The Tyndall Centre's Urban Integrated Assessment Facility

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Cities and Climate: Driving the need for integrated responses

Cities are concentrations of vulnerability to the harmful impacts of climate change. They are also, directly and indirectly, responsible for the majority of the world's emissions of greenhouse gasses. 50% of the world's population lives in cities, a number that is set to increase to 60% by 2030[1]. For all of these reasons, cities are on the front line in responding to the threats of climate change.

Around the world there is a growing awareness of the role that cities have to play in mitigating and adapting to climate change. A wide variety of measures are now being considered and piloted, including schemes to transform urban energy systems, reduce transport emissions, retrofit buildings, conserve water, build resilience to flooding and prepare for heat waves. These individual policies need to be implemented as part of an integrated strategy that can steer cities towards low carbon and well adapted futures. To do so requires understanding of the processes that are driving long term change in cities and the ways in which they interact. Demographic, economic, land use, technological and behavioural changes are all drivers, which alongside climate change, will shape the future of cities.

The Tyndall Cities programme and integrated assessment

To address these challenges, The Tyndall Centre for Climate Change Research has developed an Urban Integrated Assessment Facility (UIAF) which simulates the main processes of long term change at the scale of whole cities. The UIAF couples a series of simulation modules within a scenario and policy analysis framework. The UIAF is driven by global and national scenarios of climate and socio-economic change, which feed into models of the regional economy and land use change. Simulations of climate, land use and socio-economic change inform analysis of carbon dioxide emissions (focussing upon energy, personal transport and freight transport) and the impacts of climate change (focussing on heat waves, droughts and floods). The final component of the UIAF is the integrated assessment tool that provides the interface between the modelling components, the results and the end-user. This tool enables a number of adaptation and mitigation options to be explored within a common framework. Development of the Tyndall Centre's Urban Integrated Assessment Facility (UIAF) has focussed upon London as the case study.

Pressures in London

London currently has a population of 7.2 million which is expected to increase to over 8.1 million by 2016[2]. Due to geographical location in the warmer part of the UK and widespread urbanisation, London suffers from urban heat and associated air quality problems. Isostatic subsidence in the south of Great Britain will result in London experiencing faster relative sea rise which, coupled with storm surges, will heighten the risk of surge flooding in the tidal Thames. The southeast is the most water scarce region in the UK, having a lower than average rainfall and a very large demand[3].

Because of the concentration of population and transport, the southeast is responsible for prolific greenhouse gas (GHG) emissions. London is responsible for 8% of the UK's carbon dioxide emissions, producing 46Mt[4] each year (not including aviation) and projected to increase by 15% to 51 million tonnes by 2025 if vigorous action is not taken to reduce carbon intensity. London's Climate Change Action Plan targets 60%[5] reduction in carbon dioxide emissions by 2025 with the UK Climate Change Act demanding an 80% reduction in national emissions by 2050[6]. Excluding aviation, at the moment domestic, commercial and public buildings contribute the majority of carbon dioxide emissions. Ground based transport contributes a fifth, the majority of which come from cars. Industrial contribution is relatively small and projected to shrink, due to the relatively small proportion of heavy industry in London's economy.

London has taken several pioneering steps with respect to how climate change, adaptation and mitigation are dealt with at the city scale. The organisations most relevant to the strategic city-scale management issues considered in this work are The Greater London Authority (GLA), The Government Office for London (GOL), and The London Climate Change Partnership (LCCP). The GLA is a public authority, designed to provide citywide, strategic government for London. The principal purpose of the GLA is to promote the economic and social development and the environmental improvement of Greater London. The GOL liaises with the GLA to ensure that London planning is done within the context of national policy; and leads government responses to the GLA's strategies. The London Development Agency (LDA) has responsibility for reducing London's carbon dioxide emissions. The LCCP focuses on assessing the impact of climate change and identifying adaptation strategies. Each organisation has clear responsibilities, which cross sector boundaries. The GLA are in a position to take an overview of strategic issues related to climate change.

Key results and insights

The UIAF was applied to London, yielding the following findings:

Economic drivers of long term change: A multisectoral regional economic model has been used to generate long term projections of employment and Gross Value Added in London. Our base line simulation shows employment in London growing by about 800,000 by 2030, driven by demographic changes and changing working practices. Business and financial services, along with science-based services are expected to grow most rapidly, with heavy industry diminishing.

