Adaptation to climate change: soft vs. hard adaptation

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1. Adaptation is not an easy task

Adaptation is not an easy task

- Adaptation will require **technical know-how** and **substantial funding.**
- Adaptation requires coordination between individual actions (e.g., farmers) and public policies (e.g., water management).
- Adaptation requires political will and the presence of adequate institutional structures (e.g., risk management).

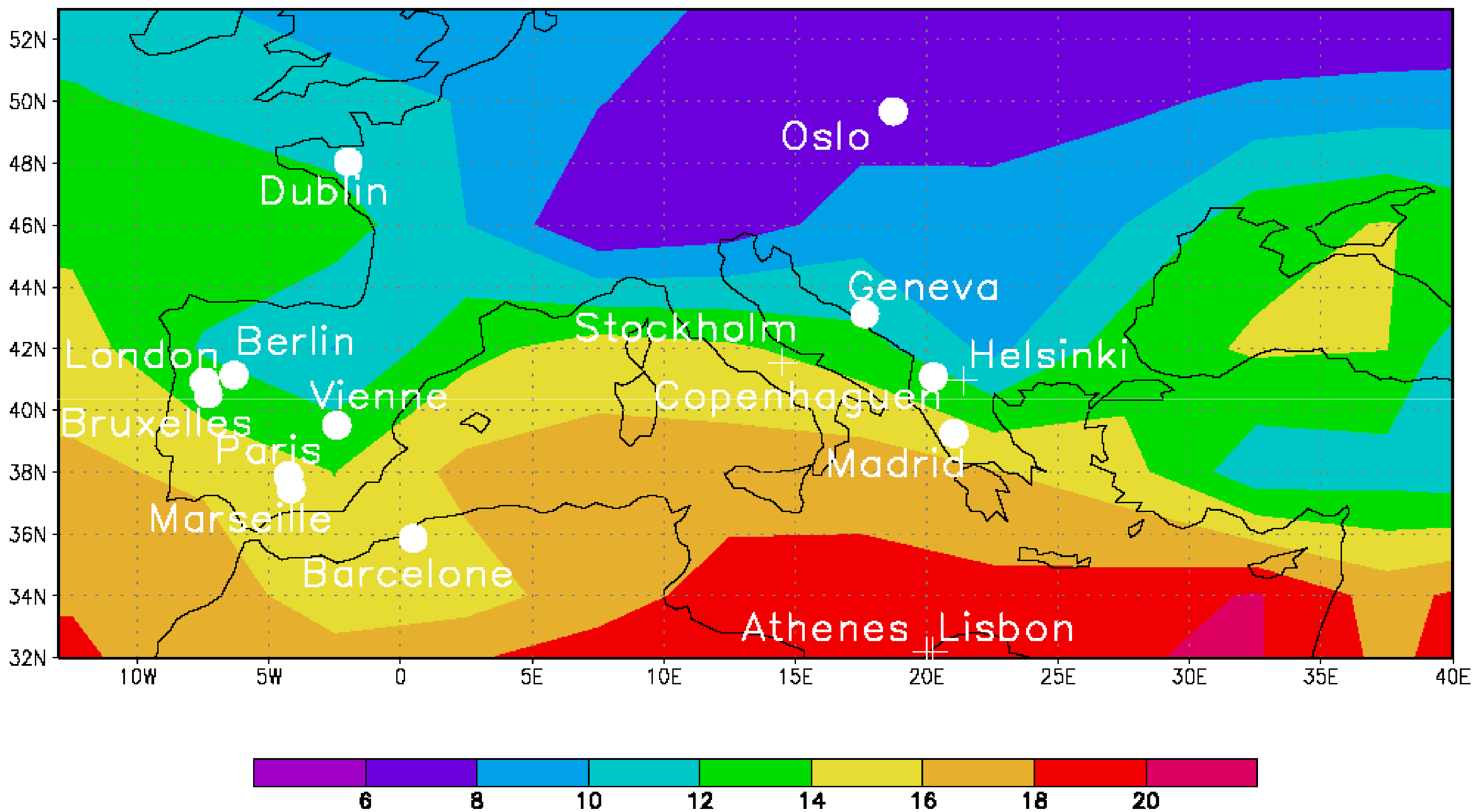
- **Adaptation requires also anticipation**, especially in sectors with long-term investments:
  - Water management infrastructure (lifetime: up to 200 years);
  - Energy production and distribution infrastructure (up to 80 years);
  - Transportation infrastructure (50 to 200 years) ;
  - Natural disaster protections (50 to 200 years);
  - Urbanism, housing and architecture (25 to 150 years).

- These infrastructures represent about 300% of GDP in developed countries;

- Anticipation is difficult, for two reasons.

Adapting to a changing climate

Climate analogues in 2070, Hadley Centre Model, SRES A2



It is neither more difficult nor expensive to design a building for the Cordoba climate than for the Paris climate. But it is more difficult (and more expensive) to design a building able to cope with both climates.

