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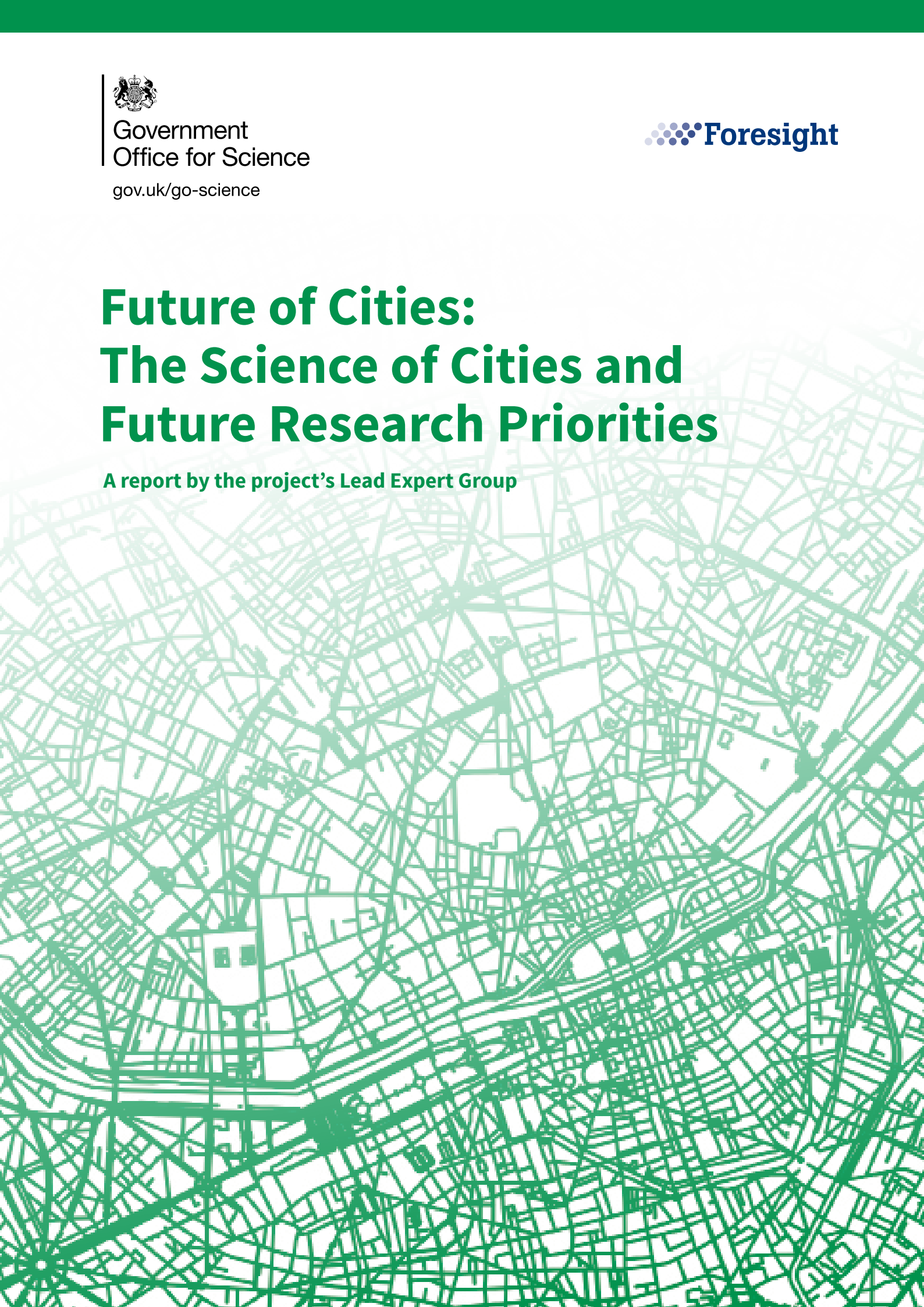
Foresight

Future of Cities: The Science of Cities and Future Research Priorities

A report by the project's Lead Expert Group



Foresight Future of Cities Project

The Foresight Future of Cities Project is run from within the Government Office for Science (GO-Science) and was launched in June 2013 by Sir Mark Walport. This major project has developed an evidence base on the future of UK cities to inform decision-makers. It has used evidence and futures analysis, taking a view towards 2065, considering how people will live, work and interact in our cities 50 years from now. The project has focused on taking a holistic, long-term view of the future of UK cities, working across spatial scales from the national system of cities to city and sub-city systems.

Foresight is not alone in this space. Through the lifetime of the project we have seen an increasing number of organisations taking an interest in the future of cities. Along with this, there has been a growing amount of research and analysis on the future of cities, both in the UK and around the world. We have sought to work with these organisations and drawn upon much of this work.

We have collected evidence in a variety of ways, from the commissioning of working papers and essays, to running futures workshops, and visiting, supporting and working with more than 20 cities of various types and sizes across the breadth of the country. There is a considerable evidence base available on the project's website including the peer reviewed working papers, essays and workshop reports.

This report examines what science can offer to helping understand the future of cities, and in what direction research could most usefully be focused in future. It sits alongside two other deliverables in the Future of Cities project's final outputs:

- *Foresight for Cities* – provides a value proposition to encourage mid-sized and smaller cities in the UK to engage in foresight exercises and offers practical lessons for implementing and managing a city foresight process. This is aimed primarily at local government officials and partners.

- *Graduate Mobility and Productivity*: An experiment in open policy-making – adopts a place-based open policy-making approach to a key challenge emerging from the Future of Cities project's evidence base. This demonstrator project encourages collaboration between national government and key local actors including local government, universities and employers to meet national policy challenges.

This report can be used as a basis for understanding research priorities identified by the project, and the contribution science can make in addressing these.

Foreword

The science of cities – using evidence to understand how cities work – is forever expanding. It is crucial for understanding how cities could develop in the future, and the Future of Cities project's Lead Expert Group has reviewed much of this in its deliberations. Our attention has been drawn to the breadth and depth of the existing knowledge base but it has also led us to develop a conceptual framework which can be used to articulate future research priorities.

This paper offers an overview of a wide range of work commissioned by the Foresight project and serves as an outline of the evidence base that can be used now to underpin policy development and plan building for the future of cities in the UK.

However, we are also conscious that this existing knowledge base is not systematically deployed in cities' 'futures' thinking and we hope that this paper will be a gateway into the rest of our work for a variety of interested parties. Our work, whether on the existing knowledge base or on future research priorities will have value only insofar as it is taken up by the cities' community of stakeholders. I am happy to commend it in this spirit.

Alan Wilson
Chair, Future of Cities Project's Lead Expert Group

Executive Summary

In this report we offer a sketch of the evidence base for our work on the future of cities. We take a broad view of the science and seek knowledge from a variety of sources. This provides a perspective on what we know but also on what we don't know, and hence a view of research priorities in this field. We draw heavily on the working papers commissioned by the Foresight Future of Cities project, and the bibliographies of those papers provide detailed support for the arguments presented here.

