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Flood Resilience in Cities:

Implications for Modellers and Decision-makers

Nigel Wright

- 2009-date
  - Professor of Water and Environmental Engineering, University of Leeds.
- 2006-2009
  - UNESCO-IHE/TU Delft
- 1993-2006
  - University of Nottingham

ENGLAND
ATLANTIC OCEAN
SCOTLAND
0 100 km
0 60 miles
Northumberland
Newcastle-upon-tyne
NORTHERN IRELAND
Carlisle
Durham
Lake District NP
Isle of Man
York
Leeds
IRELAND
Liverpool
Manchester
NORTH SEA
Nottingham
Birmingham
Shropshire
Northampton
Ipswich
WALES
The Cotswolds
Oxford
London
Celtic Sea
Bristol
Bath
Stonehenge
Canterbury
BELGIUM
Bude
New Forest
Newquay
Exmouth
Isle of Wight
The Channel
FRANCE
Isles of Scilly
Channel Islands

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Focus on *interdisciplinary* water research across:

- Natural and physical sciences
- Engineering
- Social science
- Water governance and security
- Economics
- Management
- Art and literature

Est. 2008

>100 staff

School of Civil Engineering

- Pathogen Control (PaCE)
  - Use of wastewater for irrigation (WHO)
  - Recovering energy and resources from wastewater
- Resilient Infrastructure (iRI)
  - Undermining infrastructure
  - MUSCO's

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• Sustainability Research Institute:

- **Water harvesting** for rainfed Africa: investing in dryland agriculture for growth and resilience (WAHARA, EU FP7, 2011-16, € 2 million)
- Transforming water scarcity through **trading** (EPSRC, 2011-14, £585k)
- Practice, identity, power & discourse in intended users' perspectives of a **solar-powered water technology** (2008-11)

ESRC Centre for Climate Change Economics and Policy

- Future Scenarios for a Low-carbon Economy
- Focused on energy, but being developed for water.

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Flood Risk Mgmt Research Consortium

www.floodrisk.org.uk

- £10mlln over 8 years.
- Leading-edge academic research

and

- User-focused measurable outcomes (UFMO!).

- UR1 - Measures and Serviceability Indicators Linked to a Drainage System Asset Performance and Deterioration Model.

- UR2 - Implementation Plan for Library of Tools for Uncertainty Evaluation.

- UR3 - Exploitation of New Data Types to Creat Digital Surface Models for Flood Inundation Modelling.

Is flooding increasing?

- Climate change/variability
- Urbanisation
- Economic growth

Challenges in Flood Risk Management

- Transparency
  - democratic legitimacy;
  - Co-ownership.
- Behavioural:
  - Attitudes to risk.

A risk-based approach to mitigating the effects of flooding.

Risk = Probability x Consequence

Should be considered as an integral over many probabilities

- Risk-based analysis adopted as policy in the UK;
- Increasingly used in the Netherlands.

- This leads to the evaluation of an increasing range of options...
- ...and a move from defence to resilience.

Resilience:

...the capacity of the whole-system to absorb flood waves with annual variability, and to reorganize while undergoing change in flood wave frequency and severity in the long term, so as to enable it to function normally.

Gersonius, Delft FRG, 2008.

A *resilience approach* accepts that flooding will occur and seeks to minimise damage and disruption.

- *There is no best solution – only responses.*
- *Stationarity is dead.*
- *Local adaptation can be as effective as central responses.*

- Which system's resilience are we interested in?
  - Eco-system?
  - Economic system?
  - Social system?

Source: DeltaSync, 2008

NED
0555
2224
NED
0555
2220
no mercy
NED
0851
1290

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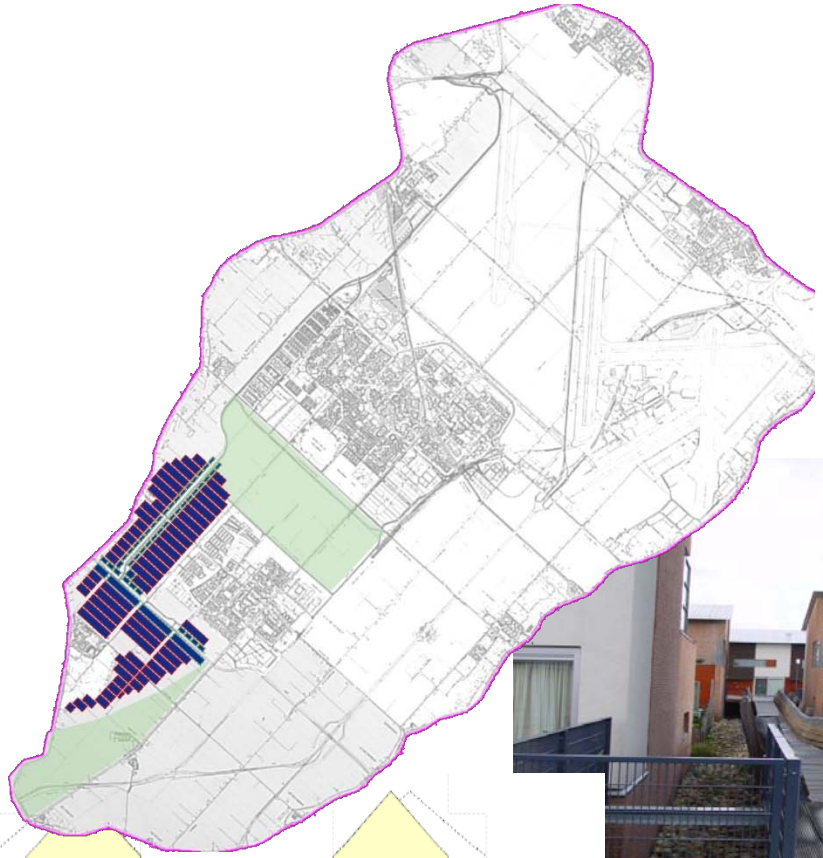
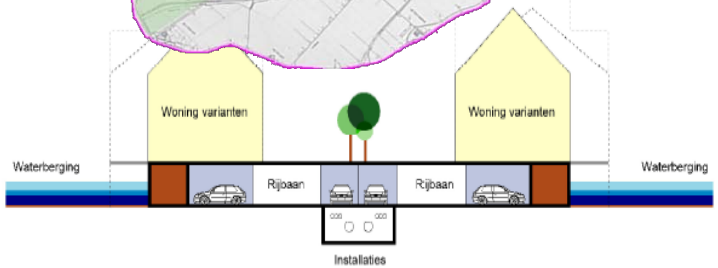
Haarlemmermeer





