# Cities of the Future

# Cambridge Forum
# for Sustainability
# and the Environment

## Cities of the Future Report
## 2017

# Cities of the Future

*"Sustainability tends to be polarised into considering either 'green' issues and efficiency or the 'human side' – vulnerability and equity – when in reality, all these dimensions need to be considered."*

JO DA SILVA
Arup International Development

*"If we are going to bring sustainability and humanity together in the long term, it is going to be important to include history, nature, health and wellbeing in our thinking as well as physical aspects of the environment as people need all of these to live rich, fulfilling, healthy, rewarding lives."*

DAME FIONA REYNOLDS
Master of Emmanuel College

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# Cities of the Future

In the future, cities will become increasingly important. In 2014, for the first time, more people lived in urban areas than in rural areas. This change has been rapid as in 1950, 30 per cent of the world's population was urban, and by 2050, 66% of people are predicted to be urban. UN projections show that urbanisation combined with the overall growth of the world's population could add another 2.5 billion people to urban populations by 2050, with close to 90 percent of the increase concentrated in Asia and Africa.

Such rapid growth creates tremendous opportunities and also tremendous challenges. The potential exists in cities for vibrant communities, long-term environmental sustainability, efficient transport and excellent infrastructure. At the same time, there is also the potential for ever-increasing pollution, urban sprawl, high-carbon lifestyles and waste of resources.

In the Forum's eight meetings between October 2013 and June 2014, a rich mixture of policy and decision makers from government and business, technical experts and researchers were invited to be expert witnesses and to provide their perspective on sustainable cities and the governance systems needed to support them.

Can we rethink how we design and live in cities in the future? How will cities adapt to the challenges facing them? Are there solutions which are not perfect but which are 'good enough' to put into practice?

Our aim is therefore to ask questions, not to answer them. In doing so, we hope that this will open up new research avenues for us all to explore in the future.

**Lord Martin Rees**
Chair

**Professor Paul Linden**
Director

*"Environmental sustainability is a cross-cutting multidisciplinary challenge that requires the input of minds from all fields to provide the expertise that will help society make responsible decisions for the future. The Forum's role is to provide the opportunity for stimulating these cross-disciplinary conversations."*

# Cambridge Forum for Sustainability and the Environment

The **Cambridge Forum for Sustainability and the Environment** was established in 2013 in the University of Cambridge to stimulate cross-disciplinary conversations about some of the great sustainability challenges the world faces in the future and the research pathways which will help to prepare for and address those challenges.

One of the Forum's aims is to bring people together who would not usually meet each other but who are working in areas which overlap enough to stimulate an interesting discussion. At any one time, the Forum has around 25 core members, drawn from 16 diverse departments, centres and institutions including Geography, Social Anthropology, Architecture, Engineering and History and Philosophy of Science as well as cross-departmental initiatives working on conservation, energy and global food security.

Professor Lord Martin Rees is the Forum's Chair and it is directed by Professor Paul Linden. Dr Rosamunde Almond is the Deputy Director, and in September 2016, Dr Konstantina Stamati joined as Head of Partnerships and Development.

The core activity of the Forum centres on monthly meetings between October and June. Each month, a panel of three expert 'witnesses', usually external to the University, are invited to help explore aspects of a particular area and provide their perspective on the gaps in knowledge and on the questions for future research. They are drawn from across and outside Cambridge and include researchers, policy and decision makers, representatives from businesses, from local government and previous witnesses who return to help question the expert panel. Each month, core Forum members and guests who work in the area under discussion are also invited to provide more specialised input.

The general theme of all the discussions is 'sustainability in an uncertain future' and specific topics change each academic year. Our first topic was 'sustainable cities' and in eight meetings between October 2013 and June 2014, 26 expert witnesses helped the Forum to explore different aspects of sustainable cities and to define the trajectory of research needed to meet these challenges.

This report uses the discussions during these eight Forum meetings and the testimonies of the witnesses to explore future research questions related to three areas: where we live, how we live in cities, and how cities respond to change. It presents these results as explorations of six overarching themes and a series of currently undefined research questions that are on the horizon and are likely to emerge as some of the most interesting intellectual challenges of the 21st century.

*"There is a potential to see cities as being a new opportunity, a crucible for new initiatives."*

PROFESSOR PETER GUTHRIE
Department of Engineering, University of Cambridge

# Introduction

**A rising population, increasing material expectations, conflicts, economic transitions and climatic changes are all reshaping how and where we live. So how do we respond?**

If societies are to be efficient, resilient and sustainable, we need to know where to place our energies to meet the challenges of the future. It is evident that there is no silver bullet. The solutions need to be multi-pronged and multi-disciplinary (or even trans-disciplinary) and incorporate disparate information. We also need an effective way to convey these solutions to decision makers.

Our first set of discussions on sustainable cities was designed to identify areas where current thinking is framing the problems of sustainable cities incorrectly or at least inadequately and unimaginatively. Different academic perspectives produce collisions that may shine some light to illuminate the 'unknown unknowns'. Thus, the Forum focussed on areas of knowledge and practice where there is not simply a dearth of data or models, but where society has not yet conceived the central problems with the clarity needed for effective research. Our discussions were not designed to review existing knowledge, to perform academic analyses and summaries of what is already known or to produce a 'gap analysis', since that kind of analysis assumes a landscape of knowledge that is simply missing a few pieces.

Our starting point for the discussions was *'How do we reconcile two views of sustainability concerning what it is like to live in a city: one focussed on environmental, conservation and ecological ideas and the other on ideas from the humanities and social sciences?'*

We started with three overarching issues – **where we live, how we live, and how we respond?** – that require both environmental and social perspectives. We divided these into six specific themes, which were posed to our expert witnesses. Each of these themes is framed by an overarching question and begins by posing three further questions for which answers are poorly developed at the moment. The gaps and the 'wicked problems' people identified during the Forum meetings are then used to explore future research pathways in more detail. Boxes provide specific examples given by the witnesses and Forum members. Each section then concludes with a succinct statement outlining 'The research challenge on the horizon'.

The testimonies of the witnesses and the conclusions drawn are necessarily qualitative and personal, as is the nature of such discussions at the edge of knowledge. They are built on the collective experience of the Forum's participants, framing questions in different ways. The aim of the Forum is to generate new questions, not to answer them. Our hope is therefore that this report will stimulate new conversations between the worlds of academia, policy and industry and bring fresh ideas and perspectives which will help to research, prepare for and address the challenges that cities face in the future.

# Six core research challenges

Over the course of the year, there was agreement that combining the social and environmental perspectives on sustainability is necessary if we are to create materially, socially and environmentally sustainable cities in which people lead healthy fulfilling lives and that co-exist in harmony with the local environment.

Our discussions identified six core challenges to current knowledge that will require not only new research, but also new research directions, new ways of conceptualising the challenges and a generation of scholars trained at the interface of environmental, economic and social sustainability.

1. **A global effort of comparative analysis to compare and contrast the performance of cities across an array of indicators.** Such a rich database would allow something akin to structural factors analysis to identify the aspects of size, form and design of cities that are most influential for these indicators, as well as the context within which the effects are expected.

2. **To improve our understanding of how the scale, location and design of green and blue spaces can deliver services to cities and to surrounding landscapes.** A mantra of 'the larger, the better' ignores pressures to create more housing and the impacts on land values.

3. **To create ICT (Information and Communication Technology) enabled sensor and data systems that improve sustainability** by both making significant changes to existing ways of collecting and analysing data and by mobilising social action based on those data.

4. **To enable smooth transitions between bottom-up and top-down decisions in governance**: allowing bottom-up solutions where they are effective and top-down solutions where they are needed.

5. **To design cities which can be utilised as living laboratories for experimentation:** identifying parts of the city where experiments can be conducted and which have systems to monitor and assess the results of the experiments and the governance structures that respond to the results.

6. **To establish a 'good enough' principle that is as robust as the precautionary principle**, which would involve specifying this concept precisely in terms of engineering, finance and planning and designing a system of monitoring 'good enough' solutions so when they fail, they do so with forewarning.

# Key questions frame the report

## Designing cities
How is the sustainability of a city influenced by the size, form and design of its buildings, infrastructure and services?

## Green spaces
How is the sustainability of a city and its surroundings affected by integrating ecosystem functions in green and blue 'natural urban spaces'?

## Smart cities
How will technology and data change the way we live in cities, how we govern them and the nature of our environmental impact?

## Governing cities
Which changes in cities will come from the top-down (e.g. central planning) and which from the bottom-up (e.g. social media or market forces)? How do they meet?

**WHERE WE LIVE**

**HOW WE LIVE**

**HOW WE RESPOND**

## A changing world
How will cities of the future adapt to the environmental, economic and social challenges facing them, so they avoid a downward spiral?

## Satisficing Solutions
Are there solutions to sustainability which are not perfect but which are 'good enough' to put into practice? What could we mean by 'good enough', and for whom?

# Designing cities

## How is the sustainability of a city influenced by the size, form and design of its buildings, infrastructure and services?

# At a glance

In 1990, there were only 10 cities with 10 million inhabitants or more. These so-called 'megacities' were home to 153 million people, representing less than 7% of the global urban population. In 2015, the number of megacities nearly tripled to 28 and they were home to 453 million people, accounting for about 12% of the world's urban dwellers; 16 of these cities are found in Asia, 4 in Latin America, 3 in Africa, 3 in Europe and 2 in North America. By 2030, the UN expects that there will be 41 megacities, and much of this growth will take place in the global South. For example in 2014, China had six megacities and ten large cities with populations between 5 and 10 million, and one more megacity and six large cities will be added by 2030.

The speed and scale of growth of these cities – and the sustainability problems they will encounter – provokes us to consider whether future cities (predominantly in developing countries) should follow the paths taken by existing cities. It must be considered whether future cities need an entirely new model of development and whether, in fact, cities in developed countries can learn lessons from those in developing countries.

# Key questions

**If a new model of development is required, how will it be defined? We identified three questions that require further research.**

- **Are bigger cities more environmentally sustainable and or better for the people who live there?**

- **Should we build outwards or upwards?**

- **Can infrastructure in large and diverse cities keep pace with the rate of change while continuing to provide essential services as populations grow, age and raise their standards of living?**

# Are bigger cities, better?

The way in which people view big cities has radically changed over the last 25 years. Once seen as dirty, dangerous places, giving rise to a 'flight to the suburbs', they are now thought of as places of opportunity and creativity, where people have higher incomes and expend less energy per capita. Edward Glaeser calls cities "our species' greatest invention, which will make us richer, smarter, greener, healthier and happier".

