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Urban form and infrastructure: a morphological review

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Urban form and infrastructure: a morphological review

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Contents

Executive summary

The report provides a baseline analysis of, and a forward look at, urban form and infrastructure in the UK. It sets out the legacy of development in the post-war period, and explains how settlement patterns have evolved in relation to investments in infrastructure (for transport, energy, water, waste, ICT, health and education). It provides a summary of the positive and negative consequences of the UK's key development patterns: compact and contained established towns and cities; edge and out-of-town developments; peripheral housing estates and urban extensions; newer settlements; and dispersed developments. It then considers emerging approaches to the governance of urban form and infrastructure, with potential lessons for the UK, in the face of a number of challenges and uncertainties related to climate change, economic instability, and demographic and social shifts. Finally, the report offers an analysis of plausible future options for the development of: a) existing places (via compaction/containment, the development of polycentric city regions and managed shrinkage); and b) new developments (via peripheral growth, new settlements or dispersed developments). The report concludes with a number of conditions necessary for the effective delivery and management of urban form and infrastructure to 2065.

Part 1 - Baseline analysis: urban form and infrastructure in the UK

1. Introduction: urban form and infrastructure in the UK - framing the debate

The purpose of this report is to twofold. First, it sets out a baseline analysis of the UK's urban form and infrastructure in the post-war period. This includes a brief historic review, and evaluation of the legacy of development patterns. Second, the report takes a forward look at plausible urban form futures, to 2065. This includes an analysis of the challenges and opportunities facing cities, an evaluation of how 'successful' different urban form options might be in the future, and the conditions that would enable them. First, it is useful to provide some key definitions and to explain the approach taken to the study.

1.1 Urban form

Urban form is the physical characteristics that make up built-up areas, including the shape, size, density and configuration of settlements. It can be considered at different scales: from regional, to urban, neighbourhood, 'block' and street. The UK's urban form has been shaped since the beginning of human settlement, and is evolving continually in response to social, environmental, economic and technological developments, mediated by policies in numerous sectors. In the post-war period, this has predominantly been planning, housing and urban policy, as well as health, transport and economic.

Currently, the UK's urban form is characterised by 64 'primary urban areas' (see Figure 1), defined for England as areas with populations of over 125,000 and with continuous built-up land (see ONS, 2013). It has one built-up megacity region (London, and the Greater South East), six large metropolitan areas (Birmingham, Leeds, Liverpool, Manchester, Newcastle-Upon-Tyne and Sheffield), and 56 towns and cities with more than 125,000 people. Adjacent to cities and towns, and in more rural areas, are small towns and villages and a pattern of dispersed, very small settlements comprising a few dwellings.

Most settlements have largely concentric densities (high-density inner areas; medium-density outer-central areas; low-density suburbs), many with a variety of relatively modern 'edge city' landscapes, contained by Green Belts or other open (rural), and often protected, land. Within settlements, a number of historically laid morphological forms are present: including dense, irregular medieval street patterns, planned radial and grid structures, curvilinear suburban layouts, hierarchically-planned New Towns, and neo-traditional plans or 'urban villages'.

Much of the UK's urban form (in terms of settlement patterns, street layouts and so on) has been in place for hundreds of years. However, the post-war period has seen some significant changes, and the emergence of new trends, which are described in more detail below.

Figure 1: The UK's Primary Urban Areas. Source: Centre for Cities, http://centreforcities.customer.meteoric.net.puas

1.2 Infrastructure

Infrastructure is the physical and related organisational structures needed for society to operate. In the UK, 'National Infrastructure' is described as 'the foundation for economic productivity and human wellbeing' (Hall *et al.*, 2012, p.1). It provides the energy and water resources that society needs to function, and enable people, information and goods to move efficiently and safely. Infrastructure is most often categorised in terms of the services it provides. For the purposes of this report, it includes the physical aspects of the sectors that are covered in UK infrastructure policy (summarised from Hall *et al.*, 2012) and HM Treasury, 2013) (a-f in the list below, and two additional categories, g and h, which are important in the context of discussions about urban form:

a. **The energy sector:** includes electricity, gas, solar, wind, other renewables and all their ancillary 'hardware' e.g. power stations (nuclear, coal, oil, gas turbines, combined heat and power systems), grids, wind turbines, photovoltaics, and gas pipelines.

b. **Transport sector:** includes road, rail, air, cycling and walking and all the supporting facilities e.g. the trunk road network, rail network, stations, airports and seaports, cycle ways, and pedestrian facilities.

c. **Water supply sector:** includes all infrastructure needed to supply domestic and non-domestic users with water at appropriate quality and quantity, with facilities that source water from rivers, estuaries, coasts and groundwater sources through a system of water treatment plants and pipes to end users.

d. **Wastewater sector:** infrastructure required to process and dispose of waste water e.g. the system of sewers, pumps and sewage treatment works.

e. **Solid waste sector:** infrastructure required to process and/or dispose of domestic and non-domestic waste, including the system of transfer stations, recycling and other processing facilities, land fill sites, and incinerators.

f. **Information and communication technologies (ICT):** comprises all communication and computation systems, including: fixed and mobile telephony, broadband, television, navigation systems, data and processing hubs, with the associated 'hardware' of: wired and wireless networks (cables, masts, satellites), broadband, voice, data, positioning and broadcast services.

g. **Cultural and social infrastructure sector:** comprises facilities needed to keep the population healthy, educated, and with access to culture. This includes education facilities (e.g. schools, colleges and universities), health facilities (e.g. doctors' surgeries and hospitals) and cultural facilities (e.g. museums, galleries, community venues).

h. **'Green' and 'blue' infrastructure:** the interconnected networks of land and water that support species, maintain ecological processes, sustain air and water resources, and contribute to the health and quality of life of communities and individuals (Olofsdotter *et al.*, 2013).

1.3 The relationship between urban form and infrastructure

Urban areas (cities, towns and conurbations) can be seen as systems in which relatively slow-changing urban forms provide the setting for more rapidly changing 'flows' of capital, people, pollutants, cultures and technologies (Wong *et al*., 2000; Castells, 1996). In the UK, cities and towns provide the places for contemporary societies to live and for businesses to function. Within settlements, populations come and go, change in composition, develop new patterns of working and communicating and so on. Businesses evolve, their space and mobility requirements change, and capital is invested and withdrawn with significant spatial impacts.

In this context, the interrelationship between 'urban form' and 'flows' is critical to understanding societies' infrastructure needs. Much physical infrastructure is 'fixed'. The UK's transport networks, power stations, and sewer systems are the result of significant historical investment: they can have life-spans and a set geography of hundreds of years. Yet these systems need to provide reliable and high quality services within both relatively 'slow' changing urban forms and the rapidly shifting 'flows' of the 21st Century. This problem has been brought into sharp focus in the last two decades with the acceleration and intensification of flows associated with globalisation (mainly of capital and people), speeding up processes of uneven spatial change (Wong *et al*., 2000).

A key issue in most developed countries is that, with some notable historic exceptions, the governance and planning of land development, and hence of urban form, has struggled to cope with the more unpredictable nature of 'flows'. In addition, major decisions on infrastructure are often made without considering spatial outcomes. The UK does not have a national spatial plan to guide urban form. This contrasts with other European countries, such as The Netherlands, which has a spatial and infrastructure plan to 2028, see VROM, 2014). The governance and ownership, of infrastructure is now highly complex and fragmented, with much in private (global) ownership. There is a National Infrastructure Plan (HM Treasury, 2013), but this takes a sectoral approach and does not include a spatial impact analysis. This inevitably results in mismatches between forms, flows, and infrastructures, characterised by temporal time lags as the different 'systems' catch up with each other, e.g. lack of schools and public transport infrastructure in new developments, or in 'crises' such as significant house price inflation, traffic congestion, power shortages etc. (Wong *et al*., 2000).

It may be that such 'instability' is inevitable in such a complex 'system of systems'. Indeed, many have argued that cities are "[…] examples par excellence" (Batty, 2008, p.770) in coping with change and providing resilient networks. However, the 21st Century provides a new set of challenges for the UK which could potentially destabilise current systems, or at least test them more than in the past. The first decade of the 21st Century, with its deep recession, unprecedented peace time migration, the acceleration of movement of global capital, and extreme weather events highlighted the types of 'shocks' that the UK needs to be able to adapt to. In the future, further demographic change, climate change, resource insecurity, 'peak loads', growing income disparities, and new technologies are all likely to have profound consequences for urban form and infrastructure.

1.4 Approach taken in this report

The purpose of this report is to better understand the links between urban form and infrastructure, in the context of the uncertain flows they might have to adapt to, and to explore which future options for urban form in the UK would be 'successful' (see definition below). It does not to propose a spatial plan for the UK, but explores conceptually a range of urban form options, and their performance in relation to various future challenges.

The aim is to build a picture of interrelationships between form and a variety of infrastructure systems, and to explore how these might be affected in the future: this is not a 'modelling' exercise, but a scoping of potential forms, infrastructures, flows and their impacts. By taking such an approach, compromises are made between complexity and simplification, and between 'place-specific' and conceptual scenarios. The aim is to present a broad, evidence-based analysis, and a discussion of 'plausible' futures. The focus is the UK, and key metrics, cities, infrastructure projects etc. will be referenced. However, there is a limit to the place-specific, sectoral and technical detail that can be included.

The report presents knowledge on urban form, from social science and policy literature, and urban science (quantified and modelled studies of urban form and systems). The purpose is to understand how urban forms function, without forgetting that they need to be liveable, and are produced within socio-political contexts (Batty, 2008).

The report is split into two parts: **Part 1: a baseline analysis of urban form and infrastructure in the UK**, and **Part 2: an evidence based evaluation of plausible urban form futures to 2065**.

Part 1:

- Presents the historical development of urban form and infrastructure in the post war period; and
- Analyses the positive and negative legacy of these patterns in terms of potential future growth.

Part 2:

- Sets out emerging international debates and ideas on urban form and infrastructure, drawing out potential lessons for the UK;
- Identifies broader challenges, opportunities, and uncertainties that might affect urban form in the future.
- Sets out the implications of these challenges and opportunities for the governance of urban form and infrastructure;
- Sets out criterion for 'successful' urban form and infrastructure; and
- Examines six different urban form options for the UK (redeveloping or extending existing places, and developing new settlements).

It is worth commenting on how the most 'successful' urban forms and infrastructure options are defined in this report. Debates about the 'best' urban forms are not new. In the past, discussions have focused on which urban forms deliver 'healthy' places (in the industrial and early post-industrial periods); better quality of life (for example, in the garden cities movement); efficiency and functionality (in the modernist period); and competitiveness and 'uniqueness' (in the post-modern context).

Current dominant conceptions are related to 'sustainable urban forms' (incorporating environmental, economic, and social aspects) and, increasingly, to 'resilient urban forms' (factoring in the potential for environmental, social and economic shocks). The debate relating forms to resilience is relatively new and focuses mainly on issues such as economic collapse and population decline (shrinking cities), peak energy, and climate crises.

For the purposes of this report, 'successful' urban forms combine elements of broad conceptualisations of sustainability and resilience, and are defined as those that: **underpin the functioning of an array of urban systems, use resources sustainably, and provide a sound economic base that provides the setting for a good quality of life for their inhabitants. In addition, they can withstand shocks and 'bounce back' or improve their conditions post-shock** (whether that shock be environmental, economic, or social). The exact physical conditions that underpin these qualities are widely contested. This broad definition is elaborated upon in the evaluative parts of the report.

At its most basic, infrastructure can be seen as 'successful' when it **meets demand and provides reliable, cost effective, and high quality services** (Hall *et al*., 2012).

However, this definition encompasses an array of issues that are widely debated in different infrastructure sectors around, for example: the side effects of infrastructure development (notably environmental and economic impacts); the affordability and accessibility of services; the balance between different infrastructures; and the resilience and sustainability of different infrastructure options. Again, this simple definition of 'successful' infrastructure (in bold above) is used throughout the report, but the broader issues are explored in the evaluation sections. For both urban form and infrastructure, it may be that global challenges now require a re-evaluation of what is meant by successful, and this possibility is discussed further below.

2. Dominant urban form and infrastructure trends and their causes

Patterns of development in the UK in the Post War period have been influenced significantly by historic settlements and infrastructure. After the War, significant investments and national engineering projects provided the UK with a legacy of cities, towns, and villages served by a road and rail network, an aging but widespread water supply and waste water infrastructure, and a centralised, but limited, system of gas and electricity infrastructure. There was an inherited stock of pre-war hospitals, schools, leisure, and cultural facilities (such as museums), but many were in need of modernisation.

During some of the pre-war period, development followed infrastructure and, at other times, infrastructure followed development. However, the post-war era heralded a new optimism that the state could 'predict' trends in population, mobility and so on, and 'provide' the required physical development and infrastructure, whilst protecting the country's natural assets. For much of the post war period, this rational, 'predict and provide' approach worked relatively well and delivered: decent homes for the majority of the population; well-connected settlements; buildings for economic activity; land for leisure; agriculture and landscape purposes; and infrastructure to keep society functioning.

However, the 1980s, 1990s, and 2000s witnessed a growing disconnect between urban forms, land uses and infrastructure, and a questioning of the ability to 'plan' in the classic sense. Numerous processes related to globalisation speeded up the systems of 'flows', making it harder to coordinate urban forms and infrastructure. The following section sets out the key post-war trends in urban form and their relationship with infrastructure chronologically.

2.1 The late 1940s, 1950s and 1960s

This was a period of optimism in the ability to plan and provide for the UK's citizens after the War. The key trends were as follows:

- Development was largely focused on rebuilding damaged cities, and policy encouraged decentralising the population from crowded inner areas and providing effective infrastructure (transport, energy, water, waste etc.).

- People were rehoused in social (council) housing in peripheral estates. 21 New Towns were developed in this period in England, including Stevenage, Corby, Crawley, Telford, Runcorn, Milton Keynes and Northampton. Six New Towns were developed in Scotland, and one in Wales.