Land use change: Future patterns of land use between now and 2100, based on changes in employment, the transport network and land use planning policy, have been simulated for all of London and the Thames Gateway. We have studied four alternative land use futures for London: (i) a baseline case, which applied current policies and trends in to the future (ii) 'Eastern axis' in which employment opportunities, transport infrastructure development and a preference for lower density living stimulate substantial population growth in east London and the Thames Gateway (iii) 'Centralisation' in which employment and population growth is concentrated in central London, with a corresponding increase in density (iv) 'Suburbanisation' in which employment remains strong in central London, but expands into the suburbs. To steer land use away from the baseline towards alternative futures requires major shifts in land use planning, transport connectivity and capacity, and employment opportunities.

Carbon dioxide emissions: Various scenarios of carbon dioxide emissions from the energy use, personal transport and freight transport have been analysed. Growth in population, economic activity and mobility are potentially strong upward drivers of emissions. We have analysed portfolios of emissions reduction policies that are currently under consideration, but find that more radical policies are required in order to meet the GLA's target for 60% emissions reductions by 2025 (Figure 2). Their success depends upon the availability of carbon neutral electricity supply and upon progressive physical changes to urban form and function.

Heat waves: A new land surface scheme has been introduced into the Hadley Centre's Regional Climate Model to represent the urban heat island effect. Using a weather generator adapted from the UKCP09[7] study we found that by the 2050s, one third of London's summer may exceed the current Met Office heat wave temperature threshold. However, the UIAF can explore how different spatial patterns of development have the potential to reduce the risk from heatwaves

Droughts: The UKCP09 rainfall scenarios for the Thames and Lee catchments were combined with catchment hydrology models and simulation of the water resource management system. London is very vulnerable to changes in the surface water regime, which will be increasingly stressed by climate change and population growth. Although new storage facilities can maximise exploitation of the surface water resource, on their own they are insufficient in the long term and will need to be accompanied by vigorous demand management and provision of new resources from desalination or inter-basin transfers (Figure 3).

Flooding: A model of flooding in the tidal Thames floodplain, which is protected by the Thames Barrier and a system of flood defences, has been used to simulate the effects of sea level rise and changing flows in the river Thames. This has been combined with our simulations of land use changes, which have a profound effect on the magnitude of increase in flood risk in the future. The 'Eastern Axis' land use scenario leads to a fourfold increase in flood risk by 2100, whilst the risk doubles for the 'Suburbanisation' scenario. A number of adaptation options are shown to reduce flood risk under all land use scenarios (Figure 4).

By analysing demographic, economic and land use changes, we have quantified the extent to which socioeconomic changes determine how hard it will be to reduce emissions and how severe impacts of climate change may be. Indeed socio-economic change over the 21st century could influence vulnerability to natural hazards as much as climate change. The research has shown that no single policy will enable cities to grow whilst reducing emissions and vulnerability to climate change impacts – a portfolio of measures is required. Due to long lead times, immediate and in some instances radical action to reduce fossil fuel dependence in the energy, building and transport sectors is required if an 80% cut in emissions is to be achieved by 2050. Measures to reduce demand (in use of energy, transport, water etc.) tend to be more cost effective and less likely to have adverse impacts in other sectors than measures taken to increase supply. However, both supply and demand side measures will be required to respond adequately to the climate and socio-economic changes.

The research has demonstrated the central role of land use planning in guiding and constraining pathways to sustainable urban layout in the long term. Land use profoundly influences carbon dioxide emissions and vulnerability to climate change. It also constrains opportunities for innovations like sustainable urban drainage systems or local heat networks. Land use and infrastructure planning decisions can become “locked in” because of the way in which infrastructure shapes land use and the built environment, and vice versa.

The work has demonstrated scenarios of how these interactions can operate over the 21st century on spatial scales from the whole city and beyond to individual neighbourhoods, providing tools for planners and infrastructure designers to assess the long term sustainability of plans and policies. By integrating adaptation and mitigation, we have been able to quantify some of their potential synergies and conflicts, for example by examining the contribution that urban energy use makes to the urban heat island. The UIAF has helped to understand how policies can be devised that yield benefits in relation to a number of objectives and avoid undesirable side-effects.