After Hallegatte, Ambrosi, Hourcade (2007)

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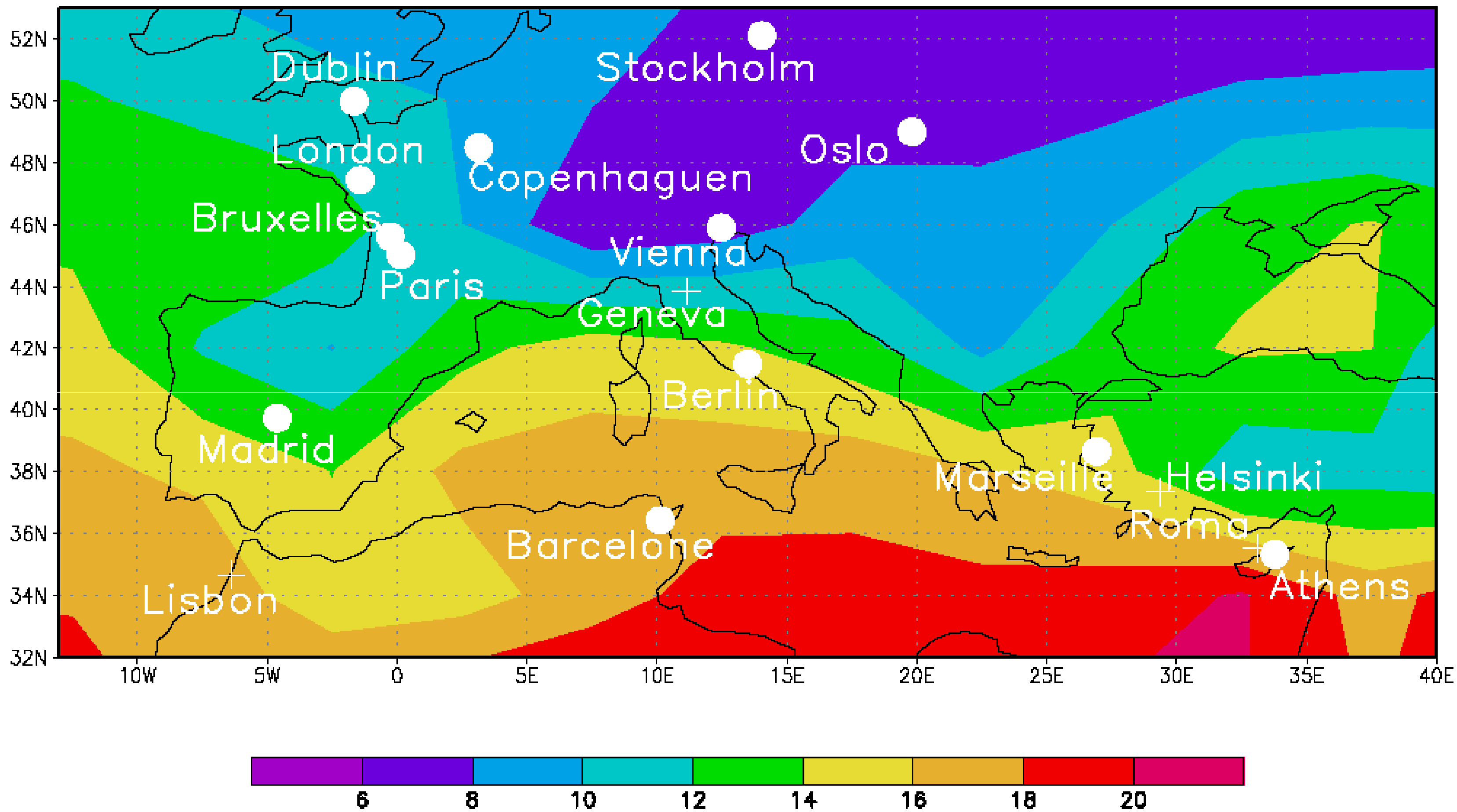
Coping with uncertainty

Climate analogues in 2070, Météo-France Model, SRES A2



After Hallegatte, Ambrosi, Hourcade (2007)

Adaptation costs will be larger where uncertainty is larger.
New strategies are required to cope with this uncertainty.

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2. Adaptation strategies able to cope with uncertainty

Looking for robustness

- Selecting no-regret strategies yielding benefits even in absence of climate change
  - Improvement in building norms to make buildings cheaper to heat and air-condition
- Selecting “safety margin” strategies increasing robustness at low cost:
  - Drainage infrastructures in Copenhagen.
- Favoring reversible strategies over irreversible ones:
  - Example of urbanization plans in flood-prone areas.
- Reducing investment lifetimes:
  - Forestry sector and tree rotation time;
- Taking into account synergies and conflicts between adaptation strategies and between adaptation and mitigation
  - Snow-making and water availability in mountain areas;
  - Water desalinization and uncertainty on future energy cost.
- “Soft” adaptation options are often more flexible than “hard” adaptation:

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3. Soft vs. hard adaptation strategies for natural disaster management

