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MEGALOPOLISES AND SUSTAINABILITY:

The UCL Environment Institute Seminar Series Report

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Preface

During January to June 2009, the UCL Environment Institute held a series of six seminars exploring a variety of issues raised by the pursuit of sustainability for megalopolises, i.e. the mega-cities that are a feature of our urban landscape. Altogether some 21 presentations were made (see Appendix 1) leading to lively discussion among the seminar participants (see Appendix 2). Summaries of the presentations and the discussions afterwards are available for each seminar on the UCL Environment Institute website at: http://www.ucl.ac.uk/environment-institute/News/megalopolis.html .

This report is a synthesis of these 18 hours of seminars, drawing out the key themes that emerged. The contributions of the all the presenters and attendees are gratefully acknowledged. However, this is the authors' view of the seminar series and no-one else is responsible for any errors, including those of omission and interpretation.

The seminar series was supported by the EPSRC-funded Bridging The Gaps Programme. Further details of this programme are available at: http://www.ucl.ac.uk/btg/.

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Executive Summary

1. Megalopolises in an urban future

We live an increasingly urbanised world. By 2030 60% of the global population will live in cities. While smaller cities are growing the most rapidly, the largest cities will remain important. By 2015 there will be 23 cities with a population of more than 10 million. Some of these, together with surrounding smaller urban areas, will take the complex form of megalopolises. Examining the sustainability of these megalopolises – particularly in terms of the climate change agenda – is therefore highly pertinent.

2. Energy use in megalopolises

In high consumption countries, there is an urgent need to change infrastructure so as to reduce the environmental burden of that consumption. An equivalent imperative exists in low consumption countries to create infrastructure systems that meet the social and economic needs of their populations. However, there is no requirement to replicate the carbon-intensive approaches adopted in major urban areas so far. Rather there is scope, particularly at the urban scale, for innovation in infrastructure to deliver low carbon living.

3. Transport within megalopolises

The interaction between urban development and transport is a complex one, influenced by a number of interconnected factors: industrialisation, demand for housing, transport technology, fare levels and structure, strong leadership, national and local politics, economic growth, ownership and regulation and car ownership. History tells us that governmental involvement and subsidy is essential for delivering transport systems that are sustainable, although this need not always extend to public ownership and delivery.

4. Flooding and storm damage

Flooding – from inundation and sea-level rise – is already a major impact of climate change but its incidence will increase. Cities, particularly the largest cities are vulnerable, often because of their coastal locations. The economic as well as social costs of flooding will be immense but the wealthier cities are best placed to cope with these threats. It is the already vulnerable communities within cities that are most at risk of total loss.

5. Heat waves

By 2040 average summer temperatures in Europe are expected to be those experienced in the heat-wave of 2003 in which between 30,000 and 35,000 people died in Northern Europe, while heat-waves in 2040 will be twice as hot as those we experience now. These impacts of climate change are exacerbated by the Urban Heat Island effect, suggesting the importance of planning new urban development with this enhanced risk in mind.

6. Water security

While increased water scarcity is a common impact of climate change across many urban areas, there is a significant difference between those cities with reticulated systems – where the very infrastructure promotes a disregard for the need to conserve water – and those cities (or parts of cities) where private water vendors, illegal connections and communal standpipes dominate. Across these very different circumstances though, arguments can be made for the value of citizen involvement in policy development and even in co-production schemes.

7. Disease and public health

Much attention has been paid to influenza pandemics and obesity as aspects of urban health, but the most significant public health issue is the availability of clean water and sanitation facilities to poorer urban communities. Established infrastructure systems such as reticulated water systems have a place but again the importance of community involvement and local innovation should not be under-estimated.

8. Modelling change

There is great potential in building models using the latest techniques to understand change in urban systems and then develop policy recommendations. Such models can highlight path dependencies in urban change as well as rapid 'phase transitions'. However, there remain questions over how far resources should be devoted to very fine-grained data collection and model-building in context where there is an urgent need to take policy steps to deliver sustainability, as in lower income countries and especially vulnerable cities.

9. Governance for sustainability

Considering the governance of major urban areas such as megalopolises throws up many dilemmas, such as the appropriate scale for governmental units, the allocation of responsibilities across governmental tiers and the different ways of financing governmental action. But the key issue in delivering action for sustainability is the way that this goal intersects with different political interests and priorities and how these conflicts may inhibit collective action.

10. Urban culture and sustainability

If sustainability is to become part and parcel of the megalopolis then it has to have meaning within that urban culture and in terms of how people live within the urban area. Sustainability is often couched in culturally conservative terms, drawing on nostalgia. However, this is a choice and the prospect remains of a more progressive cultural engagement with sustainability, opening up more options for urban change.

Megalopolises in an urban future

We live in an increasingly urbanised world. At some point during 2008, more than half the world's population came to be living in urban areas[1]. And this is a trend that is set to continue into the future[2]. The percentage of the global population living in cities is estimated to grow from 50 per cent to around 60 per cent in 2030. That means a 72% increase in the total world urban population between 2000 and 2030. The percentage change will be largest in Africa and Asia, followed by Latin America and Oceania. Growth in the urban population in North America is forecast at around 31% while for Europe the figure falls to less than 5%. People across the world will increasingly be living in urban settlements of all sizes and types. The main growth, in percentage terms, is likely to occur in medium sized cities but we will also see the continuing significance of mega-cities or megalopolises.

