



Source: UFZ, André Künzelmann

Cost assessment of natural hazards – state-of-the-art, knowledge gaps and recommendations

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Objectives of cost assessment

- Naturals hazards cause huge losses
- Cost assessment supports
 - Ex post:
assessments of recent hazards
 - Ex ante:
decisions about allocation of public budget
& efficient risk mitigation
- This requires reliable and comprehensive estimates of costs



Difficulties:

Diversity of terminology and methodological approaches for different hazards and impacted sectors

The CONHAZ project

Costs of Natural Hazards

- Instrument:** Coordination Action Project, EU FP7
*(not a research project,
i.e. no development of new methods)*
- Project duration:** 2/2010 – 2/2012



- 1 Compile state-of-the-art methods** for cost assessment
 - considering different cost types
 - across sectors and hazards;
- 2 Analyse and assess these methods**
assumptions, supporting theories, technical aspects, terminologies, data quality and availability, and research gaps
- 3 Synthesise** resulting knowledge **into recommendations** and identify further **research needs**

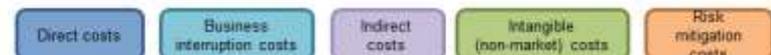
Cost types

Working definition of cost types within CONHAZ:

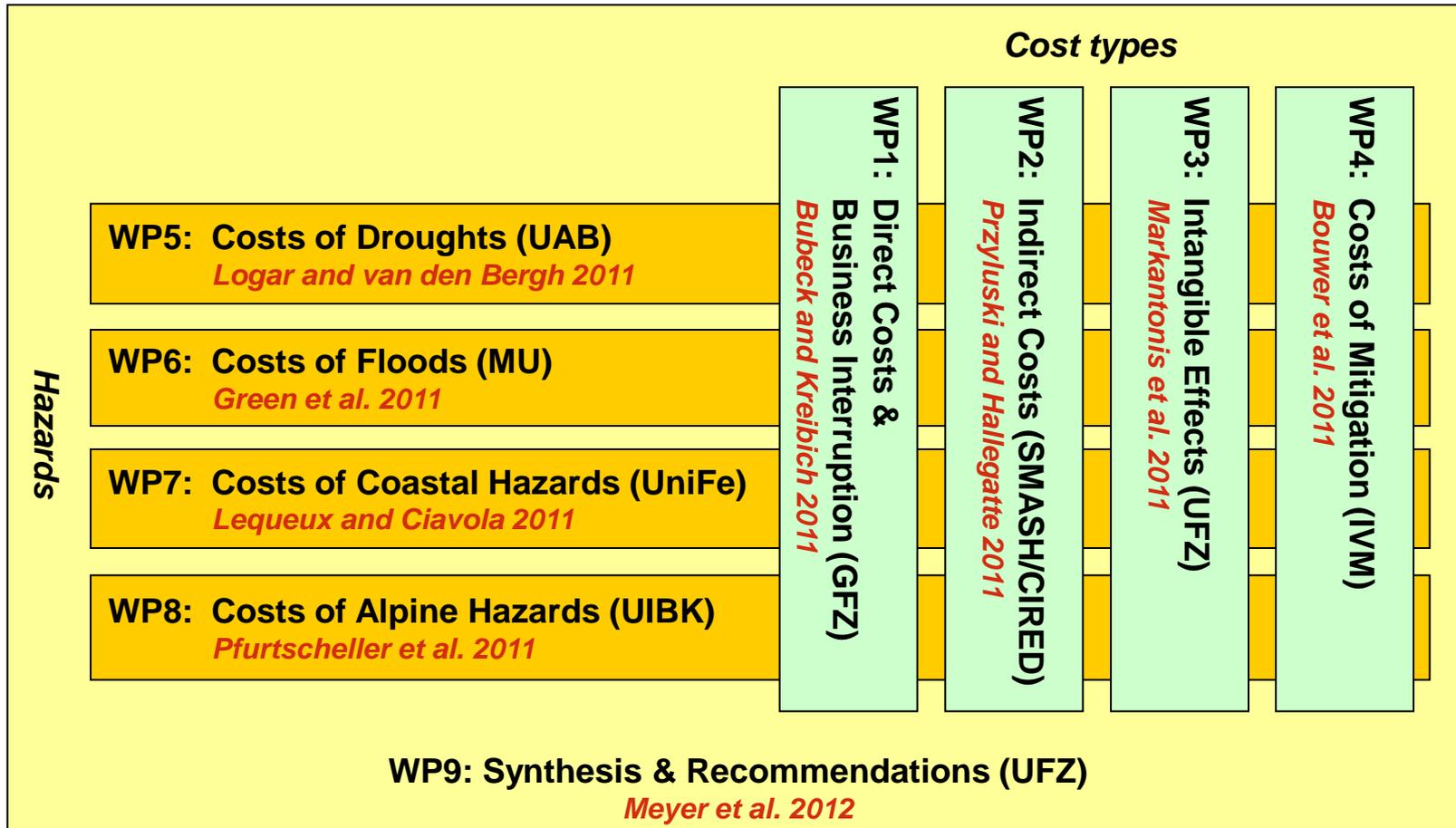
- Direct tangible costs:**
Direct physical impact on economic assets
- Losses due to business interruption:**
Losses due to interruptions in industry, commerce and agriculture directly caused by the hazard
- Indirect costs:**
Induced by direct damages or losses due to business interruption (production losses of suppliers, traffic disruption)
- Intangible (non-market) costs:**
Damages difficult to monetise (adverse health effects, environmental goods and services)
- Mitigation costs:** *Costs of risk reduction*