- New developments were provided with associated schools, shops (in purpose-built, open-air precincts or local ranks), and hospitals. Some modernisation and increase in capacity of existing older infrastructure took place.

- Green belts were designated around major cities, to contain development and protect rural land. Fourteen were formalised, covering approx 13% of England (and 164 km sq of Scotland) (see Figure 2 for English green belts and other primary landscape designations.

- 'Functional Zoning' was introduced to improve living standards by separating land uses (e.g. home, work, industrial, retail). Suburban and domestic life were planned away from the city centre, and social infrastructure was planned around these patterns.

- In terms of urban form, the 'ideal' was mono-centric, based on a central business district with office buildings and shops, and 'in and out' patterns of commuting from inner suburbs to work. Office and commercial space was predominantly in central locations.

- The 'high street' was the dominant retail location.

- Investment in transport infrastructure during the decades shifted from rail to roads, leading to some losses in rail services and an almost complete halt in new services. Building of the national motorway system was started in 1958, and continued throughout the period.

- There was significant investment in energy infrastructure. The 'super grid' was developed from the 1950s, with 4,000 miles of transmission lines. In the 1960s, new power stations and nuclear power generation were introduced, and the grid was extended by 1300 miles.

- There was a boom in university and school building as education expanded. Modern universities were developed to challenge traditional ones. School developments were spurred by the split between primary and secondary education, and large new comprehensive schools were built, often in housing growth areas and New Towns.

- By the end of the 1960s, growing car ownership had begun to affect development patterns significantly (Jones, 2009). This facilitated the 'spreading' of development. New settlements were planned specifically to accommodate the new car-owning middle classes.

- Towns and cities began to display more 'star-shaped' forms, as new arterial roads were built, and existing settlements expanded along them.

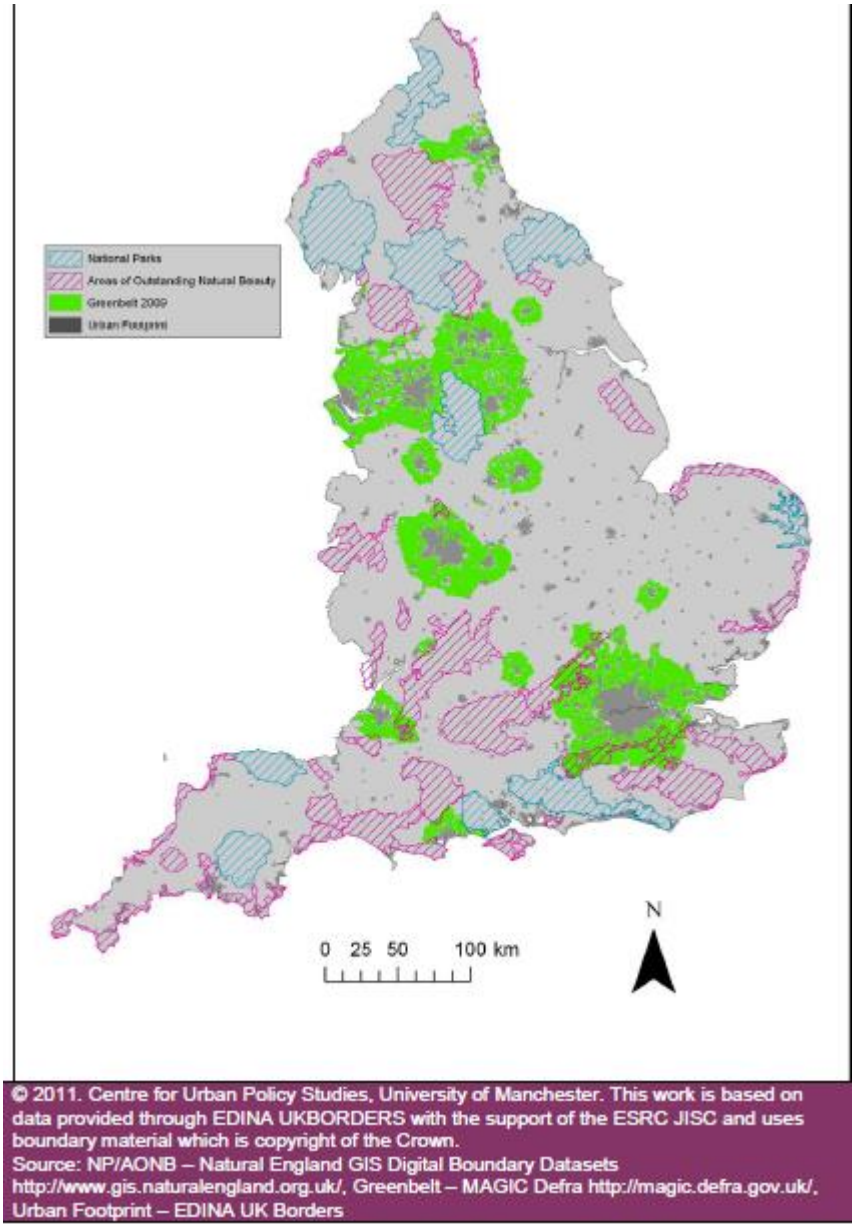

Figure 2: England's key landscape designations. Source: reproduced from Wong *et al*., 2012, original source and copyright CUPS (see foot of figure)

2.2 The 1970s and 1980s

The 1970s saw a continuation of many of the trends set in the late 1960s, particularly growing car ownership and decentralisation of populations and buildings. However, by the 1980s, deregulation and the early effects of globalisation were evident, with the following specific trends:

- Throughout the period, populations continued to decentralise, characterised by suburbanisation and the development of 'edge cities'.
- Peripheral (car-based) housing estates continued to be built, now mainly by the private sector. These often leapfrogged the immediate fringe, and were 'single use' dormitory settlements.

- The development of Greenfield sites became a political issue, especially in the South East.
- Many of the UK's main cities continued to decline, and the country experienced uneven spatial development. The South, and especially the South East, was economically strong and continued to be developed, but the 'North-South divide' (in terms of economic vitality, including land markets) widened (Wong *et al*., 2000).
- In many major cities, de-industrialisation and economic restructuring caused significant urban problems, particularly in the inner cities. But the impacts were patchy, with some cities, and some city neighbourhoods, thriving.
- Cities became less 'nodal' and more 'poly-nucleated', due to a number of macro-trends: the rapid decentralisation of economic activities, increased mobility, multiplicity of travel patterns, the fragmentation of spatial distribution of activities, changes in household structure and lifestyle, and complex cross-commuting (Davoudi, 2003; Hall & Pain, 2006).
- Decentralised clusters of employment and population emerged in new locations, such as on transport interchanges (motorway junctions etc.) and around airports. Development trends included purpose-built industrial, warehouses and business parks, and speculative housing estates, which were seen as attractive and accessible compared with those in inner city locations (Hall, 2001).
- There were significant changes in retail forms: out-of-town retailing grew, dominated by retail warehouses for groceries, DIY products, furniture, and electrical goods (Jones, 2009). This trend was fuelled by changes in population, retailing strategy, and lifestyles (especially car ownership). A number of new multi-level enclosed shopping malls were also built (mainly in inner-city locations). From the mid-1980s onwards, sub-regional and regional shopping centres provided a range of out-of-town alternatives to the high street (e.g. the Metro Centre, in 1986).
- Infrastructure provision remained relatively stable, while major restructuring of the supply markets occurred (e.g. for water, electricity, gas and public transport). Most provision was privatised or semi-privatised, and became more fragmented.
- Many large cities began to experience traffic congestion (particularly along arterial roads), so new peripheral ring roads were built. The motorway system continued to be constructed (with the M25 completed in 1986). In many places, these roads stimulated new commercial and industrial activities at the edge of cities (Antrop, 2004).

2.3 The 1990s

This was the decade when continued counter-urbanisation became politically undesirable. Stronger containment and land re-use policies were introduced and at the end of the 1990s. The 'Urban Renaissance' agenda was developed and began to have an early effect on urban form (The Urban Task Force, 1999; Williams, 2012).

- The 1990s saw the continued counter-urbanisation of people and jobs, with the population 'cascading' from the largest cities to smaller cities, towns, and villages.
- This decade also saw the beginning of a strong policy response to counter-urbanisation, with a focus on a range of 'compact city' and 'Urban Renaissance'

policies (The Urban Task Force, 1999; Williams *et al*., 2000), including higher density housing, and a preference for brownfield development over Greenfield.

- These policies, and restrictions on Greenfield land, led to redevelopment of inner-city areas, often in large new quarters, with high density flats (dockland and riverside areas were key locations).
- Open land within cities came under pressure, with 'land grabbing' of school playing fields and amenity land an issue.
- There were significant trends in subdivision of large houses into flats, and 'backland' and infill development.
- Within government policy, there was a drift away from new settlements and place-making to meeting housing numbers. Targets were set centrally, to be met locally.
- Investment in most forms of 'hard' infrastructure (particularly transport) was relatively low; although some additions to the motorway network continued. The channel tunnel opened in 1994.
- Within some cities there was a gradual transition to 'eclectic clustering' of particular new economic activities. High level financial services, technology-intensive firms, knowledge based firms and institutions, and culture and leisure activities clustered outside traditional centres in specific parts of inner cities, producing new urban landscapes. These areas attracted high tech staff and knowledge workers (new urban middle classes) (Gaspodini, 2006).
- However, some cities continued to decline, including: many coastal towns and cities; those previously based on manufacturing employment or affected by public sector restructuring; and unemployment.
- Home and work locations continued to de-couple, with traditional 'in and out' commuting patterns being replaced by a complex pattern of 'suburb-to-suburb', 'reverse' (from urban and suburban homes to non-urban workplaces), and 'split' commuting (Wong *et al*., 2000).
- New out-of-town shopping developments incorporated leisure facilities (cinemas, fast food outlets, bowling alleys, and gyms) and became significant economic and social 'hubs'. There was also a growth in outlet malls which provided significant competition to traditional retailing. The 'mega-malls' changed the centrality of major cities and created new urban forms. Many high streets and central shopping areas continued to decline.
- The university population rose significantly as a result of higher education expansion policies, leading to a growth in student accommodation, and the 'studentification' of many urban neighbourhoods.

2.4 The 2000's to the present day

During the 2000s and early 2010s there have been some marked shifts in population distribution and urban form. The post 2007 financial crisis and recession have had a significant impact, particularly on the housing market (Townsend & Champion, 2014), but global demographic shifts and UK policy changes have also been significant. The key trends are as follows:

- A far more complex pattern of development than in previous decades. There has been significant population increase in the UK as a whole, and an increase in inner-urban populations and in development in a variety of rural locales (Bibby, 2009; Champion, 2013).

- The population growth has been in all regions, with the South and East England growing fastest, but the North and West also experiencing significant gains, after two decades of urban decline, stagnation, or slow growth (Champion, 2013). The South East continued to 'heat up', with London competing well globally. This trend was seen across Europe, where capital cities fared better in the recession than second tier cities (Parkinson *et al*., 2012).

- From a position of population decline in the 1980s, and modest growth in the 1990s, metropolitan areas saw large gains in the 2000s. All other settlement types (but particularly large and small cities, and large towns) saw population increases. There were gains in small towns and rural areas too (Champion, 2013, drawing on ONS, 2013). This is, in part, a result of Urban Renaissance policies (DETR, 2000) (i.e. house building in inner- London, Liverpool, Salford, Newcastle, Leeds and Birmingham), but also of net immigration and the continued expansion of higher education (Rae 2013; Champion 2006). For example, between 2001 and 2011 Manchester's population grew by 19%, London's by 12% and Milton Keynes' by 17%.

- Major new housing provision was planned to be in 'sustainable communities' (ODPM 2003; 2005) with allied new infrastructure provided via public/private partnerships (concepts of New Urbanism and Urban Villages were influential). The plan was to regenerate an urban belt in Northern England (from Hull to Liverpool) and provide thousands of homes in the Thames Gateway, around Luton, Milton Keynes and Cambridge. Although large numbers of homes were built, less than half of the government's targets were met, and much housing was developed without adequate infrastructure (e.g. public transport facilities, schools, leisure) (Power, 2004; Williams, 2007).

- Suburbs also accommodated a large proportion of new development through intensification: From 2000–2004, 18% of England's net housing increase was in existing suburbs, and London's suburbs accommodated 69% of all new dwellings in the capital (Bibby, 2009).

- In many places the abovementioned changes represented a fundamental and rapid reorientation and realignment of the populations and functions of central areas and different quarters within them.

- In many cities the demographic changes have been coupled with new popular leisure and cultural hubs, with bars, clubs, restaurants, museums and galleries (Gaspodini, 2006).

- However, these changes are not spatially or socially neutral: much re-urbanisation has taken the form of gentrification, with deprived neighbourhoods seeing little change (Rae, 2013). Students and young professionals tend to dominate the 'new urban' classes, but fewer affluent older people, families, or older people in general have relocated (Champion, 2006).

- Average household size continued to decline (although this trend is now stabilising), with more older people, single dwellers, and couples without children. This means that

as well as population, household numbers also increased. In many neighbourhoods populations 'thinned', with fewer people in the same number of homes.

- The proportion of development taking place in rural areas in the 2000s was significant and still driven by out-migration from England's larger cities. A quarter of all new housing (2000–2004) was built in small settlements of less than 10,000 people (Bibby, 2009). This includes dispersed residential development within villages, hamlets and isolated farms. Between 2000 and 2004 this accounted for 30% of all land used for housing (barn conversions were a major trend: there were 28,000 by 2008). These homes are usually inhabited by those commuting to towns and cities for work (Bibby, 2009).

- These development patterns have an impact on the rural landscape, with the countryside affected becoming a complex multifunctional space within a 'larger urban network'. In many cases, traditional rural landscapes have become more fragmented (Antrop, 2004).

- A number of new 'eco-towns' were planned to meet the housing need, but only two are being pursued.

- New commercial development was largely outside urban areas in peri-urban locations, and mainly on previously developed land. There were increases in low intensity storage and distribution warehouses close to transport interchanges, and development on ex-public land, such as air fields (Bibby, 2009).

