Integrated urban modelling in London: Successes and challenges

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A long journey...

- Why did we start?
- What steps did we take?
- Where did we fail?
- What have we learnt?
- Where are we going now?
Challenge: Adaptation of cities and infrastructure to global change

- Socio-economic change
  - Growing global population
  - Changing demography
  - Socio-economic trends
    (IPCC 5th Assessment WG2))
  - Ownership and governance

- Urbanization
  - Concentrates infrastructure
  - Implications for ‘support’ infrastructure

- Environmental pressures
  - Climate change
  - Broader sustainability trade-offs
  - Relationship with land use

- Deterioration and replacement

(Rahmstorf et al, 2012)

(Walsh et al, 2011)
First steps: assessing climate risks
Mitigation

- The need to mitigate:
  - UK CC Act: -20% by 2020
    - London -60% by 2025!
    - BAU = +15% by 2030
  - Energy Supply mix
    - National Grid, CHP, Renewables
  - Efficiency of use
    - Losses, thermal efficiency, technology
    - Application and regulation
  - Demand management
    - Awareness, Education, Incentives
### Some complicities and tradeoffs

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

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

Stochastic, spatial, process model

Perturbed with climate model change factors for future scenarios
Economics Model

- Cambridge Econometrics E3MG

- 42 Sectors simulated (SIC)

- 15 scenarios
  - Growth rates ~1-3%
  - Decline in employment in many scenarios resulting from ageing population
  - Decline in industry
  - Growth of professional and finance service sectors
Land-use modelling

Planning policy:
Attractors, constraints etc

Transport network and
generalised cost of travel

Spatial allocation of population
and employment

High resolution downscaling
of development

The real world
Nested spatial scales

City-scale Data
- Total population
- Total employment
- Planning policies

Zonal Data
- Total population
- Total employment
- Travel costs
- Available land
- Attractors
- Constraints

Cell Data
- Population density
- Development status
- Attractiveness
- Planning restrictions
Climate vs. Socio-economic change: Flood risk

Baseline 2100

Eastern axis 2100

Centralisation 2100

Sub-urbanisation 2100

Current trends
Socio-economic vs. Climate change

Flood risk for different land use change

Future Spatial Planning

Unconstrained development

Floodplain
Constrained
Transport disruption and adaptation: Temperature thresholds

<table>
<thead>
<tr>
<th>Threshold</th>
<th>Speed restriction</th>
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</thead>
<tbody>
<tr>
<td>&lt;27°C</td>
<td>None</td>
</tr>
<tr>
<td>Poor Track ≥ 27°C &lt; 28°C</td>
<td>30mph</td>
</tr>
<tr>
<td>Poor Track ≥ 28°C</td>
<td>20mph</td>
</tr>
<tr>
<td>Moderate Track ≥ 33°C &lt; 35°C</td>
<td>60mph</td>
</tr>
<tr>
<td>Moderate Track ≥ 35°C</td>
<td>20mph</td>
</tr>
<tr>
<td>Good Track ≥ 36°C</td>
<td>90mph</td>
</tr>
<tr>
<td>Good Track ≥ 42.6°C</td>
<td>60mph</td>
</tr>
<tr>
<td>Tube Lines ≥ 33°C &lt; 36°C</td>
<td>30%</td>
</tr>
<tr>
<td>Tube Lines ≥ 36°C</td>
<td>50%</td>
</tr>
</tbody>
</table>
Transport disruption and adaptation: Disruption to travel times

Event Max Temp (°C)
- 28
- 29
- 30
- 31

Cost Increase (Minutes)
- 0 - 10.0
- 10.1 - 25.0
- 25.1 - 50.0
- 50.1 - 100.0
- 100.1 - 140.5
Transport disruption and adaptation: Benefits of adaptation

- 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?
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*. 

![Graph showing the annual gap between supply and demand over time. The graph illustrates the impact of climate change and socio-economic factors on water resources in the Thames basin.](image-url)
Drought risk: Climate vs. Socio-economic change

-34% (annually incremented) by 2100 (mid-point of sustainable homes code)

+300,000 Ml from 2020

+300 Ml/day from 2020

-40% (annually incremented) by 2100

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

Potential population capacity (millions)

- No constraints
- Heat island maximum
- Floodplain
- Flood + Heat
- Greenbelt
- Flood + Heat + Greenbelt
- Greenspace

Expected 2031 population

Relative population density of new development
Tough decisions
Exploring complex decisions with optimisation search algorithms

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*
Sister projects: ITRC

- UK national infrastructure
- Interdependencies
- Supply/demand models
- Integrated models and DBs
  - Automation
  - Central database for inputs/outputs – provenance!
  - Centralised logic and decision-making
  - Annual time steps
Modelling framework

• Towards an ‘integral’ model
• Coupled tools and data
• Python scripting framework
• Model groups
  – Iteration
  – Feedback/flow control
  – Conditionals
• Constituent models
  – Data and parameters together
  – Data an important component as well as models
• Currently under development
So…. is it all worthwhile?

- 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

So... Is this transferable?

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
- Feed back to observations?

Expectations
- Promise and potential of IA
- Maintaining interest over 3-4 years
- Reconciling priorities
- Being open with uncertainty

http://www.ncl.ac.uk/ceser/researchprogramme/costactiontu0902/
But beware…

Where are we going now?
Calculating Adaptation Costs

- **Observed**
- **Future**
- **Extreme rainfall**
  - mm/hr threshold
  - Green Adaptation: (e.g. SUDS, urban greenspace, spatial planning)
- **Flood map**
- **Transport network map**
- **Transport Impacts**
  - Locations of disruption
  - Person-hours
  - (Mean GDP?)
- **Disruption**
  - Individuals
  - Companies: productivity loss
  - Companies: inf. operators

Grey Adaptation: (e.g. infrastructure improvement)

Soft adaptation: spatial planning, work from home
Open challenges for Integrated Urban Systems Modelling

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

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

Email us:  richard.dawson@newcastle.ac.uk
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