Tyndall Centre for Climate Change Research

Newcastle University

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Centre for Earth Systems Engineering Research

Integrated urban modelling in London: Successes and challenges

Toward integrated modelling of urban systems, Lyon, October 2014

With thanks to:

Stuart Barr, Alistair Ford, Claire Walsh,
Dan Caparos-Midwood (Newcastle University)
Jim Hall, Katie Jenkins (Oxford University)
Mike Batty (UCL)

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Challenge: Adaptation of cities and infrastructure to global change

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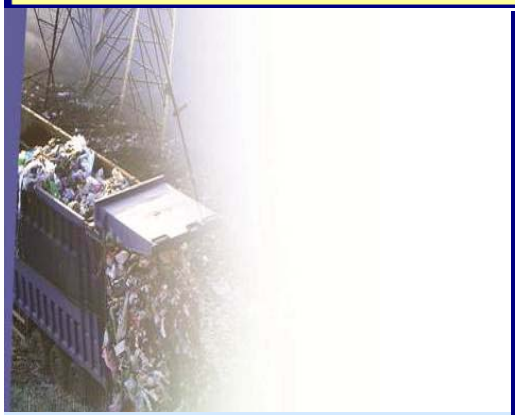
- Socio-economic change
  - Growing global population
  - Changing demography
  - Socio-economic trends
  - Ownership and governance
- Urbanization
  - Concentrates infrastructure
  - Implications for external ‘support’ infrastructure
- Environmental pressures
  - Climate change
  - Broader sustainability tradeoffs
  - Relationship with land use
- Deterioration and replacement

Some complicities and tradeoffs

Response	Potential benefit	Potential negative impact
Air conditioning	Reduce heat stress	Increase energy needs and emissions
Densification of cities	Reduce public transport emissions	Increase urban heat island intensity and exposure to grater noise pollution
Desalination plants	Secure water supply	Increase greenhouse gas emissions
Irrigation	Supplying water for food	Salinisation of soil, degradation of wetlands,
Biofuels for transport and energy	Reduce GHG emissions	Encourage deforestation; replace food crops raising food prices; can increase local air quality pollutants such as NO_x
Catalytic convertors	Improve air quality	Large scale mining and international resource movements
Cavity wall insulation	Reduce GHG emissions	Increase damages from a flood event
Raise flood defence	Reduce flood frequency	Encourage more development (positive feedbacks)
Pesticides	Control vector borne disease	Impact on human health, increased insect resistance
Conservation areas	Preserve biodiversity and ecosystems	Loss of community livelihoods
Insurance/disaster relief	Spread the risk from high-impact events	Reduce longer term incentive to adapt
Traffic bypasses or radial routes	Displaces traffic from city centre, improving air quality and reducing noise	Can increase congestion and journey times (consequently overall greenhouse gas emissions)
Vehicle user charging	Discourage vehicle use to reduce greenhouse gas emissions	Lead to greater social inequality

Adapted from: Dawson (2011) Potential pitfalls on the pathway to sustainable cities…and how to avoid them, *Carbon Management*, Vol 2(2)

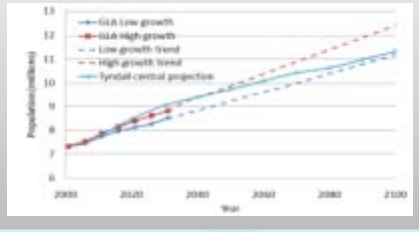
Key	Description
++	The policy is likely to contribute significantly towards the IIA objective.
+	The policy is likely to contribute positively towards the IIA objective, although not significantly.
0	The policy is considered to have no significant positive or negative effect.
-	The policy is likely to detract from the achievement of the IIA objective, although not significantly.
--	The policy is likely to detract significantly from the achievement of the IIA objective.
?	The policy has an uncertain relationship to the IIA objective. Alternatively, insufficient information may be available to enable an assessment to be made.



8. Flood Risk and Climate Change Adaptation. To ensure London adapts to the effects of climate change (both now and in the future). The effects on London particularly concern flooding, drought and overheating.

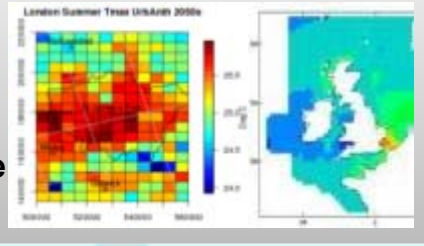
Proposal \ IIA Objective	1. Regeneration & Land-Use	2. Biodiversity	3. Health and Well-being	4. Equalities	5. Housing	6. Employment	7. Stable Economy	8. Flood Risk and Climate Change Adaptation	9. Climate Change Mitigation and Energy	10. Water Quality & Water Resources	11. Waste	12. Accessibility and Mobility	13. Built and Historic Environment	14. Liveability and Place	15. Open Space	16. Air Quality
Policy 2.6 Outer London: vision and strategy	++	0	0	+	0	0	0	0	0	0	0	++	+	+	0	0
Policy 2.7 Outer London: economy	++	0	+	+	0	++	++	0	0	0	0	+	0	+	0	0

Socio-economic scenarios

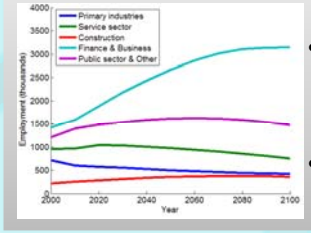


City-scale climate scenarios

- Temperature
- Precipitation
- Sea level rise
- Storm surge



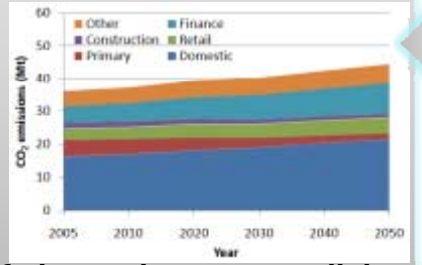
Regional economy



- Dynamic resource interactions between sectors
- Specialist energy sector module

Greenhouse gas emissions

- Multi-sectoral emissions accounting
- Detailed sub-modules for transport (personal and freight)



Analysis of city-scale energy policies

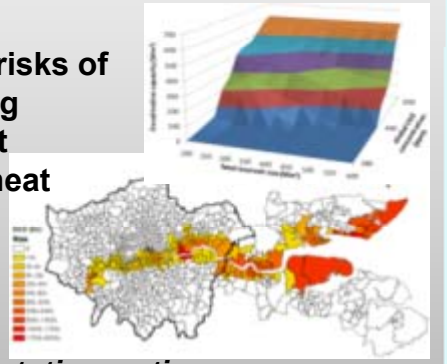
Land use Transport Model

- Employment
- Multi-modal transport
- Developed land cover
- Population
- Planning constraints and attractors