Our review is presented in terms of the six themes we have used throughout the project: living in cities, urban economies, metabolism, urban form, infrastructure and governance. We show that there is a considerable knowledge base, though it is often spread across disciplinary perspectives and not fully integrated. We also demonstrate that many aspects of this knowledge base are strongly connected and we emphasise the importance of recognising this interdependence. This leads us to take a systems view, both at the UK scale and for particular city regions.

We find that much of the available science base is not routinely applied to the tasks of policy development and planning in relation to the future of cities. So our first research priority is to recommend the application of systems analytics to both the UK system of cities and to particular city systems.

There are two further cross-cutting priorities. First, much new data is becoming available – the 'big data' revolution – and a serious research challenge is designing the architecture of the information systems that will make this available as needed to support systems analytics. Second, the analysis dimension of the knowledge base supports policy development and planning, but as forecasting for the long term is impossible, the focus has to shift to scenario development and the ways in which policies and plans can support more or less desirable scenarios. This is a research challenge in itself.

We then present a formidable agenda of research priorities that relate to the six themes, emphasising interdependence along with interdisciplinarity and interprofessionalism. We conclude with some comments on how this kind of research programme could be delivered.

Contents

What we know: a brief overview

In the project's final report *Future of Cities: An Overview of the Evidence* we argue that the future of Britain will to a great extent be the future of its cities. Our cities already concentrate the majority of our population, trade, commerce, cultural and social life. They are places of opportunity, where national policy objectives can succeed or fail, shaping not only their own future, but also that of the wider national system of cities.

The emerging 'Science of Cities' through which we seek to understand and inform this future must have a broad sweep. It must be science as 'wissenschaft', focusing on people, organisations, resources (energy, water, food and materials), land, infrastructure systems and all forms of governance, spanning across a spectrum from the local to the national, and the international context in which we are located. It must encompass multiple scales from the micro to the macro. It will have to draw on insights from a broad spectrum of disciplines, methods and analytical frameworks, both qualitative and quantitative. It will combine the construction of informative narrative with the insights of computational modelling. The science of cities will inevitably be interdisciplinary and interprofessional, though we need to be aware of what individual disciplines and professions contribute to the mix. To recognise this interdependence, we adopt a systems view of cities – as city systems and as systems of cities, the latter at both regional and national scales.

In broad terms, decision makers at every level from the individual and household to the boards of firms and councils of state need to understand how cities work: how people experience living in cities and what their aspirations might be, how organisations can be efficient and effective, how the working city can be sustainable and resilient to change, how transport, digital and other infrastructure will facilitate connectivity. Decision makers and analysts need to recognise the interdependence of these elements of knowledge, in pursuit of governance that enables productive interaction between national and local governments, the private sector and civil society to envision and implement a better future for all citizens.

What can we know about the future of cities? The distant future is not forecastable, but we can develop scenarios to be explored with the tools available to us. We can explore the achievability of desirable futures and the means of avoiding undesirable ones. We can explore in broad terms the viability of futures in terms of fiscal policies, public and private investment and regulation through effective planning, as well as creating the opportunities for innovation through the serendipitous interactions that the urban form provides.

There are different kinds of intellectual contribution. This is both a challenge and an opportunity. Efforts to develop an integrated science of cities face the challenge of reconciling the fundamentally different conceptualisations of the city that are found among diverse disciplines and professional perspectives. The idea of the city takes on very different forms for the geographer, the economist, the planner, the engineer and the sociologist. In turn each of these conceptions has very different implications for national and local governments, property developers, investors and citizens.

The different conceptualisations of the city reflect two fundamentally different kinds of knowledge represented by the natural sciences and the humanities. These are developed by Rayner and Malone[1] as the *descriptive paradigm* and the *interpretive paradigm*, which sit uneasily alongside each other in the social sciences. For example, approaches to modelling the behaviour of demographic and economic systems describe the stocks and flows of (usually) tangible elements, such as people and money. These models are essentially indistinguishable from those employed to model changes in physical systems. On this side, social science blends seamlessly with natural science. On the other side, interpretive social science concerns itself with understanding subjective experience, meanings and motivations ultimately merge into the humanities' focus on ethics and the narratives that people use to make sense of their experience.

At their best, the fields of planning and design attempt to reconcile these perspectives. Planners and designers can take many kinds of data and find coherent meanings that can be used to devise arrangements to address policy problems. Case study evidence can be used to supplement statistical data or suggest promising lines of quantitative research.

Some fields, such as regional studies and urban studies, have an honourable history of interdisciplinary research reflected in their journals and learned societies. But such efforts are often frustrated by the commitments of other specialist practitioners to their disciplinary perspectives and accompanying convictions about how the world works and how it ought to work.

The UK Research Councils, themselves siloed into seven sets of disciplines, have recognised the need for research to work seamlessly across disciplines and their funding of Sustainable Urban Environments and Climate Change programmes – and currently the ESRC Urban Transformations Programme – have developed a UK capability in effective cross-disciplinary research, as well as tools and methodologies focused on city systems. These are important but still isolated examples of how things might be done.

So the emerging science of cities must build an interdisciplinary framework that draws on the insights of a very wide variety of different approaches at multiple scales to produce knowledge that can be acted upon by diverse users.

This is crucial for articulating challenges, then evaluating plans, creating solutions and devising enabling policies – the combined responses to challenges. The

plans, solutions and policies have to be invented – in broad terms, conceived and designed – and at the heart of this process lies analysis and imagination, the keys to problem-solving. The invention part of the agenda is a research area in its own right, and relative to analysis is under-developed.

We have argued the importance of interdependence and it is helpful to illustrate this. Market-led spatial economic models can only be effectively translated into national policy when local contexts are taken into account. And vice versa: national policies should be formulated in such a way that they will be adaptable when applied locally. An understanding of the range of subjective experiences, values and citizen aspirations can assist with harnessing motivations and levers for behavioural change other than as a response to price signals or legislation, for example when considering the sharing economy and improved health and well-being.

A focus on scenario development can be an aid to liaison between communities, those who serve them and those who govern them, and crucially to the co-production of knowledge for the possibilities of future development. The key to success here is collaboration around co-created visions of a city's future synthesised into a 'city narrative'[2].

Infrastructure systems have traditionally been conceived and designed with a single purpose in mind (moving water, energy, waste, people), whereas a synthesis of these flows in cities would make many city systems far more effective and efficient. New city administrators emerging from current devolution initiatives have the chance to learn from a variety of scientific traditions. This has been facilitated through the project's workshops and City Visions Network.

In our work, we have been concerned throughout to be evidence-based, or in a broad sense, science-based. The following sections indicate what we have learned from our commissioned working papers and many other information sources, which illustrate different approaches. In almost all cases authors of the working papers have offered a historical analysis and explored the future in terms of scenarios or policy options. The detail is presented in the Future of Cities project's final report *Future of Cities: An Overview of the Evidence*.

All of this falls within our broad perspective on science. It also begins to point towards a crucial issue: the need for a science that can chart the means of development and consequences of policy options. Some of this exists[3], but there is a demand for further research.

