The Little Book of DENSITY

A Guide to Density in Urban Environments

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Contents

What this little book tells you

This little book presents the result of four studies, undertaken as part of the Urban Futures research project. Through these studies, we reveal:

- The multi-dimensional aspects of density
- A number of interesting relationships that exist between the different types of density and a diverse set of variables, such as noise and wellbeing
- Who makes density decisions and who *should* make them differs
- What people use to make decisions, the numerous formal and informal tools, techniques, methods and resources
- Where people make density decisions in the development process, and how it differs depending on whether they are thinking of themselves or others
- How we can 'future-proof' designs, policies and programmes that consider density using the Urban Futures methodology

What is density?

Density, in a spatial sense, may be defined simply as *a number of units in a given area*. However, there are many different definitions depending on what *kind* of density is being sought (see **Who uses density?** for more information about density definitions). For the purposes of this book, we are interested in density as it relates to the urban environment, so things like the density of homes, people living in a neighbourhood, rubbish bins, green spaces and trains become important.

Why is density important?

Density is used to describe, predict and control the use of land (Berghauser Pont & Haupt, 2007; DETR, 1998). It shapes how cities look, feel and are experienced in obvious and subtle ways, and it has important impacts on things like our quality of life and mental and physical wellbeing. Density also is shaped by culture, tradition and people's attitudes and perceptions (Smith, 1984). As such, it is seen as a key concept in planning, architecture and urban design (Rapoport, 1975).

Who uses density and what measure(s) do they use?

Density is used as a metric by people from many different professions and academic disciplines, including anthropology, architecture, ecology, economics, environment-behaviour studies, planning, psychology, sociology, transportation and urban design (Churchman, 1999). Not surprisingly, then, more than one measure exists (Churchman, 1999; Forsyth, 2003). In calculating density, for example, the numerator—the number of units—and/or denominator—usually the base land area—may be different (e.g., the number of people per hectare versus the number of dwellings in km^2). Also, what people include and exclude in the calculation may vary (e.g., one local authority may include pavements when calculating net density whereas another local authority may exclude it) (Churchman, 1999; DETR, 1998). *Table 1* lists some of the more common definitions of density. The first 14 definitions pertain to dwellings and people at varying scales (from parcel to metropolitan area). Definitions 15-23 concern built area *intensity* measures at the parcel or block scales, which give an indication of how a building's bulk and coverage (Forsyth, 2003).

Table 1: Common definitions of density

Density type	Metric	Users of this density type	Notes
1. Habitable rooms per hectare	The number of rooms in a dwelling that are used for dwelling purposes (except for kitchens, bathrooms and WCs) divided by total land area	Policymakers, local authority planners	Useful (along with dwellings per hectare) for providing a broad indication of the intensity/form of development on a site or in an area; it is not effective in predicting or controlling the form of development on a site
2. Habitable area	The net internal area excluding kitchen, utility, storage and notional circulation areas		A measurement of the space used by residents for furniture and activities in living and dining areas, and bedrooms; provides more accurate measure than habitable rooms per hectare, particularly when measuring flats, because it reflects the fact that dwellings may have open-plan areas rather than rooms
3. Occupancy density	Total number of occupants in an individual dwelling divided by the total floor area	Building services	Used in building services to determine services required for that space
4. Parcel or site density (or plot ratio, when used with floor area)	DU, RPa or floor area divided by total site/parcel area	Policymakers, local authority planners, developers	Often used by developers; the most un-ambiguous gross measure; easy to calculate with GIS; can be difficult to calculate from physical observations because parcel or site boundaries are not always visible; floor area is useful when the same parcel consists of land for residential and non-residential purposes (i.e., mixed-use) or in areas of high density and large buildings; adopted as a standard indicator for land use zoning and development control regulation; used in design briefing and development budgeting
5. Block density	DU or RP divided by block area measured to the kerb		Easy to measure from aerial photos and census data; reflects a unit—the block—that resonates with people living in the US and Canada
6. Part block density	DU or RP divided by clear subset of block area		Useful approximation for parcel or site density in the US and Canada where the block is a relevant unit of analysis; does include pavement, so will lead to slightly lower density numbers than parcel density
7. Net neighbourhood residential dwelling/population density	DU or RP divided by total land area devoted to residential facilities	Policymakers, local authority planners	Neighbourhood should be a census tract or city-delineated area, typically 40-200 hectares; relatively simple using GIS; care must be taken to assign land to residential uses rather than other uses (e.g., recreation)- include dwelling sites and gardens, private gardens, play spaces, landscaped areas adjacent to and related to residential use, driveways/private access drives, ancillary structures (e.g., garages), resident parking; exclude the following, unless beneath a dwelling: commercial/industrial areas, shops, commercial garages, public parks, playgrounds, undeveloped vacant land, vacant unsuitable land, schools, houses of worship, public streets, public parking spaces
8. Net neighbourhood residential building type density	Similar to net neighbourhood residential dwelling/population density but only counts dwellings of one type (e.g., terraced housing)		Relatively simple using GIS

Table 1: Common definitions of density

Density type	Metric	Users of this density type	Notes
9. Net street density	Similar to net neighbourhood residential dwelling/population density but includes the public street rights-of-way that provide access to residential parcels		The denominator is typically the parcel area plus half of the public rights-of-way adjacent to the residential parcels
10. Net neighbourhood density	DU or RP divided by the neighbourhood area with the base land area calculated to exclude city-wide uses in the neighbourhood		Includes residential land, streets and neighbourhood uses- schools, parks, houses of worship and neighbourhood shopping; excludes city-wide businesses, public uses, high schools, universities, major arterial roads, major regional parks and vacant and unusable land; different from net neighbourhood residential dwelling/population density and net street density in that it includes other neighbourhood uses while excluding regional uses; appropriate when planning for a residential neighbourhood or urban quarter
11. Gross neighbourhood density	DU or RP divided by the total neighbourhood area		Area defined as in net neighbourhood residential dwelling/population density, but without any exclusions; one of the most ambiguous measures because land use may be skewed by regional uses (e.g., zoo)
12. City density	DU or RP divided by the entire developed area of the city	Policymakers, local authority planners	Includes the entire city, but on the urban edge, it only includes developed land; a gross density measure; appropriate when planning for a major mixed-use development
13. Metropolitan density	DU or RP divided by total area	Policymakers, local authority planners	Includes undeveloped areas; a gross density measure
14. Net residential density at city or metropolitan level	DU or RP divided by residential land at a city or metropolitan level	Policymakers, local authority planners	Possible using large GIS databases; presence of housing in mixed-use areas makes it complicated, but not impossible to calculate
15. Floor area ratio	Built floor area on all floors divided by the parcel area	Local authority planners, developers	Often based on usable floor area rather than footprint area; includes wall thickness; varies by municipality; as plot ratio, it is extensively adopted as a standard indicator for land-use zoning regulation, development control and urban masterplans; used in design briefing and development budgeting
16. Building site coverage or coverage ratio	Area of ground floor footprint of building divided by the parcel area	Developers	Indicates the amount of open space left on a site
17. Building block coverage	Area of ground floor footprints of buildings divided by the block area measured to the kerb		It is used when the parcel boundaries are not known; reflects the actual experience of an environment better than parcel-by-parcel calculations
18. Impervious surface parcel coverage	Area of ground floor building footprint plus paved car parks, drives, pavements, paths, decks and other buildings divided by site or parcel area	Engineers and water professionals	Indicates the area of land that has been built upon or paved but does not easily take account of porous paving systems or decks designed for water infiltration