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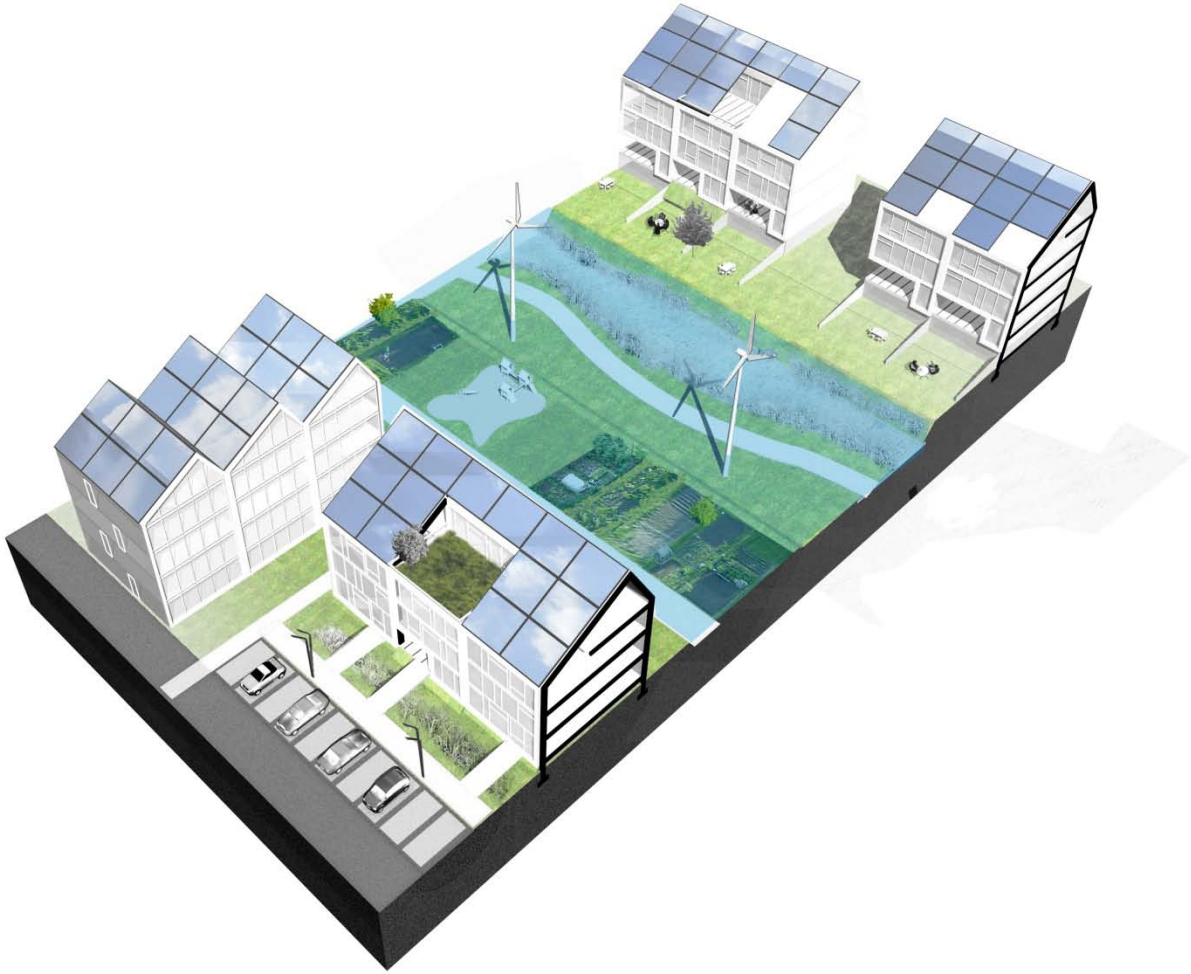

Challenges in a resilience approach

- Community acceptance.
- Uncertainty.
- Move away from design flood to a frequency map.

Challenges to modellers

- Uncertainty estimation = many runs.
- Frequency maps = long-term simulations
- Simulations in urban areas.
- Modelling “Sustainable Urban Drainage”.

"a formal environmental model can only ever be an approximation to the perceptual model of the complex processes governing the response to some forcing"