Proximity is claimed to make people more inventive, as bright minds feed off one another; more productive, as scale gives rise to finer degrees of specialisation; and more transport-efficient, as city-dwellers are more likely to travel on foot or by public transport and services are delivered by more efficient infrastructure. Part of this efficiency comes from the finding that the rate of growth of infrastructure is lower than the rate of growth of population, all while keeping service provision constant. This applies to all forms of infrastructure such as total road surface, length of electrical cables, water pipes or number of petrol stations. However, the increasing population density in cities also brings disadvantages such as congestion, overcrowding and social conflicts, which may impact negatively on health and wellbeing.

It is not clear how factors such as productivity, sustainability and social equality change with increasing city size. We therefore need to develop a 'dashboard' of indicators to help provide a snapshot of what is happening within a city, as well as a picture of how different aspects change over time. Which indicators are the best ones to represent the environmental and social sustainability of cities and what kinds of datasets could these be based on? Who would own the data, and how might they use them? Would these data – if available – show that bigger cities are more environmentally sustainable and better places for people to live and work in, or would they emphasise the disadvantages of excessive city size?

Diverse assemblages of species in nature are more resistant to change. Are cities more stable if they are more diverse? Are cities that are 'mosaics' of different spaces, developments, cultures and communities more resilient to shocks or long-term changes? Could this mixture also be important for the social sustainability of cities? If so, would the utility of a mosaic approach change with the size of a city; if so why, and in what way?

The answers to these questions may be entirely dependent on context, pointing one way in a city of central China but a different way in a Brazilian city. Despite this, it could be argued that an inevitable consequence of globalisation is that global megacities begin to resemble each other more than they do cities within their own country. Groupings of cities such as the C40 may reinforce these similarities. Are cities such as London, Paris, Shanghai and New York becoming more similar over time? Does this similarity mean they are less resilient or well-adapted to their unique surroundings or do their similarities allow them to share useful lessons?

# Linking infrastructure and social change

What binds a city together is the infrastructure that courses through it. If you want to intervene effectively at the social and physical level, a good starting point is the design and operation of infrastructure as it underlies everything a city does and everything a city is.

Radical re-imagining of infrastructure is difficult, even if the pace of social change suggests it is needed. The huge scale of infrastructure, and its costs, usually leads to a piecemeal approach to improvements, as small changes become affordable in ways that city-wide changes are not. This leads to incremental improvements but leaves the basic design unchanged.

London is a case in point. The city's population is now larger than it has ever been and is predicted to keep rising to nine million by 2020, 10 million by 2040 and maybe even 11 million by 2050. Current predictions indicate that between 40,000 and 50,000 new homes will be needed each year, which is double the number London has ever managed to build in a year (24,000) so there will need to be a sizable step change in house building to keep up with the demand. The creation of buildings requires the creation of supporting infrastructure, including both physical infrastructure such as drainage, water supplies and schools, and social infrastructure such as police and teachers.

Systems-level thinking is therefore going to be needed to answer questions about the performance of future infrastructure, and how that infrastructure will influence people's lives and their quality of life. This challenge gives rise to a number of questions. What infrastructure is needed to support the projected speed and scale of growth? How good is the current infrastructure and how can it be extended? How will people use it and how might their needs change in the future? How can this infrastructure be delivered into a regulated market which primarily responds to current needs rather than anticipating what might be needed in the future?

*"We should be planning and designing places for people to live rather than housing developments."*

PROFESSOR SIR ALAN WILSON
University College London and the Foresight Future of Cities Project

"*How do you not only grow the city in an environmentally sustainable way, but how do you also preserve a high quality of life for people living there?*"

MARK KLEINMAN
Greater London Authority

# Outwards or upwards?

Taller buildings obviously allow more people to be accommodated on a smaller land area. Height restrictions on buildings also restrict the supply of space, which pushes up the prices of housing and offices. However, much of the large multi-storey housing that dominated some UK cities in the 1960s and 1970s has been torn down, not just because of age but because this type of housing became the focus of crime and violence. They became unpleasant places to live, and so socially unsustainable.

Instead, eight to ten storey buildings are becoming increasingly common in Seoul, Beijing, Washington DC and the City of Westminster in London. It could be argued that these smaller buildings are at a more 'human scale' and make it easier for people to recognise their neighbours and form a community. However, even in the 'two-storey Britain' of terrace houses and flats, many people still do not interact with their neighbours. Are there alternative ways to design buildings or urban spaces to encourage strong social communities and does this depend on whether the buildings are upwards or outwards? The answer is anything but clear.

# The research challenge on the horizon

**What can we conclude about the relationship between sustainability and characteristics of size, form and design?**

In order to answer this question, it is vital to be able to add context and be able to understand and take into account the similarities and differences between cities and the needs of the people who live in them. A global effort of comparative analysis is therefore needed to compare and contrast the performance of cities on an array of social, environmental and economic indicators. Such a rich database would allow something akin to structural factor analysis that could identify which aspects of the city size, form and design are most influential, as well as the context within which these effects are expected. This analysis could draw on techniques of case and cohort studies, supplemented by meta-analysis techniques used in medicine and the social sciences. It may be hard to detect overall patterns due to large variations between cities in their structure and functions as well as the needs of their residents. Recent developments in interrogating 'big datasets', generated by cities in real-time, will help to provide new insights on a variety of scales. The answer in the end might be that every conclusion is completely context-specific and that no general rules exist for the interaction between the physical and social lives of cities. We will not know unless we ask the question.

# Green spaces

**How is the sustainability of a city and its surroundings affected by integrating ecosystem functions in green and blue 'natural urban spaces'?**

# At a glance

Cities can contain tree-lined roads, gardens, parks, playing fields, ponds, lakes, wetlands, rivers and canals, collectively referred to as 'urban green and blue infrastructure'. A growing body of research suggests that this urban green and blue infrastructure provides environmental services such as cooling, reducing pollution and absorbing excess rainfall, improves local economies and has a positive impact on physical and mental health.

All cities are made up of a 'patchwork' of different types of buildings, neighbourhoods and open spaces. We considered the role that green and blue spaces could play in this patchwork, and what might happen if these spaces are connected rather than isolated. Are these connections, which may require creating new green and blue spaces, essential for providing environmental services, or would they only add incremental value? Might such connections provide new benefits? Are green and blue amenities or services simply a function of the amount of space created, or does the shape or form of that space matter too?

## Key questions

**Through discussions, we identified three further questions which require further examination:**

- **How do different kinds of green and blue spaces make a city more environmentally and socially sustainable and resilient to changes in climate?**

- **How does connecting such spaces – for example along corridors – affect their environmental and social benefits?**

- **How would such connected spaces encourage biodiversity as well as the cultural diversity of residents?**

# Green and blue environmental services

Individual urban green and blue spaces have an impact on the surrounding city that goes beyond their localised amenity benefits. One example is in reducing the 'urban heat island effect' where cities tend to become hotter than the surrounding countryside. This effect is magnified in densely populated areas. For example, the centre of London is, on average, 5°C warmer than surrounding rural areas, and this difference was as much as 10°C during the heatwave in 2003. Overheating in cities is therefore predicted to become more frequent as the climate changes and urban areas expand and become denser.

The temperature of a city and the way in which heat is dispersed within it depend on a number of factors, including weather, the layout of the streets and the form and construction materials of the buildings. Buildings raise the temperature of the surrounding area by reducing airflow and trapping warm air between them, as well as producing heat themselves. In contrast, green and blue spaces lower air temperatures in surrounding urban areas. Modelling by the SCORCHIO Project based in Manchester indicates that increasing the amount of green space by only 10% in a particular area could reduce the daily maximum temperature by 2.2°C.

Much of the research on urban heat-flows is focussed within or around individual buildings, parks or water bodies but green and blue spaces influence the airflow between groups of buildings and from one side of a city to another. How does this city-wide air flow affect the rate at which buildings, streets and neighbourhoods heat and cool? How could these effects be quantified and added into existing models to foster better designs of green and blue infrastructure?

Green and blue infrastructure can be combined with engineered infrastructure to provide environmental services. This gives rise to a number of questions based on the connections between them. For example, given the current capacity of the rivers, sewers and drains within a drainage catchment, how much more would be needed to service population growth, increased run-off from new development and increased rainfall? If there is insufficient capacity or flexibility in the system, what solutions could be provided by green infrastructure? Where should street trees and green spaces be located and how should they be combined to provide shade and cooling and to absorb the most rainfall?

Quantifying the costs and benefits of these different types of infrastructure would help people to picture what measures could be taken and also to understand what other costs there may be if no changes are made. For example, how do the costs of creating or maintaining green and blue spaces compare to enlarging existing sewers or repairing damage from regular flooding? Is there a minimum area needed to realise these benefits on a city-wide scale, so that local solutions do not simply push the problem (e.g. flooding) from one part of the city to another? And how can we ensure that engineering solutions for one problem, such as mitigating flood risks, do not increase other problems, such as the heat island effect?

# Building green spaces into city governance

In the UK, planning laws are being relaxed to allow housing development on urban green belts. It is therefore increasingly important to protect green spaces and connect them to rural areas. The importance of 'green networks' is not yet reflected in policy or city priorities. Green spaces may be seen as a luxury and therefore have low priority, compared to necessities such as schools or housing. Cities also have to construct, manage and fund their green spaces and require governance to support them.

City governance models are often based on managing a single, isolated area. How can these be scaled up to encompass networks of connected spaces that bridge multiple local councils or areas of jurisdiction? What governance mechanisms could be used to support these networks? How can communities take ownership of their green spaces and play an active role in deciding what happens to them?

Two promising initiatives are the All London Green Grid, a policy framework that is designed to promote the design and delivery of green infrastructure across the city. On a larger scale, the Central Scotland Green Network aims to connect green and blue spaces in towns and cities with the wider countryside and coast from Ayrshire and Inverclyde in the west, to Fife and the Lothians in the east.

*"Combining climate projection models and models of heat and air flow within cities can build up a picture of which areas might be most vulnerable to changes in climate."*

PROFESSOR ALAN SHORT
Department of Architecture, University of Cambridge

# Green and blue social benefits

Although studies generally agree that green and blue spaces provide, both environmentally and socially, a range of short and long term benefits, how people use them varies between age groups, gender, ethnic groups and socioeconomic background. This makes it difficult to predict their effect on the health and wellbeing of a whole community. What are the differences between how different groups of people use the spaces and want them to look like? Carefully and imaginatively created green and blue spaces may also allow diverse lifestyles and cultures to co-exist thereby improving the cultural diversity of urban societies. They allow the 'nature lover' to remain in the city rather than migrating to the countryside and provide communal spaces for those who want to gather and enjoy the natural world, even where the landscape is otherwise framed by buildings and streets. However, the poorest areas of cities often have the worst quality green and blue spaces. Which aspects discourage people from using these spaces and how can they be improved so as to bring the desired social and environmental benefits?