Much conjecture has surrounded the term megalopolis. Derived from the Greek for 'great' and 'city', the term megalopolis was in use in the general press by the 1820's.[3] Twentieth-century scholarly usage, however, has largely been dependent on the definitions of polymath biologist Patrick Geddes, historian Lewis Mumford and geographer Jean Gottman. Both Geddes and Mumford gave the term megalopolis negative connotations, using the term to refer to the uncontrollable and undesirable growth of great metropolises[4]. Gottman, on the other hand, used the term to denote a large, highly connected urban region, notably that of the north-eastern USA ,and instead celebrated the cultural opportunities of the large urban agglomeration that could provide personal as well as material fulfillment.[5]

His usage is echoed by the UN, which defines the urban agglomeration, or megalopolis, as 'the built-up or densely populated area containing the city proper; suburbs, and continuously settled commuter areas. A single large urban agglomeration may comprise several cities or towns and their suburban fringes.'[6] Megalopolises are thus interesting because they are typically polycentric, connecting different built up areas. They also capture non-built up areas both within the envelope of the urban area and between the individual elements of the overall megalopolis.

In statistical terms, data is available though for the rather simpler definition of mega-cities, i.e. urban areas with a population of over 10 million. There was only one such mega-city in 1950 but by 2000 the number had grown to 19, 11 of which were located in Asia. The UN estimates that by 2015 there will be 23 such cities. While more cities are falling into this category, these very large cities are now growing more slowly than others. So their share of the world's urban population is fairly steady at about 12%. However, such cities often form part of interconnected settlements, with other smaller but faster growing urban areas; i.e. together they constitute a megalopolis. For example, Beijing, Pyongyang, Seoul and Tokyo link together a number of other urban areas in a S-shaped international regional city or megalopolis – the so-called BESETO urban corridor[7]. These complex urban systems are reshaping people's lives and constitute both a challenge and an opportunity for sustainable development.

A sustainability focus

Sustainability is now widely-held to be a desirable policy goal in many different contexts. The realm of the urban is no exception. However, sustainability is a very broad concept and the term has become increasingly opaque and diffuse (especially in its social and economic manifestations) as it has been taken up by different political agendas and even used to make commercial actions seem environmentally desirable. Environmental scientist Robert Goodland, however, provides concrete definitions and describes environmental sustainability as seeking to 'sustain global life-support systems indefinitely'.[8] These systems are, he says, source capacities that provide raw material inputs—food, water, air,

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energy—and sink capacities that assimilate outputs and waste. These source and sink capacities are, however, finite and sustainability, he argues, requires that they be maintained rather than run down.[9]

Social sustainability, Goodland contends, can be achieved only by systematic community participation and strong civil society. It requires investment in what he calls 'moral capital' that, in turn, requires maintenance and replenishment by shared values and equal rights, and by community, religious and cultural interactions. Together with investment in moral and human capital (education, health, and the nutrition of individuals), social capital can be built up in an attempt to achieve social sustainability.[10]

While, economic sustainability can be defined rather simply as the maintenance of capital, it focuses, Goodland argues, on the portion of natural resources that provide 'physical inputs, both renewable (e.g. forests) and exhaustible (e.g. minerals), into the production process.'[11] The scarcity of these natural resources arose as the scale of the human economic subsystem grew large relative to its supporting ecosystem. Thus economic sustainability depends on environmental sustainability.

To tackle all the different ways in which megalopolises are or are not sustainable in these terms would be a huge challenge. The UCL Megalopolises and Sustainability seminars therefore took a more specific focus, starting with the climate change agenda. A focus on climate change presents demands for mitigation measures – principally to reduce the carbon emissions driving climate change – and a need for adaptation to an inevitably different future. The mitigation measures can be discussed in terms of energy use, including for space heating or cooling and for transport. Adaptation meanwhile involves consideration of flooding, heat waves, water security and the implications for public health. These headings will be used to structure the next two sections of the report, before going on to discuss the responses that could occur at the level of the megalopolis in the final part. This will consider the contribution of knowledge from modelling, the different forms that governance can take and the need to imbue sustainability in the urban realm with cultural meaning.

The climate change mitigation agenda

Mitigating climate change will require a paradigm shift in economic and social activities to reduce the emissions of greenhouse gases, particularly carbon dioxide associated with the burning of fossil fuels. For the urban agenda, particularly at the scale of the megalopolis, this puts the planning of and investment in infrastructure centre-stage. And this is as true of high-income countries as it is of the low to middle-income countries.

For high-income countries, there is an urgent need to provide the infrastructural base for reducing resource take per capita. Increases in population in countries, such as the United States, with patterns of high consumption, are much more significant in terms of greenhouse gas emissions than increases in those, such as Mali, with low consumption levels. But infrastructure can support new patterns of behavior even at high absolute levels of consumption. Meanwhile in low-middle income countries, there is an urgent need to invest in infrastructure to meet the basic needs of growing populations. The United Nations Population Division predicts that, if fertility were to remain constant at the levels for 2005-2010, the population of less developed regions would increase to 9.8 billion in 2050[12]. This may be viewed as a burden on infrastructure but, given the lack of established or adequate systems in many such countries, this also offers the opportunity for a paradigm shift in infrastructure systems as new investment takes place. The fossil fuel-reliant infrastructural paradigms of wealthy nations do not have to be those adopted by lower income nations.

