Cambridge Centre for Housing & Planning Research

Housing Digital Built Britain Network

How could better use of data and digital technologies improve housing delivery through the UK planning system?

Dr Gemma Burgess
Valentine Quinio

November 2018

UNIVERSITY OF CAMBRIDGE

Cambridge Centre for Housing & Planning Research

Contents

Contact:
Dr Gemma Burgess
glb36@cam.ac.uk
01223 764547
Cambridge Centre for Housing and Planning Research
Department of Land Economy, University of Cambridge
19 Silver Street, Cambridge CB3 9EP
www.cchpr.landecon.cam.ac.uk

This project was funded by the Centre for Digital Built Britain.

The views, thoughts and opinions expressed in the report belong solely to the authors, and not CDBB.

cdbb Centre for Digital Built Britain

Cambridge Centre for Housing & Planning Research

1. The question

How could better use of data and digital technologies improve housing delivery through the UK planning system?

2. What are the key issues and why is this important?

2.1. The UK planning system

The planning system can be defined as a set of regulatory frameworks and processes concerned with land use and the development of the built environment. The National Planning Policy Framework (2018) states that "the purpose of the planning system is to contribute to the achievement of sustainable development, whose objectives can be summarised as meeting the needs of the present without compromising the ability of future generations to meet their own needs". Urban planning sets multiple objectives which can be summarised as follows:

- **Economic**: the planning system ensures the allocation of land and the provision of infrastructure to support growth, productivity and innovation
- **Social**: the planning system supports communities, fosters well-designed, high quality, safe and affordable built environments which meet the needs of everyone
- **Environmental**: the planning system protects the natural environment, improves biodiversity and ensures a sustainable allocation of natural resources

Campbell (1996), identified a "planner's triangle': planners have to ensure the realisation of three conflicting priorities: economic growth, social justice and environmentally-friendly policies.

Urban planning shapes the built environment as a whole, and straddles a wide variety of fields such as transport policies, the construction industry and environmental policies. In particular, the planning system has a key role to play in the delivery of housing. It sets the objectives for land use when identifying sites with a potential for housing development, coordinates the various stakeholders involved in the delivery of housing, attributes land rights for housing developers, and determines the proportion of housing which should be delivered based on local needs.

The UK planning system is complex, because it is divided into a "multi-scalar policy framework" (Allmendinger and Sielker, 2018). It is a "plan-led" system, which means that "the decisions upon planning applications should be made in accordance with the adopted development plan, unless there are material considerations that may indicate otherwise" (NPPF, 2018, p4). In the UK, planning decisions are taken on individual development proposals. The planning system is composed of national and local planning regulations, and for each planning proposal, a decision is made based on its conformity with the wider objectives set in the local plan (which may deal with land protection, land rights, change of use, environmental protection or public interest).

In terms of the legal framework, two pieces of legislation were particularly important in the elaboration of the national planning system: the Town and Country Planning Act and the 2011 Localism Act. The 1947 Town and Country Planning Act (TCPA) nationalised the right to develop land, meaning that all planning proposals must be secured and approved by a planning permission delivered by the local authority (Monk, 2010). The TCPA was consolidated in 1990 and introduced the "development charge" principle, giving local planning authorities the powers necessary to require contributions from developers, both in the form of affordable housing and through financial contributions.

These agreements, most of which are made under Section 106 of the Town and Country Planning Act 1990, are 'struck' alongside the process of securing planning permission (Burgess and Monk, 2016). The objective of Section 106 is to capture planning gain (the uplift in the value of land which follows planning permission for development) in order to offset the negative impacts of development on the local community, by funding infrastructure such as highways, education or housing. The 2011 Localism Act radically changed the powers of local government in England, devolving significant planning decision-making powers from central government to local authorities.

In the UK, the broad objectives of planning are set within a national framework. However, planning is a devolved matter: planning regulations and legal frameworks, although similar, vary between the countries of the UK as each country has its own planning system. Moreover, a large part of the decision-making process actually takes place at local authority level.

2.2. Different levels of the planning system

2.2.1. National planning policy

The National Planning Policy Framework (NPPF) sets out the government's planning policies for England and how these are expected to be applied. Originally published in March 2012, and updated in July 2018, it "provides a framework within which locally-prepared plans for housing and other developments can be produced" (NPPF, 2018). The NPPF is an overall national framework, which means that all local planning decisions must be in accordance with the general principles stated in the national plan. In 2014, the Government also launched an online Planning Practice Guidance (PPG) document, which sets out how the NPPF should be used in practice. Both the NPPF and the PPG are produced by the Ministry of Housing, Communities and Local Government (MHCLG).

In Northern Ireland, the development of planning policy and guidance is the responsibility of the MHCLG, however, the Regional Development Strategy 2035 (RDS) produced by the Department of Regional Development (DRD) sets specific planning objectives for Northern Ireland. In Scotland and Wales, the planning system and specific land use policies are established in two documents: the National Planning Framework for Scotland and Planning Policy Wales.

2.2.2. Regional planning strategies

With the exception of London, there is no regional spatial strategy in the UK. In London, the Mayor's London Plan provides strategic policies for London as a whole, and a regulatory framework which applies in each London Borough. The London Plan summarises policies and establishes targets in a variety of fields, including housing.

2.2.3. Local development plans

The NPPF states that each Local Planning Authority (LPA) should produce a Local Plan for its area, although there is no legal requirement to do so. Local Plans should be adapted to the specific needs of the area, and based on "adequate, up-to-date and relevant evidence about the economic, social and environmental characteristics and prospects of the area" (Commons Library Briefing Paper, 2016).

Local Plans determine strategic policies, setting an overall strategy for the area in four different fields: housing, the local economy, community facilities and infrastructure. They "should make clear what is intended to happen in the area over the life of the plan, where and when this will occur, and how it will be delivered" (MHCLG Guidance

Document, 2016). For housing, Local Plans must identify needs and specific sites for future housing development. A large part of the plan should focus on the delivery of affordable housing, but other matters should also be taken into account, such as providing accessible housing for older people or residential care homes. Local Plans must also identify a five-year supply of specific deliverable sites, that should be updated annually.

2.2.4. Neighbourhood/community plans

The 2011 Localism Act provided local councils with the authority to establish planning policies at neighbourhood level in the form of Neighbourhood Development Plans. These sit within the Local Plan's strategic context and must be in accordance with the objectives set by the development plan for the local area. Neighbourhood plans should also be in general conformity with national planning policy.

2.3. The planning system: a summary of the procedures

2.3.1. Plan making process

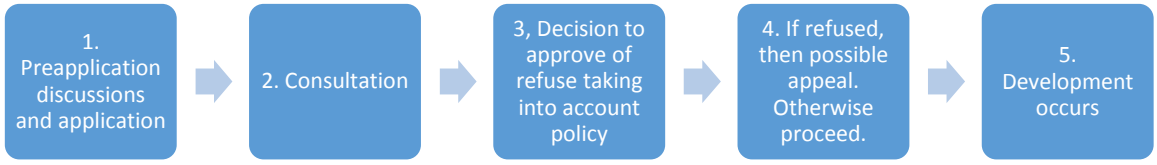
Plan making is a complex process because it is a shared procedure, led by Local Planning Authorities (LPAs) in coordination with other stakeholders: developers, landowners, other private bodies such as Housing Associations, and residents. Locals Plans set strategic policies for an area against which planning applications are assessed (MHCLG, 2018). Policies are usually composed of an evidence base the aim of which is to assess the needs and potential of a specific area across a wide range of topics, including housing, employment, retail, environmental protection and transport.

Local Planning Authorities usually launch a "call for sites" during which landowners and developers may put forward that their site be included in the Local Plan. The LPA then undertakes a sustainability assessment for these sites before publishing a draft Local Plan for public consultation. Once the consultation period has ended, the LPA submits a final draft of the plan to the Planning Inspectorate for examination. Adoption is the final stage of plan-making. The LPA has to publish, in the public domain, a copy of the Local Plan, an adoption statement and a Sustainability Appraisal (MHCLG, 2018). Once the plan has been adopted, it forms the basis for determining planning applications (NPPF, 2018).

2.3.2. Site development-planning application process

Although it is not always the case, a planning application is required for most development proposals (NPPF, 2018) and the LPA is responsible for making a decision

on the proposal in the first instance. The NPPF states that LPAs "should approach decisions on proposed developments in a positive and creative way. They should use the full range of planning tools available, including brownfield registers and permission in principle, and work proactively with applicants to secure developments that will improve the economic, social and environmental conditions of the area" (NPPF 2018, p13). After receiving a planning application, the LPA has to publicise it and open a consultation period, usually 21 days, in order to allow residents to express their views on the proposal. The LPA must take into account the residents' considerations and comments before making a final decision. Once the consultation period has closed, LPAs have up to 8 weeks to make a decision on minor applications, and up to 13 weeks for major developments. Once planning permission is delivered, the development must start within three years. The following chart is extracted from Allmendinger and Sielker (2018).