Table 1: Common definitions of density

Density type	Metric	Users of this density type	Notes
19. Impervious surface block coverage	Same as impervious surface parcel coverage but using the block as the base land area	Engineers and water professionals	
20. Building height for parcel	Measured in feet for parcel area		
21. Front parcel setback in feet for parcel	Distance from the front facade of the building to the front property line	Local authority planners	Measure of building intensity; typical measure in zoning regulations
22. Front kerb setback	Measured in feet, with the setback of each building from the kerb averaged by building over a block	Local authority planners	Rough measure of the experience of a setback; includes the pavement and planting strip area
23. Side-to-side distances between buildings	Measured in feet and averaged across a block	Local authority planners	Rough measure of building bulk

Looking at *Table 1* in more detail, we can begin to see who uses what definitions of density:

- *Policymakers* most often use parcel density, net neighbourhood residential dwelling/population density, city density, metropolitan density and, in London, habitable rooms per hectare (DETR, 1998). These measures can be found in policy and guidance (e.g., PPG3 in the UK) and at different scales: parcel density (both gross and net density) for individual housing sites, neighbourhood density for a new residential community or urban quarter, and city and larger city area density is appropriate for new settlements or city extensions (DETR, 1998)
- *Local authority planners* use the same measures as policymakers, but also will use front setbacks for kerbs and parcels, side-to-side distances between buildings, and floor area ratios and plot ratios (the latter two often found in design and development briefs)
- *Developers* are most likely to use parcel density (Forsyth, 2003), floor area ratios, plot ratios and building site coverage
- *Architects* use terminology about total floor area and converse with developers often in these terms, but they also can readily convert the calculation into dwelling density (Johnny Winter, Edward Cullinan Architects, personal communication, 6 June 2011)
- *Engineers and water professionals* may use measures about impervious surface coverage at both parcel and block scales
- *Building services* professionals may use occupancy density, as undertaking this calculation helps to determine the spatial requirements for various services and infrastructure for buildings

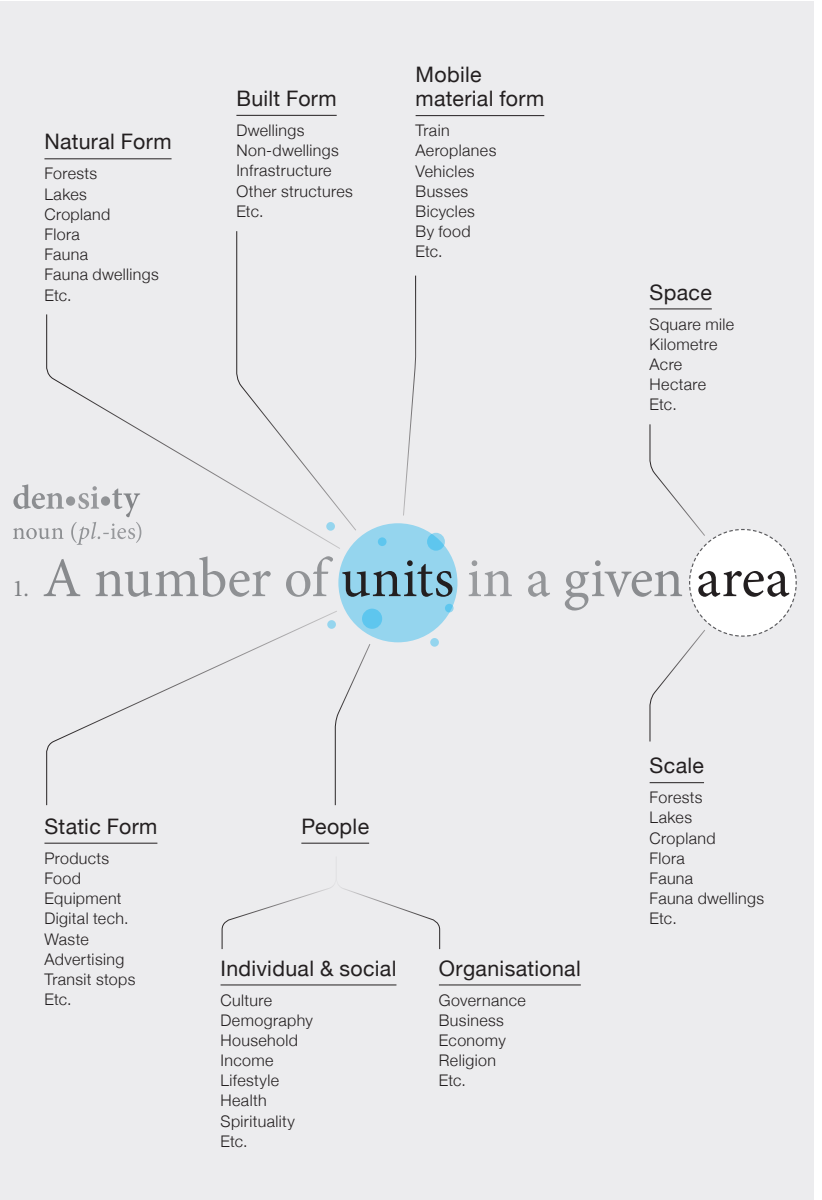
With some exceptions, there is overlap in the way that definitions are used by various professions. However, when we look at the different types of density, there are many that professionals do not consider. These types, which are discussed in **Study One** via a taxonomy of density, are highly relevant to creating cities that are sustainable and which provide a high quality of life for those living, working and recreating there.