		Measurement	
		Tangible	Intangible (non-market) costs
Damage costs	Direct	physical damage to assets: - buildings - contents - infrastructure	loss of life - health effects - loss of environmental goods
	Business interruption	- production interruption because of destroyed machinery	- ecosystem services interrupted
	Indirect	- induced production losses of suppliers and customers of companies directly affected by the hazard	- inconvenience of post-flood recovery - increased vulnerability of survivors
Risk mitigation costs	Direct	- set-up of infrastructure - operation & maintenance costs	environmental damage - due to the development of mitigative infrastructure - or due to a change in agricultural practices
	Indirect	- induced costs in other sectors	

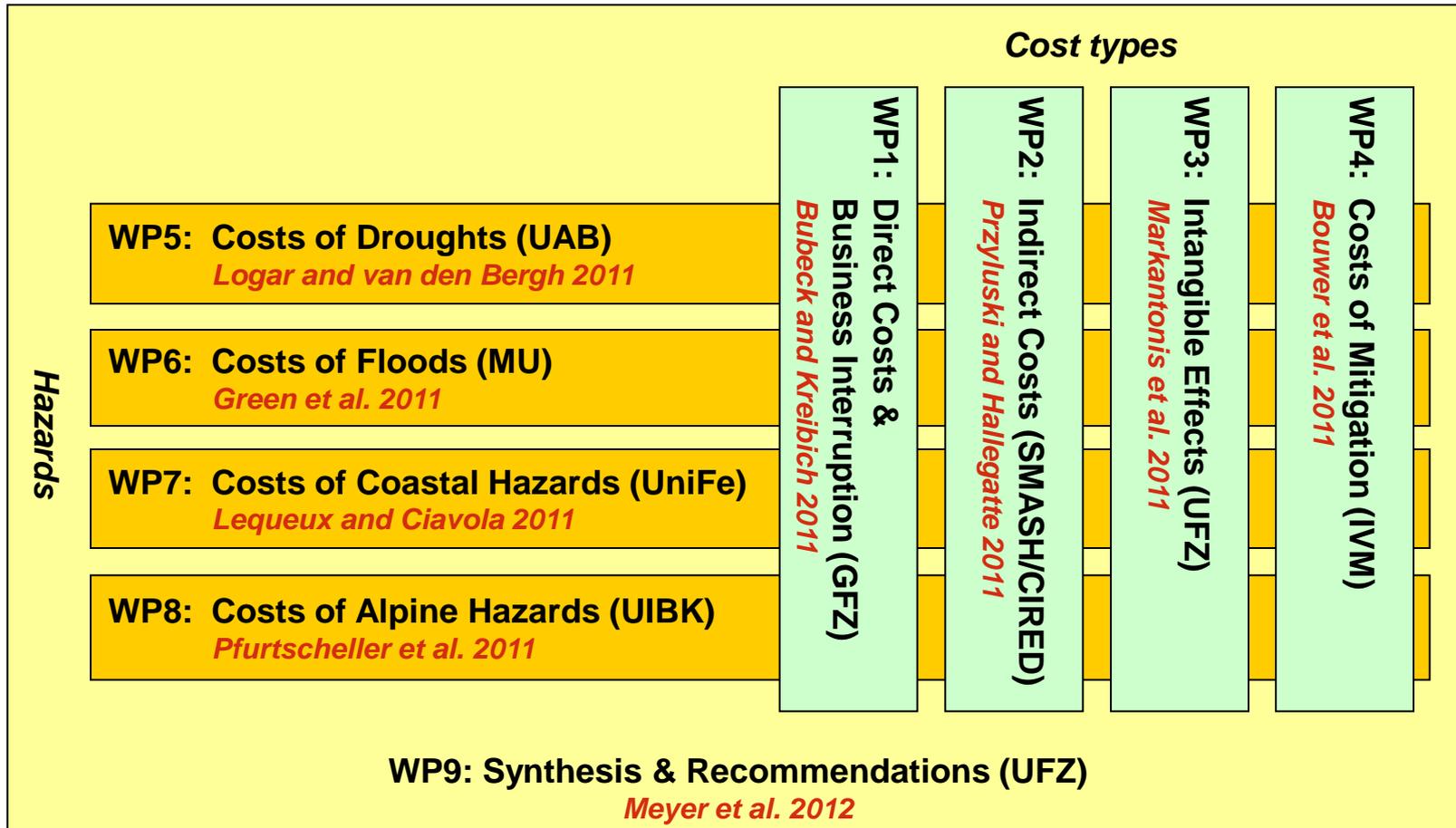
Cost categories applied in this article:



Project structure



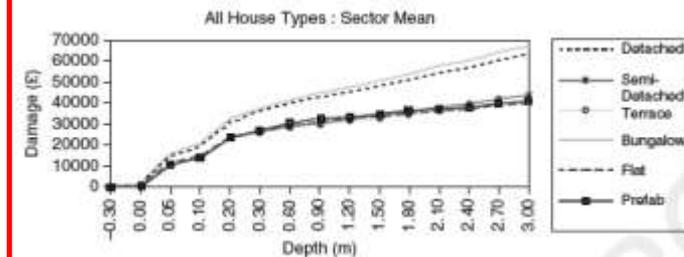
Project structure



Compilation of methods: direct costs

Table 4.1.1 Direct costs: methods, applications and examples.

General method	Specific method	Application and/or examples
Susceptibility function	Single-parameter models (based on single hazard impact parameter)	Floods: Model of ICPR (2001); Model of MURL (2000), adopted by Glade (2003); Model of Hydroteec (Emschergenossenschaft and Hydroteec 2004) Coastal Hazards: Reese, Markau and Sterr (2003) Droughts: Corti <i>et al.</i> (2009) Alpine hazards: Fuchs, Heiss and Hübl (2007b), Huttenlau (2010), Totschnig, Sedlacek and Fuchs (2011)
	Multi-parameter models (based on several hazard impact and /or resistance parameters)	Floods: HAZUS-MH (FEMA, 2011; Scawthorn <i>et al.</i> , 2006); FLEMOps and FLEMOcs models (Apel <i>et al.</i> , 2009; Elmer <i>et al.</i> , 2010; Kreibich <i>et al.</i> , 2010; Thieken <i>et al.</i> , 2008); Model of Multicoloured Manual (Penning-Rowsell <i>et al.</i> , 2003); HIS-SSM (Kok <i>et al.</i> , 2004); Model of Maiwald and Schwarz (2010) Coastal hazards: FEMA (2011), HIS-SSM (Kok <i>et al.</i> , 2004), Nadal <i>et al.</i> (2010) Alpine hazards: BUWAL (1999), Keiler <i>et al.</i> (2006), Holub, Suda and Fuchs (2012)
Market valuation techniques	Market price method	Drought: Grafton and Ward (2008)
Integrated Assessment Analysis	Biophysical-Agroeconomic Models	Droughts: Holden and Shiferaw (2004), Fischer <i>et al.</i> (2005)
	Hydrological-Economic Models	Droughts: Booker, Michelsen and Ward (2005), Ward, Booker and Michelsen (2006), Grossmann <i>et al.</i> (2011)
Computable General Equilibrium Analysis	Computable General Equilibrium Models	Droughts: Horridge, Madden and Wittwer (2005)



Compilation of methods: business interruption

Table 4.1.2 Business interruption costs: methods, applications and examples.

General method	Specific method	Application and/or examples
Sector specific reference values or models	Loss of value added	MURL (2000), Laternser (2000), SLF (2000), BMLFUW (2008a,b)
Event analysis	Sector specific models Comparison hazard and non-hazard time periods based on reported cost figures	For transport: Department for Transport (2009) Benson and Clay (1998), COPA-COGECA (2003), Fink <i>et al.</i> (2004), Martin-Ortega, González-Eguino and Markandya (2012), Rijkswaterstaat (2004), Nöthiger (2003)
Share of direct damage	Fixed share of direct damage estimates	ANUFLOOD (NR&M 2002), RAM (NRE 2000)

Compilation of methods: indirect costs

Table 4.1.3 Indirect costs: methods, applications and examples.

