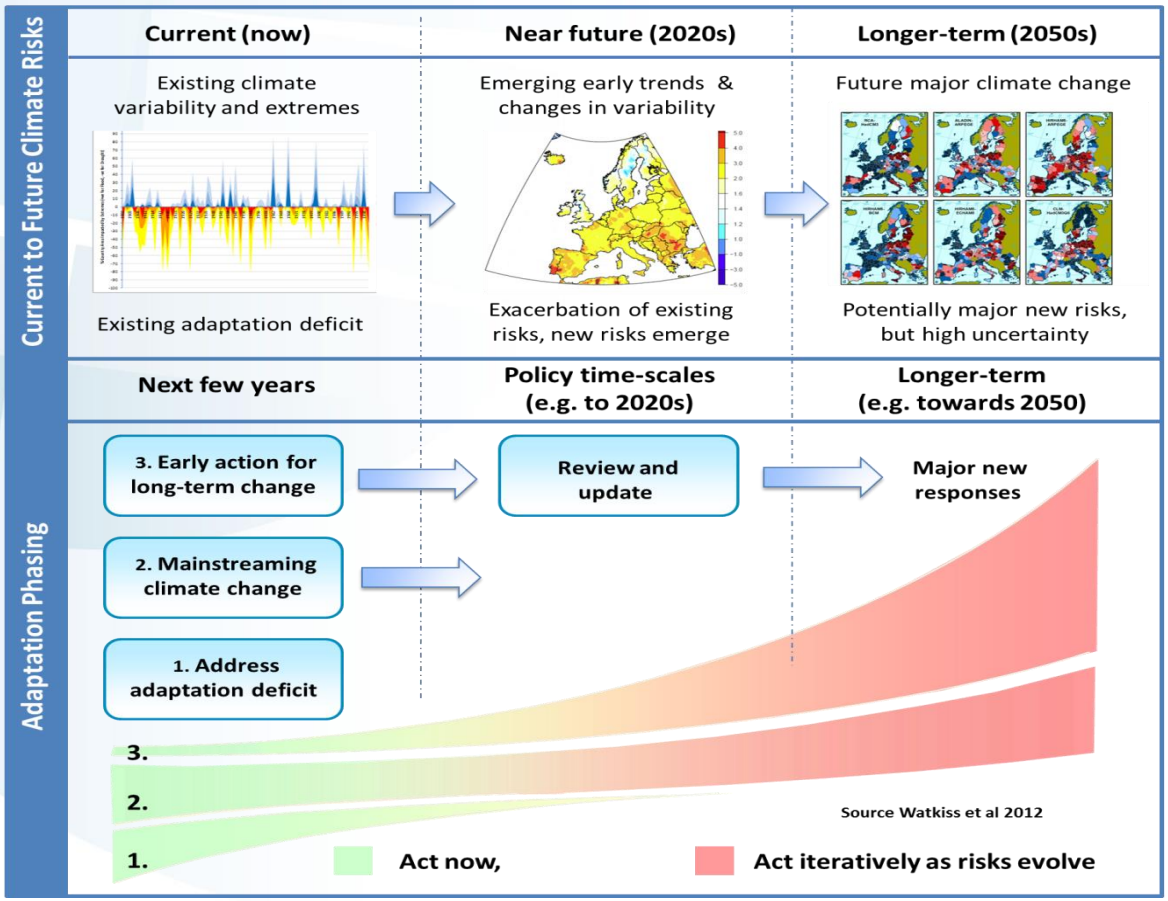
Challenge 1:
How to motivate risk management invesment?



Disaster–related financing 1991-2010

Kellet and Caravani, 2013

Challenge 2: How to support acting on climate risks now, adapting over time and learning?



Challenge 3: How to deal with (locally) dangerous climate change-related risks beyond adaptation?

Challenge 1: How to further motivate investment into risk management ?

Decision-support tools

Tool	Opportunities	Challenges	Typical Application	Multiple Dividends
Expert-focused tools for option selection				
Cost-Benefit analysis (CBA)	Rigorous framework based on comparing costs with benefits	Need to monetize all benefits, difficulty in representing intangible impacts, such as value of life	Well-specified hard-resilience projects with economic benefits (e.g., flood risk prevention)	Yes, but most suitable for hard resilience assessment
Cost-effectiveness Analysis (CEA)	Ambition level fixed, and only costs to be compared. Intangible benefits, particularly loss of life, do not need to be monetized	Ambition level needs to be fixed and agreed upon	Well-specified interventions with important intangible impacts, which should not be exceeded (loss of life, etc.)	Difficult, CEA requires well specified single objective
Robust approaches (RDMA)	Addresses uncertainty and robustness	Technical and computing skills required	Projects with large uncertainties and long timeframes (context of climate change where flood return periods may become more uncertain)	In principle, yes, in practice difficult, as requires well-specified objective definition and quantitative data
Participatory tools for informing iterative risk management decisions assessment, selection and monitoring and evaluation				
Multi Criteria Analysis (MCA)	Consideration of multiple objectives and plural values	Subjective judgments required, which hinder replication	Multiple and systemic interventions involving plural values (e.g. investing in infrastructure and education)	Yes, strongly participative
Adaptation pathways	Scenario-based decision-making at decision points depending on future system changes	Considerable investment into scenarios and stakeholder interaction	Portfolios	Yes, can also be supported by decision tools with quantitative outcomes
Capacity & resilience assessment (VCA, FRMC)	Measure and monitor capacity change over time, aligns with community-based decision process	Cannot be linked to individual intervention assessment, but program-level activities	Community-level resilience assessment	Yes

Mechler and Hochrainer-Stigler, 2019

Inventory on CBA assessments of investments in flood protection

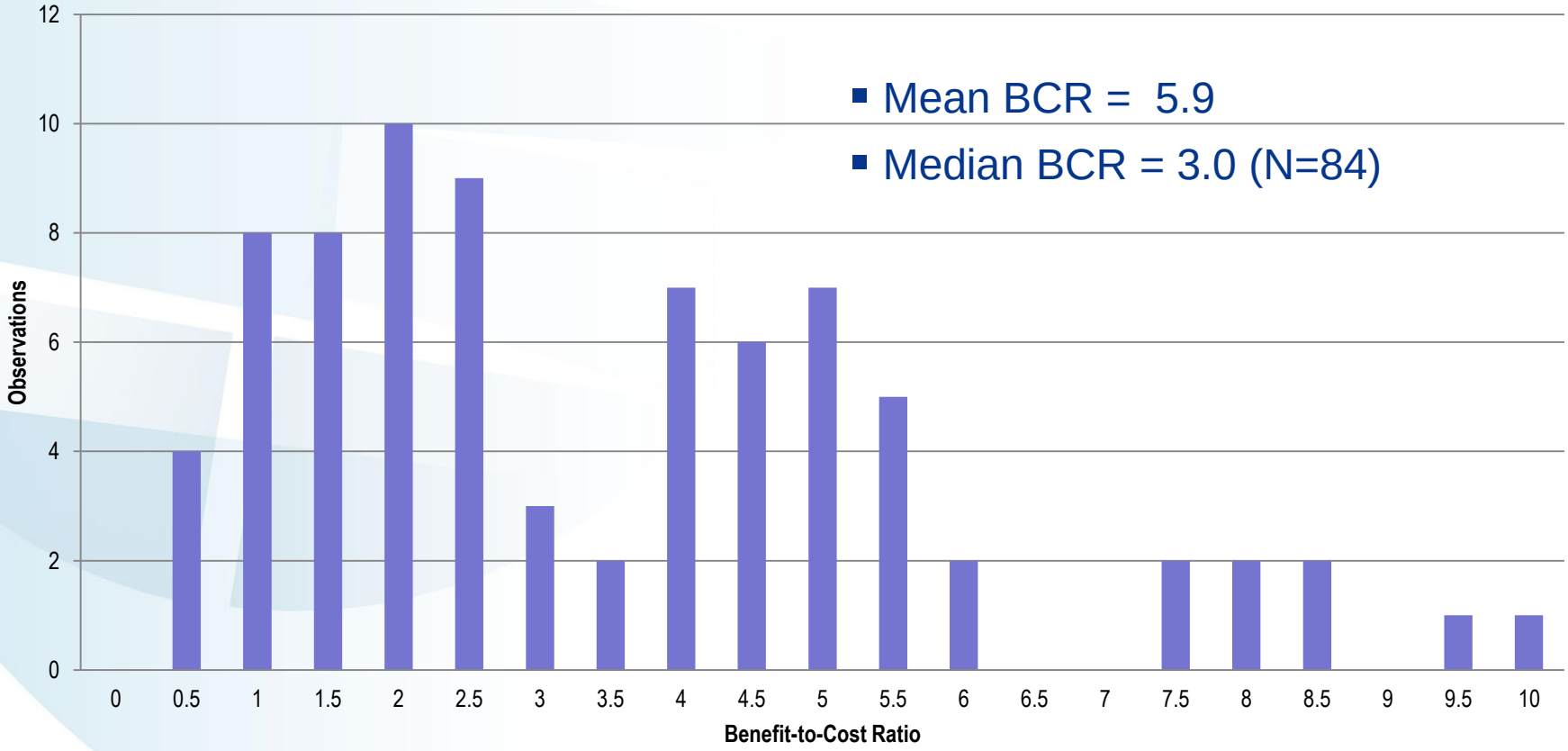
-110 observations
- 32 studies
- 17 countries
- 1991-2015

#

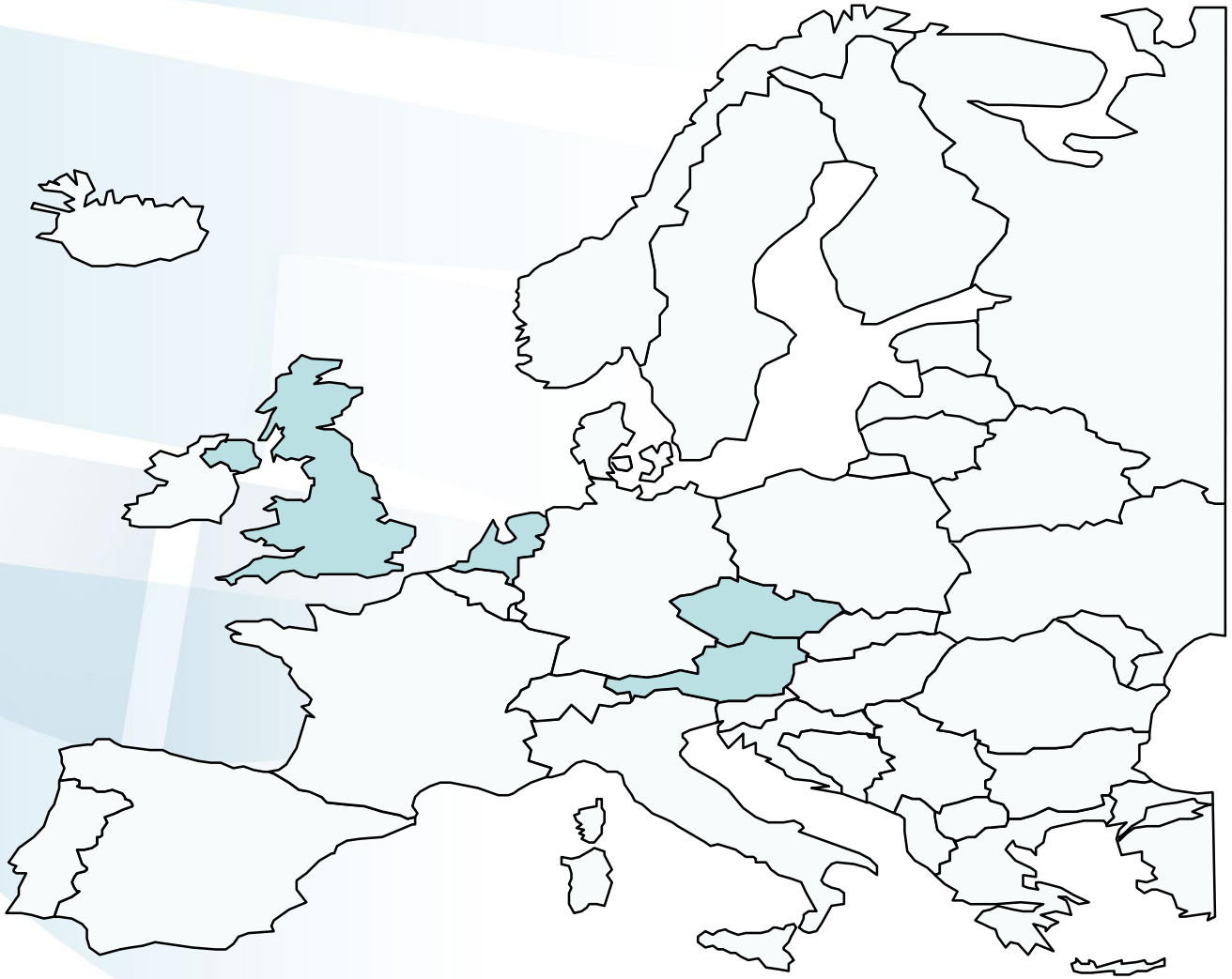
# of obs.

1

Results – Benefit-to-Cost Ratios
BCRs can be high



Case studies on decision-making



- Austria
- Czech Republic
- Netherlands
- United Kingdom

DRM investment - lessons

- Complexity of decision-making on flood risk in light of climate change at national, regional and local levels depending on the specific context and decision-making level.
  - Some countries are actively factoring-in the effects of future climate change into flood risk management strategies ((NL and UK)
  - Others, focus strongly on addressing existing risks of extremes (AT, CZ)

- Sophistication and implementation of methodological approaches varies largely
  - from simple updates of protection design standards based on one ‘most-likely’ scenario of future (climate) changes,
  - to complex applications of pathways analysis and iterative risk management

Findings

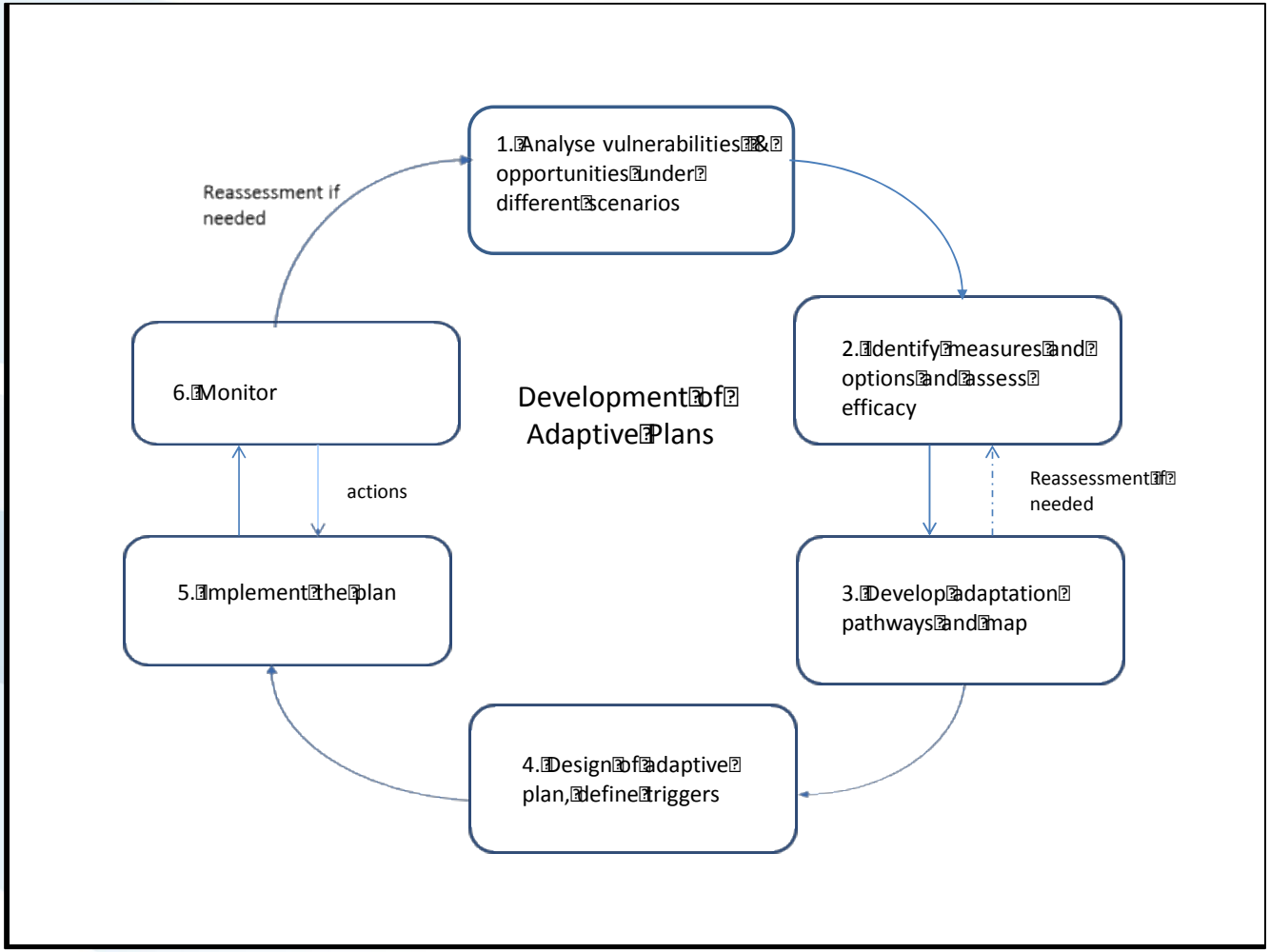
- Making an economic case for DRM remains important
  - Economic efficiency
  - Incentives for reducing risk
- Other considerations ranking high as well:
  - Acceptability
  - Equity
  - Flexibility

Beyond Cost-Benefit Analysis
Considering risk and multiple attributes

IPCC, 2014: Chambwera et al., 2014

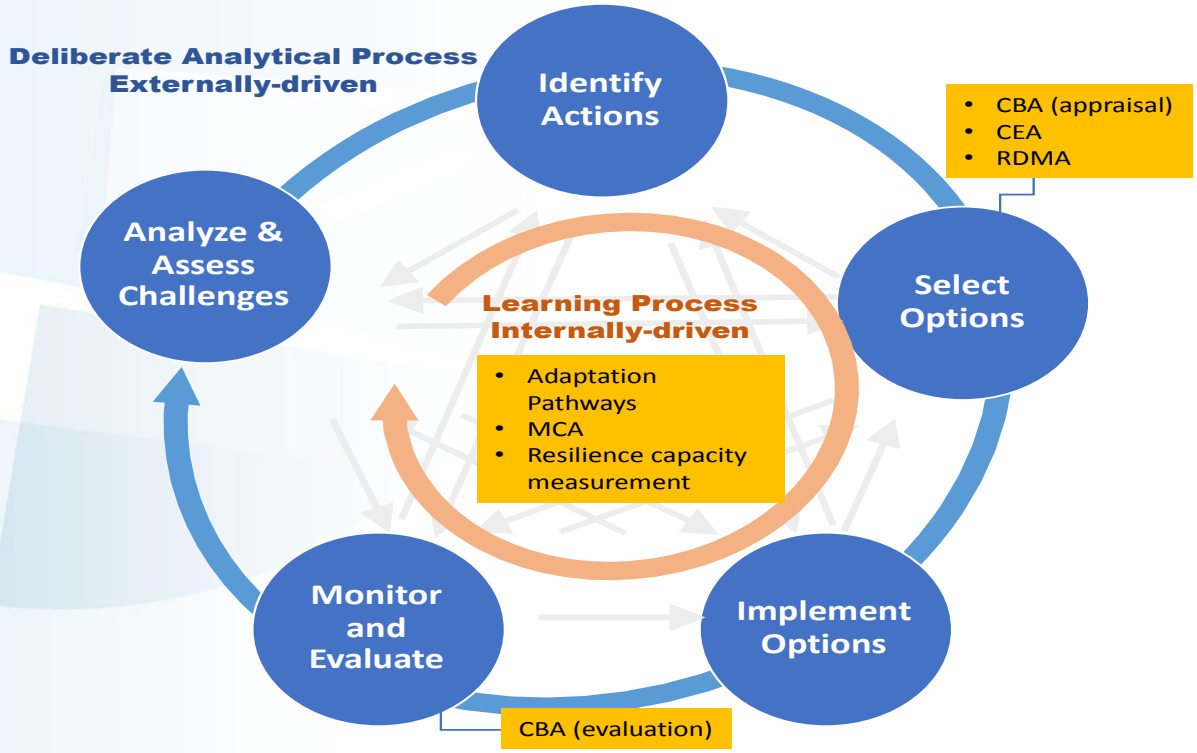
Economic thinking on adaptation has evolved from a focus on cost benefit analysis and identification of "best economic" adaptations to the development of multi-metric evaluations including the risk and uncertainty dimensions in order to provide support to decision makers (high confidence).