Water treatment, for instance, is potentially one of the largest energy consumers in any urban centre; however, if methods such as anaerobic digestion are substituted for fossil fuel intensive methods, developing cities can introduce water treatment plants without significantly affecting urban energy usage and, at the same time, bring about significant health benefits for the urban population. Innovative infrastructures can thus counter the impacts of increased populations on climate change at the same time as providing for citizens' needs.

However, paradigm shifts in infrastructure systems can be slow to achieve, since the lead time in investment is long. There is a need today to try and accelerate such shifts, asking whether prevailing government policies are encouraging or stifling the innovation necessary to make the megalopolis sustainable. Scale could be a key issue here. Smaller-scale urban experimentation is both easier to implement and provides concrete examples that can be adopted elsewhere, or scaled up. There are always hazards when scaling innovations up or down, though, and it will always necessary to monitor closely the success of experimentation if it is to be implemented on a larger scale.

Allowing the public to take part in experimentation could also be effective in fostering small-scale community-based innovation and enterprise. If institutional and market-based innovations were married with technological ones, diversity and informality could be absorbed into the system. For example, in the case of energy systems, micro-generation can make citizens both consumers and producers, resulting in innovative change to megalopolitan infrastructures.

Energy use in megalopolises[13]

The decarbonisation of energy infrastructure can be achieved at a centralized scale without changes at the urban scale. Large scale renewable energy generation, continued reliance on national (or even international) grids and investment in carbon capture and storage would produce considerable decarbonisation. However, the urban arena offers the potential for expanding the range of scales at which energy generation and distribution occurs; the larger the urban area, the greater the options for such decentralization initiatives and hence opportunities are opened up by a focus on the megalopolis.

The decentralisation spectrum can operate from the pico or appliance scale, through the building to the development site, neighbourhood, urban area or even whole city. There are energy efficiencies to be reaped at some of these scales, particularly where energy generation is combined with heat networks as in CHP plants. But there are also multiple opportunities for using renewable sources of energy as with solar or wind power, biomass of various types and energy generation from waste using various technologies to produce electricity, heat, biogas or biofuel.

However, technological change in infrastructure systems is only part of the solution. Energy is consumed (and carbon emissions generated) by people's interaction with energy systems and the associated technology. Thus understanding people's behavior in urban contexts is the key to reducing energy consumption and carbon emissions. This behavior is shaped by culture, routine practices, relationships between people in communities, governmental frameworks, market processes and the regulation of those market processes.

Thus the scale of the megalopolis also offers scope for innovation in social practices, local government policies and market institutions to influence energy behavior. Indeed it may be that this urban scale offers the greatest scope by allowing decentralised energy systems to be developed at a sufficient scale to reap economic and technological economies while also offering the possibility of local cultural and social change to generate new energy citizens, who are more active in generating energy and more effective in managing their demand for energy.

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Transport within megalopolises[14]

Transport infrastructure is similarly central to the reduction of carbon emissions associated with travel. And again the megalopolis offers considerable scope for delivering transport systems, particularly public transport systems, which will be effective in achieving less carbon-intensive travel. Scale is a necessary prerequisite for viable public transport systems. It has been argued that the increased densities of urban areas can also foster walking and cycling but this depends heavily on achieving higher densities within the urban area (and not just increased scale) and on the pattern of land uses across that area.

Study of the growth of London's urban transport system yields lessons about how developments in public transport relate to the growth and development of the megalopolis. The interaction between urban development and transport is influenced by a number of interconnected factors: industrialisation, demand for housing, transport technology, fare levels and structure, strong leadership, national and local politics, economic growth, ownership and regulation and car ownership.

Three distinct phases of London's public transport system can be mapped. The first ran from 1875 to 1941, a period in which technological innovation in electric traction and the internal combustion engine, municipalisation, and strong leadership in private enterprise saw the steady growth of transport provision and usage. The second phase between 1948 and 1981 saw the factors such as the nationalisation of public transport, Government interference, and increased car ownership contribute to a period of steady decline. And finally, the third phase running between 1981 to the present saw an increase in passenger numbers initiatives such as Ken Livingstone and the GLC's 'Fares Fair' campaign in the 80's, the introduction of zonal fares and travel cards, economic boom time, investment in the Docklands Light Railway and Jubilee Line, and the introduction of congestion charging in 2003.

Two key lessons can be drawn. First, no public transport system can cover all of its costs, thus government subsidy is always required. It is unclear, however, whether public or private ownership is better, as central government interference can be detrimental to investment and prevent sound operational decisions being made or it may support innovative change. Second, if one looks to introduction of road pricing or congestion charging, innovation is encouraged by a number of factors. A champion of the scheme is needed, technology must be tried and tested, powerful lobbies must be kept in support, and public consultation should be used with caution, particularly where policy innovation runs ahead of cultural and behavioural change.

The climate change adaptation agenda

Turning to the need to adapt to forecast climate change, the character of that change is now fairly well understood. The Prudence model (http://prudence.dmi.dk) predicts an increased frequency in heatwaves, heavy winter precipitation in central and northern Europe, increases in summer rainfall in north-eastern Europe, extreme wind speeds between 45°N and 55°N, and increases in storm surge along the North Sea Coast. The real challenge is not predicted climate change itself but how cities would cope with the increases in short term extreme events. Urban areas have a minimum and maximum coping range for temperatures and rainfall and these change slowly, perhaps more slowly than the climate itself.

