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## HR Wallingford

1947 Hydraulics Research Organisation is formed

1951 The Hydraulics Research Station comes to Wallingford

1982 Privatisation to create Hydraulics Research Ltd

1991 Company becomes HR Wallingford Ltd

1993 HR Wallingford Group set up, and Wallingford Software formed

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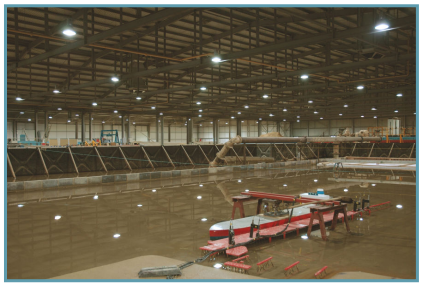
## HR Wallingford

### Today HR Wallingford Group is:

- **A private company**
  - Limited by guarantee
  - Non profit distributing
  - Independent
- **Turnover £20 M**
  - Clients and offices world-wide
- **Over 240 staff including world leading experts**



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## HR Wallingford

### Technical areas


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# Managing flood risk in a changing world

Jonathan Simm

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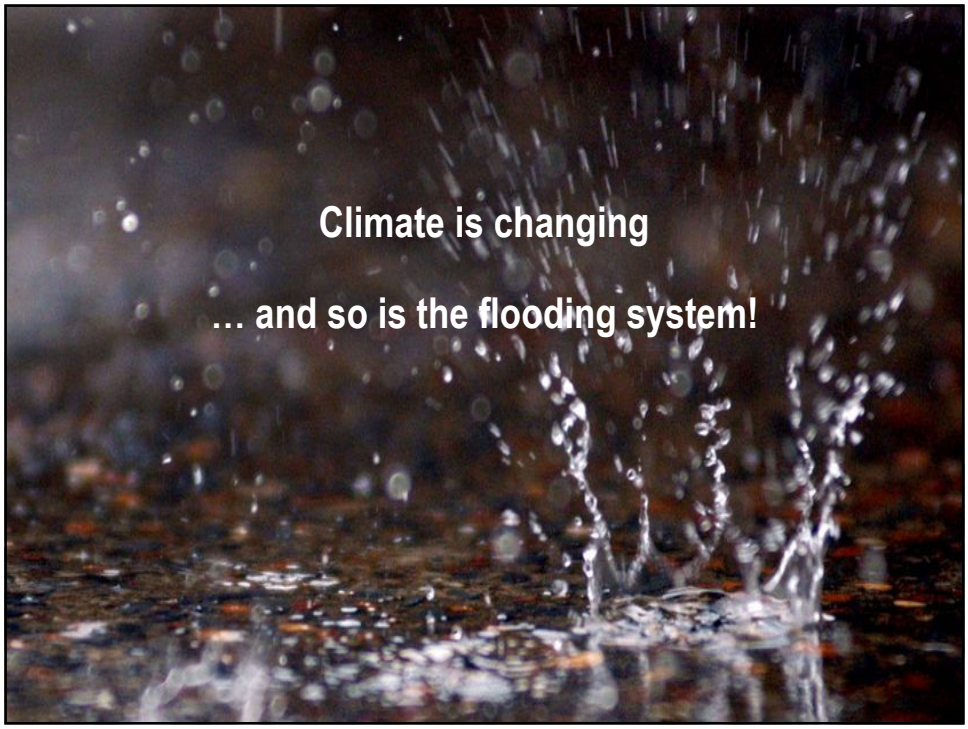
## Change is happening!


Page 5



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## Autumn 2000 floods

- Rainfall for September to November 2000 highest since records began in 1766
- Catchments waterlogged
- 10,000 homes flooded
- 11,000 families forced to evacuate their homes

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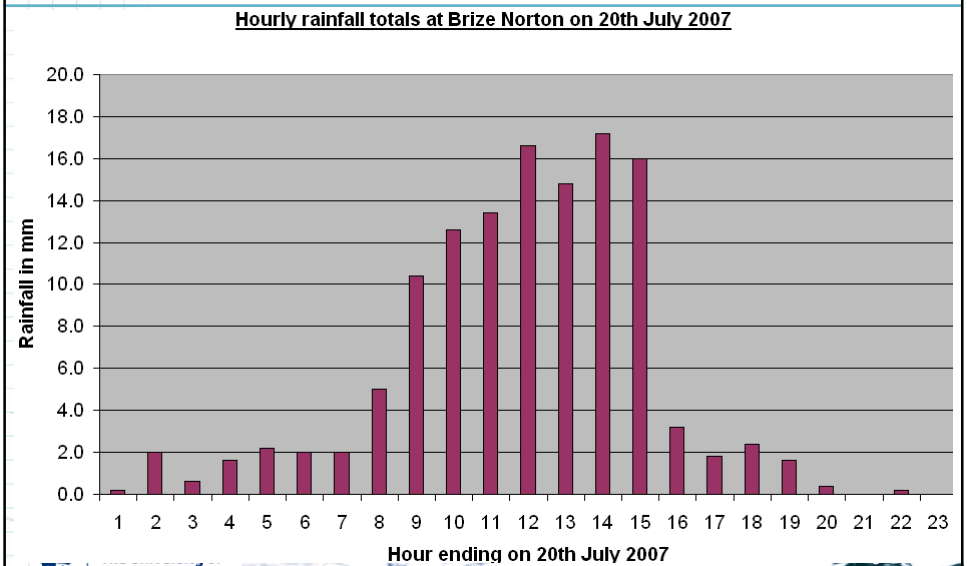
## Summer Floods 2007

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## Homes flooded, people displaced
## Insured losses £3 billion






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## Transport disrupted




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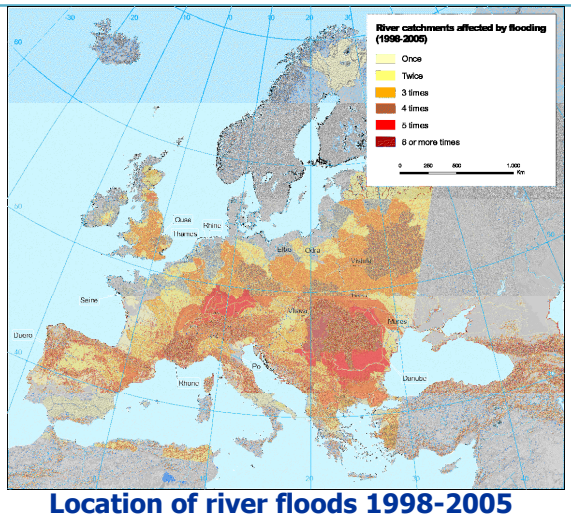
# European floods 1998-2005