Iterative risk management



Source: Deltafact

Iterative use of decision-support tools



Mechler and Hochrainer-Stigler, 2019

Challenge 2: How to support acting on climate risks now, adapting over time and learning?

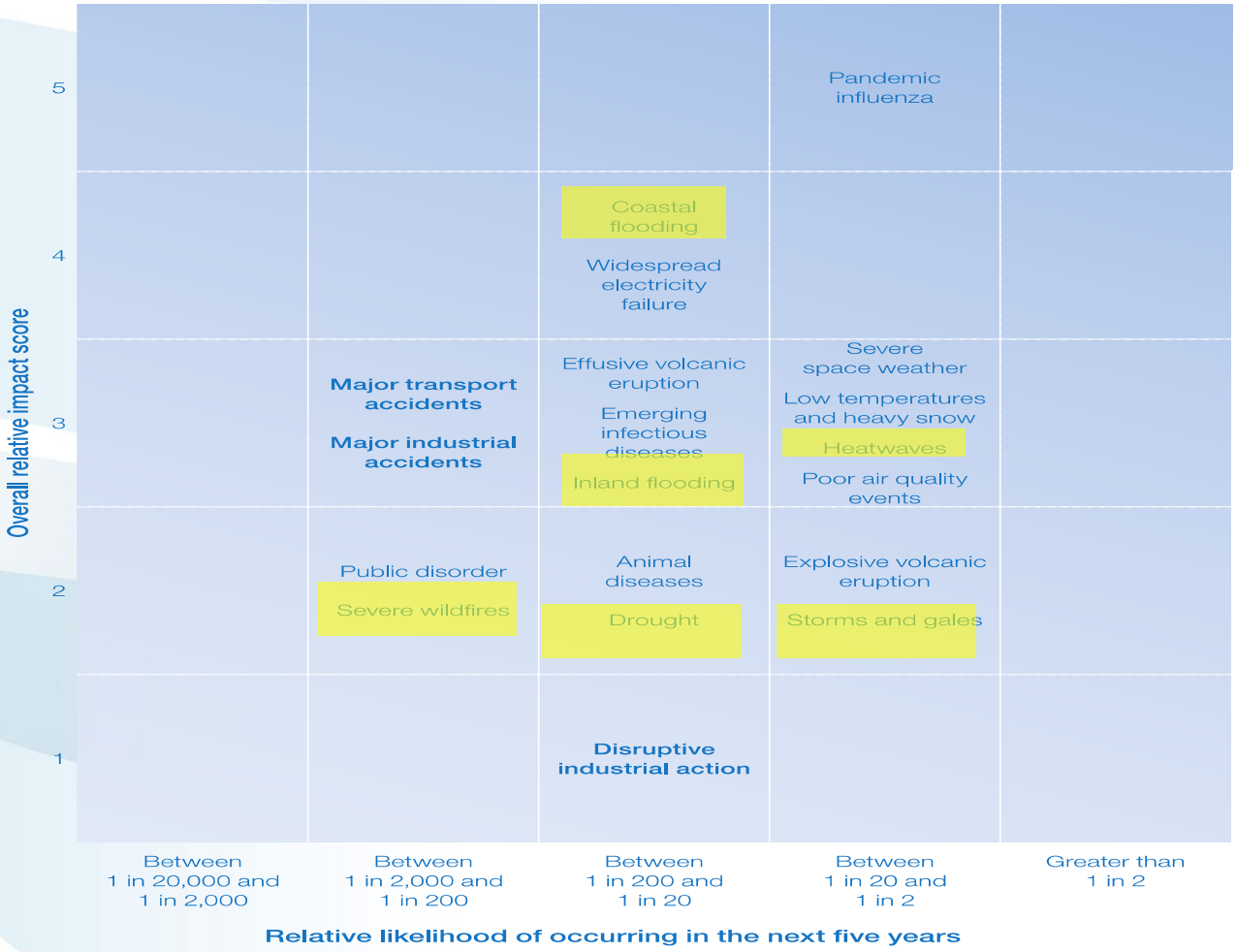
Public insurance and EU solidarity Fund

Flood Re scheme brings affordable insurance to homes in high-risk areas

New scheme expected to make insurance cover more affordable for owners of 350,000 UK homes at high risk of flooding

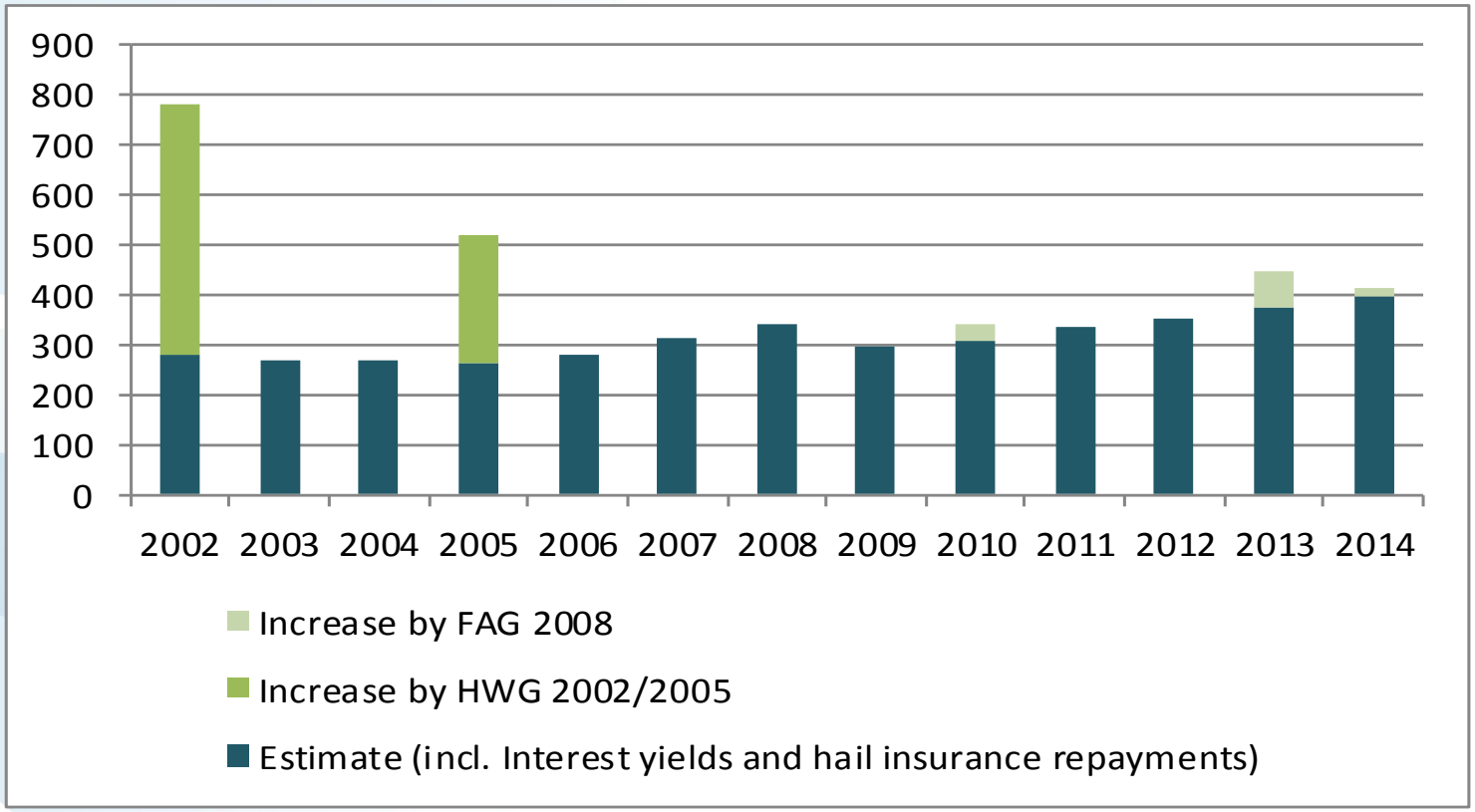
▲ A flooded street in Carlisle after Storm Desmond brought torrential rains to the area in December. Photograph: Anadolu Agency/Getty Images

Risk-based planning in the public sector



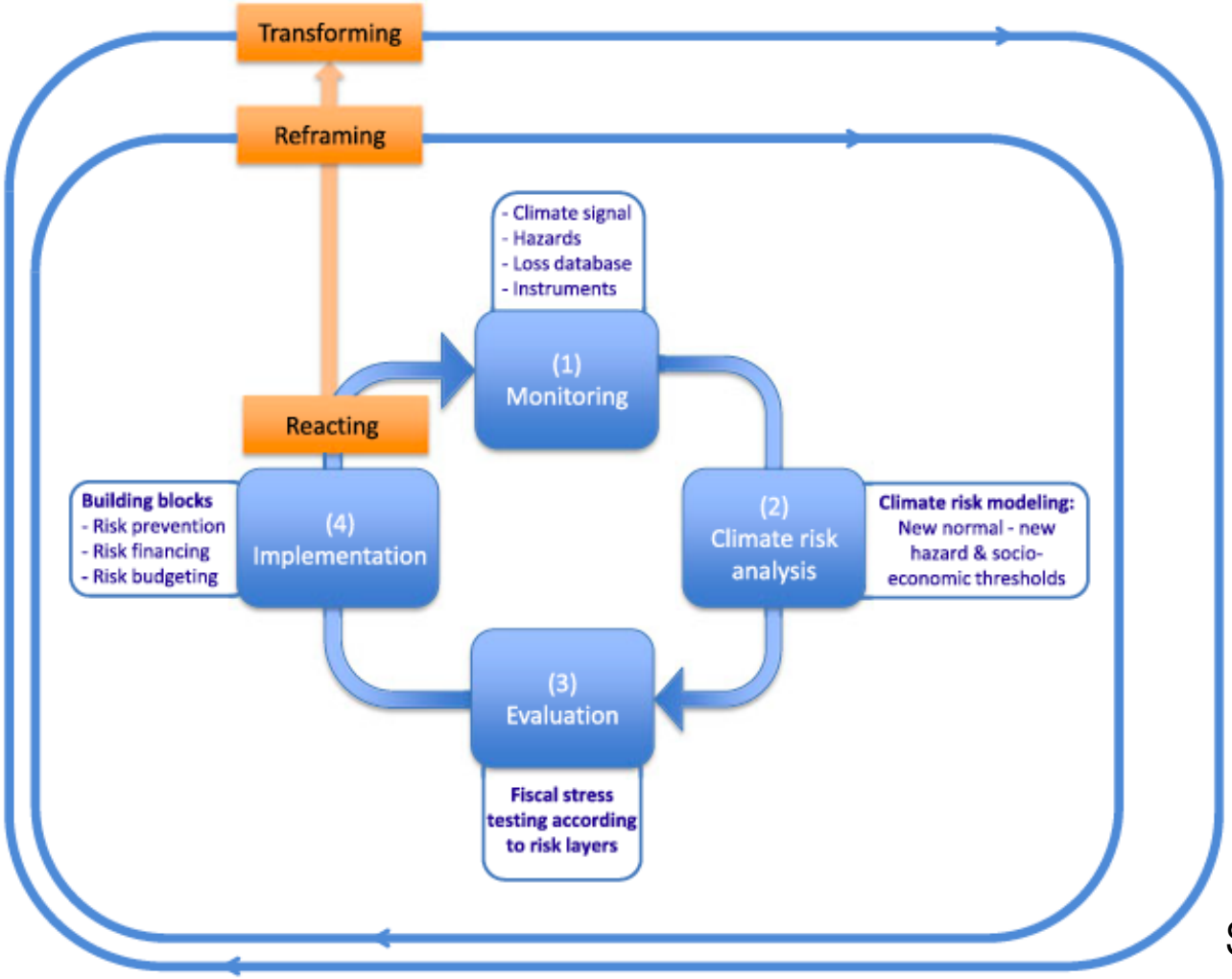
UK's risk matrix for 2015. Source: UK Cabinet Office, 2015

Austria case: Budgetary implications of flooding



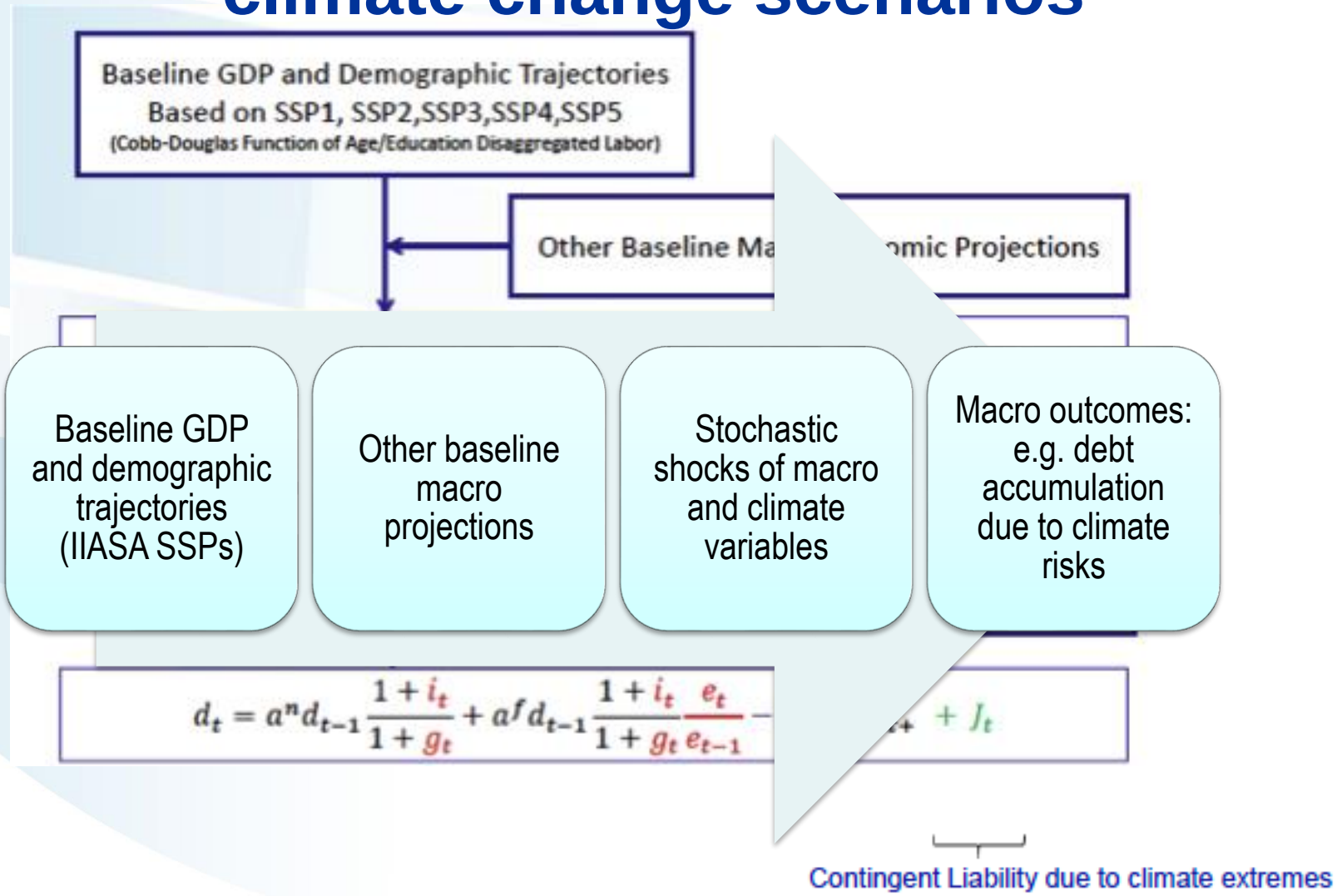
Schinko et al., 2016

Operationalizing climate risk management applied to Austria public risk management policy