2.4. The role of the planning system in the delivery of housing

2.4.1. Planning policies for housing

Housing is a central element of the UK planning system. Section 5 of the National Planning Policy Framework states that a main objective of the planning system is to deliver a sufficient supply of homes. To do so, planning policies must ensure sufficient land is delivered for housing purposes. Planning authorities have to identify the land available in their area in the form of a Strategic Housing Land Availability Assessment, and prioritise small and medium sized sites as well as brownfield land.

Planning is also the domain in charge of assessing the number of homes needed, maintaining housing supply and delivery. Strategic planning authorities must use local data in the form of a local housing needs assessments, based on the demographics of the area. Depending on those needs, LPAs should also decide upon the type and tenure of housing that should be delivered, as well as the proportion of affordable homes needed. The NPPF also states that LPAs are in charge of determining a timescale setting annual objectives for housing delivery, as well as monitoring progress in building out sites.

2.4.2. Section 106

The "development charge" was introduced in the early 1947 Town and Country Planning Act, and reinforced in the 1990 amendment of the Act in the form of Section 106. It allowed the planning system to play a key role in the delivery of housing. Traditionally, planners had no impact on housing prices, and there was no interaction between land use policies and the allocation of affordable housing (Whitehead, 2007): land use was attributed by planning permission, and owners and developers discussed tenure and price. The 1990 TCPA allowed Local Planning Authorities to enter into negotiation with applicants for planning permissions, and to constrain applicants to fund some "off-site" costs such as infrastructure or roads through Section 106.

The rationale behind this "betterment taxation" (Crook and Monk, 2011) is that developers would compensate for the negative effects of a planning project by contributing back to the wider community (Hall, 1973). This soon developed the provision of affordable housing, funded by the planning gain, which can be defined as the revenue triggered by the uplift in land value following the granting of planning permission. Since its introduction in 1990, Section 106 has been a major source of funding for the delivery of affordable housing (Monk, 2010; Burgess et al., 2011), as well as a tool to secure mixed or balanced communities (Crook and Monk, 2011).

Over the past decade, developer contributions under S106 have significantly increased, and now represent a major source of funding for the delivery of affordable housing. In 2016/17, around £5.1 billion was committed through S106 planning obligations, and the estimated value of developer contributions for affordable housing went from approximately £2.6 billion in 2005/06 to £4 billion in 2016/17 (MHCLG, 2018). In 2016/17, this contribution enabled the provision of 50,000 affordable dwellings, representing a 10,000 increase compared to 2011/12 (MHCLG, 2018).

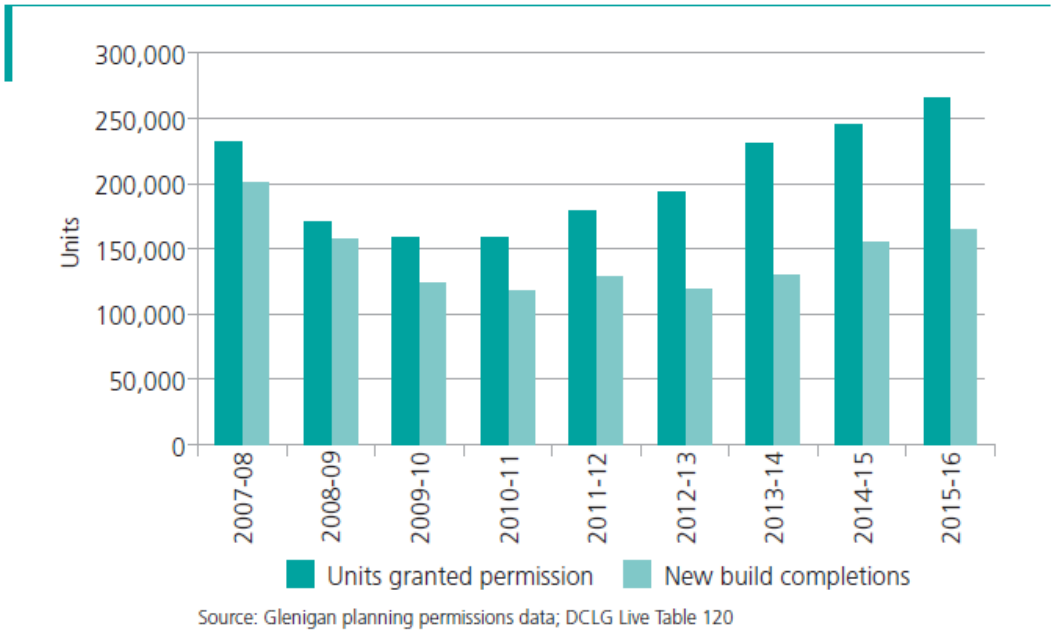
2.5. Key challenge – lack of new housing supply

Housebuilding has lagged behind demand in the past decades. A report published by the House of Commons in 2016 indicates that, between 2001 and 2010, on average 144,000 new homes were built annually. This is 100,000 fewer than in the 1970s, and it does not keep up with current housing needs and expected population growth. It has been estimated that the current need for housing completions is around 300,000 homes per annum (MHCLG, 2018).

"Fixing our broken housing market", the Housing White Paper published by the DCLG in 2017, reveals that over 40% of local planning authorities do not have a plan capable of meeting the projected growth in households in their area. More than a third of new homes that were granted planning permission between 2010 and 2016 still have yet to be built (DCLG, 2017).

The slow pace of development is also often held responsible for the housing crisis. There is still a large gap between the number of planning permissions granted and the number of new-homes built, as shown in Figure 1 below.

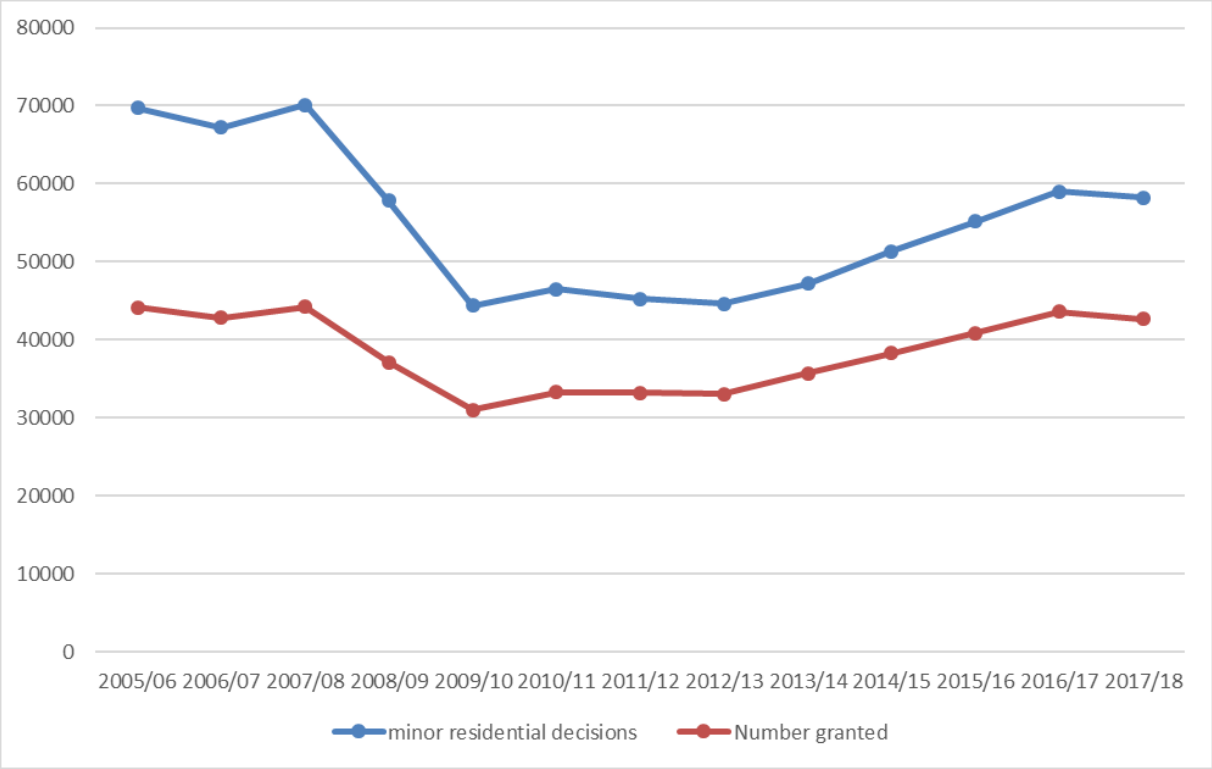
Figure 1: Annual permissions and completions in the UK, 2007-2016