A brief summary follows of the current state of the science. Then in part 2 we reflect on what we would like to know, and explore research priorities. We have avoided being bogged down in the semantics of 'what is a city' and 'what is a future city'. A variety of perspectives on these concepts is presented in *What are Future Cities?* by Moir, Moonen and Clark[4].

Living in cities

People live, work and play in cities and in different ways, determined by the workings of cities which provide the foundations for their life experience. So our knowledge base should be people-centred.

There is at least some basic science in place. Anthropology, through interpretive social science, provides an understanding of the experience of living in cities, political science of the varieties of governance. Demography is highly developed, and can describe and predict the evolution of populations based on birth, death and migration rates – though each of these raise research challenges, particularly migration. Economists offer a different kind of insight on the experience of living in cities by using the concepts of individual and household utility functions. Geography emphasises the spatial dimension: where people live in cities, how they use services, what this means for their travel behaviour, spatial responses to governance and politics.

Together, these perspectives let us assemble an evidence base that helps the understanding of challenges, present and future. How many people will live in cities? What will the age distribution be? How can we articulate the much-discussed social disparities? What do these numbers mean for housing – pressures, prices, affordability? A critical element of the geography is accessibility to jobs, education, health services, retail, other services, leisure. But while this knowledge base is rich, it is also fragmented between disciplines.

Much of what we know is captured in four of our working papers and their associated bibliographies: *Living in the City*[5]; *People in Cities: The Numbers*[6]; *Cities: The Cultural Dimension*[7] and *Coping with Change*[8].

Urban economies

We have a good level of understanding of urban economies at different scales[9]. Our knowledge base provides evidence for the performance of different kinds of cities; the growth of the knowledge economy; the productivity challenge; skills deficits; the delivery of services, present and future; the roles of colleges and universities in relation to high-level skills; the costs – capital and revenue – of different kinds of urban development – public and private.

We now live in a world in which rapid change is the norm, rather than the exception. City economies are subject to more or less constant challenges and shocks in terms of the rise of new competitors, new markets, and new technologies. As Schumpeter argued, “the fundamental impulse that sets and keeps the capitalist engine in motion comes from the new consumers, goods, the new methods of production or transportation, the new markets, the new forms of industrial organisation that capitalist enterprise creates”. His notion of

"creative destruction" to capture this process arguably has more salience today than when he coined it. The implication for cities is that they will need to be adaptive economically, able to adjust to ever-shifting conditions and opportunities, and resilient in having the economic structures, institutional arrangements, and governance mechanisms that reduce their vulnerability to, and recoverability from, major shocks and disruptions.

The evidence suggests that UK cities have varied a lot in their adaptability, for example from the industrial economy to the new, post-industrial knowledge based economy. This has been a major factor behind their divergent growth paths over the past thirty years or so. City economies are complex adaptive systems, but not all cities are equally adaptable. Increasing the adaptability and resilience of UK cities, especially northern cities, will be a key policy issue.

There is a major debate within economic geography and regional studies over how to do this, and what will be the economic roles of UK cities over the coming decades. Some argue that cities should become more specialised, since that would raise their productivity and innovation. Others argue that a diversified economic base is the best strategy for maximising adaptability and resilience; and there are various academic positions in between.

The skill base of cities – and their ability to attract and retain educated, enterprising workers – will be crucial[10]. Skilled and educated labour raise the productivity and innovation propensity of cities. The future importance of skills will derive from their *transferability*, which in turn aids and promotes economic adaptability.

Another contentious issue is agglomeration. We know that large cities tend to have higher levels of productivity. But we also know that the fastest *growth* in productivity is often observed in smaller and medium sized cities. There is no doubt that agglomeration confers a range of positive effects and benefits, but empirical findings from the USA, the UK[9] and Europe suggests that it is the second and third tier cities that are often the current growth leaders. So an issue for the future is whether to promote a few large cities, or to focus on a larger number of smaller cities, possibly linked into wider functional regional economic systems. Large cities such as London tend to have higher costs for land, housing and labour; and ever-larger expenditure on infrastructure may be needed to maintain their efficient functioning. Our current models of city economies do not sufficiently take into account the downsides of ever-increasing agglomeration.

Urban metabolism

We understand a lot about urban metabolism: about flows of energy, water, waste and people, about the natural and man-made materials that make up our cities and about the serious issues of resource depletion and pollution generation. The science of climate change tells us of the potential impacts of rising temperature and new weather patterns on different kinds of cities in different ways. There

is also a good understanding of, and a strongly growing awareness of, the importance of ecosystem service provision in cities, and of the potential benefits of exploiting ecosystem services in a more systematic manner.

The science of cities points to the many interdependencies between these societal and natural systems and the potential consequences of contextual change. – For example, it is evident that aspects of new urban development, combined with the impacts of a changing climate, can increase risks from soil degradation, flooding, storm damage, heat and drought and transport congestion, while air pollution and waste generation continue at unacceptable levels. These challenges span academic and professional disciplines and need an integrated whole-system approach in which effective working across all these disciplines occurs seamlessly.

Programmes run by Research Councils UK (such as Resilience to a Changing Climate[11]) have developed an effective cross-disciplinary research capability, as well as many tools and methodologies to enable city systems to become more sustainable and resilient. These provide an excellent baseline from which to advance towards these broader goals. More recent research into smart and liveable cities is helping to augment the science base, and, combined with the rapid pace of contextual change, the science of cities landscape and its influence on city systems is developing at an unparalleled pace.

Defining the urban metabolism of a city provides necessary evidence to calculate greenhouse gas emissions and other planetary damage. It also provides measures of resource use and efficiency, and assessment tools and strategies to guide urban and industrial development towards environmental sustainability.

Moreover there is an established relationship between urban metabolism and GDP, although there is substantial variation in the data which can be explained by factors such as climate effects, urban design and carbon intensity of electricity.

It is clear from the evidence that if we are to progress towards more sustainable, resilient and liveable future, both citizen behaviour change and technological developments are necessary – reliance on technology alone will almost certainly prove ineffective[12].

A city’s carbon footprint is materially influenced by emissions associated with household consumption that occur beyond the city boundary and these are important if we are to gain an accurate picture. Carbon footprint calculations have been made based on a few studies of the urban metabolism of UK cities, and footprints have been established for UK regions based on household consumption surveys, and these have demonstrated the need to take a life-cycle (cradle to grave) perspective when assessing the environmental impact of cities. These provide valuable leads, whereas the many ecological footprint studies of UK cities and towns are considered to be of poor scientific quality.

The above arguments hold true for all essential resources and need to be both translated throughout the systems in question and projected forward via modelling or scenarios.

Taking water as an example, the cities of the future will face a range of challenges in meeting fundamental needs of water supply, wastewater treatment and drainage, and also in safeguarding water's many indirect benefits in spheres such as health, wellbeing and biodiversity. Moreover, these goals need to be achieved while protecting the wider environment and ensuring cities' resilience against extreme events such as flooding[13].