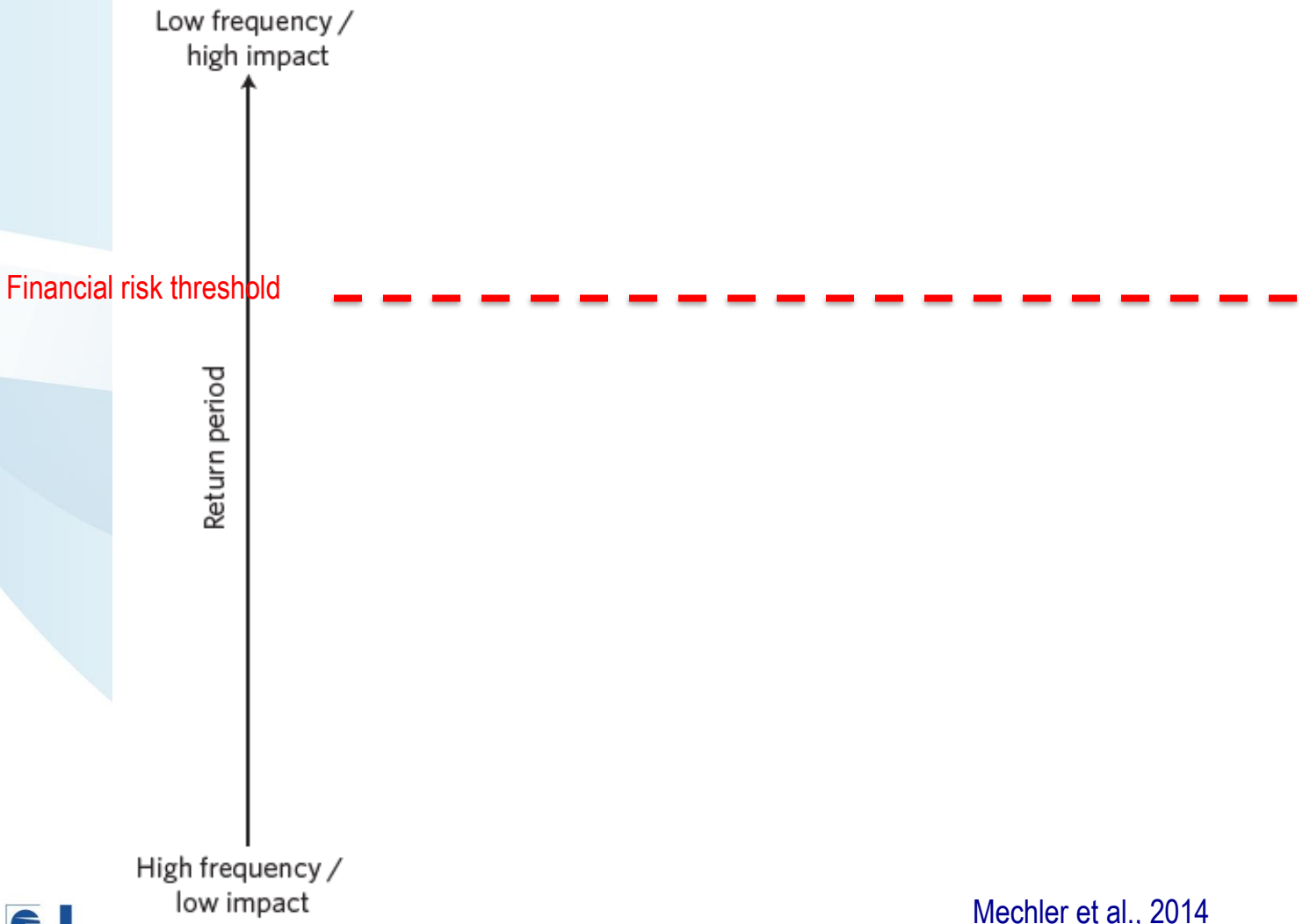
Schinko et al., 2016

Stochastic debt evaluation in light of climate change scenarios



Mochizuki, 2015

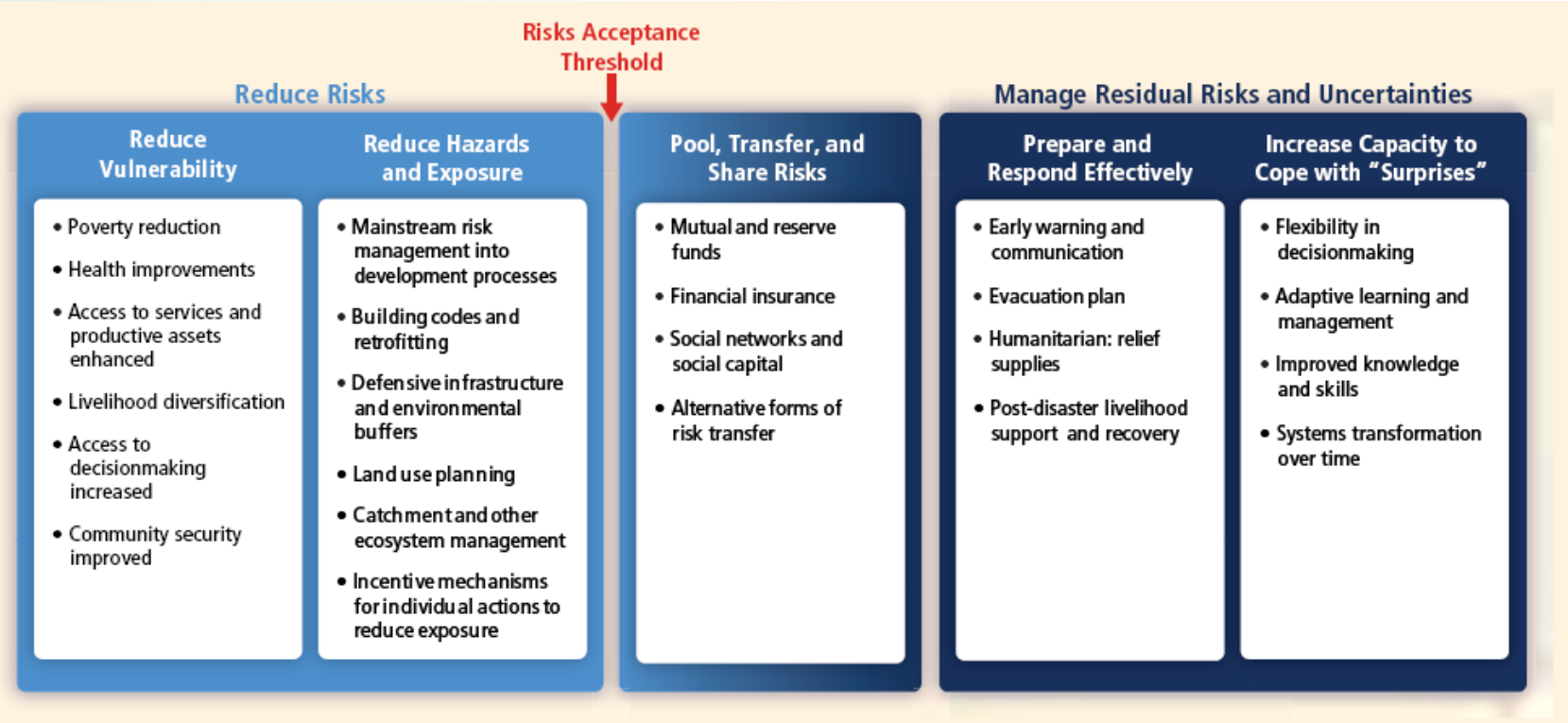
Risk layering concept



Mechler et al., 2014

Effective portfolios of risk management options

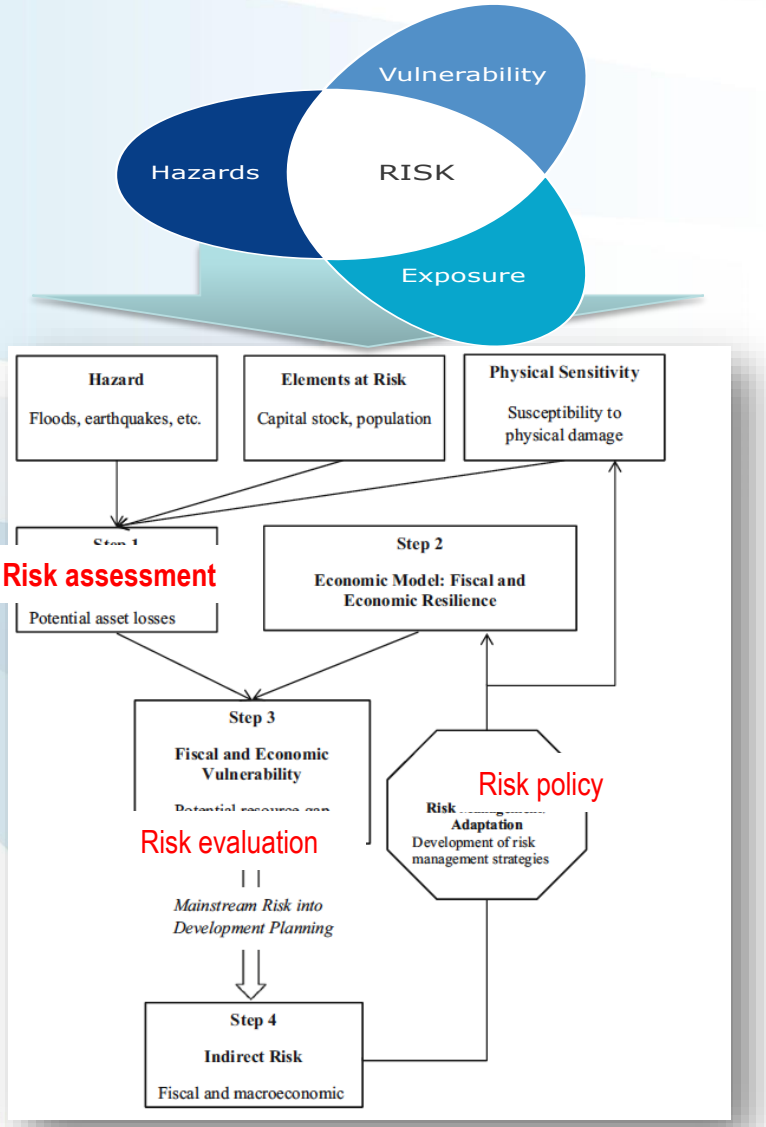
Integrating adaptation and DRM approaches for a changing climate



Effective risk management portfolios involve sound risks analysis, risk reduction, risk financing and governance

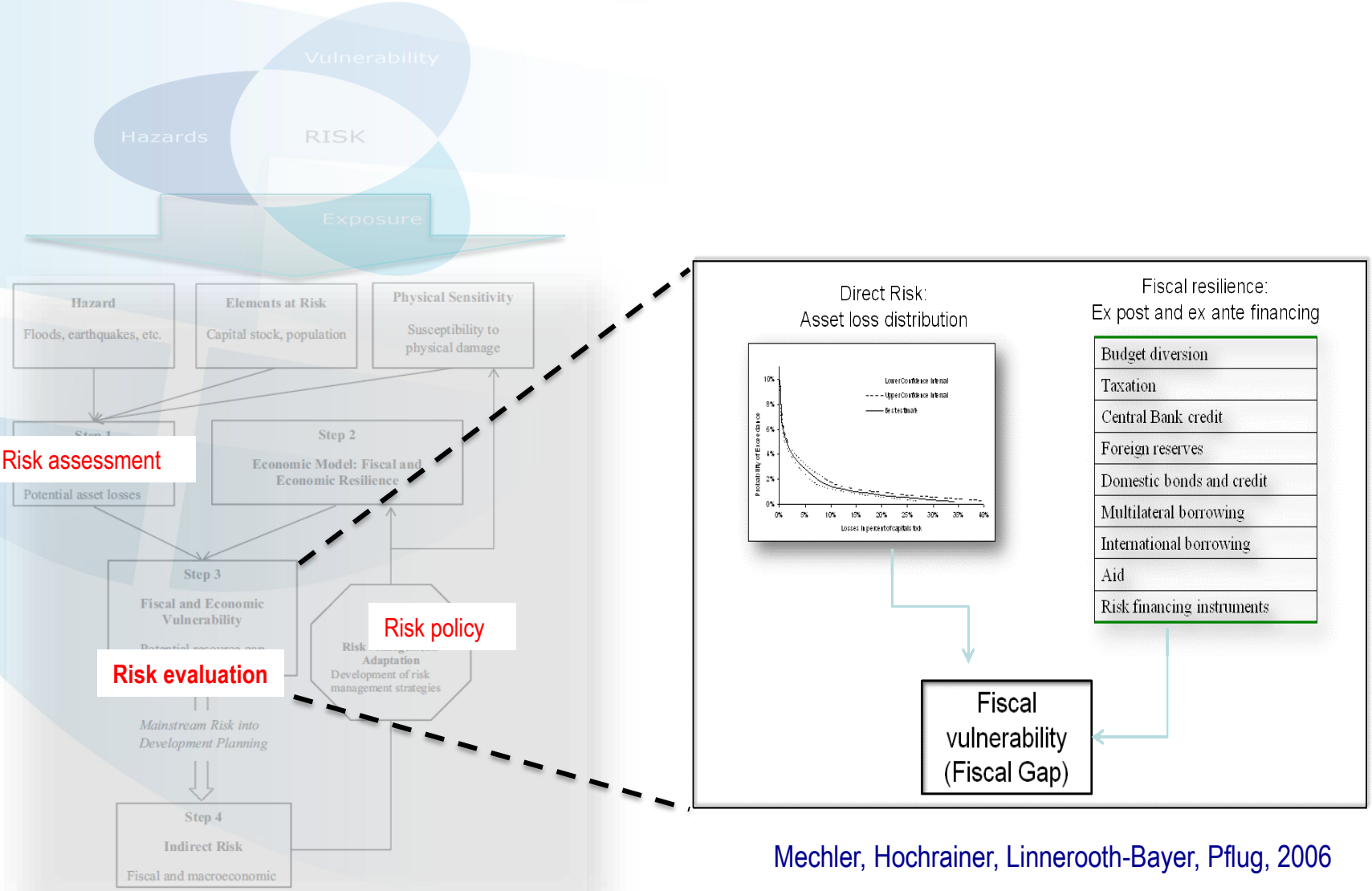
Source: Lal et al., 2012

Stress testing public finance
CATSIM model



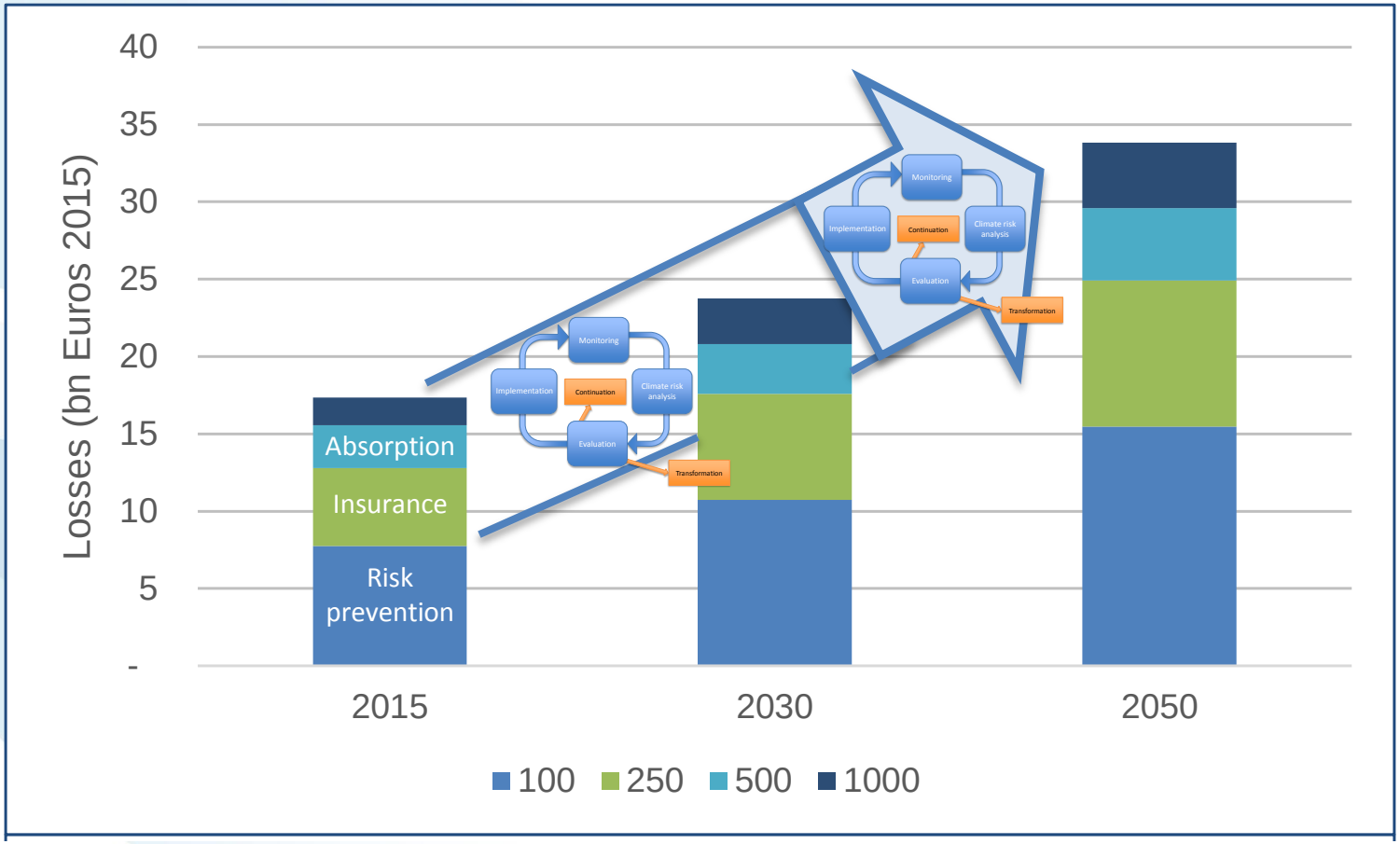
Mechler, Hochrainer, Linnerooth-Bayer, Pflug, 2006

Modelling risk and risk management
CATSIM model



Mechler, Hochrainer, Linnerooth-Bayer, Pflug, 2006

Iterative Climate Risk Management
Today's and future risk management portfolios

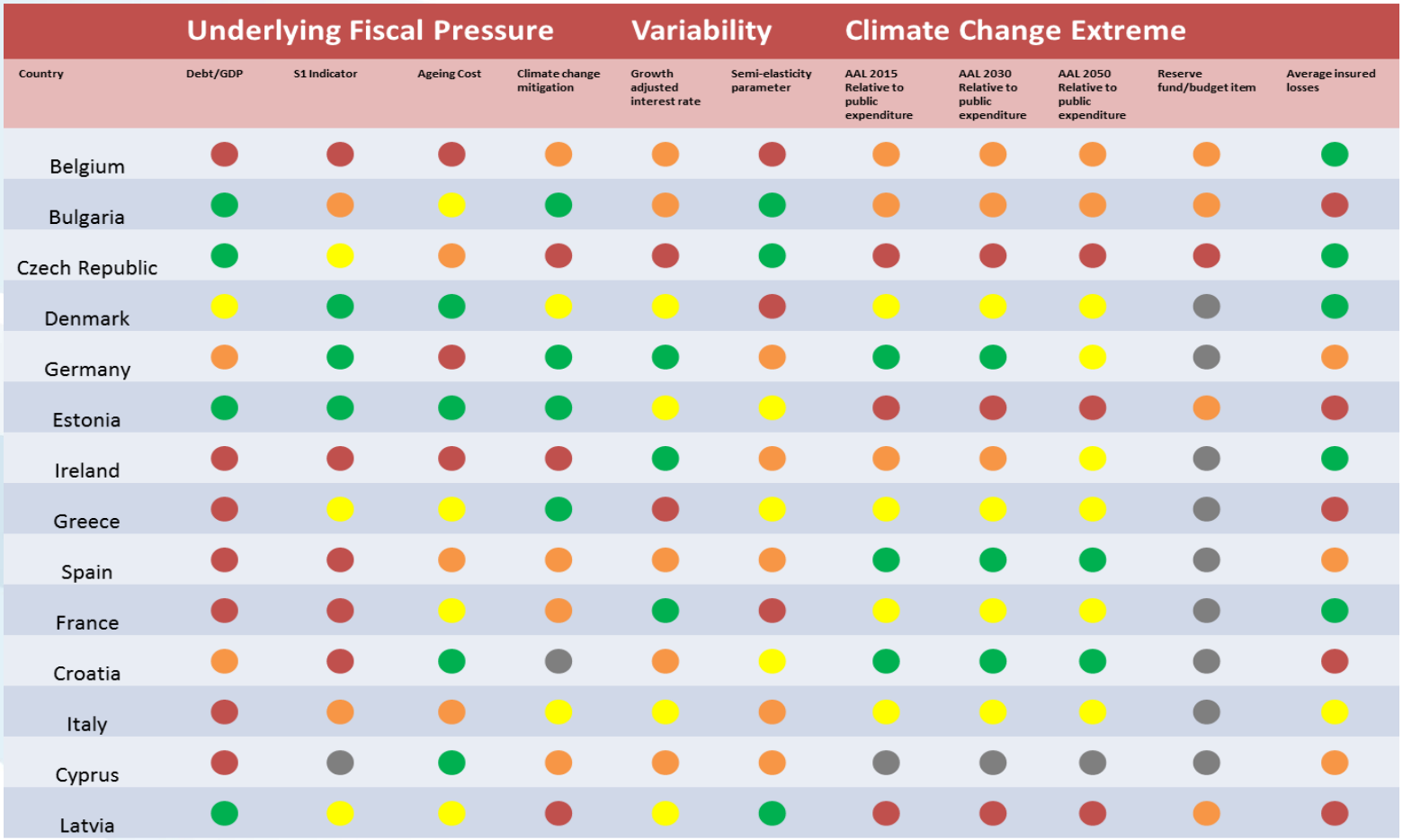


How much to ?