Beven, 2002

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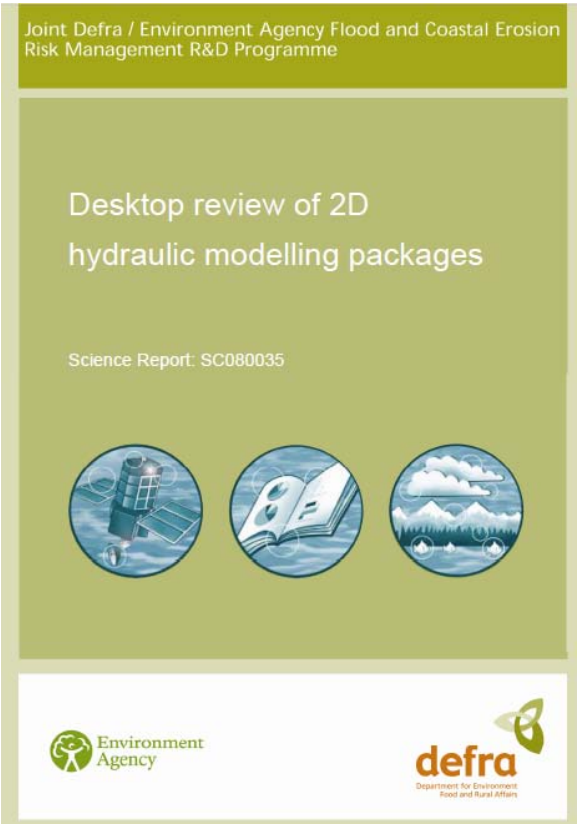
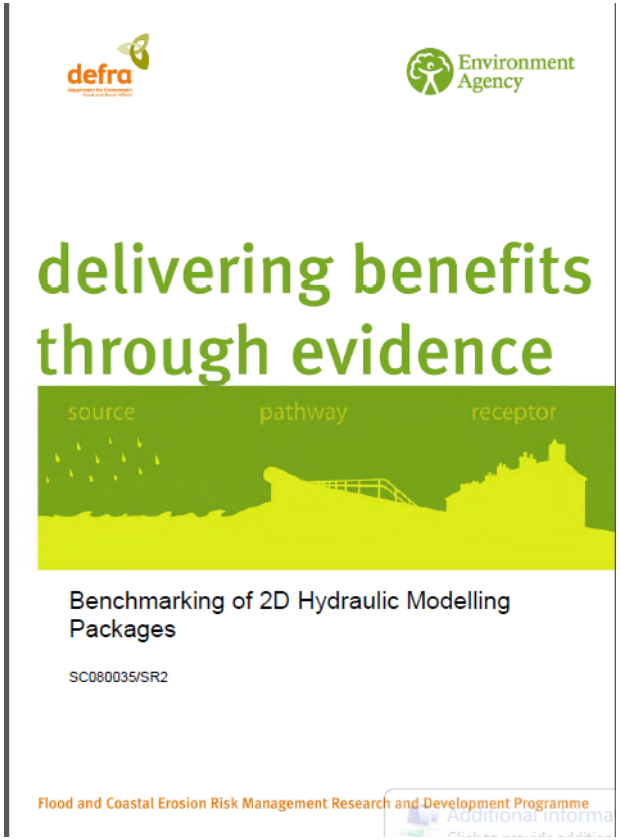
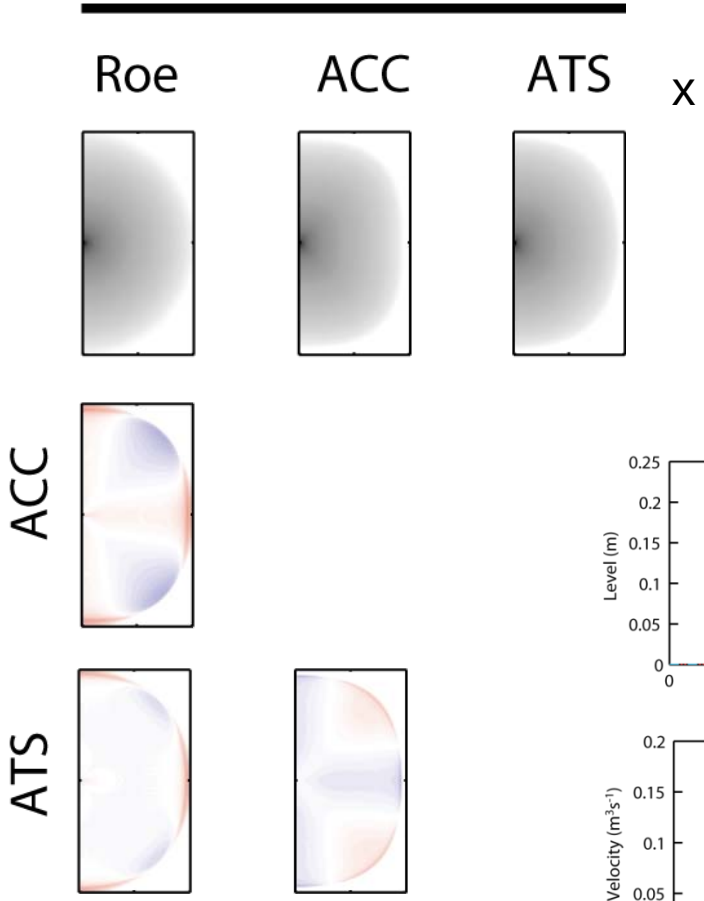
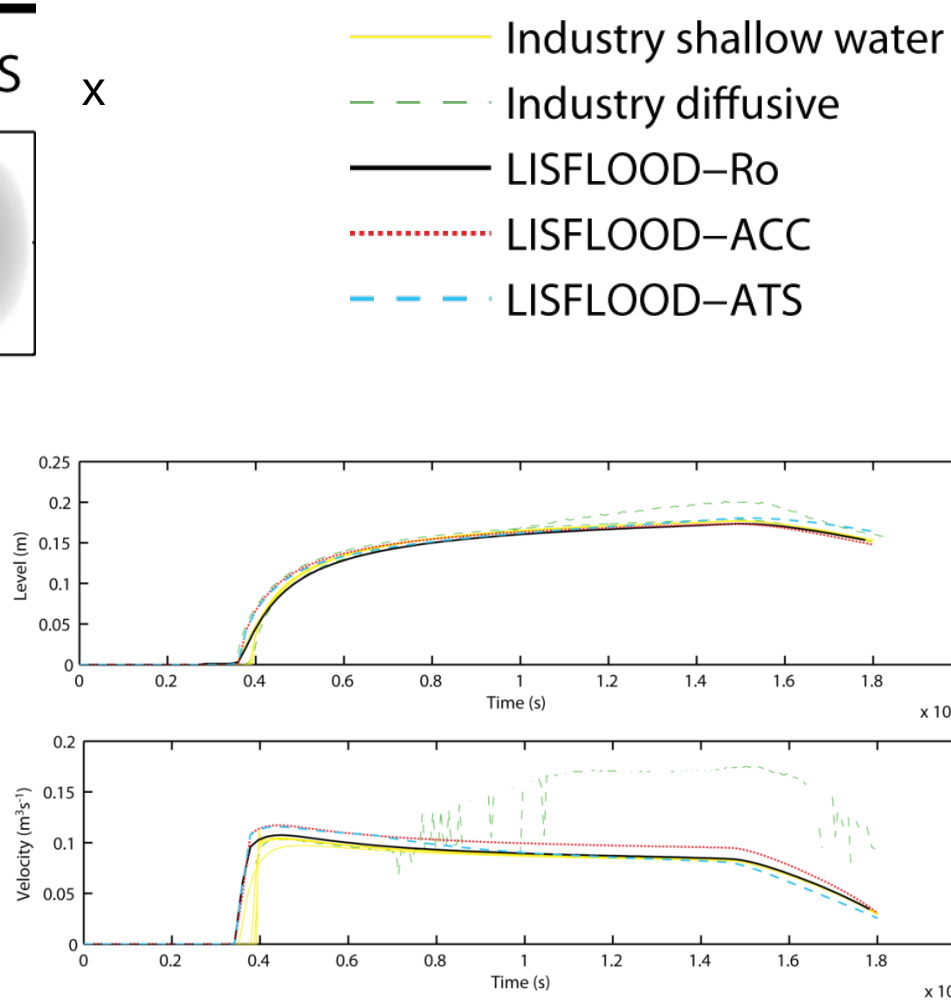
EA 2D Benchmarking project