References

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Acknowledgements

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http://www.ceser.org.uk/demonstrations/cities/tyndallcitiesreport/view
or copies can be requested from Richard Dawson (richard.dawson@newcastle.ac.uk).

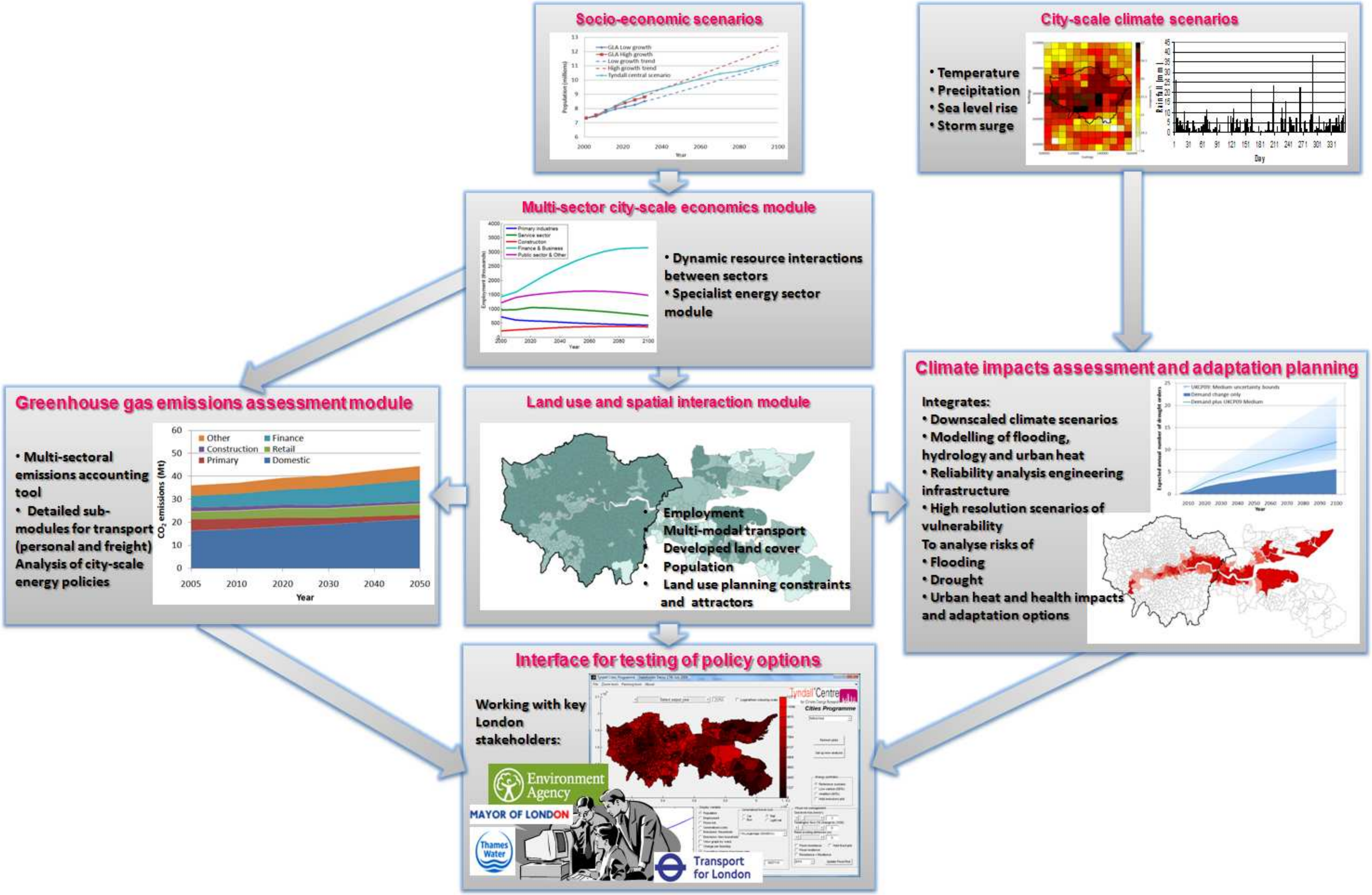

Figure 1 Integrated assessment approach for analysing climate impacts and greenhouse gas emissions in cities