STUDY 1

The Dimensions of Density

In urban environments, most people think about density in terms of dwelling density—the number of homes per hectare—or population density—the number of people per hectare. While important, there are other types of density that may influence the look and feel of cities. To list them all here would take too long and, no doubt, we would miss some out. A better way to do this is to introduce a *taxonomy of density*, which provides broad dimensions of density and is useful for organising the different types of density that are used in everyday practice as well as researched. This taxonomy was created with the help of nine expert practitioners and academics on density and the built environment who worked with us to brainstorm and identify the dimensions and types of density.

Figure 1: A Taxonomy of Density



Explaining the taxonomy

Starting from the top tier of the taxonomy in *Figure 1*, the definition of density is given: *a number of units in a given area*. Two key words from the definition, *units* and *area*, are important, as they are the words in the definition that can be further sub-divided. *Area* can be divided into *space* and *scale* (second tier), and further sub-divided into measurement units of spaces (e.g., square mile, hectare) and a range of scales (e.g., building, neighbourhood) (fourth tier)[1]. *Units* can be divided into *natural form, built form, static form, mobile material form*[2] and *people* (with the latter further dividing into a third tier—*individual & social* and *organisational*). The third tier—and the forth tier in the case of *people*—contains specific types of density as they relate to the more general types in the second tier. For example, the density of forests, lakes and cropland can be found under *natural form density*.

Testing the taxonomy

Once we created the taxonomy, we wanted to see if the dimensions we devised made sense and could be validated. To do this, we searched the academic literature and found 75 studies that dealt with density in urban environments in some capacity. Each time a study mentioned a density type(s), we made a note. When we looked through all the studies, we got an overall picture of the most common density types and dimensions from the taxonomy. We also saw which density types and dimensions were not studied, suggesting potential areas for future consideration and research into density.

Density dimensions and types

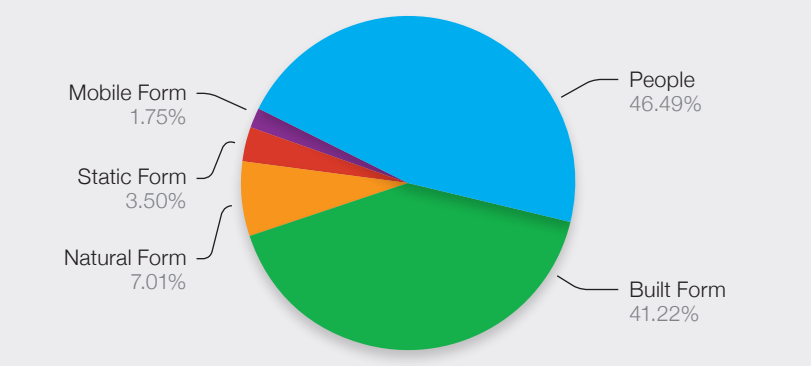
As can be seen from *Figure 2*, the majority of the 75 studies involved the density of *people* (46% of cited studies) and *built form* (41% of cited studies):[3]

1 The sub-division of *units* from the first tier was created by the authors as well as nine experts on density and the built environment who worked with authors to brainstorm and identify different types of densities that might be used in everyday practice.

2 Static form refers to objects within the built environment that are not buildings, infrastructure or spaces (e.g., transit stops, waste). Mobile material form refers to objects within the built environment that move (e.g., trains, buses).

3 These percentages are based on 114 references to density within the 75 studies. In some studies, more than one type of density was mentioned.

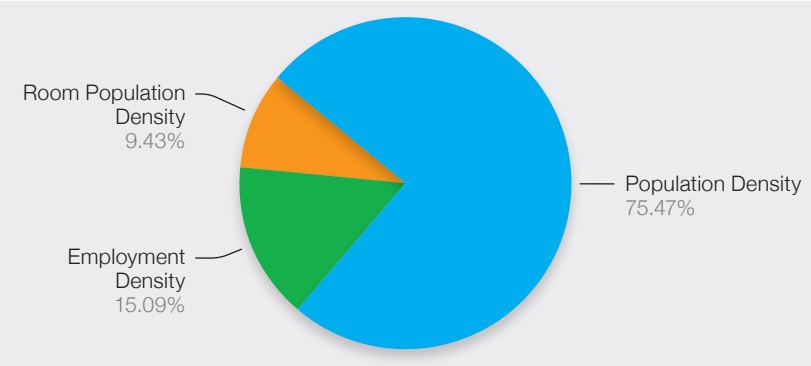
Figure 2. Percentages of studies by density type.



People

Separating *people* into its constituent parts (both *individual & social* and *organisational*), we find the following (see *Figure 3*):

Figure 3. Percentage of studies involving 'people density'.



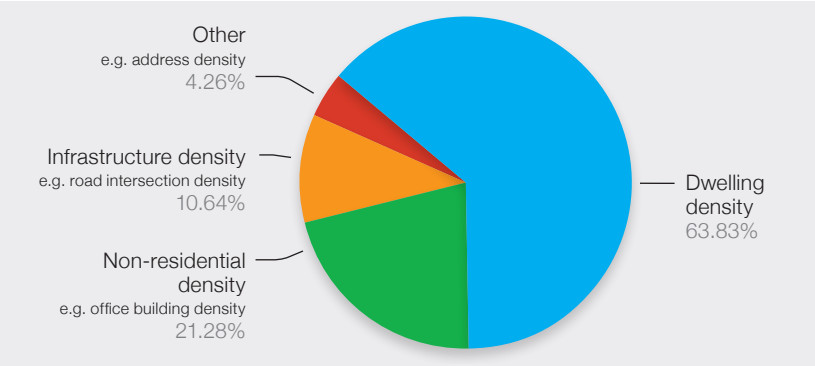
Population density (i.e., the number of people per unit area) is researched the most frequently, probably because data about people is relatively easy to obtain and readily-available from organisations like the UK Office of National Statistics (ONS) (e.g., Census data). The same can be said for employment density. Room population density (i.e., the number of people per room in a dwelling) is the least frequent type of

density found in the studies. This may be due to difficulties in trying to assess which rooms are habitable in a dwelling (e.g., is a bathroom a room in which someone sleeps?) and may be difficult to ascertain by researchers due to time and financial constraints.