As cities expand, children are increasingly growing up in urban rather than rural environments. According to recent research conducted by the Centre for Diet and Activity Research (CEDAR) in Cambridge, there are initial indications that children who are active when they are young, and have a good and positive interaction with nature, are more likely to continue being active as adults and maintain the associated health and wellbeing benefits. Does this contact with nature have to be associated with where people live, or is travel out into nature just as effective? The most effective way to incorporate green space into cities needs further research but there are creative ideas already being implemented. For example, Stockholm has continuous green spaces or 'green wedges' that stretch from the edge of the city to the centre. On a smaller scale, similar continuous green areas are being added to housing developments, including the University of Cambridge's North West Cambridge Development. These have the potential to both connect and protect green spaces and bring greenery to the heart of a city or a development. They also have the potential to reduce exposure to air pollution by providing alternative, non-motoring routes across and out of the city.

The value of gardens for enhancing urban biodiversity has also long been recognised. Together with neighbouring green and blue spaces, they allow diverse species to exist in a highly engineered city habitat. As many species require a minimum area to persist, we need to decide how biodiverse we wish our cities to be and design urban landscapes that connect green and blue spaces on a large enough scale. How can people be encouraged to look beyond their own garden fence and think of their own gardens as part of a larger neighbourhood-wide or city-wide network? How can that 'big picture thinking' be built into what people decide to grow and what to leave in a more wild state. Finally, what could catalyse these changes in thinking and the way that green spaces and gardens are planned and maintained? Would community-level activities or top-down city-scale initiatives be more effective?

*"There is an urgent need to 'green' cities and reconnect people to nature, not only through green spaces and trees but also knowing where their food comes from and how their actions affect the environment around them."*

DAME FIONA REYNOLDS
Master of Emmanuel College

# The research challenge on the horizon

**What can we conclude about the relationship between green and blue spaces and the environmental and social sustainability of a city?**

The largest missing piece of the conceptual puzzle is an understanding of the scale at which green and blue spaces must be created, where and in what form. A mantra of 'the larger the better' ignores pressures to create more housing and the impacts on land values. It also ignores the possibility that there may be some minimal amount of green and blue spaces that will suffice for the services we seek. Ignoring the issue of 'where' raises the possibility that only the wealthy will have access to these spaces. Proper consideration of the form of green and blue spaces will increase the potential role of such spaces to provide alternative paths for mobility, both for residents and the species we want to attract. The theories and methods applied so effectively in ecosystem studies of the countryside and of analyses of catchment areas are a first step in this direction. This in turn requires a richer understanding of the roles of scale, location and form of green and blue spaces in regulating temperature, air quality, water, biodiversity and wellbeing and the follow-on effects for energy use or flooding.

# Making the invisible city, visible

How will technology and data change the way we live in cities, how we govern them and the nature of our environmental impact?

# At a glance

The use of real-time analysis and large datasets generated by 'smart cities' has grown significantly over the last decade. The largest area of development has been in the control of traffic flow. Can smart cities, however, move beyond merely controlling traffic lights to positively impacting the environment and the lives of their residents? Can large scale deployment of sensors, an 'internet of things' and social media lead to appropriate technological and governance systems?
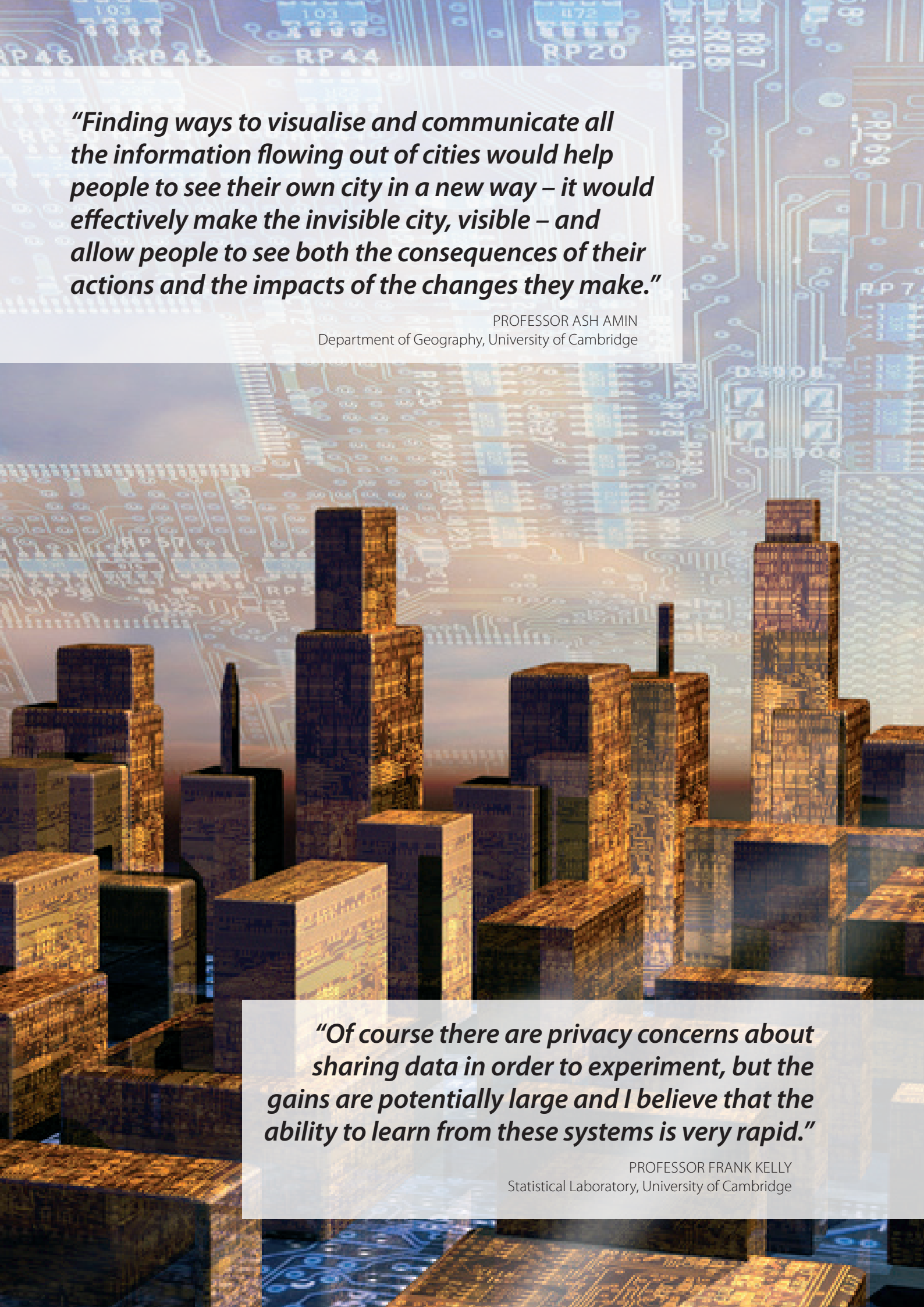
We implicitly assume that collecting and analysing more data will lead to better decisions on the allocation of resources. But we need to extract information from the data to inform decisions and link this with city governance. How does a city exploit the internet and social media to enable and mobilise residents to take action, while avoiding the increased surveillance and erosion of civil liberties that become possible through the information in such large datasets?

# Key questions

**These ideas then led to three more specific questions for which answers are surprisingly poorly developed at the moment:**

- **How can 'smart' data and 'smart' cities positively impact the environment and the lives of the people who live there?**

- **Is it possible to have too much data, or data that are so poorly organised they impede, rather than inform decisions?**

- **Can we transfer lessons learned from smart cities to cities without the resources to pay for information and communication technology (ICT) solutions?**
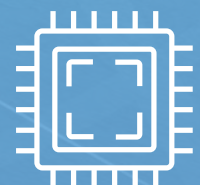
"*Finding ways to visualise and communicate all the information flowing out of cities would help people to see their own city in a new way – it would effectively make the invisible city, visible – and allow people to see both the consequences of their actions and the impacts of the changes they make.*"

PROFESSOR ASH AMIN
Department of Geography, University of Cambridge

"*Of course there are privacy concerns about sharing data in order to experiment, but the gains are potentially large and I believe that the ability to learn from these systems is very rapid.*"

PROFESSOR FRANK KELLY
Statistical Laboratory, University of Cambridge

# Smart cities: making the invisible city, visible

The term 'smart cities' was coined to highlight the growing importance of ICT in enhancing the way in which people live, work and move around cities as well as their quality of life, impact on the environment and engagement with governance. Smart city technology is being developed by companies such as IBM, Cisco and Samsung and used in cities ranging from Rio de Janeiro to Beijing, Barcelona and one of the world's newest cities, Masdar in the United Arab Emirates.

Many of the smart cities initiatives focus on improving the material and energy efficiency of cities, particularly of transport systems. One of the most common uses of 'big data' is to monitor and respond to traffic flows at a city scale to help ease congestion and reduce pollution 'hotspots'. For example, the Greater London Authority (GLA) is combining 'geo-fencing' technology and mobile sensors to improve air quality. Monitoring systems in diesel-electric hybrid cars will create a real-time air-quality monitoring network and change the fuel they consume in response to the pollution levels in particular areas. These cars would run on electric mode in the dirtiest areas at the dirtiest times but automatically change to diesel mode in cleaner areas. Collecting data like this in an intelligent way and being able to use them in real time allows a city a very fine level of control over how to keep traffic moving and how to stop the development of pollution 'hotspots'. The GLA are also looking at the potential of electric vehicles to function as temporary energy stores: charging them when energy is abundant and feeding energy back into the grid if they are parked at peak times.

Data and technology also have the potential to 'make the invisible city, visible' because visualising and effectively communicating information about a city makes it easier for people to see patterns and better understand the consequences of their own actions on environmental and social conditions. For example, the GLA is currently building a 'triple jeopardy map' of London that looks at how the urban heat island creates hot spots within the city. This includes which buildings might be prone to overheating and where the most vulnerable people might be so that they can deploy extra resources there when needed. An experimental approach is already being taken in Singapore which uses the equivalent of London's Oyster transport card to collect data on where and how people travel, and randomised controlled trials also test how people respond to disruptions and changes in their normal route. These tests are improving the Transport Authority's sense of what people can do and what they might do under different circumstances. Bringing together different datasets can therefore be a powerful way to make previously unknown connections visible and then to direct resources to where they have the greatest impact on reducing problems.