- Urban form began to be affected by new ICT. The effects of telecommuting, outsourcing, and hot-desking all led to changes in demand for commercial space, especially reducing demand for centrally located buildings (Jones, 2009; Dixon 2005; Dixon *et al*., 2003).

- New retail space was spread more evenly than in previous decades. There was a policy-driven slowdown in out-of-town development, some peri-urban development, and a renaissance of new retail within urban areas, particularly in regional capitals. Retail development was, however, affected significantly during the recession and many small towns and district high streets are still in decline.

- There was a continued lack of public investment in infrastructure and few major projects, although there was some continued road development, e.g. the M60 was completed, and there were road and rail projects in London and the Thames Gateway.

- More recently, there has been a new policy focus on infrastructure, prompted by the role of infrastructure projects in stimulating economic growth, a realisation of the UK's relative vulnerability (particularly in the energy sector), and the consequences of market fragmentation (Hall *et al*., 2012). To enable long term investment, develop long term plans, and priorities and improve delivery, there is a National Infrastructure Plan (HM Treasury and Infrastructure UK 2011; HM Treasury 2013) setting out infrastructure needs in the UK. It identifies a pipeline of over 500 infrastructure projects (mainly energy and transport) to 2015 and beyond. HS2, airport expansion, and renewable energy infrastructure are priorities.

3. Urban form and infrastructure legacy and associated challenges

The historic development patterns described above have produced a complex pattern of urban form and infrastructure across the country. Overall, much of the UK's building stock and infrastructure is very old and will need significant modernisation or replacement in the coming decades (HM Treasury, 2013). New infrastructure and buildings for a range of uses will also be required to provide the UK's inhabitants with a decent quality of life, and to ensure the country remains competitive. The key legacy issues facing the UK are as follows (for **urban form** first, then **infrastructure**, and then **in combination**):

3.1 Urban form legacy

3.1.1 A relatively small total proportion of built-up land, but high density settlements

On the whole, containment and planning policies have been relatively successful in guiding development to existing built up areas and protecting valued greenspace. The UK is one of the most densely populated countries in Europe, but even so, only approx. 13% of land is now built on, with the rest being agricultural, woodland and protected natural environments (Williams, 2009). The UK has a legacy of valued, historic built environments and natural landscapes, with a mixture of largely successful post-war planned settlements, and less successful car-oriented schemes. Much of the problematic post-war social housing has now been demolished, remodelled or sold into private ownership. However, critical decisions need to be made about the future requirements for land, the 'capacity' of the country to support different population sizes (the UK's population is projected to rise to 78 million by 2037) (ONS, 2014), and the need to use land for different purposes and in different forms in the future.

3.1.2 Uneven spatial development

The South East dominates the UK's built up urban area (in terms of population, housing densities and land cover), with many describing the region as 'overheated'. London is a global megacity, with a broad regional impact (Clark & Clark, 2014). The rapid development of the South East has not been matched by adequate housing and infrastructure provision, especially transport. Other regions of the UK, particularly outside of city centres in the north, do not demonstrate the same urban development patterns. In these places it is difficult to recycle brownfield sites and to attract infrastructure investment. This raises challenges in terms of infrastructure provision associated with uneven demographic and economic conditions, particularly given projected future trends in climate and resources.

3.1.3 An emerging urban revival in some cities

Some indicators point towards an upturn in the UK's core cities and some other cities and towns (e.g. in selected coastal towns). However, some have not recovered from structural changes and continue to experience decline (characterised by deprivation, low productivity and poor health). This raises challenges about how to improve the conditions in all cities in a globally competitive market.

3.1.4 A new edge city

The proliferation of new 'edge' landscapes in the UK in the post war period is marked. Many major cities and towns are now surrounded by new forms of retail, leisure, industrial and business parks, miscellaneous warehousing and large employment buildings, ring roads, and motorway interchanges. Such developments are rarely the outcome of 'positive planning' at the local level, but are pragmatic or strategic responses to the need for economic development and new infrastructure. These landscapes bring challenges about how they can be integrated into cities, and become more sustainable in the longer term.

3.1.5 Not enough homes to meet demand

Although there has been a steady flow of house building since the war, there has been a slowdown for several decades. In addition, social housing has been sold into private ownership, and rates of new social housing construction have declined steeply. These factors have combined to leave the UK with significant housing shortages (e.g. in 2012, 230,000 new households were formed, and only 98,280 homes built, DCLG, 2014), and an affordability crisis. The homes that have been built recently are among the smallest in Europe (Williams, 2009). This raises the challenge of how to provide decent, affordable, housing that is fit for purpose for all.

3.1.6 New retailing and commercial landscapes

The lifecycles of retailing and office space have evolved rapidly since the War. We now have a mixed legacy of central, peripheral and out-of-town locations. In some places, large regional retail and commercial developments have had a significant and negative impact on nearby retailing centres (see, for example, Guy's study of Cardiff, 2010). In others, markets have grown and diversified, and different types of settings thrive simultaneously. This raises questions about if, and how, change in the sector can be managed and about the impacts of different support strategies.

3.1.7 A changing rural landscape

The considerable development in the last 30 years, but especially in the last decade, in rural areas, villages and small towns has dispersed the built-up area. Some have argued that this form of development is akin to a new form of sprawl. This raises questions as to whether such patterns are sustainable, and should be curtailed.

3.1.8 Car-dominated urban form

Much post war urban development has been facilitated by, and planned for, car use, locking residents into car use as they have no other viable ways of travelling. This has led to lower density housing estates on the edge of cities and in more rural locations, and facilitated accessibility to edge-city leisure, retail and employment locations. This raises challenges as less carbon intensive futures are sought and as fuel prices rise.

3.2 Infrastructure legacy

Much of the UK's infrastructure predates the War. Major road, rail, water, and waste infrastructures were set in place historically. The Post War period saw the development of the motorway network, new power stations, and the development of the electricity grid. Hospitals and other health facilities, universities, schools, and cultural facilities, localised water and energy infrastructure largely kept pace with new urban developments and

settlements, with some shortfalls in the last few decades (particularly around public transport provision). The UK's infrastructure is now ranked 28th in the world according to the World Economic Forum's Global Competitive Report (2013). This is below France and Germany, which are ranked in the top ten, although our ICT infrastructure is ranked in the top 15, Hall et al, 2012. The key legacy issues facing the UK now are:

3.2.1 Infrastructure 'lock in'

The legacy of infrastructure and the investments it embodies mean that the UK is 'locked in' to certain spatial patterns, behaviours, and policies at least in the medium term (Hall *et al*., 2012; ULI and BBW, 2014). This raises challenges about whether these past patterns are desirable, given future trends, and if and how transitions can be made. The most obvious concerns are in the transport (road and air), energy (centralised supply), and waste (incineration and landfill) sectors where more sustainable futures are required.

3.2.2 Lack of capacity

The nation's infrastructure was planned and provided for largely historic conditions. Although much of it had some capacity for future growth, in some sectors that is now being reached or breached due to demographic, social, cultural, economic, and environmental changes. Problems of 'peak load', when a city's infrastructure cannot cope with the demands on it, are a real risk (Gann quoted in CBI, 2012). Traffic congestion and power cuts are the most obvious manifestations, but parts of the UK are also reaching capacity in water supply and landfill (Hall *et al*., 2012). Challenges arise around strategies to cope with capacity issues, and debates focus on demand management, pricing mechanisms, and increasing capacity.

3.2.3 Sectoral separation

Different infrastructure sectors have largely been planned and provided independently. They now have different governance and regulatory structures and, with the possible exception of transport, are not planned comprehensively in relation to their future spatial impacts. This leads to systemic weakening of the resilience of systems. The link between energy and all other sectors is particularly important (Hall *et al*., 2012).

3.2.4 Ageing infrastructure and lack of investment

A considerable amount of infrastructure was built in the 19th Century (e.g. over 44% of London's water mains are over 100 years old) and therefore requires repair, modernisation, or upgrading (Hall *et al.*, 2012). ICT infrastructure also needs to be continually developed (Indovina, 1999). The challenge is how to meet this need. The past several decades have seen uncoordinated, incremental, and inefficient spending (HM Treasury and Infrastructure UK, 2010), with investment in infrastructure as a percentage of GDP reducing significantly (Hall *et al.*, 2012). A £250 billion investment is planned over the next 5 years, and the energy sector alone will require £200 billion between now and 2020 (HM Treasury and Infrastructure UK, 2011).

3.2.5 A partially planned network of green and blue infrastructure

The UK has protected its waterways and greenspaces relatively well. Most towns and cities have networks of private and publicly owned greenspaces (gardens, parks and so on) and of rivers, lakes, and streams, and in some places, coastal resources. These spaces and water resources have been protected historically for their amenity and

landscape value. More recently, their contribution to ecosystem services has been recognised. Ecosystem services are all the benefits that people obtain from ecosystems (MEA, 2005; Gill *et al*., 2008). This includes: soil formation; nutrient cycling; photosynthesis; food and water provision; regulating services that affect climate, floods, disease, waste and water quality; and cultural services that provide recreational, spiritual and aesthetic benefits (MEA, 2005). This raises challenges about how to ensure that these spaces and resources, as well as planted green infrastructure (e.g. trees and shrubs) and the water system, are maintained and/or improved to contribute to the wide range of ecosystem services that might be required in the future. In particular, the challenge of joining green spaces with traditional grey infrastructure to create hybrid grey-green-blue systems that function to retrofit cities for greater sustainability and resilience is key (Olofsdotter *et al*., 2013).

3.3 Combined urban form and infrastructure legacy

There have been different relationships between the development of urban form and infrastructure over time and between sectors. For example, at times, urban form and transport infrastructure have been closely planned (with new settlements around train stations and motorways), while at other times, road building has led to speculative and unplanned developments. For some infrastructure sectors there has been little influence on urban form or morphology, other than providing services to new developments. For example, water and energy infrastructure is usually planned to service new developments once the master plans have been drawn up: rather than the infrastructure playing a part in shaping the layout.

The legacy of this is that planners', urban designers', and speculative developers' preferences for layouts have predominated and provided whatever has been deemed 'best practice', or most profitable, at the time. This has led to a form of 'lock-in', where some infrastructure options that may now seem desirable are difficult to implement in existing settlements and would require new urban forms in the future. For example, centralised energy production (from power stations) has facilitated high density developments at a distance from the energy supply (Sherrif & Turcu, 2013). However, if a switch was made to a more decentralised model, more land, close to dwellings is likely to be needed. More decentralised energy production also gives the best opportunity to capitalise on interdependencies between infrastructure sectors (Hall *et al*., 2012) e.g. via local waste to energy conversion or combined heat and power, and more opportunities for rainwater harvesting, but this model requires specific development patterns (Williams *et al*., 2010).

4. The consequences of current urban form patterns

4.1 An evaluation of the legacy of the UK's development patterns

The discussions above have highlighted the complexity of the relationships between urban form and infrastructure, and set out the UK's legacy. This has resulted in several key urban form patterns occurring simultaneously in the UK:

- **Compact and contained established towns and cities** - largely surrounded by protected green belts or other open land, many showing signs of re-urbanisation and growth in terms of buildings and populations, but others stable, and others still in economic decline

- **Edge and out-of-town developments** - mixed landscapes of largely retail and commercial buildings
- **Peripheral housing estates and urban extensions** - attached to existing settlements
- **Newer settlements** - New Towns, and 'Sustainable Communities' in growth areas
- **Dispersed developments** - housing and small business developments in rural areas and smaller settlements

Table 1 examines these forms on the basis of a range of positive and negative aspects of their legacy. The Table is a necessary simplification of a complex picture. There has never been a comprehensive evaluation of the impacts of spatial patterns in the UK, although many have called for this (Champion, 2014). Hence, the Table summarises evidence drawn from numerous studies and presents a consolidated picture. It simplifies a number of complex issues, and indicates where the legacy of different settlement patterns has been positive and/or negative for different groups in society. No attempt is made to 'weight' or prioritise the impacts, but the implications of the findings are revisited in Part 2 of the study.

Table 1: An evaluation of the positive and negative legacy of the UK's development patterns

Positive legacy	Negative legacy
Compact and contained established towns and cities	
• Containment of built up area of the UK • Protection of rural, agricultural and open landscapes • Regeneration of existing places • Revitalisation of historic buildings and spaces • Popular for some sectors of the population e.g. young, childless • Efficient use of existing infrastructure • Efficient provision of infrastructure (in some sectors) due to economies of scale • Supports (partly) use of non-car travel: walking, cycling, public transport in cities, hence reduced CO2 emissions • Improves accessibility to employment, services, and amenities • Improves safety as more natural surveillance • Provides variety in cultural experience/activities etc.	• Increased house prices (reduced affordability) in some places • Small homes and gardens (in some places) • Reduced choice of housing locations • Some loss of urban greenspace • Not popular for all sectors e.g. families, older people • Infrastructure capacity reached or breached in some places and sectors e.g. roads, public transport and health services • Contributes to long commuting patterns, hence increased CO2 emissions • More people exposed to poor urban air quality
Edge and out-of-town developments (retail/commercial/leisure)	
• Provides cost-effective space and buildings for new commercial, retail, and leisure activities	• Development of valued peripheral land (in some cases) • Requires the provision of new, often costly,

• Provides some benefits of agglomeration e.g. science parks/business parks • Accessible and efficient for businesses and car users • Popular with the public (retail and leisure)	infrastructure • Generates car trips, increasing CO2 emissions • Contributes to decline of central areas (retail and office) • Usually poorly designed, unattractive landscapes
Peripheral housing estates and urban extensions	
• Efficient use of land, adjacent to built up areas • Provides for housing need • Provides lower density homes, with gardens (sometimes) • Connects to existing infrastructure systems (where capacity exists) • Some developments have implemented best practice in integrated infrastructure • Some very well designed, attractive places • Popular with home buyers • Relatively good accessibility to host city amenities • Generally safe places	• Development of valued peripheral green space (in some cases) • Newer homes are unaffordable for many • Some homes very small and unpopular with residents • New infrastructure required • Increases car use (few developments have good public transport) • Increased CO2 emissions • Lack of adequate infrastructure (in some cases) e.g. community facilities, play space • Accessibility problematic for car-less residents • Many developments lack design quality, sense of place, or integration with existing settlement
Newer settlements	
• Provides for housing need • Provides required infrastructure e.g. schools, doctors' surgeries, public transport (in some cases) • Provides affordable housing, particularly for families (in some cases) • Provides high quality living environments (in some cases) e.g. well designed New Towns, and 'Sustainable Communities' • Provides homes accessible by car to work, countryside, and other larger cities	• Built on valued Greenfield land (in some cases) • Provides smaller homes and gardens (in some cases) • Can be unaffordable to many (and lack social housing) • Increased car commuting, and CO2 emissions (function as dormitory settlements) • Variable design quality and sense of place
Dispersed developments	
• Provides homes for rural families (in some cases) • Supports rural economies (in some cases) • Makes use of existing buildings and rural brownfield sites (in some cases) • Popular with residents: fulfils lifestyle aspirations • Generally well designed/good quality	• Development of valued rural land • Incrementally changing the rural landscape and function • Homes do not always match local needs (size/affordability) • Generated car use (not well served by alternative modes of transport), and CO_2

4.2 Conclusion

Part 1 of this report has set out the relationship between urban form and infrastructure in the UK, and provided an overview of the key trends over time. It has then presented a summary of the legacy these trends have resulted in, and its pros and cons. Overall, the UK's development patterns are characterised by the containment of development, uneven success of different towns and cities, and dispersed, development in the countryside. These patterns are serviced by infrastructure provided by different sectors, in a largely disjointed way. The UK faces a severe housing and affordability crisis, and challenges related to social, economic, and environmental change. The next section of the report looks at how the UK's legacy can be built on for a successful future.