Climate impacts and adaptation

Analyse risks of

- Flooding
- Drought
- Urban heat



Test adaptation options

Testing of policy options

Working with key London stakeholders

Urban weather generator

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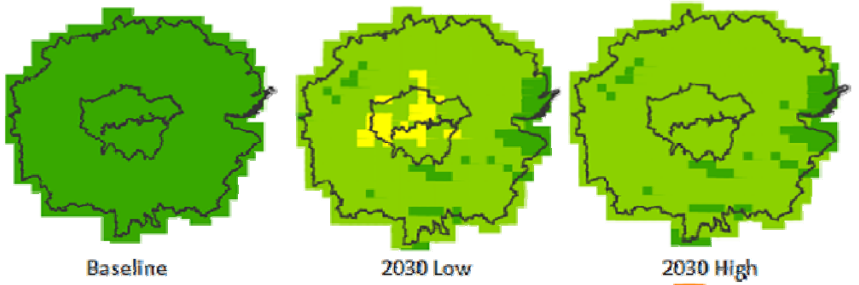
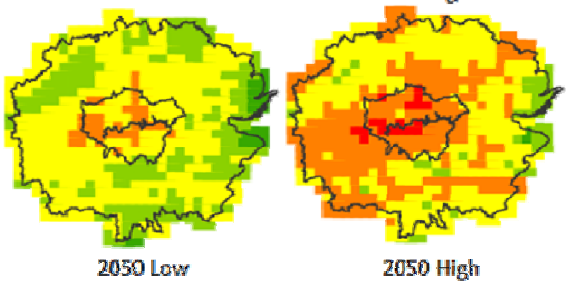
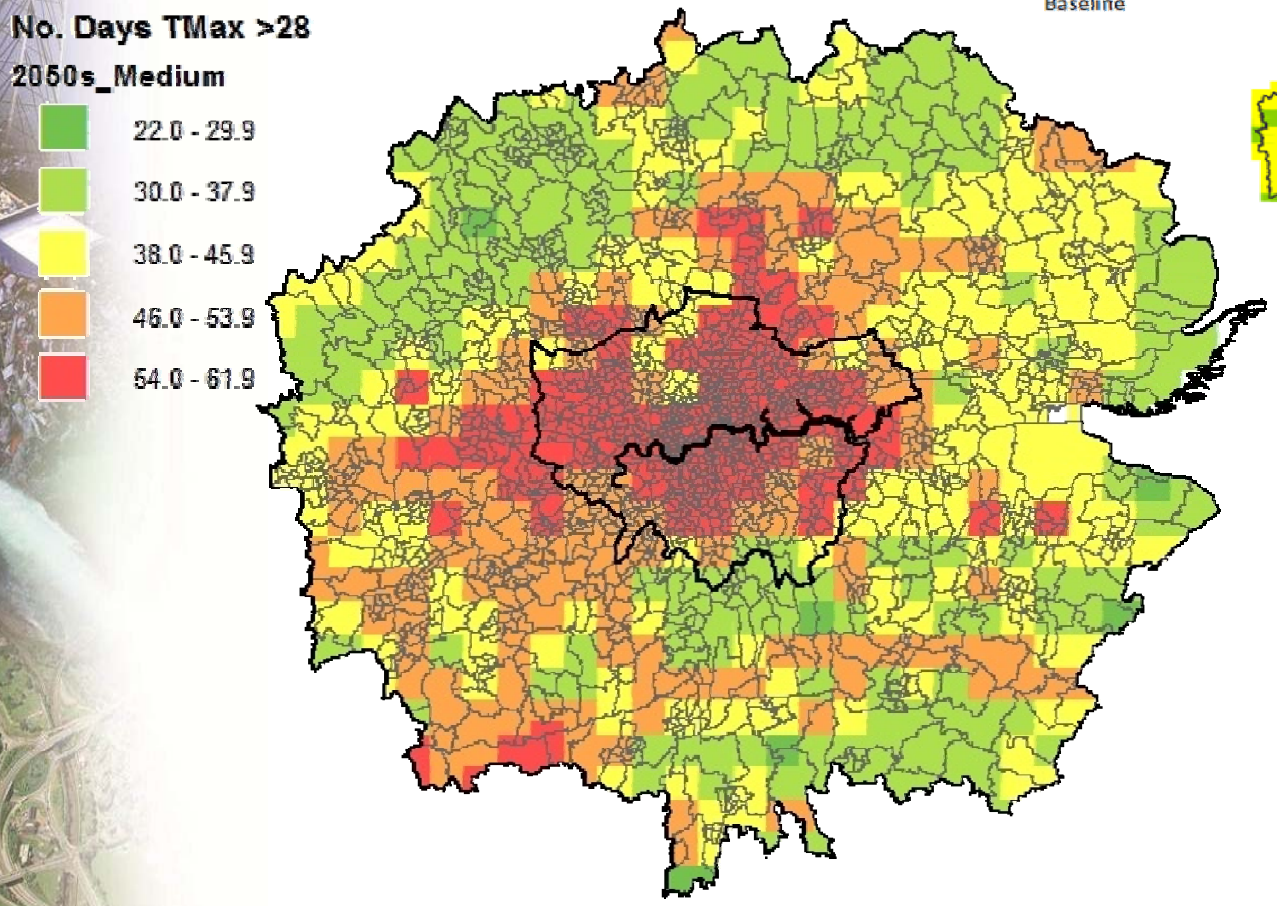
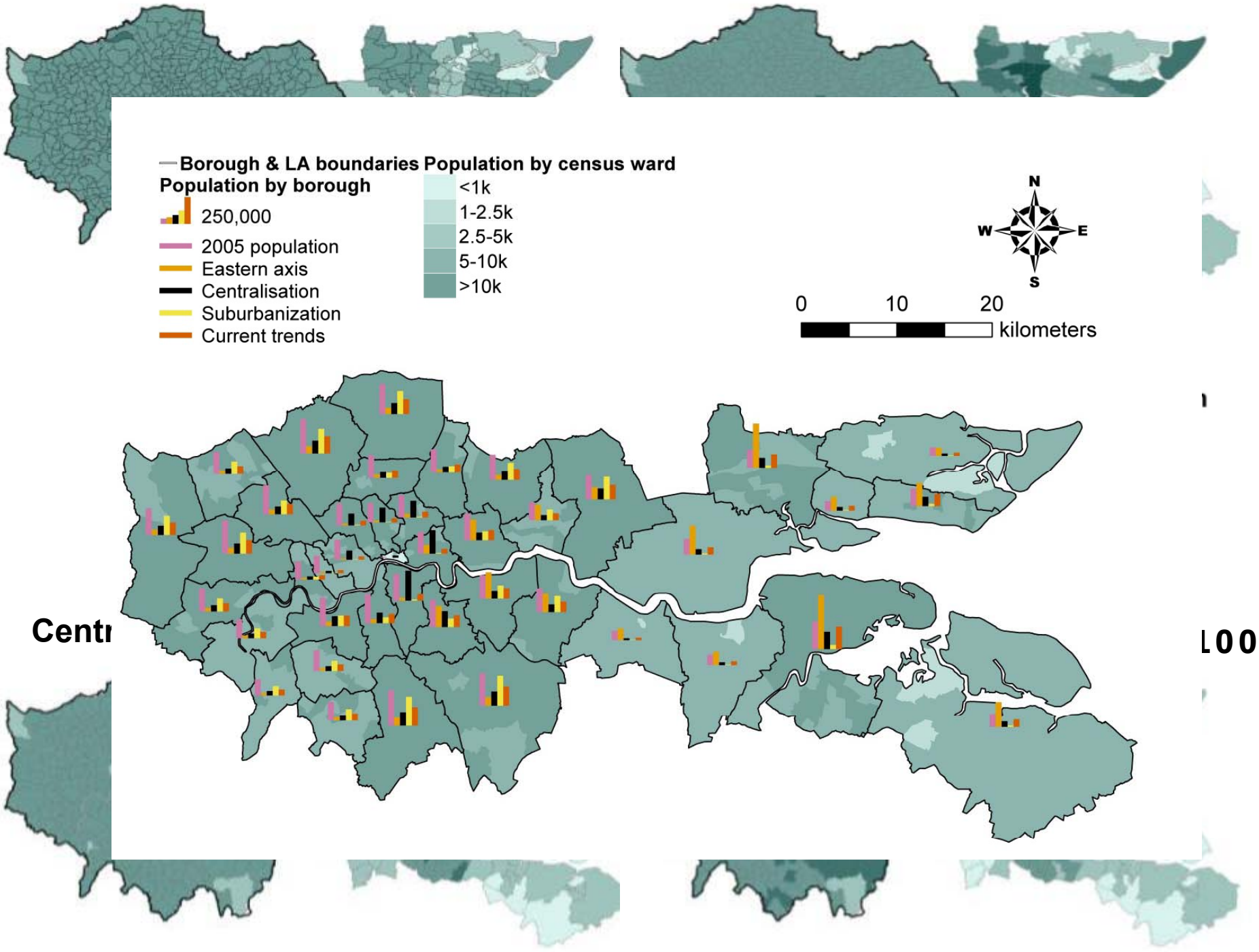
Stochastic, spatial, process model

Perturbed with climate model change factors for future scenarios








Borough & LA boundaries
Population by borough
250,000
2005 population
Eastern axis
Centralisation
Suburbanization
Current trends
Population by census ward
<1k
1-2.5k
2.5-5k
5-10k
>10k
N
W
E
S
0
10
20
kilometers

Transport disruption and adaptation: Temperature thresholds

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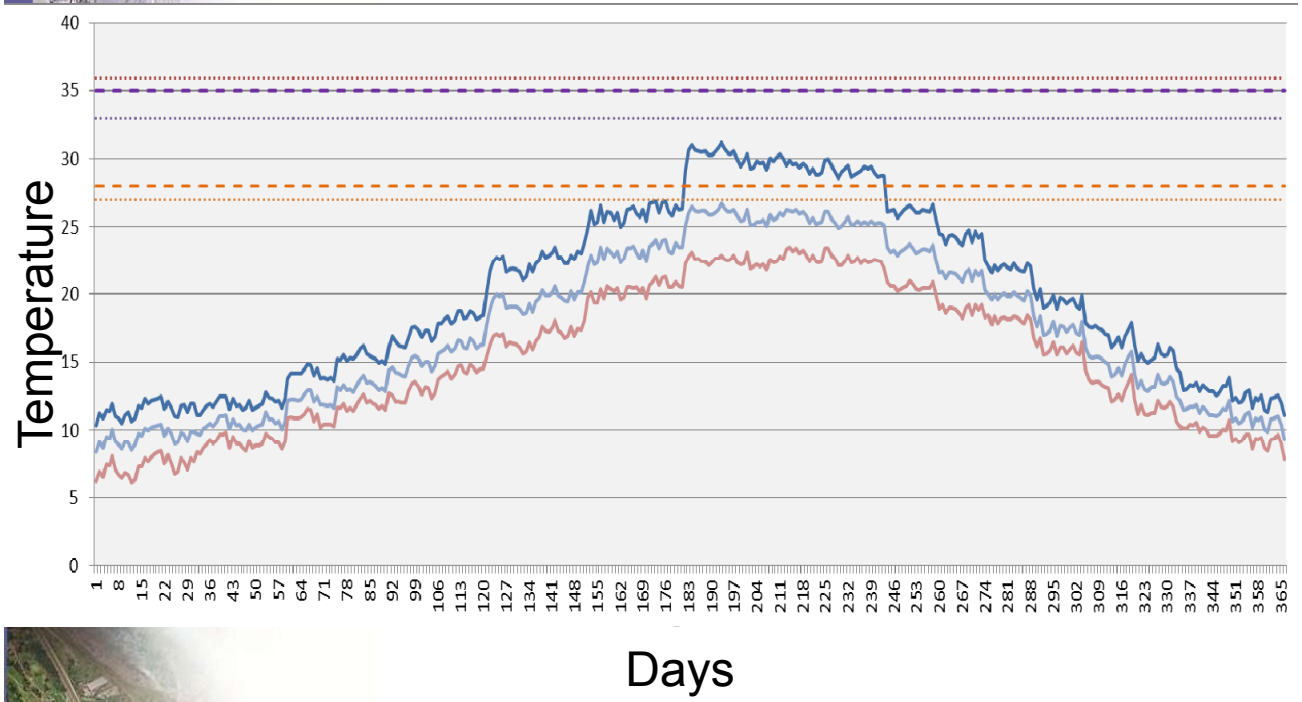

Threshold	Speed restriction
<27°C	None
Poor Track ≥ 27°C < 28°C	30mph
Poor Track ≥ 28°C	20mph
Moderate Track ≥ 33°C <35°C	60mph
Moderate Track ≥ 35°C	20mph
Good Track ≥ 36°C	90mph
Good Track ≥ 42.6°C	60mph
Tube Lines ≥ 33°C <36°C	30%
Tube Lines ≥ 36°C	50%