# Swimming in a sea of data

We know how to create the ICT that makes smart cities possible. However, one of the greatest challenges is not necessarily collecting data but knowing what to do with them. Although 'big data' is collected from cities in real time, much of it stays in raw form and cannot be used in any practical way. This can be because it is not reaching the people who need it, they do not know it is there, there is simply too much of it to consider or because they do not have the institutional capacity to use it. Even when information can be collected, analysed and brought together in a systematic way, one hurdle to conveying information on a city-wide scale is the complexity and sheer volume of the data.

One remedy is to create a new style of 'atlas' that would help decision makers visualise the wealth of real-time data flowing out of cities. This atlas would generate millions of potential maps of a city ('layers' in Geographic Information Systems), each of which would contain and combine information about different aspects of the city tailored to specific decision problems posed by the user. An intelligent search facility would allow specific information to be extracted, helping to turn this unmanageable 'sea' of data into a form that a city could use in real time to create a dashboard of sustainability indicators.

What new connections can technology make between people and their environment, drawing on the power of big (and intelligent) data? Cities are highly diverse, and so there are constantly 'natural experiments' going on in different parts of the city from which lessons can be learnt. For example, no police agency looks at the number of police patrols on the street at any given time, hour by hour, with any policy principles in mind. Yet if London had done so, it might have prevented or at least ameliorated the 2011 riots. Like a blood pressure monitor for humans, using real time data in this way could act as an hourly measure of pressure for cities. These data can also be studied annually, and the same natural experiment approach used for many other measures of city performance are explored in more detail in Section 5 about 'cities in a changing world'.

ICT systems and the internet of things may offer individuals a more direct role in governance because they can allow people to communicate rapidly as environmental and social changes take place, to mobilise actions that enhance sustainability and to provide a barometer to government on the opinions, values and concerns of citizens. Conversely, it could be argued that there is a need to recognise that much of the 'smart cities' rhetoric so far fails to connect with the concerns of city residents and city politicians. Some of these concerns relate to privacy. At its worst, the idea of a smart city can be perceived negatively and as a set of top-down technocratic 'fixes' in which city residents are at the end rather than the beginning of the process. In managing the urban system, the role of city leaders lies in promoting and supporting a smarter approach to urban growth through making the best use of new technologies. Good governance is crucial; when it comes to creating smarter, more sustainable cities, it is just as important as technological fixes that city leaders be accountable for their actions and maintain dialogue with city residents.

*"Using information collected within cities, you can start to calculate quite sophisticated indicators. A possibility would be a system of flashing red lights which highlight the areas where something is going wrong. This information would point people straight to the problems. A logical extension of this would be to feed the information back into the system automatically to help it to overcome similar problems in the future."*

SIR ALAN WILSON
University College London and the Foresight Future of Cities Project

# Making connections globally

Cities in the developed world are taking the lead in becoming 'smart' in the sense of ICT and developing countries may try to emulate them. This is good if such solutions truly are exportable, but could send cities down the wrong paths if the conditions that make ICT effective are not met, such as the availability of a reliable electricity supply or an effective governance system. Sometimes solving a problem does not require new technology but putting on 'new glasses' and seeing the system in a different way. Within a factory, for example, making an industrial system more sustainable does not necessarily rely on a single new technology and on brand new scientific solutions. Instead, it is often a transition and a change within the existing system that creates new connections, new architectures and new opportunities.

We have a tendency to think about sustainability from a Western perspective and to turn to new technologies when making infrastructure changes. Although these are potentially effective in the right context, we should caution against 'over engineering' sustainability. Simpler, cheaper solutions that use locally sourced materials, expertise and social processes would be easier to apply to a broader range of cities. There has been a huge wave of optimism over the past few years as African nations see their less high-tech way of collecting, assessing and transmitting information as the solution to their sustainability challenges. Furthermore, there is a growing belief that those solutions can be applied on a global scale. Many of these may be 'low tech' and low cost but still very effective when the right social systems are in place. In developing countries, it is therefore important to ask whether there are local analogues that build on existing social and information networks without trying to recreate the complex ICT systems of what is called a 'smart city' in richer nations. Conversely, could the richer cities have overlooked their own older solutions in a rush towards the latest technology? Is it possible that cities in less developed countries can provide solutions that can be applied in cities worldwide?

# UN Habitat and changing the way we view cities

The UN programme for human settlements began life as the United Nations Habitat and Human Settlements Foundation (UNHHSF) and is the first official UN body dedicated to urbanisation. It is now known as UN-Habitat and its mission is to "promote socially and environmentally sustainable human settlements development and the achievement of adequate shelter for all". At the first two meetings in 1976 and 1996 much of the discussion focussed on rural development. Since then, there has been a shift in the UN's focus towards cities, a shift that recognises that the environment they have to deal with is increasingly urban. Around two-thirds of development in cities in developing countries is in the informal sector such as in slums or in favelas. Inequality is also growing in these cities as more people are moving into and living in very poor conditions. The third meeting – UN Habitat III – was held in Ecuador in 2016, and it focussed on renewing political commitment for sustainable urban development, assessing accomplishments to date, addressing poverty and identifying and addressing new and emerging urban challenges. For example, how do we provide clean water to informal settlements in cities? How do they get electricity? What are the building materials that people can use themselves? In his introduction to the Forum, Professor Richard Sennett argued that to find solutions to these questions and to challenges related to sustainability and the environment in cities and their informal settlements, there is a need to change the mind-set of architects, designers and engineers so that they find solutions that are cheap and applicable to the very poorest people.

*"This is really an age of urban growth almost unparalleled in human history. Issues of climate change and sustainability are a big part of this, and they are very contentious politically and made more contentious by the speed with which cities have grown."*

PROFESSOR RICHARD SENNETT
London School of Economics

> *"Every place can surely prosper or grow sustainably, let's just create the conditions for them to do that. Let's not try and pick winners around which cities we want to support and which we do not."*
>
> STEPHEN ALDRIDGE
> Department for Communities and
> Local Government

# The research challenge on the horizon

**What can we conclude about the role of ICT and big data in improving the sustainability of cities?**

So far, many of these technologies are more aspirational than transformative. A step change is needed to allow an ICT-enabled sensor and data system to improve sustainability beyond marginal changes in existing ways of collecting and analysing data and mobilising social action based on those data. We need to fully understand the human–technology interface between data, decisions and governance. One can imagine a city improved by these technologies, but also imagine a city in which banks of computer servers consume power that allows ever greater production of data and analyses that then sit in those servers and never reach a decision maker or that reach a decision maker who is incapable of interpreting them. Additional key questions are how the social structures underlying data use are to be matched with the increasing complexity of the disorganised sea of data produced by modern technologies, and whether older, less technologically advanced forms of information are sometimes sufficient to guide cities along the path to sustainability.

# Top down versus bottom up

**What changes in cities will come from the top down (such as central planning) and what will come from the bottom up (such as social media or market forces?  How do they meet?**

# At a glance

Modern, technocratic public policy began in the 19th century to replace what was seen as the selfish whims of individuals with dispassionate, multi-criteria analysis, optimisation and systems thinking. Since that time, there is an emerging sense that the pendulum may have swung too far, with increasingly top-down decisions that lose sight of local, highly contextualised knowledge. The challenge is to redefine the balance between these two modes of governing cities for sustainability as we learn more about which problems can be addressed top down and which can only be resolved through bottom-up, collective action.

How can unofficial governance be incorporated into and/or complement traditional modes of city governance? What are the risks inherent in this approach? When is it appropriate? Cities will sometimes need top-down governance to ensure the free actions taken by one group do not impede others. But how do you build a system that can cope with emergent, bottom-up governance as well as top-down planning while simultaneously making cities more socially and environmentally sustainable?

## Key questions

**These issues led to three areas where better answers are needed:**

- **How can cities use larger-scale systems approaches for the built environment while allowing for local flexibility?**

- **How can informal and formal systems of governance run in parallel and complement each other? At what spatial scales is one or the other appropriate?**

- **How can people be enabled and inspired to act in a more sustainable way without prescribing set answers or imposing solutions on them?**

# How local are systems?

The top-down approach to city design and operation allows trade-offs between different parts of the city and different elements of infrastructure. For example, energy supply and demand can be balanced, surface water run-off can be directed to where it will do the least overall harm and transport systems can be optimised so the greatest number of people is served. Further, cost effectiveness of investments in sustainability can be improved.

However, this top-down approach comes at the expense of residents' control over their local community. The system of the entire city is optimised, but this creates winners and losers. A more bottom-up approach reduces this problem, but at the expense of creating a patchwork of solutions that is less than optimal for the performance of the city's engineered systems.

At what spatial scale must a system be optimised to provide harmony between the top-down and bottom-up approaches? In hydrological systems, it is often possible to treat catchment areas separately: solutions that work for one catchment area need not be imposed on all catchment areas uniformly. What is the analogue within cities? At what spatial scale can a city allow local citizens to find local solutions to sustainability, and how can a top-down approach then ensure that these local solutions are brought together to bring sustainability to the city overall?

*"As a senior policy maker, I see an increasing trend of moving on from considering sustainability and infrastructure as a series of separate, individual issues and towards viewing them collectively, as part of a city s]ystem. But we must avoid the trap of thinking of a city only as a 'system of systems'. Cities are where people, ideas and creativity come together."*

MARK KLEINMAN
Greater London Authority

# Questions of scale

How do we create effective institutions within cities, when they might be involved in both formal and informal planning? Governance can operate outwards, starting with local city governing bodies and progressing on to regional, national or even international bodies. By coordinating these levels of decision, nesting them one inside the other (the quintessential form of top-down planning), it becomes possible to coordinate actions so they are, in some sense, 'optimal' ways of reaching environmental and social sustainability. But governance can also operate inwards into parts of the city, city blocks or even individual groups of residents, where NGOs, local citizen organisations and charities play important roles. Somewhere in the middle sits a network of governance, with smooth transitions from top-down to bottom-up approaches when one or the other is needed. To date, no city has solved the problem of making the transition smoothly, in large part because the two approaches usually meet at points where they come into conflict. Does local governance lead to more adaptability and greater sustainability, or would local governance be more vulnerable to pressure groups, local interests or to delivering only short-term solutions?

Local governance is important in helping cities adapt to changing circumstances and making decisions which are in their own best interests. It is difficult to unearth evidence that localism and decentralisation benefits cities in the UK. Similarly, there is limited evidence concerning the benefits of centralised governance, so it is not at all clear which approach (top-down, bottom-up or a hybrid approach) would be favoured by increased evidence.