Part 2: Looking forward: an evidence based evaluation of plausible urban form futures to 2065

This Part of the report examines plausible future options for urban form and their implications for infrastructure in the UK. It is based on a long term view (notionally to 2065). However, given the relatively slow change of urban form and infrastructure and the uncertain nature of 'flows', this date is a relatively arbitrary point in the future. Its purpose is to anchor some key trends and projections and to focus debate away from immediate plans.

5. Future urban forms and infrastructure: emerging international debates and lessons for the UK

5.1 The current debate about 'successful' urban forms

Since the early 1990s, the dominant conception of a successful or sustainable urban form has been the 'compact city' (Jenks *et al*., 1996; OECD, 2012). The EC, OECD, World Bank and national governments in most developed nations support the development of contained, high density, mixed use cities and towns. The model is seen as the solution to housing the world's growing urban population in a way that protects productive and environmentally important land, reduces sprawl, minimises travel (and thus emissions), and accrues the benefits of efficiencies of scale in providing housing, public services, and infrastructure. The pros and cons of this model have been widely researched: there is much evidence to both support and counter its claimed benefits and its feasibility in different contexts. Yet it remains an exceptionally widely prescribed policy across the world (Olofsdotter *et al*., 2013; OECD, 2012).

The only significant adaptation of the compact 'ideal' model in the last 30 years has been a move from prescribing a single-centre configuration, to the promotion of polycentric cities (Hall & Pain, 2006). In Germany, France, and Australia, for example, compactness is advocated but with a clear polycentric strategy (Keenleyside *et al*., 2009). Such polycentric cities seek to provide clear distinctions between quarters and districts to maintain their identity and to keep 'in-between' space free from building.

In addition, the part that compact cities play within networks of cities has also been developed. In some countries, 'polycentric city' plans have been imposed at a wider scale than the individual city to encompass a range of closely located existing settlements. In these instances, the way that different settlements function together is considered and planned for (for example, in the Netherlands settlements are planned according to their connectivity, Falk, 2011). Hence, compact poly-nucleated networks of cities can take on different shapes, forms, and sizes, such as galaxies of settlements, polycentric nets, or fractal cities, but within these the ideal is still usually for each settlement to be high density, mixed-use and contained (Olofsdotter *et al*., 2013).

5.2 Emerging international debates and lessons for the UK

There are a number of schools of thought internationally that offer alternatives to, or variations on, the compact city model. Many deal with growth scenarios, and have evolved from different visions of the future. Key debates are as follows:

5.2.1 Smart growth

This is an influential concept in North America, Australia, and parts of Europe (Handy, 2005). It has much in common with the compact city model, but focuses more on managing growth in areas of rapid change (in the USA the compact city terminology is not widely used, but anti-sprawl and smart growth discourse is common). It focuses on planned growth in existing built up areas and near transport nodes (Transit Oriented Development and Transit Zones), and providing appropriate infrastructure. It favours reusing urban land and infrastructure and regenerating existing places, but also developing strategically important new land for employment and housing. It is largely a response to unplanned, disconnected, failing development in the USA.

5.2.2 'Smart cities' (not to be confused with 'smart growth')

This is a vision of the future where ICT is used to enable a more efficient and networked city. Smart cities use data (often generated by intelligent sensors in everything from a city's transport infrastructure, buildings, energy, waste, and water networks), together with information provided by residents to make systems work together more efficiently and manage the city more effectively (Olofsdotter *et al*., 2013). Smart cities are seen as necessary in a highly mobile and competitive globally-networked society (Eames *et al.*, 2013). There is currently much interest in the USA and Europe on the development of smart cities, and global ICT companies are investing heavily in the development of technology to support them.

5.2.3 Eco-towns, sustainable communities and urban extensions

These are relatively mature concepts that were advocated across Europe from the 1990s onwards, with many developments built as 'millennium projects'. These are developments based usually on neo-traditional morphologies or inner-urban morphologies, including blocks of flats, for infill developments. These incorporate environmental technologies, try to reduce car use, and provide good quality of life and amenities. Examples can be found across Europe (e.g. Vauban, Freiberg and Bo01, Malmo) and in the UK (e.g. Greenwich Millennium Village). Many are built on brownfield sites, some are completely new towns or settlements, and some take the form of urban extensions (Falk, 2011; Worthington & Bouwman, 2012)).

5.2.4 Self-reliant (bio-regional) cities

Debates about self-reliant cities have evolved from critiques of urban footprints, and arise from the fact that cities function well beyond their natural resource capacities. Advocates of self-reliance argue for settlements that can live in harmony with nature, using resources mainly from their own region. Some go as far as arguing that cities should become self-replenishing, self-resilient systems with a circular metabolism. Advocates of such systems argue that cities should be moving towards this model to address their global responsibilities and live within their own limits (see Eames *et al*., 2013). However, opponents argue that this vision is unobtainable given global flows of resources and people, and undesirable in terms of reduced living standards.

5.2.5 Dispersed, low-density development

This is advocated by two very different groups: supporters of land liberalisation (free market advocates), and pro-rural 'deep green' groups who favour a self-supporting, 'living off the land' lifestyle, with a return to more rural values (Jabareen, 2006). Many free market advocates argue that less regulation would reduce housing costs and provide more people with their ideal home. Green groups argue that dispersed living enables each householder (or small group) to be more self-sufficient in terms of resources (food, energy, water), and that only a return to simpler lifestyles will address future climate and resource crises. Opponents of this position argue that the global population could not be sustained in such a way, and it would be undesirable for the majority of people. Strategic arguments for dispersed living have not been influential in policy debates.

5.2.6 Multi-functional land uses

Many argue that land should be used far more productively than at present, and be more multi-functional. For example, built-up areas should be retrofitted to provide land for food production, vertical greening, water recycling and so on. This may represent a more intensive use, and is closely related to a future where cities are more in tune with ecosystems. Multifunctional land uses were considered in the UK's Foresight Land Use Futures Review, which concluded that they were desirable, but would require a combination of new institutional and regulatory mechanisms, and economic incentives to achieve (GOS, 2010).

5.2.7 Shrinking cities (or parts of cities)

Most 'future cities' literature from the USA and Europe pays significant attention to the issue of shrinking cities. This somewhat misleading term describes a previously densely populated area that has lost population (in the whole city or parts of it) and/or is undergoing economic transformations with some symptoms of a structural crisis (Olofsdotter *et al*., 2013). Cities such as Pittsburgh and Buffalo in the USA (which have lost almost 50% of their populations since the 1950 and 60s) or Sheffield and Belfast (which have declined steeply since the 1970s and 1940s respectively) can be characterised in this way. In the UK, such cities would be described as 'declining', and may be subject to renewal efforts. But there is a striking absence of either the term 'shrinking cities', or consideration of strategies for them in UK literature and policy. In the USA and Europe, policies mainly relate to economic issues, but there are spatial elements to the plans too, with strategies for targeted demolition and for 'lean cities'. These do not attempt to reverse the decline in population and economic base, but to positively adapt to new conditions e.g. by developing green infrastructure on disused land, utilizing empty buildings for community/arts/social purposes and so on (Olofsdotter *et al*., 2013).

5.3 Emerging approaches to understanding urban form

It is worth commenting briefly that, as well as distinct schools of thought on different urban forms, there is a shift in how urban problems are conceptualised and approached. This has a bearing on our understanding of urban form and infrastructure, and how they might be planned or managed (or not) in the future.

There has been a growing acceptance that the complexity of modern society requires new responses: the 'rational planning' model proved inflexible and was unable to cope

with global ‘flows’. There is also a growing argument that we should not be seeking a single ‘model’ for the future, but looking for the benefits of a range of different urban forms, or futures, and ensuring they function for different groups (Guy & Marvin, 1999; Williams, 2010).

Related to this is a shift from more static planning for an ‘end product’, to the desire to manage change and towards a more dynamic model of adaptation, transition and multiple solutions in different locations and contexts (Guy & Marvin, 1999; Williams, 2010). Similar thinking is happening within infrastructure planning, for example, Hall *et al*. argue that: “[…] the notion that a unique and comprehensive plan for infrastructure provision could be developed is obviously unrealistic. […] given the long term nature of infrastructure provision and the complex inter-sectoral interdependencies, it is necessarily to define broad directions of travel” (2012, p.9). ‘Transition management’ has been proposed as a way to deliberately stimulate transitions to a more sustainable future; and key elements include systems thinking across multiple domains, actors and scales.

These more dynamic and multifaceted approaches to urban management are yet to truly play out in practice, with practitioners struggling with the complexity and uncertainty of issues they are dealing with. The development of decision support tools, futures models, visualisations, and scenarios is helpful, but such tools are not yet optimally developed or deployed in urban form and infrastructure planning and deliver.

6. Future drivers of change and their potential consequences

There is currently considerable interest in predicting future trends and how they might impact on cities, form and infrastructure, partly in response to the rapid changes experienced in the last 20 years. The nature of built form and infrastructure is that it embodies significant investments, and therefore both private and public investors want to know that they are making the ‘right’ decisions. Governments know the considerable risks in making the wrong choices and the costs of inaction in these sectors, hence the interest in projections, predictions, scenarios and forecasts to underpin policy decisions. The key challenges, opportunities and uncertainties, and their potential consequences for future development patterns are set out below.

6.1 Environmental change

The UK is facing considerable changes to its climate, even by 2065 (DEFRA, 2014). There will be warmer, drier summers (with droughts and water stress becoming significant in all areas, but particularly in the South), warmer, wetter winters, more extreme events, and flooding, and sea surges. The effects of these changes will be felt by people, and through effects on the physical environment. The challenge is to ensure that urban forms and infrastructure both adapt to inevitable change, and mitigate against further climate change (GOS, 2010; Betsill *et al*., 2007; Williams *et al*., 2010, 2012; Dixon & Wilson, 2013).

Key practical challenges will be to ensure that existing urban forms are well adapted (i.e. buildings and open spaces are appropriately retrofitted and/or remodelled) and that future development takes place in locations and forms that are resilient to climate change e.g. are not on flood plains and do not breach water supply capacities (see Figure 3 of land within the floodplain of England, and Figure 4 of areas at risk of drought in England and Wales for illustrations of these issues). In addition, it will be important to ensure that water supply and waste water infrastructure can cope across the country (given new

climate geographies); that flood infrastructure is sufficient; and that energy supply and transport systems are not vulnerable to extreme events.

