Towards an integrated urban assessment framework

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Project team:

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Background to the Tyndall Centre for Climate Change Research: Phase II 2006-2009

The Tyndall Centre brings together scientists, economists, engineers and social scientists, who together are working to develop sustainable responses to climate change through trans-disciplinary research and dialogue.

**Informing international climate policy**... how can international action on climate change be effectively developed after 2012?

**Constructing energy futures**... what are the pathways to global decarbonisation?

**Building resilience to climate change**... what are the limits to adaptation?

**International development** ... how can international development be sustained in a warming world?

**Sustainable coasts** ... how can shorelines be managed for the third millennium?

**Engineering Cities** ... how can cities grow while reducing vulnerability and emissions?

**Integrated modelling**... innovating integrated assessment systems

www.tyndall.ac.uk
Engineering cities

Rationale:

- Urban areas are concentrations of climate vulnerability as well as being major greenhouse gas emitters

- Urban areas need to be studied in the context of national and global socio-economic and climate changes

- Innovative approaches to adaptation and mitigation can be developed by integrated assessment of urban systems

- Development decisions we make today will alter our vulnerability to climate change and our emissions profiles for many years to come

Aim:

- To develop a city-scale assessment capacity that simulates the evolution of climate impacts and emissions over the 21st century and can be used to simulate, evaluate and compare alternative adaptation and mitigation strategies.
Introduction to London

- Largest city in the European Union
- Population in decline between 1939-89, but ‘resurging’
- Relatively low density (~2/3 population live in the suburbs)
- Governed by the Greater London Authority

Drivers for change:
- Population growth (~2/3rds through immigration)
- Economic growth
- Environmental issues
- Social and technological change (eg. younger population prefer denser central living)

- Much of this driven by more general global change – but London like most cities adds its own ‘flavour’ to the problem
Greater London and the Thames Gateway

- Significant development planned already over next 15 years in London area

2012 Olympics

GLA Boundary

Thames Gateway Development Areas
Thames Gateway Areas
London’s changing climate

**Temperature:**
- Warmer winters *and* summers
- Increased variability in extremes
- Amplification of urban heat island (currently up to 6ºC)

**Precipitation:**
- Wetter winters *BUT* drier summers
- Increased frequency of winter rainstorms

**Storms:**
- Increased winter windspeeds (up to 10%)
- Increased windstorm and coastal surge frequency

**Other:**
- Reduced cloud cover
- Reduced soil moisture
- Increased sea level

- Storm sewer exceedance
- River/tidal flooding
- Drought
- Built environment
- Heat/health
- Air quality/health
- Others:
  - Business and finance
  - Biodiversity
  - Tourism

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Emissions

In 1997 London used more energy than all of Ireland

London’s $\text{CO}_2$ emissions:
- 44% Housing
- 29% Commercial buildings
- 21% Transport

Buildings:
- >35,000 new houses each year
- ~1 million jobs (and associated commercial space) over next 20 years
  - New buildings planned for flood prone areas
  - Greater demand on water resources
  - Potential for increased heat island effect

Transport:
- 26 million trips a day made by Londoners
- Transport significant contributor to GHG emissions

*BUT* impact of climate on transport can be enormous
- Passenger comfort (up to 11°C difference between over- and underground), delays etc.
- Flooding of road and railways
- Heat damage to transport infrastructure
Stakeholder review: Greater London Authority policy objectives

- Accommodate growth within current boundaries without encroaching on open spaces
- Strengthen and diversify economic growth
- Increase social inclusion and reduce deprivation
- Improve accessibility: public transport, cycling, walking *i.e.* reduce use of cars
- Make London a more attractive, well-designed green city:
  - reduce waste management
  - re-use brownfill sites
  - increase self-sufficiency
  - better air quality
Stakeholder review: Some policy questions

- What can we do immediately?

- What are the implications, in terms of climate impacts and emissions of different economic and climate scenarios? Must there be tradeoffs?

- Are there planning strategies that can reduce vulnerability and emissions?

- Is brownfield development sensible in terms of vulnerability?

- Is London subsidising (in emissions terms) its commuters?

- Climate impacts: How do we adapt to water scarcity, heat and flooding without increasing emissions?