- Prevent
- Insure
- Absorb

Schinko et al., 2016

EU wide
Fiscal Risk Scorecard



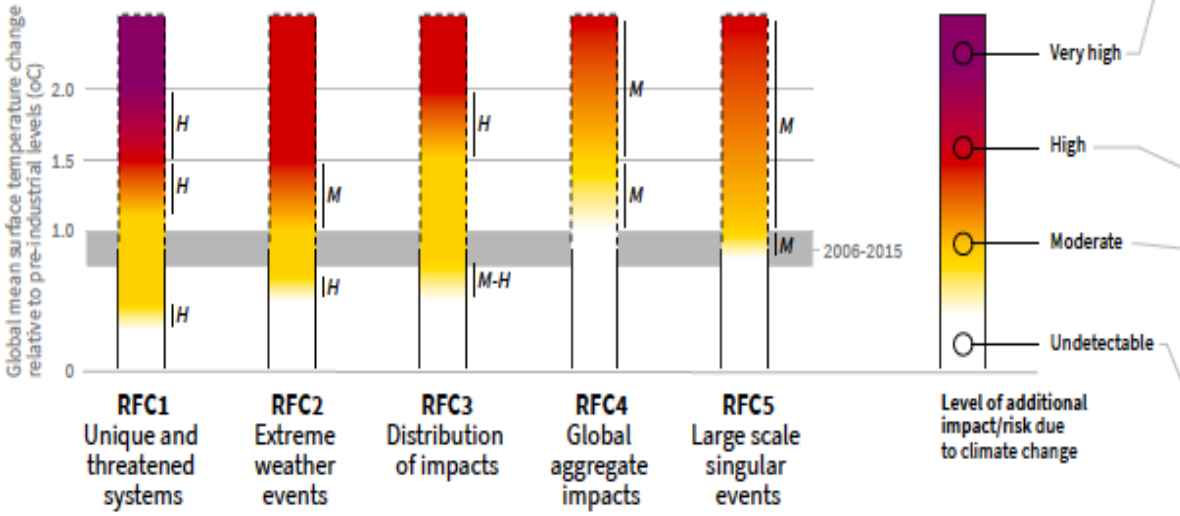
Mochizuki et al., 2017

Challenge 3: How to deal with (locally) dangerous climate change-related risks beyond adaptation?

Risks in the IPCC SR15
The Reasons for Concern

Five Reasons For Concern (RFCs) illustrate the impacts and risks of different levels of global warming for people, economies and ecosystems across sectors and regions.

Impacts and risks associated with the Reasons for Concern (RFCs)



Purple indicates very high risks of severe impacts/risks and the presence of significant irreversibility or the persistence of climate-related hazards, combined with limited ability to adapt due to the nature of the hazard or impacts/risks.

Red indicates severe and widespread impacts/risks.

Yellow indicates that impacts/risks are detectable and attributable to climate change with at least medium confidence.

White indicates that no impacts are detectable and attributable to climate change.

Chapter 3: Hoegh-Guldberg et al., 2018

Adaptation at 1.5° C vs. 2 C°

B6. Most adaptation needs are lower for global warming of 1.5°C compared to 2°C (*high confidence*). There are a wide range of adaptation options that can reduce the risks of climate change (high confidence).

- There are **limits to adaptation and adaptive capacity** for some human and natural systems at global warming of 1.5°C, with associated losses (*medium confidence*).

- **become more pronounced at higher levels** of warming and vary by sector, with site-specific implications for vulnerable regions, ecosystems, and human health (*medium confidence*).

- A3. Future climate-related risks would be reduced by upscaling and acceleration of far-reaching, multi-level and cross-sectoral climate mitigation and by both **incremental and transformational adaptation** (*high confidence*).

IIASA

ipcc INTERGOVERNMENTAL PANEL ON climate change

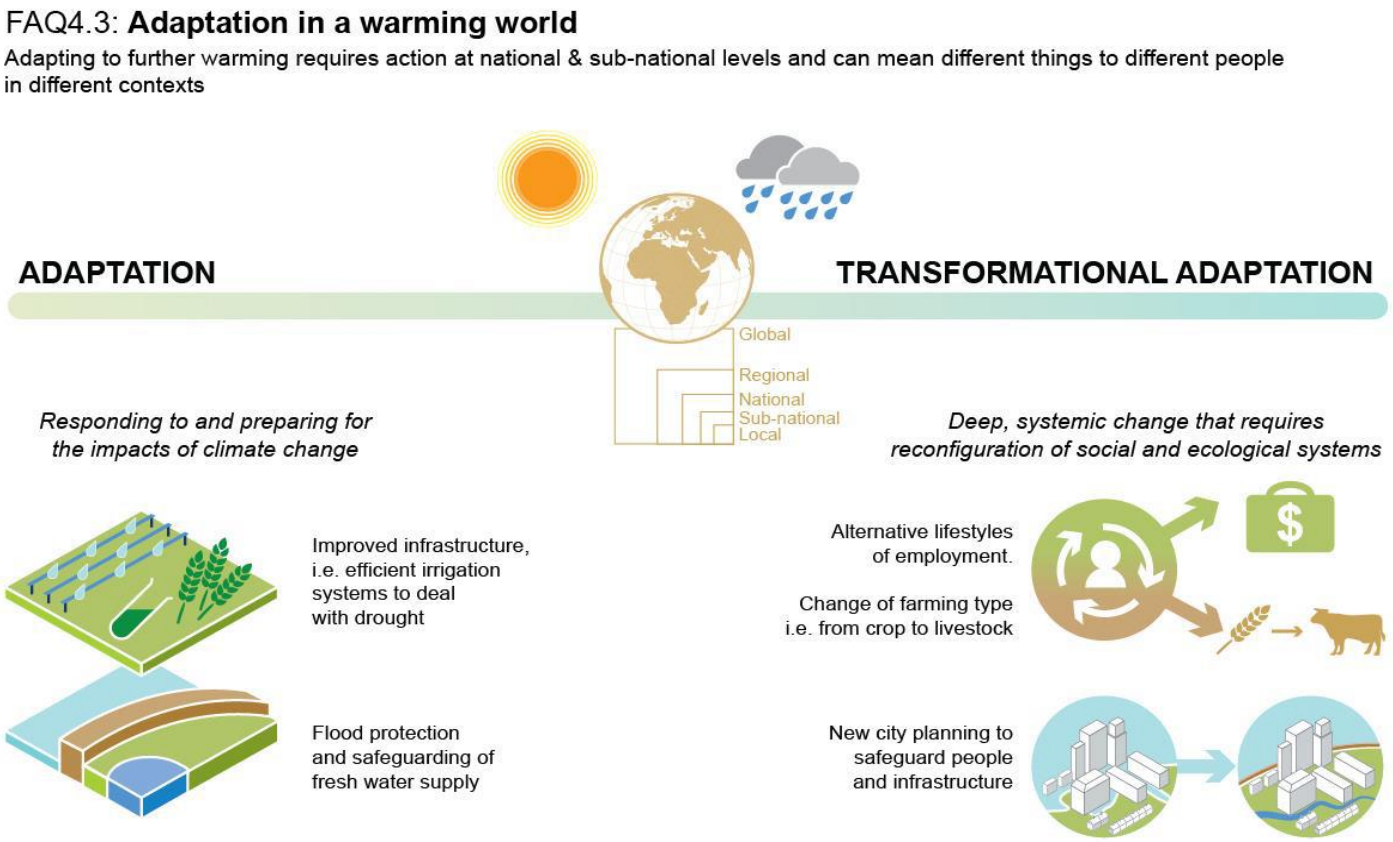
WMO UNEP

Risk, Adaptation, Limits

System (RFC*)	Regions	1.5°C	2°C	Adaptation options	Scope for adaptation	Limit
Coral reefs (1)	Tropics	70-90% loss	99% loss	Artificial reefs, water clean-up	Very limited	Hard [natural]
Terrestrial and wetland ecosystems (1)	Global	6% of insects, 8% of plants and 4% of vertebrates lose over 50% of the climatically determined geographic range	18% of insects, 16% of plants and 8% of vertebrates	Water and vegetation management, increased connectivity	Limited	Hard [natural]
Human health (2,3,4)	Global, part. tropics	+ 350 million people exposed to deadly heatwaves in megacities by 2050	Annual occurrence of heat-waves similar to deadly 2015 heat-waves in India and Pakistan	Hydration, cooling zones, green roofs	Medium, low in tropics	Soft and hard (e.g. for outdoor work) [technological]
Coastal livelihoods and islands (2,3)	Global, Asia, SIDS in Pacific and Caribbean	31-69 million people at risk. Sea level rise and increased wave run up, increased aridity and decreased freshwater availability leaving several atoll islands uninhabitable	32-79 million people at risk	Coastal defences, ecosystem-based adaptation, reef restoration	Low-medium	Soft and hard [technological, socio-economic]

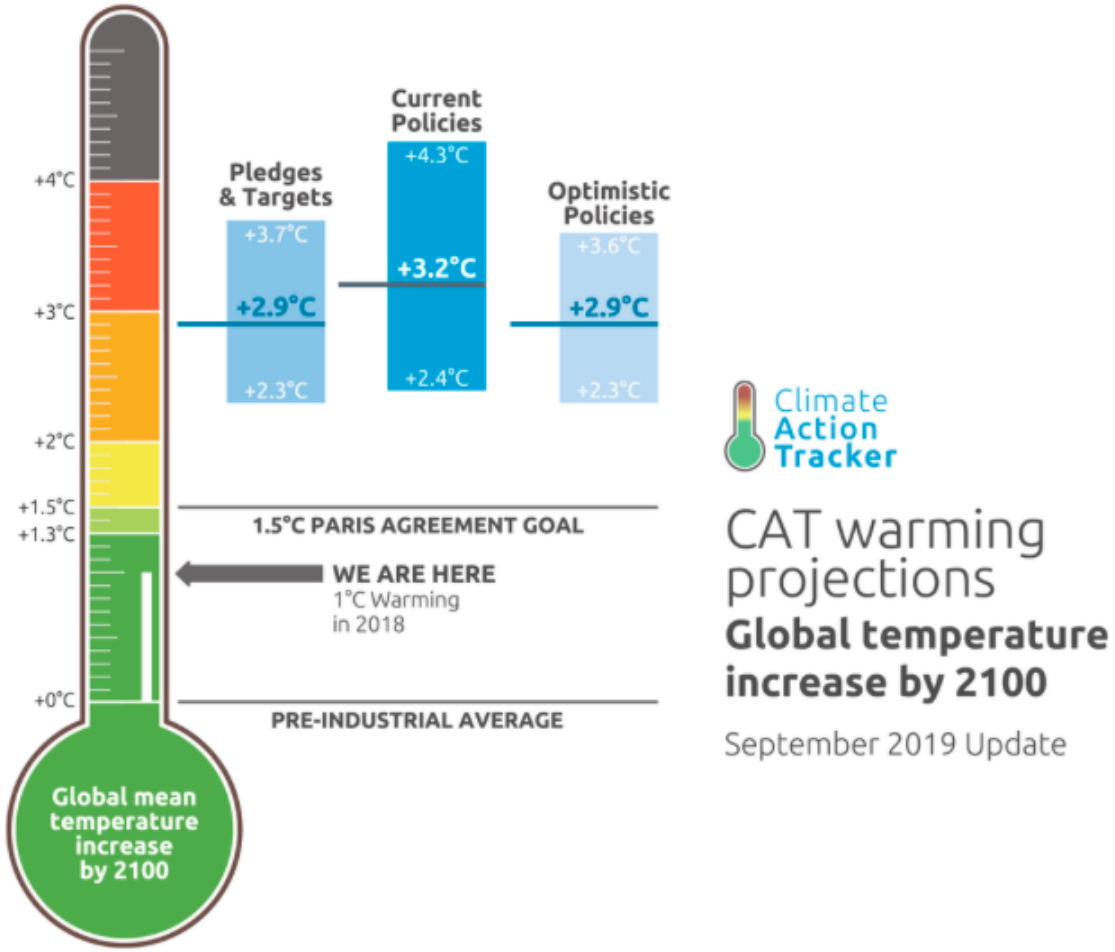
Mechler et al., *unpublished*
Synthesis from IPCC SR15 2018 (ch.3,4, 5)

For soft limits:
Incremental and Transformational adaptation

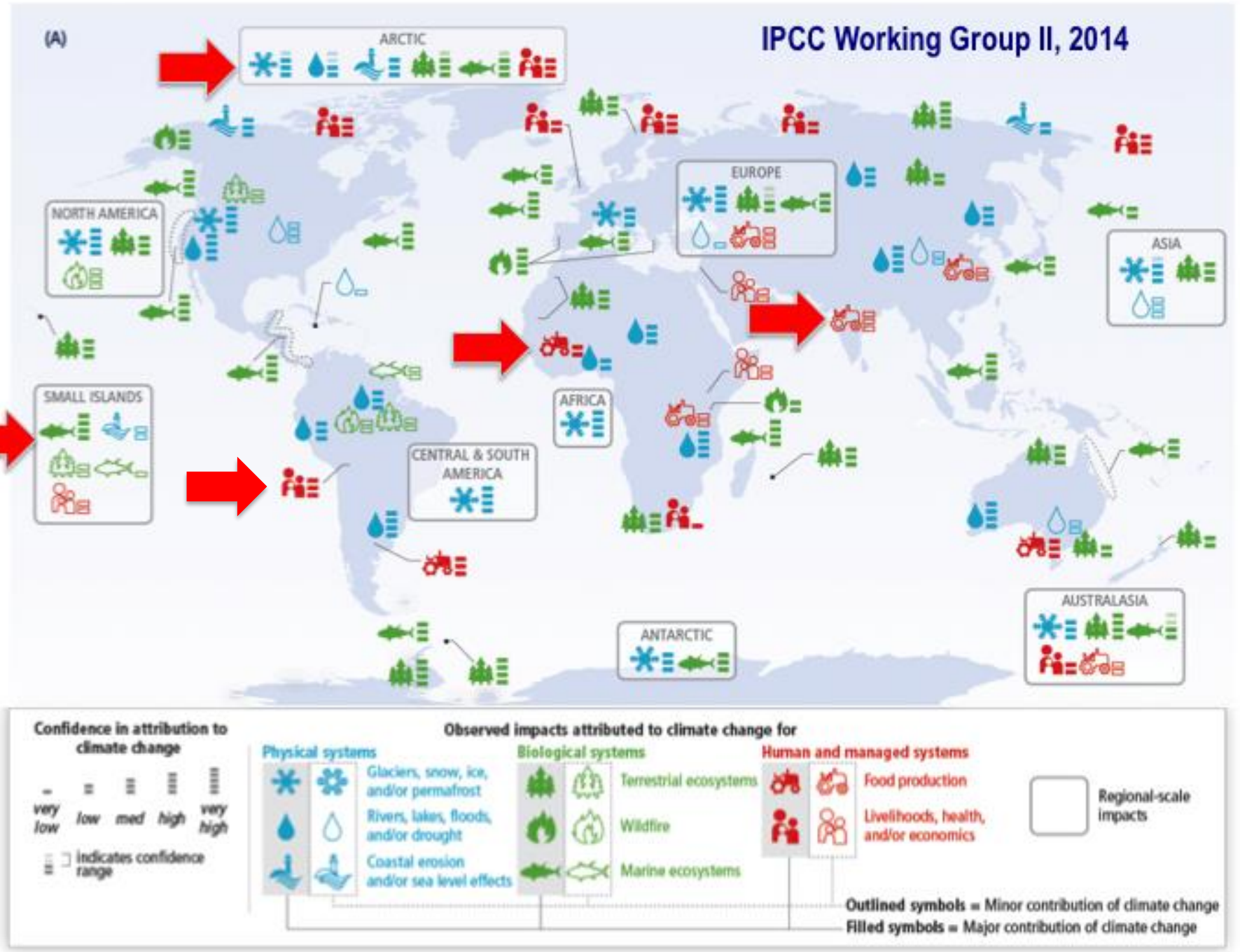


IPCC, 2018

Status observed and projected global warming



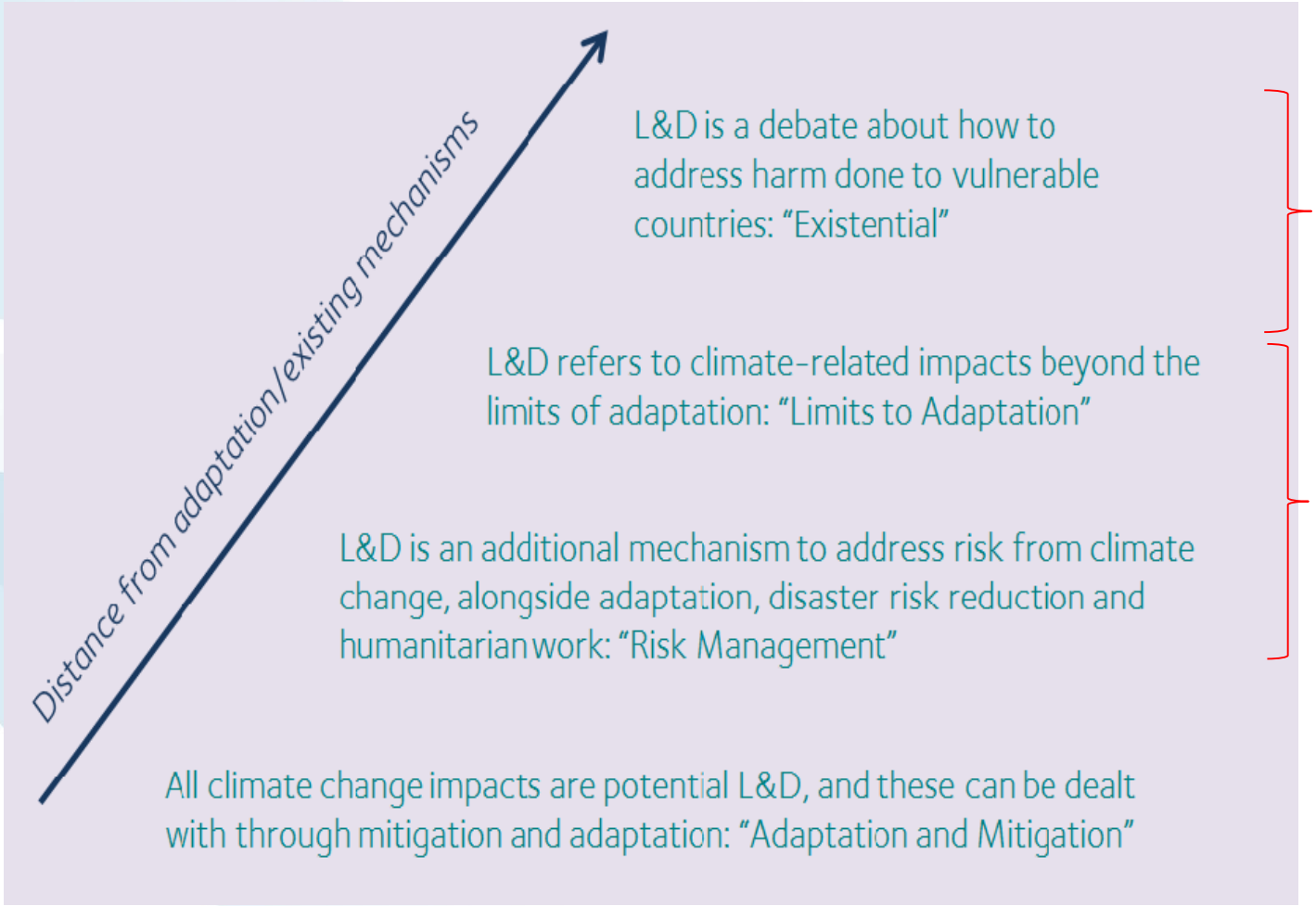
Climate Action Tracker, October 2019


(A)
IPCC Working Group II, 2014
ARCTIC
NORTH AMERICA
EUROPE
ASIA
SMALL ISLANDS
AFRICA
CENTRAL & SOUTH AMERICA
AUSTRALASIA
ANTARCTIC
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

The Loss & Damage Policy debate
Policy response for risks beyond adaptation

- **AOSIS** in **1991** proposed establishment of a compensation scheme for the most vulnerable small island and low-lying coastal states
- Warsaw **Loss and Damage mechanism institutionalised** in **2013**
- L&D with **stand-alone article in Paris agreement 2015**
- **3rd pillar of deliberations** under the UNFCCC in addition to mitigation and adaptation
- **Contested terrain**
  - 'Southern countries' at risk (such as AOSIS) demand **compensation**, reject risk management as involves national responsibility
  - OECD negotiators willing to support **risk management**, part. **insurance**, but liability and compensation considered red lines

Perspectives on Loss and Damage

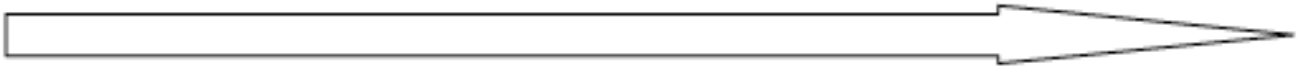


Legal liability for attributed impacts

International support for transformational risk management and payments for irreversible impacts

Boyd, James and Jones, 2016

A risk perspective: avoided, unavoided, unavoidable



Avoided	Unavoided	Unavoidable
Avoidable damage avoided → Damage prevented through mitigation and/or adaptation measures.	Avoidable damage and loss not avoided → Where the avoidance of further damage was possible through adequate mitigation and/or adaptation, but where adaptation measures were not implemented due to financial or technical constraints.	Unavoidable damage and loss → Damage that could not be avoided through mitigation and/or adaptation measures; e.g., coral bleaching, sea level rise, damage due to extreme events where no adaptation efforts would have helped prevent the physical damage.