LISFLOOD-FP


Roe
ACC
ATS
x
ACC
ATS


Industry shallow water
Industry diffusive
LISFLOOD–Ro
LISFLOOD–ACC
LISFLOOD–ATS
Level (m)
Time (s)
x 10^4
Velocity (m³s⁻¹)
Time (s)
x 10^4

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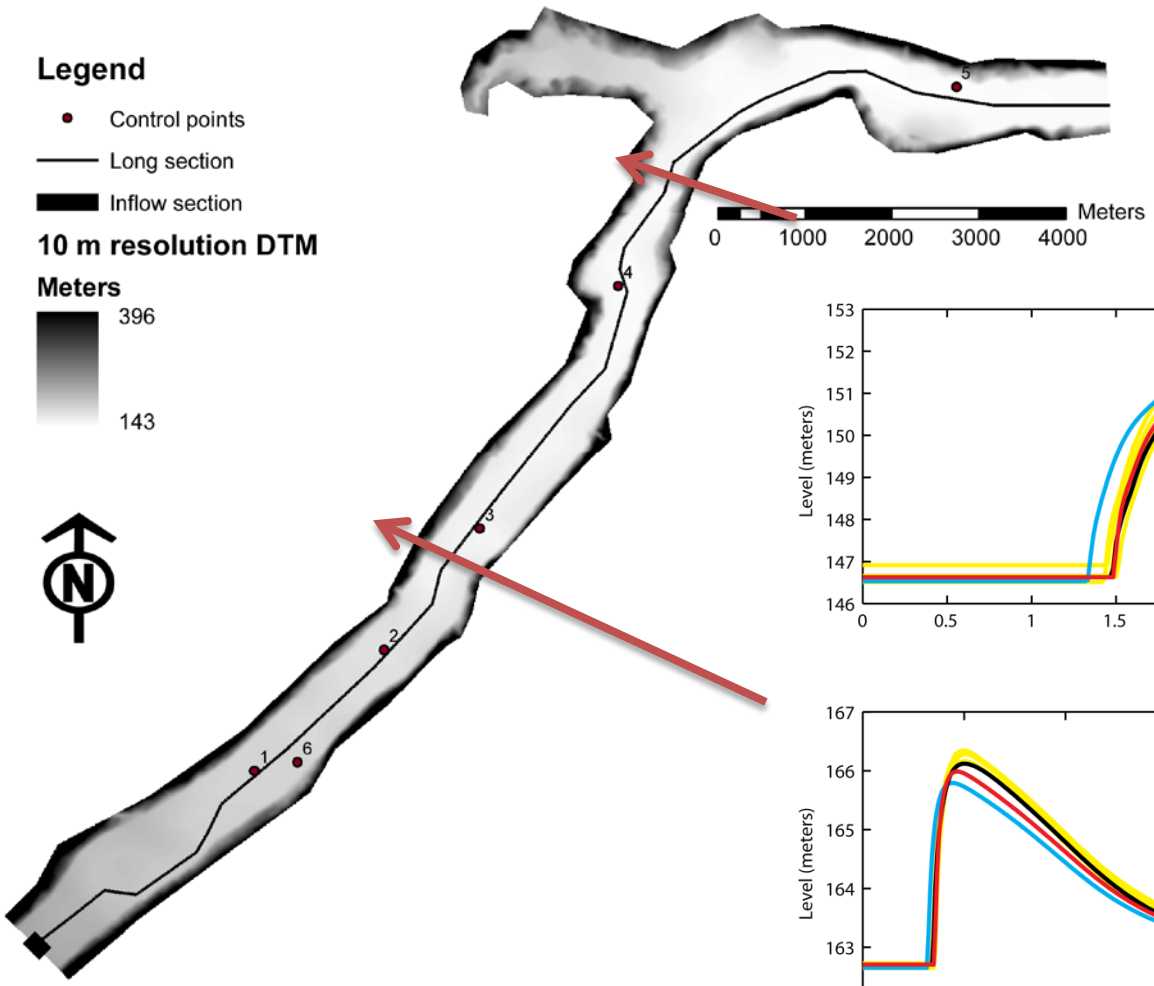
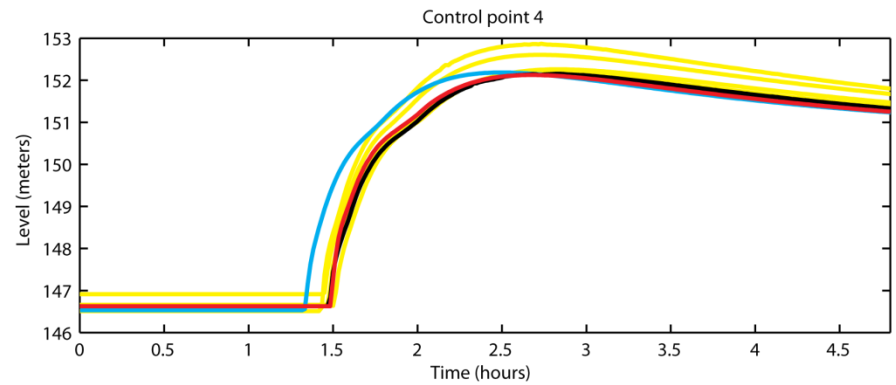
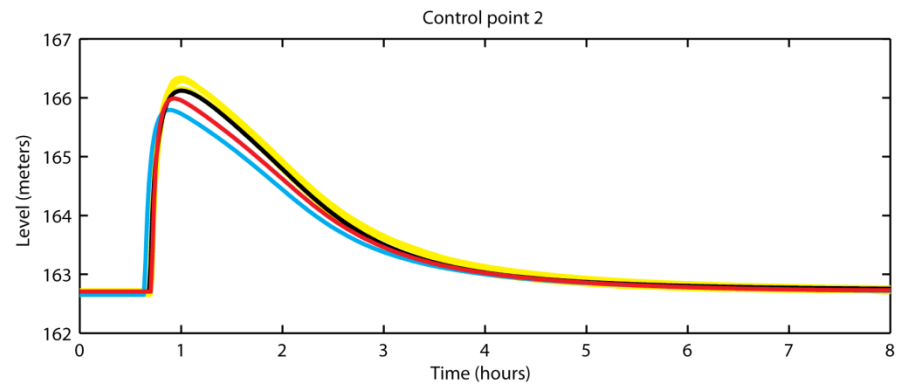