Source: Fixing our broken housing market report, DCLG, February 2017

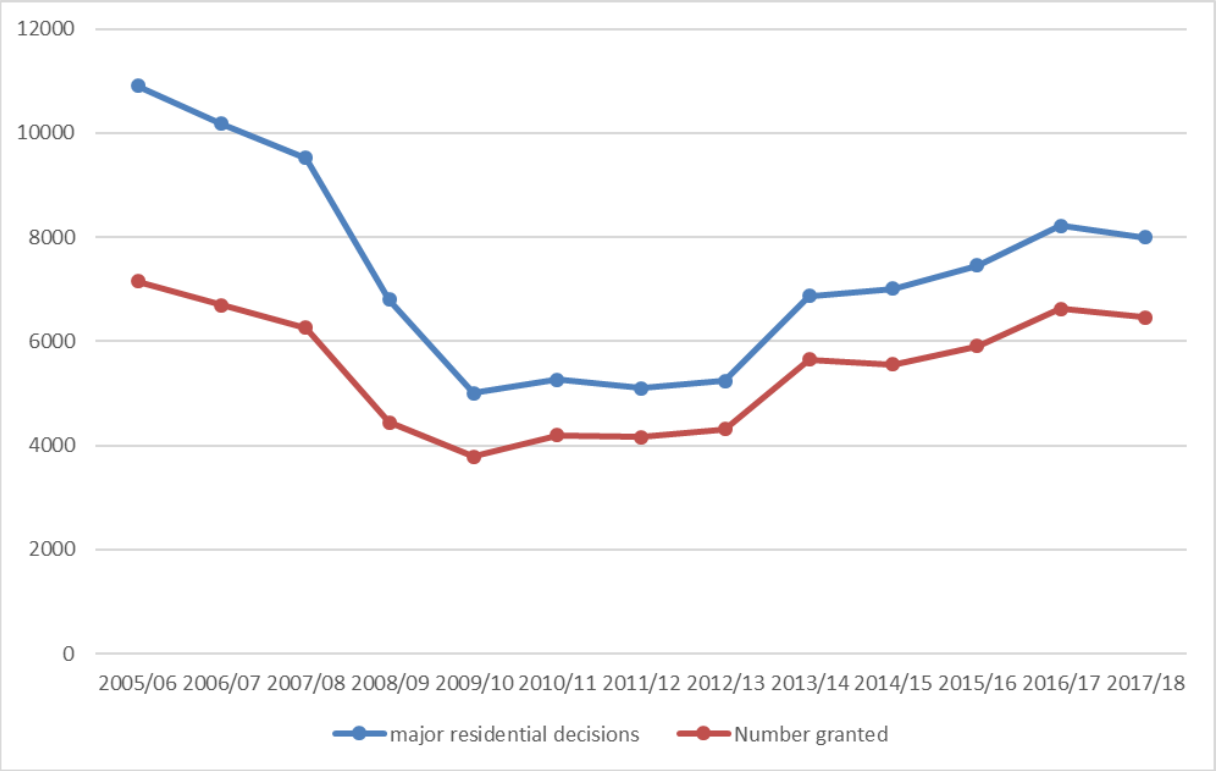
Figures 2 and 3 set out the annual number of residential planning applications decided and granted by district authorities by type (i.e. major development or minor). The latest numbers decided and granted for the major developments were 7,995 and 6,454 respectively. The equivalents for minor developments were 58,207 and 42,688. All the numbers had declined slightly in comparison to the previous year's levels – by 224 (major decision), 163 (major granted), 805 (minor decision) and 925 (minor decided), but well above those in the latest recession and aftermath period (around 2009/10 to 2012/13).

Figure 2: Major residential planning applications decided & granted by district authorities England, 2005/06 to 2017/18



Source: MHCLG Live Table P120A. Note: The 2017/18 figures are provisional and subject to revision

Figure 3: Minor residential planning applications decided and granted by district authorities England, 2005/06 to 2017/18



Source: MHCLG Live Table P120A. Note: The 2017/18 figures are provisional and subject to revision

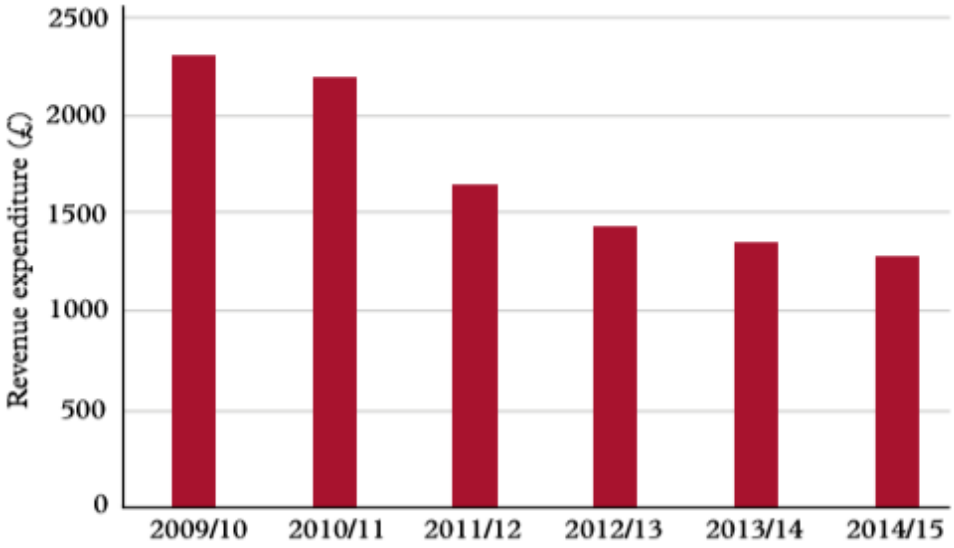
2.6. Critique of the planning system

The planning system is often said to be slow, complex and costly (House of Lords Economic Affairs Committee, 2016) and the main criticisms often levied at the UK planning system are as follows:

- There is a lack of up-to-date plans. In 2017, 34 local authorities in England had not published a Local Plan for consultation, and only a third had done so since the NPPF was adopted in 2012 (DCLG, 2017). In the absence of a solid Local Plan, permission may be contested, stopping or slowing down planning by infrastructure and utility companies.
- The current planning system is onerous, particularly when there are delays, appeals or negotiation costs between the LPA and the developer. Local authorities have experienced a decrease in funding in the past decade, severely impacting planning departments. On average, producing evidence based studies can cost around £100,000 (Future Cities Catapult User Research Report, 2016).

The graph below shows that, since 2009, LPA spending on planning has almost halved.

Figure 4: Local Authority net revenue expenditure on planning and development services (England) 2009-2015



Source: House of Lords Select Committee on Economic Affairs, "Building more homes" report (2016)

- Planning is a slow process. It can take roughly 9 months to produce an evidence base, although this varies across LPAs (Future Cities Catapult, 2016). It takes between 4-7 hours to process a typical household planning application, "yet around 50% of them are returned to applicants as invalid because they lack the right information or require modifications" (Future Cities Catapult, 2016).
- Public authorities often suffer from a lack of incentives for the provision of housing, and there is no immediate financial benefit from the planning process. The "windfall" created by the grant of planning permission is kept by the landowner. Furthermore, there might be an interest for developers or speculators to "snap up land for housing and then sit back for a while as prices continue to rise" (DCLG, 2017), although this is disputed by developers.
- There is no systematic approach to addressing the blockages which slow down the building of new homes. Many applications go to appeal, and a great number of local authorities struggle to handle applications. Between 2013 and 2018, 92,075 planning applications went to appeal (Planning Inspectorate, 2018).

- There is a lack of skill within public authorities. A survey conducted in 2016 by Knight Frank revealed that many developers consider that the lack of capability in planning departments prevent them from getting on site and carrying out the development process (Knight Frank Housebuilding Report, 2016). The "Building more homes" report states that "as the complexity of planning increased, their in-house resources were no longer sufficient to navigate the process and they needed to employ outside agents and consultants" (House of Lords Select Committee on Economic Affairs, 2016).
- There is a lack of standard methodology, guidance and support for assessing housing requirements, making it difficult for many local planning authorities to produce a five-year assessment for land supply. This jeopardises the production of the Local Plan and sometimes makes it out of date.
- There is little transparency on data about land ownership, control or interest of the land. The fact that such data are not available for all makes it difficult to identify precisely which sites may be suitable for housing development.
- The planning system also suffers from a lack of consistency across local areas. The NPPF provides general guidance for the elaboration of Local Plans, but it does not set specific requirements on the detailed evidence which needs to be provided in the planning process. In some places, this can lead to an over-creation of documents. While some LPAs produce around 10 evidence based documents for their Local Plan, others produce more than 20 (Future Cities Catapult,2016). This also contributes to the fragmentation of data between different LPAs, and prevents the creation of a common evidence base.

In short, the lack of efficiency of the planning system triggers a vicious circle. This is well explained by the DCLG (2017) report:

> "Slow building of new homes undermines local and neighbourhood plans. Where an authority cannot demonstrate a five-year supply of land against the housing target in its local plan, it is vulnerable to speculative development. This means the local community can lose a significant degree of control over where new housing is built, which undermines public confidence in the plan-led system" (p36).

Moreover, the fact that planning is often time-consuming, costly, lacks transparency and creates high barriers to entry, limits the possibility for new actors to enter the market and enhance competitiveness.

3. What does current research and evidence tell us?

The planning system uses and generates large quantities of data, shared and exploited by the large variety of stakeholders involved at every stage of the planning process. Although there are already some digital innovations that intend to address the current challenges in the planning system, research shows that it is far from being fully digitised. There is currently no national guidance on the use of digital tools in the planning system. The NPFF does not provide a regulatory framework for the uptake of digital tools, and only states that "plans should be accessible through the use of digital tools to assist public involvement and policy presentation".