Transport disruption and adaptation: Disruption to travel times

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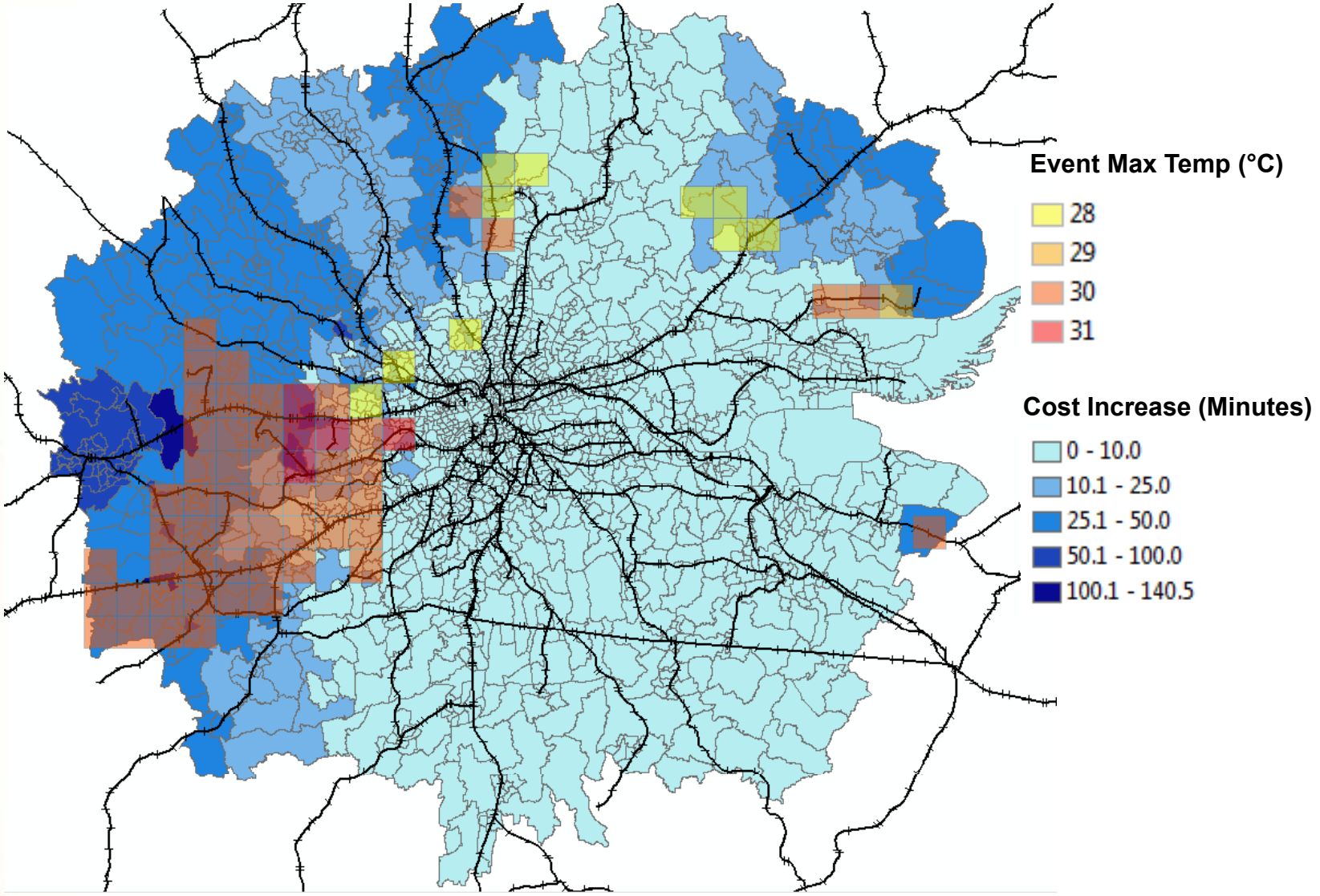

Transport disruption and adaptation: Benefits of adaptation

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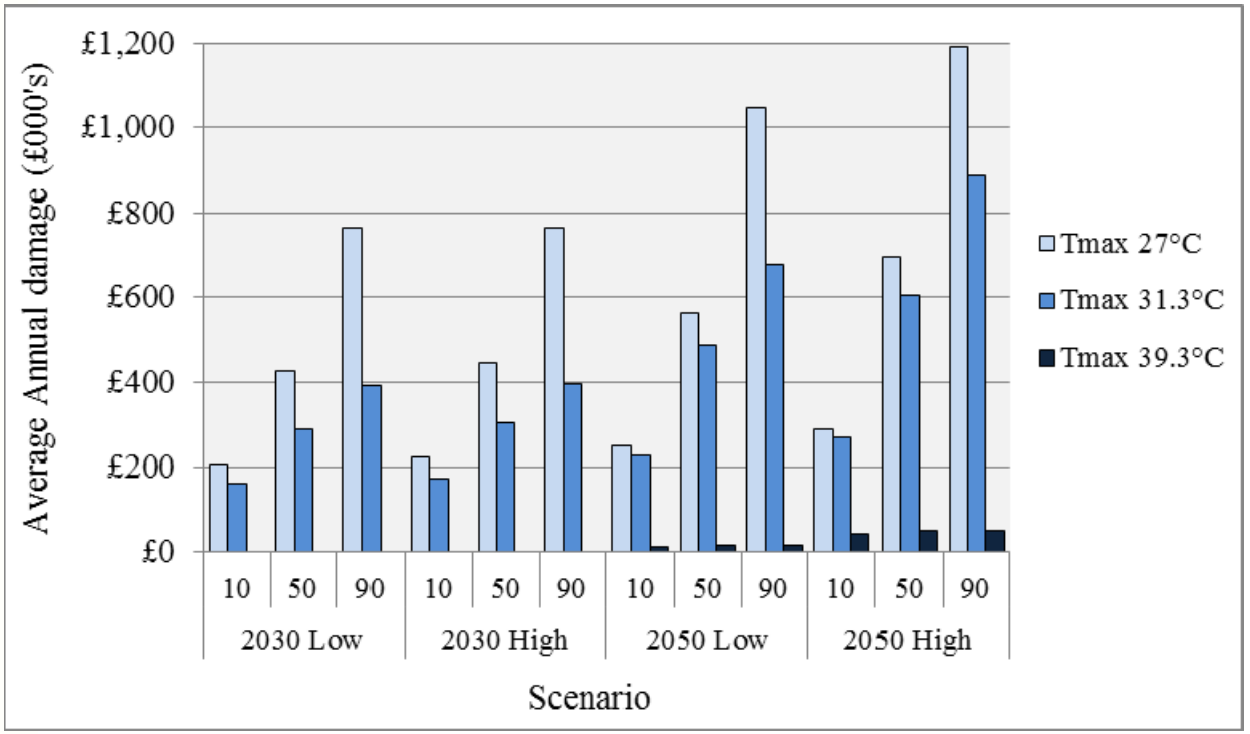
- Significant reduction in present day and long term costs from disruption through track replacement and upgrade

- Might there be long term influence on development from no adaptation?



Socio-economic vs. Climate change

Flood risk for different land use change

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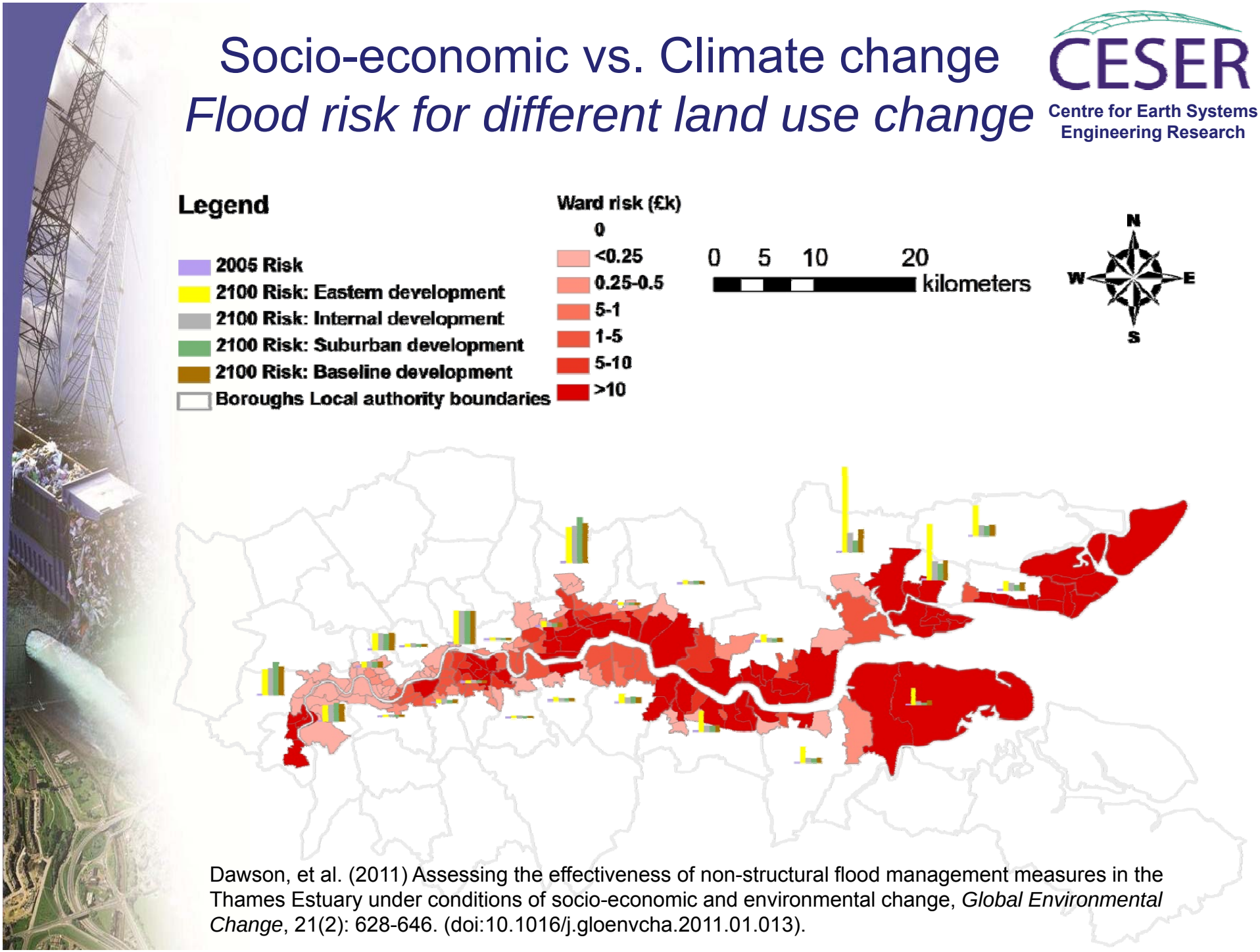