- 100 major floods
- 700 deaths
- Displacement of 500,000 people
- Economic losses > US$30 billion




**Location of river floods 1998-2005 (European Environment Agency)**

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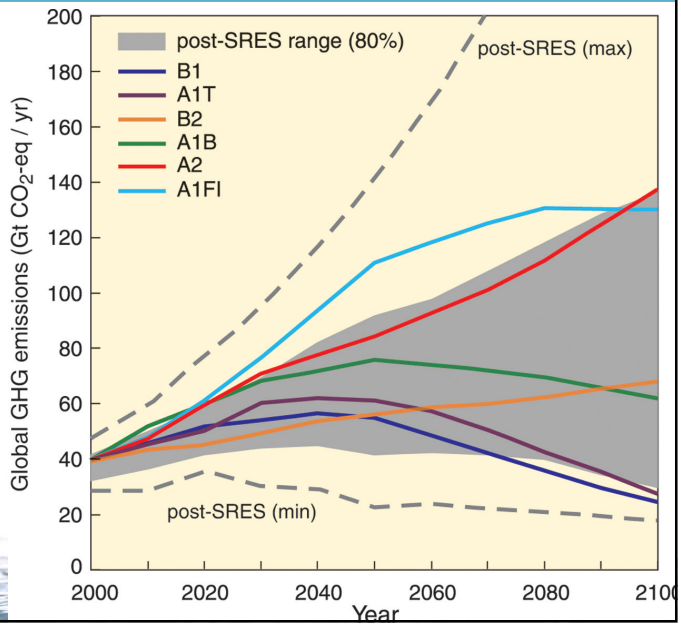
# Climate is changing

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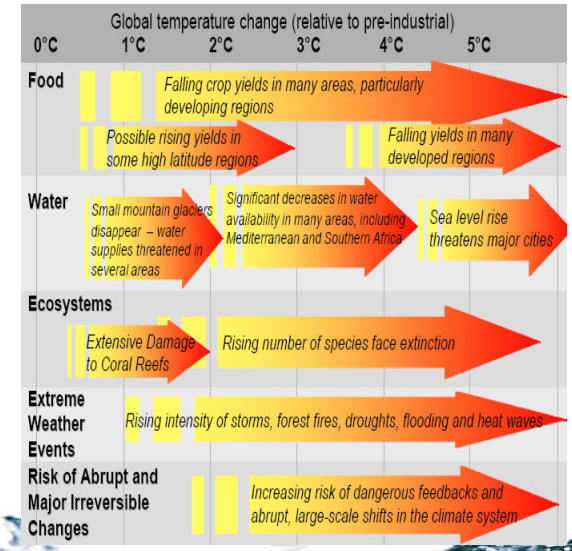
# Amount of climate change uncertain

**Climate futures are grossly uncertain and can fundamentally change the choices we make**




Source: Stern, 2006

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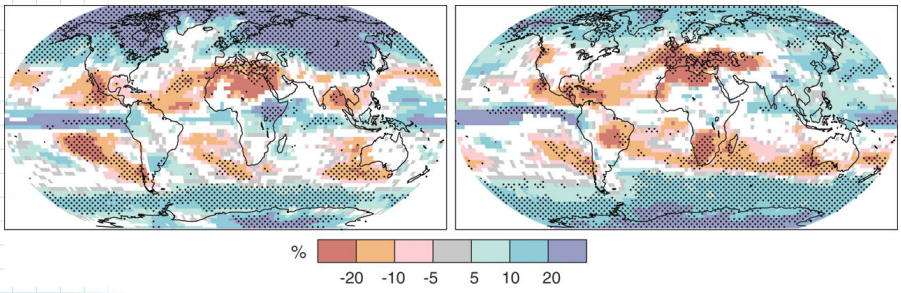
# Precipitation changes 21st century

Winter

Summer




From IPCC 4th Assessment Report 2007

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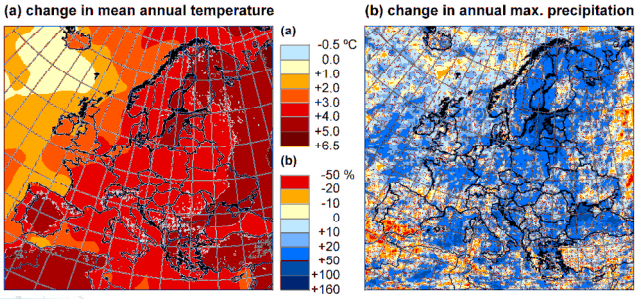
# Climate change effects on rainfall

- warmer and wetter winters
- increase in magnitude and frequency of intense rainfall – even where mean rainfall reduces




Changes between the control period (1961-1990) and future projection (2070-2099). HIRHAM, 12 km spatial resolution, SRES A2 scenario

After Feyen (2006)

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# Other European climate change impacts

- Change from snow melt to rainfall floods in major basins
- Changes in moisture capacity over Mediterranean – transported to C. Europe
- Increases in strength and frequency of storm surges
- Increases in wave height and changes in direction

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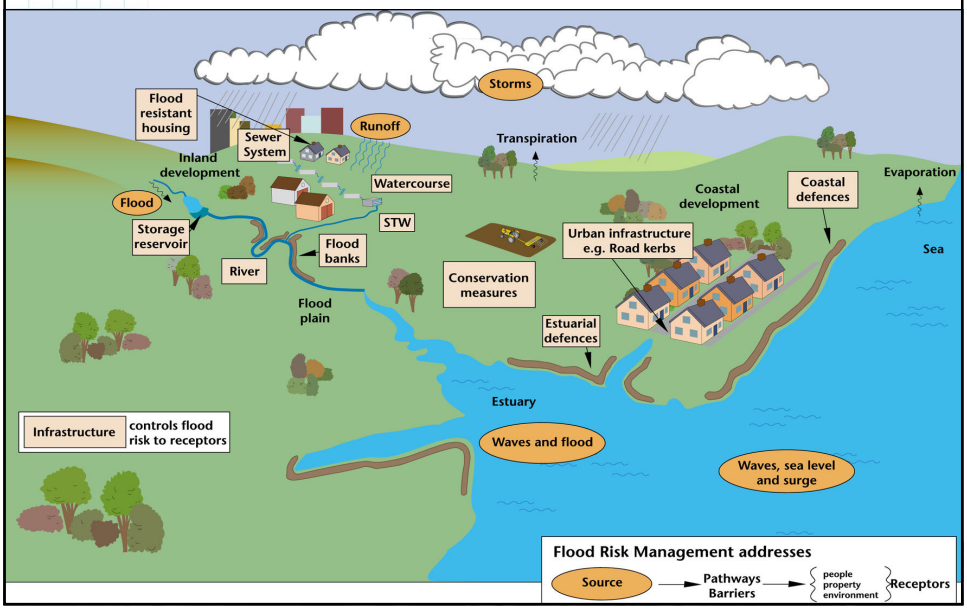
# Understanding flooding system