However, digital innovation in planning is expanding. The Housing White Paper published in February 2017 announced objectives for digital planning in order to make plans and planning proposals more accessible: "The Local Plans Expert Group recommended that more plans should be accessible online, using interactive tools and improved facilities for online consultation" (DCLG, 2017). The Government also recently announced the creation of a new Planning Delivery Fund in order to enable councils to boost planning application processes and tackle housing challenges. A specific funding of £1.07 million has been allocated to promote innovation in planning. It will be awarded to LPAs which make "innovative use of digital or other tools to support more effective and efficient plan-making, design quality or development management" (DCLG, 2017).

3.1. How is data used in the planning system?

3.1.1. Plan making process

The plan making process is based on the use of data on local needs, collected through local authority surveys. The data is aggregated and analysed to formulate policies in the Local Plan and evidence-based surveys (on demographics, household growth projection, current needs for affordable housing or amount of land available) are conducted by professionals, either the LPA or external private consultancies. Data is gathered in two main documents: the Strategic Housing Market Assessment (SHMA) and the Strategic Housing Land Availability Assessment (SHLAA).

3.1.2. Planning application process

The Ministry of Housing, Communities and Local Government (MHCLG) currently publishes time-series statistics on planning applications and the decisions on

applications for residential developments and enforcement activities as Live Tables[1]. The key variables include the numbers (absolute and relative) of applications for planning permissions, decisions and permissions granted and application type (e.g. major or minor development). The geographical levels of the statistics range from the national to Local Planning Authority levels, and the update frequency is, in general, quarterly.

However, data is not always available to the public, which makes the planning application system sometimes obscure and opaque. For instance, after debate over whether MHCLG should open up the Land Registry (which contains information on land use and land ownership) or privatise it, the Government announced in 2016 that the Land Registry would not be privatised; however, HM Land Registry still charges fees for any application or transaction which necessitates registering land or leases[2].

3.1.3. To what extent is the planning system digitised?

The State of the Art Innovations in Digital Planning report published by Future Cities Catapult (2016) states that only "basic digital tools are in place for planning application administration". Most planning applications are submitted online via the Planning Portal[3], and then submitted to the LPAs. The planning portal now receives more than 2000 applications a day (Planning Portal, 2017). Today, around 90% of planning applications are submitted through the Planning Portal.

However, the planning application process as a whole is not fully digitised. As part of their "Future of Planning" programme, Future Cities Catapult explored the limits of the current planning system and questioned the digitisation of the current planning system. They argued that "innovation is sparse, with few places adopting digital and data driven techniques across all elements of the planning system" (Future Cities Catapult, 2016). The following list summarises their findings, and shows the extent to which the planning system needs further digitisation:

- In some places, there are no online services. Planning applications are submitted in paper form.

[1] https://www.gov.uk/government/statistical-data-sets/live-tables-on-planning-application-statistics
[2] HM Land Registration Service fees are detailed in the following website https://www.gov.uk/guidance/hm-land-registry-registration-services-fees
[3] The planning portal is a joint venture between the MHCLG and TerraQuest Ltd. It was established in 2002 in order to allow planning applications to be processed electronically. It was privatised in 2015. See also https://www.planningportal.co.uk/

- Even where there is access to the Planning Portal, applicants are not compelled to use the online form. Applicants may download the standard planning application form in paper format and send it by post.
- Even when submitted electronically through the Planning Portal, the system remains analogue because applicants simply upload digital versions of paper documents which are very often quite heavy. The use of paper for planning notices or case files is problematic, as files can be lost or posted to the wrong LPA department.
- Very often, planning records are still on paper, in non-machine readable formats. This makes them ill-suited to sharing.
- At the other end of the planning chain, documents are received and processed by a planning officer or a committee which must then evaluate the applications and make a judgment as to their impact and feasibility. The planning system is still a person-centric process, even where digital technologies are used.
- Most of the data used in a planning application is not captured or structured, which makes it difficult to analyse and aggregate the information received: "For example, Planning Departments will rarely have access to historical data on height of proposals, overall floor space submitted, number of bedrooms, predominant materials, viability or any of the incredibly valuable information contained within the thousands of applications they assess" (Future Cities Catapult, 2018).
- The site notice and consultation process is not fully digitised either. There are a wide range of methods available for LPAs; some use online planning record services which allows residents, local businesses and other stakeholders to view the document online and comment it, but others still use paper notices.

3.1.4. Site search and appraisal process

Site searches and appraisals are used in both the plan making and planning application processes. Informed by sustainability appraisals, LPAs select the sites they include in the plan, identifying land for residential development, or assessing the number of affordable units that can be provided. Developers also appraise sites suitable for development before submitting a planning application. It is a fragmented process. Although it requires gathering large quantities of information (planning history, heritage, environmental constraints such as flood risk, existing infrastructure), such data is not coordinated and integrated in single data sets. The site search process is usually operated by land agents, surveyors or planning consultants and is still largely a manual process which makes little

use of digital tools: "Sites are found through connections with agents or through adverts in the press, such as the Estates Gazette" (Future Cities Catapult, 2016).

3.1.5. Plan monitoring process

The plan monitoring process allows LPAs to check that the development process is meeting the needs that it is supposed to address. This is usually done through annual on-site surveys and tools such as performance indicators. It ensures the housing delivered corresponds both to the plan's initial announcements and to the area's needs. The monitoring process is one of the least digitised stages of the whole planning process (Future Cities Catapult, 2016), and there is little innovation. The report (ibid) says: "Plan and development monitoring data is not neatly aggregated or readily accessible, with much data being privately held by construction market intelligence firms such as Glenigan and Barbour ABI, who use the data to provide the construction industry with leads for development projects, not to monitor plans." (p 17)

3.2. What are the potential benefits of digitisation?

It is quite difficult to precisely and quantitatively evaluate the benefits of the uptake of digital tools in the planning system. However, there are many expected potential benefits, in terms of costs and time savings, transparency and efficiency. Every stage of the process (plan-making, planning application, public consultation or development control) can be positively impacted.

According to the RTPI report "Better Planning: Smart City-Regions" (2017), bridging the gap between tech-sector innovation and LPAs would trigger the following benefits:

- Quicker and more responsive plan-making
- Simplification of the planning application process
- Improved community engagement
- More consistent management of developments

If more digital technologies are introduced to the planning system, they could enable:

- Integration with other systems such as transport, health, infrastructure, etc.

  Although urban planning has an impact on a wide variety of sectors, the UK planning system is organised in departmental 'silos' (RTPI, 2017). Digitisation can break down such planning silos, for instance by integrating a wide diversity of

challenges on the same digital planning platform. More than just visualisation tools (such as Land Insight or Urban Intelligence), this would allow identifying areas with cross-sector planning issues. Digitisation could enable different policy goals to be tackled simultaneously through a better and more efficient understanding of their interdependency - such as housing and health, transport and local economy, existing infrastructure and industrial heritage etc.

Digitisation can foster communication and collaboration at every stage of the planning process between different stakeholders (such as planners, architects, local businesses, LPA), in a domain where communication is key but often missing (Future Cities Catapult, 2016). Sharing data can allow a more holistic, multidimensional and multiscalar approach to the planning system (Eräranta and Staffans, 2015). These benefits are described in the State of the Art report published by Future Cities Catapult: "the objective of many of the innovations is precisely to break the silos that divide and delay processes, and to combine and integrate as much as possible to simplify and cut costs, while generating valuable insights" (p7).

- Better risk assessment

  Much has already been written about the role of data in natural disaster resilience, particularly in cities often exposed to floods or other natural hazards, focusing on spatial data and software such as GIS or Spatial Data Infrastructure (Lyu et al., 1018; Falco, 2015). In 2012, the World Bank launched the Open Cities Project in order to "create open data ecosystems that will facilitate innovative, data-driven urban planning and disaster risk management" (World Bank, 2014).

  Digitising the planning system may allow a better risk assessment, for instance by making risk-related data available for all planning stakeholders. This is the objective of digital platforms such as Land Insight which provides information on environmental constraints such as floods as well as planning decisions on a single map-based platform (Future Cities Catapult, 2016).

- Integration and consideration of all stakeholders

  As explained earlier, digitising the planning system can foster communication and collaboration between planning stakeholders such as local planners, architects and local businesses. It might also encourage participation and community involvement, by making information more accessible and creating platforms of discussions, approval or contestation. Public involvement and

engagement within the planning system can be difficult to achieve, and remains relatively low (Holman and Rydin, 2013; Wilson et al., 2017). When it is achieved, it is not fully digitised: very often the public expresses its views on a planning project via e-mail, post, or by commenting directly a pdf document. The wider uptake of digital tools, online participation platforms, web or mobile apps (such as Stickyworld [4]) which make planning information more available, visual and accessible might be a way to involve a wider community in planning decisions and create a more democratic process.