Dawson, et al. (2011) Assessing the effectiveness of non-structural flood management measures in the Thames Estuary under conditions of socio-economic and environmental change, *Global Environmental Change*, 21(2): 628-646. (doi:10.1016/j.gloenvcha.2011.01.013).

Socio-economic vs. Climate change
Attribution of flood risk

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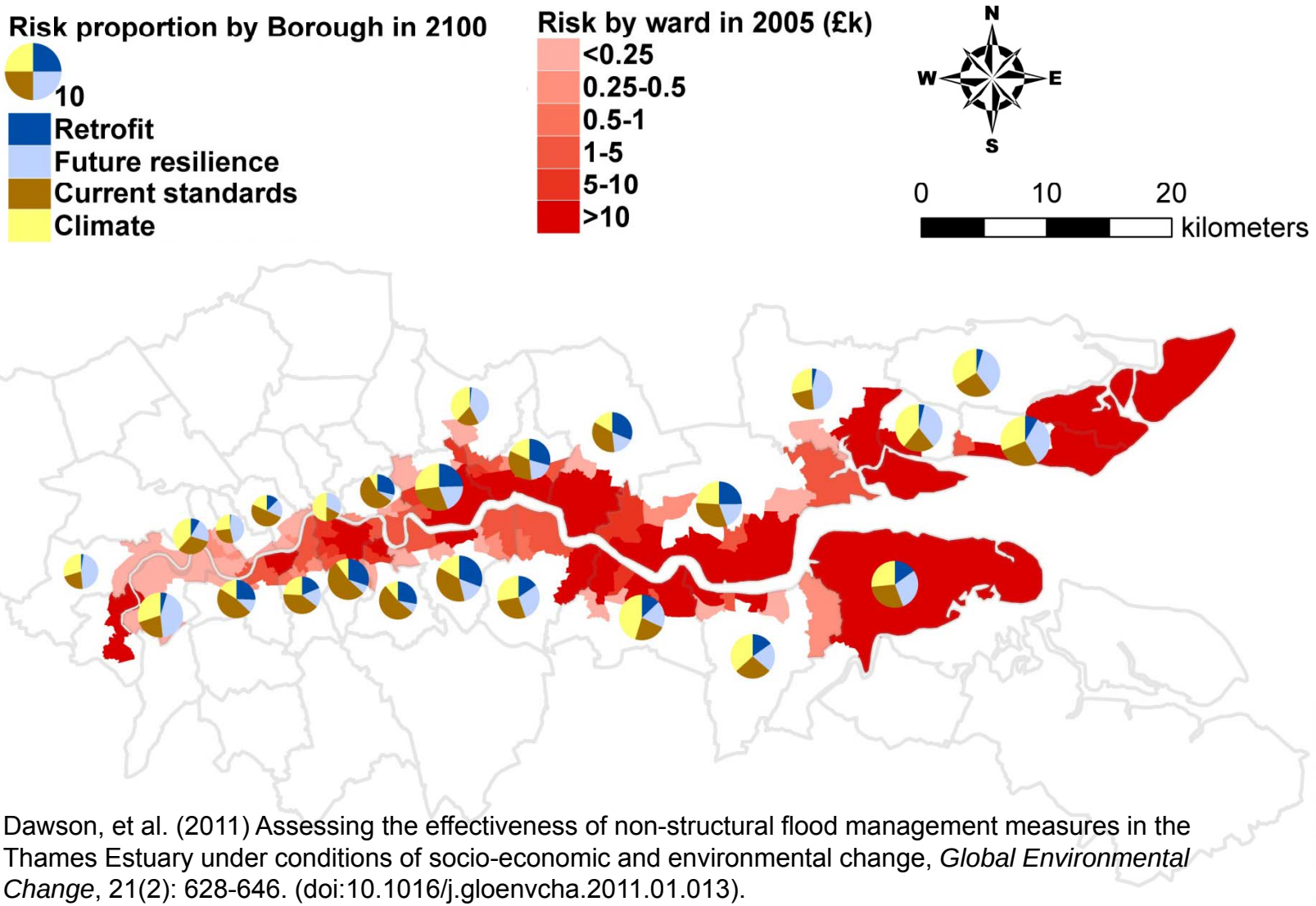

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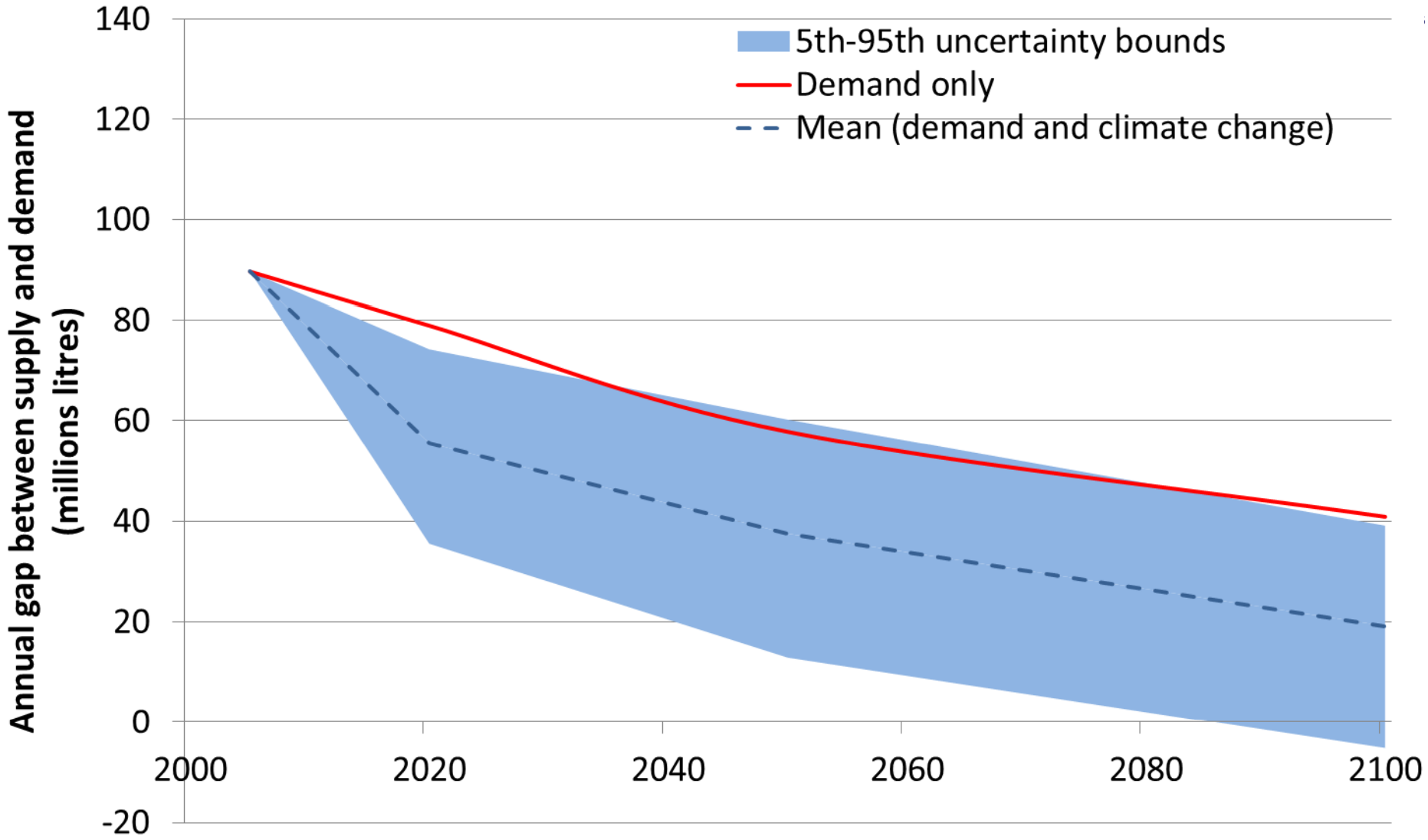
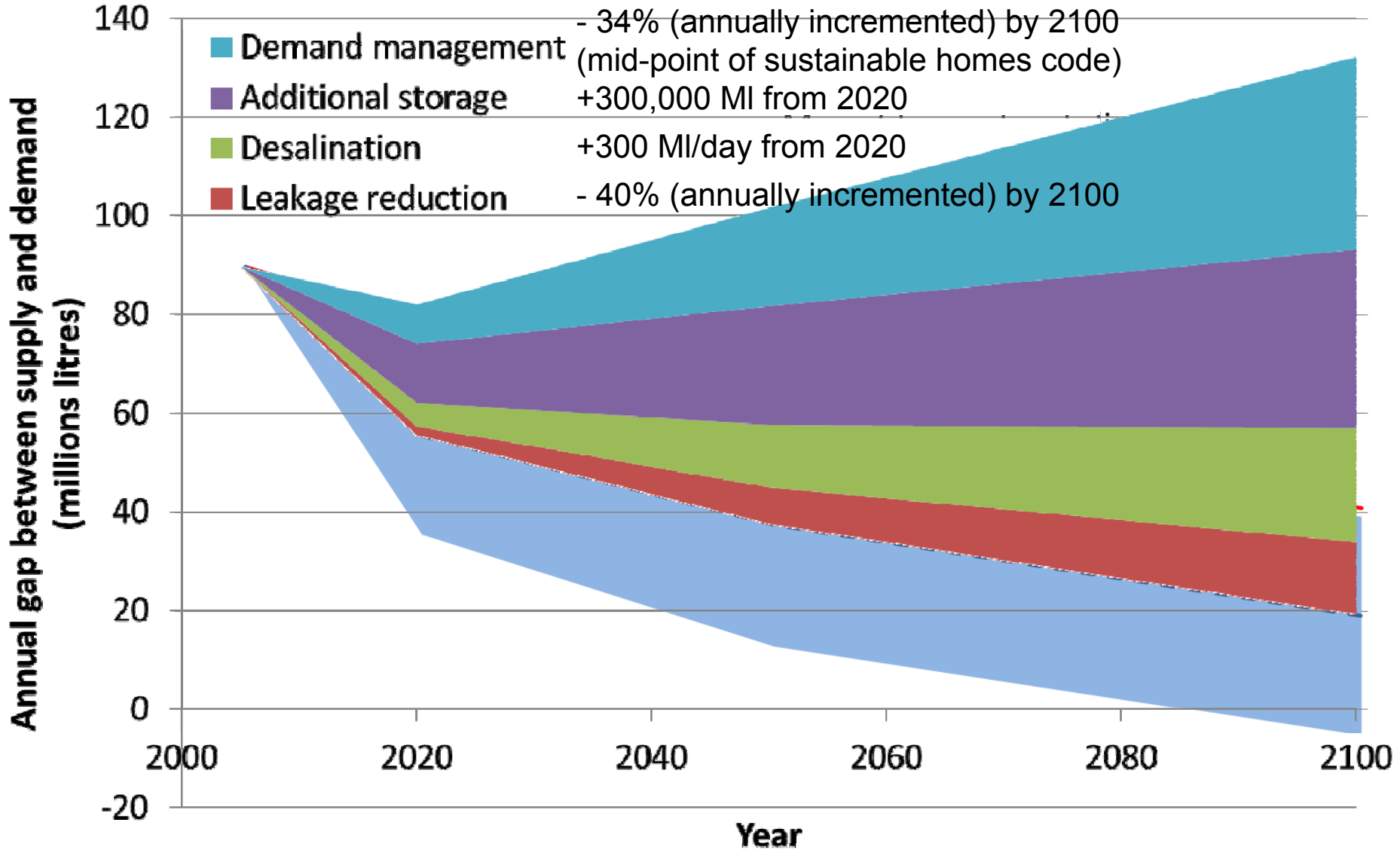
Drought risk: Climate vs. Socio-economic change