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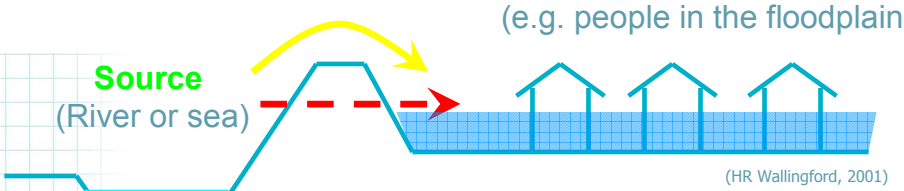
# S-P-R framework

**Pathway**
(e.g. beach, defence and floodplain)

**Receptor**
(e.g. people in the floodplain)

**Source**
(River or sea)



(HR Wallingford, 2001)

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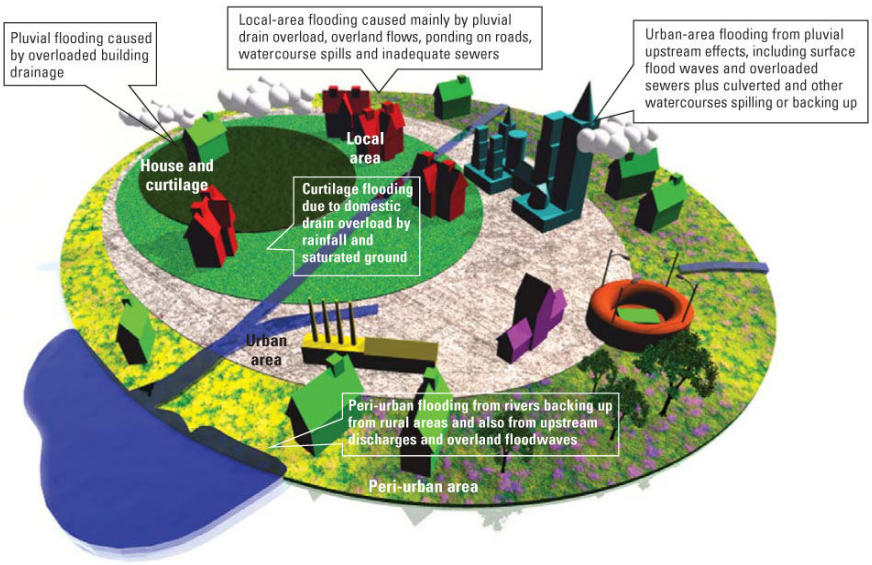
## Urban flooding system

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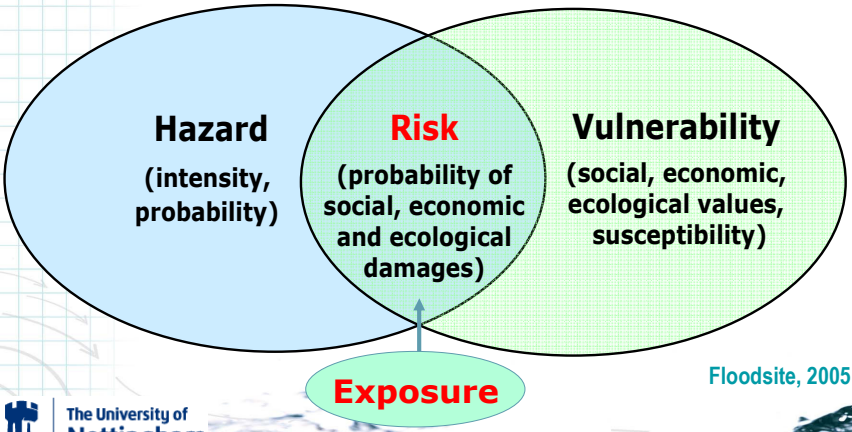
## Shared definition of risk

### Risk = Probability "x" Consequence




Floodsite, 2005

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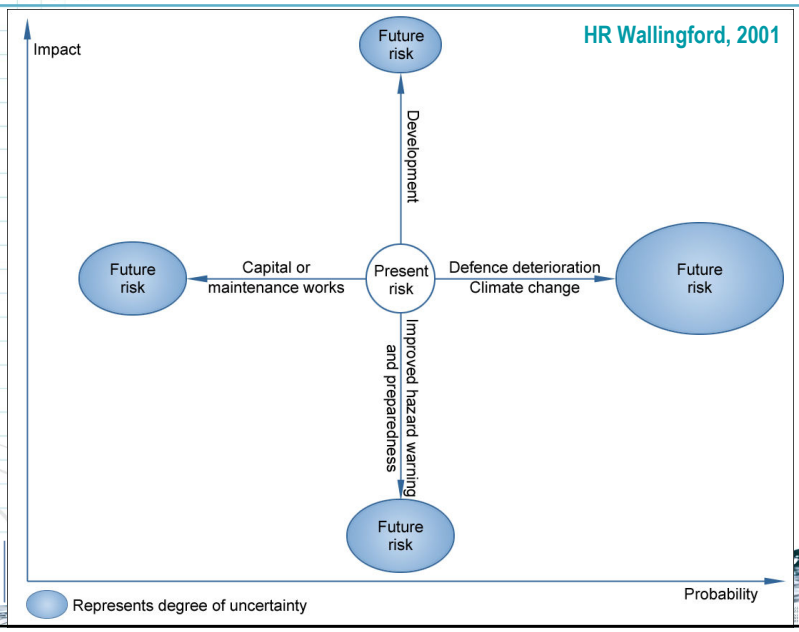
## Drivers or responses that change risk



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## Foresight Flooding Study 2004


- Long term vision for future flood and coastal risks in the UK and their future management
- Scientific base to underpin future policy-making