3.3. Which existing technologies could be used for planning purposes?

In his blog "Time for a digital overhaul of the planning system", Peter Madden, Ambassador and former CEO of Future Cities Catapult, gives three examples of existing technologies which could transform the planning system:

Sensors are already used in many cities to collect data on how people use cities and places, how many people use spaces or how many cars are being used in a given place. This data could be extended (with, for instance, real time data on how homes are occupied) and exploited by the planning system. Having a better sense of the use of spaces with real time data would allow the planning application process to be better tailored to local needs. This has been explored in literature around smart cities and Big Data analytics (Rathore et al. 2015). For instance, sensors were used in the city of Aarhus (Denmark) to determine road traffic volume and to adapt the Local Plan to meet the needs identified by such devices: "Pre-defined sensor pairs were used to determine road traffic in between two points. Sensors deployed in selected parking lots of Aarhus city gathered parking information, including used space and availability" (Silva et al. 2018).

Virtual Reality (VR) is increasingly used in the planning system with the help of existing gaming software. It allows the development of "interactive models of entire city-regions, offering a consistent way to understand and communicate the impact of development proposals on issues like sunlight, visibility, protected views and transport" (RTPI, 2017 p 17). Virtual Reality offers the potential to monitor the progress of a project, anticipate future needs, and also to visualise plans for future developments.

[4] https://info.stickyworld.com/

Virtual reality has the potential to facilitate dialogue, inform better plan making and decision-making processes and involve citizens through a bottom-up approach to urban planning. It makes planning more accessible: award-winning projects like Smart Favela, developed by the French technology company Toolz in collaboration with the city of Rio, uses VR to enable residents to review projects and leave feedback on future planning developments in their area. As explained on the Toolz website[5], residents have the "opportunity to see in a pedagogical way each project in 3D, accompanied by information on the context, the functioning, the cost and the expected benefits via the realization of videos and interactive cartographic analyses".

Existing digital platforms such as VU.CITY [6] provide accurate, fully interactive digital city models which are already being used by architects, land owners, developers and public authorities in a variety of cities, including London, Manchester, Belfast, Birmingham and Paris. The London Borough of Southwark licenced VU.CITY for the development of their Area Action Plan in Old Kent Road. As detailed in Southwark Council's Planning Performance Agreement, new planning development proposals must be submitted into the Council's VU.CITY model.

Agent-based modelling technology allows the creation of complex models using population demographics, land markets, transport and social infrastructure. Modelling these elements simultaneously instead of conducting separate analysis for each element may improve the efficiency and accuracy of the data used for plan making or planning applications. In the construction industry to date, this has mainly been used in the form of Building Information Modelling (BIM), but existing research shows that it can find an echo in the planning sector (Allmendinger & Sielker, 2018, see below).

[5] https://www.toolz.fr/uk/en_EN/projet_en.php?inc_smart_favela_en
[6] See https://vu.city/

Focus: How can BIM improve the planning system?

In the building and construction industry, the current form of ongoing transformation of the built environment through the use of digital tools is known as Building Information Modelling (BIM). BIM is a process of "designing, constructing or operating a building or infrastructure asset using electronic, object-orientated information". Autodesk (2018) defines it as "an intelligent 3D model-based process that gives architecture, engineering and construction (AEC) professionals the insights and tools to more efficiently plan, design, construct and manage buildings and infrastructure". According to Araszkiewicz (2017), "advanced digital technology is a source of numerous solutions that facilitate acquisition, processing, redundancy and compression of information utilised about building, making it easier to develop cause and effect models, draw conclusions and make forecasts."

However, there is also the potential for BIM to engage with the planning system and improve the outcomes of the planning process. Initially, BIM was conceived as a "process for generating and managing digital representations of buildings and places" (Allmendinger & Sielker, 2018). New BIM technologies under the name of "BIM Levels 3 and 4" move "beyond construction efficiency to information to support the growth of current and future cities". The engagement of Architecture, Engineering and the Construction Industry gave birth to the experimentation of BIM at the city-scale, under the name of City Information Modelling. Its aim is to create and exploit a "digital DNA of cities" (Allmendiger and Sielker, 2018). CIM tackles a variety of challenges which are central to the emerging "smart cities" research and elements of these initiatives and innovations can be implemented in the planning system. The use of digital information can improve planning efficiency, for instance by including real time monitoring or simulation in the planning process.

There is currently no mention of BIM at a national planning policy level, and there is a lack of awareness of and engagement with BIM at the local level. Research conducted by Allmendinger and Sielker (2018) suggested that BIM should be referenced in the NPPF: Government should publish a Planning Practice Guidance on BIM which would help LPAs to use BIM in many stages of the planning process, whether plan making, planning application, development control, consultation or monitoring.

For housing purposes specifically, the use of BIM can improve the efficiency of the planning system (the following list is extracted from Allmendinger and Sielker (2018):

- Improving local strategic planning by linking infrastructure, housing and transport through better information
- Better co-ordinated investment decisions (based on better data and information) and reduced blockages in the development and production process
- Improving construction productivity and efficiencies through shorter build times

A concrete application of BIM in the planning application process is the use of 3D digital modelling in the impact assessment. Allmendinger and Sielker quote the draft Cambridge Local Plan: "The use of 3D digital modelling and visualisation by applicants for tall buildings is strongly encouraged at pre-application discussions with applicants. As part of the planning process, developers may produce 3D computer models of their scheme to illustrate the scale and massing of the proposed development".

3.4. Existing examples of innovation

3.4.1. Compiling data and simplifying the evidence-making process

LandInsight

LandInsight[7] compiles data on land ownership, land use, environmental constraints (e.g. flooding and other risks), historic preservation (such as listed buildings) and planning history on a single map-based platform. It aggregates the data necessary for a viability assessment before the launch of a planning application. It allows developers and other applicants to gauge whether the site is likely to receive a planning application, as well as the potential type of development. It attempts to address the issue of unequally distributed knowledge, while allowing time and cost-savings for site search and appraisal.

[7] https://www.landinsight.io/

3.4.2. Site search: identify, prioritise and allocate sites for new developments

Future Cities Catapult Land Information Platform

A part of their "Future of Planning" initiative, Future Cities Catapult worked with MHCLG to develop an innovative tool which would help LPAs to identify and allocate sites for new development. The conceptual prototype, called the "Land Information Platform"[8], intends to address the speed and efficiency of the site search process. Using and compiling existing data sets (such as Land Registry, historic planning data and energy performance certificates), the platform would automatically identify land available for a specific development. For housing developments, the tool would be able to gauge the number of homes that can be provided.

3.4.3. Facilitating the planning application process

iApply, Idox Software Ltd

Launched in 2015, this planning application submission portal intends to simplify the planning application process by "providing every required form, bulk uploads, and collaborative features facilitating sharing of applications with colleagues and clients" (FCC, Research Report). It also allows a user to track the application throughout the process, both for the applicant and the LPA in charge of evaluating the proposal. It intends to expand and serve as a single platform for planning transactions across LPAs in the UK, thus addressing the lack of consistency in planning application methods.

3.4.4. Monitoring planning developments

Future Cities Catapult monitoring system

The monitoring process is one of the least digitised stages of the planning process. It lacks consistency because every LPA has their own method of monitoring - there is no shared, standardised procedure between different LPAs. Some conduct qualitative interviews on site, others use quantifiable evidence or measure the "value added" of a project. It is very often a manual process, without standardised data sets, which increases the likelihood of errors and poor quality data. To address this problem, Future Cities Catapult organised a "Design Sprint" method in which it conceived a new monitoring system[9] which would allow users to "make precise assumptions on what has been

[8] https://futurecities.catapult.org.uk/2017/10/19/blog-land-information-platform-levelling-playing-field/

[9] The prototype can be found https://projects.invisionapp.com/share/83G0ETGWUX5#/screens/281179557_03

planned, permitted, started, completed and occupied, and the speed at which individual developments move across these four stages." It would include:

- A main page summarising key information about the development, as well as the stages reached for each listed site.
- For each stage of the planning process, a range of data sets will be automatically generated and checked before moving to the next stage. For instance, the "planned" stage will use data from the Strategic Housing Land Availability Assessment.
- A summary box will reveal the number of homes (by size and tenure) at every stage of the process, as well as automatically produced information such as the cumulative CIL (Community Infrastructure Levy) generated by the development.
- Detailed site information will allow the user to verify the data sources that have been used and generate a confidence rating for this data. The data sources will be listed on the platform and can be checked by the user. For each stage of the process, different data sources will be used. For instance, the "permitted" and "started" stages will use data such as the SHLAA, Planning Decision Notice, Building Control Health and Safety Certificate or S106CIL certificates, while the "occupied" stage will use Tax and Revenue registers, Building Insurance or Energy usage.

3.5. Case studies

3.5.1. National example: innovative planning in Plymouth

Plymouth City Council has won national awards for excellence in planning. For the elaboration of its 2011-2031 Plymouth Plan[10], it adopted innovative approaches at every stage of the planning process. It put the emphasis on the potential of digital tools for encouraging community participation and public engagement in plan-making. The emerging Joint Local Plan is not only presented as a PDF document but as an interactive website (created in partnership with a local gaming company) where citizens can browse, search for information and give their opinion, applying filters based on their status (citizen, developer, private enterprise) or their interest (economy, cultural policy, transport etc.). It also provides a tab allowing users to track the progress of the plan, and

10 See https://plymswdevonplan.co.uk/policy

might soon be completed with live datasets which automatically monitor developments in order to appraise their compatibility with the objectives set by the plan.