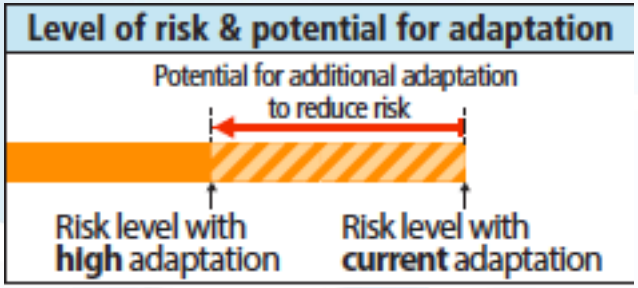
Source: Verheyen, 2008

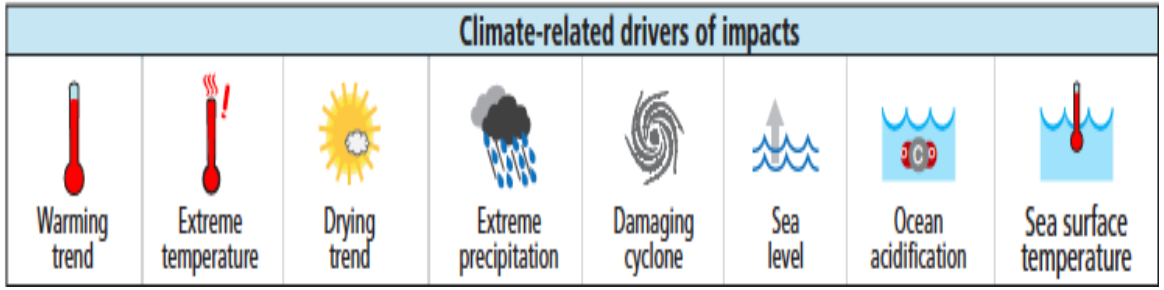
Dealing with unavoided risks today AND avoiding future risks and preventing unavoidable risks?

How different –or the same- as adaptation and disaster risk management?

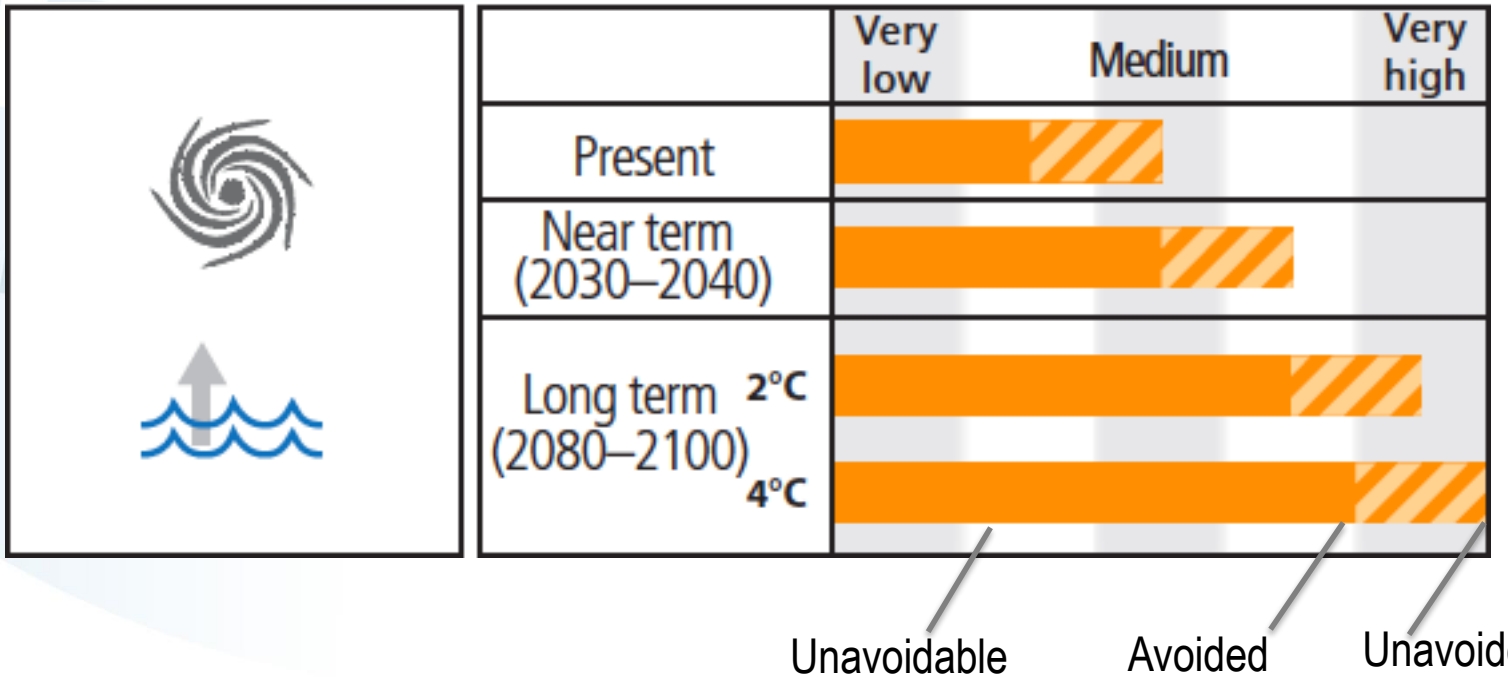
What is the risk and options space?

Key risks approach: comprehensive risk and risk management potential

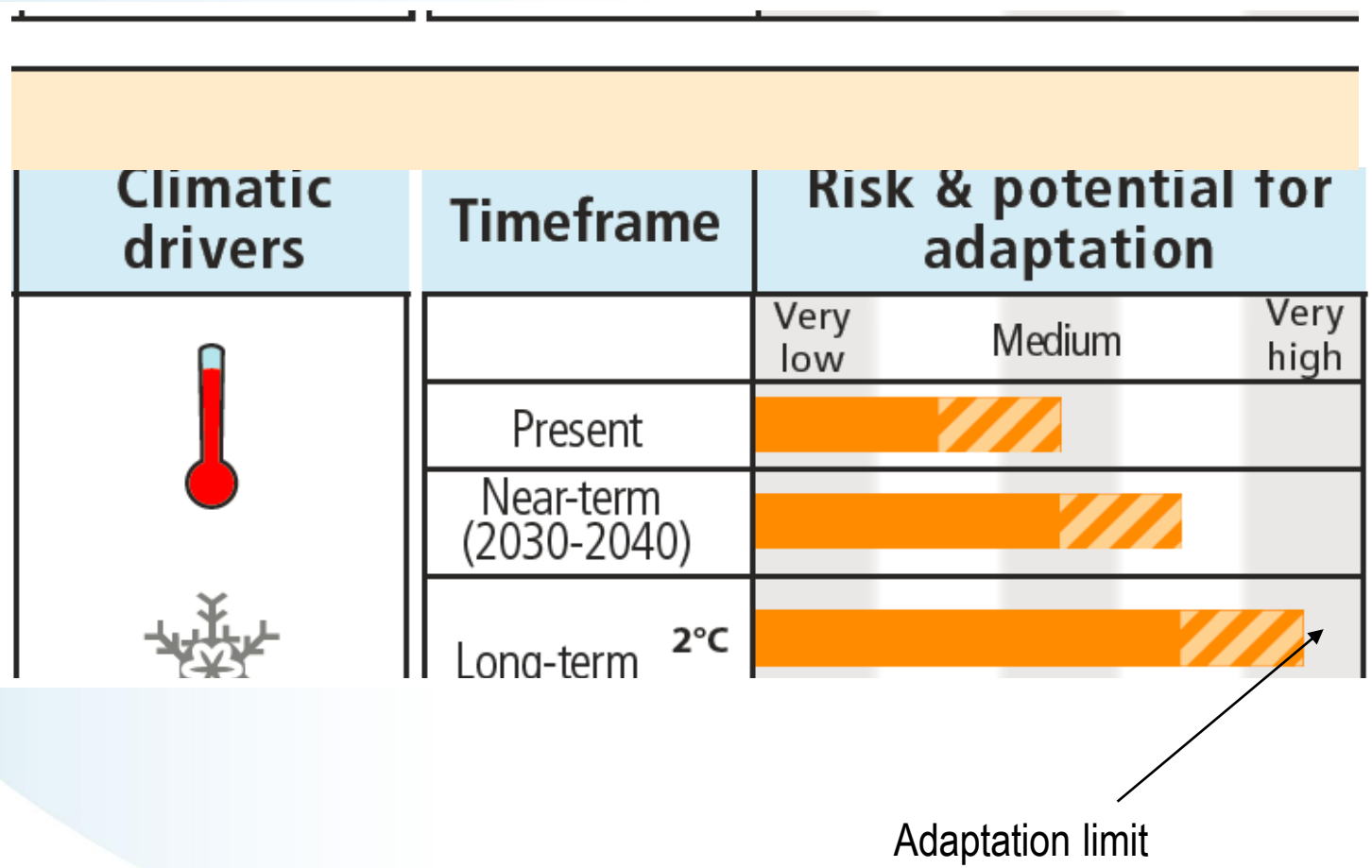




SIDS
Rising global mean sea level in the 21st century with high-water-level



Coral reefs: Impact on biodoversity, fisheries, coastal protection



Methodological elements for a risk approach to Loss and Damage

- Principled approach to the L&D debate
  - Integrate evidence from attribution studies and work towards **compensatory justice** → curative options
  - Supporting climate risk management via **distributional justice**→ transformational options
  - Signaling urgency of 1.5º/2º C ambition
- Building blocks for policy proposal on Loss&Damage
  1. Comprehensive risk analytics
  2. Risk evaluation: risk preference and tolerance
  3. Justice principles

Mechler&Schinko, 2016

1. Understanding climate change and disaster risk

Images:
IPCC, 2014

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 - <u>currently</u> (IPCC, 2012&14)

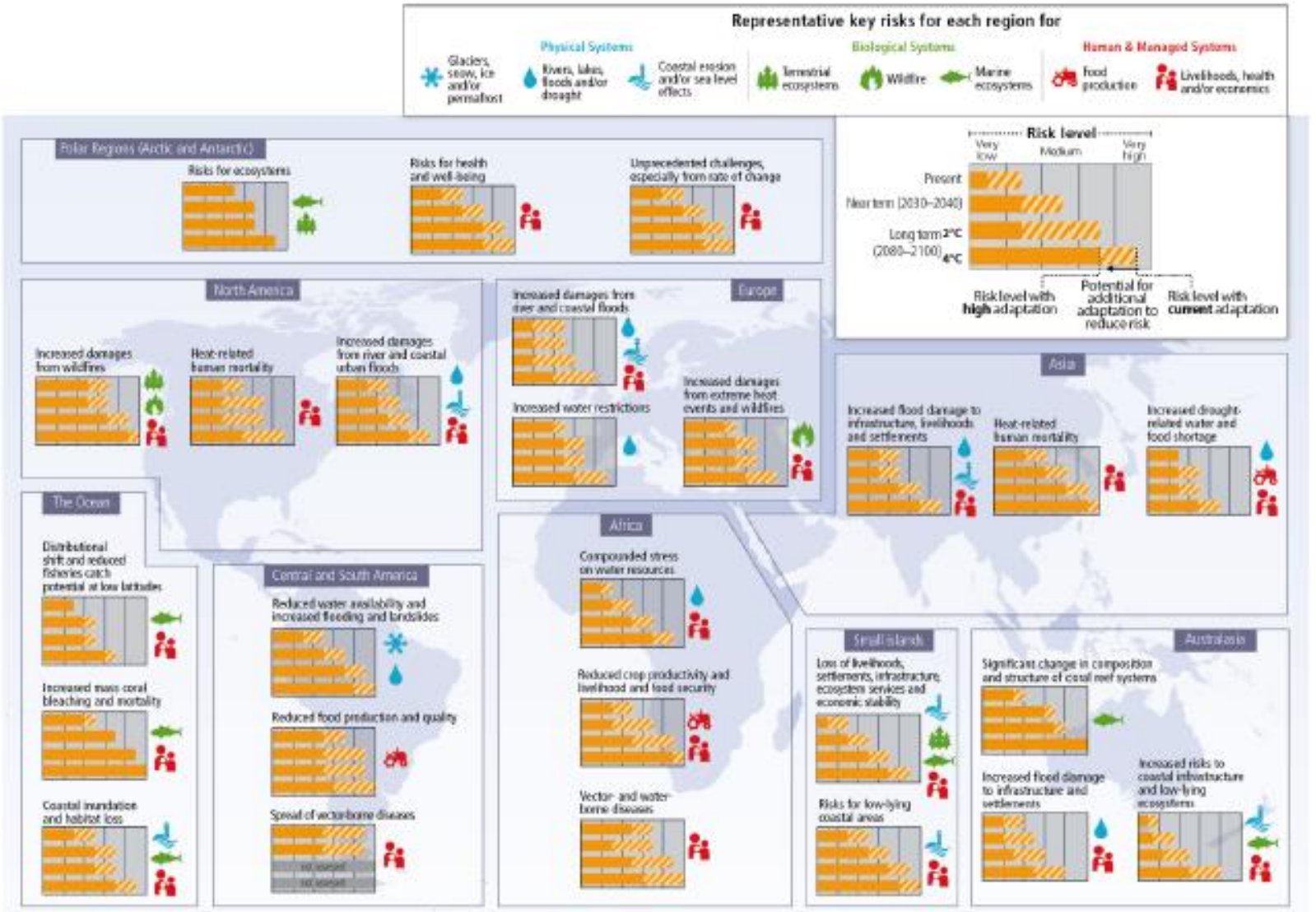
Vulnerability

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

Risk

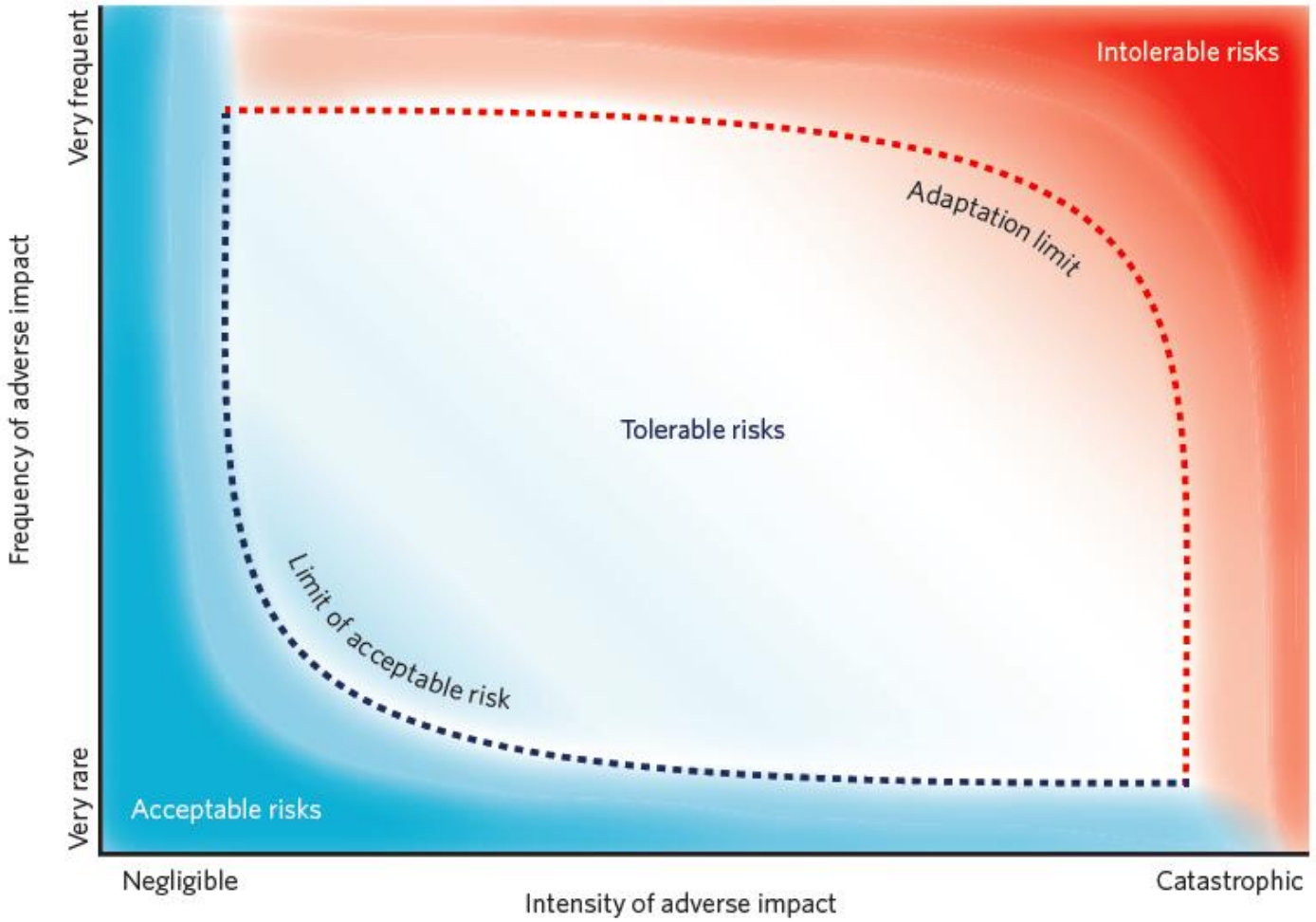
Climate risk attribution very complex (only Schaller et al., 2016)

Future risk: IPCC Working II regional climate risk analysis



IPCC, 2014

2. Risk evaluation



Acceptable, tolerable and intolerable risks
Dow et al. 2013b after Klinke and Renn 2002; Renn and Klinke 2013)

Risk evaluation

- Understanding risk preference
  - Acceptable: no further action necessary
  - Tolerable: further action keeping resources in mind
  - Intolerable:transformational responses required
- Two basic approaches:
  - semi-quantitative surveys or focus group-based assessments, which gauge risk tolerance from reported risk perceptions and risk responses;
  - risk-based modelling formalising risk-based decision-making building on modelled risk perceptions, e.g. to understand government actors risk tolerance for dealing with climate-related risks

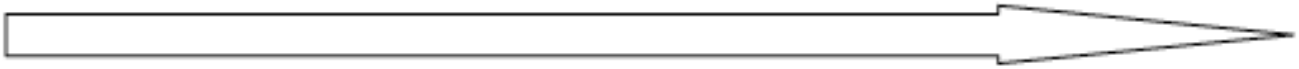
3. Climate Justice

- Identifying roles and responsibilities for dealing with risks involves attention to climate justice principles

- *Compensatory justice*
  - Polluter-pays principle,
  - due to the unequal distribution of historical and current emissions, as well as potential irreversible loss,
  - attributing impacts to anthropogenic climate change and identifying harm-doing.