The key papers here are *Urban Metabolism: A review in the UK context*[14] and *The future of the urban environment and ecosystem services in the UK*[15] as well as the work of the Infrastructure Transitions Research Consortium.

Urban Form

We can provide an excellent historical understanding of how urban form in the UK has evolved, largely following compact city principles. The UK's cities have been shaped by the legacy of development in the post-war period, while subsequently settlement patterns have evolved in relation to investments in infrastructure (for transport, energy, water, waste, ICT, health and education). This has resulted in a number of development patterns – compact and contained established towns and cities; edge and out-of-town developments; peripheral housing estates and urban extensions; newer settlements; dispersed developments – all with positive and negative consequences. Emerging approaches to the governance of urban form and infrastructure have potential lessons for UK city development in the face of challenges and uncertainties related to climate change, economic instability, and demographic and social shifts. A number of conditions necessary for the effective delivery and management of urban form and infrastructure looking forward to 2065 are now understood. However, it is clear also that some fundamental changes are needed if the UK is going to be able to meet the challenges it will face by 2065, both in how to shape existing places and how to provide new development.

A Visual History of the Future[16] complements these ideas with a range of graphically arresting visions of future urban form envisaged in the past.

The theory of land use is a critical part of the underlying science. It connects housing, industry, utilities, services, offices, green space and urban infrastructure – especially transport structures as the basis of connectivity. Within these land-use patterns, increasing housing supply is a key challenge facing the UK, and according to Michael Edwards[17] it is a challenge that needs to be reframed. He argues for a greater understanding of the complex interplay between tax regimes, investment flows, wealth creation including intergenerational equity transfers, and land policies. This exemplifies the need for an interdisciplinary and

interprofessional approach to such complex problems and the advantages of taking a long-term view[18]. More broadly, we can use this knowledge to provide evidence for the performance of different kinds of urban form. But the extent to which idealised forms can be realised depends on another set of factors including land ownership, viability, regulatory frameworks and societal attitudes to increasing densities.

Considering natural and built environments is important. While surface considerations (such as topography, proximity to the coast and effects of sea-level rise) are usually evident, the influence of the subsurface is less so. While ground conditions rarely prohibit development entirely they do introduce material planning considerations including flood risk, development of contaminated land, capacity of subsurface infrastructure, incompatible or unacceptable use (which extends to land stability and shallow geological hazards) and implementation of sustainable drainage systems. Data sets on geo-hazards and difficult ground conditions have been developed by the British Geological Survey and others. These maps and tools allow potentially difficult ground conditions to be identified and mitigated, but although they are widely accessible, they are not necessarily well understood.

Urban infrastructure

We live in cities supported by ‘hard’ and ‘soft’ infrastructure systems.

Hard infrastructure systems include those that deliver our essential resources such as food, water and power, remove waste, and move people, raw materials and manufactured goods. This also includes the built environment more broadly, including housing, offices, factories, retail buildings, hospitals and schools.

Soft infrastructure includes service delivery systems such as health care.

While there are good models of the workings of all these systems in terms of demands and uses, albeit in disconnected silos, there are future uncertainties such as the distribution of population growth, costs of infrastructure service provision, and imbalances in spatial distribution.

Modern city infrastructure must be robust, resilient and adaptable – particularly to natural disasters and climate change – and optimised in terms of efficiency, cost, low carbon footprint and service quality. It can do this by being ‘smart’, exploiting emerging technologies in sensor and data management such as wireless sensor networks, computer vision and energy harvesting. These new technologies can revolutionize the construction and management of city infrastructure, while also being applied to advanced monitoring of existing critical infrastructure assets to quantify and define the extent of their ageing and the remaining life. This would form part of a whole-life approach to achieving sustainability and resilience in construction and infrastructure design and

commissioning, the construction process, exploitation and use, and eventual de-commissioning.

Focusing on the materials from which infrastructure and the built environment will be made, the bulk materials mix in cities will not change significantly in the future. However, increased use of trace materials crucial for low-carbon technologies will expose cities to critical supply issues. Much of this material will never physically cross city boundaries and thus cities must be considered as nodes in a wider infrastructure network. For example, the rare-earth metals used in offshore wind farms are essential for supplying energy to cities, but never actually enter the city. The low-carbon and resource conservation agendas will also put pressure on supply and disposal of bulk materials. Reuse of components to recover function and urban mining must be given equal prominence to traditional materials recycling.

When posing the question “what will cities of the future be made of?”, there are two sets of materials to consider: the ‘fixed’ materials in the artefacts that make up a city (infrastructure and the built environment), and the materials in the products that circulate in a city (cars, clothes, consumer goods, etc.)[19]. The latter change much more rapidly in response to market or regulatory pressures and can be readily substituted if necessary, so it is the fixed materials that are of most concern – these make up the largest proportion by volume and are difficult to change. In this respect, the hinterlands and supporting/linking infrastructure of cities to the wider national and global scales should also be considered.

Urban governance

There are many alternative systems of governance across various interlocking scales[20 21]. That provides opportunities to broaden the role of the planning system, to connect to other arms of government and to offer a more integrated approach to urban development. A radical upgrade in the role of planners can promote creative, long-term thinking on urban sustainability and resilience, and enable more organic growth[2].

Our work provides evidence of trends to integrate knowledge across functions of national and local governments that have traditionally operated independently of one another. At the local level this can mean integrating across housing, transport and planning departments, as with the appointment of a Director of Futures in Bristol Council. These trends are also seen in the current position of the planning system; the structure of Whitehall policy agendas and the extent to which subsidiarity principles have been defined to support devolution.

There is also a growing appreciation that it is good to widen conversations beyond formal decision makers, and to embrace emergent policy solutions embodying the viewpoints of diverse stakeholders[8]. This way of inventing policies that meet apparently conflicting objectives also requires new kinds of leadership[22].

Preliminary conclusions

The themes represented in the preceding five headings are deeply interdependent, so it is important in foresighting work to link these themes and to build integrated overviews. This can be done by having an extensive toolkit available – as outlined in the Future of Cities project's *Foresight for Cities* report and proceeding in an interdisciplinary and interprofessional way. But it also presents a research challenge that we will develop in part 2 below.

The science base can be seen as a toolkit, with components that can be deployed in different combinations in different ways. For example, it can be used for identifying and articulating challenges such as the drivers of migration and future population forecasting; the possible sources of work and income for population groups; charting utility functions; and working out what must be done to achieve low-carbon targets. It can provide the means for evaluating alternative policies, plans and scenarios against politically-determined criteria.

However, much of the core science knowledge is fragmented – located in disciplinary silos. That makes it difficult to reconcile fundamentally different conceptualisations of the city that are found among diverse disciplines and professional perspectives. It may fall to planners, designers and policy makers to reconcile these differences, and to be explicit and transparent in how the knowledge based is used. This is a responsibility shared with the academic community. Transparency, as a basis for building trust in the planning and policy making process, demands the avoidance of jargon and black boxes.