The Council have also invested in opening up their data. DATA Plymouth[11] is a website which offers access to a range of open data and statistics collected from national and local data sources and information on a range of topics such as population, ethnicity, employment, health, deprivation and crime. Statistics and key facts are presented in an accessible, highly visual form, but the website also offers access to a variety of original data sets. Plymouth Council also have a DATA Play[12] website. DATA Play is about working with local talent and tech companies to explore how open data and technology can be used to help the Council deliver services in new ways. They run 'play days' throughout the year to encourage people to come together and play with the datasets they have opened, focusing on different themes and some of the challenges the Council face.

Plymouth City Council also used an innovative crowdfunding online platform[13] (called Crowdfund Plymouth) which redistributed the neighbourhood portion of CIL (Community Infrastructure Levy) to the wider community (social enterprise businesses, charities, community groups etc.). The aim was to make the allocation of the development benefits more transparent to the local population. This process has transformed the usual method of local consultation. The Council will only fund a local campaign launched on Crowdfund Plymouth when it reaches 25% of its funding target, demonstrating local support.

3.5.2. International example: digital planning in Singapore

Singapore is increasingly known for cutting edge innovation in the construction and architecture industry. In order to keep up with massive industrialisation rates and housing needs, the sovereign city state quickly became an international leader in the BIM industry, and reached BIM Level 3 in 2015 – while the UK intended to reach Level 2 by 2016 (Sielker and Allmendinger, 2018). This was partly achieved through the launch of the Construction and Real Estate Network programme (CORENET). The 2011 Building and Construction Authority (BCA) roadmap set a target of 80% use of BIM in the construction industry by 2015.

[11] http://www.dataplymouth.co.uk/
[12] http://www.dataplymouth.co.uk/dataplay
[13] https://www.plymouth.ac.uk/news/plymouth-university-welcomes-the-launch-of-crowdfund-plymouth-which-will-provide-_60000-to-local-projects

By integrating BIM into the construction industry, and therefore digitising tools and techniques used in the building industry, Singapore also modernised the planning system.

In 2002, the BCA launched an e-submission system involving 16 regulatory authorities and 8 government ministries in charge of the construction and real estate industry. It allows applicants to submit planning applications online (with no need for hard copies of plans, paper planning records or on site visits), adding transparency whilst allowing users to track and monitor their applications online.

In 2016, the Singapore government launched the e-Plan Check system and made it mandatory for new build projects over 5,000 metres square. Through this system (which is fully funded by the government), architects and engineers can check their planning applications to make sure they correspond to the objectives set by plans. Such automated models are also used to check "BIM e-submission compliance" (Sielker & Allmendinger, 2018). The aim of the system is to shift from traditional 2D design drafts to digital modelling, where the Building Information Model gathers project information throughout the building life cycle. This new database can be progressively completed at every stage of the project, creating a system which also allows building professionals and regulatory officers to check regulatory compliance and conduct audit checks through the same platform.

The government also recently launched a new project called "Virtual Singapore", a new public-private partnership led by the National Research Foundation, Singapore Land Authority (SLA), Infocomm Development Authority of Singapore (IDA) and the French Multinational software company Dassault Systèmes. The aim of the project is to create a "digital twin", a dynamic 3D model of Singapore that can be explored, researched and manipulated by a variety of stakeholders involved in planning decisions, as well as by citizens. The system would capture data (such as pedestrian movement or traffic) which would then be accessible on the platform, sharing visual information through a live digital replica of the city. It would allow planning authorities to conduct "virtual experiments" before taking planning decisions[14].

[14] See also https://www.nrf.gov.sg/programmes/virtual-singapore and https://govinsider.asia/digital-gov/meet-virtual-singapore-citys-3d-digital-twin/

Ministry for Housing Communities and Local Government (MHCLG) Digital

The Minister for Housing Communities and Local Government (MHCLG) created in 2018 a new Digital Land Policy team. This is part of the new MHCLG Digital initiative, which "aims to upskill and equip the Ministry for the internet age" and "stimulate the move towards common standards and design patterns for local public services". Beyond the digitisation of the Ministry's internal services, the objective of the new team is to support the wider uptake of data-driven tools and digital technologies to address housing policy and planning issues.

The MHCLG Digital blog specifies that "on housing that means achieve more homes for people by encouraging the diversification of the housing market through supporting digital and data 'PropTech[15] entrepreneurs'" as well as "working with innovators in these sectors to help modernise the planning system". The Digital Land Policy team has multiple objectives. It aims at making data on land, planning and housing more accessible, as well as supporting the process of plan-making with a wider use of digital tools and new technologies. It also seeks to make it easier for users to navigate the planning system and make every stage of the planning process quicker and more effective. Finally, it also intends to make planning more accessible for the wider community, while raising awareness, information and the ability to understand and shape local planning decisions. To do so, it will work closely with local authorities and local governments to help them improve their digital services, as well as private organisations specialised in the tech sector applied to urban planning such as Future Cities Catapult (FCC). The team will also work with the Geospatial Commission to provide reliable data infrastructure and open up base level maps.

Local Digital Declaration

In order to support Local Authorities in their digital transition, the MHCLG and the Government Digital Service launched in July 2018 the Local Digital Declaration. It reaffirms the need to transform local authority services using digital tools, and commits to:

- Design services that best meet the needs of citizens

[15] The term "PropTech" used by MHCLG Digital refers to "Property Technology".

- Challenge the technology market to offer the flexible tools and services we need
- Protect citizens' privacy and security
- Deliver better value for money[16]

Local Digital Fund

The MHCLG announced in July 2018 the launch of a new Local Digital Fund which supports local authorities in their development of new digital solutions and their use of digital technologies. Totalling £7.5 million, this new fund will allow local authorities to submit applications and receive grants available for projects "that demonstrate they benefit local public services" as well as providing digital training skills to local authority staff and employees working on digital solutions. In December 2018, the Expert Local Digital Fund panel announced the funding of 16 projects for the first round, out of 77 applications received. Most of these projects group local authorities and private partners, which were awarded funding for diverse projects such as helping people in the social rented sector to report housing repairs online or uncover common patterns for chatbots and artificial intelligence in local councils. The full list of awarded projects can be found on the MHCLG Digital website.

[16] Source https://localdigital.gov.uk/declaration/

3.6. What are the constraints on the wider use of data and digitisation in the UK planning system?

3.6.1. Decentralisation

Digitising the planning system is a complex challenge, given the level of decentralisation in the UK planning system. In the absence of national guidelines, Local Planning Authorities have few incentives to develop shared, interactive plans with neighbouring authorities or to use digital tools to address cross-boundary issues such as traffic congestion or housing. In England, "policies and plans are made in departmental 'silos' with little integration and coordination" (RTPI, 2017).

3.6.2. Data collection: issues of ownership, privacy and security

The wider uptake of digital tools in the planning system is hampered by issues of data collection, ownership and use. This issue has been raised by Future Cities Catapult (2018):

> *"There is a need for policies to review the process of data collection in the public realm, from sensors, digital street furniture, advertising and other new technologies being embedded in the urban environment. This collection of data needs to be regulated so as to ensure that the data being collected will help provide better services without infringing on the privacy of citizens."*

Data privacy is a concern for a majority of citizens (van Zoonen, 2016), but it is also a major challenge for the planning profession because of the conflicting objectives of transparency imperatives and data privacy. For example, a monetary penalty notice was issued against Basildon Borough Council in Essex in 2015 and the UK's Information Commissioner's Office (ICO) fined the Local Authority £150,000 after it published sensitive personal information contained in a planning application.

The new EU General Data Protection Regulation (GDPR) which came in to force in May 2018 replaces the EU's Data Protection Initiative (1995). It intends to strengthen data protection in and outside of the EU, with new obligations for companies and reinforced fines for personal data breaches. Its impact on the planning system and planning profession has not yet been established.

3.6.3. Lack of time, skills or resources for change

Whether it is for the plan making process or the planning application process, digitising the planning system can be time consuming and costly. Some software or digital tools

are onerous to develop, and Local Planning Authorities might lack resources to access them. For instance, the Virtual Reality platform VU.CITY which provides 3D and interactive digital city models costs £5,000 per Local Planning Authority. Using and manipulating digital tools may also require specific skills which could be costly and time-consuming to develop.

A lack of information on existing technologies may also hinder the digitisation of planning processes. In their research on Urban Planning and BIM, Allmendinger and Sielker (2018) explain that "analysis of Local Plans and discussions with key stakeholders provides little evidence of awareness of BIM and DBB (Digital Built Britain)". They also put the spotlight on unequal levels of information between different stakeholders. Large developers and architects show "big awareness" of BIM technologies and their potential in the planning system, but there is "medium to low awareness" in Local Authority planning departments. This imbalance may be a barrier to the wider uptake of digital tools in planning.