Flooding and storm damage[15]

Flooding poses a particular challenge. In the UK floods like those of 2000 would become standard under climate change. The Thames Barrier's ability to protect London against a one in five hundred year storm will steadily decrease so that by 2080 London will be at risk of flooding. More catastrophically a 7 metre sea level rise is predicted if Greenland or West Antartica ice melts, 14 metre if they both melt. This raises the prospect of investing in extensive flood defences but also, in some locations, the more radical option of abandoning or relocating coastal settlements, including the many major cities in coastal regions. Two thirds of cities are located in coastal areas making them inherently vulnerable to the disruption of our climate.

But there are great differences amongst such cities. Cities that lie on the coast and/or in areas in which extremes of climate are already common include Dhaka, Tokyo, Shanghai, Lagos and Mumbai. The economic role of these cities means flooding here would have financial as well as human impacts. If London were flooded, the 24 hour global trading network would be irreparably disrupted, causing economic chaos that would be felt world-wide. But these cities' increased economic capacity also means they are able to invest in climate change adaptation, thus making them more resilient to extremes in weather.

For climate change exacerbates a city's existing vulnerability. Tokyo may not be destroyed by a storm; however, Dhaka may well be. Urban governments are now trying to fund climate change adaptation. This, however, only funds adaptation that deals with *increased* risks due to climate change. The framing of climate change often fails to address the fact that already vulnerable cities that are without effective infrastructure need funds to deal with *existing* vulnerability to external weather, regardless of the impacts caused by climate change. Similarly a focus on resilience theorises ways in which stress can be absorbed while maintaining function. In a context of climate change, however, the problem of resilience is not how to maintain livelihoods and lifestyles in a context of change, but rather, how to improve well-being and human lives for those that are already marginalized.

The city of Houston can be given as an example. Despite being one of the richest cities in the USA, it is also the site of deplorable poverty. The city lies almost entirely on low level swamp land and the only high ground is occupied by the wealthy. The overall infrastructure thus does not provide for its poorer inhabitants and makes them the bearers of risk, risk which they cannot insure against unlike their wealthier neighbours.

As yet, it is still difficult to obtain city-scale models that will predict the impacts of extreme weather events. Insurers look at risk by analysing 3 component parts—hazard, exposure, and vulnerability—and consider which of these can be reduced most easily. Hazard can be reduced by cleaning rivers and drains of weeds, modifying lakes, rivers, and reservoirs to cope with increased rainfall, applying sustainable drainage techniques, and promoting natural flood management. Vulnerability can be reduced by building in architectural features that make the building less vulnerable, encouraging demountable defences, and extending housing benefit to pay for contents insurance. Finally, exposure can be reduced by not building in the flood plains, purchasing and demolishing flood damaged properties and publishing detailed flood maps in local shopping centres.

Governments are usually looked to in the face of such risks but national and international engagement with localised risk is often problematic and local government can lack the capacity to act on these issues. Therefore, a focus on locally-generated capacity to respond to such risks may be more appropriate. For despite a lack of knowledge and a lack of top-down engagement with these risks, in some localities the people affected are generating knowledge by creating hazard maps and building the local capacity for resilience through social capital and micro-credit. In recent years, there has been a move towards sustainable flood management in Japan, in which control has been taken out of the hands of the engineers and handed to the communities. Since 2000 people in upland communities have started to plant trees and block off their land drains to slow down the water flow down the mountains.

Anonymity in urban areas can contribute to an increased vulnerability to environmental hazard, so building active local community is vital when adapting to the increased environmental hazards of the megalopolis affected by climate change. The most effective way to protect to the future is in the investment in strong integrated local communities.

Heat waves[16]

By 2040 average summer temperatures in Europe are expected to be those experienced in the heat-wave of 2003 in which between 30,000 and 35,000 people died in Northern Europe, while heat-waves in 2040 will be twice as hot as those we experience now. These impacts of climate change are exacerbated by the Urban Heat Island effect, which results in temperatures across a city such as London varying, with central areas being on average significantly hotter than suburban areas.

Models, using data such as air temperatures taken from vehicles moving across London, surface temperatures detected by satellite remote sensing, land-use information, and building heat emissions, can calculate the possible health and comfort benefits and disbenefits of London's heat island, and so determine how much cooling or heating specific locations in London might need in winter and summer. Bespoke weather files could therefore project future summer temperatures to include contributions from the urban heat island and future climate change. This information could then be used when calculating, for instance, compliance with building regulations that specify that employees should not spend more than 1% of working hours in offices that are at over 28ºC.

Using a process called morphing, models can capture the general shape of predictions for future scenarios. Feeding in different future scenarios it would then be possible to calculate their differing effects across specific locations in London. Scale models could look at the thermal impacts of planned developments, or calculate the expected level of mortality in a heat-wave at specific locations. At the moment the Greater London Authority intends to create an 'Urban Heat Island Action Area', in which future developments would have to demonstrate that they would not exacerbate the urban heat island effect; however ways in which this can actually be monitored are yet to be developed.

Water security[17]

Cities are becoming thirstier and more erratic in their demands for water, just when supplies are in fact decreasing and are set to decrease even more as the effects of climate change become ever-more apparent. Recent social and cultural research has shown that consumption itself is shaped by infrastructure. While demand management campaigns tell customers that water is a limited resource, infrastructure actually tells them the opposite. The endless supply of water has created new cultural practices and expectations that are harder to shift than simply telling consumers about falling reservoir levels. Rather than viewing consumers as nodes of demand for infrastructure to supply, the demands of sustainability require engineers and planners to open up infrastructure to citizens to conceive of new ways of supplying cultural expectations of water, including the co-production and provision of infrastructures that involve consumers in the creation of their own water-infrastructure.