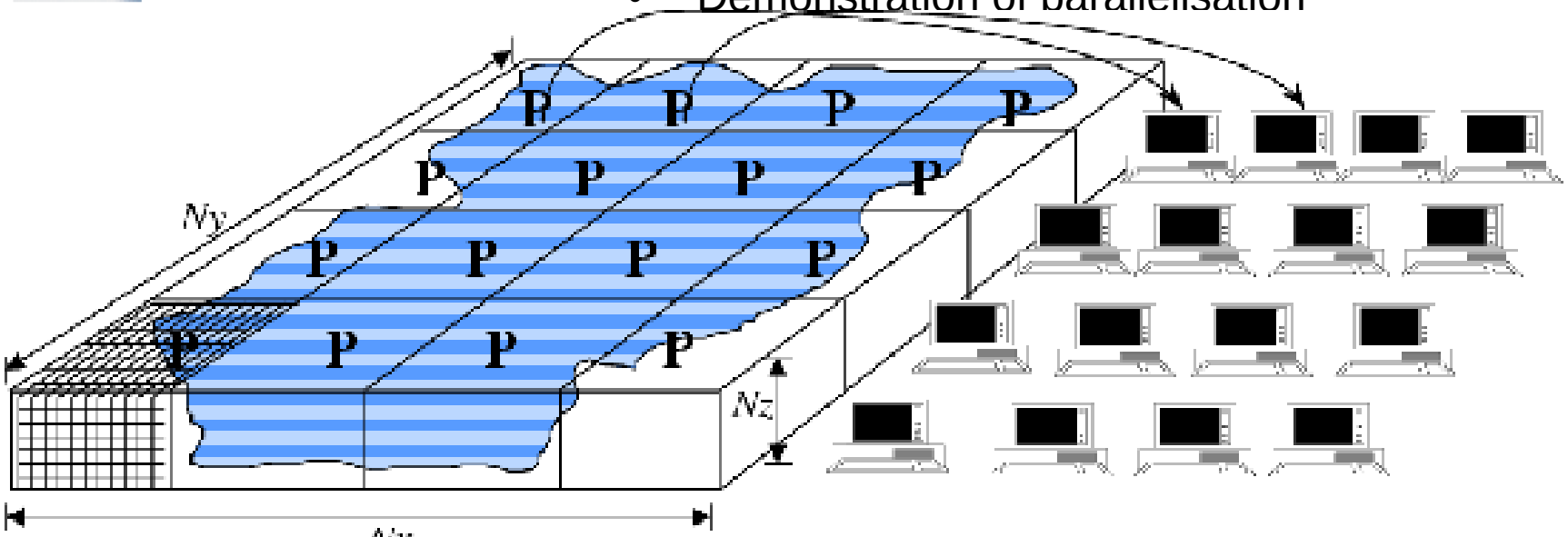
Roe 10m

ACC 10m

ATS 10m

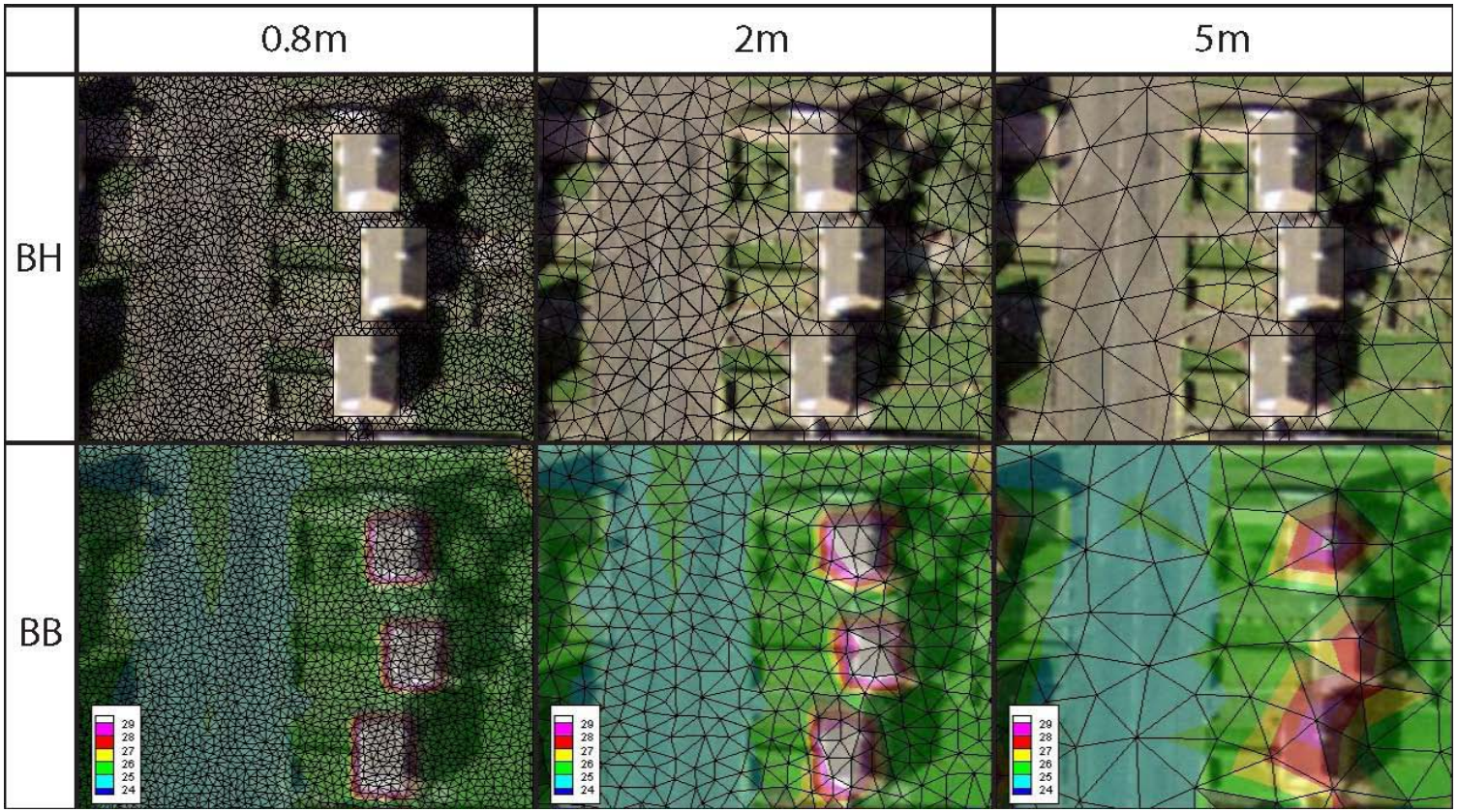
Industry

- Demonstration of parallelisation




```
for(i=0;i<nx;i++)
{
  c[i]=0.;
  for(j=0;j<ny;j++) c[i]+=a[j*n+i];
  c[i]=sqrt(c[i]);
}
```