Furthermore, Local Authorities have experienced significant cuts in funding in the past decade. The Institute for Fiscal Studies estimated that central government funding to local authorities decreased by 20% between 2009 and 2015 (House of Lords Select Committee on Economic Affairs, 2016). As shown in Figure 4 (above), budget cuts have significantly affected local authority spending on planning. Planning departments are often under pressure to deliver an increasing number of housing units to meet local housing needs with an increasingly limited budget. They might therefore lack the time and resources necessary to explore existing innovations and develop new tools.

3.6.4. Resistance to change

Resistance to digitisation may also be a constraint on the wider use of data and digitisation of the UK planning system. Although this has not been extensively studied in the field of urban planning specifically, wariness of the use of big data, or fears of robotisation of the planning system might hamper further digitisation. Milton Keynes Council (who recently won an innovation funding grant from MHCLG and urban innovation agency Future Cities Catapult) will soon use Artificial Intelligence (AI) to make planning decisions, answer general planning inquiries and validate planning decisions. The replacement of human-based decisions by AI could generate resistance. Planning is still fundamentally a democratic and person-led system, with elected members having powers to vote on planning applications and there is likely to be resistance to innovations which are perceived to erode such powers.

3.6.5. Scattered and uncoordinated innovation

As illustrated in the aforementioned "State of the Art" (2016) report published by Future Cities Catapult on existing innovation in the field of urban planning, there is a considerable innovation in the housing sector. The report lists more than 60 different innovations being developed at different scales and steps on the planning system, in the UK and the rest of the world. Such innovation is not coordinated, rather, it seems scattered between the stakeholders involved in the planning system (LPA, architects, developers, planners, start-ups and companies specialised in digital innovation), at different levels (from neighbourhood or local planning level to national and sometimes supranational planning guidance), and at different stages of the planning system.

This lack of coordination could constrain the wider digitisation of the UK planning system. Companies like LandInsight and Howard Architectural have developed generic subscription systems for England, but some municipalities have developed standalone databases to meet local planning needs, e.g. the London Development database and the London Infrastructure Map, while other tools have been developed for specific cities (such as City Swipe in Santa Monica).

4. What are the gaps in knowledge?

This rapid review of the literature and discussion at the first Housing Network event has identified several areas in which further research is needed.

4.1. Lack of research on the benefits of digitisation

Although much has been written about the potential or expected benefits of digitisation on the planning system, there seems to be little research on the exact benefits of digitisation and how they could be measured. Very often, expected benefits are listed (cost saving, time saving, increased efficiency), but there is little empirical or quantitative evidence on the cost or time-savings saving associated with the use of digital tools in the planning system. In the fields of digital facilities management (DFM) and BIM, there has been some research and evaluation of such benefits: for instance, US-led research proved that using digital records might help to save 5% of the cost of the construction of newly built projects (Hackitt Report, 2018)[17].

[17] See the CCHPR position paper on the use of digital tools for governance, maintenance and management of the UK housing stock

Similar research still needs to be conducted and expanded, based on existing empirical evidence in the places already experimenting with digital planning, in order to measure the precise effects of digitisation on the planning system. Knowing more about how digitising the planning system would impact upon the pace of delivery or the affordability of the new stock would encourage a wider uptake of digital tools. It would incentivise Local Planning Authorities to engage with new digital platforms, tools and methods in order to meet the objectives set by their Local Plans. There is a need to engage with, evaluate and gather learning from industry leaders in innovation, but also from innovative Local Authorities across the UK and the world, and to disseminate this learning. To this end, further research needs to conduct impact assessments in order to determine which benefits can be expected and how they can be applied in different contexts.

4.2. Lack of research on the specific application of such knowledge to the housing sector

The majority of existing research on digital planning focuses on the uptake of BIM technologies in the building and construction industry in general, or deals with the broad concept of 'smart cities' and the general advantages of digitisation in the urban environment, whether it is transport, the economy, or large infrastructure projects. There has been little research specifically related to housing. This needs to be explored: how can a wider uptake of digital tools in the planning system address the current housing crisis? Housing delivery is a main objective of planning, and future research should explore how the uptake of digital tools and better use of data might improve housing supply. For example, how might the systematic use of digitised data on local needs help in allocating the right amount of housing in the right place?

4.3. Digitising the planning process: what are the priorities?

Some stages of the planning process are more digitised than others: while most planning applications are now submitted electronically, implying savings in terms of costs and time, the digitisation of other stages of the planning process is an area that has been less well explored through research. There have been significant improvements in the use of digital platforms for online consultation and community engagement, but in order to be aware of ongoing online consultations, residents must express their interest or frequently read the local press, which leaves many groups out of the loop. There needs to be further research on how digital consultation can target groups which do not often have a say in the planning process.

4.4. Lack of research on the optimal regulatory framework level

There is a lack of clarity concerning the optimal level for digitisation of planning. Although existing research has pointed out that the uptake of digital tools should be mentioned and explored further in national planning documents such as the National Planning Policy Framework (Allmendinger & Sielker, 2018), it is unclear whether digital planning guidance should be provided at a national or local level. If it seems more appropriate to consider Local Plans as "key vehicles for the further roll-out of DBB and BIM given the position at the nexus of national policy concerns and local needs and issues" (Allmendinger & Sielker, 2018), leaving local authorities a large room for manoeuvre may also generate inequalities between those who have resources to implement digital tools (such as London) and others who may lag behind.

There has been little research on how responsibility for coordinating and evaluating innovation should be attributed. If each individual LPA is responsible for adopting innovation and developing its own tools, then there is a risk of an increased fragmentation of knowledge, as well as scattered requirements and processes between different LPAs. This would make it harder and more costly for developers who often work across different LPAs. Data collection at a national level might also be hampered by non-standardised and heterogeneous innovative techniques in each LPA. This needs to be tackled by further research.

4.5. Lack of research on robotisation and Artificial Intelligence (AI)

Robotisation and Artificial Intelligence are central in the wider uptake of digital tools, particularly when it comes to the construction industry (with the use of BIM) and its application in city-modelling (in CIM technologies, see above). The use of AI technologies has been investigated in current research on smart cities (Chandler, 2018), for instance in the use of sensors, prediction models for traffic congestion or parking spaces (Lau et al., 2015). However, there has been limited research on the direct use of robots and AI for urban planning purposes.

The extent to which robots can replace planners, or the benefits and risks of the uptake of AI in planning decisions (as opposed to human decisions) still need to be explored. More generally, there is a current lack of knowledge on the need for new skills in the planning system, on how robots and AI might address this lack, and what ethical issues

this could raise. Little research has already been done on how AI might address the current flaws of the planning system - for instance whether it would allow a more objective decision-making process.

These new digital tools are, however, progressively being explored by Local Authorities: Milton Keynes is developing planning decision-making entirely based on AI, particularly for permitted development applications which only require technical assessments. In London, the borough of Southwark is looking into the use of algorithms "that will advise applicants on the likelihood of getting planning permission" (RIBA, 2018). Such innovative processes must be investigated by research, in order to assess their potential risks and challenges, as well as assessing their exact benefits. Furthermore, although these digital tools found an application in the construction industry, and possibly in urban planning more generally, little is known about their impact on the housing industry. Research must explore their ability to accelerate housing delivery or allow a more democratic decision-making process, based on local people's need for housing.

Cambridge Centre for Housing & Planning Research

5. References

Allmendinger, P. and Sielker, F. (2018). *Urban Planning and BIM*. Centre for Digital Built Britain Mini-projects Programme 2017-2018. Cambridge: University of Cambridge. Available at: https://www.cdbb.cam.ac.uk/CDBBResearchBridgehead/2018MiniProjects

Allmendinger, P. and Sielker, F. (2018). *International experiences: Future Cities and BIM*. Centre for Digital Built Britain Mini-projects Programme 2017-2018. Cambridge: University of Cambridge. Available at: https://www.cdbb.cam.ac.uk/CDBBResearchBridgehead/2018MiniProjects

Araszkiewicz K. (2017). Digital Technologies in Facility Management – The State of Practice and Research Challenges, *Procedia Engineering,* Volume 196, 2017, 1034-1042. [online] Available at: https://www.sciencedirect.com/science/article/pii/S1877705817331867#bibl0005

ARUP and RIBA (2017). *Designing with data: shaping our future cities*. London: RIBA/Arup. Available at: https://www.architecture.com/-/media/gathercontent/designing-with-data/additional-documents/designingwithdatashapingourfuturecitiespdf.pdf

Autodesk.com (2018). *What is BIM?* [online] Available at: https://www.autodesk.com/solutions/bim

BCA (2013). Singapore BIM Guide Version2. [online] Available at: https://www.corenet.gov.sg/media/586132/Singapore-BIM-Guide_V2.pdf

BCA (2011). Singapore BIM Roadmap. [online] Available at: https://www.bca.gov.sg/newsroom/others/pr0211_2011_BIB.pdf

Burgess, G. and Monk, S. (2016). Delivering planning obligations – are agreements successfully delivered? In A. Crook and C. Whitehead, eds., *Planning gain: providing infrastructure and housing*. Oxford: Wiley Blackwell.