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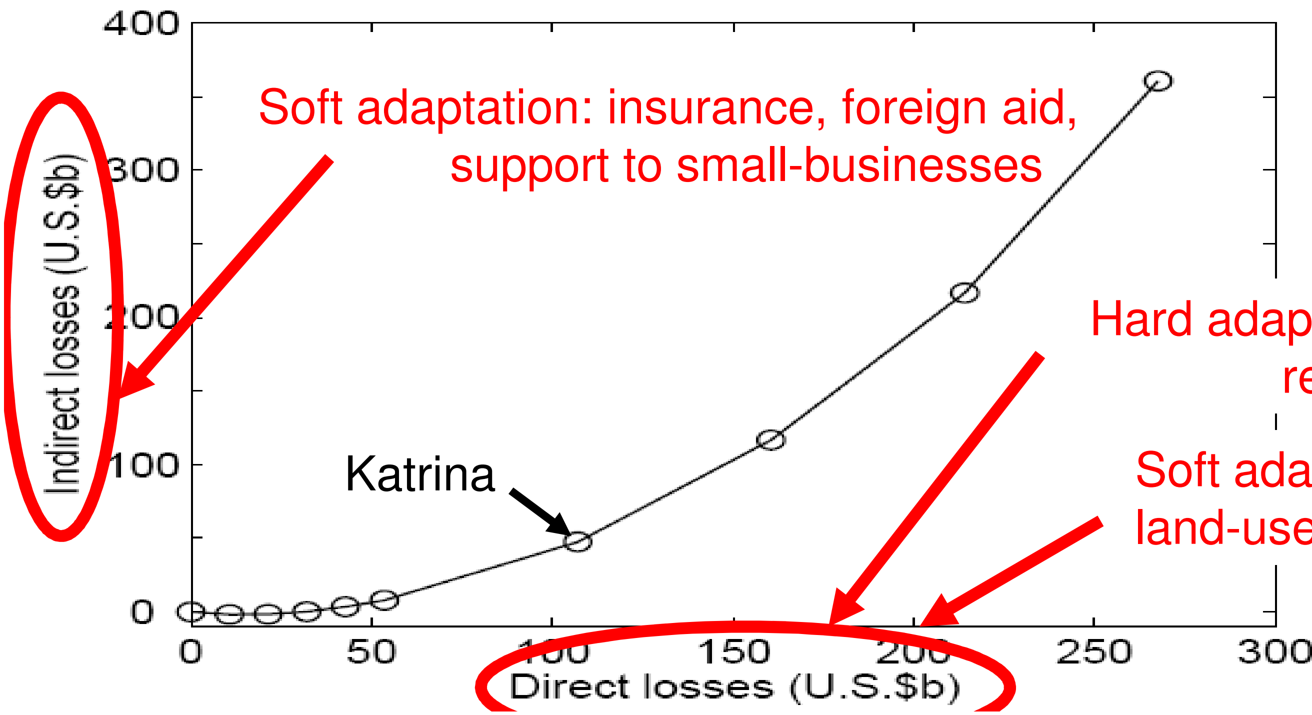
Soft vs. Hard adaptation: Natural Disasters

Direct losses:
1. Casualties and injuries
2. Direct economic losses

Indirect losses:
1. Emergency costs (Katrina: $8 billion)
2. Business interruption, supply-chain disruption, and propagations
3. Lost production during the (long) reconstruction period
4. Macro-economic feedbacks and political destabilization
5. Psychological trauma & social network disruption



Direct losses vs. Indirect losses in Louisiana, Hallegatte (2008, Risk Analysis)

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Hard protection in the New Orleans case

Cost of protecting New Orleans against cat-5 hurricanes: about $30 billion

Benefits from this protection:

- Lifetime > 100 years
- Avoidable losses: about $50 billion in case of cat-5 on New Orleans
- Occurrence probability ?
  - Current climate: about 1/500 years: benefits about $10 billion
  - With climate change?
  - Landsea: unchanged: benefits about $10 billion
  - Emanuel: probability x 10 : benefits about $100 billion

Climate uncertainty makes it difficult to decide about the protection system of New Orleans

What about "soft" options?

What is the cost of land use management?

Land use planning is generally considered as the most cost-effective risk-management strategy.

But how to explain the lack of risk-management-oriented land-use planning?

1. Impact of land-use plans on existing assets and political pressure
2. If one prevents a business to settle in an at-risk area, this business may:
   - settle a few kilometers away, in a safe place: no cost, high benefits;
   - settle in a different region, in a safe place: regional cost, high benefits;
   - settle in a different region, in an at-risk area: regional cost, no benefit;
   - Give up the project: costs and benefits.

The question is the measure of the comparative advantage of at-risk areas:

- Positive externalities (transport infrastructure, job markets externalities, geographical specificities, etc.);
- WTP to live in at-risk areas?
- New Orleans: "an inevitable city on an impossible site.", Pierce Lewis

Other options: Early warning, evacuation scheme, insurance support, enhanced reconstruction capacity

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Early warning and evacuation

- Casualties and injuries: 2000 lives + 5000 injuries = $10 billion in the Katrina case
- The “content losses”:

½-hr warning (1)	2-hrs warning (2)	4-hrs warning (3)	> 4-hrs warning (4)
Color television (console) Color television (portable) Stereo equipment Smallest electric appliances Vacuum cleaner Personal effects	Carpet sweeper Larger appliances, such as microwaves, blenders, toaster ovens Items in cupboards Expensive clothing Curtains and drapery Vehicles Additional personal effects	Largest appliances, such as dryer and refrigerator Bookcases Dining table and chairs and other furniture Food Some carpet Additional clothing and personal effects	Appliances such as dishwasher, oven, freezer, and washer Kitchen utensils Central heating system Piano Dressers Beds Linoleum/tiles

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Early warning and evacuation

- Casualties and injuries: 2000 lives + 5000 injuries = $10 billion in the Katrina case
- The “content losses”:

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In France, for river floods, we estimated that about 300 million euros of content losses are avoided every year thanks to flood warnings

It is the Météo-France annual budget

Depth (ft) (1)	Mitigation time, hrs 0 (2)	1 (3)	6 (4)	12 (5)	24 (6)	36 (7)	48 (8)
-3							
-2							
-1							
0							
1							
2							
3							
4	35	32	27	27	23	20	19
5	40	37	33	32	27	25	23
6	45	42	36	36	31	27	25
8	55	51	44	43	38	33	30
10	60	55	48	46	40	35	31
15	60	55	48	47	40	35	31
20	60	55	48	47	40	35	31

Content loss ratio, as a function of flood depth and warning time

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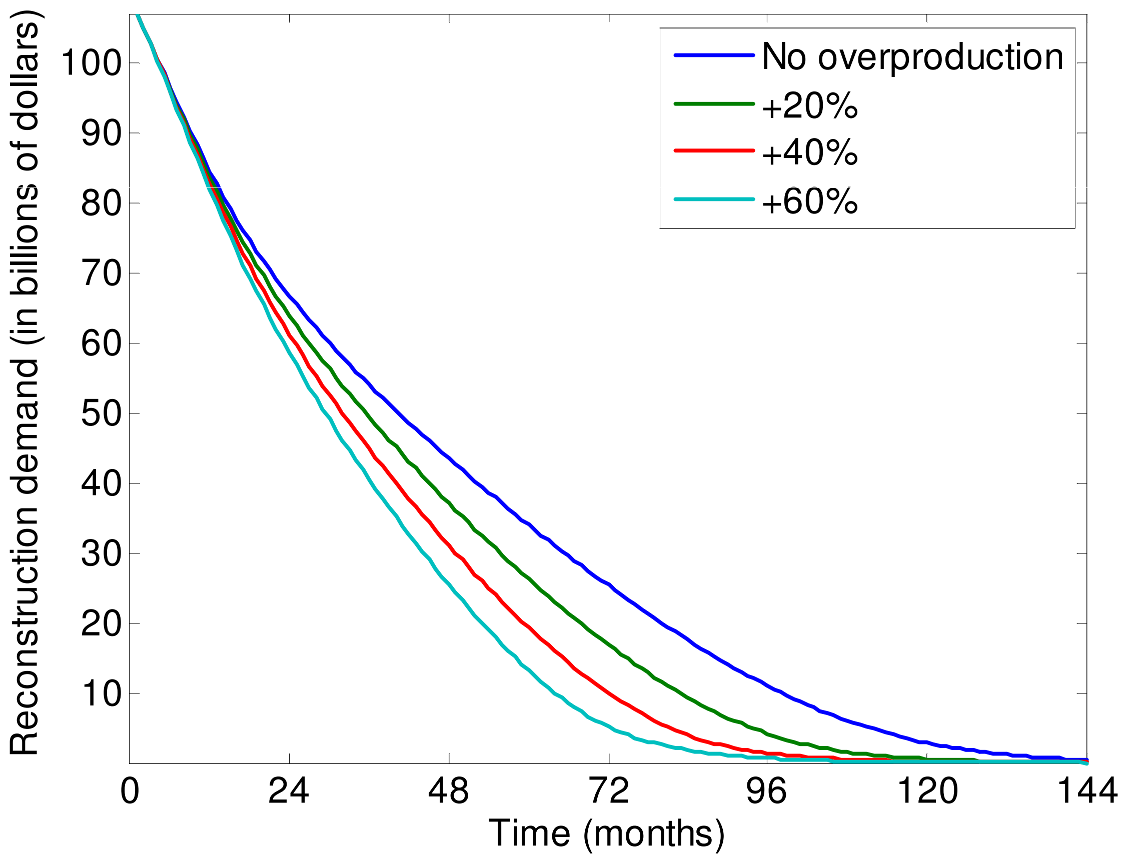
Improving reconstruction capacity?

- Production losses depend on reconstruction duration
- Reconstruction duration depends on the capacity of the construction sector to increase its production in disaster aftermaths.



Modeled production losses:

No overproduction:	$99b
+20%	$47b
+40%	$1.4b
+60%	$0.8b

What is the cost of allowing workers from outside Florida to work in Florida in disaster aftermaths?