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Water-scarce regions, such as the south-east England, have reached their hydrological limits. Desalination and the treatment and reuse of waste water are thus seen as alternatives. Potable reuse involves treating waste water to a very high standard and then reintroducing this water to reservoirs, rivers and aquifers before being abstracted again and going through the usual treatment. Public opposition campaigns have, in the past, closed down waste water treatment works, as PR campaigns, working on a deficit model of public understanding have unsuccessfully tried to persuade consumers of the safety of this technology. When it comes to new supplies, the public is no longer willing to trust the engineers to make technical decisions in their best interests.

Alternative decision making networks must, therefore, be found. Work with Thames Water on the feasibility of potable reuse systems involved deliberative forums, providing members of the public with the opportunity to question engineers on new technologies. Ideally, these deliberative forums would be delegated the authority to make the decisions, Thames Water, however, have not gone this far. This pilot scheme showed, however, the benefits of making decision making more democratic as after deliberation, the public were more favourable to potable reuse.

One should be very cautious in supposing a teleology of urban form based on examples from Europe and North America and imposing this in other global regions. Lagos is a typical example of one of the fast growing cities of the global south and has very different forms of social and political mobilisation than those historically observed in the evolution of the public sphere. Lagos has only a limited formal reticulated water infrastructure, with only around 30% of households connected to a dysfunctional and unreliable municipal system. Other systems therefore emerge: private water vendors dominate slums and illegal connections to municipal pipes provide water.

However, there is a growing consensus that a shift towards small scale community based co-production could produce major changes in the way we both produce and consume water. Innovation on a small-scale allows populations to adapt to the effects of climate change; however, it is necessary for these small-scale innovations to feed into larger infrastructural models – including both their technological and institutional dimensions – if these innovations are to bring about long-term change.

Disease and public health[18]

Megalopolises and other urban areas are often seen as sites of concentration of disease and means of increasing contagion. Certainly Increases in urban populations lead to concentrations of people and human to human contact that can spread infection. But attention paid to the impact of health crises revolving around SARS or BSE in wealthy nations rather than the effects of cholera or malaria in poorer ones, for instance, is disproportionate to the numbers actually affected, and ignores the fact that cities have driven the health reforms that have doubled our standard of living and life expectancy. When populations are concentrated in urban areas there are actually huge potential health advantages: sanitation and reticulated water supplies, emergency services, disaster preparedness. It is only when governments fail urban populations that they suffer substantial health risks.

Urbanisation is very strongly associated with economic growth and cities tend to concentrate people with higher incomes. The Whitehall Study investigated the importance of social class, psychosocial factors and lifestyle as determinants of disease, and found that a person's health was influenced by the conditions in which he or she lived and worked. [19] In short, income is a determining factor in health. With the development of the European and North American city since the Victorian era, there has been a general move to the elimination of environmental health hazards. Higher standards of urban institutions, competence and capacity produce higher life expectancy. The importation of the obesity agenda and low-risk environmental health concerns to lower-middle income economies can become a concern at this stage.

Urban scale does not itself negatively affect life expectancy, infant mortality rates, the provision of water and sanitations, and quality of life. As cities increase with size so does the likelihood that they will have developed sanitation infrastructures that make urban inhabitants as healthy, or healthier, than their rural counterparts. Cities, in which inhabitants suffered worse health than the rest of the nation, were historically either in the process of industrialisation or victim to specific circumstances in which social and political reforms had failed to catch up with the speed of economic growth and the city's subsequent expansion.

Access to treated water is essential to public health in urban regions. Although access has generally improved worldwide, further improvements are still vital in order to combat the diseases that contribute to high mortality and infant mortality rates. Although reticulated water systems designed by engineers and provided by the public sector have made major improvements to water access, the fast growing peri-urban areas are often neglected by large regulated frameworks. Poor water resources in peri-urban contexts, however, cannot be explained by the unsustainable growth of cities; there is no correlation between city-size and the sustainability of water resources. Issues surrounding the sustainable extraction, supply and consumption of water were better explained by hydrological systems, water governance regimes (the institutional dimensions of the provision of access to water), water demand and consumption patterns (influenced by lifestyle), and socio-economic inequality.

Alternative solutions have to be found to take into account the difficulty of creating reticulated systems for these fast-expanding areas, and whether such provision is actually desirable in environmental sustainability terms. Policy-makers instead have to look at decentralised methods of distribution of treated water, allowing, for instance, local communities to manage their own water supply and sanitation, resolving conflicts over access to peri-urban aquifers, and controlling the price-fixing of local cartels without stopping small-scale suppliers. This reinforces the point made above that a new water culture could thus be created that might make the supply of water a co-production between state and citizens, empowering peri-urban communities and groups within those communities, such as women, by enabling them to manage their own water supplies and thereby ensuring public health.

Responding to the climate change agenda

Modelling change[20]

Responding to the climate change agenda will require new knowledge. Advocates of modeling see mathematics and computer science being used as tools to model the functioning and evolution of large city regions as complex systems, and then used to anlayse the effects of climate change on the megalopolis. The megalopolitan system is comprised of population, economy, employment, products and services (and their uses), and their interactions in transport and communications. These factors go towards creating what can be called an urban physiology or 'DNA' that characterises the structure of the city, and determines its development. The principle sectors within a modeling framework or megalopolitan system are population, housing, economy, public services, retail services, economic capacity and government. The spatial interactions of these sectors lie in journeys between homes, work, businesses and public services for instance, which lead to the definitions of key variables. The analytic challenge lies in breaking down these variables to create viable models that can in turn be used to plot and project the dynamics or 'DNA' of the megalopolis, and thus the impact of climate change upon it.