Built form

Looking more closely at *built form*, we notice a similar trend to people density (see *Figure 4*):

Figure 4. Percentage of studies involving 'built form' density.



That is, like *people* density, there is one, dominant type of built form density from the studies: the density of dwellings (i.e., the number of dwelling units per unit). Again, data for the number of dwellings in a particular area are readily available from organisations like the ONS and these density figures would be relatively easy to calculate, which may be why researchers have chosen to look at this type of density more than others. What is encouraging is that there seems to be interest in other built forms, like fast food restaurants (see Reidpath *et al.*, 2002).

Natural form, Mobile Material form & Static form

Most of the studies cited under *natural form* considered tree or plant cover within a defined urban area, but not much else. And we did not find many studies that looked at *mobile material form* or *static form*, but that could be because it is difficult to try and confirm where mobile material forms and some static forms reside (i.e., should private vehicle density be calculated at their departure or arrival points, or be

calculated *en route*?). Another reason why we could not find much is that the *quantity* of some of these things, such as digital technology and waste is more important to decision-makers than their *density*.

Looking again at *Figure 1*, we can begin to see where there are gaps in the density literature. From the studies we examined, there were a number of density types that did not get considered within *mobile material form*, *static form*, *natural form* and *people* (see *Table 2*):

Table 2. Density types that were not examined within the 75 cited studies.

Natural form	Mobile material form	Static form	People- Individual & social	People- Organisational
Cropland	Trains	Products	Culture	Governance
	Airplanes	Food	Lifestyle	Business
	Buses	Equipment	Health	Religion
	Bicycles	Digital technology	Spirituality	
		Waste		

Thinking about the density types in *Table 2*, it makes sense that some of them were not considered. For example, how do you calculate the density of spirituality or use the calculations in practice? You could try calculating the density of churches, mosques, temples and synagogues in an area, but it is unlikely to capture the essence of what spirituality means to people. And using houses of worship to understand the density of spirituality means using *built form*, rather than an *individual & social* density type, in the calculations. People making decisions about these things, therefore, need to think carefully about how best to calculate different densities and to understand the relationships between what you *have* to measure and what you are *able* to measure.

In order to understand the impacts of the dimensions of density on urban life, it is clear that there is potential to understand much more about relationships. Decision-makers can begin to map out these relationships and consider to whom they would need to communicate to bolster the positive aspects of these relationships as well as to minimise the negative aspects (e.g., speaking with the police to discuss how to lower robbery rates in areas with high densities of bars and clubs).

Density relationships

In addition to investigating the 75 studies by density *type*, we examined the *relationships* between density and other variables (e.g., CO_2 in the atmosphere, noise) among the density dimensions. Here is a summary of what we found (for more detailed information of the studies, please see Appendix 1 as well as our paper on density in *Progress in Planning*):

1. Higher densities appear to support public transport (including walking for transportation, choice of transportation mode, operating costs etc.) and create opportunities for less private transport use and ownership (including fuel consumption, frequency and amount of trips etc.). However, there are more pedestrian casualties and people walk less for leisure purposes in higher, versus lower, densities.
2. In terms of energy, higher-density buildings are more efficient than lower-density buildings in that they do not lose heat as easily and emit less greenhouse gas. The relationship between infrastructure efficiency and density is less clear, however.
3. At a psychological level, our mental well-being seems to be mostly negatively affected by higher densities, resulting in depression, withdrawal, strain, poorer quality of family life and cognitive development, less privacy and friendliness and, in some instances, hospitalisation. Comparatively, physical health does not fare much better: higher densities contribute to increases in occurrences of adolescent obesity, poorer heart rates and drinking among adults.
4. People living in high-density dwellings are better able to control their contact with others (including strangers), and have neighbours as friends (even though they may not like their neighbours or like casual neighbouring), than similar people living in lower-density dwellings. Also, higher densities create better social situations in terms of equality and mixed-tenure (including affordable housing) than do lower densities.
5. Higher densities of plants and some animals (e.g., birds) have tangible benefits to urban areas in terms of ecological sustainability, counteracting some of the damage caused by human intervention in the name of development, growth and progress.

STUDY 2

How people think about density

The way people perceive of density in a situation can influence how they behave and how they respond, emotionally, to others as well as to things around them (Glass & Singer, 1972; Sherrod, 1974). These perceptions, in turn, are influenced by a number of factors, such as the physical and symbolic aspects of places; the timing and time associated with activities and events; the social and cultural aspects and experiences of individuals, groups and settings (Cheng, 2010; Forsyth, 2003; Raman, 2010; Rapoport, 1975).

Here, we present the results of an online survey we did with 129 built environment professionals about their perceptions of density.[4] The findings highlight the key drivers of density and what they believe are low, medium and high dwelling density in numerical terms.

The drivers of increasing density in cities

Policymakers and other decision-makers have many reasons why they would choose to increase densities in cities. They may, for example, base their decisions on

4 These findings are part of a larger report about density and decision-making: Boyko, C. T., & Cooper, R. (2011). *Urban Futures Density Survey Report*. Lancaster: Lancaster University.

environmental, societal, economical, physical and mobility reasons (see Boyko & Cooper, 2011, for a more comprehensive list). In our survey, respondents were asked to prioritise their top three choices (see *Table 3*).

Table 3. The top drivers for increasing density in cities.

Number	Driver
1	**Efficient use of land**
2	**Increased profitability/return on investment**
3	**More use of public transport**
4	Efficient use of resources
5	Promoting a critical mass to support services
6	Policy/regulation
7	More people immigrating to cities
8	Creating area employment
9	Improving housing choice and affordability
10	Less use of private transport
11	Reduced energy consumption
12	Other
13	Increasing diversity in an area

As we can see, the top three drivers—efficient use of land, increased profitability/return on investment and more use of public transport—align pretty well with the idea that developers and local authority planners make most of the density decisions on planning projects. In terms of the most-cited reason, many density policies at national, regional and local levels use terminology such as 'efficient use of land' in the hopes of creating and sustaining cities that are not sprawling, but are more compact or consolidated (e.g., Planning Policy Statements 1 and 11 in the UK, ODPM, 2004, 2005). Developers also may want land to be used more efficiently because they can have a greater return on their investment and increase profitability, which is the second-most cited reason for wanting to boost urban densities. The third-most cited reason by respondents was to increase the use of public transport. Again, density policy will highlight this issue, and local authority planners and highways departments will be trying to manage the very practical issue of congestion in urban centres and its consequent knock-on effects to the economy, the environment and society (see DCLG, 2011).