Individual companies can take action on sustainability, but genuine impact will only come if these actions are scaled up to the level of a city. However, if the scale is too large, then effective change becomes impossible. Cities occupy a 'sweet spot' as they are a manageable size and are the right scale to be effective agents of change. Because of their size – sitting between individual businesses and global initiatives – cities may have more power than national governments to effect local change and can potentially respond more rapidly and be more targeted in their responses than national government legislation.

While city governance can be powerful, there is a role for central government, especially in regional planning and development and reaching national sustainability targets through local decisions. There can also be a role for multi-national planning under some circumstances, since sustainability solutions in one city or one nation can – through the global supply chain and global economies – affect the sustainability of other nations. This can occur, for example, with leakage of carbon through global trade, or water usage embedded in products that are consumed in one city but produced elsewhere. What is the relationship between what happens at a city level and what happens nationally or multi-nationally? Can cities proactively take actions on complex large-scale environmental issues, or can they only adapt to them?

# Catalyzing and communicating change

Cities can create a list of sustainability actions but, in order to put these into practice, collective action is needed. Formal governance is one possible lever to stimulate change, but in areas where there is no governance, or governance would not be an effective tool which actions can still be taken? How can people be moved to take actions if not required to by governance institutions?

The answer lies in part in identifying 'high value' institutions and knowledge brokers, or people who are thought to influence others. Who are these leaders in cities? How do they exert their influence, and whom do they affect? How can we better understand these actors and networks? Are there 'acupuncture-like' interventions (such as targeting specific street corners to reduce crime at a neighbourhood level) where a change in governance or change to the way we act at a local scale has ripple effects throughout a city? Spatially and socially resolved networks, supported by motivating 'intermediaries' and 'thought leaders', possibly play a larger role in governance now than they have in the past.

We need to be more inclusive in our thinking about decision-making. There are governance structures, businesses and the third sector, but there is also groundswell – the informal process whereby viewpoints are expressed – which can affect how certain things get done and how other things are blocked. The security of cities is a good example: the police cannot do their job without the support of the majority and no-go areas can develop. Essentially, societies comply with the law because the law reflects what society sees as reasonable. The compliance is far more impressive than the failure to comply. Does this mean that city governments are at the mercy of their citizens, not the other way round?

To inspire change and capture people's hearts as well as their minds, messages around sustainability must be communicated in an emotionally engaging way because the sustainability challenges we are facing are not just technical but also personal and political. This includes providing visions of what it would be like to live in such future cities.

How can people be enabled and inspired to change their behaviour or to act in a more sustainable way without simply providing them with the answers or imposing the solutions on them? Is it possible to create solutions to sustainability that are so intuitive people do not have to think about them? And if we want to engage people in collective action, what sort of narratives work best? Is it most effective to say, for example, that we can all come together in a city like Cambridge to work collectively to deliver energy efficiency (bottom up) or is it more effective to be prescriptive and say 'this what I want you to do' (top down)?

> *"You need local governance to understand the contextual nuances which you're never going to get elsewhere. And for me it's only through local governance that you're going to address how to get to sustainable and resilient cities."*
>
> JO DA SILVA
> Arup International Development

# The research challenge on the horizon

**What can we conclude about the relative value of bottom-up and top-down approaches to the design and governance of cities for sustainability?**

It is clear that we do not yet have a 'transmission' for the governance vehicle. Some solutions can safely be taken from the bottom up, empowering local communities to act in whatever way best meets their needs and aspirations. Other aspects of sustainability require at least some top-down design and management to ensure local communities do not simply pass off their sustainability problems to other communities. But we do not know where this transition between top-down and bottom-up governance occurs. We have two gears but no clutch, causing us to lurch from one gear to the other. Thus, the central research question for the future is how can we design governance systems that allow for a seamless and collaborative transition between bottom-up approaches that are effective at a local level and top-down constraints necessitated by the sustainability concerns of the larger city?

**Governing Cities**

# Cities in a Changing World

**How will cities of the future adapt to the environmental, economic and social challenges facing them?**

# At a glance

The concept of resilience and the capacity to learn and adapt to new situations lies at the heart of creating and maintaining sustainable future cities. It is not possible to predict all future challenges so cities must strike a balance between long-term investments to protect against expected future damage and preserving resources and flexibility to deal with unexpected future damage. Long-term investment on its own runs the risk of 'mal-adaptation' (a good response under one future scenario turns out to be a poor response under another). Resilience is likely to flow from diversity, monitoring and experimentation, rather than from planning solely on the basis of predictions. This approach allows for adaptive management and robust decision-making that will prove useful regardless of the possible futures which emerge.

This raises a key question: Are there therefore limits to the effectiveness of planning in cities? Is more research really needed into specific solutions under all potential future scenarios? Or could we create room for innovation in city governance so cities can learn and adapt to new situations in real time as these emerge? Could policy mechanisms be created or engineered so that city governance becomes a learning machine based on experience, as much as on models – essentially creating a 'thinking city' that can automatically respond to our environmental and social needs?

# Key questions

Can governance systems be designed so that they are more flexible and responsive to long-term changes and sudden shocks, or is there a risk that this will encourage short-term thinking? These issues led to three more specific sets of questions:

- Are we in danger of 'over planning' cities so they are only resilient and sustainable under selective futures? Is it possible to legislate for a less planned approach?

- Can governance systems be designed so that they are more flexible and responsive to changes and sudden shocks?

- Could room be built in for natural experimentation, and what are the implications for governors if an experiment fails?

# Limits to planning

Rapidly expanding cities in Latin America, Africa and Asia are raising questions about the way in which we traditionally see cities as being planned and controlled, and about the role of citizens in the way they are governed. New phenomena such as informal governance and informal economies coupled with rapid urban growth are beginning to challenge our underlying assumptions about the way cities are governed and the role that top-down planning plays in that.

Are there limits to the effectiveness of planning in cities? Is 'over-planning' required to achieve sustainability or can an organic approach – where the city develops from the ground up without being planned – do just as well or, even, better?

Patterns in the way cities develop depend on a large range of diverse factors such as climate change or depletion of local resources and migration, many of which are highly unpredictable. Against this background, how do we make robust decisions? We can include formal uncertainty analysis in planning, combined with a decision framework to make use of this uncertainty. The uncertainty is then 'built into' or at least reflected in investment decisions that will be in place far into the future. Alternatively, we can deal with uncertainty by stepping back from long-term planning and allowing room for change as the future emerges.

Instead of trying to predict all social and environmental conditions at a future date and designing and optimising hyper-planned cities, we can ask ourselves further questions. Is it possible to plan a city to recognise and make use of self-organising social networks and changing resource networks to deal with environmental, social and economic changes? When we think about sustainability, are we in danger of 'over planning' cities? Is it possible to legislate for a less planned approach to sustainability? What evidence do we have that a 'looser' approach to planning would work? If hyper-planning leads to the danger of mal-adaptation, could a less planned approach lead to chaotic investments that are ineffective because they are uncoordinated?

*"The nature of life, the nature of economic activities, the nature of cities is that when the unexpected happens, innovations occur. A lot of the evolution of a city is therefore driven by the unexpected, it's driven by experimentation and trial and error, not planning in advance."*

PROFESSOR STEPHEN ALDRIDGE
Department for Communities and Local Government

*"Instead of simply calling for more research in specific areas, how can we view the city as a system and feed the information it generates back into it so that it constantly learns and adapts to new situations?"*

PROFESSOR LAWRENCE SHERMAN
The Institute of Criminology, University of Cambridge

## Making space for change

*"Without having space, change within a 'living' city becomes very difficult."*

MARCIAL ECHENIQUE
Department of Architecture, University of Cambridge

All cities and urban communities are continually changing. It is crucial to factor in space into city design to allow flexibility as conditions change. A city loses the capacity to adapt to new circumstances if hyper-planning has already committed every hectare to a specific purpose and planning rules do not allow re-purposing of that space. For example, new-build cities tend to have uniform development whereas combining different areas and types of space could enhance them and allow future changes.

The same could be true on a city scale. London has always been a mixture of social housing and richer suburbs, with council estates such as Golden Lane next to high-value property like the Barbican. This mixture is seen as being one of the most positive features of the city, and, although individual suburbs may become richer or poorer over time, the city is still a patchwork of different kinds of development. In other cities, such as Paris, lower-income housing has been pushed out into the suburbs to leave room for higher-income housing in the centre. Similarly, slums and favelas in cities all over Africa, Latin America and Asia are being cleared and replaced with new developments in city centres. Such shifts not only change the make-up of the city, they can also be socially divisive and foster entrenched divisions between communities which are difficult to change. Combining different areas and types of space within both developments and within existing cities can both enhance them and allow room for changes in response to the future needs of the people who live there.

# The city as a living laboratory

There is great diversity between cities and between communities within a city. This opens the possibility of using this diversity as a laboratory for conducting 'natural experiments' of different potential responses to the future. Could an experimental approach complement or stimulate a city's evolution or might it push a city towards instability by threatening sustainability and the attraction of investments?

An experimental approach is already being taken by some cities. Singapore is running randomised controlled trials to improve their underground system. In various places, such as the London Underground, the effectiveness of interventions aimed at reducing levels of crime is being tested. An initiative funded by the UK government, the 'Future Cities Catapult' project is asking whether future cities can think for themselves. It aims to make four areas of London into 'living laboratories' and collect data, build evidence and experiment with new ideas, making the city itself into a test bed for innovation in the built environment.