- *Distributive justice*
  - Burden sharing necessary as many vulnerable countries in need of international support for tackling today's adaptation deficits
  - Does not require climate attribution of past, present and future risks for generating international support, such as provided via the Global Facility for Disaster Risk Reduction (GFDRR).

Proposal for Loss and Damage
Transformational and curative measures



Avoided	Unavoided	Unavoidable
Avoidable damage avoided → Damage prevented through mitigation and/or adaptation measures.	Avoidable damage and loss not avoided → Where the avoidance of further damage was possible through adequate mitigation and/or adaptation, but where adaptation measures were not implemented due to financial or technical constraints.	Unavoidable damage and loss → Damage that could not be avoided through mitigation and/or adaptation measures; e.g., coral bleaching, sea level rise, damage due to extreme events where no adaptation efforts would have helped prevent the physical damage.

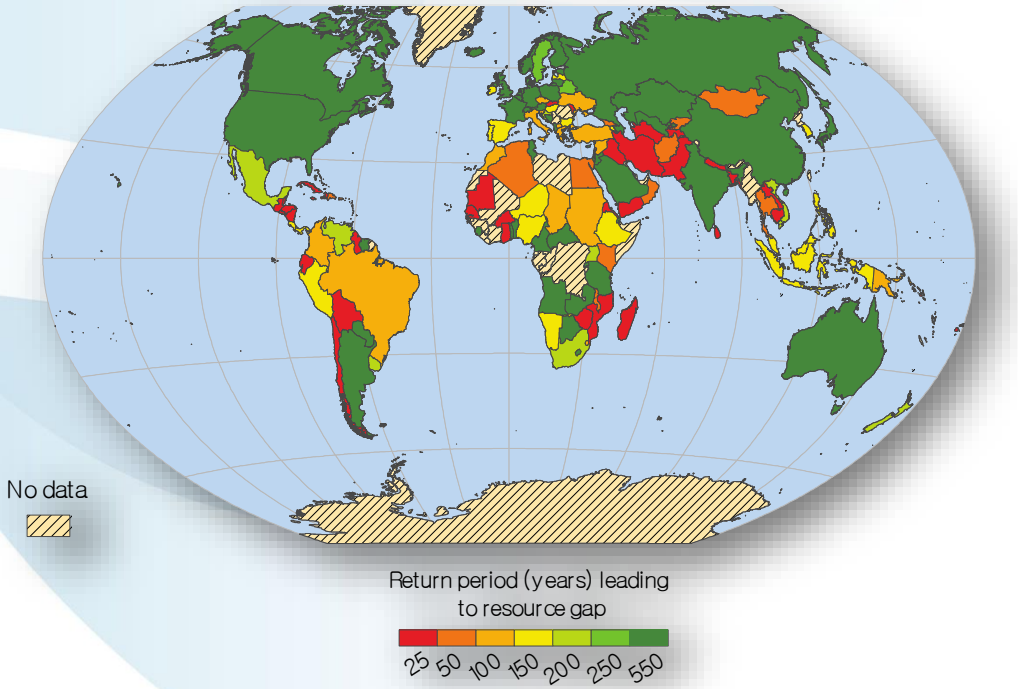
Transformational measures
Avoiding risks *ex-ante* through transformative risk management (building on DRR and CCCA)

Curative measures
Dealing with unavoidable impacts *ex-post*

Source: Verheyen, 2008

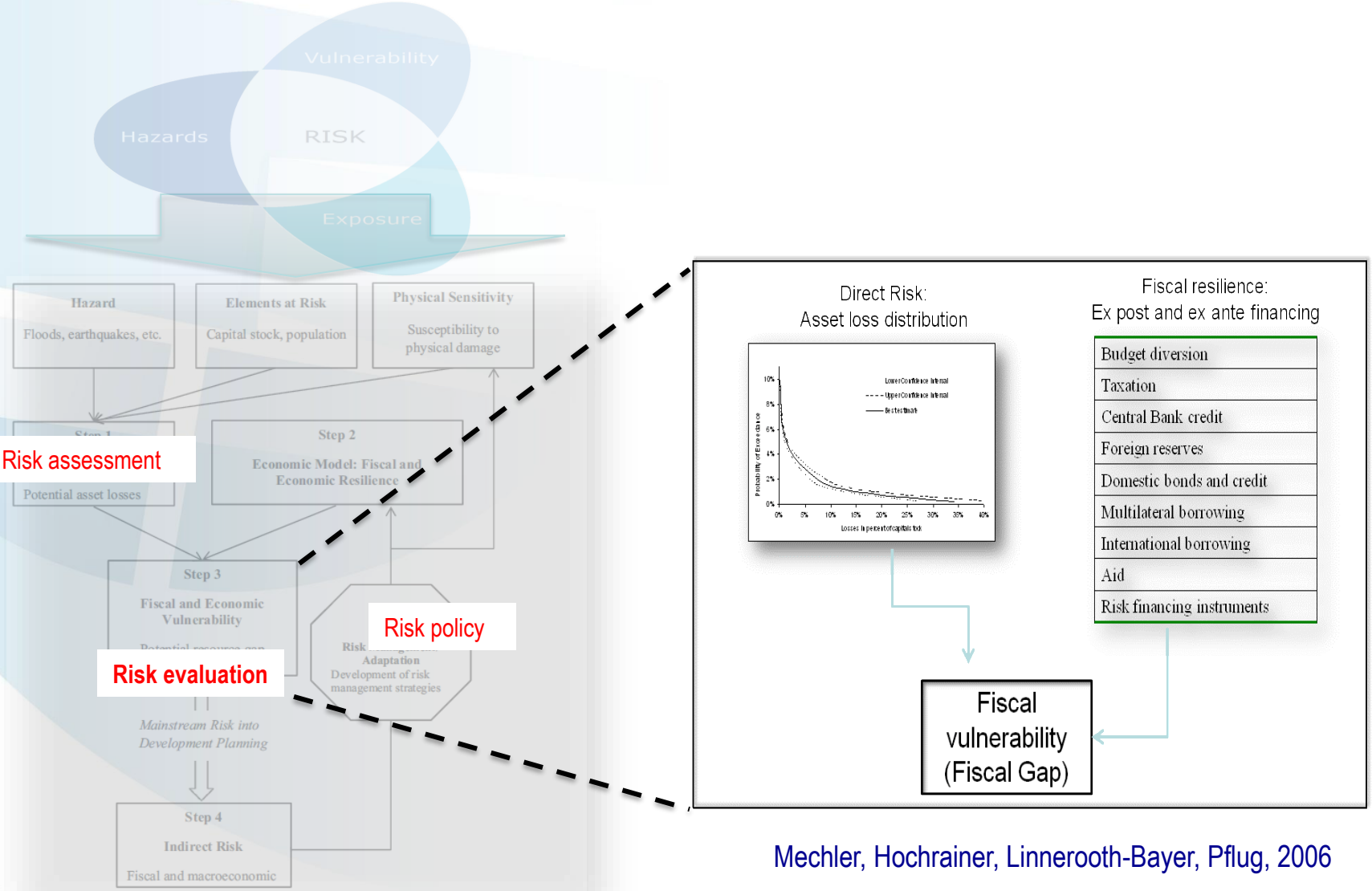
Mechler and Schinko, 2016

Application 1:
Model-based stress testing & Risk acceptance thresholds



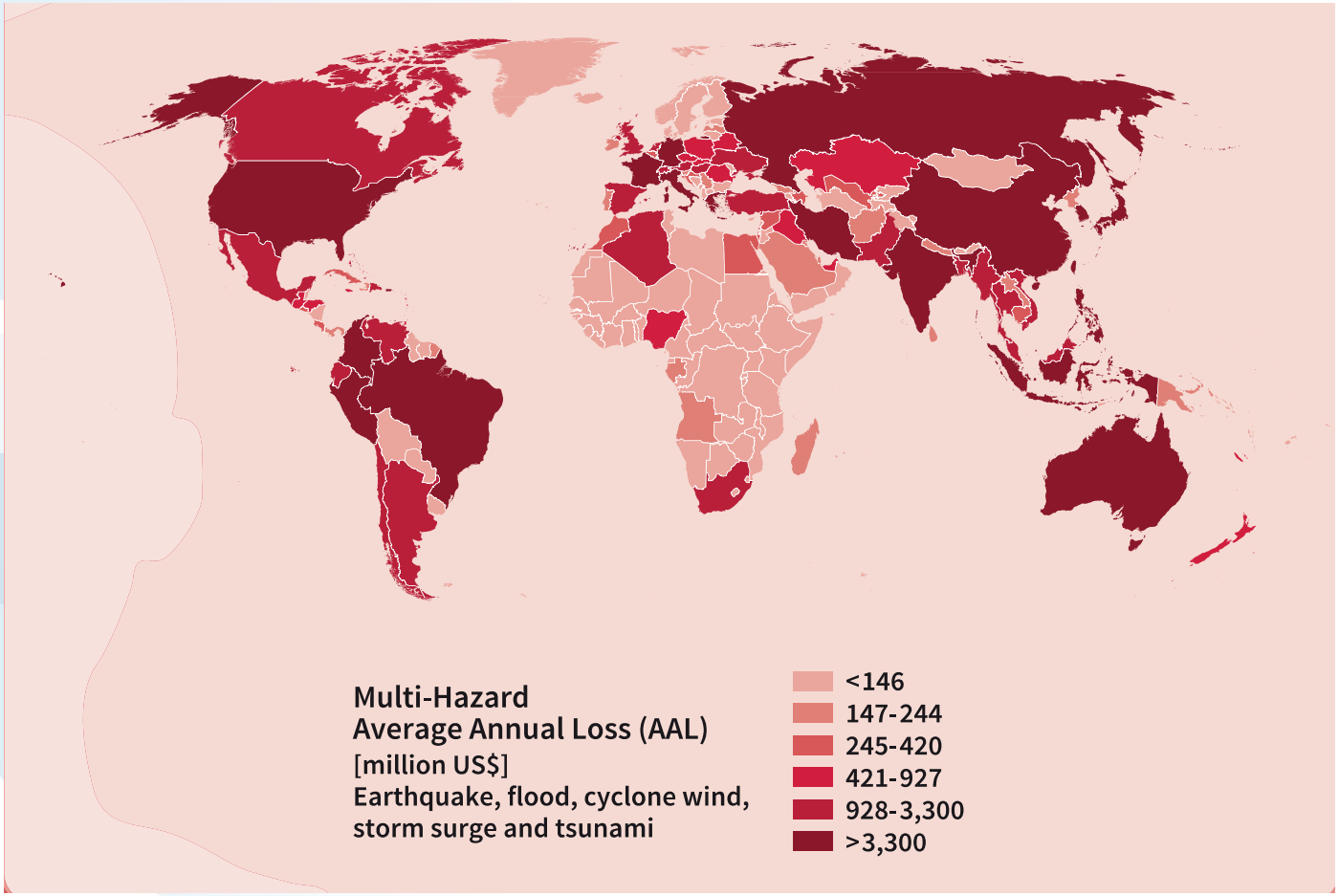
Calculating country-level stress from climate variability
Hochrainer-Stiegler et al., 2014

Modelling risk and risk CATSIM model



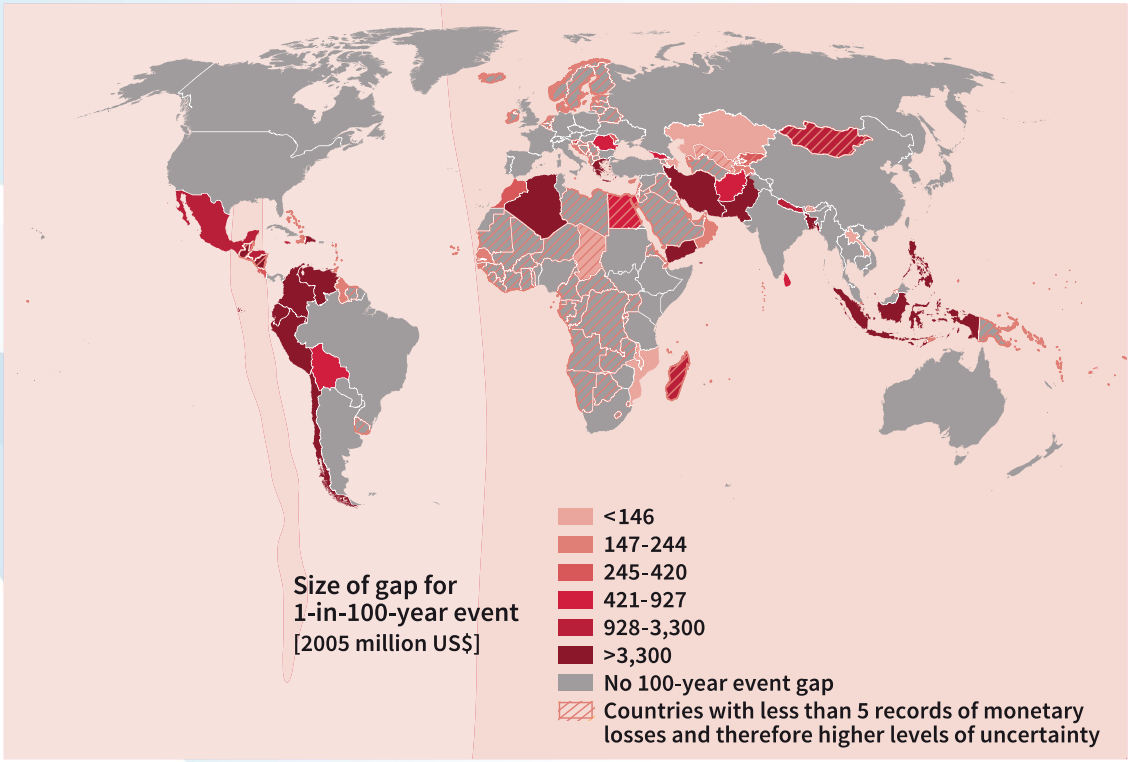
Mechler, Hochrainer, Linnerooth-Bayer, Pflug, 2006

Country-level disaster risk



Global disaster risk today

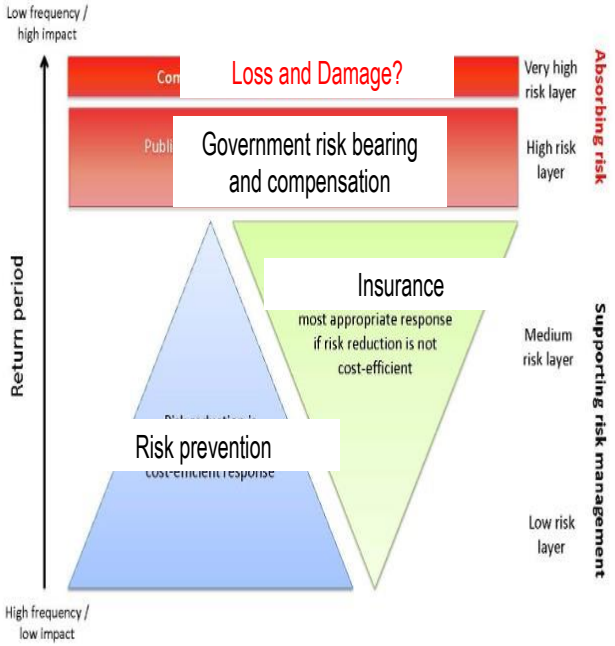
Disaster risk stress testing for 100 year events



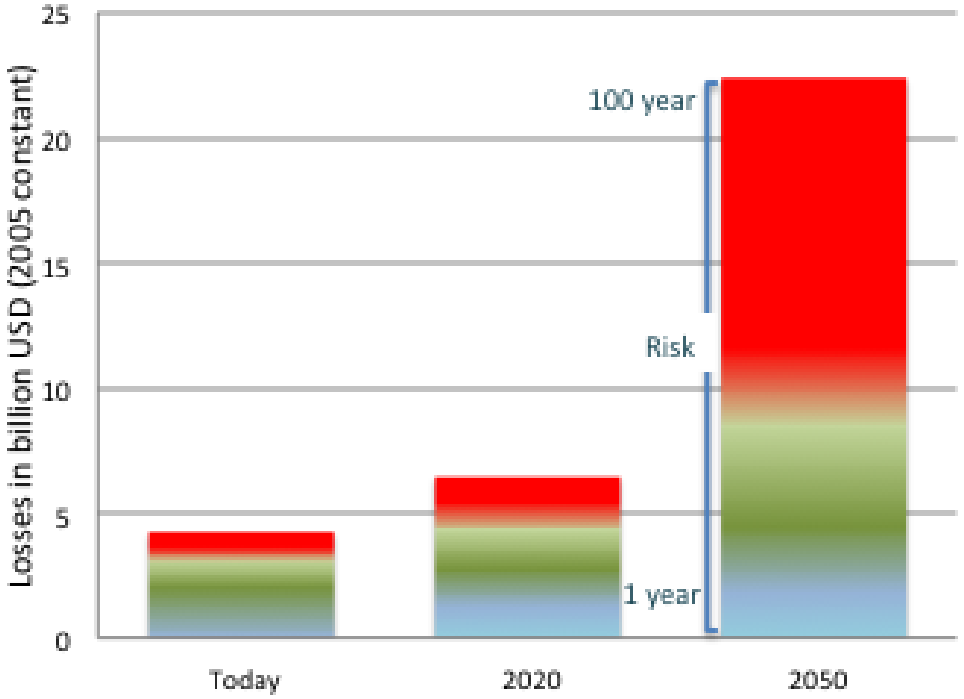
- Compensating all countries for loss and damage beyond their coping capacity
- ~ USD 10 billion annually
- Increasing over time
- Signal for mitigation challenge