Perceptions of low, medium and high dwelling density

When discussing density, many people talk about buildings, neighbourhoods or cities as 'low density' or 'high density'. However, one person's 'low density' might be another person's 'high density' (a person from inner London versus a person in rural Scotland perhaps?). Thus, our perceptions will very much depend on a variety of issues, such as history, culture and societal norms.

The idea that a quantitative figure for dwelling density is not standardised in practice or policy can lead to decision-makers making decisions based on unequally-comparable figures. To try and arrive at a more standardised notion of density, we asked survey respondents to give us a numerical answer for what is low, medium and high dwelling density. As you can imagine, the ranges of the answers varied tremendously, from 1-70 dwellings per hectare (dph) for low dwelling density, 5-200 dph for medium density and 10-400 dph for high dwelling density (see *Table 4*).

Table 4. Perceptions of low, medium and high dwelling density.

Dwelling density	Mean (dph)	Median (dph)	Mode (dph)	Range (dph)	Standard deviation
Low	23	20	30	1-70	11.68
Medium	44	40	30	5-200	23.97
High	79	60	50	10-400	58.47

Looking more closely at the data, we found that:

- *Low* average dwelling density was about 23 dwellings per hectare (dph) (median= 20dph, mode= 30dph, standard deviation= 11.68dph)
- *Medium* average dwelling density was about 44dph (median= 40dph, mode= 30dph, range= 5-200dph)
- *High* average dwelling density was about 79dph (median= 60dph, mode= 50dph, range= 10-400dph)

Among other things, what *Table 4* demonstrates is that people have very different ideas about what is low, medium or high density even though the terms are used in planning applications and policy as if everyone knows what they mean. The survey responses also point to the importance of context (i.e., international, national, regional and local variations).

STUDY 3

Density and decision-making

Understanding how built environment professionals think about density in their day-to-day practice gives us some ideas about how density fits into the wider urban development process. This involves knowing who makes decisions about density in urban development projects, when density decisions are made and what people use to make density decisions. We return to our online density survey for more answers.

Who makes and who *should* make decisions about density

Survey respondents were asked who they thought made most of the decisions about density in the practice of urban development. Almost 88% said that developers made the most density-related decisions. This was followed by local authority development control/management officers and local authority policy planners , urban designers, architects, private sector planners, Central government, Councillors on planning committees, financiers, the highways department, residents, local businesses and other (which included public health professionals, property agents, development agencies, landowners and community organisations and specialist groups) (see *Table 5*).

Table 5. Groups who make decisions about density.

Who makes density decisions?	Response	Response %
Developers	99	87.6
Local authority development control/management officers	95	84.1
Local authority policy planners	95	84.1
Urban designers	82	72.6
Architects	74	65.5
Private sector planners	72	63.7
Central government	71	62.8
Councillors on planning committees	68	60.2
Financiers	49	43.4
Local authority highways department	29	25.7
Residents	21	18.6
Local businesses	6	5.3
Other	6	5.3
Total	767	100.0

Survey respondents also were asked whom they believed *should* make most of the density decisions, as we thought their answers might be different. It turned out we were right: 87% said that local authority policy planners should make most of the density-related decisions. In order of declining percentage, other professions included local authority development control/management officers, urban designers, architects, Councillors on planning committees, residents, developers, private sector planners, Central government, the local authority highways department , financiers and local businesses. The Other category included collaborative teams from a number of the above groups, transport planners, leisure and recreation planners, development agencies, community groups and specialist organisations (see *Table 6*).

Table 6. Groups who ***should*** make decisions about density.

Who makes density decisions?	Response	Response %
Local authority policy planners	99	86.8
Local authority development control/management officers	95	76.3
Urban designers	95	70.2
Architects	82	53.5
Councillors on planning committees	74	50.9
Residents	72	46.5
Developers	71	43.9
Private sector planners	68	37.7
Central government	49	35.1
Local authority highways department	29	22.8
Financiers	21	12.3
Local businesses	6	5.3
Other	6	5.3
Total	631	100.0

From what our respondents said, it seems that only five of the above groups—local authority policy planners, local authority development control/management officers, urban designers, architects and Councillors on planning committees—*should* really be making those decisions (based on each group having at least a 50% response rate). Interestingly, developers, who were the most-citied group of density decision-makers in current practice, were seventh on the list of decision-makers who should be making density decisions, below residents. This finding suggests that developers have too much power when it comes to making decisions about the density of urban development projects, and that more emphasis should be placed on local authorities and professional designers to make those decisions.

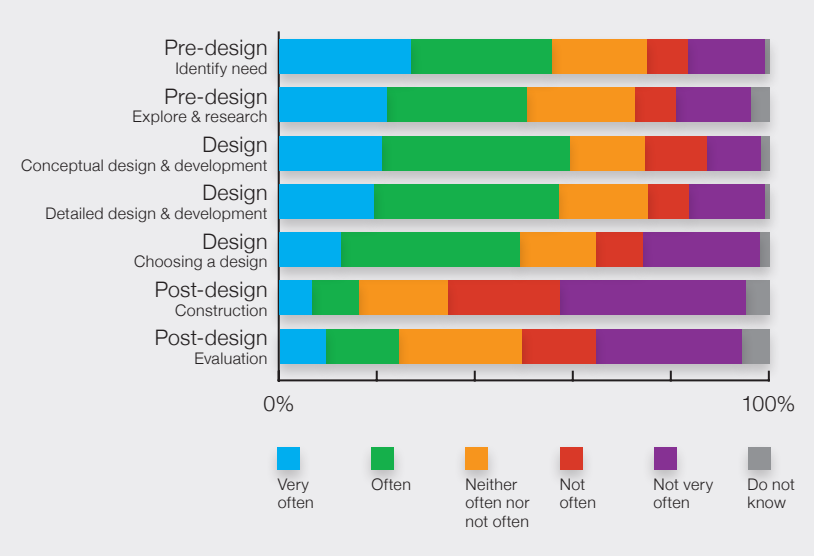
When in the process do people make density decisions?