2^{24}	256	20.0	4.29×10^{9}



Collaboration with Sanders at UC Irvine

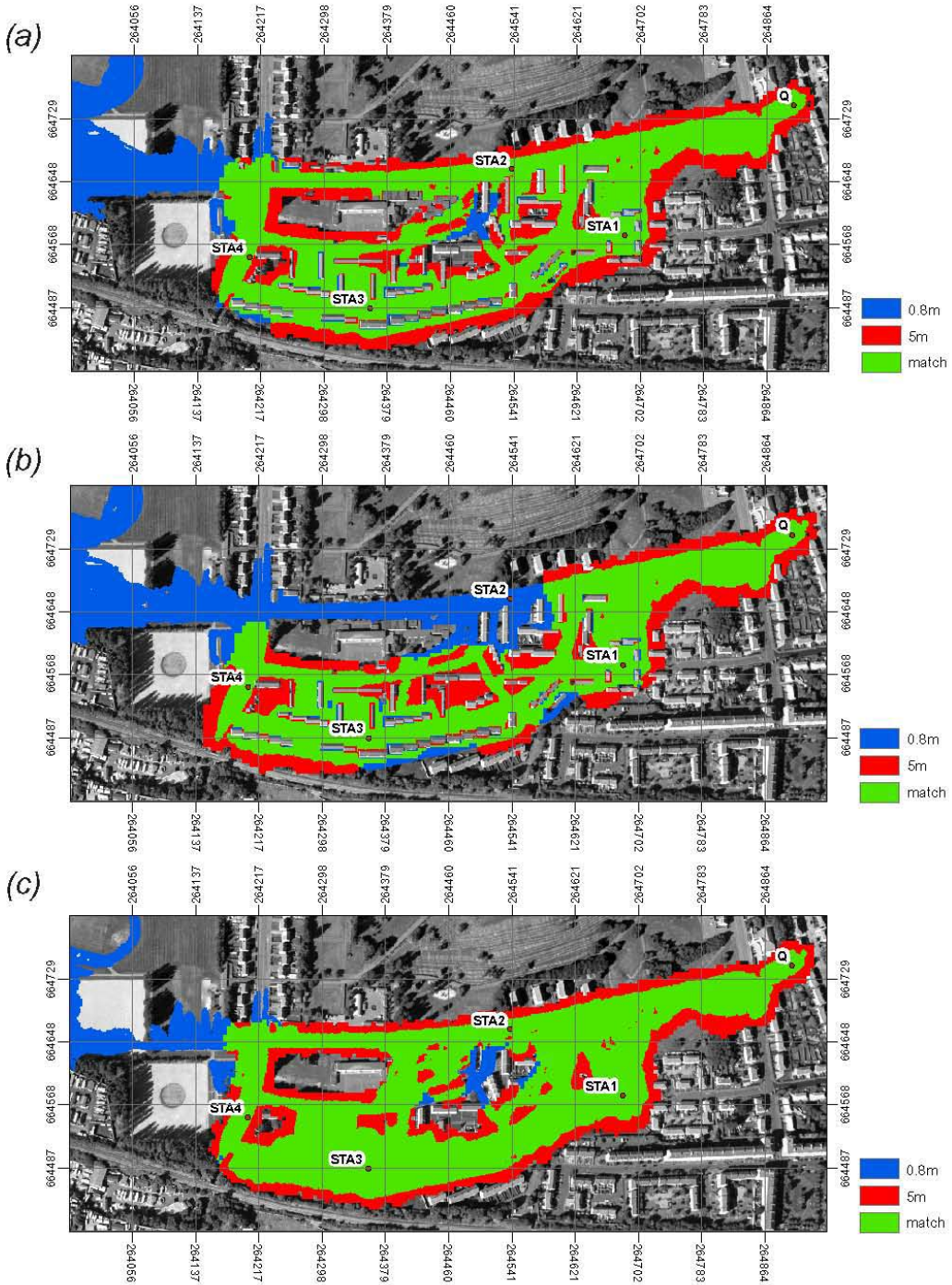
BH

Glasgow

Effect of building treatment and resolution

BB

NB



Flood vulnerability

- Aspects: physical, social, economic, environmental.
- Indicators: physical, social, economic, institutional.

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Flood Vulnerability Index - FVI - Windows Internet Explorer

http://www.unesco-ihe-fvi.org/

Flood Vulnerability Index - FVI

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Flood Vulnerability Indices (FVI)

Vulnerability

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What is FVI?

Flood Vulnerability Indices

- **Vulnerability**
- System
- Flood Vulnerability Factors
- Indicators
- Spatial Scales

FVI Data

- Discussions Forum
- Browse Data
- Add Data
- Poll / questionnaire

- Logout *Balica, Stefania*

- Administration

Flood Vulnerability

Defining vulnerability can help us understand the best ways to reduce it. The main objective to assess vulnerability is to inform decision-makers or specific stakeholders about options for adapting to the impact of flooding hazards (Douben, 2006b). The need for vulnerability analysis is noted in scientific literature, and the concept includes natural vulnerability, social vulnerability and economic vulnerability.