Could a similar approach be taken to designing policy mechanisms themselves so that city governance becomes a learning machine based on experimentation? There are two general ways of designing systems. The first involves building slack and redundancy into a system from the beginning so that it is possible to experiment freely without disrupting more stable and long-term parts of the system. The second is to optimise a system to such a degree that if any one part of it fails, there are not negative consequences throughout the system. This second approach only leaves room for 'just-in-time experimentalism' which tends to result in very short-term or small-scale interventions, rather than grander experiments that explore whether an entire system (or system of systems) needs adjusting. Are there ways to design city governance systems so that self-learning can be incorporated into them?
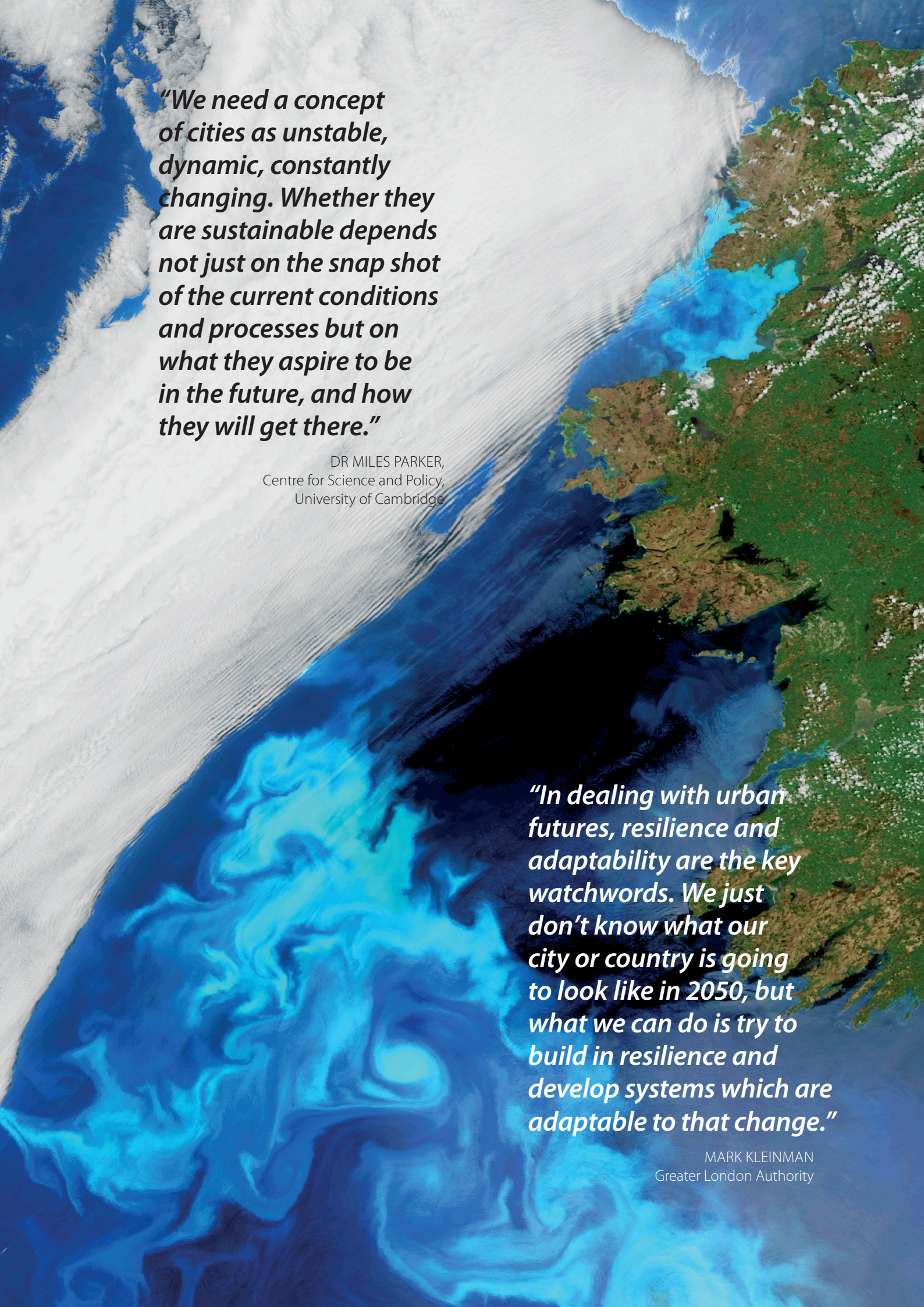
Some experiments will succeed, but inevitably, others will fail. Is it possible to create 'safe places' to experiment and to innovate within cities without compromising citizens' rights to essential services? How would such spaces be created and governed? How can the impacts of experimental failure in one part of the system be prevented from flowing back into other parts of the system? A city's size and diversity means that there are always pieces that can be isolated from overall interdependence to conduct the necessary experiments and some experiments may only be practical in a confined area. How can we also allow failure in the political environment, even if that failure leads to improved understanding for the future?

*"The city is an ideal lab for trying out experiments with big data."*

MARK KLEINMAN
Greater London Authority

The great diversity between cities can also be harnessed for conducting 'natural experiments' of potential responses to the future. City leaders are increasingly making direct links and forming networks with similar, like-minded cities, even in other parts of the world. Such collaborative networks include the C40 Cities Climate Leadership Group, "a global network of large cities taking action to address climate change by developing and implementing policies and programs that generate measurable reductions in both greenhouse gas emissions and climate risks". It was founded in 2005 by Ken Livingstone, then Mayor of London, and now includes 69 affiliated cities ranging from Addis Ababa and Lagos to San Francisco, Copenhagen and Bangkok. It believes that "cities have the power to change the world." What kinds of networks would be most effective at sharing information like this so that the strengths and weaknesses of alternative strategies can be tested and assessed?

A Changing World

*"We need a concept of cities as unstable, dynamic, constantly changing. Whether they are sustainable depends not just on the snap shot of the current conditions and processes but on what they aspire to be in the future, and how they will get there."*

DR MILES PARKER,
Centre for Science and Policy,
University of Cambridge

*"In dealing with urban futures, resilience and adaptability are the key watchwords. We just don't know what our city or country is going to look like in 2050, but what we can do is try to build in resilience and develop systems which are adaptable to that change."*

MARK KLEINMAN
Greater London Authority

# Keeping pace with change

National, regional and city governance tends to be slow to change. How can governance systems be designed so that they are more flexible and responsive within time scales that match those of changing physical and social circumstances? These could include disparate challenges such as the unpredictable effects of climate change or greater demand for local autonomy in planning decisions. An inherent tension is that sustainability is a long-term goal, whereas political agendas tie in with election cycles, and market investments are often based on short-term return. How could cities build opportunities to revisit decisions and to regularly look at the effectiveness of governance and interventions? Revisiting decisions opens the possibility of revealing a decision that resulted in ineffective investments. Decision makers generally do not want to explain unsuccessful investments even if the circumstances determining these are outside their control.

# The research challenge on the horizon

**What can we conclude about the governance structures and planning rules needed for responding to an uncertain future?**

The uncertainties regarding how the future will change are so profound that highly centralised, long-term planning cannot be the only way forward. There is a need to treat cities as places of experimentation. However, experiments require laboratory equipment – the city analogues of which are sensors that measure key resilience and sustainability metrics. They require parts of the city where experiments can be conducted and spaces within the city that are left 'fallow' so new ideas can be tested as innovators develop them. Additionally we need the ability to understand the differences between the different settings of the experiment, to measure the outcome of policies and measures, to assess the reasons for these results and to design even more refined experiments to better understand the reasons for success or failure. The challenge for the future is to create this capacity to use cities as living laboratories for sustainability and then to back this up with governance structures and planning rules that allow for such experimentation without putting decision makers and service providers at risk when some experiments succeed and some fail.

A Changing World

# Finding 'satsificing' solutions

**Are there solutions to sustainability which are not perfect but which are 'good enough' to put into practice?  What could we mean by 'good enough', and for whom?**

Photo by @camdiary

# At a glance

Economists divide decisions in to three broad categories. First there are decisions based on optimisation, where the decision maker lines up the options, assigns important metrics to the decision (e.g. cost, sustainability, acceptance), measures these for each option and finally chooses the option with the highest overall utility. Behavioural economics clearly shows that most people are not optimisers. The second category of decisions is undertaken by those known as 'satisficers', who search for options that may not be the best, but are 'good enough'. They are not being irrational but instead they are accepting that there is limited time for analysis and uncertainties are so profound as to make optimisation impossible. Finally, there are 'transformational' decisions: investments in the future that are neither optimal nor sufficient under current circumstances, but made with transformation in mind.

How can we enable all three types to have a place when selecting options for sustainability? What are the roles of these different decisions in the evolution of cities in different countries? If developing nations have limited resources for seeking optimal solutions, they will move towards satisficing or transformational approaches. What can developed nations learn from them? Can we find solutions to sustainability questions which are just 'good enough', making them easier to implement and ensuring broad political consensus?

# Key questions

**These issues led to three more specific areas where further research is needed:**

- **Which timescales and scenarios promote which types of decisions? How can we use this knowledge to promote certain types of decisions?**

- **What opportunities are there in the rapidly expanding cities in developing countries to explore innovative low-cost and low-tech ways of approaching sustainability?**

- **How can we recognise when a transition or solution is 'good enough', and good enough for whom?**

# How far must we look in to the future?

Sustainability is not a steady state, but a moving target. This raises questions about how far planners must look into the future to design transitions. Can long-term dynamic models be developed that help us to think about sustainability over different timescales? Can short-term and long-term measures of sustainability be harmonised, or will they be in conflict? What does resilience to sudden shocks and long-term stressors mean for cities over different timescales? How do you incorporate random elements of cities – such as the behaviour of individuals or unanticipated events – into models?

The evolution of a city is dependent not just on the current dynamics driving it but also on the initial conditions created by past investments: this is known as path dependence. It is quite difficult to make the shift to doing something new from a policy perspective when there is lock-in from these past investments.

From 2010, the UK Government was rapidly developing a path in which an increasing range of negotiated powers were devolved to some cities and city regions, making it an appropriate time to create a project to systematically explore drivers of change, options and imperatives for the longer-term future of UK cities. In 2013 this led to the Foresight Future of Cities Project, run by the Government Office for Science, which considered three types of scenarios for the development of cities:

- **Projections:** where cities think they will be

- **Aspirations:** where they want to be

- **Extremes:** extreme scenarios to frame the challenge

If cities are recognised to be complex, adaptive and nonlinear systems technically, then certain consequences follow immediately when thinking about how to build these scenarios. People must ask how to get from where the city is at the moment to where it aspires to be, and what kind of policy changes and investments are required to facilitate that transition.

*Some projects will be over in the next three weeks, some will be over in the next three years, some will shape what the city is like in 30 years time"*

LAWRIE ROBERTSON
Happold Consulting

Imagining change or action over the short term, including over the next 5 years, can be easier than thinking about how a city and its needs may change over a 20 or even 50 year timescale. The planning processes to meld short-term and long-term considerations, and to balance them when they are in conflict, are not currently well developed. The needs, resources and financial capacity of cities in the developed world are very different from that of cities in the developing world. One striking feature of developing countries is the speed at which they are changing, making long-term planning more difficult or at least less certain. It can be hard for local people to imagine the future because they are travelling so fast and caught up in what is currently happening. When scenario planning in Surat, India, was undertaken with the Chamber of Commerce and the city government, asking workshop participants to describe their city ten years ago ('backcasting') enabled them to see how far and how quickly they had travelled, and how the pace was accelerating. This helped the planners to develop a longer-term perspective and start thinking about where the city might go.