Research priorities

Introduction

The science base sketched in part 1 provides a good starting point, but it is incomplete. There are many gaps and known challenges. It is urgent to research these challenges because there are potential benefits in the short term as well as the long term – for example in relation to housing needs, a rapidly evolving economy, sustainability and climate change, and the impact of global urbanisation.

There are two kinds of research here: 'research on' and 'research for'. Much academic research focuses on cities – their history, present and future possibilities – and often this is not seen to contribute directly to the needs of policy makers and planners. Then there is some, but far less, research performed for organisations that have responsibility for planning and policy development. Of course these two overlap. Very roughly, they correspond to core–knowledge-based research and practice-based research. For example, our working papers are focused on historical analysis – why we are where we are – and on scenario or policy options for the future.

The 'research on' agenda is to show how these scenarios and policy options can be explored systematically, and to be able to evaluate them and to explore the consequences of policies being adopted – this in the context of understanding interdependence (see section 2.2.1).

We begin, therefore, with a focus on interdependencies and offer an argument that much more extensive and comprehensive applied research provides a good platform for moving forward. We can then proceed by the Future of Cities themes, building on the analysis of what we know and the available evidence in part 1.

We need to bear in mind the 'research on' versus 'research for' distinction, and in each area below, we have a 'policy development needs' subheading that is in effect part of the 'research on' agenda. Indeed, the argument can be taken a step further: that some research might be co-produced – and hence be 'research with'.

Interdependencies and integration

The knowledge base sketched in part 1 is very fragmented. In some areas, there are competing and contested approaches; and applications have usually been very limited with many cities being seriously under-researched and analysed. So it is important to focus on interdependence at the outset.

We can approach this formally by adopting a systems perspective and then adding the information base and all relevant modes of analysis under the heading

of systems analytics. We have adopted two scales – the UK system and city systems – and at each scale, we have deployed six themes – people (living in cities), economies, metabolism, form, infrastructure systems and governance. Each theme commands its own systems analytics and indeed there will be further subdivisions forming a hierarchy of systems. The full handling of interdependence demands a holistic systems approach.

In approaching research priorities therefore, we can think of the two scales, a holistic systems analytic approach at each scale, and then the elements of this at lower levels in the hierarchy, starting with themes. The practical reality is that most research projects are related to low levels in the hierarchy and achieving synthesis to higher levels is a tough challenge.

We can then identify three potentially fruitful research areas.

Systems analytics for the UK system and for city systems

First it would be valuable to build a comprehensive and integrated programme of research and development using the existing toolkit. For selected cities, this would provide a formal analysis of past, present and directions of possible change. Some forecasting would be possible. Future scenarios could be explored based on alternative projections and alternative policy options and plans.

There are systematic ways of exploring and evaluating future scenarios – the basis of our third topic below. The current fragmentation of effort – from research analytics to the application of professional skills – would make this a substantial undertaking. In other words, there is a strong case for an investment that seeks to integrate sources of knowledge in the context of challenges faced by particular cities. This would have a substantial benefit in bringing the recognition of interdependencies to the fore and would also be an effective way of generating future research priorities.

This kind of research is potentially problematic for some academic communities. It is not easy to assemble resources on the scale needed; and it may be seen as ‘applied research’ – applying and integrating existing methods – which is perceived as of lower esteem than ‘blue skies’ research.

The architecture of information systems

Second, this process would be facilitated by a project to provide researchers and analysts with a common and comprehensive database – especially given the developing abundance of data. This is a non-trivial issue and there is scope for a research programme on the architecture of information systems for urban research, planning and forecasting. As a computer science challenge, this should be added to the developing agenda of the Turing Institute[24].

There are ethical arguments to be confronted. Can we find ways to present the data at the appropriate scale with confidentiality preserved where appropriate?

Policy options and future scenarios

Third, with a big picture in place it is possible to focus on policy options and future scenarios. There are three aspects to this process:

policy development – articulate objectives;

design – invent responses to challenges; and

testing – apply systems analytics to evaluate the alternatives.

This is challenging applied research. Exploring policy options and future scenarios allows cities to articulate the challenges facing them and develop priorities for addressing these challenges. Such a formulation builds on the best practice of local strategic partnership place-making and place shaping that characterised an earlier generation of local government reforms.

We now proceed to look at research challenges by theme. This will further expose interdependencies: should housing be located in ‘living in cities’, ‘economies’, ‘urban form’, ‘infrastructure’ or ‘governance’?

Living in cities in the future

Integration across disciplines

To provide actionable information to government, particularly local authorities, urban analysts need to integrate knowledge across disciplines and scales. As noted in part 1, this integration ranges from interpretive social science – finding the categories, for example, on cultural identities with a corresponding theoretical base – to modelling approaches which offer an account of numbers and pressures on employment, housing, services and transport. Both contribute to a major challenge relating to social disparities.

Better articulated and associated empirical research in micro-economics is needed on individual and household utility functions – live, work and play, constrained by income. More research is needed on the economics of micro-scale human behaviour and this would provide an opportunity to link economics to the interpretive social science agenda. Specifically, an integration of utility-based geo-economic knowledge with sociological and ethnographic approaches could be very fruitful and would strengthen existing models and evaluation practices.

We have the elements of knowledge here, but exploration and integration through interdisciplinary teams is a preliminary research challenge. There are many specific challenges which need to be explored in the wider context – for example, the impact of ageing in some cities where this has high potential impact. The knowledge base required ranges, from relating the experience of ageing and associated accommodation and service requirements, to understanding the present numbers and current trends.

Longitudinal data – partly as a basis for plan evaluation

There has been a massive investment in building longitudinal databases, notably by the Economic and Social Research Council. However, there is a concern in the social science research community that this needs to be deepened in a way that would enable the evaluation of the impacts of inner city regeneration schemes and to encompass a much wider view of the practices of urban living embracing leisure, holidays, hobbies, politics and friendship for example beyond the usual surveys of employment paths. Much social data has administrative or commercial sources and it would be valuable, with appropriate anonymising, to make more of this available to researchers.

The future of services

Technology can and does change the way we live, for example in the exponential growth of the digital world. This will affect how services can be delivered in the future – a field that is as much about design and soft engineering as it is about traditional science.

A component of this is how services can be paid for. In a future world robotics will probably provide many of the functions formerly performed by unskilled or semi-skilled labour. Will new forms of labour emerge to ensure that people have the income to pay for services?

The research challenges here are demanding – requiring combinations of new forms of data and technological and behavioural change. There is a research base on which to build, embracing demonstration projects and pilot projects.

Home building and social disparities

Research into policy invention involves finding alternative ways of tackling challenges, and future research into analysing and evaluating the consequences of implementing policies could help further inform policy development. Priority areas include research into increasing both social cohesion and the rate at which homes are built in cities, both of which are linked to place-making and access to jobs, services and sustainable transport. For example, research into increasing the rate of home building might involve exploring alternative forms of housing development at a variety of densities.

Urban economies: why do cities differ so much in economic performance and success?