General method	Specific method	Application and/or examples
Event analysis	Surveys at firm level	Boarnet (1998), Kroll <i>et al.</i> (1991), Tierney (1997)
Econometric approaches	Surveys at the household level	McCarty and Smith (2005)
	Gross regional product effect assessment	Noy and Vu (2009), Strobl (2010)
	National Gross domestic product effect assessment	Albala-Bertrand (1993), Cavallo and Noy (2009), Hochrainer (2009), Jaramillo (2009), Noy (2009), Loayza <i>et al.</i> (2009), Noy and Nualsri (2007), Raddatz (2009), Skidmore and Toya (2002)
Input-Output Analysis	Input-Output Models	Hallegatte (2008), HAZUS-E (see also McCarty and Smith, 2005), Haimes <i>et al.</i> (2005), Okuyama, Hewings and Sonis (2004), Rose and Liao (2005), Rose and Miernyk (1989)
Computable General Equilibrium Analysis	Computable General Equilibrium Models	Berritella <i>et al.</i> (2007), Boyd and Ibararán (2009), Horridge, Madden and Witwer (2005), Pauw, Thurlow and van Seventer (2010), Rose, Oladosu and Liao (2007), Tsuchiya, Tatano and Okada (2007), Wittwer and Griffith (2010)
Intermediate models	Hybrid Input-Output / Computable General Equilibrium Models	Hallegatte (2008), Rose, Oladosu and Liao (2007)
Public Finance Analysis	Analysis of the impact on public finance	Mechler, Linnerooth-Bayer and Peppiatt (2006)
Idealized Models	Modeling interactions of hazard impacts with technical change	Hallegatte and Dumas (2008), Hallegatte and Ghil (2008)

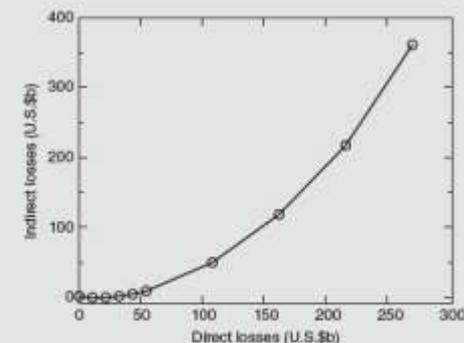


Figure 4.1.7 The direct losses – indirect (output) losses as a function of direct (asset) losses, in Louisiana for Katrina-like disasters. Source: Hallegatte (2008). Reproduced with permission of Wiley.

Compilation of methods: intangible (non-market) costs

Table 4.1.4 Intangible effects: methods, applications and examples.

General method	Specific method	Application and/or examples
Revealed preferences methods	Travel Cost method	Hartje, Meyer and Meyerhoff (2001)
	Hedonic Pricing method	Hamilton (2007), Chao, Floyd and Holliday (1998), Cavailhes <i>et al.</i> (2009)
	Cost of Illness approach	DEFRA (2007)
	Replacement Cost method	Leschine, Wellman and Green (1997)
	Production Function Approach	n.a.
Stated preferences methods	Contingent Valuation method	Birol, Karousakis and Koundouri (2006), Daun and Clark (2000), DEFRA (2004), Leiter and Pruckner (2007), Pattanayak and Kramer (2001b), Turner, Doktor and Adger (1993), Zhai and Ikeda (2006), Zhongmin <i>et al.</i> (2003)
	Choice Modelling method	Brouwer and Schaafsma (2009), Daun and Clark (2000), Hensher, Shore and Train (2006), Olschewski <i>et al.</i> (2011)
	Life Satisfaction Analysis	Carroll, Frijters and Shields (2009)
Benefit or Value Transfer methods		Martin-Ortega, González-Egiuno and Markandya (2012)

Knowledge Gaps & Recommendations

Comprehensiveness:

Cost assessments still biased, incomplete

Focus of practice (and methods) still very much **on direct costs**,
indirect and intangible costs often neglected

→ also consider

- costs due to business interruption
- indirect costs
- intangible/non-market costs

→ **complete picture** of the costs of natural hazards

→ **all relevant information** for supporting decisions

Uncertainty and Validation

Cost assessment still very uncertain

Still very **high uncertainties** in all parts of cost assessment

- improve the availability and quality of **data**
(see recommendations on data)
- advance **models**
(see recommendations on methods).