Burgess, G., Monk, S. and Whitehead, C. (2011). Delivering local infrastructure and affordable housing through the planning system: the future of planning obligations through Section 106. *People, Place & Policy Online,* 5/1, 1-11. Available at: https://extra.shu.ac.uk/ppp-online/delivering-local-infrastructure-and-affordable-

housing-through-the-planning-system-the-future-of-planning-obligations-through-section-106/

Cambridge Centre for Housing and Planning Research (2013). The changing delivery of planning gain through Section 106 and the Community Infrastructure Levy. Cambridge: CCHPR. Available at: https://www.cchpr.landecon.cam.ac.uk/Projects/Start-Year/2012/Developing-a-Planning-Gain-Model/S106-Community-Infrastructure-Levy-Report/Report

Campbell, S. (1996). Green Cities, Growing Cities, Just Cities? Urban Planning and the Contradictions of Sustainable Development. *Journal of the American Planning Association*, 62(3), 296-312. Available at: https://my.vanderbilt.edu/greencities/files/2014/08/Campbell1.pdf

Chandler, D. (2018). The Future of Smart Cities Relies on Artificial Intelligence. EC & M, p. EC & M, May 10, 2018.

Crook, A. and Monk, S. (2011). Planning Gains, Providing Homes, *Housing Studies*, 26, (7-8), 997-1018. Available at: https://www.tandfonline.com/doi/abs/10.1080/02673037.2011.619423

DCLG (2017). *Fixing our broken housing market.* London: Department for Communities and Local Government. Available at: https://www.gov.uk/government/publications/fixing-our-broken-housing-market.

DCLG (2017). *Planning Delivery Fund*. London: Department for Communities and Local Government. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/664455/Planning_Delivery_Fund_Prospectus.pdf

Eräranta, S., & Staffans, A. (2015). From Situation Awareness to Smart City Planning and Decision Making. Available at: https://www.semanticscholar.org/paper/From-Situation-Awareness-to-Smart-City-Planning-and-Er%C3%A4ranta-Staffans/fe8f8b2af835938d175c5b1553310337aa0540ba

Falco, G. (2015). City Resilience through Data Analytics: A Human-centric Approach. Procedia Engineering, 118, 1008-1014. Available at:

https://www.researchgate.net/publication/283172010_City_Resilience_through_Data_Analytics_A_Human-centric_Approach

Future Cities Catapult (2018). *How to Upgrade the Planning Application Service*. [online] Available at: https://futurecities.catapult.org.uk/2018/03/12/blog-upgrade-planning-application-service/

Future Cities Catapult (2017) *Land Information Platform: levelling the playing field.* [online] Available at: https://futurecities.catapult.org.uk/2017/10/19/blog-land-information-platform-levelling-playing-field/

Future Cities Catapult (2016). *Future of Planning - State of the Art Innovations in Digital Planning*. [online] Available at: https://futurecities.catapult.org.uk/2016/12/01/future-planning-state-art-innovations-digital-planning/

Future Cities Catapult (2016). *User Research Insights Report. Prototyping the future of planning*. [online] Available at: https://futurecities.catapult.org.uk/project/future-of-planning/

Grayston, R. (2017). *Slipping through the loophole. How viability assessments are reducing affordable housing supply in England*. London: Shelter. Available at: https://england.shelter.org.uk/__data/assets/pdf_file/0010/1434439/2017.11.01_Slipping_through_the_loophole.pdf

Hall, P. (1973). *The containment of urban England.* London: George Allen & Unwin Ltd.

Holman, N, Rydin, Y (2013) What can social capital tell us about planning under localism? Local Government Studies 39(1): 71–88.

House of Commons Library Briefing Paper (2016). *Comparison of the planning systems in the four UK countries.* [online] Available at: https://researchbriefings.parliament.uk/ResearchBriefing/Summary/CBP-7459

House of Commons Library (2017) *Planning Reform Proposals.* [online] Available at: https://researchbriefings.parliament.uk/ResearchBriefing/Summary/SN06418

House of Lords Select Committee on Economic Affairs (2016). *Building more homes.* [online] Available at: https://publications.parliament.uk/pa/ld201617/ldselect/ldeconaf/20/20.pdf

Knight Frank (2016) Housebuilding Report 2016. London: Knight Frank LLP. Available at: https://kfcontent.blob.core.windows.net/research/297/documents/en/2016-3851.pdf
Lau, Merrett, Weddell, & White (2015). A traffic-aware street lighting scheme for Smart Cities using autonomous networked sensors. Computers and Electrical Engineering, 45(C), 192-207. Available at https://dl.acm.org/citation.cfm?id=2831558

Local Plans Expert Group (2016). *Report to the Communities Secretary and to the Minister of Housing and Planning*. [online] Available at: http://lpeg.org/wp-content/uploads/2016/02/Local-plans-report-to-governement.pdf

Lyu, Sun, Shen, & Arulrajah. (2018). Flood risk assessment in metro systems of mega-cities using a GIS-based modeling approach. Science of the Total Environment, 626, 1012-1025. Available at: https://europepmc.org/abstract/med/29898510

Madden, P. (2017). *Time for a digital overhaul of the planning system*. [online] Available at: https://www.huffingtonpost.co.uk/peter-madden-obe/time-for-a-digital-overha_b_16922848.html

Monk, S. (2010). England: Affordable housing through the planning system: the role of Section 106. In N. Calavita & A. Mallach, eds., *Inclusionary housing in international perspective: Affordable housing, social inclusion, and land value recapture* (pp. 123–168). Cambridge, MA: Lincoln Institute of Land Policy.

MHCLG (2018). *National Planning Policy Framework*. London: Ministry of Housing, Communities and Local Government. Available at: https://www.gov.uk/government/publications/national-planning-policy-framework--2

MHCLG (2018). *Independent Review of Building Regulations and Fire Safety: Final Report.* London: Ministry of Housing, Communities and Local Government. Available at: https://www.gov.uk/government/publications/independent-review-of-building-regulations-and-fire-safety-final-report

MHCLG (2018). Supporting housing delivery through developer contributions. Available at:

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/691182/Developer_Contributions_Consultation.pdf

MHCLG Guidance documents (2016). Local Plans. Available at: https://www.gov.uk/guidance/local-plans--2

Monk, S. (2010). England: Affordable housing through the planning system: the role of Section 106. In N. Calavita & A. Mallach, eds., *Inclusionary housing in international perspective: Affordable housing, social inclusion, and land value recapture* (pp. 123–168). Cambridge, MA: Lincoln Institute of Land Policy.

Morrison, N., & Burgess, G. (2014). Inclusionary housing policy in England: The impact of the downturn on the delivery of affordable housing through Section 106. Journal of Housing and the Built Environment, 29(3), 423-438. Available at: https://pdfs.semanticscholar.org/6ac7/d0a93a9aba789a48176930b667560429c385.pdf

Planning Inspectorate 92018). Planning inspectorate Appeals Data. Available at: https://www.gov.uk/government/statistics/planning-inspectorate-appeals-database

Planning Portal (2017). Blog-Planning portal new website launch: one year on. Available at: https://blog.planningportal.co.uk/2017/04/20/new-website-launch/

Rathore, Ahmad, Paul, & Rho. (2016). Urban planning and building smart cities based on the Internet of Things using Big Data analytics. International Journal of Computer and Telecommunications Networking, 101(C), 63-80. [online] Available at: https://dl.acm.org/citation.cfm?id=2939046

Rathore, M., Ahmad, A., & Paul, A. (2015). Big Data and Internet of Things: An Asset for Urban Planning. *Proceedings of the 2015 International Conference on Big Data Applications and Services*, 20-23, 58-65. [online] Available at: https://dl.acm.org/citation.cfm?id=2837067

RIBA (2018). Planning decision-making by AI on the horizon. Available at: https://www.architecture.com/knowledge-and-resources/knowledge-landing-page/planning-decision-making-by-ai-on-the-horizon

RTPI (2017). *Better Planning: Smart City-Regions*. [online] Available at: https://www.rtpi.org.uk/knowledge/better-planning/better-planning-smart-city-regions/

Silva, et al (2018). Urban planning and smart city decision management empowered by real time data processing using Big Data Analytics. Sensors; 18 (9); 2994. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6164728/

Thompson, et al. (2016) Planners in the Future City: using City Information Modelling to support planners as market actors. *Urban Planning*, Volume 1, Issue 1, 79-94. [online] Available at https://www.cogitatiopress.com/urbanplanning/article/view/556

Wilson, A., Tewdwr-Jones, M., & Comber, R. (2017). Urban planning, public participation and digital technology: App development as a method of generating citizen involvement in local planning processes. *Environment and Planning B: Urban Analytics and City Science*. https://doi.org/10.1177/2399808317712515

Whitehead, C. (2007). Planning policies and affordable housing: England as a successful case study? *Housing Studies*, 22, (1), 25-44. Available at: https://www.tandfonline.com/doi/abs/10.1080/02673030601024580

World Bank Group, GFDRR (2014). Open Data for Resilience Initiative: planning an open cities mapping projects. Available at: https://www.gfdrr.org/sites/gfdrr/files/publication/Planning-an-Open-Cities-Mapping-Project_0.pdf