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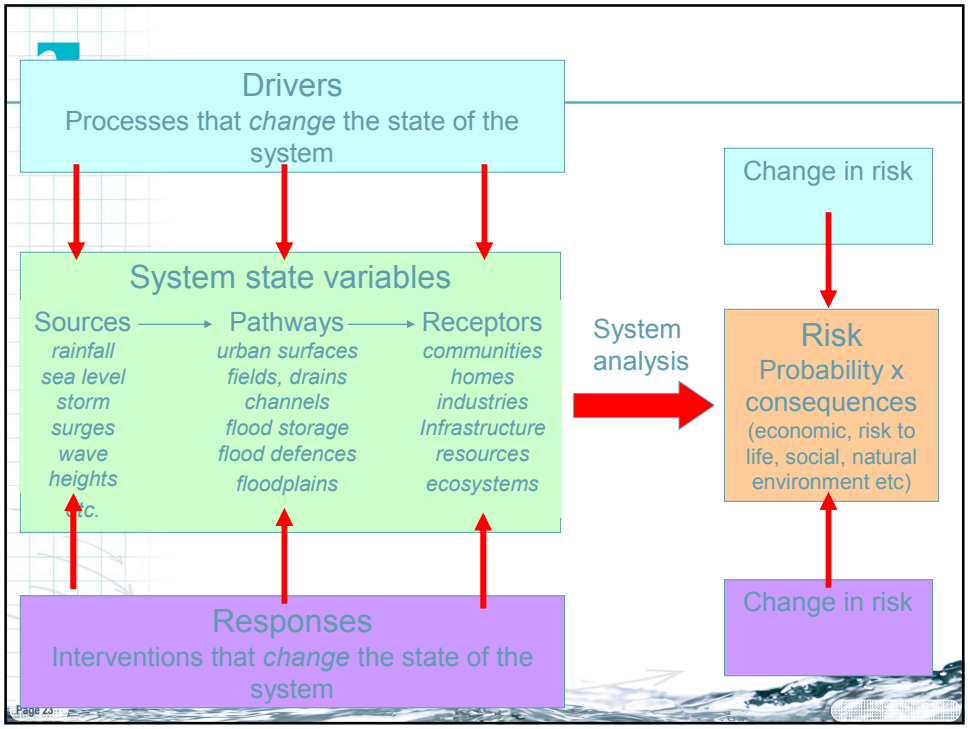
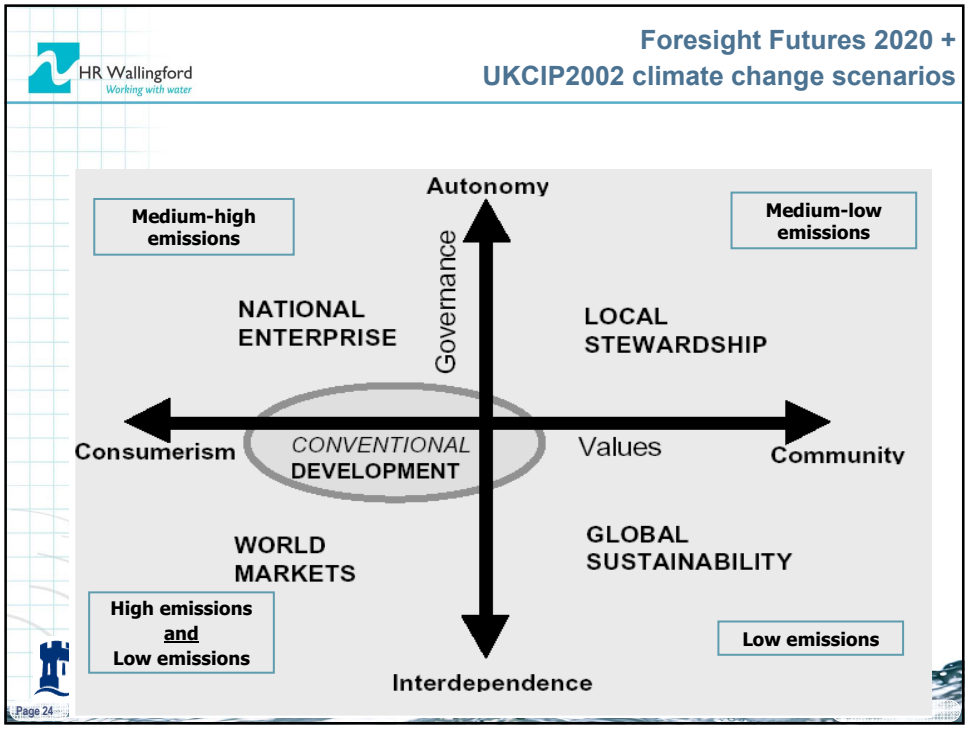

Drivers
Processes that *change* the state of the system
System state variables
Sources
rainfall
sea level
storm surges
wave heights
etc.
Pathways
urban surfaces
fields, drains
channels
flood storage
flood defences
floodplains
Receptors
communities
homes
industries
Infrastructure
resources
ecosystems
Responses
Interventions that *change* the state of the system
System analysis
Change in risk
Risk
Probability x consequences
(economic, risk to life, social, natural environment etc)
Change in risk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Foresight Futures 2020 +
UKCIP2002 climate change scenarios
Autonomy
Governance
Medium-high emissions
Medium-low emissions
NATIONAL ENTERPRISE
LOCAL STEWARDSHIP
Consumerism
CONVENTIONAL DEVELOPMENT
Values
Community
WORLD MARKETS
GLOBAL SUSTAINABILITY
High emissions and Low emissions
Low emissions
Interdependence

| Drivers of fluvial and coastal flooding | | |
|---|---|---|
| Driver group | Driver | SPR classification |
| Climate change | Precipitation | Source |
| | Temperature | Source |
| Catchment runoff | Urbanisation | Pathway |
| | Rural land management | Pathway |
| | Agricultural impacts | Receptor |
| Fluvial Systems and Processes | Environmental regulation | Pathway |
| | River morphology and sediment supply | Pathway |
| | River vegetation and conveyance | Pathway |
| Coastal processes | Waves | Source |
| | Surges | Source |
| | Relative sea level rise | Source |
| | Coastal morphology and sediment supply | Pathway |
| Human behaviour | Stakeholder behaviour | Pathway |
| | Public attitudes and expectations | Receptor |
| Socio-economics | Buildings and contents | Receptor |
| | Urban impacts | Receptor |
| | Infrastructure impacts | Receptor |
| | Social impacts | Receptor |
| | Science, engineering and technology | Receptor |

## Drivers of Flooding and Coastal Erosion Risk

"… phenomena that change the state of the flooding system…"