However: all data and cost estimations are **inaccurate to some extent**

- **documentation & communication** of remaining uncertainties

Lack of **ex post data** availability and quality

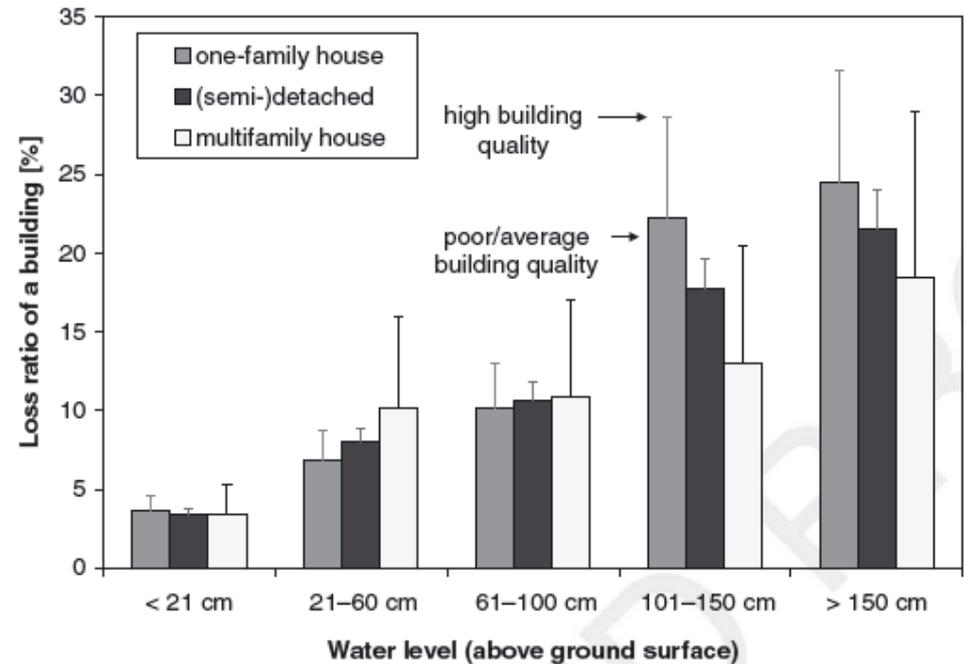
- ex post damage data
 - Data on costs of mitigation
-
- **framework** for supporting data collection on European level
 - **minimum data quality standards**
 - **consistency** of European and national databases

Improvement of methods

1. shock to the system – direct costs

Simple **one-parameter models** may lead to inaccurate estimates

- better capture the **variety of damage influencing parameters**
- **multi-parameter** damage models
- **resistance** parameters



Source: Thieken et al. 2008

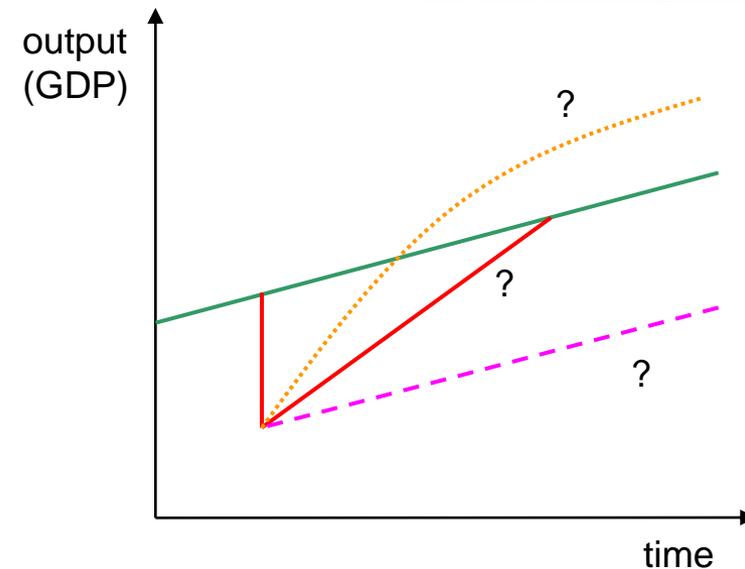
Link to indirect cost assessment still weak...