The economics of growth and decline

- Why do cities have such variable success in achieving adaptive and transformative growth? Is it differences in human capital, agglomeration economies or governance structures?
- How is the pattern of city growth influenced by our centralised political economy?
- To what extent will the legacies of history shape future developments?
- How will technological change shape city economies and their differential performance?
- How do UK cities fit into the global economy?
- Perhaps above all, do we need an explicit understanding of city productivity?

This series of inter-linked questions constitute a major research undertaking.

UK inter-city flows data

Explicitly charting money flows would help to provide a fuller understanding of the interlocking nature of the generation of income and its expenditure. This could include an urban version of a social accounts matrix and be carried out at various scales, from the national level to the neighbourhood level. This is an example of the methods being available, but the topic not being pursued for lack of data.

What could a future urban economy look like?

At the city-systems scale, in-depth charting of a knowledge and core services economy for different kinds of cities could be used to: examine the consequences of possible hollowing out; explore methods to accelerate growth of knowledge-intensive industries and improve productivity; and to ask whether colleges and universities offer more direct contributions to urban economic development. The development of spin-out companies and the co-location of activities on science parks partly meet the latter of these, and the co-production of knowledge-intensive economic activity could be taken further with university-owned bolt-ons with equity funding.

Land and housing markets

The structure of urban living is underpinned by land values. The prices of land and the costs of development determine where people with different incomes can live and access work, services and leisure. There is a considerable amount of

research in this area, which needs to be brought to bear on policy development: for example on the matter of capture for public investment of increases in land value when land is developed, particularly when the increase is supported by public investment.

Urban metabolism: what will a sustainable future look like?

An integrated systems metabolism of UK cities

This is another theme where an integration priority is important. There is a need to explicitly chart the full metabolism of the UK's cities, making evident the interdependencies between the multiple systems and how their synthesis might be brought about.

Only a few city and regional studies have supported carbon footprint calculations, while ecological footprint studies have poor scientific credibility. This is an inadequate base from which to advance. Rigorous life-cycle analyses, such as the application of input-output models, are required to assess the environmental impact of the UK's cities alongside the relationship with citizen wellbeing, and these need to be integrated to help understand the consequences for the UK's system of cities. These analyses should embrace uncertainties and consider the consequences of technological, social and policy innovations.

City systems are influenced by their supporting infrastructure, relying on energy, water, ICT and other 'material feeds' to operate, yielding another dimension of system interdependency. A holistic analysis of energy generation, transmission, consumption and waste in cities could yield major insights and opportunities for beneficial change. Potentially transformative research challenges include translating this thinking to water and other material resources, and to data flows (such as shifts from wired to wireless operations), all linked to citizen and planetary health and wellbeing.

To maximise ecosystem service provision, one priority is to synthesise green infrastructure with the blue (natural water), the grey (built environment), utility services (electricity, gas, water, sewerage, drainage, solid waste) and transport infrastructure – particularly in relation to issues of soil degradation, flooding, storm damage, heat, drought, congestion, pollution and excessive waste generation. This should become a key element of strategic city planning.

Integrated systems for industrial ecology, or industrial symbiosis, are already making progress, and through eco-design and eco-investment are slowly gaining ground, but more research is needed into methodologies, guidance and toolkits to enable this transformation. This kind of research programme should be complemented by research on the human use of utilities and related structures, in part to investigate the possibilities of behaviour change as a contribution to the sustainability agenda.

Metabolism scenarios

To shape far-future visioning processes, strategic planning and policy development, a second synthesising project is to establish what a sustainable, resilient and liveable city would look like. This provides target end states from which it is possible to cast back to the present to explore the barriers to achieving them. The Foresight FoC project has employed many, and developed new, methods for foresighting and far-future scenario creation, and these need to be tested in depth to provide an evidence base on which cities can build when doing their own foresighting work.

Economics of metabolism

Providing an 'economic lens' to this argument is potentially powerful in terms of research challenges, and can help better understand the relationship between the urban metabolism and the GDP of cities.

Ecosystem service provision

Although there is a good understanding of ecosystem service provision in cities, there is a poor understanding of how effectively these services are consumed by individuals in their daily lives (that is, how and when they are consumed), and of the equity of ecosystem service provision among different cohorts of city dwellers. Considering ecosystem service enhancement, there are significant opportunities in community green space, food cultivation, and benefits in health, education and local enterprise. Meanwhile creative adaptation to climate change is a relatively new agenda for the interactions of humans and ecosystems.

In response to the trend towards privatisation and enclosure of public and 'ecosystem service' space, creative forms of governance are needed to deliver new systems of access, stewardship and investment for such spaces. The ultimate ambition is for cities to become net generators of ecosystem services.

Water

Each of the essential resource systems that support life in cities has its own challenges. The Foresight team has engaged with the water sector in detail to exemplify the issues, so that the consequent learning can be translated to the other sectors.

Key to meeting these challenges is the development of a clear picture of the many ways in which use, needs and resilience challenges could be met. Transformative ideas for water, for example, include rethinking the concept of the catchment for water supplied to cities, encouraging the creation of resilient defence communities and introducing multiple means of temporary local storage and citizen behaviours to smooth out the peakiness of consumption in the context of changing weather patterns, thus bringing the city's behaviour into harmony with natural variation[13].

Urban form: how to create better places

Citizen needs and alternative urban forms

Urban form – land-use patterns, densities, and the associated infrastructure – are key elements of the future of cities. To accommodate a growing population, the UK will need to develop new places and reshape existing urban areas. Research can assist in giving greater understanding of the demands of different groups within society, from the aspirations of young professionals for city centre living to the needs of the growing numbers of frail elderly for different forms of assisted accommodation. There are challenges to providing high-quality housing in sufficient quantity and of sufficient variety within our market economy.

Place-making

Many of the ingredients of good place making are well understood, and yet there are serious barriers to successful delivery. It is necessary to explore the range of opportunities whether through urban intensification, restructuring edge of town retail areas, retrofitting existing stock, reallocating road space, exploiting underground space, or creating new public realm. What new forms of partnership structure might break the mould of traditional house-building models? What national legislative changes would be needed for them to use different forms of land value capture?

Connectivity and urban form – UK and city systems

This needs to be accompanied by a clearer logic around the connectivity (physical and virtual) of settlements and their hinterlands, and the relationship of future development patterns with infrastructure supply and demand. A more strategic, long-term focus for urban form and infrastructure is needed to deliver more certainty and stability in planning and development systems, along with a clearer vision for infrastructure planning. Important research questions are: how to develop successful urban places around transport nodes; how to connect public transport with walking and cycling modes (and establish the associated health benefits); how to value transport investments in terms of economic, social and environmental benefits.

Transformations for sustainability

Significant investment in long-term programmes of retrofitting, upgrading and remodelling existing urban areas and infrastructure requires a new understanding of how such transformative work aligns with the sustainability, resilience, liveability and smart agendas in cities, if it is ultimately to meet cities' and citizens' aspirations. The UK's current piecemeal and under-resourced response is unlikely to address future challenges effectively.