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Conclusions

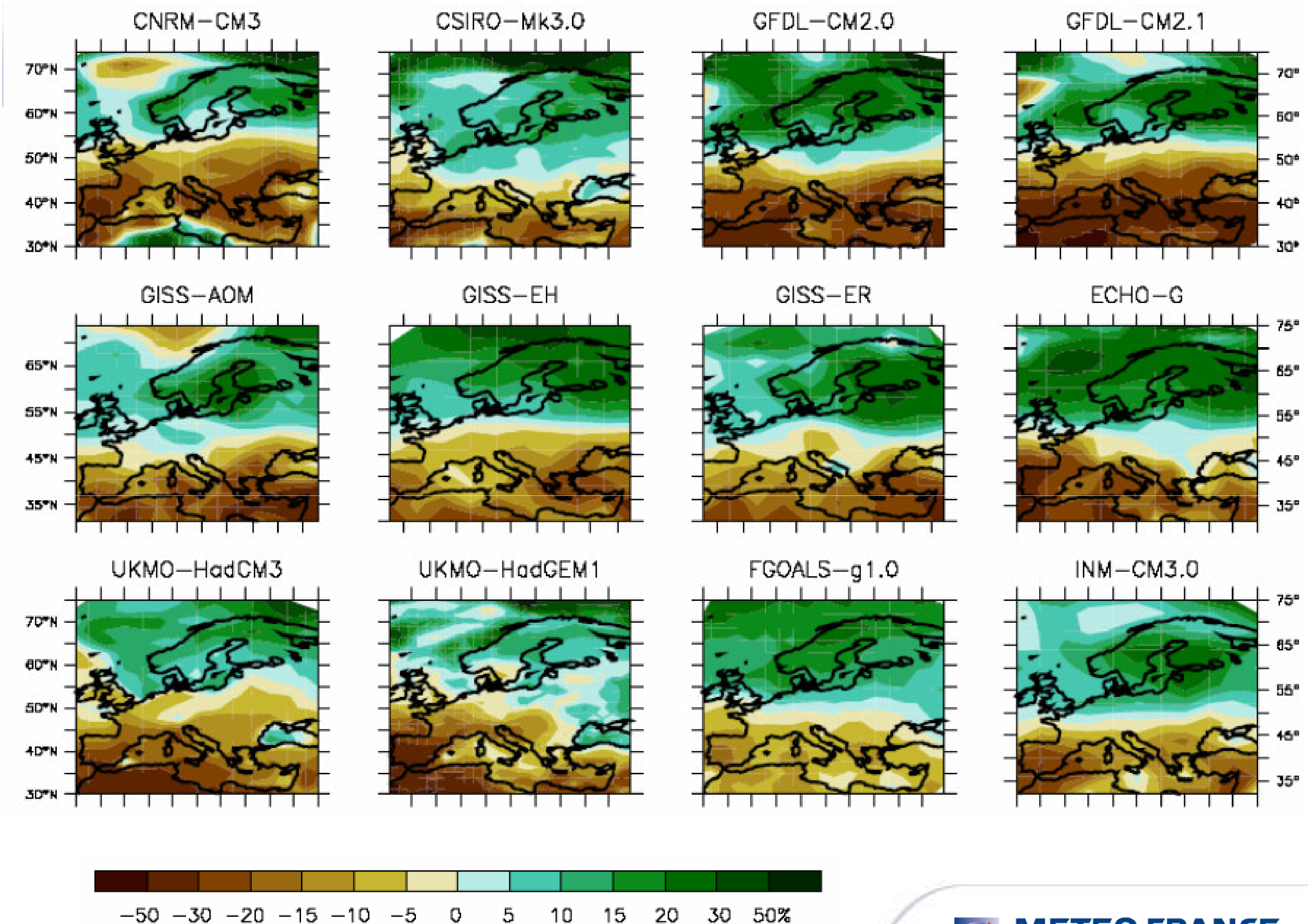
- **Adaptation can be efficient to reduce (some) climate change impacts.**
- But adaptation is not an easy task:
  - In several economic sectors, **climate change should already be included in decision-making frameworks**, especially in developing countries where infrastructures are being constructed.
  - Because of uncertainty, inadequate adaptation strategy can worsen the situation. **Innovative strategies that improve robustness to climate change can be proposed**.
- **Soft adaptation strategies are often better able to manage uncertainty than hard adaptation strategies**.
- **In the current context of large uncertainties, soft adaptation strategies should be considered very seriously and be the topic of more research.**

Adaptation options

Sector	Examples of adaptation options	No regret strategy	Existence of cheap safety margins	Reversible / flexible	Reduced decision horizon	Synergies with mitigation
AGRICULTURE	• Developing crop insurance	+ +		+		
	• Irrigation (with water storage & transport)	+	Y	–		
	• Forestry with shoter rotation time	–		–	Y	
	• Development of resistant crops	+ +				
COASTAL ZONES	• Coastal defences / sea walls	+	Y	–		
	• "Easy-to-retrofit" defences	–	Y	+	Y	
	• Enhanced drainage systems	+ +	Y	–		
	• Restrictive land use planning	+	Y	+		
	• Insurance, warning and evacuation schemes	+ +		+		
	• Relocation and retreat	–		–		
HEALTH & HOUSING	• Air conditioning					–
	• Improved building standards	+	Y			+
	• Improvements in public health	+				
	• R&D on vector control, vaccines	+				
WATER RESOURCES	• Loss reduction (leakage control, etc.)	+ +				
	• Demand control	+ +		+		
	• Storage capacity increase (new reservoirs)	+	Y	–		
	• Supply increase (desalination, water reuse)	+	Y	–		–
HUMAN SETTLEMENTS	• Climate proofing of new building and infrastructure	+	Y	–		+
	• Climate proofing of old building and infrastructure			–		+
	• Improvement of urban infrastructures	+ +	Y	–		+
	• Restrictive land use planning	+ +	Y	+		
	• Only short-term investment in potentially at-risk areas	–		+	Y	
	• Flood barriers, storm / flood proof infrastructure	+	Y	–		
	• Development of early warning systems	+ +		+		