Improvement of methods

2. Indirect, economic system

Little understanding of the **economic response to external shocks**

- More research how markets function outside equilibrium,
 - **role of networks**
 - **dynamics of return to equilibrium**



Improvement of methods

3. intangible, non-market

Intangible costs rarely considered in cost assessments

Monetary valuation methods are available,
but not often applied in practice

Physical processes/impacts of natural hazards
on environment and health often not well understood

- Better estimation of ecological impacts, health effects
- Better inclusion into the decision making process:
- **Multi-Criteria Analysis** framework
(non-monetary)
- or **Cost-Benefit Analysis** framework
(monetarisation necessary)



Improvement of methods

4. costs of mitigation

Costing of mitigation measures focus on estimating **direct costs**, especially **investment costs**

- More attention to **operation and maintenance costs**, **indirect** and **intangible costs** of mitigation measures

Non-structural measures often not considered in decision support frameworks

- better estimation of the **costs of non-structural measures**, together with structural alternatives



Future dynamics

most ex ante cost assessments assume current risk situation

Dynamics of risk drivers not often considered in cost assessment

- More **research** is needed on **effects of climate and socio-economic change** on the future costs
- how to integrate such dynamics in cost assessment approaches



Distribution of costs and risk transfer

How are costs (and risks) **distributed within society**:
who pays, who benefits etc.?

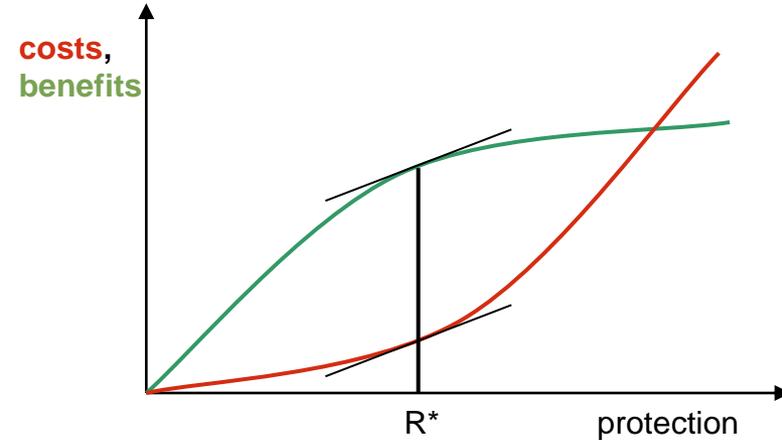
- more research is needed on the distribution of the costs:
- on potential **risk transfer systems** (including insurance)
- effect on **society's ability to recover**
& influence total damage costs
- **incentives** for risk mitigation



Decision support

cost assesement for better decision support

- Cost estimations often **incomplete** & to some degree **uncertain**
- **Optimisation will remain an illusion** (by means of Cost-Benefit Analysis)



→ **Need for decision support tools & guidance**

- consider & communicate uncertainties
- transparent
- participatory
- iterative



see www.conhaz.org

Cost type reports:

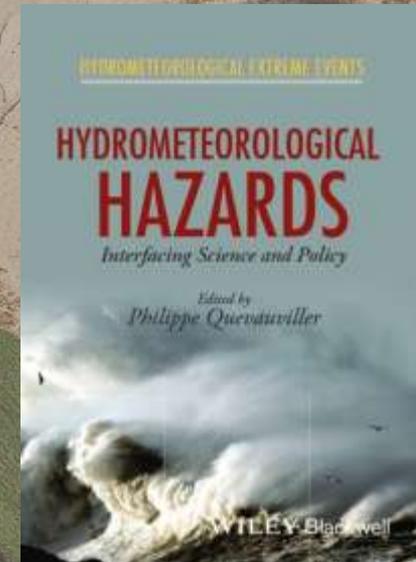
- direct costs and costs due to business interruption (Bubeck and Kreibich 2011)
- indirect costs (Przyluski and Hallegatte 2011)
- costs due to intangible, non-market effects (Markantonis et al. 2011)
- costs of risk mitigation (Bouwer et al. 2011)

Hazard types reports:

- droughts (Logar and van den Bergh 2011)
- floods (Green et al. 2011)
- coastal hazards (Lequeux and Ciavola 2011)
- Alpine hazards (Pfurtscheller et al. 2011)

Synthesis Report, Papers & book chapters:

- Meyer et al. 2012 (synthesis report)
- Meyer et al. 2013 (in NHESS)
- Kreibich et al. 2014 (in Nature Climate Change)
- Meyer et al. 2014 (in Quevauviller 2014)



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