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These computer models could therefore be used to identify phase transitions—the shift from slow to fast dynamics of the city. Slow dynamics are the slow changes of infrastructure in the city, while fast dynamics are quicker reactions to contingent situations. They can radically alter patterns within a short period of time. Comprehensive megalopolitan models could thus identify and project what the possible phase transitions caused by climate change might be. The analysis of phase transitions also has to take account of path dependence, since outcomes are heavily constrained by a set of initial conditions—the megalopolitan DNA. These models would therefore allow us to consider what the effects of adjusting the DNA of the megalopolis might be. The research challenge lies in learning how to represent climate change, sustainability and extreme events as possible changes in the model's variables, thus enabling us to explore and identify the changes in the fast and slow dynamics of the megalopolis.

Research conducted as part of the cities theme at the Tyndall's Centre brings together models and data collected by CASA at UCL, Newcastle University, Leeds University and Cambridge Econometrics among others[21]. Emissions models, global climate models, GIS models, flood models, population site models and others are stitched together, and using a land-use and transportation model built for Greater London and the Thames Gateway, the Tyndall Centre assesses the impact of climate change on small areas in the metropolitan region, looking in particular at rising sea levels and pollution in the next 50-100 years. Visualisations are then produced by these models and can, for instance, show how employment changes can affect the population density of different areas of London, or what rises in water levels would do to London's urban landscape. These models and visualizations can thus be used to explore and predict the effects of climate change on the city, and so be utilised when calculating how changes in urban infrastructure could meet the demands of extreme events such as flooding.

Caution is necessary though when using generic models. Conceptually a model applicable to a western European city is not necessary applicable to a developing city. Several different models need to be created for every situation in order to account for fundamental cultural differences that might make generic models problematic. Models of London have a wealth of data to draw on that can be used to predict possible futures; however, the amount of available data in developing cities such as Lagos or Jakarta can be easily overestimated. This raises the question of how much data is sufficient in order to create viable models that can plot and predict the effects of climate change. There is a difference in the amount of data required for modeling for peer review and that needed to drive policy. Viable generic models already exist that need a fraction of the data available and are often sufficient to drive policy.

In order to create statistically reliable models, however, large sets data are needed. Satellite remote sensing data has rich data sets relating to traffic, congestion and movement from across the developing world that could be used in order to create models for developing cities. Relatively little data is needed from the ground in order to create and calibrate these models. Generic urban heat island models are, in fact, being generated using just this kind of remote sensing data. Ground level data can, however, also be collected, and involving local communities in the collection of data can be instrumental in changing behaviour.

Governance for sustainability[22]

Urban contexts give characteristics to risk; however, cities are not inherently risky in and of themselves. Governance is the key issue. Although cities have the capacity to marshal resources and skills to reduce vulnerability to climate change, observation indicates that urban governance is consistently failing to do this. There needs to be political will, inclusiveness in decision making, and good relationships between municipal and national government if cities are to increase their capacity to handle risk. The capacities of local government and the role of strong leaders and personalities within that government were seen to be vital. It was noted that some current mayors (and especially those in some South American cities) were able to drive through considerable change; sometimes they were following the model of the nineteenth-century heads of private companies who effected enormous change to urban transport systems in the UK. However, it was also possible for other forms of local governments to work with and around the constraints of existing local government systems to implement significant change, using tried and tested technologies but innovating in terms of institutional frameworks. Further down in scale are deliberative forums and community groups using democratic and informal strategies to effect change in local areas. The problem lies in getting local government leaders to acknowledge the potential of these decentralised structures to create real capacity for change in the megalopolis.

Examining the economics for different arrangements of governments and the types of government that might be appropriate for megalopolises leads to the question of what the areas of responsibility of decentralized governments should be. In order for a large scale urban area to function efficiently, it is critical to organize and finance governance effectively. Governments are financed by taxes, cuts in tax revenues (hypothecated tax revenues) and direct financial transfers from other levels of government. Choices made on decentralized government, how it is organized and how it is financed can have significant implications for the effective functioning of government and the spatial pattern of economic activity.

A continually growing megalopolitan government may grow beyond the efficient scale of operation. Government organizations typically reach a point at which cost per unit/ cost per person served start to rise, and a government that covers the whole unit may therefore be inefficient for the production of government services. Large scale will also make formula-based allocation of financial transfers to local areas very difficult. The pace of growth and change means that any government organization that is set up needs to be capable of accommodating rapid transitions in the spatial distribution of people and their activities. Any form of decentralized government needs to take into account the rapid pace of growth and change. There are three options: unitary government (unattractive due to its scale and risk of inefficiency), spatially defined decentralized government (difficult because there is no natural way of spatially subdividing megalopolises), and layered government structures that separate the functions of government. Layering could avoid the problems of large scale and subdivision.

The shape of our future cities will also have immense implications for their wider regions. Variables such as migration and climate change make it difficult to make confident predictions that allow for effective policy making and the provision of infrastructure. Conflicting issues of national and local interest lead to unsustainable decisions for short term economic growth that, for instance, propose building runways and airports in areas of the greenbelt despite established policy that dictates otherwise. In the UK, dominant policy can be turned upside down for the sake of political or economic expediency, making ours one of the most flexible planning systems in the world. The government will often make national decisions disregarding local issues. When managing the sustainable cities of the future there needs to be increased public participation to act as a democratic check. It is also necessary to link the dilemmas of growth vs. environmental protection and local vs. regional/national, while combining the market with elements of governmental restraint and diverse political priorities.