Adaptation options

Sector	Examples of adaptation options	No regret strategy	Existence of cheap safety margins	Reversible / flexible	Reduced decision horizon	Synergies with mitigation	Soft strategy
AGRICULTURE	• Developing crop insurance	+ +		+			Y
	• Irrigation (with water storage & transport)	+	Y	–			
	• Forestry with shoter rotation time	–		–	Y		
	• Development of resistant crops	+ +					
COASTAL ZONES	• Coastal defences / sea walls	+	Y	–			
	• "Easy-to-retrofit" defences	–	Y	+	Y		
	• Enhanced drainage systems	+ +	Y	–			
	• Restrictive land use planning	+	Y	+			Y
	• Insurance, warning and evacuation schemes	+ +		+			Y
	• Relocation and retreat	–		–			
HEALTH & HOUSING	• Air conditioning					–	
	• Improved building standards	+	Y			+	
	• Improvements in public health	+					
	• R&D on vector control, vaccines	+					
WATER RESOURCES	• Loss reduction (leakage control, etc.)	+ +					
	• Demand control	+ +		+			Y
	• Storage capacity increase (new reservoirs)	+	Y	–			
	• Supply increase (desalination, water reuse)	+	Y	–		–	
HUMAN SETTLEMENTS	• Climate proofing of new building and infrastructure	+	Y	–		+	
	• Climate proofing of old building and infrastructure			–		+	
	• Improvement of urban infrastructures	+ +	Y	–		+	
	• Restrictive land use planning	+ +	Y	+			Y
	• Only short-term investment in potentially at-risk areas	–		+	Y		Y
	• Flood barriers, storm / flood proof infrastructure	+	Y	–			
	• Development of early warning systems	+ +		+			Y



IPCC, 2007

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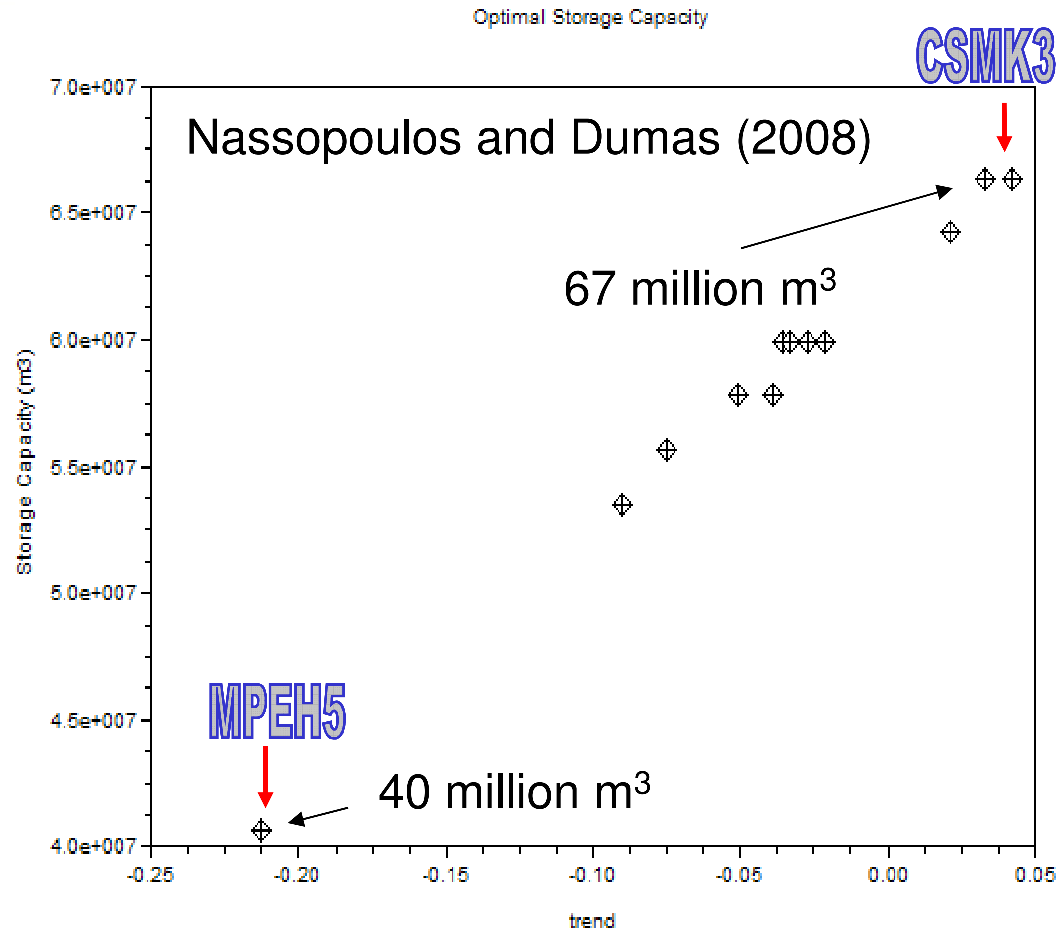
Soft vs. Hard adaptation: water supply

- Hard:
  - desalinization;
  - water reuse;
  - water transport;
  - dams and water storage.

- Soft:
  - Demand management;
  - Changing dam operational rules.