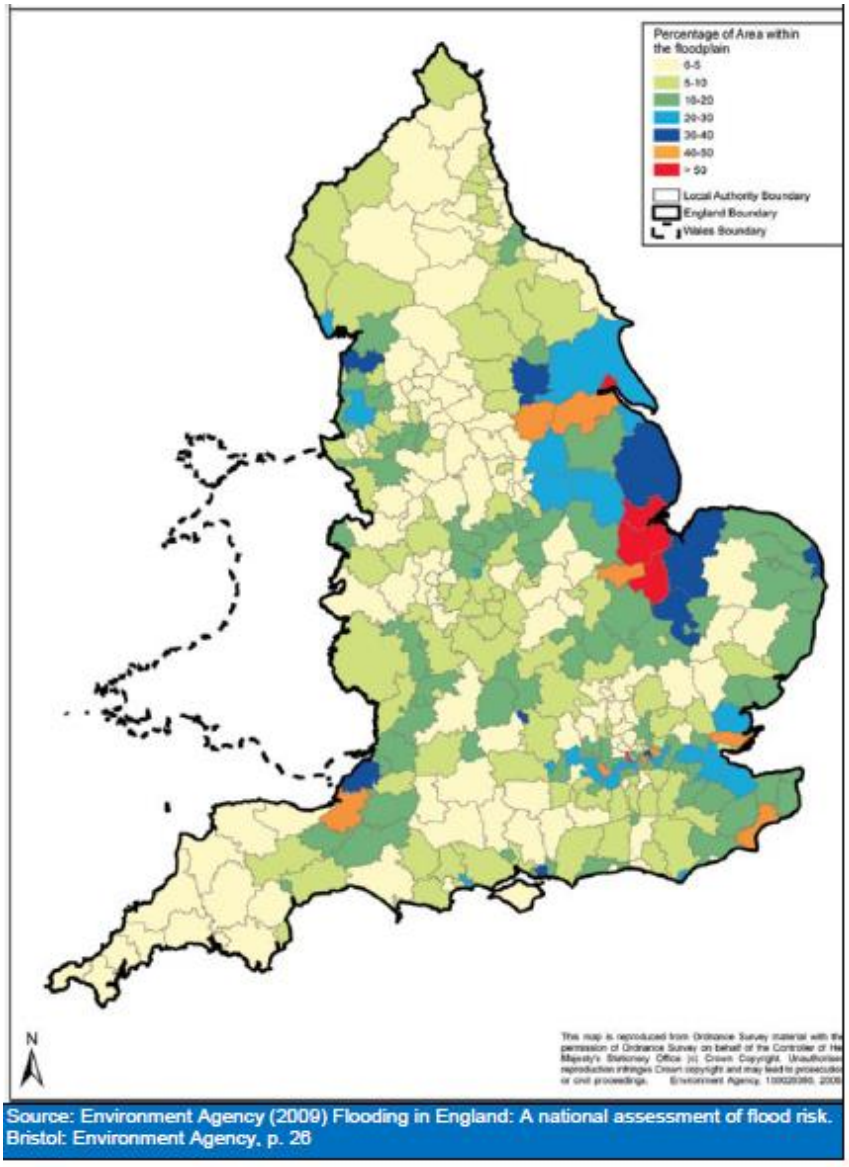

Figure 3: Land in England within the floodplain. Source: reproduced from Wong *et al*. (2012), original source and copyright: Environment Agency (see foot of Figure)

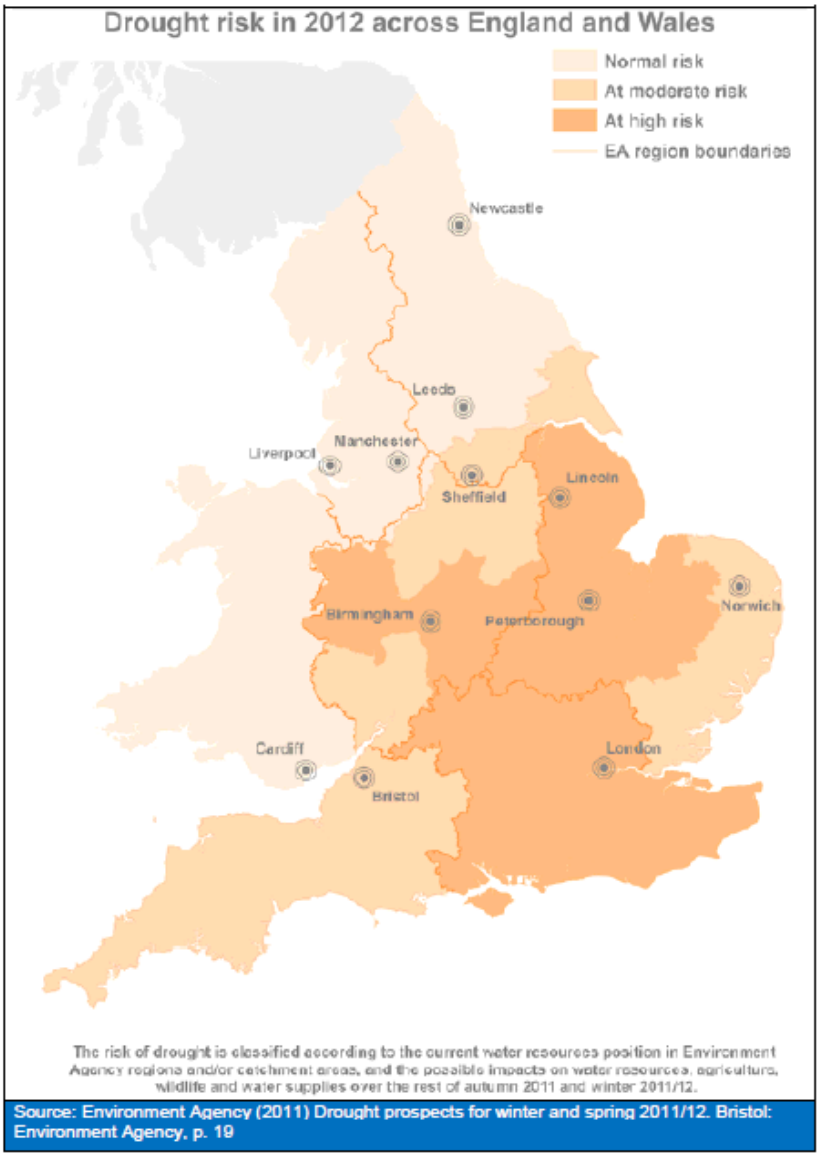

Figure 4: Land at risk of drought in England and Wales (2012). Source: reproduced from Wong *et al.* (2012) original source and copyright Environment agency (see foot of Figure)

For infrastructure provision, the long term risks of climate change can amplify interdependency risks over time (Hall *et al*., 2012). Events such as power cuts can be very disruptive to a number of other related systems (i.e. ICT, transport, health, education, waste etc.). Hence, ensuring resilience to shocks across sectors is critical (Hall *et al*., 2012).

At a more fundamental level, decisions will need to be made about long term interconnected urban form and infrastructure futures. These futures could provide positive opportunities, but their likelihood of implementation is uncertain. For example, by 2065, the UK could:

- Shift to more decentralised energy supply systems and renewable energy sources, which may require different urban forms and more land to be allocated for energy production, e.g. for energy crops. This may increase competition for land and affect development patterns (GOS, 2010; Sherrif & Turcu, 2013; Hall *et al*., 2012).

- Transfer to zero-carbon systems, which would require more integration of infrastructure and land uses, e.g. around waste (Olofsdotter *et al*., 2013).
- Make existing cities green, healthy, and resilient, and therefore more desirable and sustainable. This may require leaving more urban land for greening/cooling etc. (Hermant-de Callataÿ & Svanfeldt, 2011).
- Develop new blue-green-grey infrastructures, and more multi-functional land uses in cities, which benefit the ecosystem and improve quality of life, thus facilitating 'intensification' of land uses (Hermant-de Callataÿ & Svanfeldt, 2011).
- Develop new energy, water, and waste technologies that can lessen the environmental footprint of urban development (GOS, 2010).
- Develop more 'autonomous' dwellings or new settlements, drawing on local resources and using their own infrastructure.
- Turn more land over to food production, within and outside of cities (capitalising on longer growing seasons, improving food security and reducing CO_2 emissions).
- Invest less in road and air travel to reduce CO_2 emissions, thus changing the future dynamics of the value of development based on accessibility to these modes, and positively influencing proximity to more central locations again (accessed by rail, foot, bike).

6.2 Demographic and social change

The last 15 years has seen rapid demographic changes globally, driven partly by turbulent political and economic conditions. In Europe, migration has been a key factor within and between countries. In the UK, net inward migration, in conjunction with a long trend of declining birth rates, and a recent trend of rising birth rates, has led to high demand for homes and jobs in some cities and regions. In Europe as a whole, 40% of all cities with more than 200,000 inhabitants are currently experiencing population decline, and 54% of urban regions in the EU have lost population in recent years (Olofsdotter *et al*., 2013). This has left more pronounced spatial differences between rich and poor (Hermant-de Callataÿ & Svanfeldt, 2011). Similar patterns of rapid population increase and decrease, with significant spatial impacts, have been experienced in the USA. Hence, there is deep political concern about the impact of migration on the future of towns, cities, and regions. A key concern is the provision of adequate infrastructure, as societies become less stable and it becomes harder to 'keep up' with rapid change.

These changes highlight potential future population volatility for the UK, and a key uncertainty when dealing with providing homes and infrastructure. The last decade was characterised by a large population increase, but in the future populations could leave *en masse*, or more people could choose to settle here, due to as yet unpredicted drivers. National projections currently go to 2083 and estimate a high growth scenario of 108 million (see Figure 5), but a range of uncertain assumptions necessarily underpin these figures.

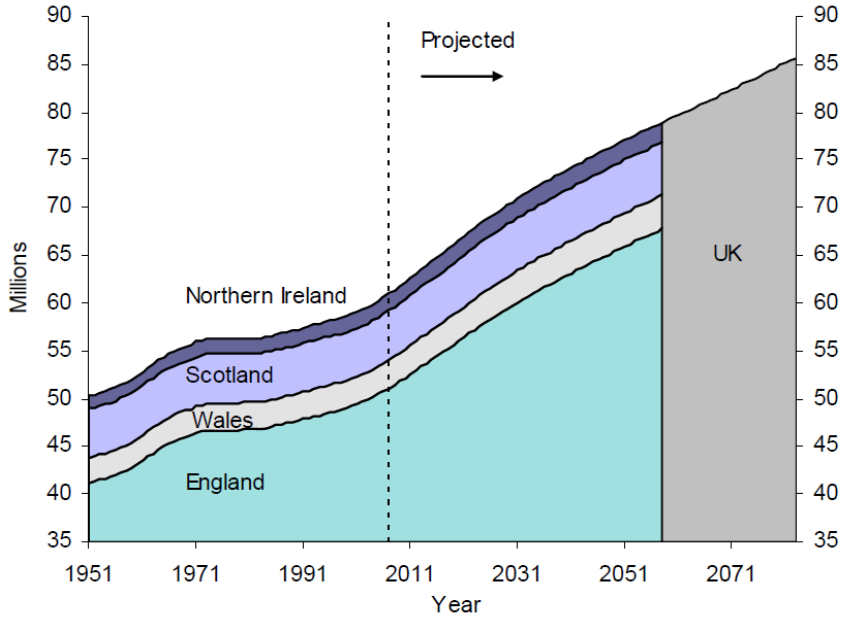

Figure 5: Actual and projected population growth in the UK and constituent countries, 1951-2083. Source and copyright: ONS, National Population Projections 2008-Based, Series PP2, No.27

Aside from migration, there are other demographic changes in the UK. The population is aging, and average household size has been declining for several decades (as more people live alone, in couples or have fewer or no children). Although this trend has slowed over the last decade, it still affects the demand for homes. There is some evidence that smaller households require smaller, affordable, homes, but many one and two person households, especially of older people, want to remain in larger dwellings. Hence the demand for a variety of dwelling types, including more family homes and dedicated residential and care settings for older people, is likely to remain.

Social changes will also affect future requirements for urban form and infrastructure. Shifts in working patterns, such as a growth in self-employment, home working and part time working may change requirements for commercial and retail space and, alter travel patterns (Dixon *et al*., 2003). Similarly demand for mobility is predicted to increase (Hall *et al.,* 2012), putting further demands on public transport, road and air infrastructure. Shifts in consumption will also have an impact: from where people decide to shop (in-town, out-of-town, or on-line), to where they spend their leisure time (e.g. at a shopping centre, UK seaside resort, or in their homes). Cultural norms and aspirations are also likely to change: fashions for inner-city living and country dwelling have shifted in the past and may do so in the future as new lifestyles are influenced by different technologies or values. Similarly, rising affluence for some has had a significant impact on urban forms in the UK (Echenique *et al*., 2012) fuelling counter-urbanisation trends, and preference for larger homes, more cars, and personal space. In the future, people who can afford to might be drawn to rural living to escape worsening urban conditions, or because of 'green' lifestyle aspirations.

Such demographic and social changes are incredibly difficult to predict, with few certainties, but are likely to have a significant bearing on settlement patterns and infrastructure, generating challenges to 2065 such as:

- Ensuring that sufficient homes and infrastructure are provided where people want to live;
- Managing places experiencing population decline (e.g. rural areas, parts of cities, whole cities and/or regions);
- Managing urban form and infrastructure to avoid spatial inequalities;
- Managing the likely significant increase in demand for housing, transport, water, food, and energy associated with population growth (GOS, 2010);
- Delivering infrastructure provision for a changing and aging population (e.g. health care and appropriate housing), in the right place and at the right time;
- Reconciling individuals' preferences and locational decisions with societal and environmental capacities.

6.3 Economic change

The globalisation and liberalisation of business organisations, supply chains, markets, financial flows, production, and consumption have had a significant bearing on the UK's urban form, and will continue to do so (Wong *et al*., 2000). The 'overheating' of the South East (related significantly to the international finance sector), including in-migration, and the rapid growth in homes and jobs, has contributed to the economic divergence of London from the rest of the country (Simmie *et al*., 2006; Clark & Clark, 2014). Increasing wealth has also facilitated counter-urbanisation to larger suburban homes, and much of the dispersal of development into the countryside, as incomes are buoyed through international commerce. Much 'edge city' development in the UK is also the result of international investment.

Counter to this, many areas have been adversely affected by the withdrawal of global capital: towns and cities based on production (e.g. of cars or electrical goods) have seen mass unemployment. Other smaller cities and towns are simply not on the radar of global investors and remain largely reliant on local markets.

Changes in the ownership of infrastructure have also had an impact on its provision in the UK, and arguably moved it further away from considerations about local conditions. Much UK infrastructure is now owned by multi-national companies, which may make co-ordination harder in the future. It may also make it difficult to secure investment in more costly projects (e.g. in more remote areas): this can already be seen in the provision of high speed broadband.

In terms of urban form, it is important to view economic change in terms of the competitiveness of cities, and to understand what might make them attract investment in the future (to sustainable levels for the country). The UK's cities will have to position themselves in the global market to remain viable. However, this may mean 'leaving the national state behind', which is arguably what is happening with London. This raises a number of challenges, but also opportunities for the UK:

- To determine if strategies are required (and desirable) to redress regional disparities (Hildreth & Bailey 2013; Hildreth 2009). Many argue that global capital is too strong to be countered by local economic policies; others disagree and believe such policies are urgently needed in the UK (Simmie *et al*., 2006).

- To understand the attributes of competitive cities, parts of cities, or towns, and to develop those attributes (this links with debates about creative cities, the value of quality of life and cultural infrastructure, innovation and good governance) (Simmie *et al.*, 2006).
- To develop effective mechanisms for shrinking or declining cities or parts of cities.
- To strengthen local markets to ensure the UK is more resilient to economic shocks.
- To secure sufficient investment in infrastructure, given reductions in public resources, a competitive, and international market, and given that new infrastructure technologies can be more risky (DEFRA, 2011; Cabinet Office, 2011).