To better understand when density decisions are made in urban development projects, survey respondents were asked to identify the process stage(s) in which *they* made decisions about density. From our book chapter on the urban design and development process,[5] we identified the following key stages:

- Pre-design: Identify need or opportunity
- Pre-design: Explore and research
- Design: Conceptual design and development
- Design: Detailed design and development
- Design: Choosing a Design
- Post-design: On-site implementation and construction
- Post-design: Evaluation

Just under 60% said that they made density decisions very often or often during the *Conceptual design and development stage*. They then made decisions at the *Detailed design and development* stage, the *Identify need or opportunity* stage, the *Explore and research* stage and the *Choosing a design* stage. They did make density decisions often or very often during the final two stages of the process: *On-site implementation and construction* and *Evaluation* (see *Figure 11*).

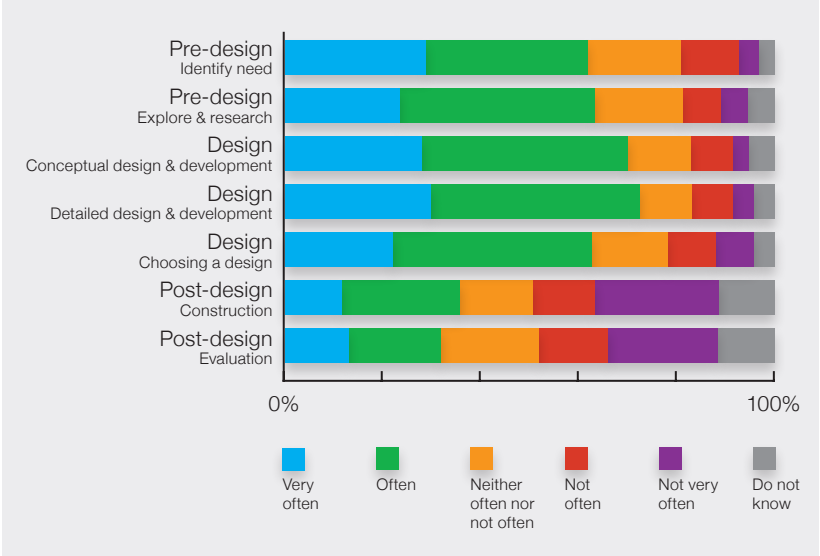
Figure 11. When respondents make density decisions in urban development projects.



5 Boyko, C., & Cooper, R. (2009). The urban design decision-making process: A new approach. In Cooper, R., Evans, G., & Boyko, C. (Eds.), *Designing sustainable cities* (pp. 43-50). London: Wiley-Blackwell.

Asked when they felt *other people* in their organisation make density decisions in the urban development process, around 72% said that the *Detailed design and development* stage was when other people made density decisions very often or often. They then felt that other people made density decisions very often or often at the *Conceptual design and development* stage, the *Explore and research* stage , the *Choosing a design* stage and the *Identify need or opportunity* stage. The respondents were unsure about whether other people made density decisions in the final two stages—*On-site implementation and construction* and *Evaluation* (see *Figure 12*).

Figure 12. When respondents felt ***other people*** make density decisions in urban development projects.

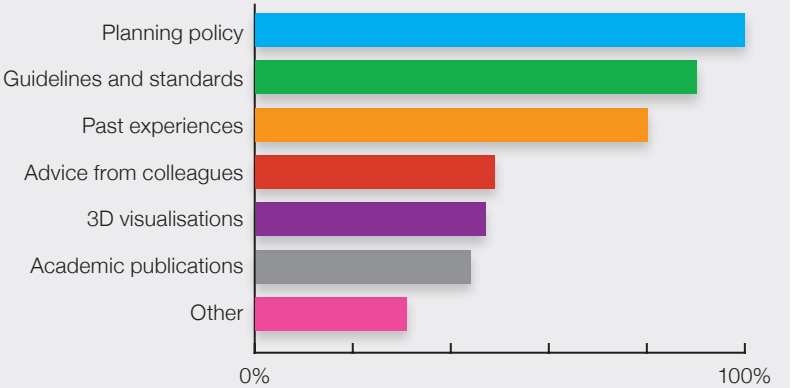


The above findings show that respondents felt other people made density decisions later in the urban development process, versus themselves. Reading further into this finding, respondents may feel as though other people make decisions about density *too late* in the process, thus resulting in developments that do not 'work' in terms of their density. Additionally, respondents may feel that making decisions about density at the detailed design stage does not give sufficient time to think about density and its many impacts on developments and the surrounding area.

What people use to make density decisions

Survey respondents were asked to list the things they used most often when making decisions about density, such as tools, techniques, methods and resources. What we found is that the majority used planning policy, looked at guidelines and standards or were informed by past experiences. Less than half asked for advice from colleagues, used three-dimensional visualisations, read academic publications or did something else (labelled 'Other'), like referred to resources from CABE, carried out public consultation and design review, accessed Supplementary Planning Documents and masterplans, visited other developments, found best practice examples, assessed the surrounding context, looked for statistical data and examined the financial viability of a scheme (see *Figure 13*).

Figure 13. What people use to make density decisions.



We also asked survey respondents to mention *specific* tools, techniques, methods and resources that they use for making density-related decisions. This is what we found:

- The most-mentioned 'tool' that respondents used to make density decisions was *knowledge of the local context*. This could include a design or physical analysis of the local area, taking stock of the general character or consulting with local people during the urban development process.

- Having *appropriate standards and guidelines* also was important, which include:
  - Best practice guidance on density
  - Clear guidance at the national, regional and local level about the importance of getting the right balance between density and design quality
  - Guidance about participatory processes to help show what density looks like
  - Guidance on legal policies for density and related issues
  - A 'pattern book' of similar densities with different physical forms to improve innovation, variety and the quality of buildings and spaces
  - Recreation space standards
  - Highways standards for existing urban design developments
  - Standards from Central government that illustrate 'good' and 'bad' examples of residential density and their impacts on the public realm, infrastructure, neighbourhoods and cities
- Having access to *case studies from around the world* to demonstrate what 'good density' looks like and how it functions could be useful in making more informed density decisions. Case studies could focus on, among other things, the tradeoffs between density and *transportation*, and density and *social issues*, like social equity and privacy
- In fact, 'tools' can be divided into those that are more *formal*, such as planning policies, guidelines and standards, and more *informal* or *social*, such as past experiences, visits to other developments, advice from colleagues, having knowledge of the local context, being able to look globally at best practice and considering wider transportation and community issues

STUDY 4

Future-proofing 'sustainability solutions' relating to density

The three previous studies have dealt with density issues that built environment professionals are *currently* thinking about or doing in their day-to-day practice. This fourth study takes us into the *future*: here, we present a methodology, created as part of the Urban Futures project, which considers how to make cities more resilient. What we mean is that, too often, built environment professionals only think of the present or the short-term when designing, planning and developing

our urban environments. Even when designs, policies, programmes and physical objects are put in place with the idea that they will be sustainable (what we call *sustainability solutions*), most people do not think beyond a few years. Our Urban Futures methodology helps people see how sustainable their ideas are, using a 50-year timeframe, which allows for longer-term thinking.