Table 2.4b **National ranking of catchment-scale drivers – 2080s**

| | World Markets | National Enterprise | Local Stewardship | Global Sustainability |
|---|---|---|---|---|
| | 2080s | 2080s | 2080s | 2080s |
| 1 | Social Impacts | Relative Sea Level Rise | Social Impacts | Environmental Regulation |
| 2 | Relative Sea Level Rise | Infrastructure Impacts | Relative Sea Level Rise | Relative Sea Level Rise |
| 3 | Surges | Surges | Environmental Regulation | Vegetation and Conveyance |
| 4 | Infrastructure Impacts | Buildings and Contents | Surges | Social Impacts |
| 5 | Buildings and Contents | Coastal Morphology and Sediment Supply | Precipitation | Precipitation |
| 6 | Coastal Morphology and Sediment Supply | Social Impacts | River Morphology and Sediment Supply | River Morphology and Sediment Supply |
| 7 | Waves | Precipitation | Coastal Morphology and Sediment Supply | Buildings and Contents |
| 8 | Precipitation | Urbanisation | Waves | Infrastructure Impacts |
| 9 | Stakeholder Behaviour | Waves | Vegetation and Conveyance | Coastal Morphology and Sediment Supply |
| 10 | Urbanisation | Urban Impacts | Urban Impacts | Surges |
| 11 | Urban Impacts | Rural land Management | Temperature | Urban Impacts |
| 12 | Rural land Management | Vegetation and Conveyance | Agriculture Impacts | Waves |
| 13 | River Morphology and Sediment Supply | Environmental regulation | Infrastructure Impacts | Temperature |
| 14 | Vegetation and Conveyance | River Morphology and Sediment Supply | Buildings and Contents | Agricultural Impacts |
| 15 | Temperature | Temperature | Urbanisation | Rural land Management |
| 16 | Agriculture Impacts | Agriculture Impacts | Rural land Management | Urbanisation |
| 17 | Environmental Regulation | Stakeholder Behaviour | Stakeholder Behaviour | Stakeholder Behaviour |
| | Science and Technology – known to be important but not quantified | | | |
| | Public Attitudes and Expectations – known to be important but not quantified | | | |

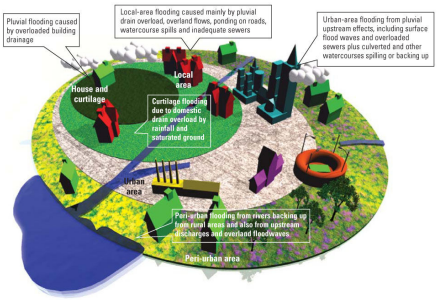
## Expert description and ranking of river and coastal flood drivers

- Socio-economic drivers
- Climate change
- Coastal drivers
- Environmental Regulation
- *Big scenario differences*

| Legend | Driver Impact Category | Risk Multiplier (M) Range | Colour Code |
|---|---|---|---|
| | High increase | $M \geq 2$ | |
| | Medium increase | $2 > M \geq 1.2$ | |
| | Low impact | $1.2 > M \leq 0.83$ | |
| | Medium decrease | $0.83 \geq M \geq 0.5$ | |
| | High decrease | $M < 0.5$ | |

| Driver group | Driver | SPR classification |
|---|---|---|
| Climate change | Precipitation | Source |
| Runoff | Urbanisation | Pathway |
| | Management of Peri-Urban Rural Land | Pathway |
| Urban conveyance systems and processes | Environmental Management and Regulation | Pathway |
| | Urban Watercourse Conveyance, Blockage and Sedimentation | Pathway |
| | Sewer Conveyance, Blockage and Sedimentation | Pathway |
| | Impact of External Flooding on Intra-urban Drainage Systems | Pathway |
| | Intra-urban Asset Deterioration | Pathway |

## Drivers of intra-urban flood risks




Plus……

- Stakeholder behaviour
- Urban planning policy

Page 2

Tables 3.3b **Driver ranking for the 2080s – urban**

| | World Markets 2080s | National Enterprise 2080s | Local Stewardship 2080s | Global Sustainability 2080s |
|---|---|---|---|---|
| 1 | Social Impacts | Infrastructure Impacts | Social Impacts | Environmental Management and Regulation |
| 2 | Infrastructure Impacts | Stakeholder Behaviour | Environmental Management and Regulation | Social Impacts |
| 3 | Buildings and Contents | Buildings and Contents | Stakeholder Behaviour | Precipitation |
| 4 | Intra-Urban Asset Deterioration | Social Impacts | Precipitation | Stakeholder Behaviour |
| 5 | Sewer Conveyance, Blockage and Sedimentation | Intra-Urban Asset Deterioration | Impact of External Flooding on Intra-Urban Drainage Systems | Buildings and Contents |
| 6 | Stakeholder Behaviour | Precipitation | Urbanisation | Infrastructure Impacts |
| 7 | Precipitation | Sewer Conveyance, Blockage and Sedimentation | Intra-Urban Asset Deterioration | Urbanisation |
| 8 | Urbanisation | Urbanisation | Urban impacts | Intra-Urban Asset Deterioration |
| 9 | Urban Watercourse, Conveyance, Blockage and Sedimentation | Urban Impacts | Urban Watercourse Conveyance, Blockage and Sedimentation | Urban Watercourse Conveyance, Blockage and Sedimentation |
| 10 | Urban Impacts | Impact of External Flooding on Intra-Urban Drainage Systems | Sewer Conveyance, Blockage and Sedimentation | Sewer Conveyance, Blockage and Sedimentation |
| 11 | Impact of External Flooding on Intra-Urban Drainage Systems | Urban Watercourse Conveyance, Blockage and Sedimentation | Management of Peri-Urban Rural Land | Urban Impacts |
| 12 | Management of Peri-Urban Rural Land | Management of Peri-Urban Rural Land | Buildings and Contents | Impact of external Flooding on Intra-Urban Drainage Systems |
| 13 | Environmental Management and Regulation | Environmental Management and Regulation | Infrastructure Impacts | Management of Peri-Urban Rural Land |
| | Science and Technology – known to be Important but not quantified. | | | |
| | Public Attitudes and Expectations – known to be Important but not quantified. | | | |

## Expert description and ranking of intra-urban scale drivers

- Social impacts
- Asset deterioration
- Precipitation
- Environmental management and regulation
- Buildings and contents

| Legend | Driver Impact Category | Risk Multiplier (M) Range | Colour Code |
|---|---|---|---|
| | High Increase | M > 2 | |
| | Medium Increase | 2 > M > 1.2 | |
| | Low Impact | 1.2 > M < 0.83 | |
| | Medium decrease | 0.83 > M > 0.5 | |
| | High decrease | M < 0.5 | |

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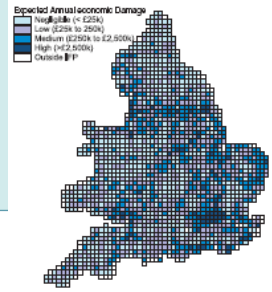
# Modeling: National quantitative risk analysis:

**R**isk
**A**ssessment
for
**S**trategic
**P**lanning

## Data used:

Rivers and coastlines
Floodplain mapping
Standard of protection
Condition of defences
Addresses of all properties/people at risk
Flood damage by depth
Social vulnerability
Agricultural land grade