6.4 New technologies

New technologies may affect the ways in which society works, travels, lives, and provides energy (Worthington, 2013; Dixon, 2005, see Figure 6 for a map of UK Communications Infrastructure). They may also improve healthcare, and thus increase life expectancy, changing demographic patterns. Some new technologies may have an impact on the shape and size of settlements, and the ways in which they develop. This has happened in the past with the development of rail, the electricity grid, and mobile communications, and is currently happening, for example, through the ICT-enabled growth of home-working and more 'footloose' office locations, and on-line shopping affecting traditional retailing.

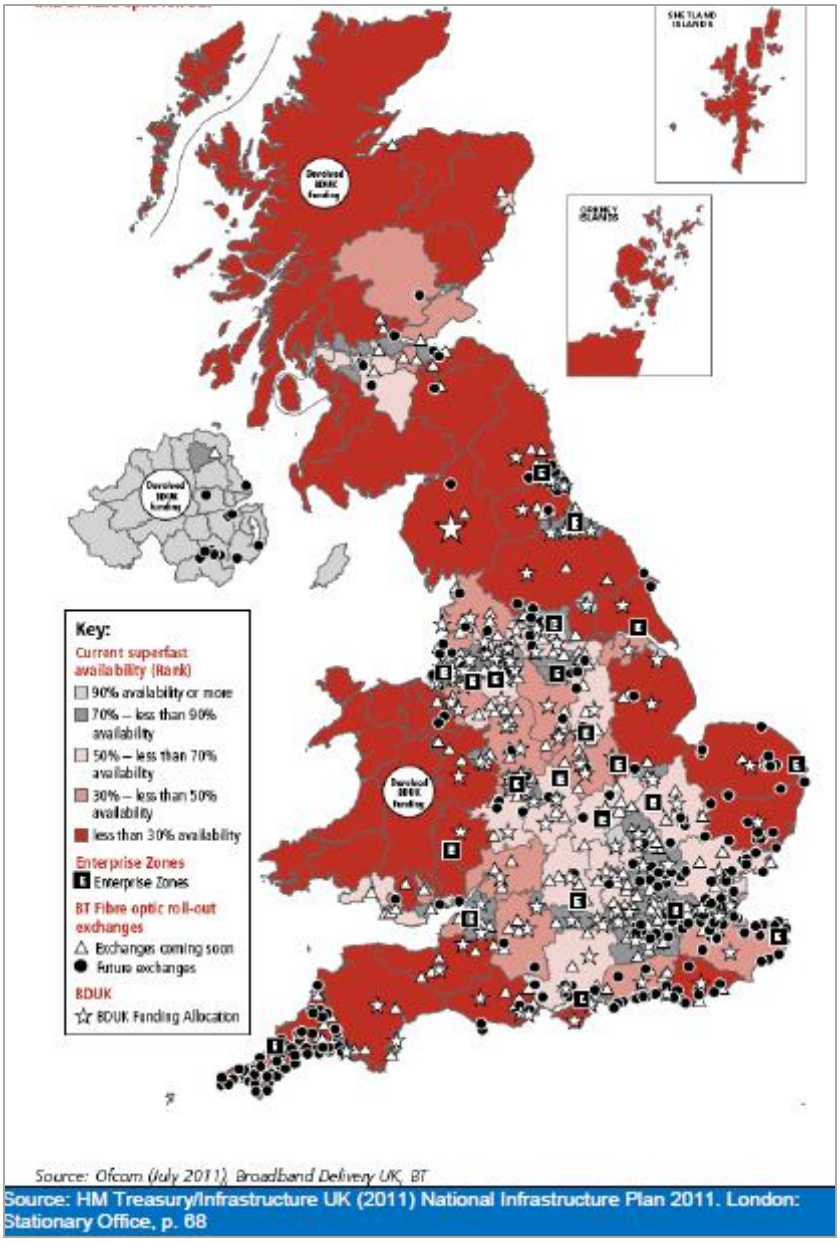

Figure 6: UK Communications infrastructure. Source: reproduced from Wong *et al*. (2012), original source and copyright HM Treasury, 2011

More specifically the development of smart city applications could make cities more efficient and improve quality of life for their inhabitants in the future:, for example, by better coordinating transport modes and reducing journey times, or facilitating more efficient water use, shopping, and waste recycling. Smart infrastructure systems could provide far better integration between sectors.

Some new technologies might also shift anxieties about current urban forms, e.g. electric cars, or zero carbon personal travel, might negate some of the negative impacts of more dispersed development patterns, or make inner-city living more desirable. However, some technologies might require new forms to be favoured, e.g. community wind turbines require open space to function, but this is not usually available in high density settlements.

This said, predictions of the impact of technology have been notoriously inaccurate in the past, and a significant report on the future of European cities recently cautioned against: 'exaggerated beliefs in urban innovation and technological fixes to address all critical challenges of contemporary and future cities' (Olofsdotter *et al*., 2013, p.16).

6.5 Policies and regulations

Policy and regulatory regimes at different levels (global, EC, national, regional and local) and in a number of sectors (e.g. environment, finance, competition, migration) could have a significant effect on urban form and infrastructure in the future, either directly, or indirectly. For example capping migration would alter many of the demographic challenges and opportunities facing the UK. More stringent regulations of CO_2 emissions might affect energy and transport policies. Energy policy itself could favour further centralised supply, or a significant move to decentralised systems, including renewables. Urban policies could continue to strongly support the 'compact city' model, or there could be a move to a more deregulated land market, which would facilitate more dispersal. The strength and nature of planning policies will also be key. The 2010s have already seen a move to localism (DCLG, 2012) and the weakening of the imperative for urban land reuse, demonstrating how quickly national objectives can alter.

7. The implications of these trends for urban governance

The legacy of the UK's urban form and infrastructure, combined with the future challenges above, give rise to questions about appropriate forms of urban governance. Unsurprisingly, debates about governance span a range of perspectives, from those arguing that it is now almost impossible to manage urban areas in any real sense, to those calling for comprehensive new means of management, regulation, and planning.

Urban form is formally governed through the planning system, which confers permission from the state to develop land. However, the system is often characterised as 'reactionary' as, although it can make detailed plans, it can only permit, or not, development brought forward by private or state interests. As has been described above, flows of capital and people shape the space of cities, but the recent intensification of social and economic change has exceeded local conditions in many places, giving rise to more chaotic and less planned development, which is not just market-led but flow-led (Antrop, 2004), making it harder for planning processes to keep up.

Recent research by Bramley & Kirk (2005), which looked at 'whether planning mattered' in Scotland, concluded that: the planning system exerts far more power in high demand areas than low; has more power over housing than other development types (at least over industrial and business development); Greenfield development is allowed where local authorities are competing for development; planning can steer development to brownfield sites, but cannot make it happen; and institutional fragmentation and public resource shortages mean that public transport infrastructure rarely accompanies new developments. These types of findings reflect the reality of development patterns in the UK. Edge cities, dispersed rural development, and housing schemes lacking adequate infrastructure are not planned but are the imperfect results of the interplay between market and regulatory mechanisms.

Some of these problems are related to the fact that the governance of urban areas is now more complex than previously: an issue identified in the Foresight Land Use Futures report, which observed: "The processes of governance, divided between various agents

and strategies, are complicated and have created uncertainty […] The urban-rural divide is no longer clear-cut and the separation of governance responsibilities may not be helpful in tackling (future) challenges […] Much urban land is now managed by a range of quasi-public private, private or market-led management and delivery mechanisms. These sit alongside the local authority planning mechanisms, and are not easily co-ordinated" (GOS, 2010, p.27). The report concluded that the systems and mechanisms that guide land use change in the future will need to reflect the new priorities, new trends in patterns of use, and changing concepts of how land creates value (GOS, 2010).

Emerging from this context are some valuable debates about how urban governance might function better in the future. These include:

- **Embracing the dynamic nature of urban form and infrastructure** and developing more flexible 'transition' approaches (Eames *et al*., 2013), focusing on gaining agreement around broad principles rather than fixed plans (Hall *et al*., 2012), and facilitating decision making through local collaborations and partnerships. This approach would make use of long term data projections, scenarios, forward and back casting methods, and require skills in adaptation and long term visioning.

- **Moving away from 'fixed' administrative boundaries for governance** towards "an area, or catchment-based approach to land use policy" (GOS, 2010, p.17). Hermant-de Callataÿ & Svanfeldt recently observed that: "The administrative boundaries of cities no longer reflect the physical, social, economic, cultural or environmental reality of urban development and new forms of flexible governance are needed." (2011, p. vi.; see also Clark & Clark, 2014). This could help facilitate integration between urban form, infrastructure, and natural resource management.

- **A clearer combination of horizontal coordination of different tiers of governance** (e.g. local authorities) to manage a functional area for strategic and visioning purposes, as well as delivery of key functions. In addition, a clear vertical coherence is required around specific issues, with the participation of citizens in the development and implementation of urban form policies (OECD, 2012).

- **Innovation in macro-economic policies** or in the land economy to redirect increased land values to address uneven spatial development. For example, Simmie et al. (2006) argue for spatially differentiated macro-economic policies to reverse decades of divergence between the lagging cities in the UK and the Greater South East. Profits from development could also be redirected into community resources (i.e. ensuring finances are released back into local economies to pay for new energy schemes, other infrastructure upgrades). Systems such as this are far more common in Germany, for example, which has over 600 energy co-operatives (TCPA, 2013).

- Far more attention at all levels of governance to the spatial impacts of all policies. This could facilitate integration between sectors and avoid unintended consequences. Simmie *et al.* (2006) suggest it might be useful for all government policies be tested for their spatial impact.

- **Simplification, improved clarity, and increased capacity in the governance of infrastructure and better integration with urban form governance**. Many commentators argue that the UK lacks capacity to govern infrastructure in a way that will enable it to transition to meet future requirements (Bolton & Foxon, 2014). They argue that the institutions and resource mechanisms we have are unable to meet the challenge. Furthermore, capacity to manage infrastructure varies in different parts of

the UK: London is in a relatively strong position, but other major cities are hampered by lack of power and resources (Clark & Clark, 2014). Within the UK's infrastructure sectors the most prominent actors are now: government departments, economic regulators, and environmental regulators, along with emerging EU institutions (Hall *et al*, 2012). Many of these operate relatively separately, and are divorced from concerns of spatial impacts. Hence significant questions are being raised about the UK's capacity to invest in and transform its infrastructure systems.

- **The development of governance strategies for 'new' urban landscapes**, such as peri-urban areas, which are often not well planned, and once built are rarely retrofitted. These areas have been wasteful of public investment and provide problematic legacies for the future (Hermant-de Callataÿ & Svanfeldt, 2011).

- **New forms of place-based leadership**. The complexity and fast pace of urban change has led some to argue that a return to strong and consistent local leadership is needed to maintain and communicate a vision over long periods of time and to maximise benefits from new situations (Hambleton, 2014). Models such as directly elected mayors with clear visions and local democratic mandates seem to be having a renaissance (although the UK, with several notable exceptions – London, Bristol and Liverpool - has largely resisted this model).

- **Innovation in the specification and procurement of key development and infrastructure projects**. This could lead to rapid uptake of new technologies (particularly learning from places that have taken a more integrated view, such as San Francisco and Barcelona).

Overall it is difficult to predict which, if any, of these innovations will be pursued, or to determine if they would be effective. A useful exercise is to examine governance systems in other countries to see if they offer better solutions than the UK model. A recent study by Keenleyside *et al*. (2009) compared urban governance under a number of different international regimes. The researchers chose countries that offered different approaches (Germany, Japan, the Netherlands, New Zealand and Sweden), and concluded that the Swedish model, with its focus on environmental sustainability, international responsibility, and long term consistency of direction, appears to be the most closely aligned to the land use challenges facing the UK. The Swedish system benefitted from a more pro-active and regional focus, and was far less adversarial than the UK system (Keenleyside *et al*., 2009).

8. Characteristics of 'successful' urban form and infrastructure in the future (to 2065)

8.1 An evaluation of successful urban form and infrastructure

At the outset of the report, definitions of 'successful' urban forms and infrastructure systems were proposed:

- **Urban forms** were described as successful when they: **underpin the functioning of an array of urban systems, use resources sustainably, and provide a sound economic base that provides the setting for a good quality of life for their inhabitants. In addition they can withstand shocks and 'bounce back' or improve their conditions post-shock (whether that shock be environmental, economic and/or social).**

- Infrastructure was deemed successful when it **"[…] meets demand and provides reliable, cost effective and high quality services"** (Hall *et al*., 2012).

Given the UK legacy (Part 1), and the discussions of future challenges, opportunities and uncertainties, and considerations of governance (Part 2), these definitions can be elaborated to a wider set of criterion (set out in Tables 2&3). These criterion are drawn from numerous sources, and encompass normative notions of 'successful places', which are sustainable, resilient, healthy, socially just, safe, desirable, and economically viable. Implicit in these qualities, as has been illustrated above, are fully functioning supporting infrastructures.

As has been described, the UK has an established pattern of urban form and infrastructure: the vision to 2065 needs to take stock of this legacy and focus on the best ways to shape future change. The range of key trends and uncertainties described above also need to be factored into any analysis of potential future urban form options, as should the lessons from emerging good practice.

Two, related, processes need to be considered: how best to develop, remodel, and retrofit existing places and how best to deliver new places. Each can be achieved via a number of urban forms.

For existing places, the most plausible options are:

- **Compaction/containment of existing places:** a continuation of urban intensification processes within existing built-up areas. This includes processes such as infill development, brownfield development and redevelopment at higher densities.
- **The development of polycentric city regions:** the development (maybe through intensification, and some planned growth) of a number of existing settlements, at a sub-regional or regional scale, based on a network-based logic related to connectivity and urban function. Polycentric city regions are argued to facilitate well-connected agglomerations that are economically and socially robust and qualitatively enrich the region (Growe, 2012; Hall & Pain, 2006).
- **Managed shrinkage:** the managed adaptation of urban form in existing places (entire towns/cities, or parts of them) to respond to loss of population and economic function. Processes can include targeted demolition of buildings, provision of new open space, re-use of buildings, and decommissioning of (or lying dormant) infrastructure.