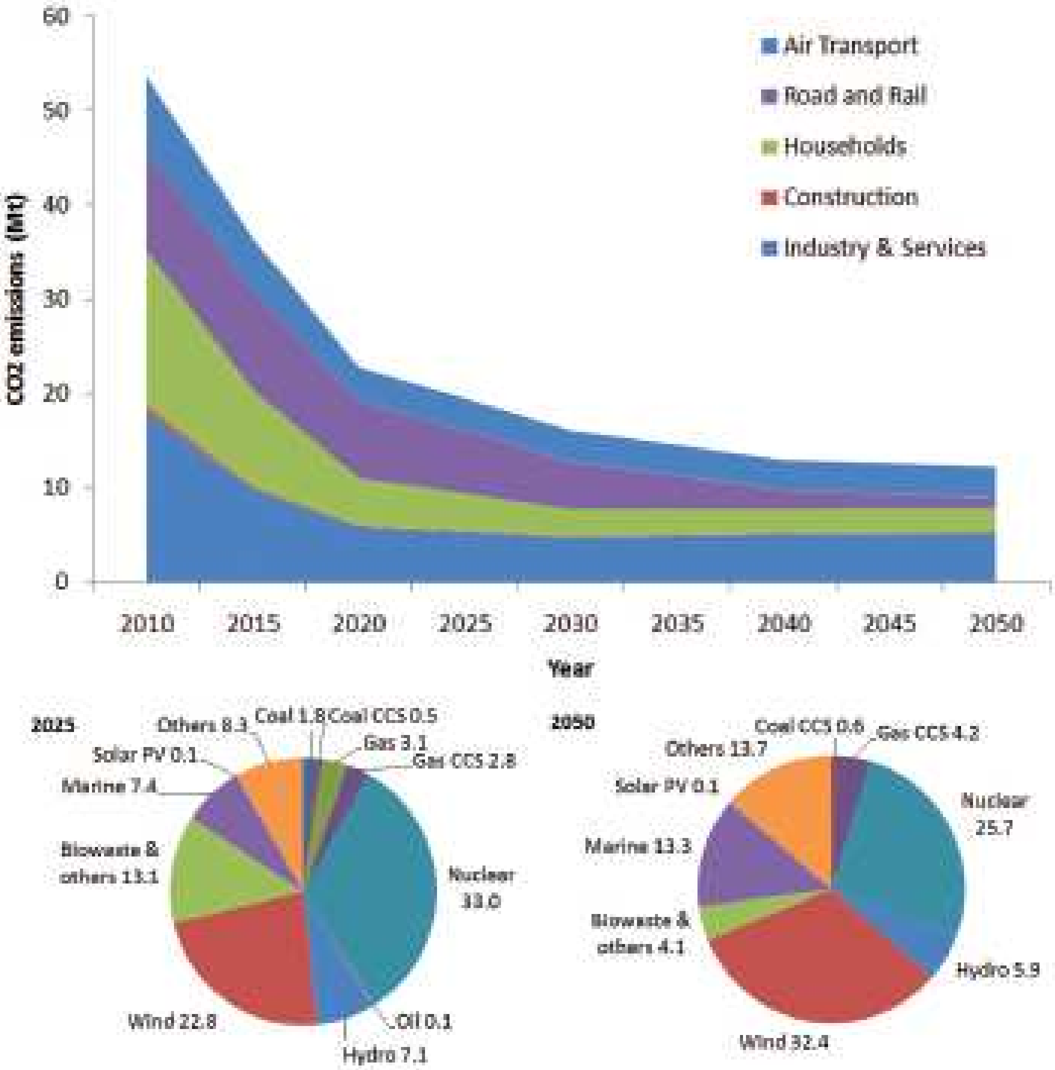

Figure 2 One portfolio of measures that could achieve 80% reduction in CO2 emissions; showing sector contributions (graph) and technology mix (piecharts). In this package of mitigation measures, no demand management is assumed, giving an indication of the radical and rapid shift in energy generation mix required to sustain our current per capita energy demands.