What is Vulnerability?
The notion to vulnerability has changed over the last 20 years.

Vulnerability is considered in the study of Flood Vulnerability Index (FVI) as *the extent of harm, which can be expected under certain conditions of exposure, susceptibility and resilience.*

Why Flood Vulnerability Index?
Human population world wide is vulnerable to natural disasters. In recent years the impacts of floods have gained importance because of the increasing amount of people who are exposed to its adverse effects. The aim of vulnerability studies is to recognize correct actions that can be taken to reduce vulnerability before the possible harm is realized. FVI is a powerful tool for policy and decision-makers to prioritize investments and makes the decision making process more transparent. Identifying areas with high flood vulnerability may guide the decision making process towards a better way of dealing with floods by societies.

Vulnerability equation:

Vulnerability = Exposure + Susceptibility - Resilience

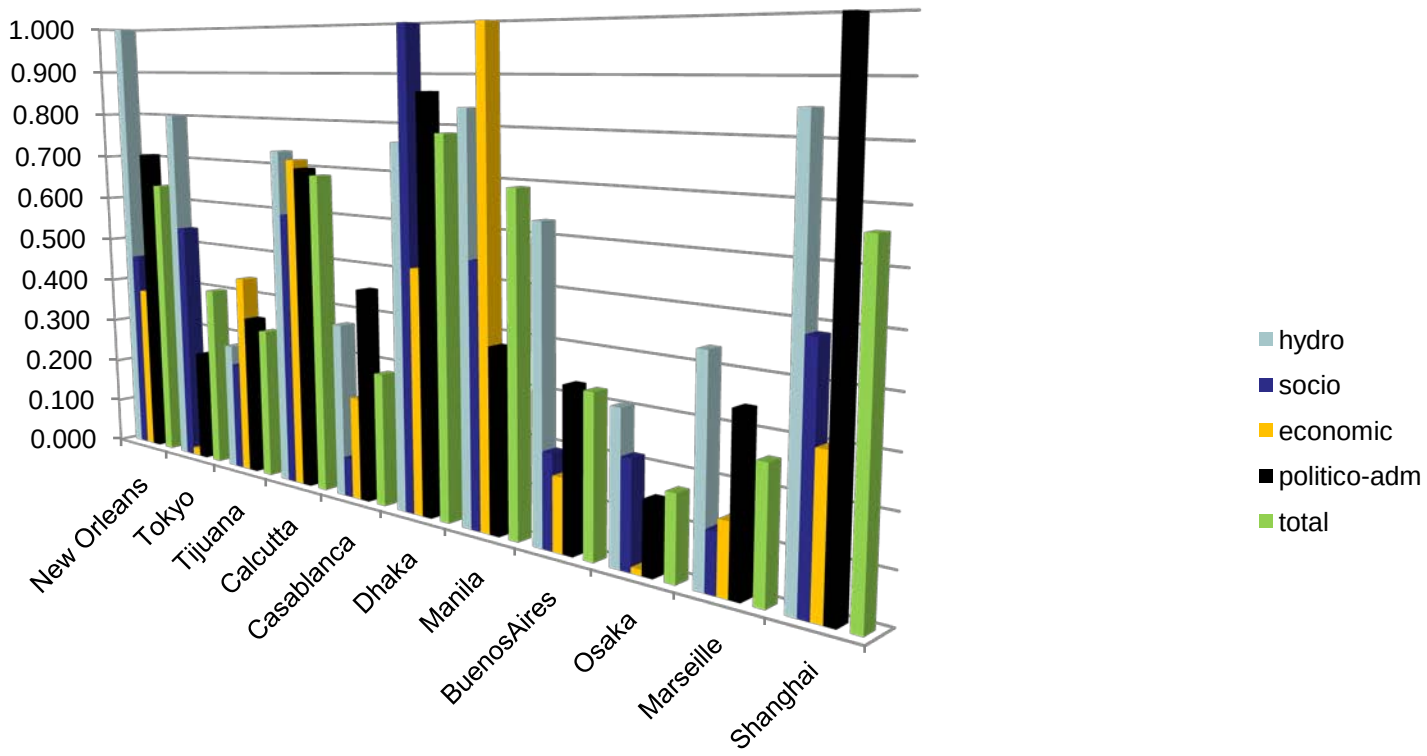
- the *degree of incapability to cope* with the consequences of climate change and sea-level rise. *IPCC CZMS (1992)*