The Urban Futures method in brief

The key steps to the Urban Futures method[6] are as follows:

- **Step 1:** Identify a sustainability solution and an intended benefit from implementing that solution. For example, a solution could be promoting *high dwelling densities in city centres*, and one of the intended benefits of doing so would be to *support local retail and services*
- **Step 2:** Identify the conditions necessary for this solution to be implemented
- **Step 3:** Determine how the conditions will change in the future using future scenarios adapted to the UK urban context
- **Step 4:** Determine whether or not the sustainability solution will be resilient to future change
- **Step 5:** Decide what to do next: to implement the solution as is, adapt it to address the problems you have identified from Step 4 (and return to Step 2), or replace it with an alternative solution (and return to Step 1).

We can now show you an example of one sustainability solution related to density—high dwelling density in city centres—with a related intended benefit—to support local retail and services—to take you through the process of future-proofing.

6 For a more detailed description of the Urban Futures method, including the futures scenarios we used, please see Lombardi, D. R. *et al.* (2012). *Designing resilient cities: A guide to good practice*. Watford: BRE. Also, try Rogers, C. F. D. *et al.* (2012). The urban futures methodology applied to urban regeneration. *Engineering Sustainability, 165* (1), 5-20.

Future-proofing high dwelling density to support local retail and services

Step 1: Identify solution and an intended benefit

Dwelling density refers to the number of dwelling units (e.g., flats, detached houses, terraces) per hectare. There are no specific guidelines as to what constitutes a high dwelling density, as 'high' is influenced by previous experiences, culture and perceptions. In previous UK policy, more than 30 dwelling units per hectare, or between 30-50 dwellings per hectare, were considered as barometers for making more efficient use of land. However, there are no accepted numbers or ranges that are associated with high dwelling density. High dwelling density also depends on context: for example, 20 dwellings per hectare may be considered high in rural Alaska whereas 300 dwellings per hectare may be considered high in Hong Kong.

There are many intended benefits for implementing high dwelling density as a sustainability solution. These include (with the one **in bold** being the one we will consider in this example):

- **Greater support of local retail and service areas due to the promotion of a critical mass in an area**
- Reduced fossil fuel emissions/carbon footprint due to reduced vehicle usage
- Enhanced accessibility, as more infrastructure and services are closer to where people live, work and recreate
- More viable and efficient public transportation due to the critical mass in area
- Decreased pressure to develop on land adjacent to high-density areas
- Decreased private vehicle usage
- Reduced social segregation and exclusion/isolation
- Increased safety by having more 'eyes on the street'

Step 2: Identify the conditions necessary for this solution to be implemented

Once we have decided on the sustainability solution and the intended benefit, we have to come up with conditions that are necessary for the solution to be implemented. What we mean here is that the conditions are things that must be in place if the sustainability solution is going to work, both now and in the future. To help us along with this process of identifying conditions, we could ask the following questions:

- How will *technology* be used? What will happen as technology changes?
- How important are market drivers? Where will future funding likely come from?
- Does the sustainability solution and associated benefit rely on or conserve a natural resource?
- Does the sustainability solution and associated benefit rely on particular policies or regulations?
- Does the sustainability solution and associated benefit rely on particular social or cultural conditions?
- What power do communities have?
- What are the conditions that enable the sustainability solution to keep functioning?
- What are the conditions that enable the sustainability solution to be used so that it delivers its intended benefit?

Based on this process of asking questions and/or thinking about what the conditions are, we can come up with a series of conditions that we feel are necessary for the sustainability solution to achieve its intended benefit:

- High dwelling density is protected in the future
- Close proximity of site to other uses perceived as useful or important, locally
- Strong and widespread willingness to live, work and recreate in an area
- Amenities in the area that people will want to use
- Manage and maintain buildings and spaces for safety
- Spatial design requirements to promote better sound insulation

Step 3: Determine how the conditions will change in the future

For each of the conditions we identified in Step 2, we can now determine how they might change in the future. To do this, we use future scenarios.

Scenarios are used by many different people and organisations to help create stories about how the future may unfold. These stories can be quite fanciful, but also are grounded in 'hard numbers' (e.g., Census data) (Raskin *et al.*, 2005). They give us insights into the present day by identifying what drives change in a place as well as what the uncertainties are, thereby providing decision-makers, like local authority policy planners and private sector developers, with a more resilient way to plan, whatever the future holds.

Scenarios have been used successfully at a range of scales, from the global to the city-region, to address a wide range of problems. Because the *Urban Futures* project is looking at UK urban regeneration, we thought it best to tailor the scenarios we are using to suit that scale. Thus, we developed four scenarios, adapted from the Global Scenarios Group (Gallopin *et al.*, 1997; Kemp-Benedict *et al.*, 2002; Raskin *et al.*, 1998, 2002), that represent four plausible worlds in which we could end up: New Sustainability Paradigm UK Urban, Policy Reform UK Urban, Market Forces UK Urban and Fortress World UK Urban. We also chose 2050 as the year in which we would 'drop in' to see if our sustainability solutions were still delivering their intended benefits because it was far enough into the future that we could see change happening within our lifetime, yet not too far that we would not be around. Here are some short descriptions of the scenarios:[7]

UK Urban New Sustainability Paradigm

In this scenario, new socio-economic arrangements and fundamental alterations in societal values change the character of civilisation. The conventional notion of progress via economic growth is openly challenged, such that sustainability becomes embedded in decision-makers' thinking about how society grows, and the search for a deeper basis for human happiness and fulfilment is sought. An ethos of 'one planet living' pervades, facilitating a shared vision for a more equitable and sustained quality of life, now and in the future.