Walsh et al. (in review) Managing water resources in changing socio-economic and climatic conditions in the Thames basin, *Journal Water Resources Research*.

Drought risk: Climate vs. Socio-economic change



Walsh et al. (in review) Managing water resources in changing socio-economic and climatic conditions in the Thames basin, *Journal Water Resources Research*.

Drought risk: Adaptation vs. Mitigation

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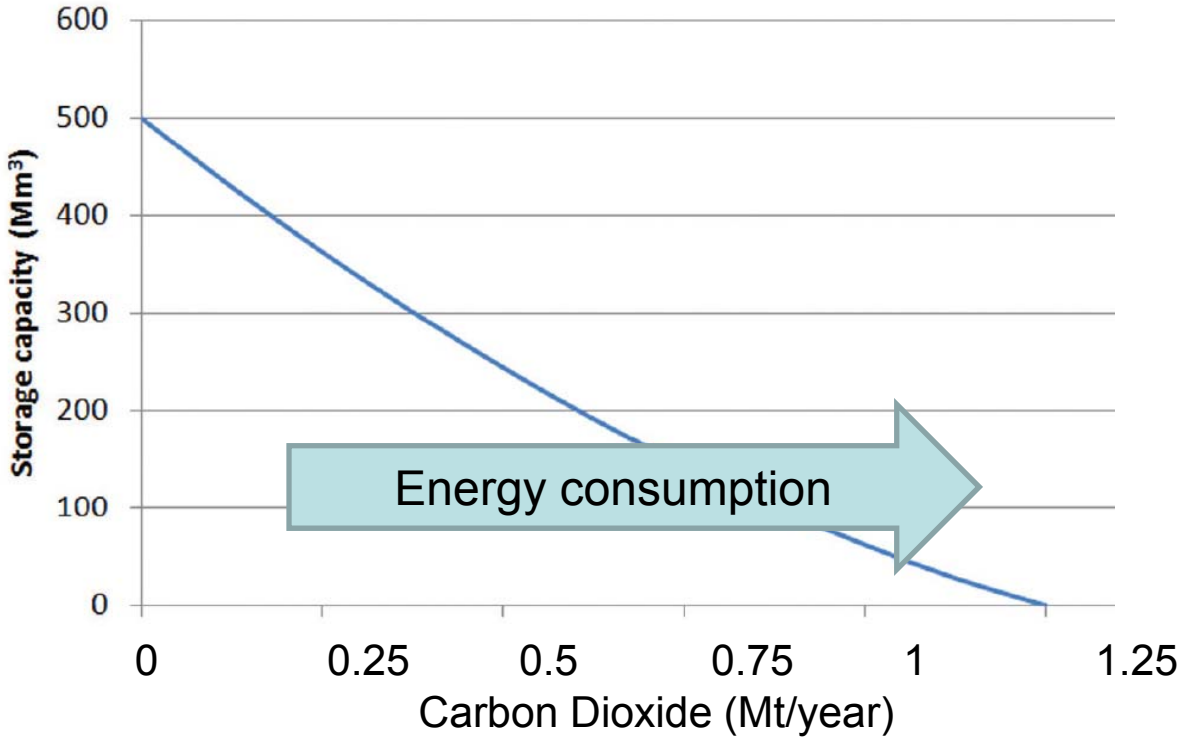