IIASA, 2015

Climate risk layering
Example Bangladesh



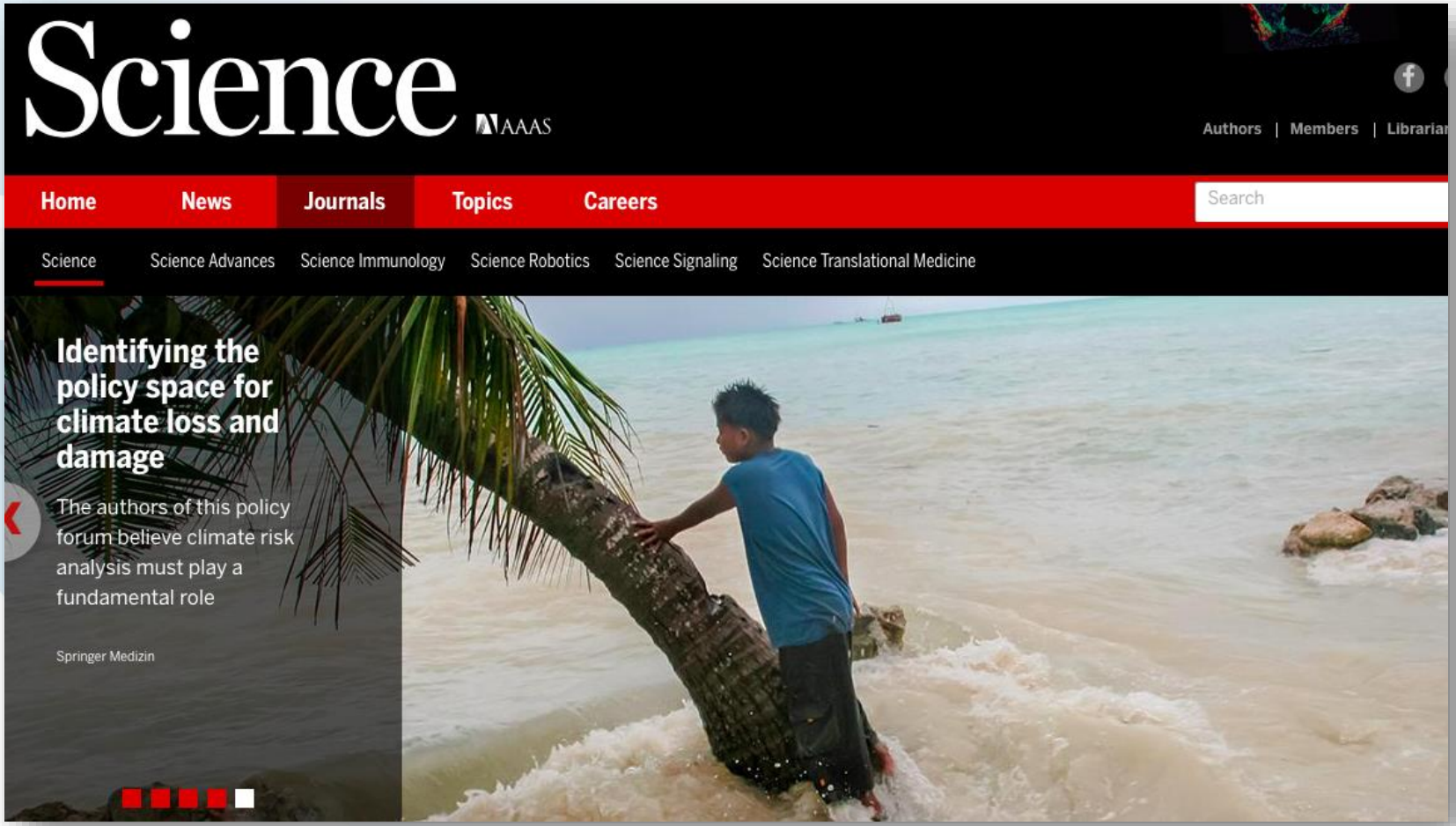
Layering risk management



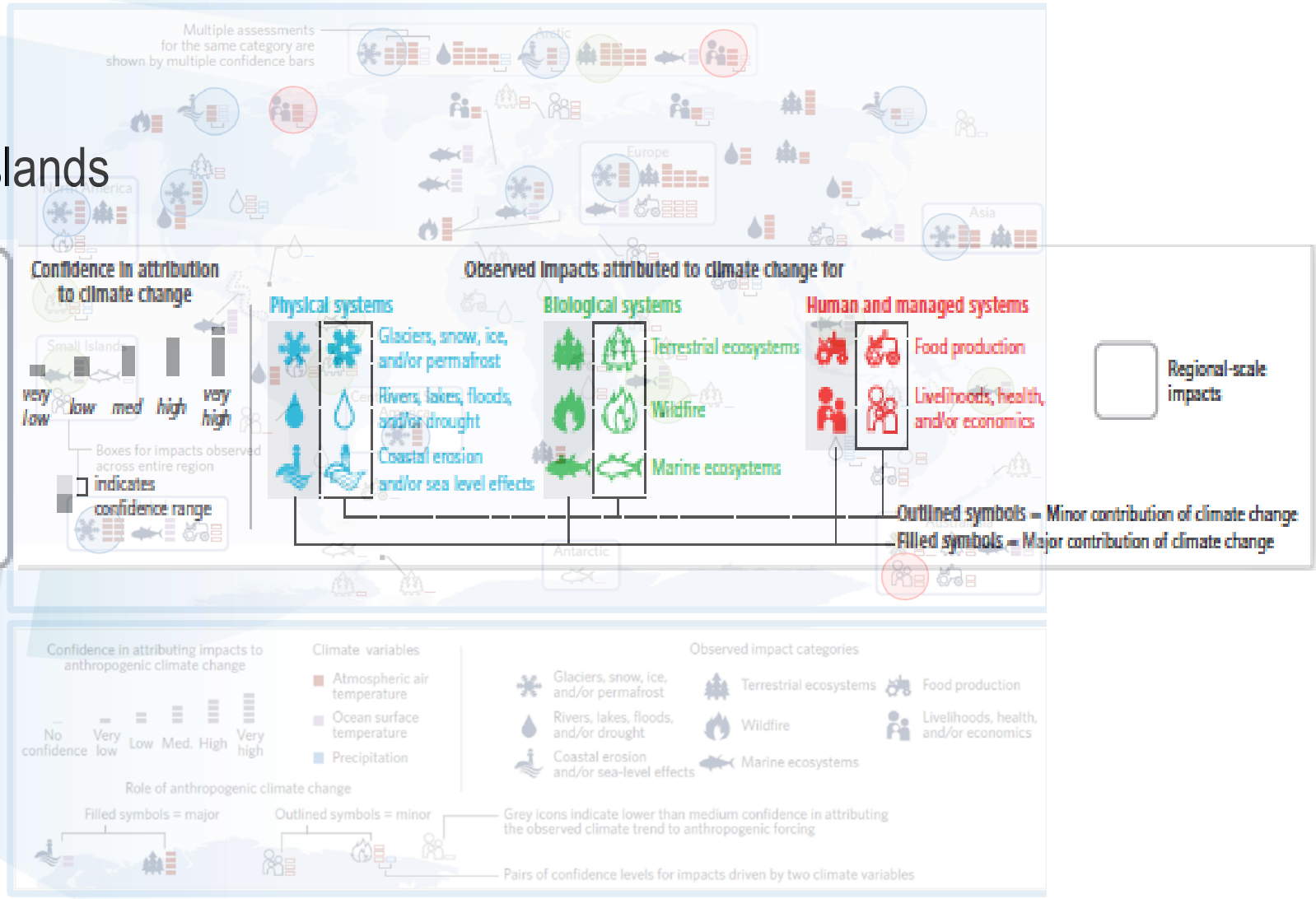
Risk layers with climate change
(B1 scenario and no additional risk reduction)

Based on Mechler and Bouwer, *Climatic Change,* 2015

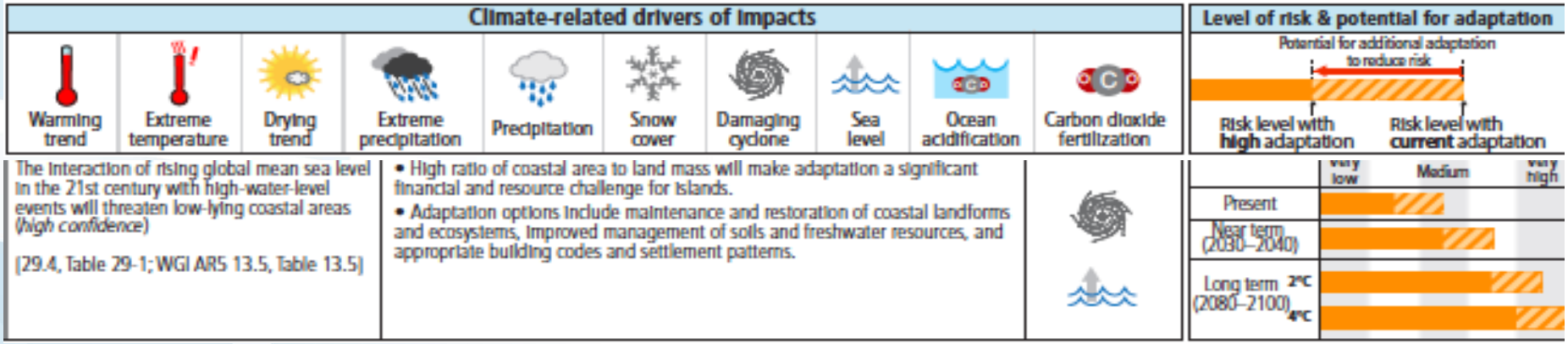
Application 2:
Risk and Policy space for Loss and Damage Small Island States



Small Islands



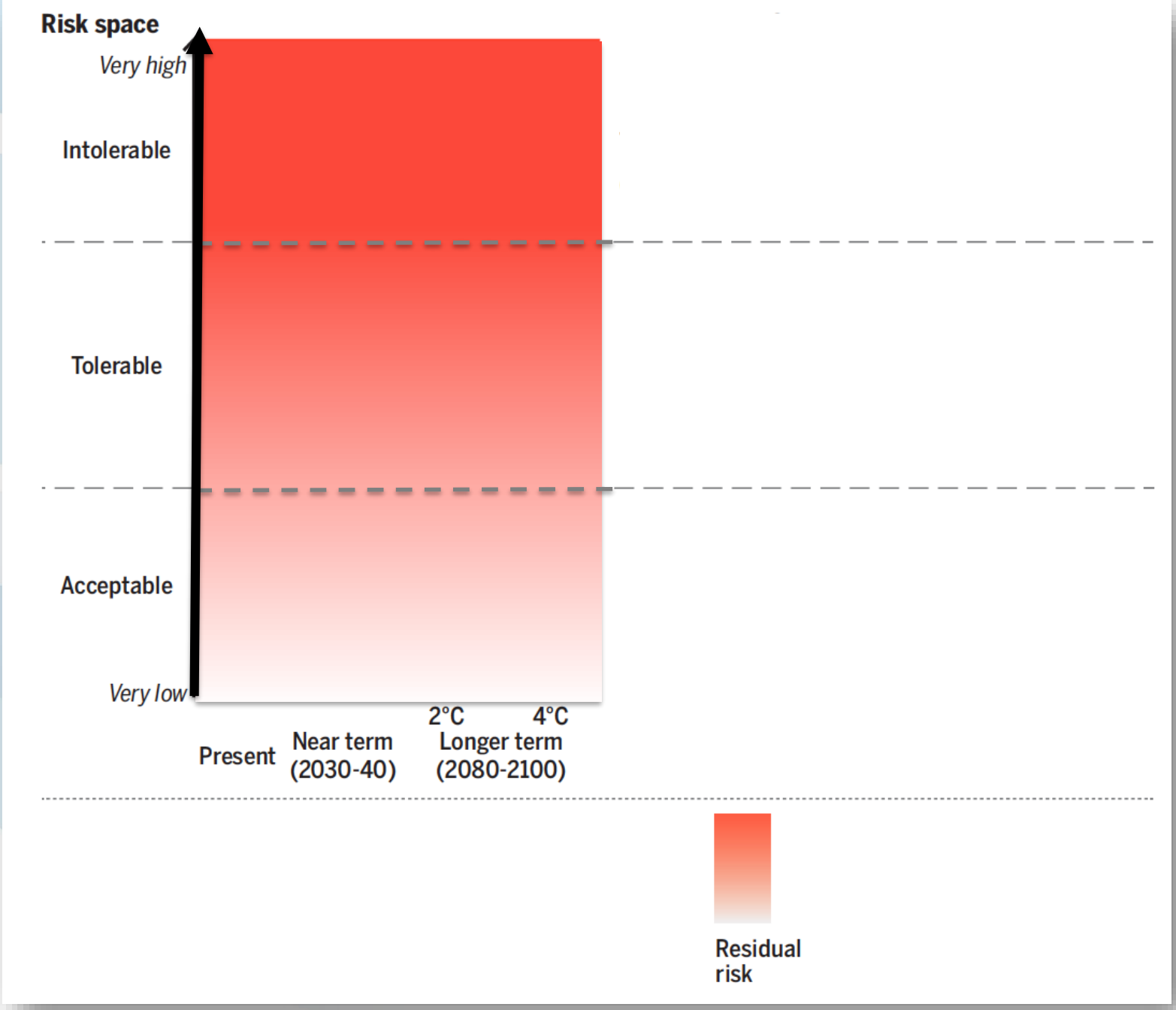
Small Islands: sea level rise and high-water events



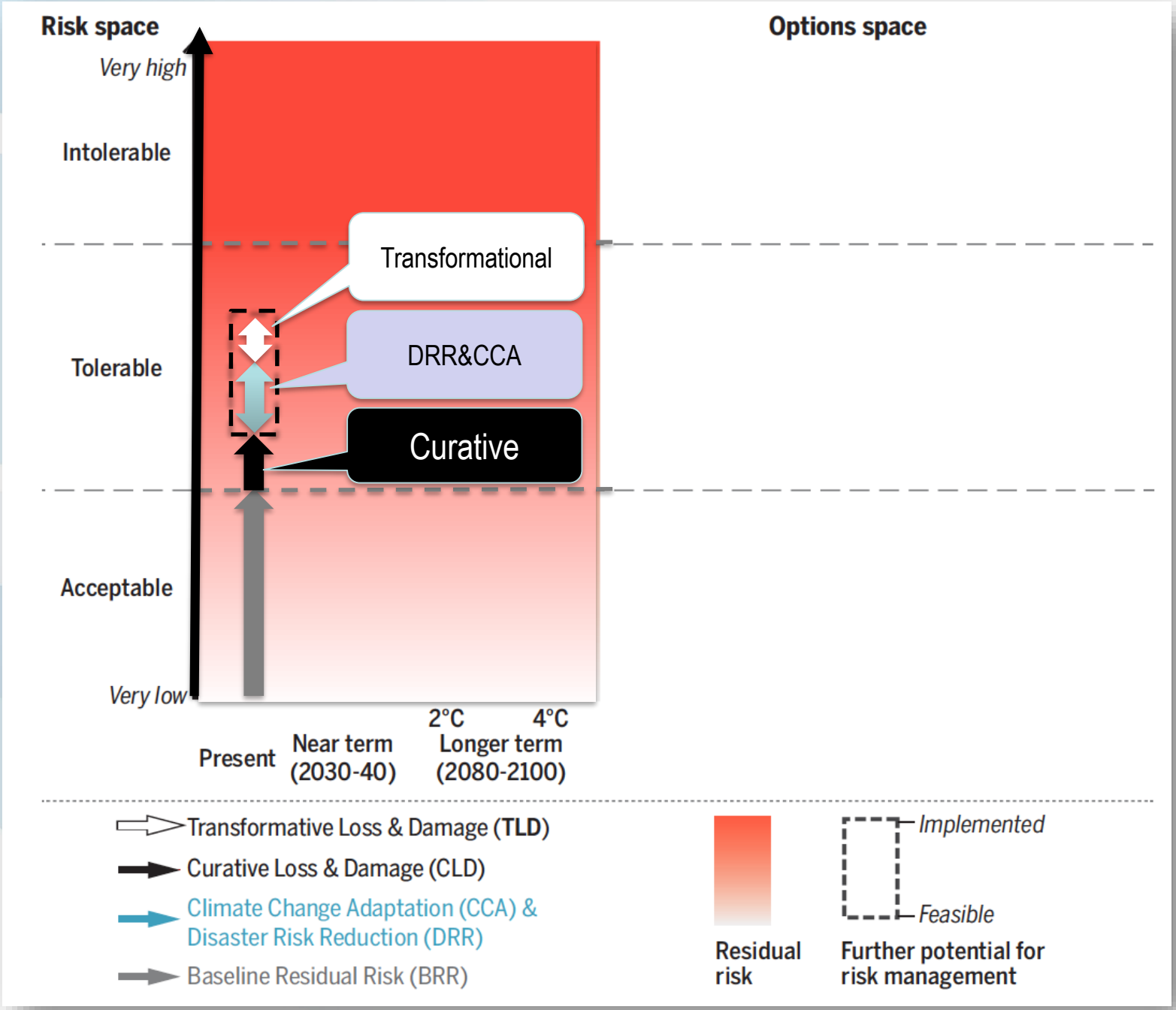
IPCC, 2014

Methods

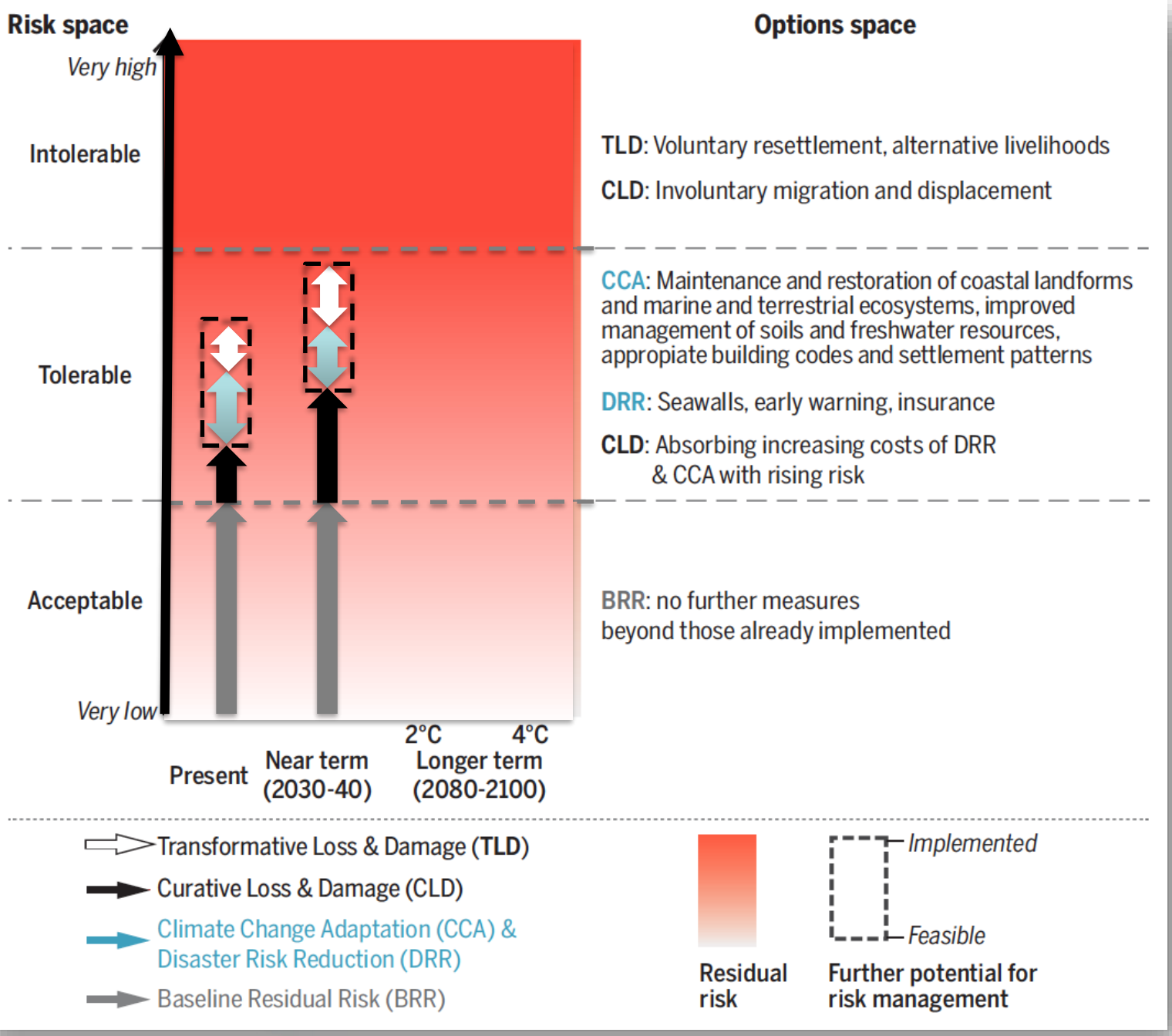
- Key risks as basis
- Literature review
- Reinterpretation of risk reviews to integrate risk tolerance