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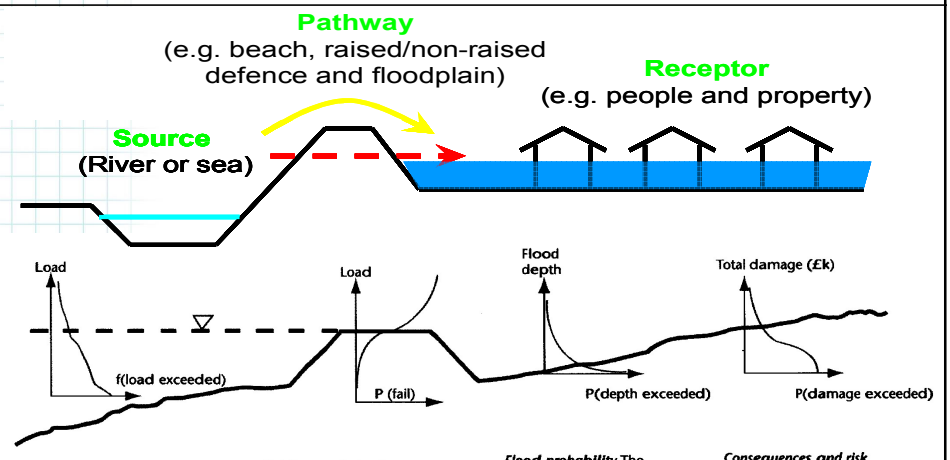
# Calculating Flood Risk




***Extreme loads*** Sources of flooding risk quantified by 'return period', indicating how frequently a particluar load will be exceeded.

***Reliability analysis*** The performance of flood defence structures and systems shown by a 'fragility curve' - the probability failure with load. These depend on the structure, materials, failure mechanisms and condition.

***Flood probability*** The flood extent and depth depend on breach size, overtopping and topography. Flood spreading models are combined with reliability anaylsis to assess depth / probability relationships.

***Consequences and risk*** Flood damage or harm are related to depth. Risk is assessed by the probability that particular damage values are exceeded.

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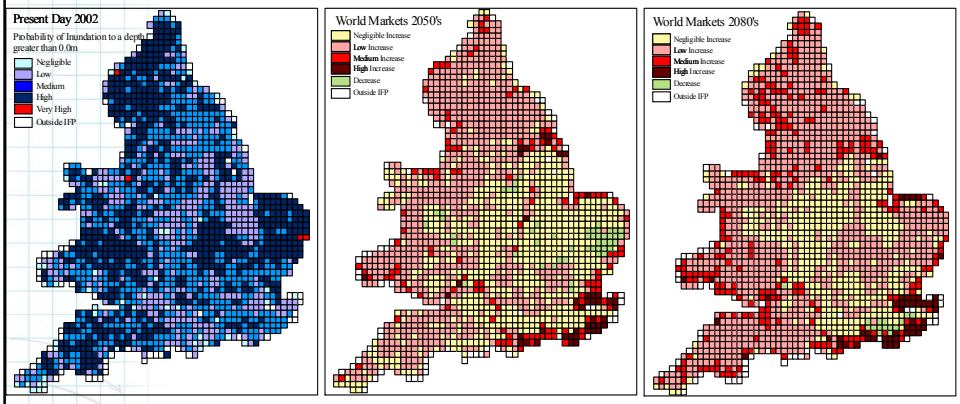
# Flood Risk in 2050 and 2080 for 'World Markets'

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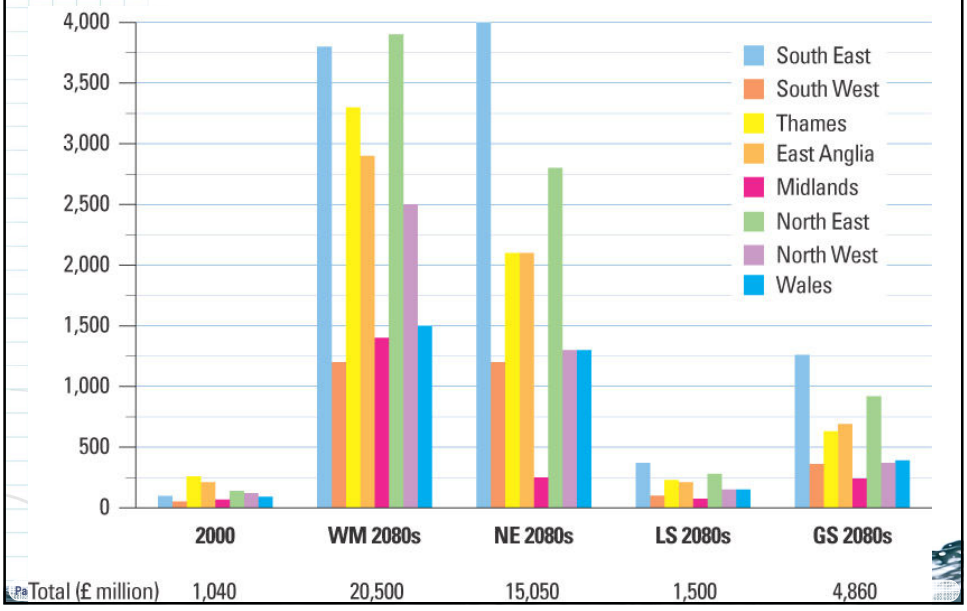
# Expected annual damages (£ million)




| | 2000 | WM 2080s | NE 2080s | LS 2080s | GS 2080s |
|---|---|---|---|---|---|
| Total (£ million) | 1,040 | 20,500 | 15,050 | 1,500 | 4,860 |

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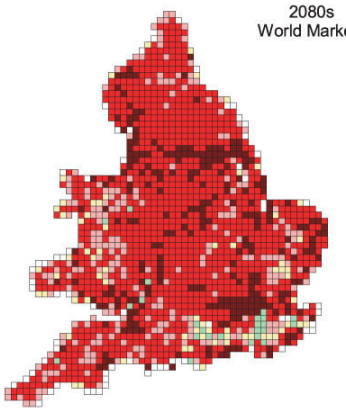
## 'Foresight': baseline conclusions




### Unless we act:-

- Future flooding and coastal erosion are very serious threats to the UK.
- They represent a major challenge to government and civil society.
- Combining the World Markets and Low emissions scenarios reduces future expected annual economic damages by only ~25%.

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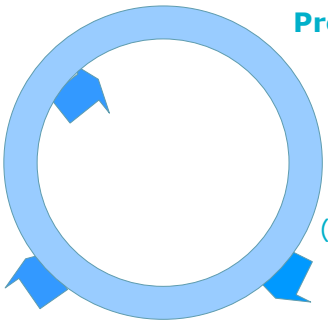
## Gilbert F White (1942) – 8 'adjustments'

**Flooding is a 'man-made problem'. So adjust by**

1. Flood abatement (room for river)
2. Emergency measures during floods
3. Elevation of land or buildings
4. Structural resilience of buildings
5. Land use planning (reduce building in flood plain)
6. Relief for victims
7. Insurance
8. Flood protection (but defences are deteriorating)



## Responses and the flooding cycle



**Post-flood measures**

Relief, clean-up, reconstruction, regeneration, etc.