Land use: Adaptation vs. Mitigation

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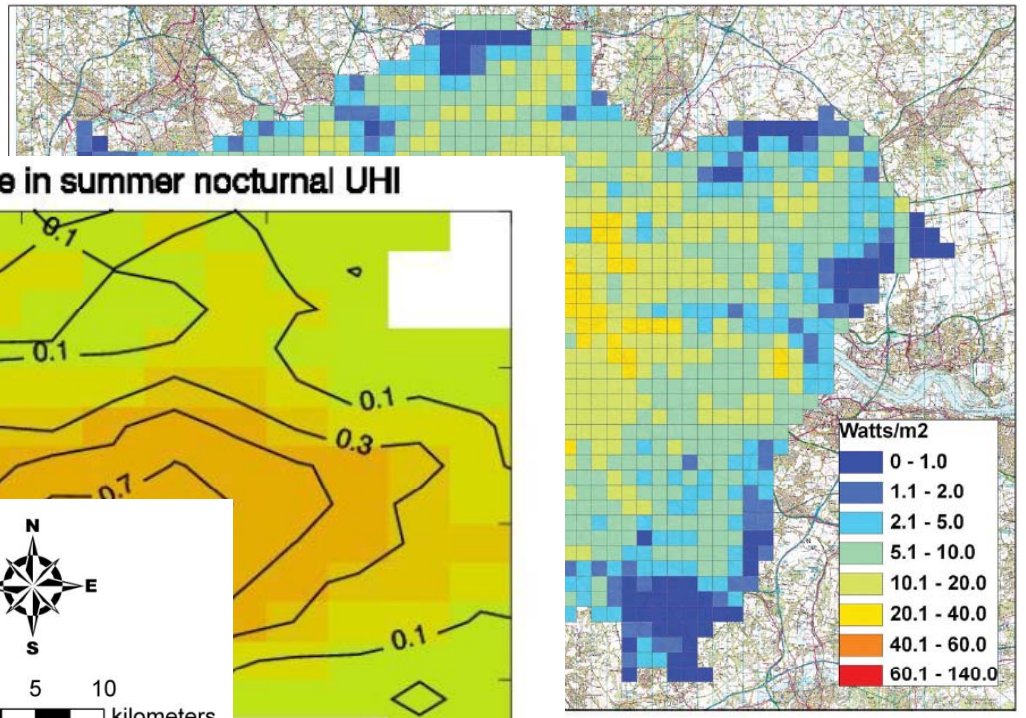
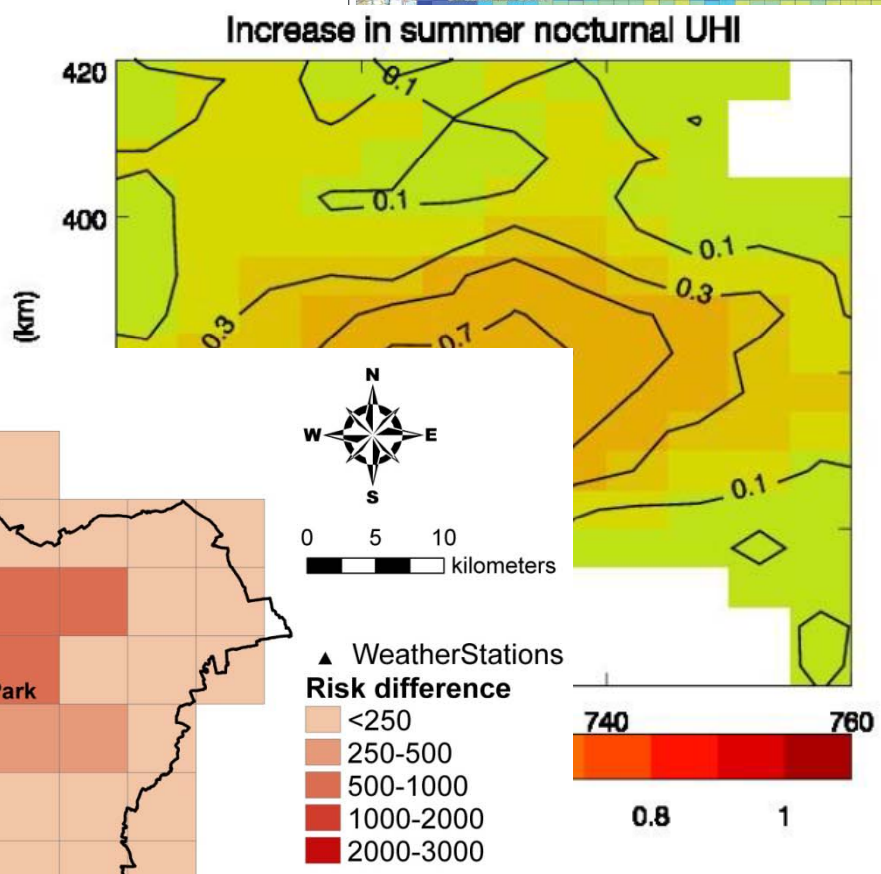
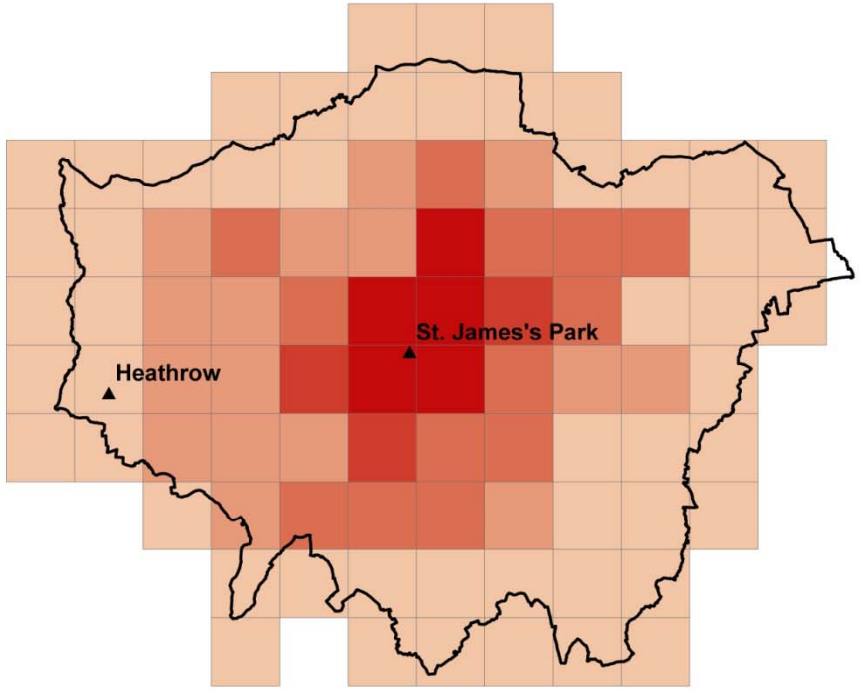
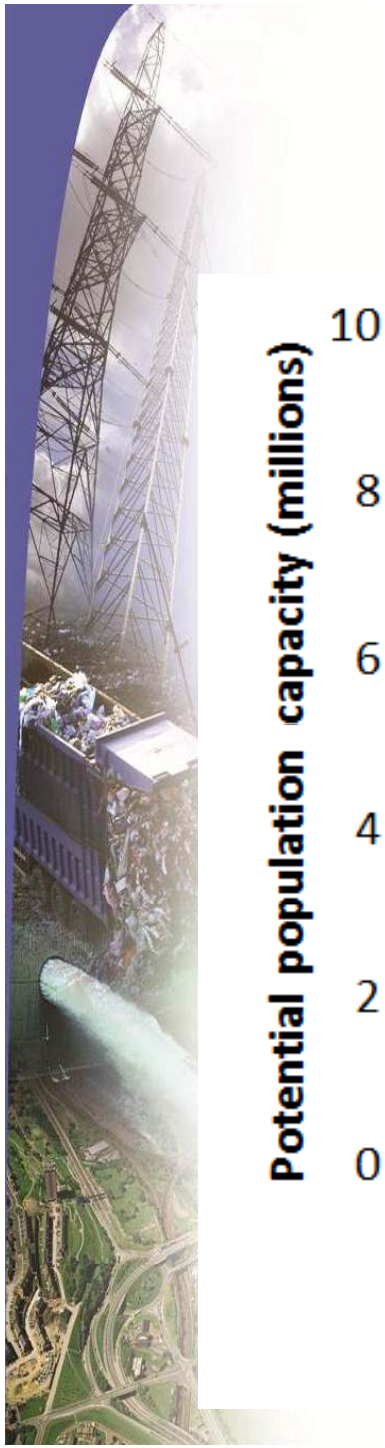
Average current heat emissions









Land use pressures

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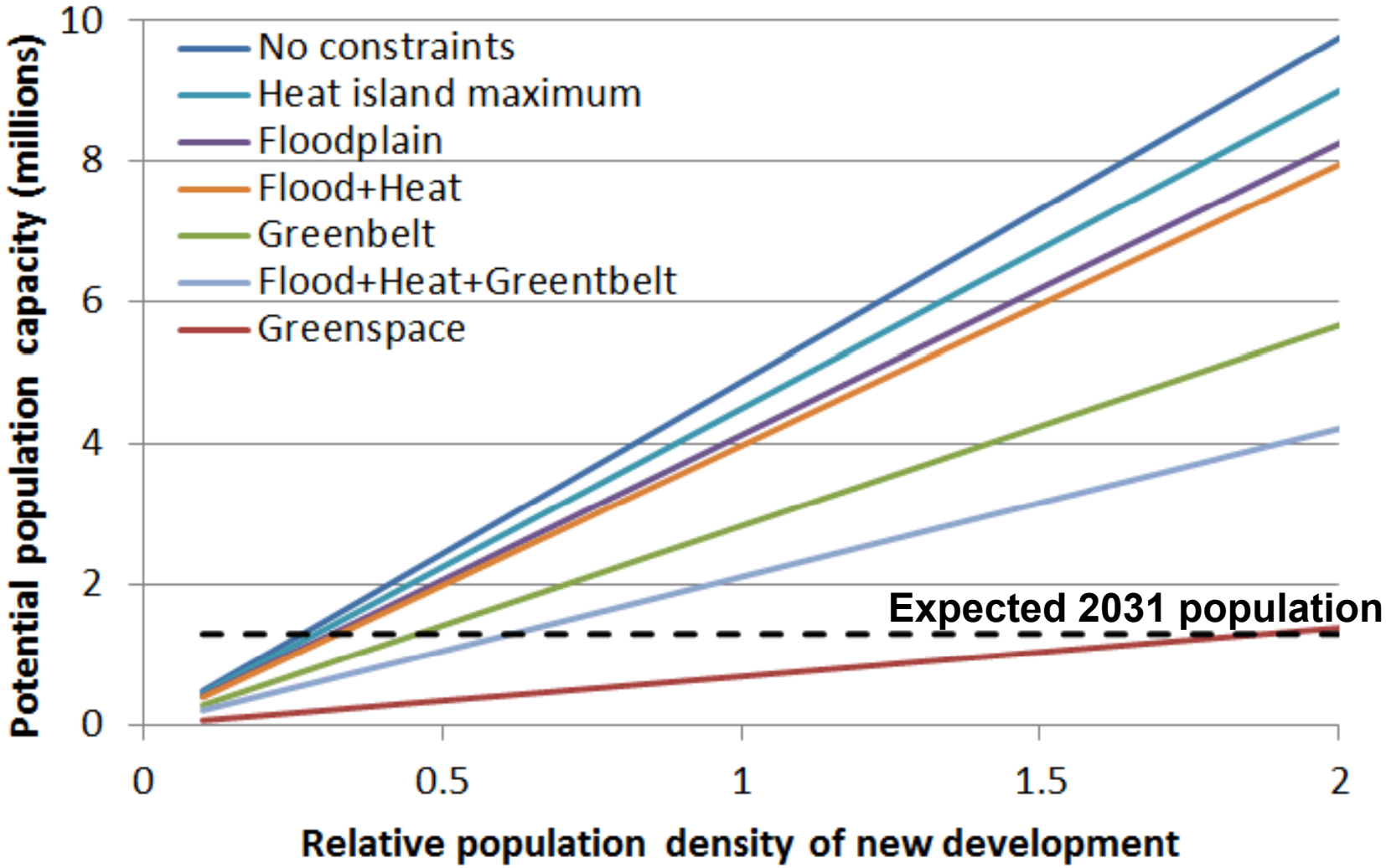