Optimal storage capacity of a dam in a Greek catchment, according to 12 IPCC climate models

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Soft vs. Hard adaptation: agriculture

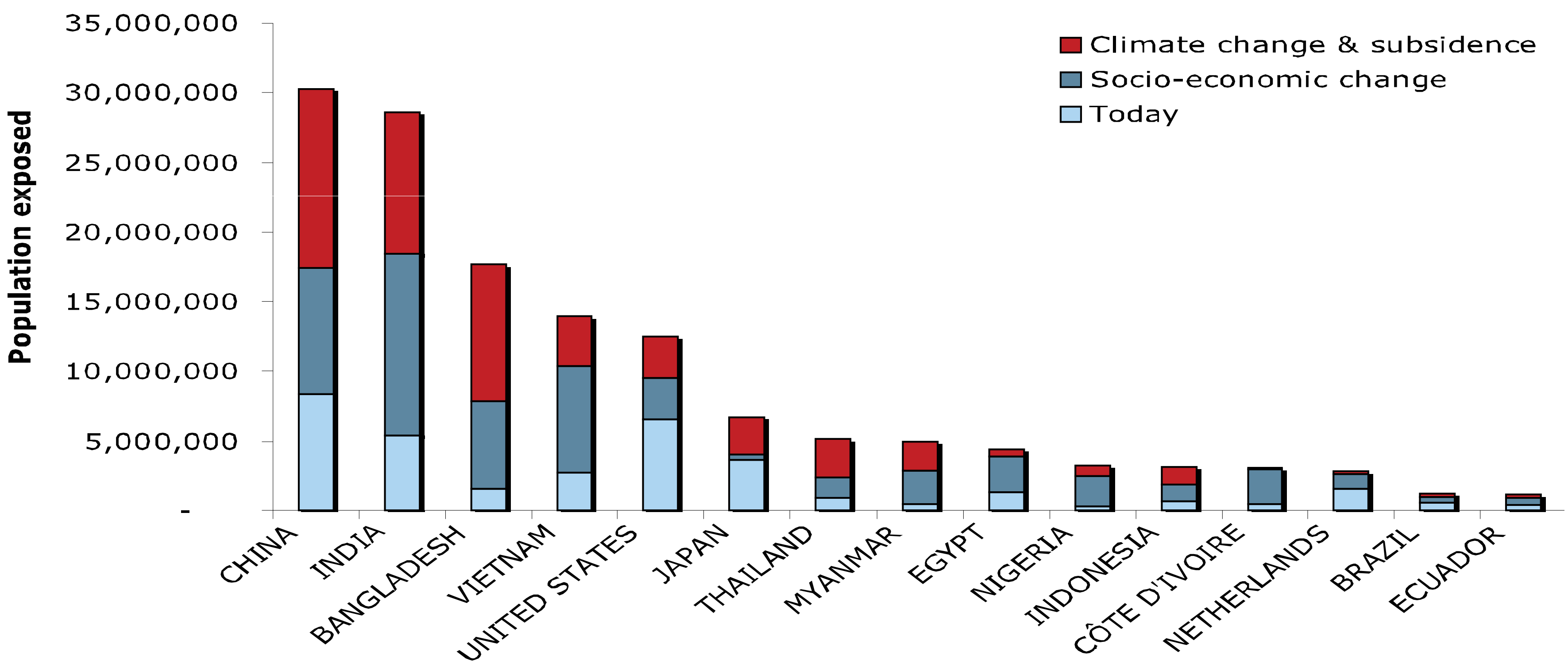
For changes in precipitation patterns and variability:

- Hard: irrigation, water storage, water transport
- Soft: change in activity, crop insurance
- Example in Malawi (see S. Hochrainer, R. Mechler, G. Pflug, 2008):
  - a crop insurance scheme implemented in Malawi in 2005
  - allows farmer to access loans (and higher-yield crops and other inputs)
  - avoid bankruptcy in case of drought
  - good adaptation measure against increased variability
  - relevant in the current climate
  - climate change will require additional back-up capital to maintain the robustness level (if premiums are not increased)
  - Increase in back-up capital up to 2000% of annual premiums
  - Can be adjusted regularly in response to climate change

1. How adaptation can reduce climate change impacts: illustration on coastal flooding

Climate change will increase natural hazards

Example: Population exposed to the 100-yr flood today and in the 2070's, with a 50cm sea level rise.



OECD Report on the exposure of large coastal cities to storm surges, Nicholls et al. (2007)