**Pre-flood measures**
**Preventive risk management**

Spatial planning, contingency plans, flood defence (mitigation) measures, asset management insurance, preparedness, etc.

**Flood event measures**

**Real time risk management**

Forecasting and warning, reservoir control, evacuation, rescue, etc.

## Foresight: Potential responses

80 individual responses

Organised into 25 response groups

And 5 response themes

- Reducing urban runoff
- Reducing rural runoff
- Managing flood events
- Managing flood losses
- Engineering and large scale re-alignment or abandonment



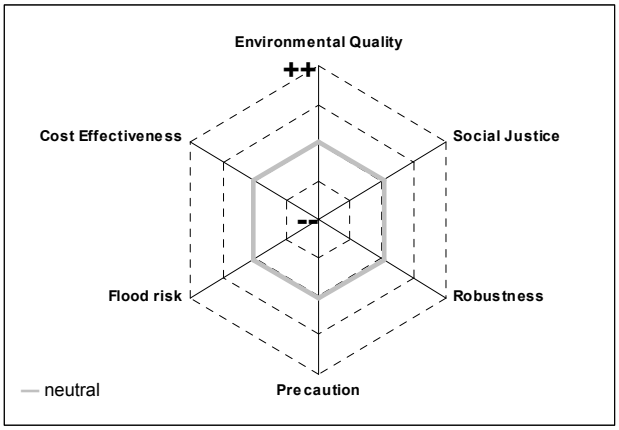
## Foresight: Expert analysis of responses

Definition, Function and Efficacy

Governance

*Sustainability*

- ***Potential for implementation under each Foresight future scenario***



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## Responses with the most potential for risk reductions

- Structural: Rethink Coastal & River Defences
- Non-structural: Manage down flood & erosion consequences

**Legend**

| Colour code | Interpretation |
|---|---|
| | Major reduction in flood risk ( S < 0.7) |
| | Marked reduction in flood risk (0.7 < S < 0.9) |
| | Minor reduction in flood risk (0.9 < S < 1.0) |
| | Ineffective ( S = 1) |
| | Likely to Increase flood risk ( S > 1.0) |

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**Responses Groups ranked by potential risk reduction in the 2080s**

| Rank | World Markets | National Enterprise | Local Stewardship | Global Sustainability |
|---|---|---|---|---|
| 1 | River Defences | River Defences | Land Use Planning and Management | Land Use Planning and Management |
| 2 | Coastal Defences | Coastal Defences | Flood Proofing Buildings | Catchment-Wide Storage |
| 3 | Flood Proofing Buildings | Reduce Coastal Energy | Individual Damage Avoidance | River Defences |
| 4 | Reduce Coastal Energy | Realign Coastal Defences | River Defences | Coastal Defences |
| 5 | Morphological Coastal Protection | Morphological Coastal Protection | Catchment-Wide Storage | Flood Proofing Buildings |
| 6 | Realign Coastal Defences | Coastal Defence Abandonment | Pre-event Measures | Rural Conveyance |
| 7 | Real-time Event Management | Flood Proofing Buildings | Real-time Event Management | Realign Coastal Defences |
| 8 | River Conveyance | River Conveyance | Engineered Flood Storage | Reduce Coastal Energy |
| 9 | Individual Damage Avoidance | Catchment-Wide Storage | Rural Conveyance | Morphological Coastal Protection |
| 10 | Pre-event Measures | Land Use Planning and Management | River Conveyance | Engineered Flood Storage |
| 11 | Engineered Flood Storage | Engineered Flood Storage | Rural Infiltration | Real-time Event Management |
| 12 | Land Use Planning and Management | Real-time Event Management | Manage Urban Runoff | Pre-event Measures |
| 13 | Manage Urban Runoff | Pre-event Measures | Flood Water Transfer | Individual Damage Avoidance |
| 14 | Flood Water Transfer | Rural Conveyance | Coastal Defences | River Conveyance |
| 15 | Catchment-Wide Storage | Rural Infiltration | Realign Coastal Defences | Rural Infiltration |
| 16 | Rural Conveyance | Individual Damage Avoidance | Morphological Coastal Protection | Manage Urban Runoff |
| 17 | Rural Infiltration | Manage Urban Runoff | Reduce Coastal Energy | Flood Water Transfer |
| 18 | | Flood Water Transfer | Coastal Defence Abandonment | |

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## Foresight: Estimated cost of responses

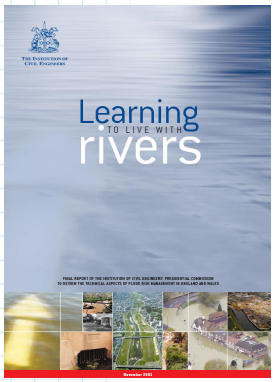
Table 5.10 **Investment required to raise defences to achieve present day standards in the 2080s for the Global Sustainability scenario**

| Global Sustainability 2080s | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Floodplain type | New Build | Significant Major Works | Major Works | Significant Minor Works | Minor Works | No Works | Total investment (£m) | Length of defence improved (km) |
| Lowland valley | 56% | 27% | 13% | 4% | 0% | 0% | 12,000 | 49,000 |
| Steep valley | 55% | 30% | 11% | 4% | 0% | 0% | 8,000 | 36,000 |
| Coastal | 74% | 20% | 4% | 1% | 0% | 0% | 32,000 | 17,000 |
| | | | | | | | 52,000 | 102,000 |

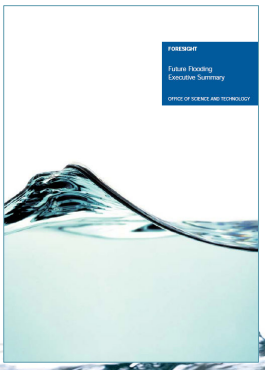
The cost of using structural defences alone to achieve the indicative standard of defence in 2080s as part of an integrated portfolio of structural and non-structural responses is ~ £22 billion

The cost of implementing engineering- based structural approach alone to achieve the same standard of defence is ~ £52 billion

## UK initiatives since Autumn 2000 floods




"Learning to live with rivers"
( ICE Presidential Commission, 2001)




Foresight Future Flooding
(OST, 2004)

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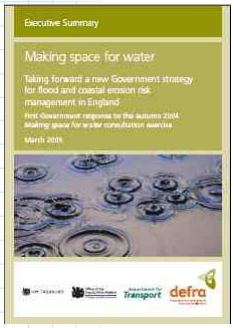
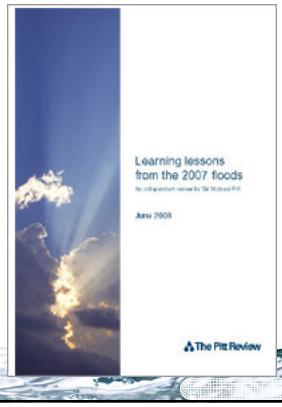
## UK initiatives since Autumn 2000 floods