Tough decisions

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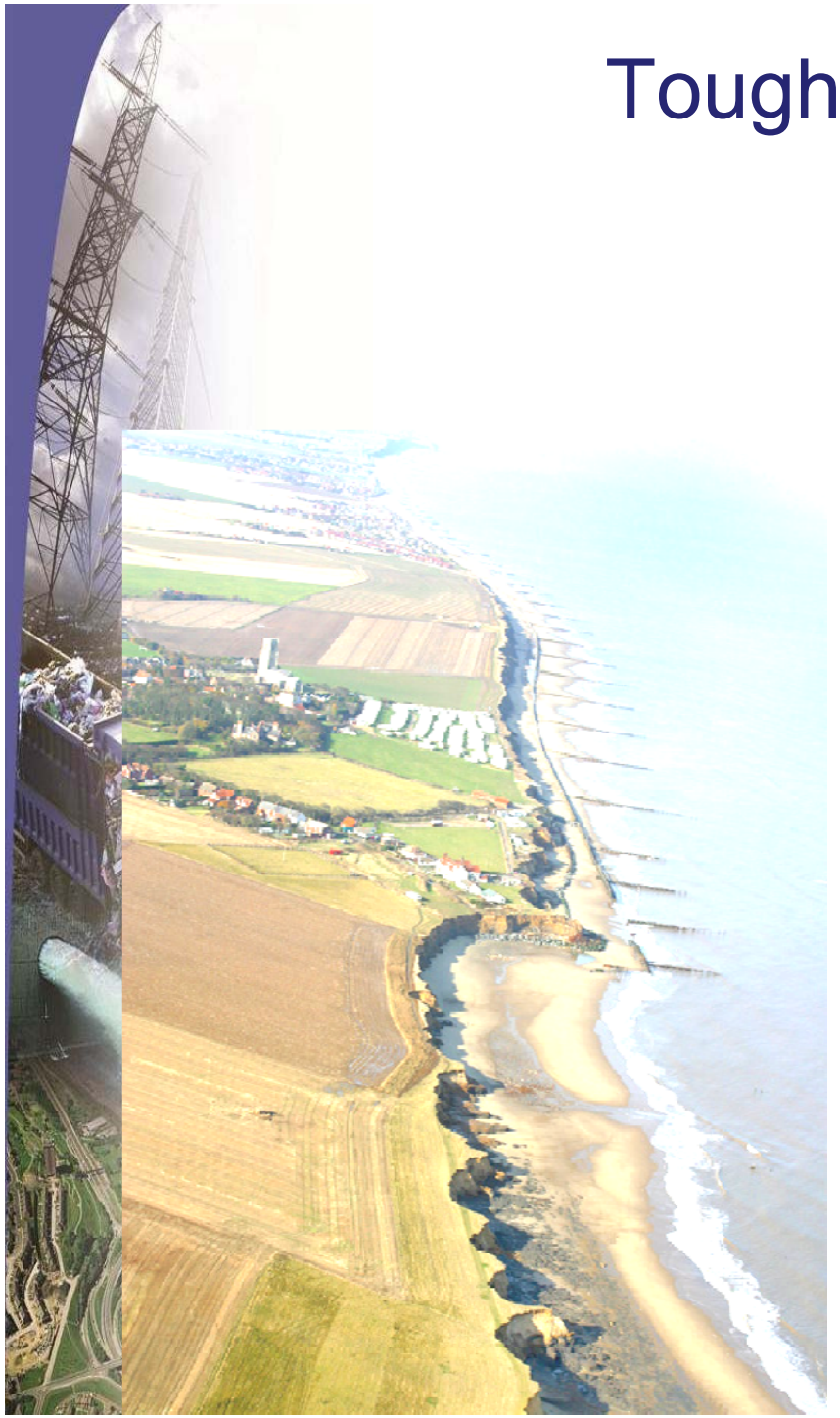

Exploring complex decisions with optimisation search algorithms

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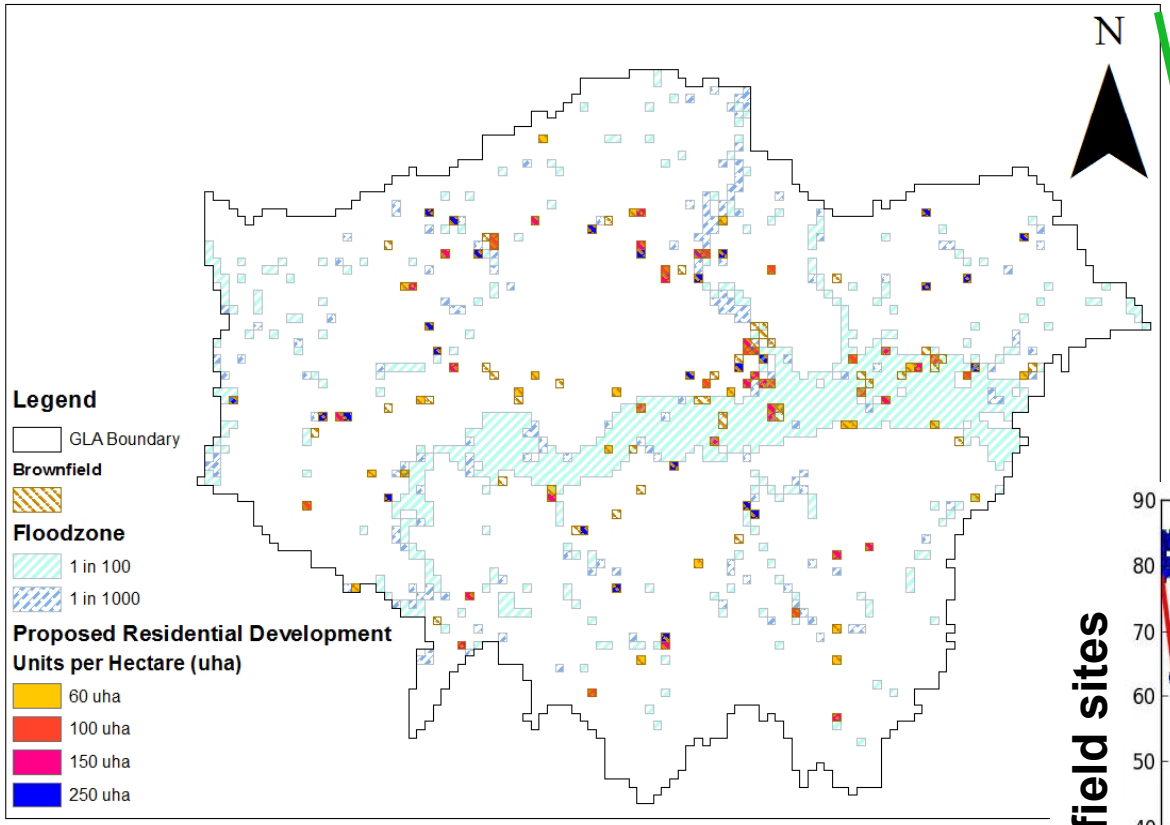
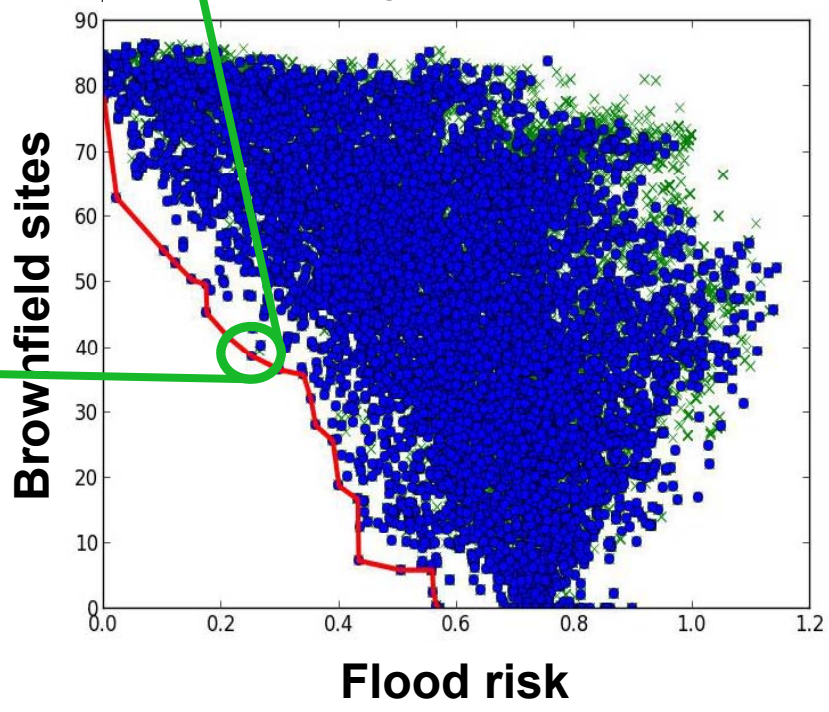
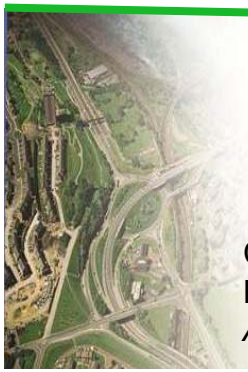


Test spatial plans against multiple objectives

- Flood risk
- Heat risk
- Travel emissions
- Accessibility
- Urban sprawl
- Use of brownfield
- Save greenfield land





Caparos-Midwood et al. (in review) Optimized Spatial Planning to meet Urban Sustainability Objectives, *J. American Planning Association*

So…. is it all worthwhile?