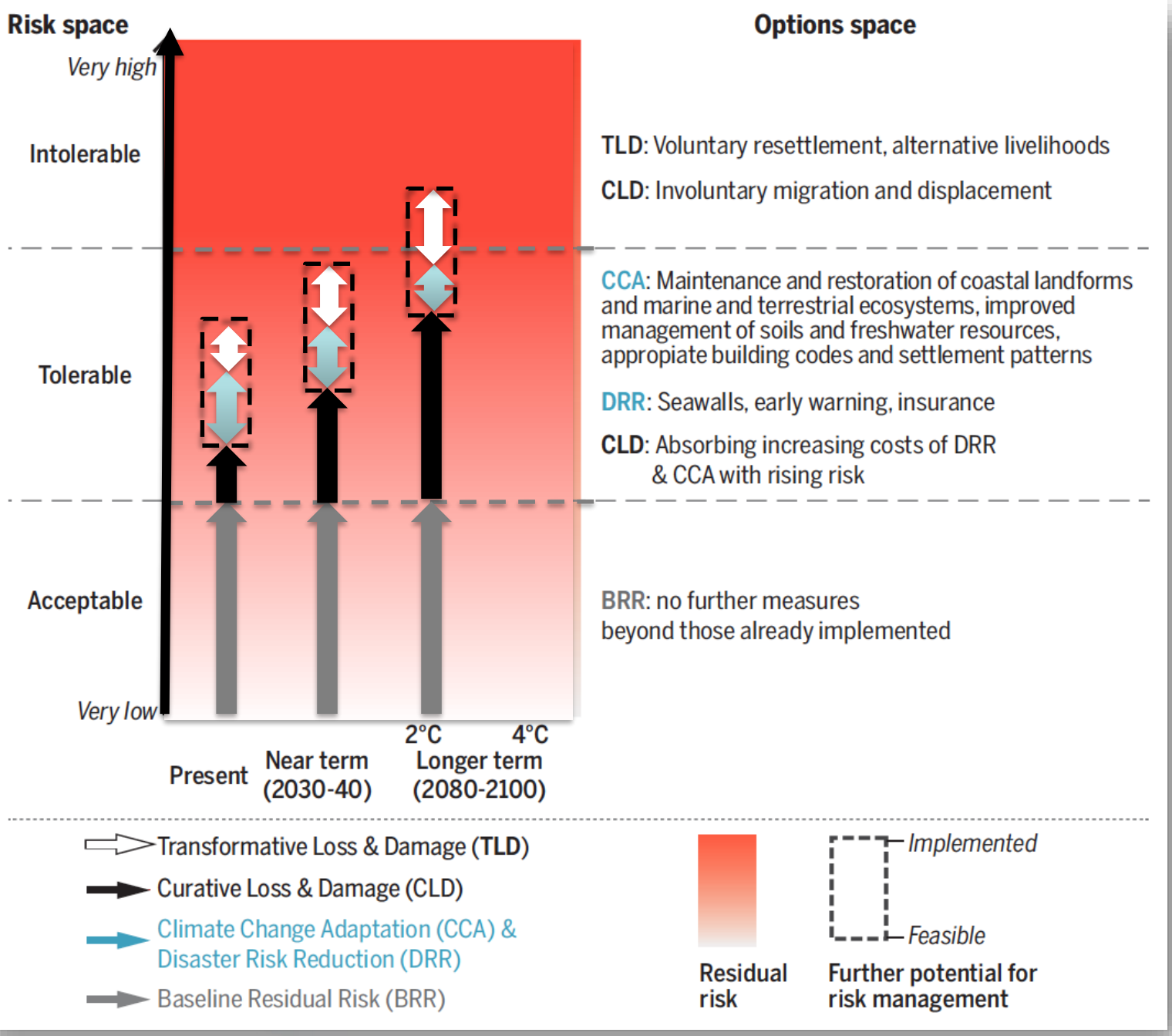
Mechler & Schinko, 2016



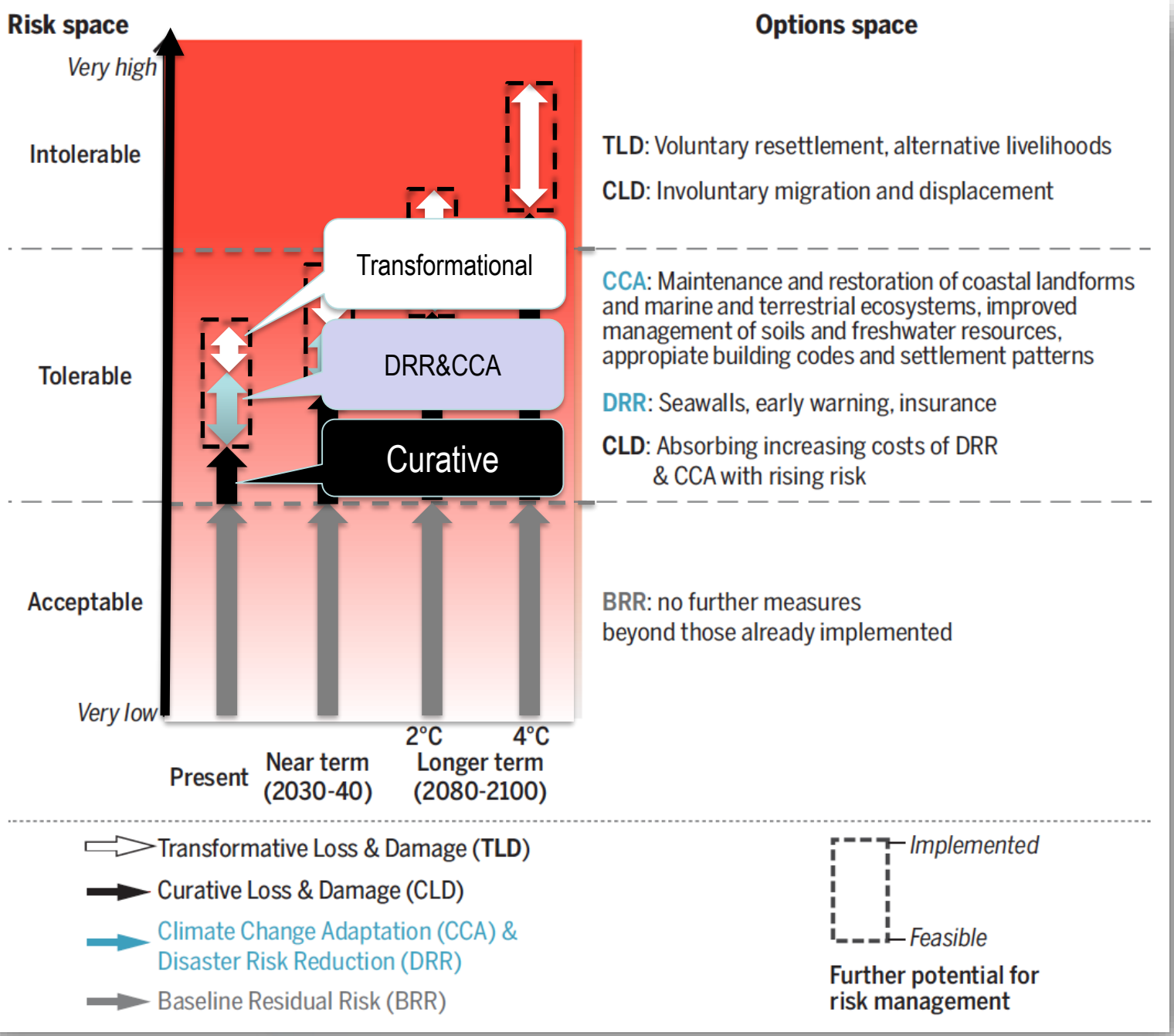
Mechler & Schinko, 2016



Mechler & Schinko, 2016

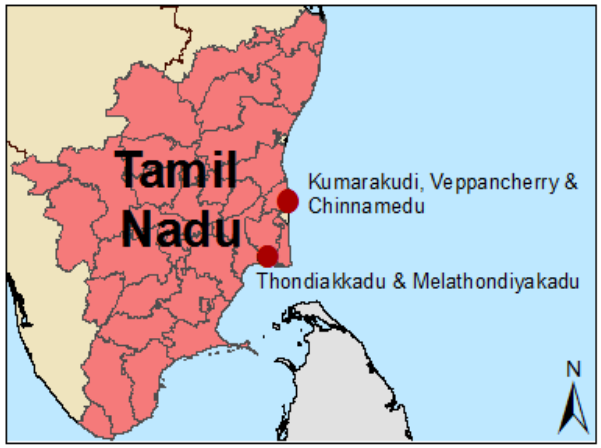


Mechler & Schinko, 2016



Mechler & Schinko Science, 2016

Application 3:
Household survey on risk perception and risk management options -Tamil Nadu, India



Methods

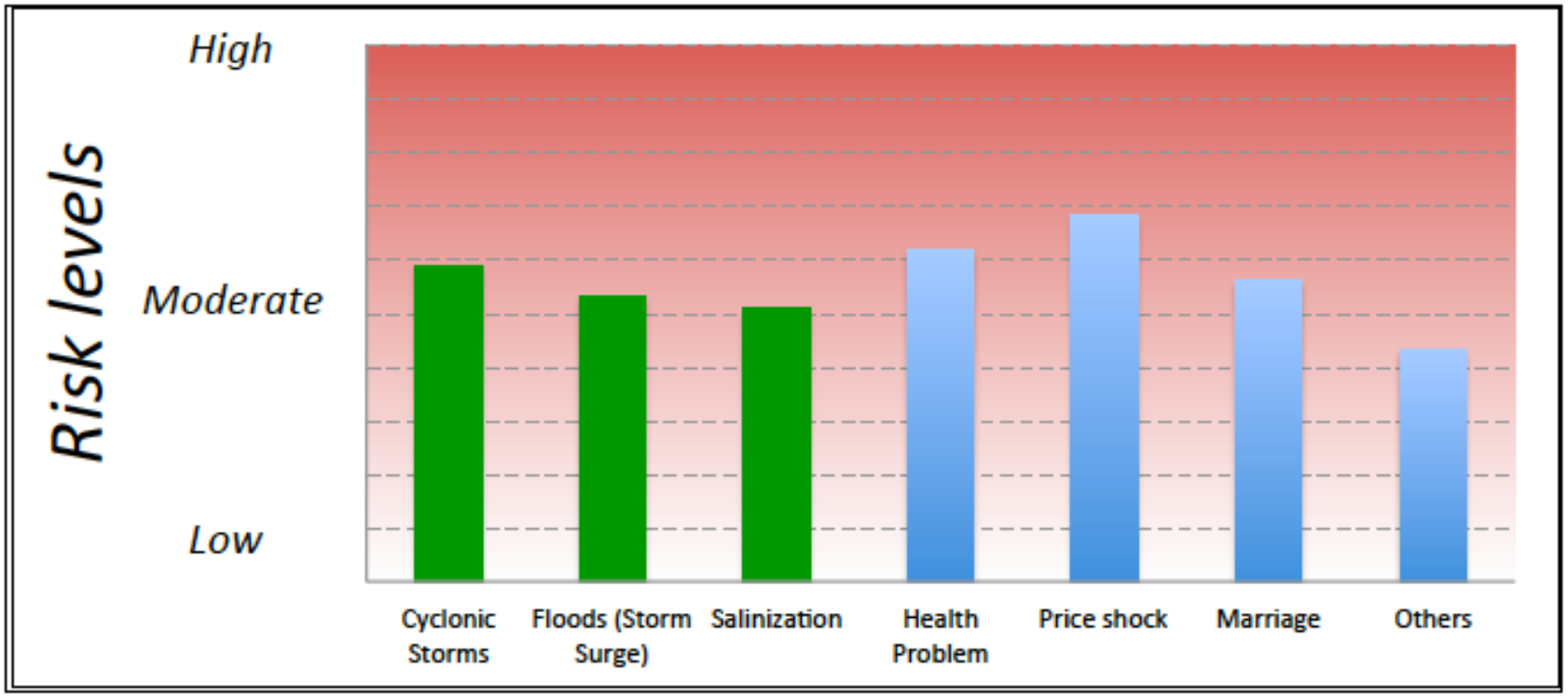
- Household Survey
- Risk-risk comparison
- Categorization of risk responses according to survey responses and risk levels

India Tamil Nadu
Household survey on risk perception and options

Risk and Shocks	Very High & High		Moderate		Low & Very Low		No Response	
	No.	%	No.	%	No.	%	No.	%
Cyclonic Storms	14	21.54	21	32.31	17	26.15	13	20.00
Floods (Storm Surge)	8	12.31	13	20.00	23	35.38	21	32.31
Salinization	13	20.00	6	9.23	40	61.54	6	9.23
Health Problem	22	33.85	6	9.23	18	27.69	19	29.23
Price shock	29	44.62	9	13.85	9	13.85	18	27.69
Marriage	0	0.00	12	18.46	3	4.62	50	76.92
Others	0	0.00	1	1.54	5	7.69	59	90.77

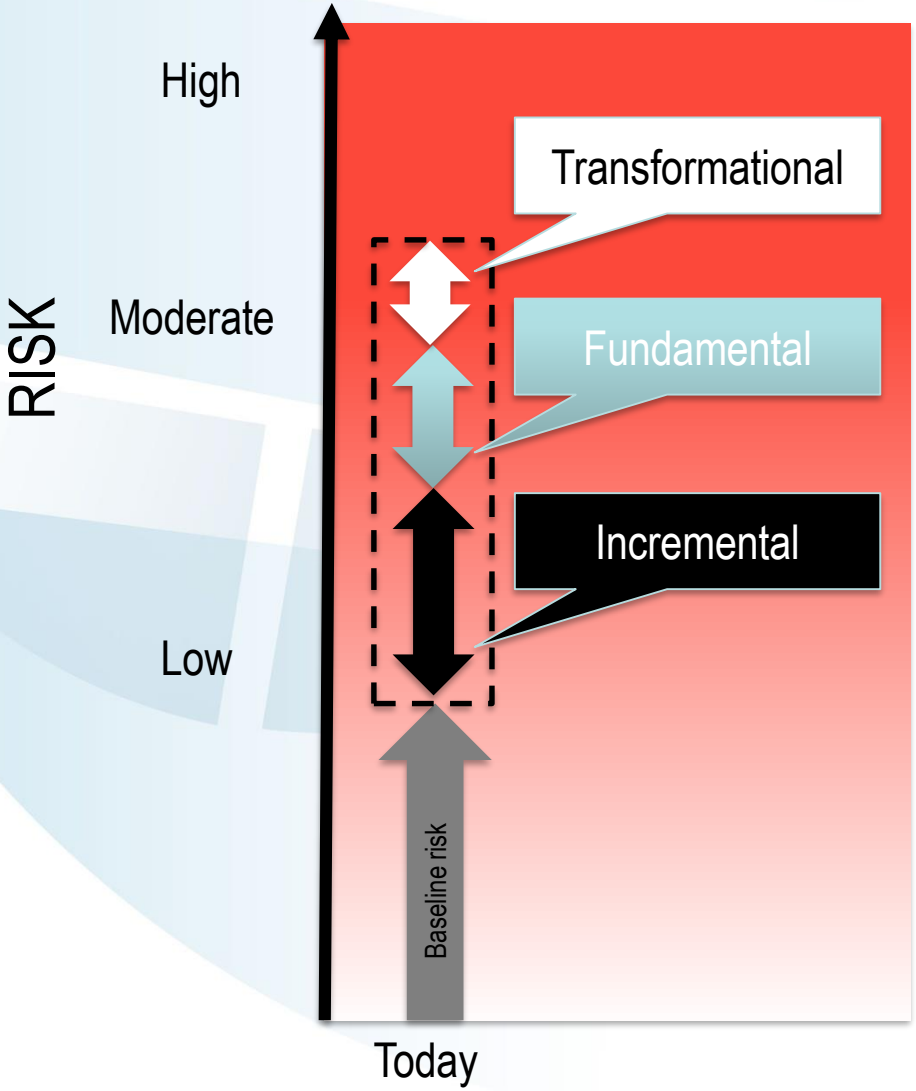
Characteristics	Options	Category
Farm Level	• Farmers keep land uncultivated	Transformative: Negative Coping
	• Salt tolerant high yielding varieties of paddy seeds • Fertilizers (mixed with gypsum)	Fundamental: Non-standard actions for managing risks
	• Agricultural insurance • Sea dyke/bund • Increasing height of field bunds • Desalinization of land • Desilted canal through • Created sand bund with urea bag filled with mud • Constructed overhead water tank • Building up of new pond • Renovation of tank and reservoirs	Incremental: Actions out of DRR and CCA toolbox
Household Level	• Availing both formal and informal loans to smoothen both income and consumption	Fundamental: Non-standard actions for managing risks
	• Repair the damaged nets and boats	Incremental: Actions out of DRR and CCA toolbox
Public Sector	• Public provision of insurance (agriculture and cyclones) • Compensation scheme (only cyclones and during rough season for loss of life, boat and net for fishermen	Incremental: Actions out of DRR and CCA toolbox

Risk perceptions



Risk tolerance for Tamil Nadu as evaluated from household responses

Multiple risks to farming households in Tamil Nadu



Farmers keep land uncultivated and seek alternative livelihoods

Salt tolerant high yielding varieties of paddy seeds
Fertilizers (mixed with gypsum)
Building up of new pond,
Renovation of tank and reservoirs.

Sea dyke/bund
Increasing height of field bunds
Desalinization of land
Desalted canal through MGNREGS for few distance.
Created sand bund with urea bag filled with mud.
Constructed overhead water tank

Risk and options space in Tamil Nadu as identified from household responses (farm level)

GIZ, IIASA, KPMG, 2018

Final remarks

Climate risk methodological approch focusses on **Adaptation** and **Mitigation decisions in the context of Sustainable Development** in order to better

1. Understand today's and future climate related risk from climate change and climate variability
2. Construct risk as determined by socio-economic and climatic risk drivers,
3. Truly support decisions on adaptation and risk management
4. Understand limits of adaptation, impacts of in-action and need for transformation

References
Risk framework

- IPCC (2014). Summary for Policymakers. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1-32.
- WG II volume, particularly chapters
  - 2: Foundations for Decision Making
  - 16: Adaptation Opportunities, Constraints, and Limits
  - 17: Economics of Adaptation
  - 19: Emergent Risks and Key Vulnerabilities
  - 20:Climate-Resilient Pathways: Adaptation, Mitigation, and Sustainable Development
  - WG III, Chapter 2: Integrated Risk and Uncertainty Assessment of Climate Change Response Policies
- Birkmann, J. and Mechler, R. (2015). Advancing climate adaptation and risk management. New insights, concepts and approaches: what have we learned from the SREX and the AR5 processes? *Climatic Change* 33 (1) : 1-6
- Mechler R. and Bouwer, L. (2015). Reviewing trends and projections of global disaster losses and climate change: Is vulnerability the missing link? Climatic Change 33 (1) : 23-35
- IPCC, 2018. Summary for Policymakers. Global Warming of 1.5°C. IPCC, Geneva.
- IPCC, 2019: Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate [H.-O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, M. Nicolai, A. Okem, J. Petzold, B. Rama, N. Weyer (eds.)]. In press.

References
Risk management and policy

- Mechler, R. and T. Schinko (2016). Identifying the policy space for climate loss and damage. Science 354 (6310): 290-292.
- Schinko, Mechler, R. and S. Hochrainer-Stigler (2016). A methodological framework to operationalize climate risk management: managing sovereign climate-related extreme event risk in Austria. Mitigation and Adaptation Strategies for Global Change DOI 10.1007/s11027-016-9713-0
- Mechler R, Bouwer L, Schinko T, Surminski S, Linnerooth-Bayer J (eds) (2018). Loss and Damage from Climate Change. Concepts, Methods and Policy Options. Springer: Cham.