*"We are living in future cities now and we need to start now to achieve a sustainable future."*

KIRSTEN HENSON
KLH Sustainability

# Cities will change in different ways

All cities have common problems: providing housing, transport and infrastructure for expanding populations. However, cities in the developing nations have less 'lock-in' to past investments, and hence they may be more nimble at responding to innovation. Innovations are less disruptive in such cities, enabling them to lead the way in making the transition to ambitious sustainability aspirations.
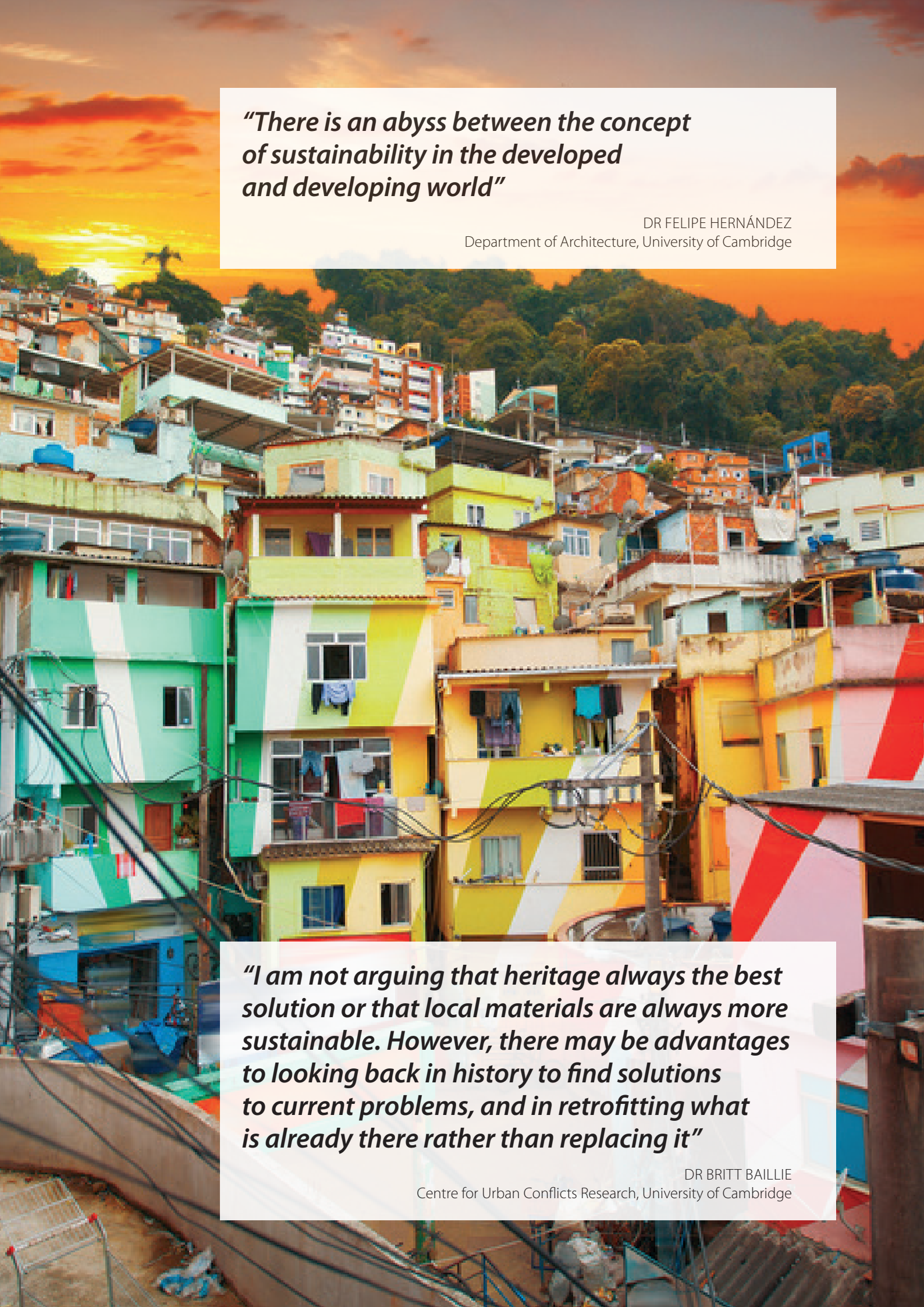
However, we should question whether such aspirations always need to follow concepts exported from developed countries. What does a 'modern' city look like? Should all cities aspire to gleaming skyscrapers, wide boulevards and green parks, despite differences in their historical development? Developed countries are perhaps exporting models of idealised 'global cities' – often through international aid – to cities in other parts of the world without questioning whether these models are suitable. Buildings that are seen as 'modern', such as glass skyscrapers, may not be suited to hotter countries and future changes in climate. Factories have previously been exported to developing countries, which are now taking 21st century technology and trying to follow the same path as industrialised countries to support that technology. Imported technology can represent the end point of a transition, rather than being the most appropriate means to facilitate the desired transition.

Cities are intrinsically connected to the countryside around them. This 'hinterland' provides essential resources such as water, food and energy. Cities in developing countries draw more on these surrounding areas for resources, such as firewood or wild food, than cities in developed countries: in some cases so heavily that they are threatening the resources and the ecosystems they depend upon. For example, we can observe 'waves' of deforestation and resource depletion spreading out from the city of Dar es Salaam in Tanzania.

Are there ways of creating a better symbiosis between the rural surroundings and cities and avoiding the reliance of richer cities on a global supply chain that could be disrupted by climate change or other future uncertainties? Do lessons from transitions in developed nations hold anything of value for cities in developing nations who have very different connections to their surrounding landscape?

*"Cities need to be flexible, agile and able to respond to whatever shocks and stresses come their way in future."*

STEPHEN ALDRIDGE
Department for Communities and Local Government

*"There is an abyss between the concept of sustainability in the developed and developing world"*

DR FELIPE HERNÁNDEZ
Department of Architecture, University of Cambridge

*"I am not arguing that heritage always the best solution or that local materials are always more sustainable. However, there may be advantages to looking back in history to find solutions to current problems, and in retrofitting what is already there rather than replacing it"*

DR BRITT BAILLIE
Centre for Urban Conflicts Research, University of Cambridge

# 'Best' versus 'good enough'

As explored in the section on 'making the invisible city, visible', the broader issue of environmental sustainability may not be about the most advanced or perfect solution or even about best practice, but rather 'good enough' practice for people who have little or no money or help from governments. Can we find solutions to sustainability questions which are not necessarily perfect but which are just 'good enough' and so easier to implement in practice and better able to reach the most vulnerable residents? Is it possible to develop a principle of 'good enough' as robust as that of the precautionary principle to specify precisely what that means in terms of engineering, finance and planning practices?

The concept of 'good enough' appears in decisions on acceptable levels of city air pollution. Even when a regulatory standard is met, the air is still not completely free of pollutants, but 'free enough' to keep adverse effects at acceptable levels. Can we, and should we, apply this concept more broadly to sustainability? If applied to structural design, services, houses and infrastructure, 'good enough' could allow us to build less engineered, less expensive and more rapidly constructed buildings, which could benefit many more people. However, this could lead to more buildings and structures collapsing and killing people. Should we be prepared to design for an increased level of failure in certain circumstances? And can we put in place early warning systems so that when 'good enough' buildings or infrastructure fail, people can be moved out of harm's way?

A substantial problem lies in both where that minimum 'good enough' threshold is set and who decides where that is and what trade-offs are made as a result. For example, if we cannot build a seawall that will be effective against all climate scenarios, should we build one at all? The ideal answer would be that everybody is protected or at least that the most vulnerable are protected first. This leads to the following key questions: what is the minimum standard of protection, and how many and which people should this encompass?

How could the concept of 'good enough' square with international standards, particularly if such minimum requirements have already been established in richer nations and before monitoring systems have developed? There are an increasing number of international standards and legislation governing different aspects of environmental sustainability. For example, the British Standards Institution (BSI) works with thousands of businesses and organisations in more than 150 countries to implement standards ranging from energy and environmental management to occupational health and safety.

Might applying the concept of 'good enough' lower our environmental ambitions and lead to lock-in of existing technologies with lower environmental performance? Ambitious legislation on energy performance in the UK has fundamentally changed how the building industry operates. Should we be content with 'just' good enough solutions that only lead to incremental changes, or can 'good enough' also include transformational decisions? Can a redefinition of 'good enough' shift the centre of 'gravity within an industry to catalyze more fundamental changes?

*"The human element of cities, the human adaptive capacity has to be central to what we're doing."*

JO DA SILVA
Arup International Development

# The research challenge on the horizon

**What can we conclude about the concepts of satisficing and optimisation in regard to making the transitions to more sustainable cities?**

Ideally, we would have the knowledge, time and resources to find the optimal solution to any problem of sustainability and then implement it. In reality, we rarely have all three of these requirements, especially as sustainability challenges such as climate change, resource depletion, global recession and biodiversity loss are coming over the horizon rapidly. Now is the time to develop a principle of 'good enough' as robust as that of the precautionary principle to specify precisely what that means in terms of engineering, finance and planning practices. The next step is to design a system of monitoring the performance of 'good enough' systems so when they fail, they do so with forewarning.

Satisficing Solutions

# In conclusion

**What measures can be taken to make cities more resilient to disasters or to climate change?**

**Can we rethink how we design and live in cities? What will the impact of increasing numbers of people living in cities be on society, biodiversity or food, water and energy security?**

**What do we know at the moment, and where are the gaps we must fill to arrive at sound decisions which will improve the sustainability of cities?**

These were some of the questions that framed our monthly meetings between October 2013 and June 2014. Each month the Forum assembled with a panel of expert 'witnesses' and discussed their perspectives on the characteristics of a sustainable city and the governance systems needed to support them. Witnesses consisted of decision makers, business leaders and research experts, and their backgrounds included the social, biological and physical sciences as well as the arts and humanities. However, they all worked in three overlapping areas regarding cities: where we live, how we live and how we adapt. These fundamental questions were then expanded to form a report consisting of six sections.

The speed and the scale of growth for future cities led to questions about the size and form of future cities, and how building design can influence both environmental and social sustainability. Most cities will face challenges concerning how to manage and build on their existing populations and infrastructure while growing, or in some cases declining. Thus a section regarding 'Designing cities' considered the need for a global effort of comparative analysis to compare and contrast the performance of cities across an array of social, environmental and economic indicators.

How do resources, people and goods link and influence each other within, around and between cities? Green spaces in cities – parks, gardens, canals and waterways – are an ideal testing ground for ideas related to connectivity and flow as they are crucial to our physical and mental wellbeing, local economies and the environment. The section 'Green spaces' therefore looked at what we need to know regarding the scale, location and design of green spaces for the betterment of cities and their inhabitants.

Technology and big data can radically change the way people live in cities. A much broader question concerns how 'smart' data and smart cities can significantly and positively impact the environment and the lives of city inhabitants and whether technological solutions are always appropriate. Accordingly, one section explored 'Making the invisible city, visible' by creating information and communication-enabled sensor and data systems that usefully reveal new ways of improving a city's sustainability.