- Buildings: What are building replacement rates for different types? What are the emissions associated with different building types and building adaptations? What is the spatial relationship between energy and construction?

- Infrastructure: What are the capacities and vulnerabilities of our infrastructure?

- What decisions are robust to uncertainties?
City-scale integrated assessment

Global simulations:
- Economics
- Climate change

City-scale simulations:
- Economy
- Land use
- Climate change

Climate impacts assessment:
- Heat
- Flooding
- Water resources
- ...

Integrated assessment of:
- Development/policy scenarios
- Adaptation and mitigation
- Uncertainty and robustness

Emissions accounting:
- Transport
- Buildings
- Industry
- Energy

Urban Development

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Economic modelling

- Effectiveness of economic instruments
- Cap & trade schemes
- GHG taxes
- Climate shocks/disasters on city economy
- London vs. UK/Global policy

![Diagram](attachment:image.png)

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Cambridge Econometrics E3 Models
Land use model

- Simulates spatial interactions and transport movements between the residential (population) sector and the employment (work) sector and translates these activities into land use demand.

Population

Transport:
- Activity
- Connectivity

Economic activity:
- Employment
- Trade
- Etc.

Social surveys and projections

Landuse changes:
- Residential
- Industrial
- Etc.
Transport emissions

- Changes in taxation and pricing
- Changes in speed and volume of traffic
- Technological impacts
- Modal shift
- Influence of regulation and tradeable quotas
- Investment in low carbon public transport
- Road user charging
- Restrictions on vehicle types
- Use of soft measures
- Investment in local distribution facilities
Establish the impacts of building stock profiles, demand changes, fuel switches, generating technologies etc.

Data courtesy GLA

http://www.grip.org.uk/
GIS and decision support tool

- Time series (over 21st Century) of aggregated
  - Emissions (in various categories)
  - Impacts (in various categories)
for a variety of global economic/climate scenarios, local economic and development scenarios

- Spatially explicit scenarios of development, emissions and impacts

- Spatially explicit mitigation and adaptation options (sector specific and portfolios)

- Explicit spatial and temporal representation of uncertainties

- Portfolio and robustness analysis of options

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Preliminary exploration of impact on water resources

- Water supply
  - Very old infrastructure – 50% >100 years old, 30%>150 years old
  - Reservoir capacity:
  - London clay: Corrodes water mains, expands and contracts seasonally
  - London uses 80% surface water (most UK regions use nearer 30%)
  - Uses 60% of available water already!
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- **Reduced summer rainfall**
- **Increasing population: 75-100k/year**

- **Desalinisation**
  - 150million litres/day
  - ~£200million
  - 22,600 tonnes CO₂/year
  - Equates to ~0.3% all 2005 CO₂ emissions
  - *BUT* if GLA emissions cuts achieved this could be ~1% by 2050!

- But perhaps a necessary evil? Over extraction from Thames will lead to poor water quality and severe ecological impacts and drought politically unacceptable
Uncertainty analysis

Now

Future

Probability

Population at risk (%)
Robustness of decisions

- Info-gap robustness analysis is used to identify options that are less sensitive to severe uncertainties
- It is only of use in distinguishing between qualitatively different options
- Can be done against multiple criteria
Program and further work

- End 2007:
  - Integration of impacts modules with emissions accounting
  - Three climate impacts modules

- Regional interactions and attribution of emissions

- Further impacts modules:
  - Subsidence (inc. underground infrastructures)
  - Windstorm
  - Air quality/Health
  - Waste
  - ...

- Construction of portfolios of adaptation/mitigation with stakeholders
Some final thoughts…

- Integrated assessment of urbanisation is a significant but necessary challenge.

- There will usually be tradeoffs which we must understand to make rational and responsible decisions regarding our stewardship of the urban (and Earth) system – but first we need the tools to analyse and communicate the issues!

- Cities are centres of vulnerability and potential destabilisers of the Earth System **BUT** consequently they are also our greatest opportunity.

- London is not really the frontline of the ‘climate/carbon battle’ **BUT** is data-rich.

- How will we address other cities?
  - Remote sensing technologies
  - Sparse modelling of systems
  - Emulators and proxies
  - Decision making under extreme uncertainty

Global simulations:
- Economics
- Climate change

Urban Development

City-scale simulations:
- Economy
- Land use
- Climate change

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