Another way of looking at these issues is to consider the ways in which the structures of, and interactions between, horizontal and vertical governance affect drives for sustainability. Problems of sustainable development often require collective action because air and water pollution, for instance, cross local boundaries. No one government necessarily has the incentive to act first, while entrepreneurial action by one local government can result in free-riding by others. Levels of difficulty in negotiation depend on transaction costs. If transaction costs are low, local governments may negotiate. As transaction costs rise and problems cross multiple boundaries, negotiation becomes problematic and collective action problems proliferate. Small autonomous local government structures can be innovative and competitive; however, they also have a tendency to be fragmented and more prone to horizontal collective action problems. In U.S cities, powerful, autonomous local governments are often reluctant to surrender authority to regional governments, while in the U.K local governments are still largely seen as subservient to national government.

Cooperative policies work best with committed local governments. These are also more likely to join voluntary international climate change initiatives. Some local governments, however, show little commitment to sustainability initiatives and may require coercion, increased capacity, and the improvement of citizen awareness. Increased public consultation with neighbourhood associations and environmental groups in the U.K and U.S and the replacement in some U.S cities of large elections with district elections has led to better representation of local environmental interests. Eliciting participation of local interests could help limit growth and promote environmental sustainability. Local autonomous governments could be good for innovation in sustainability initiatives but a commitment and capacity to overcome cross-boundary problems is necessary. Guidance and resources from regional and national tiers of government is, however, still vital in the creation and maintenance of sustainable cities.

Looking at local planning in particular, the planning establishment arose to try and rectify the ills of poor quality housing, unemployment and Victorian infrastructure. It was argued thus that there needs to be a new political consensus around sustainability of the sort that supported planning in the past, setting forth clear principles into which economic models could be fitted and around which debates about environmental assessment could take place. The concern, however, is whether sustainability can be planned and conversely whether planning can sustain sustainability. Sustainable development as a political policy objective has been bolted on to the existing system. Should we in fact get rid of our existing planning system and start with the land and natural resource capacities, then consider sustainable land-use and development, and then proactively plan for this option? The problem with sustainability in the UK is that it has been politicized and made infinitely malleable. There needs to be a return to core principles about what we do and do not value about our urban spaces and the impact of the city on wider regions.

Urban culture and sustainability[23]

If sustainability is to become part and parcel of the megalopolis then it has to become embedded within that urban culture, that is, it needs to have meaning within that culture. This means that it needs to be part of the way that lives are lived in the urban environment and this varies from urbanlocality to urban locality. Culture is a way of representing how people use cities but it also has the ability to shape the ways in which people use it.

For example, an ESRC funded project looks at resilience, urbanisation and climate change in 4 cities: Cancun, Playa del Carmen, Tulum, and Mahahual in the Quintana Roo region of Mexico-the most rapidly urbanising place in the Americas. Cancun, marketed as a beach resort, has a tiny stretch of sand and sits in a vulnerable position between beach and a lagoon. Yet residents attached their identity not to their home villages but vulnerable tourist resorts. The resorts and the residents were thus remarkably independent of, and unattached to, place. To understand this jargon heavy vocabulary needs to be discarded in favour of a more poetic and embodied expression of aspects of everyday life. The term sustainability could thus be used as a tool to consider how tightly enmeshed the idea of an imagined sustainable community is with the idea of a sustainable ecological system.

One issue that arises is to what extent are rapid changes (or phase transitions) in climate, cities, and social behaviour related to ideological discourses and conservative or progressive change? Historically the notion of crisis engenders a rapid social and political response. In an urban context, structural elements can be gradually taking shape and then very suddenly recombine in a new form creating the perception of a very sudden change to the city. Inaccurate ideas about the rapid change in the ethnic composition of Scandinavia, caused by poor immigration policy that saw extreme demographic changes very small pockets of the urban environment, had led to a conservative discourse and panic about the rapidity of change. Rapid change, in this context could thus lead to conservative discourse.

Furthermore social sustainability as a term suggests ways in which to sustain and create better communities and improve their quality of life. The term often implies inertia and is redolent of memory and nostalgia, looking back instead forward. Collective memory, its symbols and rhetoric, are often manipulated for the purposes of nationalism.

However, there is a choice. The response to climate change might well take shape in an alternative form of politics. Memory can also be used as a resource to better understand contemporary challenges. The critical and analytical tools of the humanities and social sciences thus have an important role to play in analyzing past and present urban conditions and cultures to inform the ways in which people might move towards creating more sustainable and socially equitable cities. The recurring temptation to look for design solutions sometimes occludes engaging with the social and economic determinates of equality and inequality in the urban arena. The humanities and social sciences have an important role to play in reflecting urban practices back upon themselves. If architects, planners, politicians, builders, and developers could better use these lessons and reflections on their disciplines they may have a much more interesting and informed point of departure.