City region functions and subsurface planning

Policy development could be aided by the effective creation of local spatial strategies, building capacity and capability as required, to provide a balance between the built and natural environments in cities and surface and subsurface development.

Future urban form will be influenced by ever widening activity patterns arising, among other things, from the knowledge economy and new forms of agile working. Hence we may anticipate the growing importance of city regions, not just those centred on a dominant city, but also more dynamic multi-centred networks of cities. Research has an opportunity to provide new insights into how such polycentric city-regions function, including through spatial density modelling, to evaluate different options for the location of new development based on a network-based logic related to connectivity. This would include exploring the costs of possible futures on some assumed economic base, and articulating the costs of different kinds of development in different parts of the city or city region – housing, buildings for organisations, transport modes.

There are, of course, different ways of defining city regions. It will often make sense to include the second and third tier cities that connect strongly to the first tier city. The Greater Manchester Combined Authority provides an example. There may be examples where the central city provides a greater than proportionate share of employment growth and the lower tier cities, a greater share of housing growth. This has implications for the growth of public transport within the region, bearing in mind the sustainability challenges for the longer run. The integrated systems analytics argument of section 10 then applies to this wider scale of city region.

There is a subsidiary but important question to add to this: how to make best use of the subsurface to support urban development; and the need for new forms of underground space governance. There is a need to identify and quantify the ecosystem service benefits that the ground can provide to cities as they develop[24]. We need to understand the geo-systems that operate below the urban environment, their value to cities, their interactions with each other and with urban form and infrastructure, and how the subsurface evolves when considered as a single system.

Urban infrastructure: how to be smart for the long run

Infrastructure systems and urban form

With rising demands for and costs of utilities and transport systems, new intelligence is required about the interdependencies between urban form and infrastructure – especially in light of vulnerabilities related to peak load, climate change, and demographic change.

Part of the solution is investment in new, smart infrastructure. The hierarchies of transport systems are particularly important. High speed rail could facilitate the rebalancing of the economy for the Greater South East and further gains could be made by integrating high speed, conventional rail and other modes of public transport, and their relative investment needs. There are research opportunities in exploring how to achieve this: better planning and accelerating training and labour supply in construction to facilitate investment delivery for example.

Smart cities

There is a case for using sensing and data analysis to enable smarter, proactive asset management decision-making for city infrastructure. Being proactive enables preventive maintenance, and it is essential to capture and analyse the right data at the right time for city asset management decisions to be effective. The data needs should be defined by appropriately-designed decision-support systems, which must be responsive to all stakeholder needs and to change of whatever kind (environmental or social context, technical developments). These data should then feed into a rationalisation of design approaches for civil engineering structures, buildings and infrastructure, based on actual observed performance. This will be of direct economic benefit to city infrastructure, leading to more efficient designs, reduced material requirements and faster construction.

Materials

The engineering, management, maintenance and upgrading of city infrastructure requires fresh thinking to minimise use of materials, energy and labour while ensuring resilience. Such synthesis of understanding, sensor technologies and data management remains an important research challenge.

There is a need to align the intended benefits of the regulators of infrastructure service providers so that they combine to deliver the best overall outcome for citizens rather than focusing solely on the delivery of benefits from the single infrastructure system under consideration. Alignment is equally needed between the many custodians of the subsurface (local authorities, private landowners, regulators, utility service providers) to avoid a disconnect in governance and planning.

There is also a need to develop a framework for assessing criticality of materials in urban development. This would allow planners to judge the risks associated

with policy decisions in terms of vulnerability to critical materials supply. Allied to this, bottom-up CO2 assessments for design purposes would facilitate far better environmental stewardship, since current top-down post-facto Life Cycle Assessment analyses offer little guidance to designers when selecting materials for low-carbon infrastructure.

Physical infrastructure facilitates a city's urban metabolism, and depends on the functions that the metabolism effects – form follows function – while the urban form is similarly influenced by these considerations, exemplifying again the need for understanding of the interdependencies between city systems.

The manner in which this growing population is accommodated in UK's cities will govern the nature and geographical location of enhanced infrastructure provision – whether concentrated in London and the greater southeast, the major cities, the 64 primary urban areas, the ring encompassing the Midlands and the north, or otherwise. So infrastructure provision must be responsive and adaptable, which requires a revolutionary movement away from the current paradigm of infrastructure provision that either fixes patterns of behaviour for decades or becomes ineffective in supporting city systems and/or city connectivity.

Policy development needs include recognition of the interdependencies between the goals of infrastructure systems in and between cities, as well as the delivery of services that they support, and how these might be realised using smart systems that deliver social and economic benefits while mitigating concerns around resource security and environmental harm.

The breadth of the research agenda

As well as emphasising the engineering and systems analytics elements of the research agenda on infrastructure, we should point to the importance of an integrated social science contribution to financing and planning, legal frameworks and developmental control; and of following through the connections to public health, life expectancy and the sustainability agenda.

Urban governance

Multi-disciplinary perspectives

Governance systems within cities, as well as between cities and other tiers of government, are growing themes within political science, sociology, economic geography, organisational theory/management science and decision science. There is an increasing interplay between the work undertaken at business and management schools that addresses leadership and governance of organisations, and wider work led by geographers, economists, and political scientists that addresses the management and organisation of cities.

Several strands of investigation emerge from this cross-discipline current convergence on city governance.

The first concerns the efficiency and effectiveness of different city governance systems. As cities have re-emerged in the developed world, and emerged rapidly in the developing world, concern that cities should be well managed, well-led, and well governed has become a key preoccupation of both national and state governments and the academic community. Efficiency and effectiveness decisions could take into account the organisation of cities, with a focus on the tiers and departments of governments. They and also seek to address the spatial integrative considerations that lie at the heart of systems thinking, both cities as systems of systems, and cities as nodes within systems of cities.

Investigating costs and benefits of alternative governance models for cities is a primary focus alongside consideration of value for money of local services. Two key observations from most work in this field are the crowded and complex nature of public governance systems when applied to public policy issues that have specific local dimensions; and, especially in relation to cities, the problematic fit between complex and dynamic locations where concentrated processes are at play, and the responsiveness of a mosaic of governance bodies that have widely varying spatial and sectoral responsibilities.

The second strand is how to optimise the participation of citizens in city decision-making. Political science and sociology find that within the same national system widely different levels of political participation might happen at the local level, and different national systems appear to give rise to different levels of participation. This leads to assessments of the desirability of different systems and the ability of such system to recruit and engage an active citizenry, and to evaluations of different means to enhance citizen involvement such as consultation, citizen budgets, shadow councils, and other processes. This strand of enquiry often examines how far specific groups of citizens engage in, and are served by, city governance – using age, gender, income, race and ethnicity, and locational segments to explore participation and exclusion.

The third concerns fiscal systems and investment. Economists and public finance researchers consider how well and how far cities are able to align investment capital for infrastructure, and revenue finance for services, with reasonable assessments of needs of citizens and other stakeholders in cities, now and in the future. These enquiries consider not just absolute rates of taxation, investment, and expenditure but also the different roles of distinct tiers of governments raising revenues and investing capital, the distributional effects of such systems, and alternative means to raise revenues (user fees, dedicated levies and new taxes, for example) and other sources of investment capital (such as debt financing and PPPs).