Governance is a key issue in cities but there are many different levels of governance ranging from national to regional, county and city levels as well as the public and private sector. At what level should decisions be made and how can cities be more inclusive in their decision-making? The section 'Top-down or bottom-up' examined the need for smooth transitions when different levels of decision-making and governance come into conflict.

Cities are often considered as systems whose growth must be managed in coordinated fashion. In reality, much of what really happens in cities is completely unplanned and resides in the hidden elements of a city: the slums and the illegal and informal networks. Consequently, 'over planning' all parts of a city's system can be problematic or even counterproductive. The section 'Cities in a changing world' highlighted the need to design cities that can operate as living laboratories for experimentation in uncertain environments.

Every city is unique. Nevertheless the concepts of resilience and the capacity to learn and adapt to new situations are fundamental to ensuring a sustainable city. There may be sustainability solutions which are not perfect from the perspective of systems optimisation, but which are 'good enough'. The final section called 'Finding 'satisficing' solutions' looked at the need to establish and define a 'good enough' principle for urban engineering, finance and planning.

The Forum and Cities of the Future Report identified the key areas where a lack of knowledge is reducing the ability of society to make sound decisions and encourages researchers to fill these gaps. Throughout the process, the focus was cross-disciplinary and examined the problem of recognising, designing and operating sustainable cities. The Report is designed to be a thought-provoking appraisal of the challenges for future cities and the areas in which our current ways of thinking need to be tackled by future researchers and decision makers. Addressing the questions in this report will help us to forge sustainable cities that can respond to these dynamic challenges.

# FORUM MEMBERS, WITNESSES AND GUESTS

# Forum members

There are around 25 core Forum members at any one time. For this topic, members were drawn from 15 University departments, centres and institutes, ranging from History and Philosophy of Science, Engineering and Architecture to Social Anthropology and Astronomy, as well as the British Antarctic Survey and cross departmental initiatives working on food security and biodiversity conservation. People from the Cambridge Institute for Sustainability Leadership (CISL) and the Cambridge Centre for Science and Policy (CSaP) are also founding members of the group.

The Chair of the Forum is Lord Martin Rees, Emeritus Professor of Cosmology and Astrophysics, Department of Astronomy. The Forum's Director is Professor Paul Linden, G.I. Taylor Professor of Fluid Mechanics in the Department of Applied Mathematics and Theoretical Physics (DAMTP). Dr Rosamunde Almond is the Deputy Director and she is also based in the Department of Applied Mathematics and Theoretical Physics (DAMTP).

Forum members included:

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|---|---|
| Dr Bhaskar Vira | Director, University of Cambridge Conservation Research Institute and Reader in the Political Economy of Environment and Development, Department of Geography |
| David Cleevely | Founding Director, Cambridge Centre for Science and Policy (CSaP) |
| Professor Doug Crawford-Brown | Executive Director, Cambridge Centre for Climate Change Mitigation Research (4CMR), Department of Land Economy |
| Dr Emily Shuckburgh | Head of Open Oceans, British Antarctic Survey |
| Gordana Najdanovic | Head of Partnership Development, Research Strategy Office |
| Dr Helen Curry | Peter Lipton Lecturer, Department of the History and Philosophy of Science |
| Dr Hildegard Diemberger | Senior Associate in Research, Mongolia and Inner Asia Studies Unit, Department of Social Anthropology |
| Professor Koen Steemers | Head of Department and Professor of Sustainable Design, Department of Architecture |
| Professor Larry Sherman | Director of the Institute and Wolfson Professor of Criminology, Institute of Criminology |
| Dr Mike Rands | Executive Director of the Cambridge Conservation Intiative, based at the Judge Business School, Cambridge Conservation Initiative |
| Dr Miles Parker | Associate Fellow, Cambridge Centre for Science and Policy (CSaP) |
| Nicolette Bartlett | Senior Programme Manager, Corporate Leaders Network for Climate Action (CLN), Cambridge Institute for Sustainability Leadership (CISL) |
| Professor Peter Guthrie | Director of the Centre for Sustainable Development, Department of Engineering |
| Polly Courtice | Director , Cambridge Institute for Sustainability Leadership (CISL) |
| Dr Tiago Cavalcanti | University Senior Lecturer, Department of Economics |

# **Witnesses**

A selection of experts or 'witnesses' were invited to each monthly meeting to provide their perspective on sustainability and governance in future cities and to answer questions about the greatest challenges they face in their area of expertise. One of the aims of holding these witness sessions was to bring people together who would not usually meet each other but who are working in areas which overlap enough to stimulate an interesting discussion. Forum witnesses included:

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|---|---|
| Professor Alan Short | Professor of Architecture, Department of Architecture, University of Cambridge |
| Sir Alan Wilson | Professor of Urban Regional Systems, University College, London, and chair of Foresight 'Future Cities' expert panel |
| Alex Nickson | Policy and Programmes Manager for Climate Change Adaptation and Water at the Greater London Authority |
| Professor Ash Amin | 1931 Professor and Director of Research in the Department of Geography, University of Cambridge |
| Dr Britt Baillie | Affiliated Lecturer in the Division of Archaeology and a Research Member of the Centre for Urban Conflicts Research, University of Cambridge |
| Carmel McQuaid | Manager of Sustainable Business at Marks and Spencer |
| Professor Catharine Ward Thompson | Professor of Landscape Architecture, University of Edinburgh and the Director of the OPENspace Research Centre |
| Dr Craig Davies | Senior Manager, Climate Change Adaptation at the European Bank for Reconstruction for Reconstruction and Development |
| Dr David Ogilvie | Programme Leader at the Medical Research Council Epidemiology Unit, University of Cambridge |
| Dr David Pencheon | Director of the, National Health Service's Sustainable Development Unit |
| Diane Haigh | Director of Allies and Morrison, Architects and Fellow and Direct of Studies at Trinity Hall, University of Cambridge |
| Dr Felipe Hernández | Senior University Lecturer in the Department of Architecture, University of Cambridge |
| Dame Fiona Reynolds | Master of Emmanuel College |
| Professor Frank Kelly | Professor of the Mathematics of Systems, Statistical Laboratory, University of Cambridge |
| Jo da Silva | Director of Arup International Development |
| Jon Alexander | Founder and Director, The New Citizenship Project |
| Kirsten Henson | Director of KLH Sustainability |
| Professor Lawrence Sherman | Wolfson Professor of Criminology and Director of the Institute for Criminology, University of Cambridge |
| Lawrie Robertson | Partner and Director at Happold Consulting |
| Professor Marcial Echenique | Emeritus Professor of Land Use and Transport Studies, Deptartment of Architecture, University of Cambridge |
| Mark Kleinman | Director of Economic and Business Policy, Greater London Authority |
| Professor Mike Batty | Professor of Planning and Chairman of the Centre for Advanced Spatial Analysis, Faculty of the Built Environment, University College, London |
| Professor Richard Sennett | Professor of the Humanities, New York University and Centennial Professor of Sociology, London School of Economics |
| Simon Marsh | Head of Planning Policy, the Royal Society for the Protection of Birds |
| Stephen Aldridge | Director for Analysis and Innovation at the Department for Communities and Local Government |
| Professor Steve Evans | Professor and Director of Research in Industrial Sustainability at the Institute for Manufacturing |

# Guests

Each month, experts who work in the areas we are discussing join our meetings as guests.  For this topic, people from within the University included

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|---|---|
| Professor Alan Short | Professor of Architecture, Department of Architecture |
| Professor Alison Smith | Professor in the Department of Plant Sciences, Department of Plant Sciences |
| Dr Britt Baillie | Affiliated Lecturer in the Division of Archaeology and a Research Member of the Centre for Urban Conflicts Research, Department of Archeaology |
| Ed Barsley | Graduate student in the Department of Architecture |
| Dr Felipe Hernández | University Lecturer and one of the researchers in the 'Cities South of Cancer' initiative, Department of Architecture |
| Dr Heather Cruickshank | University Lecturer, Department of Engineering |
| Jamie Anderson | Graduate student in the Department of Architecture and Knowledge Transfer Fellow at BuroHappold |
| Dr Max Sternberg | University Lecturer, Department of Architecture |
| Dr Peter Hedges | Head of the Research Strategy Office, Research Strategy Office |
| Samir Doshi | Research Associate in the Industrial Sustainability group, Institute for Manufacturing |
| Professor Wendy Pullan | Senior Lecturer in the History and Philosophy of Architecture and Director of the Martin Centre, Department of Architecture |
| Dr Ying Jin | Senior Lecturer, Department of Architecture |

Guests also joined us from across and outside Cambridge:

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|---|---|
| Professor Charlie Kennel | Formerly the Director of the Scripps Institute of Oceanogaphy, University of California, San Diego |
| Dr Claire Craig | Deputy Head, Government Office for Science |
| Darren Ferry | Planning and Environmental Manager, Kier |
| David Hart | Head of Economic Regulation and Quinquennial Review and a CSaP Policy Fellow, British Airways |
| Deborah Pullen | Group Research Director, Building Research Establishment (BRE) |
| Diane Haigh | Director of Allies and Morrison, Architects |
| Eleri Jones | Leading the Secretariat for the Foresight Future of Cities project, Government Office for Science |
| Hywel Lloyd | Advisor, clients include Stoke-on-Trent City Council, NESTA, HWL Special Projects Ltd |
| Mark Dowson | Sustainability engineer, Buro Happold |
| Mike Ratterman | Responsible for the Sustainability Plan at the Arup Building, Kier |
| Richard Morris | Farm Manager, Wimpole Estate, Cambridgeshire, National Trust |
| Stijn van Ewijk | Institute for Sustainable Resources, University College London |

**The Cambridge Forum
for Sustainability
and the Environment**

**Cities of the Future Report
2017**

# Cambridge Forum for Sustainability and the Environment

The Cambridge Forum for Sustainability and the Environment (CFSE) is a Forum in the University of Cambridge that aims to stimulate cross- disciplinary conversations about some of the great sustainability challenges the world faces in the future, and the research pathways which will help to prepare for and address those challenges.

The overarching theme for the Forum is 'sustainability in an uncertain future'. Specific topics change each academic year, and these are designed to enable CFSE to bring together a broad range of academics and experts from industry and policy to discuss research challenges with global implications. This report provides key insights from discussions during the first year and subsequent topics have included land-use change, exploring 'risk, resilience and response' in the context of cities, food and water supplies, and energy, and forging connections between health, wellbeing and sustainability.

More information about the Forum and outputs from these topics can be found at:

**www.cfse.cam.ac.uk**

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