Conclusions

This brief discussion of sustainability in the context of the largest and most complex urban areas has shown that the challenges of an increasingly urbanised world are substantial but that the scale of the megalopolis offers great opportunities also. It provides a scale at which infrastructures can be reshaped and urban governance used to deliver improvements in public health and quality of life. It allows for economies of investment to be reaped but also for social experimentation at the level of the community to be encouraged. The aim is to provide structures in terms of technology and institutions at the scale of the urban entity that also provide spaces for bottom-up innovation and the active engagement of the urban citizen. In these ways it is possible – even, or perhaps particularly in megalopolises – to make sustainability a reality.

Appendix 1 Seminar Programme

1. Climate change and the megalopolis - 21st January 2009

Prof. Sir Alan Wilson (Centre for Advanced Spatial Analysis)
Megalopolis: analysis through modelling

Prof. Mark Maslin (UCL Department of Geography)
Large Scale Climate Changes and Effects on Large Urban Areas

Prof. Michael Davies (Bartlett School of Graduate Studies)
London's Urban Heat Island

Prof. Michael Batty (Centre for Advanced Spatial Analysis)
Climate Change and Cities

2. Transport, energy and water infrastructure, sustainability and the megalopolises - 25th February 2009

Dr Sarah Bell (UCL Department of Civil, Environ and Geomatic Engineering)
Water Infrastructure in the Megalopolis and the New Engineer

Prof.Roger Mackett(Department of Civil, Environ and Geomatic Engineering)
Transport in the Megalopolis

Dr. Julio Davila Silva (Development Planning Unit)
So Close To The City, So Far From The Pipes: the governance of water and sanitation and the peri-urban poor

3. Health, climate change and the megalopolis - 18th March 2009

Dr. Ben Croxford (Bartlett School of Graduate Studies)
Pollution, Health and the Home

Dr. David Satterthwaite (Development Planning Unit)
Health and Climate Change Resilience in the World's Megalopolises

Dr. Ka-Man Lai (Department of Civil, Environ and Geomatic Engineering)
Healthy Infrastructure Research Centre – a hub for education and research to prepare for the 21st century infectious diseases

4. Security, resilience and the megalopolis - 29th April 2009

Prof. Gloria Laycock (Jill Dando Institute of Crime Science)
Ensuring Security and Resilience in the Megalopolis

Prof. David Crichton (Benfield UCL Hazard Research Centre)
Climate Change and Catastrophe Risk: an insurance view

Dr. Mark Pelling (Kings College London Department of Geography)
The Urbanisation Process and Resiliency in a Rapidly Expanding Mexican Urban Region

5. Sustainability, society and culture in the megalopolis - 20th May 2009

Prof. Matthew Gandy (UCL Department of Geography)
Liquid City

Dr. Paolo Favero (UCL Department of Anthropology)
Delhi, Anil and the Phantasms

Dr. Claire Thomson (UCL Department of Scandinavian Studies)
"The sun will shine on the homes of the future"; Urban Planning and Ethnicity in New Danish Cinema

6. Policy frameworks for megalopolises: economics, planning and governance - 17th June 2009

Prof. Alan Penn (The Bartlett School of Graduate Studies)
Managing Urban Dynamics: space, institutions and markets

Prof. Stephen Smith (UCL Department of Economics)
Policy Frameworks for the Megalopolis: economics

Prof. Mark Tewdwr-Jones (Bartlett School of Planning)
Managing the Land: governance and resilience for sustainable cities

Dr. Colin Provost (UCL School of Public Policy)
The Governance of Sustainable Development in the US and UK

Dr. Jane Holder (School of Laws)
Planning and Governance Through Environmental Assessment

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Appendix 2

List of Seminar Participants

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Ali Fahim (Department of Electronic and Electrical Engineering, UCL)

Allison Wylde (London Metropolitan University Business School)

Arata Yamamoto (Bartlett School of Graduate Studies, UCL)

Aris Christodoulou (Centre for Transport Studies, UCL)

Athina Lazaridou (Space Syntax Lyd)

Carrie Bradshaw (Faculty of Laws, UCL)

Celine Verissimo (Bartlett DPU, UCL)

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Stuart Umbo (Contemporary Science Content Developer, The Science Museum)

Thomas Claydon (Library Services, UCL)

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12 http://www.dotearth.blogs.nytimes.com/2009/03/11/un-young-old-boom-on-road-to-9-billion/

13 The section draws on the analysis of the Foresight project *Powering Our Lives* published by the Government Office for Science in 2008; available at http://www.foresight.gov.uk/OurWork/ActiveProjects/SustainableEnergy/ProjectHome.asp

14 This section draws on Professor Mackett's presentation in Seminar 2

15 This section draws on Dr. Satterthwaite's presentation in Seminar 3and Dr. Pelling's and Professor Chrichton's presentations in Seminar 4

16 This section draws on Professor Davies' presentation in Seminar 1

17 This section draws on Dr. Bell's presentation in Seminar 2 and Professor Gandy's presentation in Seminar 5

18 This section draws on Dr. Davila Silva's presentation in Seminar 2 and Dr. Satterthwaite's presentation in Seminar 3

19 http://www.ucl.ac.uk/whitehallII/findings/index.htm

20 This section draws on Professor Wilson's and Professor Batty's presentations in Seminar 1

21 Tyndall Centre for Climate Change Research, 'Engineering Cities: how can cities grow whilst reducing emissions and vulnerability?', 2009, Newcastle University

22 This section draws on Professor Smith's, Professor Tewdwr-Jones' and Dr. Provost's presentations in Seminar 6

23 This section draws on Dr. Pelling's presentation in Seminar 4 and Dr. Favero's, Dr. Thomson's and Professor Gandy's presentations in Seminar 5

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