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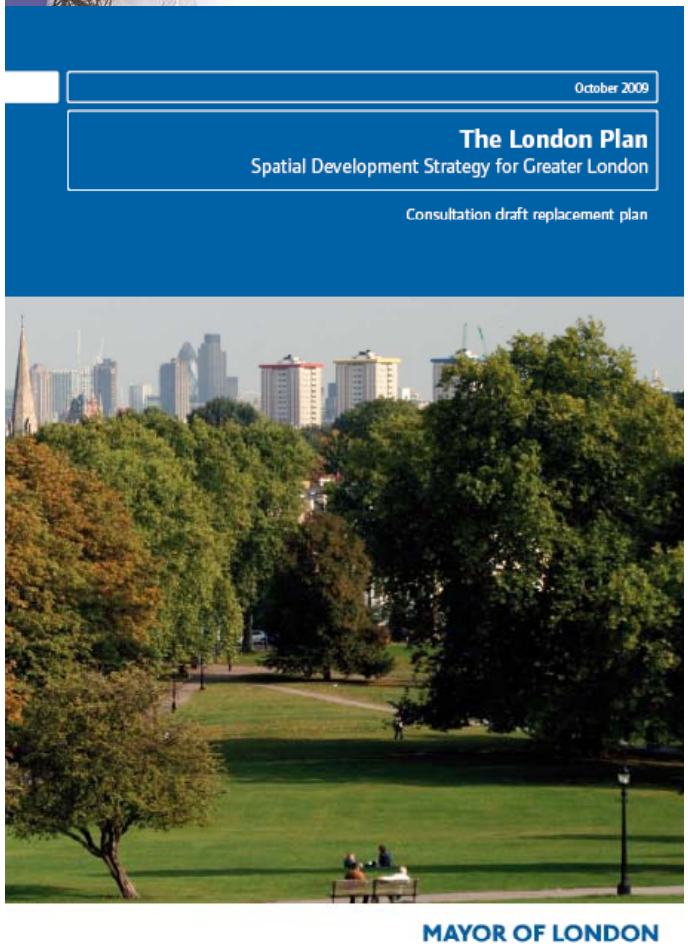

- Does not provide all the answers or 'design variables' BUT it does stimulate the conversations and interactions that are needed to drive forward cross-cutting agendas
- Evidence-based *integrated assessment* of urban systems enables
  - Develop collective understanding of policies concerning
  - Explore multiple issues
  - Involve wide range of stakeholders – local government rarely have all the power
- In London our analysis showed the city can address climate challenges through existing technologies
  - Contributed to London Plan, although that is much broader
  - Opportunities for new build limited compared to other cities
  - No magic bullet, and potential for conflicts:
    - Socio-economic *vs*. climate change
    - Demand reduction *vs*. supply increase
    - Tradeoffs between mitigation, adaptation, living density etc

After: Walsh et al. (2013) Experiences of Integrated Assessment modelling in London and Durban, *Environment and Urbanisation*, 25(2):257-376.

So… Is this transferable?

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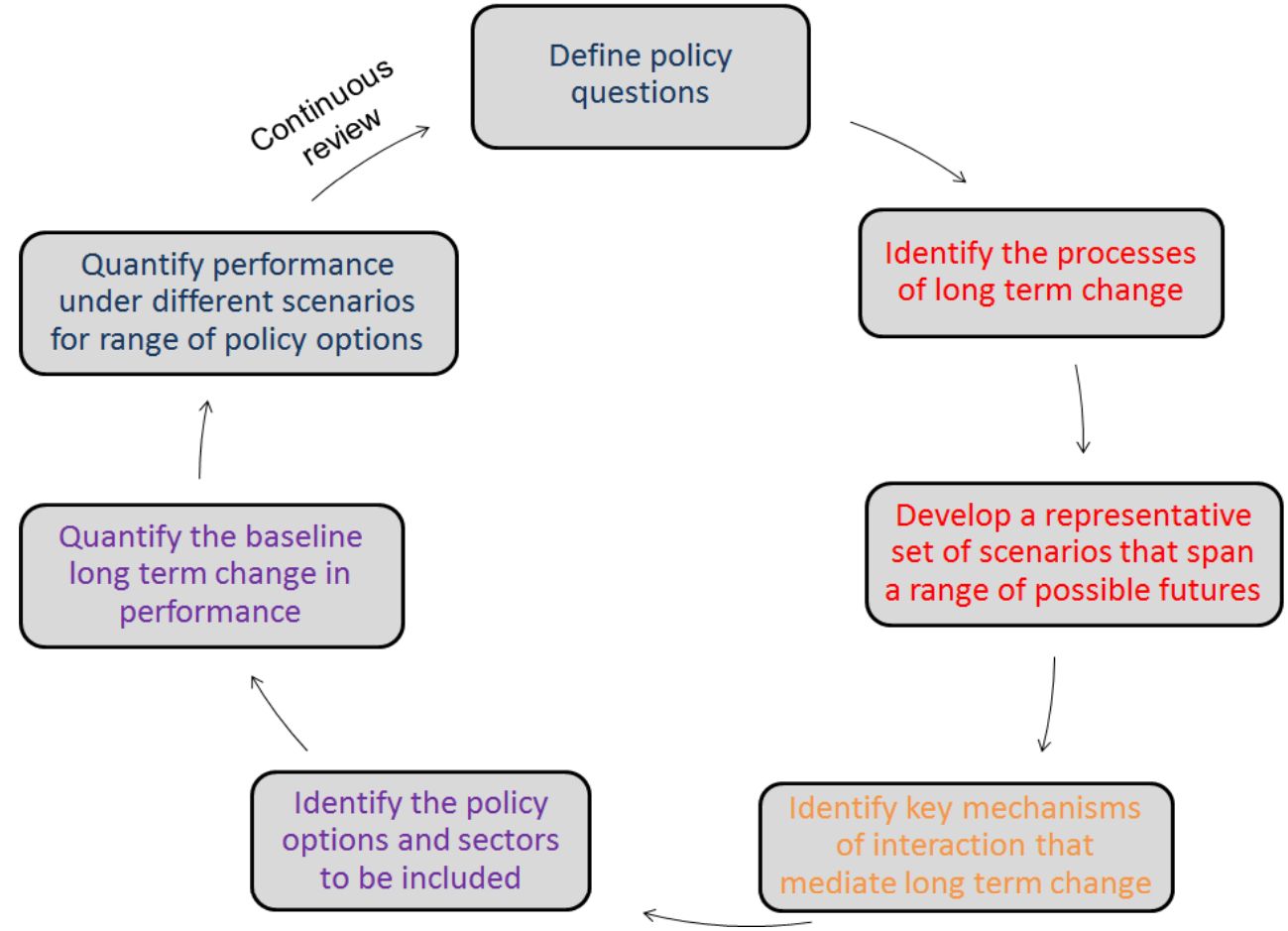
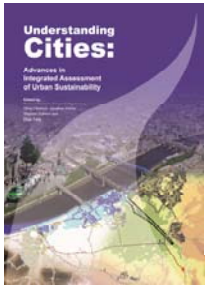
Research management
- Overhead of interdisciplinary 'learning curve'
- Team continuity
- Co-development with stakeholders

Using information from IA
- Capacity to interpret complex results
- Model and data limitations
- Simplicity vs. potential insights

Expectations
- Promise and potential of IA
- Maintaining interest over 3-4 years
- Reconciling priorities





Dawson et al. (2014) Understanding Cities: Advances in integrated assessment of urban sustainability.
http://www.ncl.ac.uk/ceser/researchprogramme/costactiontu0902/

But beware…

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Voinov and Shugart (2013) 'Integronsters', integral and integrated modeling, *Environmental Modelling and Software*, 39: 149-158

Open challenges for Integrated Urban Systems Modelling

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1. How far is far enough in tracking down consistency, interactions and feedbacks?

2. How can we estimate, communicate and make decisions under uncertainty?

3. How transferable are integrated insights and models to other cities worldwide?

4. How can we build a global coalition of researchers and practitioners equipped to address integrated problems?

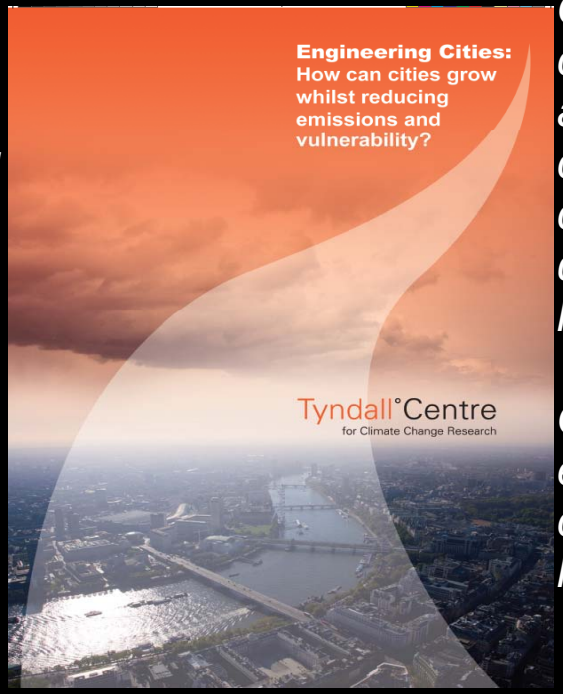
5. How can we best engage stakeholders (including the public) and inform decision making?

"We have come to recognise how integrated modelling of the type delivered by the Tyndall Centre Cities programme can help to bring different stakeholders together to develop common understanding of processes and consequences of long term change.

That collective understanding is essential if we are to manage change rather than become its victims."

Alex Nickson,
Strategy manager: climate change adaptation and water,

Greater London Authority



« Nous avons enfin reconnu qu'une modélisation intégrée telle que celle proposée par le Tyndall Centre Cities Programme peut contribuer à fédérer différents acteurs autour d'un même objectif, celui de parvenir à une meilleure compréhension des processus et des effets de ces changements à long terme.

Cette compréhension collective est essentielle si nous voulons gérer le changement plutôt qu'en devenir les victimes. »

Alex Nickson,
Directeur de la stratégie
Adaptation au changement climatique et ressources en eau,

Greater London Authority

London report: ***http://www.ncl.ac.uk/ceser/researchprogramme/outputs/***

Email me: ***richard.dawson@newcastle.ac.uk***

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