For new development, the most plausible options are:

- **New peripheral development:** the development of planned extensions at the edge of existing towns or cities. These can vary in scale and in mix of use/function (TCPA, 2007).
- **New settlements:** free standing new settlements (these can take the form of, for example, eco-towns, sustainable communities, new towns, and garden cities).
- **Dispersed development:** development of residential and other uses in small villages or hamlets, or in open countryside, and on agricultural land.

These options are evaluated against a number of 'success criteria' in Tables 2 and 3, which require some explanation. It is quite likely that all these forms (perhaps with the exception of 'managed shrinkage') will take place to some degree simultaneously, in

different locations in the future, either as the result of planning or of the interplay between ‘flows’ of people and capital, and regulatory mechanisms. Many planning bodies in the UK argue for a mixed portfolio approach to further growth and/or shrinkage (TCPA, 2007).

It is also the case that all options can have both positive and negative consequences, which vary for different sectors of society, and aspects of the environment and economy. Knowledge about some of these consequences, and debates about the merits of different forms is relatively mature. For others the impacts are only just being realised. In most cases there is a consensus that urban form in itself is necessary, but not sufficient to bring about benefits: i.e. there are certain (usually complex) conditions that render different urban forms ‘more’ or ‘less’ successful (as was seen in Part 1). Therefore, in presenting an analysis, such conditions need to be considered. This is important because some conditions are more plausible (between now and 2065) than others, and some require policy and investment decisions to be taken.

For example, compact city policies have been implemented for long enough to establish that transport benefits do not ‘naturally’ occur at higher densities, without the provision of adequate infrastructure (for public transport, walking and cycling). Hence the compact city might only ‘Facilitate efficient transport management (systems and behaviours)’ (Table 2) if new non-car infrastructure is provided. Likewise, certain forms may be able to ‘Facilitate efficient water management (systems and behaviours)’, but only under certain population and climate conditions.

Hence, Tables 2&3 include brief notes on key conditions under which each future urban form option could be successful. It is also worth clarifying that the forms cannot be compared directly with each other because they solve different problems and are not discrete. For example, shrinkage cannot be compared as an option against intensification as the former deals with population loss and the latter with growth. Likewise, the development of polycentric city regions, *may* also include the intensification of some settlements, and hence those two options need to be understood independently.

Table 2: Conditions for achieving successful existing places to 2065

Existing places			
Characteristics of successful urban forms in the UK	**Compaction/containment of existing places (intensification)**	**Polycentric city regions**	**Managed shrinkage**
Environmental characteristics **Successful urban forms are ones that:**	**Can this be achieved?**	**Can this be achieved?**	**Can this be achieved?**
1. Make **sustainable use of the UK's land** resource (accommodating demographic change without loss of valued land)	Yes, if strategically important urban land is not developed (e.g. parkland, essential green urban infrastructure). But, there are physical 'limits' to intensification, so with large population increases, care would be needed to avoid overdevelopment.	Yes, if the benefits of connectivity are maximised and valued space between settlements is protected. But currently there is no effective sub/regional governance system to achieve this.	Yes, if sustainable new land uses are delivered:: e.g. green spaces/allotments on previously developed land, and if shrinkage in some cities/regions is not offset by overdevelopment in others.
2. Make **sustainable use of the UK's environmental resources** (including protecting and enhancing biodiversity)	Yes, as long as opportunities for efficient resource use are exploited: e.g. investment in non-car travel, protecting urban biodiversity.	Yes, as long as opportunities for efficient resource use are exploited: e.g. investment in non-car travel (especially between settlements), protecting biodiversity within and between settlements.	Yes, as long as opportunities for efficient resource use are exploited: e.g. enhancing urban biodiversity.
3. Are physically **adapted for the UK's future climate**	Yes, if existing settlements are appropriately retrofitted (i.e. buildings are adapted and adequate space is left for green and blue infrastructure). But potential for significant disruption to high density, large populations, if not adapted (e.g. through increased urban heat island, flooding, damage to infrastructure systems).	Yes, if existing settlements are appropriately retrofitted (i.e. buildings are adapted and adequate space is left for green and blue infrastructure). But significant disruption to high density, large populations, and connections between them, if not adapted (e.g. through disruption to transport and energy infrastructure, ICT).	Yes, poses a good opportunity to adapt existing places by providing new space for green and blue infrastructure, and retrofitting buildings. But resources may not be available in declining areas.
4. Do not **contribute to future climate change** (i.e. reduce carbon emissions, exceeding or matching international targets)	Yes, if low/zero carbon building and infrastructure (especially transport) systems are introduced (e.g. through retrofitting and incremental changes), but some increases in CO2 may be inevitable with growing population.	Yes, if low/zero carbon building and infrastructure (especially transport) systems are introduced (e.g. through retrofitting and incremental changes) and if new physical and virtual connections between settlements are low carbon, and/or reduce travel demand. But some increases in CO2 may be inevitable with growing population.	Yes, as reduced populations and economic activity may naturally lead to reduced carbon emissions.

5.	Improve (or do not worsen**) air quality**	Yes, if low carbon/emission building and infrastructure (especially transport) systems are introduced (e.g. through retrofitting and incremental changes), and if good air quality management is implemented. But, potential to expose larger populations to poor air quality.	Yes, if new infrastructure is low carbon/emissions. But if not, may worsen air quality through increased travel within and between settlements.	Yes, reduced populations, economic activity and numbers of trips may lead naturally to fewer emissions and better air quality. Urban greening in new spaces could help air quality.
6.	Facilitate efficient **water management** (systems and behaviours)	Yes, if water infrastructure systems are upgraded and modernised. But high density, large populations may breach supply capacity in some areas (especially areas with lower precipitation and/or high demand).	Yes, if water infrastructure systems are upgraded and modernised. But high density, large populations may breach supply capacity in some areas (especially areas. with lower precipitation and/or high demand).	Yes, may reduce demand for water, and provide more space for porous surfaces and rainwater recycling systems. But may underutilise existing water infrastructure.
7.	Facilitate efficient **energy management** (systems and behaviours)	Partly, if energy (electricity and gas) continues to be supplied through a centralised system to large, consolidated populations, then the compaction model is efficient. It also supports combined heat and power, and integrated energy to waste systems. But large, high density populations may breach capacity. Hence, it would require upgraded and modernised energy infrastructure. Compaction also protects open land for energy generation (e.g. land for wind farms, energy crops).	Partly (same arguments as for intensification); with added benefits through sub-regional or regional energy planning (e.g. allowing for a mix of energy supply models).	Yes, may reduce energy demand, and provide opportunities/space for localised generation/innovation. But may underutilise existing energy infrastructure, and there may not be resources for investment in declining areas.
8.	Facilitate efficient **transport management** (systems and behaviours)	Yes, if transport infrastructure is upgraded and new infrastructure retrofitted (e.g. for walking, cycling and public transport). High density, mixed-use supports people to walk/cycle/use public transport because of proximity of uses. But if people do not switch from car to other modes, can cause congestion.	Yes, if transport infrastructure is upgraded and efficient new infrastructure between settlements provided (network model). But currently there is no effective sub-regional/regional governance system to achieve this.	Yes, can provide opportunity to improve walking/cycling environments. But reduced population densities and economic decline may worsen public realm, and render public transport not viable.
9.	Facilitate efficient **waste (solid and water) management** (systems and behaviours)	Yes, if waste infrastructure is upgraded (particularly recycling facilities, waste to energy etc.) it can be provided efficiently to large numbers of people in close proximity (although there may be some space constraints). But high densities may breach demand for nearby landfill if waste is not reduced/reused or recycled.	Yes, if waste infrastructure is upgraded (particularly recycling facilities, waste to energy etc.) it can be provided efficiently to large numbers of people at a sub-regional/regional scale.	Yes, there may be less waste, and more space for waste recycling/composting etc.

10.	Facilitate the **efficient integration of different infrastructure systems**	Yes, significant opportunities to efficiently service large populations if well-planned and integrated retrofitting/upgrading of different infrastructure systems is implemented. But currently, infrastructure systems are fragmented and not often planned in relation to urban form.	Yes, significant opportunities to improve existing places and connect better across sub-regions and regions. But currently infrastructure systems are fragmented and there are no effective governance systems to support this.	Yes, especially infrastructure systems that require space (such as water recycling, some renewable energy generation methods). But, there may be fewer resources to invest in declining areas.
	Social characteristics			
1.	**Adapt to future changes** (social, economic and environmental) in a **socially equitable** way.	Partly, some compact, contained settlements have proved relatively robust in the past. Resilience depends on many issues other than urban form (e.g. industrial diversity, flood risk).	Partly, allows for some sub-regional/regional management of change. If settlements have different functions/characteristics they may be more resilient to shocks than if they are in competition.	Partly, if well planned. But very difficult to manage shrinkage in a socially equitable way. Population and economic decline will impact some groups more than others.
2.	Are **desirable** to the population	Partly, if high quality urban environments are achieved, these are desirable for certain sectors of the population (often younger, smaller, student and professional households), and some families in suburban areas etc. However, many families, more affluent people, and older people have a preference for smaller settlements and more rural locations. Intensification can result in undesirable, poor quality, high density housing, and very little personal space.	Partly (as for intensification). Different functions and types of settlement may give more choice. Good connectivity between settlements is desirable.	Not usually: can be seen initially as a negative policy (fatalistic). But once positive 'projects' are underway can be seen as a desirable option.
3.	Provide a **range of housing types and tenures** to meet needs and be affordable	Yes, if well planned. But consolidation policies can push up house prices, reducing affordability.	Yes, but consolidation in the existing settlements, and lack of developable land in protected areas, can push up house prices, reducing affordability. Different types/functions of settlements can offer more choice.	Partly, if poor housing is demolished and existing buildings are refurbished and improved (e.g. with more open space). But in areas where housing is abandoned, stock may be lost.
4.	Are **accessible for all**	Yes, local accessibility can result if there is a mix of uses and places are supported by good mobility infrastructure (for public transport, walking and cycling).	Yes, within settlements, if they are mixed-use and served by good mobility infrastructure. And yes, between settlements if good transport infrastructure and services are provided.	Partly, if physical accessibility can be retained for existing populations. But accessibility to employment/services etc. may inevitably decline.
5.	Provide **access to health/education/culture/leisure services** for all	Yes, services can provided at low per capita costs, in close proximity, making them accessible to large, high-density populations. But large populations might mean that services become overstretched.	Yes, services can provided at low per capita costs, in close proximity, making them accessible to large, high-density populations. A functional differentiation between settlements can allow for the provision of more specialised services to a number of settlements in a region (e.g. health services). But large populations might mean that services become overstretched.	Partly, if well managed, service levels can be maintained at levels appropriate for the population. Pressure may be eased where services were previously overstretched. But reduced resources may make it difficult to maintain service levels (for some services).

6.	Are **healthy**	Yes, if people lead active lives and make use of urban open spaces etc, and of open land outside urban areas. And if people enjoy city living and thrive emotionally in an urban setting. But low quality, high-density areas can be associated with lack of physical and well-being.	Yes (as for intensification).	Yes, if well designed (e.g. with more greenery, new pedestrian and cycle connections etc.). But areas in decline can be associated with poverty, aging populations and poorer health in general.
7.	Are **safe**	Yes, if areas are vibrant and convivial, and there is more natural surveillance. But not if people with differing lifestyles and behaviours live in close proximity and cause tensions.	Yes (as for intensification).	Yes, if maintaining/improving safety is planned for (e.g. places are well-lit, disused buildings are rapidly reused). But declining areas can be associated with poorer public realm, and reduced perceptions of safety.
	Economic characteristics			
1.	Do not cause **land/property price shocks/instability**	Partly, tight control on the availability of land can exacerbate impact of recession/boom, leading to inflexibility in land and property markets, and hence volatile pricing.	Partly, tight control on the availability of land can exacerbate impact of recession/boom, leading to inflexibility in land and property markets, and hence volatile pricing.	Partly, explicit shrinkage strategy might lead to a spiral of disinvestment and depress the land market further. But, plans may be seen as positive action to improve an area, and stimulate new/different demand/markets.
2.	Enable **efficiencies in infrastructure costs**	Yes, huge potential if economies of scale are realised and infrastructure sectors become more integrated. But significant barriers to this.	Yes, great potential to achieve efficiencies in infrastructure provision by providing it at the sub-regional or regional scale. Allows for cost effectiveness by planning interdependencies between infrastructure (e.g. energy and waste, transport and ICT). But significant barriers to this.	Partly, if under-used infrastructure is decommissioned (or lays dormant in anticipation of future need). But wasteful in terms of historic investment and costly to decommission.
3.	Enable **efficiencies in public service costs**	Yes, because populations are concentrated, per capita costs are lower.	Yes, because populations are concentrated, per capita costs are lower. And great potential to exploit use of smart, networked, delivery systems.	Partly, may require high public service costs in the short term to assist in economic restructuring/retraining population etc. But, efficient in the longer term once areas adjusted to new functions.
4.	Enable **efficiencies in transport costs** (for suppliers and residents)	Yes, if efficient transport infrastructure is provided to serve the large, high density populations.	Yes, great potential if modern, innovative systems are procured as high densities of population and well planned connectivity between them.	Partly, if services are matched to new requirements. But may be costly to provide to a 'thinner' population.
5.	Support **local economies and economic diversity**	Yes, if populations use local supply chains, money circulates within the urban economy, and local supply chains are supported.	Yes, great potential to provide strong local economies (see intensification) and if synergies can be realised between different settlements (in terms of creativity/supply chains/skilled workforces etc.).	Partly, if new types of economic activity can be supported. But difficult to support diversity in declining economic base.