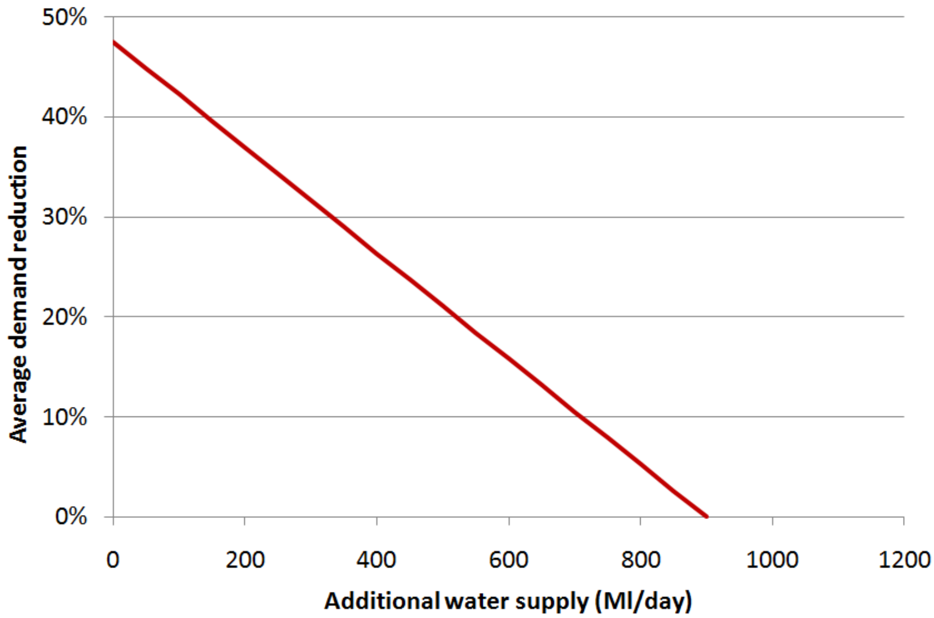

Figure 3 How to maintain the present day level of service for water resource provision in the 2050s under the UKCP09 medium scenario and given increased demand: the tradeoff between the reduction in water demand (in terms of per capita consumption, industrial use and leakage) or additional supply (from desalination or inter-basin transfers).

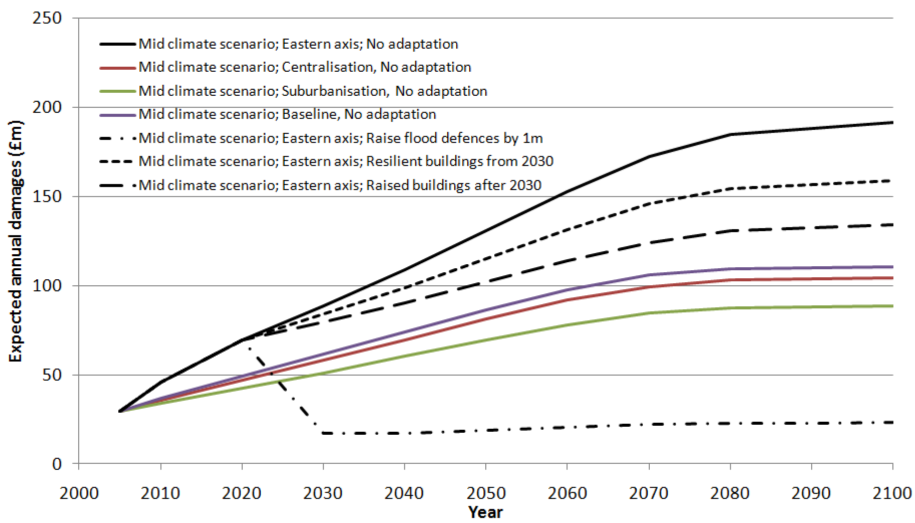

Figure 4 Profile of flood risk (expressed in terms of expected annual damages in London and the Thames estuary, real terms and not discounted) through time on same axis for (i) the four different landuse paradigms under the UKCP09 Medium climate change scenario, (ii) a range of adaptation options for the Eastern axis land use paradigm including (a) raising the existing flood defence system by 1m, (b) making all new development after 2030 fully flood resilient, (c) raising all new development (e.g. on stilts) after 2030.