"Making Space for Water"
(Defra, 2004 ++)

Plus: [Slightly] increased investment in Flood Risk Management




Pitt Review
(Cabinet Office, 2007, 2008)

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## Changes in flood risk management in EU

**European Commission (2004): 'Communication on flood risk management: flood prevention, protection and mitigation'**

**(a) recommended incorporation into FRM of:**

- Prevention, Protection, Preparedness, Emergency response, Recovery & lessons learned

**(b) proposed an action programme including:**

1. Information exchange, experience sharing & promotion of best practice.
2. Targeting of funding (via CAP, Cohesion Policy & Solidarity Fund)
3. A legal instrument on flood risk management (Floods Directive)



## EU Floods Directive (2007/60/EC)

**Directive 2007/60/EC on the assessment and management of flood risks entered into force on 26 November 2007. This Directive now requires Member States:**

- **to assess if all water courses and coast lines are at risk from flooding,**
- **to map the flood extent and assets and humans at risk in these areas and**
- **to take adequate and coordinated measures to reduce this flood risk.**

**This Directive also reinforces the rights of the public to access this information and to have a say in the planning process.**

http://ec.europa.eu/environment/water/flood_risk/

## New US Flood Risk Management Program

**Vision:** To lead collaborative, comprehensive and sustainable national flood risk management to improve public safety and reduce flood damages to USA.

**Mission:** To integrate and synchronize the ongoing, diverse flood risk management projects, programs and authorities of the US Army Corps of Engineers with counterpart projects, programs and authorities of Federal Emergency Management Agency (FEMA), other Federal agencies, state organizations and regional and local agencies.

*National Flood Risk Management Program*

FEMA



## US Flood Risk Management Program
### Strategic Goals

1. Provide current accurate ***floodplain information*** to the public and decision makers.
2. Identify and assess flood hazards posed by ***aging*** flood damage reduction ***infrastructure***
3. Improve ***public awareness*** and comprehension of flood risk.
4. ***Integrate*** flood damage and flood hazard reduction ***programs*** across local, State, and Federal agencies.
5. ***Improve capabilities*** to collaboratively deliver and sustain flood damage reduction and flood hazard mitigation services to the nation.


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# Sustainable development

HM Government

Securing the future
delivering UK sustainable development strategy

**Living Within Environmental Limits**
Respecting the limits of the planet's environment, resources and biodiversity – to improve our environment and ensure that the natural resources needed for life are unimpaired and remain so for future generations.

**Ensuring a Strong, Healthy and Just Society**
Meeting the diverse needs of all people in existing and future communities, promoting personal wellbeing, social cohesion and inclusion, and creating equal opportunity for all.

**Achieving a Sustainable Economy**
Building a strong, stable and sustainable economy which provides prosperity and opportunities for all, and in which environmental and social costs fall on those who impose them (polluter pays), and efficient resource use is incentivised.

**Promoting Good Governance**
Actively promoting effective, participative systems of governance in all levels of society – engaging people's creativity, energy, and diversity.

**Using Sound Science Responsibly**
Ensuring policy is developed and implemented on the basis of strong scientific evidence, whilst taking into account scientific uncertainty (through the precautionary principle) as well as public attitudes and values.

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## White paper: July 08


## People: Pitt Review emphasis

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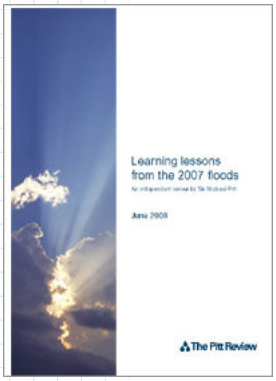


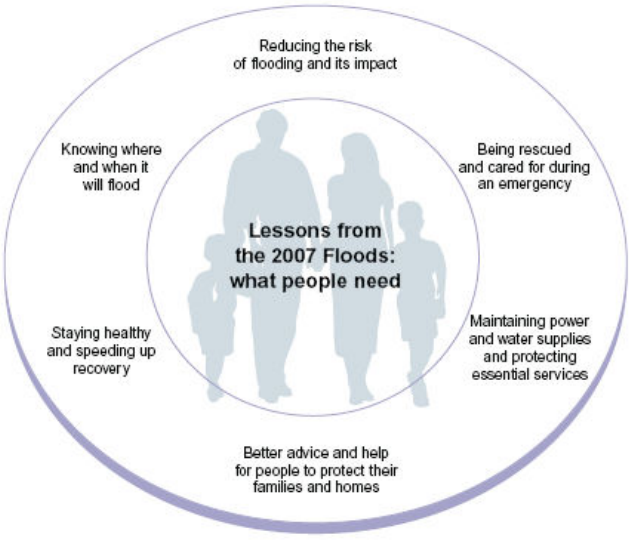


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## Pitt Review

In paragraph 7.50 of the Pitt Review it states "*that voluntary contributions and actions to fund flood risk management measures locally, providing they are technically and environmentally sound and sustainable, should also be encouraged.*"

This led to Pitt Review Recommendation 24 that "*The Government should develop a scheme which allows and encourages local communities to invest in flood risk management measures.*"



## Participation

Participation: "The voluntary involvement of people who individually or through organised groups deliberate about their respective knowledge, interests and values while collaboratively defining issues, developing solutions, and taking or influencing decisions" (Finger-Stich & Finger, 2003)

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## Sherry Arnstein's 'participation ladder' (1969)

| | |
|---|---|
| Citizen control (self-governance) | Degrees of citizen power (or participation) |
| Delegated power | |
| Partnership (co-operation) | |
| Placation | Degrees of tokenism (or symbolic participation) |
| Consultation | |
| Informing | |
| Therapy | Levels of non-participation (contrived to substitute for genuine participation) |
| Manipulation | |

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Recent floods in Hungary: local volunteers join officials and soldiers in raising dike and providing temporary repair to a failing section

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## Volunteering

- Different from lobbying or influencing.
- Being prepared to give time and energy
- May be short-term, perhaps only few weeks
  - In UK, BTCV (British Trust for Conservation Volunteers) offers volunteering 'holidays'

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## Stewardship

Stewardship is more than occasional volunteering

- 'Caring for, maintaining well-being, being vigilant, accepting responsibility & understanding the importance of accountability' (Lerner, 1993)
- 'Implies a relationship with the earth based on respect for nature … a current & ongoing commitment to "active earthkeeping" … a custodial or guardianship role' (Carr 2002)

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