- the amount of *potential damage* caused to a system by a particular event or hazard. *Jones and Boer (2003)*

- a function of *dependence, redundancy and susceptibility*. *Veen & Logtmeijer (2005)*

- a function of *susceptibility, resilience, and state of knowledge*. *Gheorghe (2005)*

- the extent of harm, which can be expected under certain conditions of *exposure, susceptibility and resilience*, *Balica et al (2009).*


1.000
0.900
0.800
0.700
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0.400
0.300
0.200
0.100
0.000
New Orleans
Tokyo
Tijuana
Calcutta
Casablanca
Dhaka
Manila
BuenosAires
Osaka
Marseille
Shanghai
hydro
socio
economic
politico-adm
total

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New project:

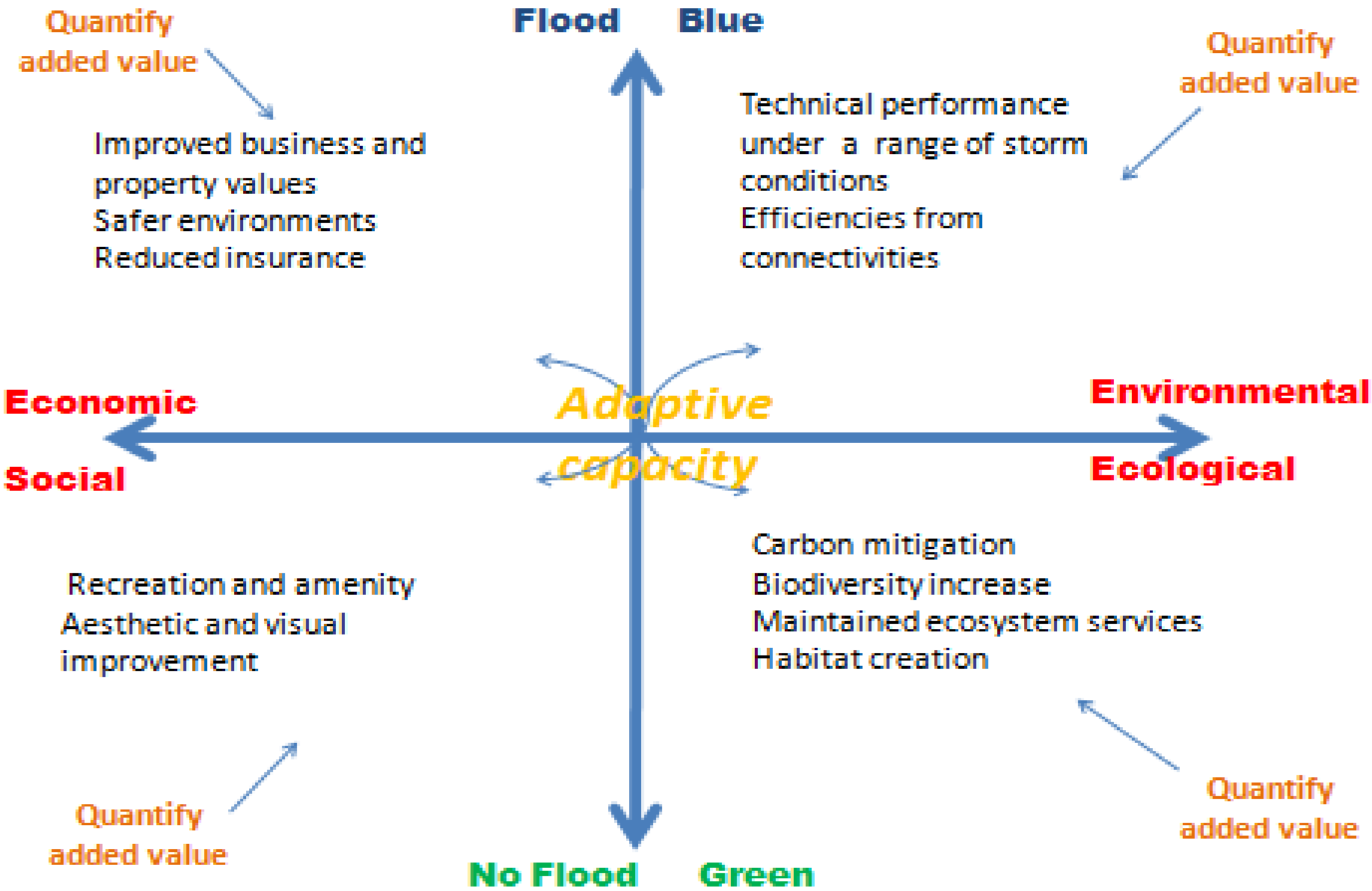
Delivering and Evaluating Multiple Flood Risk Benefits in Blue/Green Cities

Nottingham, Leeds, Cambridge, Newcastle, LSE, Bristol, Cranfield

To develop novel ways of driving new, resilient urban forms and fabrics through:

- delivering measures to manage flood events sustainably while simultaneously:
  - enhancing urban life;
  - providing scope for radical solutions under new build;
  - realising possibilities for improving existing performance through retrofit and urban renewal.

The Research Space



1. Put stakeholders at the centre of the research.

2. Model existing flood risks using coupled surface/sub-surface hydrodynamic models;

4. Employ agent-based modelling to understand the behavioural responses of individuals & organisations.

5. Synthesise existing and novel performance measures to identify the value added at a range of scales.

Extended range of performance metrics:

- technical efficiency,
- public acceptance/peace of mind,
- health and well being,
- ecosystem services,
- economic growth and prosperity,
- aesthetic improvement;
- carbon management.