Within the overall governance enquiry are comparative study elements. A growing series of international comparative studies on the advantages

and disadvantages of different city governance models are supported by inter-governmental organisations such as the Organisation for Economic Cooperation and Development, United Nations, World Bank, European Union and others. These are perceived to provide helpful comparative assessments to guide reform processes within nations. Then there are many emerging inter-sectoral studies and observations that pursue comparative governance assessment between cities and other complex institutional frameworks such as these that exist in business sectors, national government sectors, and NGOs. These assessments tend towards observations about leadership models, decision making, strategic planning, and other approaches that are the subjects of management science.

From this kind of analysis, observations emerge about city leadership models and styles that draw upon scientific observations of business leaders and their effectiveness. Should city leaders be more like the CEOs of major firms, concentrating decision-making and building strategic cycles of change? Should cities seek to compete in the way that firms do? Will business tools such as branding really work for cities, and what adaptations will be required?

Set against this broad articulation of research priorities, we can identify a number of specific topics.

Functional city regions

To what extent are the geographical boundaries of cities functionally efficient? And what the implications are for both governance and possible reform? From different scientific perspectives come distinctive concerns that city boundaries are largely historic and do not reflect the functionality of cities in current social, economical, and ecological terms. This frequently leads to well-argued propositions that city boundaries should be expanded to encompass a broader geography of a ‘functional city’ (with the substantial institutional reforms required) or that cross border co-operation is an imperative if the functional (larger) city is to avoid costly co-ordination failures between neighbouring municipalities. This form of enquiry plays back into considerations about the flexibility and adaptability of cities. How can city governance arrangements be flexible to changing realities and continuously adapt?

Subsidiarity

At a national scale, the research challenge is to explore the relationships between cities and the state, building on such concepts as legitimacy and inclusiveness. The flows of, and responsibilities for, finance are critical to this. In the context of increasing devolution of powers, a particular research challenge is to articulate appropriate principles of subsidiarity – building on research on money flows referred to in section 1.3. Given the present variety of forms of local government in England, part of this research might be to build on the Centre for Cities paper on how to achieve unitary authorities[25].

Leadership

There is a need for a system that creates inspirational local leadership elected on the basis of an ability to respond to future challenges. Local government leaders in turn need to be empowered by a balanced degree of devolution of power from national government, an ability to raise finances locally, and structures that enable effective cooperation with organisations beyond the city's boundaries (regional, national and global)[26].

To bring this about, there is a need for research into new forms of governance. Allied to this, cities need financial and business models that allow them to experiment, enable them to invest for the long-term, and facilitate the capture of economic, social and environmental returns on investment[26]. The considerable existing research into sustainability assessment frameworks needs to be reinterpreted in terms of economic, social and environmental value, and then captured in alternative business models (extending the argument in section 13 above) that allow new forms and sources of investment.

Capability for foresighting

There is great benefit to be had from exploring how local government can gain the capabilities to connect to this kind of research programme. However, the practical dimension must be considered when enabling capacity-building. Importantly, this must take into account the economic resources of local authorities. A list of the organisations that need a science base and the professions that can contribute could be used to could help identify and target resources, and build capacity through new forms of engagement that connect cities and universities – examples of which are already being seen. In some cases, this might be facilitated by an appropriate brokerage role.

Here, applied and translational research is needed to understand how to offer foresighting tools to local authorities, and the challenge is in ensuring this is integrated and interprofessional.

Adaptability

Research is needed to show how infrastructure systems can be nimble and adaptive in relation to changing societal needs. What are the alternative business models that could capture social, environmental and economic benefits?

To drive research forward, we need to ensure that there are skills and capabilities available both to do the research and to apply it – and articulating and identifying ways of responding to this challenge is a research task in itself. There are particular needs for skills in interdisciplinary and interprofessional practice and in spatial practice. It is recommended that there should be a radical upgrade in the role of planners to promote creative, long-term, thinking on urban sustainability and resilience, and to enable more organic growth within that strategic framework[26]. In this role planners should act as integrators of urban practitioners and other urban stakeholders, drawing on the skill development proposed above.

Policy needs include articulating the principles of subsidiarity as above; exploring the possible forms of local government particularly in relation to city regions, regions of cities and counties as 'distributed cities'; enabling citizens to co-create their city visions and help deliver them; facilitating the introduction of alternative, holistic business models for city investments; and reinventing and empowering the role of planners as convenors of city professionals.

International

In this paper, we have focused very much on the UK. There are two aspects of an international dimension that need further consideration. First, there is a high level of interest in the future of cities around the world and it will be an important element of UK research to be aware of, and to deploy where appropriate, the knowledge that can be gained from this experience. Secondly, we are aware of the significant volume of research internationally. Innovation centres, urban labs and city observatories are being trialled in many parts of the world. As the UK research programme develops, it should be fully connected to these endeavours.

Concluding comment: the delivery of urban research

One question that stands out from the governance agenda is: what structures are needed to deliver urban research effectively? Today, research funding is spread among a range of institutions each of which has its own objectives. Discovery research is the business of the seven UK research councils, and the European Research Council. Translational or applied research is the business of Innovate UK and the Future Cities Catapult, as they seek to stimulate the contribution of UK industry to the agenda. Industry itself can contribute. We can then add the universities, as contributors to the funders' portfolios and using their own resources; and foundations and trusts such as Nuffield and Rowntree. There are specialist contributions from other Catapults and through the Alan Turing Institute for Data Science. Government, particularly central, is a funder and can articulate its own objectives; and we should add learned and professional societies. The extent to which these different agents can deliver interdisciplinary and interprofessional programmes is a research study in itself.

It does not make sense to seek a grand coordination of urban research. Perhaps what could be more valuable from a Foresight perspective is the extent to which the research priorities articulated here (with much scope for their further development) can be met – not simply in terms of interdisciplinarity and interprofessionalism, but through partnerships generated by the needs of local communities, public services, and national and local governments. This will involve more emphasis on 'research for' rather than 'research on' for some fraction of the funding available – perhaps extended into collaborative, co-produced research ('research with').

Can we chart a forward path? Some possible steps follow:

(1) Invite funding agencies, universities and cities to review the research priorities presented here with a view to extending and refining the list and incorporating some of them in relation to their own objectives.

(2) Coordinate key funders and users under a grand-challenge umbrella. This could involve a few major city region demonstrators, used to articulate a baseline which would then provide the foundation for long-term policy development. A national government demonstrator could research challenges associated with the UK system of cities, such as the future distribution of population.

(3) Seek serious funding for this agenda. Such a portfolio of programmes would not be cheap but is potentially affordable by combining resources from different collaborating funding agencies under a grand-challenge umbrella. The domestic benefits of such a programme, as well as the potential for exportability, are likely to outweigh the costs.

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