6.	Attract **inward investment**	Yes, if intensification in delivered in a way that provides attractive, vibrant, diverse places that are well connected and served by effective infrastructure attractive to investment capital.	Yes, if the networked city region offers a diversity of attractions for inward investment, develops the capacity for growth and innovation 'from within', and can offer good connectivity between settlements.	Partly, improving local conditions may attract funding for different types of activity (e.g. arts programmes, community start-ups).
7.	Facilitate **innovation and creativity**	Yes, if intensification if delivered in a way that brings creative groups together (e.g. in innovation clusters).	Yes, if it attracts and retains capacity and/or diversity of skilled population (within and between settlements), and facilitates the development of innovation clusters.	Partly, if creative people are remain or attracted to such places (perhaps by cheaper living costs), can provide cheaper spaces for innovation. But, can also lead to exodus of skilled/creative population, leaving only those unable to relocate.
8.	Facilitate **efficient ICT provision**	Yes, high population densities can make investment in smart technologies cost-effective.	Yes, if is well planned and resourced both within and between settlements. But, high quality provision is essential to facilitate the benefits of the networked city region (e.g. smart city applications, synergies and connectivity).	Partly, only if it is an explicit aim of shrinkage strategy and is a resourcing priority. But many areas in decline are poorly served by ICT.

Table 3: Conditions for achieving successful new places to 2065

New places			
Characteristics of successful urban forms in the UK	**New peripheral developments**	**New settlements**	**Dispersed development**
Environmental characteristics			
Successful urban forms are ones that:	**Can this be achieved?**	**Can this be achieved?**	**Can this be achieved?**
11. Make **sustainable use of the UK's land** resource (accommodating demographic change without loss of valued land)	Yes, if sited in appropriate locations: e.g. not on land of high ecologically/landscape value.	Yes, if sited in appropriate locations: i.e. well connected, not on land of high ecological/landscape value.	Not usually, although individual developments might not be problematic, in aggregate, continued *ad hoc* dispersal would develop valued open land.
12. Make **sustainable use of the UK's environmental resources** (including protecting and enhancing biodiversity)	Yes, if planned sensitively. But there may be some inevitable loss if developing on greenfield sites.	Yes, if delivered using sustainable planning and design principles, including best practices (e.g. in Sustainability Impact Assessment, responsible sourcing, and integrated infrastructure – such as waste to energy). But there may be some inevitable loss if developing on Greenfield sites.	Partly, small scale changes may not be problematic, but in aggregate are inefficient and may damage biodiversity.
13. Are physically **adapted for the UK's future climate**	Yes, if future climate is considered from the outset in design, planning and construction.	Yes, if adaptation is considered during design and construction.	Partly, if individual developments consider future climate from the outset in design, planning and construction. But harder to plan/manage collective/community scale solutions.
14. Do not **contribute to future climate change** (i.e. reduce carbon emissions, exceeding or matching international targets)	Yes, if they are zero/low carbon developments, and do not generate transport emissions. Travel emissions can be minimised through providing a mix of uses in the development, and good connections to existing settlement.	Yes, if low/zero carbon design is applied from the outset, and if new physical and virtual connections to existing settlements/destinations are low carbon, and/or reduce travel demand.	Partly, if autonomous (micro) energy generation solutions are used. But likely to result in significant transport emissions (car travel).
15. Improve (or do not worsen) **air quality**	Yes, if development is designed as zero emission from the outset, and good connections are made to adjacent settlement. But are likely to inevitably generate some emissions from increased car use.	Yes, if development is designed as zero emission from the outset and good connections are made to existing destinations. But are likely to inevitably generate some emissions from increased car use.	Unlikely, few alternatives to car travel for dispersed development, so continued emissions likely (unless major change to electric vehicles).
16. Facilitate efficient **water management** (systems and behaviours)	Yes, if new, efficient water infrastructure is provided (e.g. sustainable urban drainage systems) and connections are made to supply infrastructure in adjacent settlement (to maximise use of any 'spare' capacity). And if new development promotes water efficient behaviours (e.g. By using water meters,	Yes, if new, efficient water infrastructure is provided (e.g. sustainable urban drainage systems) and connections are made to supply infrastructure in adjacent settlement maximising use of any 'spare' capacity. And if new development promotes water efficient behaviours (e.g. by using water meters, providing water butts	Partly, can facilitate localised water harvesting and recycling (at the level of a dwelling or group of dwellings). But is not efficient for mains water provision, and waste water processing.

	providing water butts etc.). But there may not be enough water for populations in some areas (given regional disparities and climate change).	etc.). But there may not be enough water for populations in some areas (given regional disparities and climate change).	
17. Facilitate efficient **energy management** (systems and behaviours)	Yes, if new efficient energy supply systems are provided (e.g. renewable) and/or the new development links to and makes use of spare capacity from adjacent supply sources. But new population may breach existing supply.	Yes, if new efficient energy supply systems are provided (e.g. renewable) at the outset.	Partly, can facilitate localised energy generation (at the level of a dwelling or group of dwellings). But is not efficient for provision from the grid/pipelines.
18. Facilitate efficient **transport management** (systems and behaviours)	Yes, if new efficient transport infrastructure is provided to adjacent settlement and wider destinations. And if peripheral development is large enough to provide mix of uses and facilitate walking/cycling.	Yes, if new efficient transport infrastructure is provided. And if the new settlement is large enough to provide mix of uses and facilitate walking/cycling.	No, dispersed development is difficult to service with public transport, and low carbon travel (walking and cycling) levels tend to be lower.
19. Facilitate efficient **waste (solid and water) management** (systems and behaviours)	Yes, if new efficient waste infrastructure is provided, and/or linked to any spare capacity in adjacent settlement.	Yes, if waste management systems are well planned and infrastructure provided.	Partly, can facilitate localised waste management, e.g. there may be space for compositing. But, inefficient for general waste collection, recycling services etc.
20. Facilitate the efficient **integration of different infrastructure systems**	Partly. Where new infrastructure is required there may be the opportunity to introduce new integrated systems (e.g. energy to waste). But where infrastructure is connecting to existing systems, there may be lock-in.	Yes, if best practice in integrated systems (e.g. energy to waste, smart transport) are planned and provided.	Partly, if it facilitates small scale integrated infrastructure systems (e.g. within autonomous housing). But is inefficient and costly for mainstream systems (e.g. transport, energy, waste).
Social characteristics			
8. Adapt to **future changes (social, economic and environmental) in a socially equitable way**	Partly, if designed/developed to be flexible to future changes.	Partly, if designed/developed to be flexible to future changes.	Partly, provides some small scale flexibility. But not responsive to major social changes, e.g. does not provide enough affordable housing.
9. Are **desirable** to the population	Yes, if high quality extensions, with a mix of house sizes and types, are provided at affordable costs. And if the adjacent settlement is desirable.	Yes, if the development is high quality, and provides a mix of house sizes and types at affordable costs.	Partly, very desirable, particularly to more affluent householders seeking larger homes/more space, for second home owners, and to rural residents, seeking to remain in their home towns/villages. Not desirable for those unable to afford it.
10. Provide a **range of housing types and tenures** to meet needs and be affordable	Yes, if designed to accommodate a variety of household types.	Yes, if designed to accommodate a variety of household types.	No, dispersed development has tended to provide housing at the higher end of the market, with affordability a problem.
11. Are **accessible** for all	Yes, if good connections to the adjacent settlement and to wider destinations are provided.	Yes, if good connections within the development and to wider destinations are provided.	No, accessibility is a key problem for dispersed developments (in terms of distance, range of nearby destinations, and car dependency).

12.	Provide **access to health/education/culture/leisure services** for all	Partly, if residents can access existing provision in adjacent settlement (and there is capacity). Or, if adequate new services are provided within the extension.	Partly, if the new settlement provides adequate services, or if they are provided in other settlements nearby.	No, accessibility to services is a key problem for dispersed developments (in terms of distance, provision of nearby services, and car dependency).
13.	Are **healthy**	Yes, if planned and designed according to healthy urban planning principles. Can provide significant opportunities for good peripheral design where people can thrive. But, if they are not well connected, can become car-dominated dormitories characterised by inactive travel.	Yes, if planned and designed according to healthy urban planning principles. Can provide significant opportunities for good design. But, if they are not well connected, can become car-dominated dormitories characterised by inactive travel.	Partly, if they support an active, rural life. But can become car-dominated, with inhabitants relying on inactive travel.
14.	Are **safe**	Yes, if well planned and designed (e.g. high quality public realm, active frontages, natural surveillance).	Yes, if well planned and designed (e.g. high quality public realm, active frontages, and natural surveillance).	Yes, if homes are secure.
	Economic characteristics			
9.	Do not cause **land/property price shocks/instability**	Partly, this depends on how much land is released and how this affects local/regional supply and demand.	Partly, this depends on how much land is released and how this affects local/regional supply and demand.	Partly, incremental process so does not usually have dramatic impact. But demand for this type of development by more affluent, and by those buying second homes has changed the rural housing market.
10.	Enable efficiencies in **infrastructure costs**	Yes, if extensions are relatively high density then new infrastructure can connect to existing infrastructure in the adjacent city (where there is capacity), and be provided cost effectively. And, new infrastructure (such as combined heat and power systems) can be provided to serve the new population.	Yes, if well planned, and if new infrastructure systems are integrated. If densities and mix of use are well planned then low per capita costs.	No, it is costly to service dispersed developments. Per capita costs are high because of spatial distribution.
11.	Enable efficiencies in **public service costs**	Yes, if extensions are relatively high density then the development can use services already provided in the adjacent development (i.e. where there is capacity), or new services can be provided (e.g. schools) cost effectively to the new community.	Yes, if populations are large enough then services can be provided at efficient per capita costs. However, there are different population thresholds for different services (e.g. primary schools, hospitals), so some costs may be borne by adjacent towns/cities.	No, public services are costly per capita in dispersed developments, because of spatial distribution (e.g. waste collection, social care).
12.	Enable efficiencies in **transport costs** (for suppliers and residents)	Yes, if connections to adjacent settlement (transport interchanges and hubs) are optimised.	Partly, if developments are large enough, and well planned, then per capita costs can be low for supplying transport services, and residents will have options to walk/cycle. However, there will be infrastructure costs connecting to other hubs.	No, transport infrastructure is costly to provide to dispersed developments.

13. Support **local economies and economic diversity**	Yes, if the development is large/mixed enough and its population is economically active within the adjacent settlement, or in the new extension.	Yes, if the development is large/mixed enough to enable residents to be economically active within the settlement.	Partly, may support rural economies through diversification/modernisation.
14. Attract **inward investment**	Yes, if a high quality development, and if it provides buildings/services/connections desirable to investors.	Yes, if a high quality development, and if provides buildings/services/connections desirable to investors.	No, investment in dispersed locations tends to be small scale and piecemeal.
15. Facilitate **innovation and creativity**	Yes, if attracts creative/skilled population, and supports capacity in adjacent or nearby creative clusters.	Yes, if attracts creative/skilled population, and supports capacity in adjacent or nearby creative clusters.	Partly, there can be small scale innovation, but most innovation/creativity is associated with clusters/hubs of skilled people/businesses.
16. Facilitate efficient **ICT provision**	Yes, if links to provision in adjacent development, and is part of a connected city region.	Yes, if its part of a connected city region.	No. dispersed developments are difficult and costly to service with ICT.

8.2 Conclusions

This report has presented a baseline analysis of urban form and infrastructure in the UK (Part 1), and offered a forward look at plausible urban form futures to 2065. It has reviewed key challenges that the UK faces, and set out the conditions in which key urban form futures might be achieved: both in terms of how to **shape existing places** and how to **provide new development**. In setting out these options, it is clear that some quite fundamental things need to change if the UK is going to be able to meet the challenges it will face by 2065. While Tables 2&3 show that there are potential merits in a number of urban form options, achieving successful outcomes is dependent on a critical shift in how urban form and infrastructure are conceptualised and delivered. Specifically, the UK requires:

- **A clearer spatial strategy** - This is needed to give direction on which forms and locations should be prioritised for future growth, and which functions supported within them. This needs to be accompanied by a far clearer logic around the connectivity (physical and virtual) of settlements and their hinterlands, and the relationship of future development patterns with infrastructure supply and demand. This is critical for all regions in the UK, particularly given the uneven picture, skewed by London the Greater South East. Lessons can be learned from countries like the Netherlands and Germany, which have fully-developed and integrated functional city-region strategies.

- **A more strategic, long term focus for urban form and infrastructure** - in particular, more certainty and stability in planning and development systems, and a clearer vision for infrastructure planning. This is required to enable all stakeholders to take the long-term view, based around agreed priorities. Environmental challenges need to be prioritised and not linked to short term-political cycles. This is particularly critical in the energy and transport sectors.

- **New forms of governance** - This Century's challenges, particularly the shift to a low-carbon future, require new institutions, powers, knowledge, coalitions and ways of operating to transform existing places and infrastructure systems. Our current market-led mechanisms are delaying, and creating, problems for future generations and are likely to need radical reform (Bolton & Foxon, 2014).

- **Significant investment in retrofitting and remodelling existing places** - Existing urban areas and infrastructure are going to require significant and prolonged programmes of retrofitting, upgrading and modernising. The UK's current piecemeal and under-resourced response is unlikely to meet future challenges.

- **More 'spatial literacy' and sectoral integration in infrastructure planning** - Better understanding of the future spatial requirements for infrastructure, and of the opportunities that could be gained (and risks avoided) from more integrated systems is needed. This requires new intelligence about the interdependencies between urban form and infrastructure (driven by vulnerabilities related to peak load, climate change, and demographic change). Part of the solution is significant investment in new, smart infrastructure.

- **A renewed focus on place making, liveability and wellbeing, not just delivering housing numbers** - This will require bold planning, skilled practitioners, and a confidence that high quality new places can be delivered in a variety of urban forms. The UK could be an international leader in exemplary built environments, utilising talented professionals to demonstrate that resource-efficient, liveable and beautiful cities and towns are possible.

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