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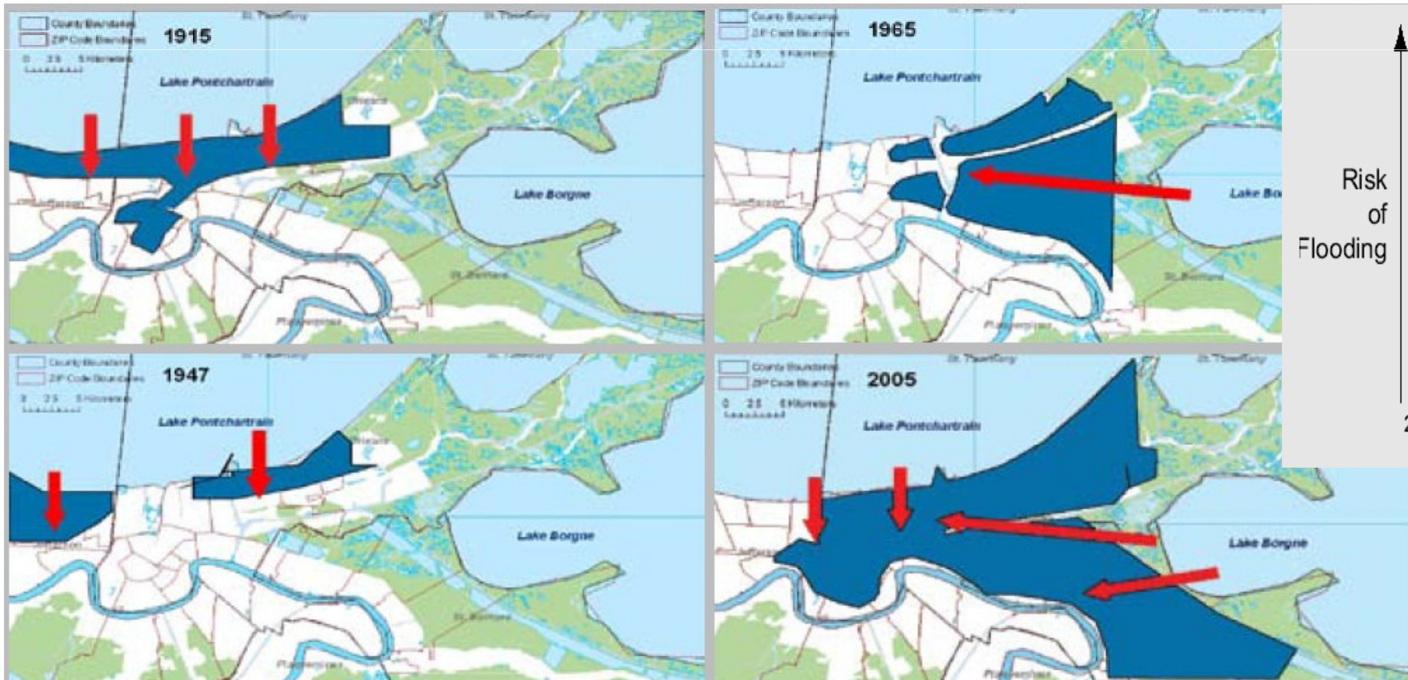
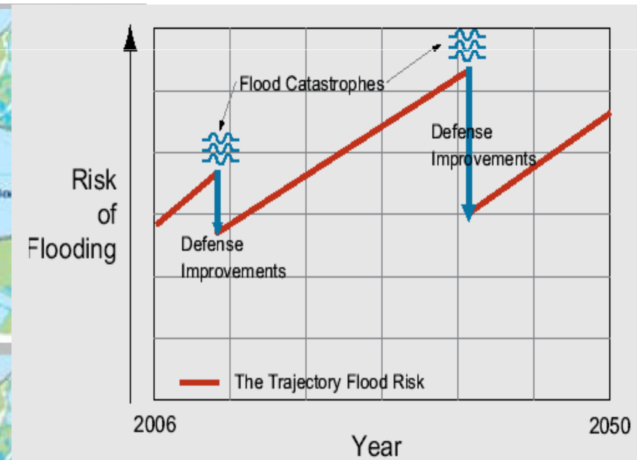
An example of increasing risks: New Orleans

- Sea level rises in New Orleans by 50 cm/century, increasing the risk of coastal flooding;
- After each floods, flood defenses have been improved
- **But no systematic risk management practice has been implemented**;
- The 2005 flood affected 80 percent of the city and killed 1800 people.



Historical flooding in New Orleans in 1915, 1947, 1965 and 2005

From Muir-Wood et al. (2006)



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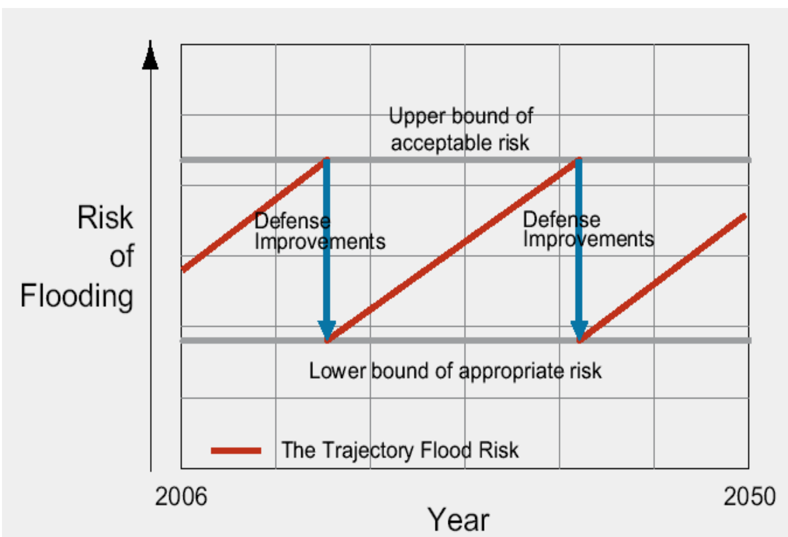
Another example of increasing risks: The Netherlands

- Sea level rises in the Netherlands (by 0.2m/century);
- After the 1953 great flood, **institutional and legal innovations** were implemented to manage future risks.
- Flooding risks are now monitored and managed on a regular basis.
- **Climate change is naturally taken into account**



From Muir-Wood et al. (2006)

Depending on how they are managed, increasing risks can translate, or not, into series of large-scale disasters.

Risk management is not (only) a financial an technical issue, it also requires institutional capacity.

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