UK Urban Policy Reform

In this scenario, co-ordinated and comprehensive government action is initiated to reduce poverty and social conflict while enhancing environmental sustainability; market forces are 'encouraged' to produce socially-desirable outcomes, but by no means are they silent. Strong policies and growing environmental and social consciousness emerge to support some changes in consumer behaviour. Such policies also slow, but do not reverse, trends toward high distributional inequity that the market alone would do little to address. Tensions still exist between the continued dominance of conventional ideologies and values and the key sustainability goals espoused in the World Commission on Environment and Development (1987) report.

7 For a more detailed account of the scenarios, please see Lombardi *et al.* (2012).

UK Urban Market Forces

In this scenario, current demographic, economic, environmental, and technological trends unfold without major surprise. The self-correcting logic of the market is expected to cope with problems as they arise, although the elasticity of market-driven control is not infinite. Sustainability issues are addressed more through rhetoric than action. Materialism and individualism spread as core human values, whereas social and environmental concerns are secondary. Competitive, open markets drive development.

UK Urban Fortress World

In this scenario, powerful actors organise themselves into alliances in an effort to safeguard their own interests and resources. The world divides into two groups: an authoritarian elite who live in interconnected, protected enclaves controlling access to resources (called the 'haves'), and an impoverished majority outside (called the 'have nots').

With the stories of the scenarios in front of us, we can now look at each of the conditions necessary for the sustainability solution and see how they might change in each of the futures (see Table 7).

Table 7. Conditions necessary for the sustainability solution and how they might change in each of the futures.

Conditions	New Sustainability Paradigm	Policy Reform	Market Forces	Fortress World
High dwelling density is protected in the future	Sustainable development is a priority, with communities deciding the appropriateness of high density in areas.	Strong governance models encourage higher densities, although personal choices may undermine policies	Focus is on short-term socio-economic gain, rather than social or economic sustainability, so high density occurs only where market drives it	Strict control over planning ensures that rich areas are not high-density; no control over planning in poor areas means high densities may continue out of necessity, but are not protected in the future
Close proximity of site to other uses perceived as useful or important, locally	Integrated settlements, almost self-contained and self-sufficient, have many uses in close proximity	Good provision of public services in local areas as required by policy	Fragmentation exists, with little or no long-term vision in planning urban growth – local uses may vary	Urban sprawl in rich areas suggests less proximity to useful/important services; in poorer areas, useful/important services may be in close proximity
Strong and widespread willingness to live, work and recreate in an area	Emphasis is on living locally, as people travel less and have homes for life and/or live in co-housing	Neighbourhoods and cities favour a compact model of development, with more people willing to live, work and recreate in an area	Willingness to live, work and recreate in an area is low. This manifests in neighbourhood fragmentation	Willingness is generally low both for the rich and the poor. For the rich, class-differentiated mixed use meets security and resource concerns; for the poor, it may become a necessity

Conditions	New Sustainability Paradigm	Policy Reform	Market Forces	Fortress World
Amenities in the area that people will want to use	Emphasis on local communities means supporting local amenities to strengthen the local economy. Hours accommodate local needs and provide local jobs	Amenities driven more by the market than social or community needs, so only meet some community needs	Profit-making at the core of business activities so less profitable amenities may be absent	Rich have good access to local amenities, although they may only operate at key times; poor may be lacking some local amenities, but they may operate for long periods, to maximise customer traffic.
Manage and maintain buildings and spaces for safety	Effective management and maintenance of spaces and buildings means most spaces and buildings are perceived as safe	Existence of planning policies to ensure management and maintenance of spaces and buildings; thus, many spaces and buildings are perceived as safe	Private-led and based on willingness to pay, so some are safer than others, depending on the area	Rich support management and maintenance of their spaces and buildings; for poor, many buildings and spaces perceived as unsafe due to limited/no resources for management and maintenance
Spatial design requirements to promote better sound insulation	Policy conforms to Buildings for Life criteria, thus supporting better sound insulation	Developments are driven to enhance dwellings (thus retain communities) and better sound insulation is supported	No policy enforcing or supporting promotion of better sound insulation; market may demand it, however	Strong enforcement of policy that supports better sound insulation for rich; sound insulation is not promoted for the poor

Note: Green cells represent change in the condition that is robust in a particular future. Amber cells represent change in the condition that is questionable in a particular future. Red cells represent change in the condition that is not robust in a particular future.

Step 4: Determine whether or not the sustainability solution will be resilient to future change

Once we have created the table in Step 3, we can look at all the cells and see whether or not the sustainability solution will be able to deliver its intended benefit (i.e., will be resilient to future change). We do this by adding up all the green, amber and red cells:

- If most are green, we can say that the sustainability solution is resilient to change in the future
- If most are amber, we might want to adapt the sustainability solution in some way before we implement it, looking at the red cells for reasons why it may not be resilient to change in the future
- If most are red, we can say that the sustainability solution is not resilient to change in the future and we should think about alternative solutions

In our case, 13 of the 24 cells are amber, which suggests that the sustainability solution may not deliver the intended benefit unless we adapt the solution in some way. On the positive side, only 2 of the cells are red, which means we may not need to change the solution too much to make it work, no matter what the future holds

Step 5: Decide what to do next

In this final stage, we would make a decision to do one of three things: (1) Implement the sustainability solution, (2) Adapt the sustainability solution, (3) Replace the sustainability solution.

If we want to implement the solution, the process would be over. However, if we wanted to adapt the solution so that it is resilient to change in the future and delivers its intended benefit, we would go back to Step 2 and decide on new conditions. And if we wanted to replace the sustainability solution altogether, we would go back to Step 1 and start over.

For the particular sustainability solution that we are looking at in this example, we might decide to adapt the solution, as there are many uncertainties (i.e., many amber cells). However, we also might tell decision-makers that they should continue to recommend high dwelling densities as a sustainability solution to deliver local services and infrastructure, but ensure that buildings and spaces are designed and built for better sound insulation. Furthermore, we could say that it is crucial to get the right mix of amenities (e.g., services, infrastructure)—as well as amenities that are profitable, open during convenient times and are perceived as safe to use and get people to/from—so that people will want to continue living, working and recreating in the area.

Conclusions

This little book has shown that spatial density, while easy to define on the surface, is actually quite a complex concept. Many built environment professionals use density in their day-to-day work, yet consider it quite narrowly; that is, density really only pertains to houses and people. However, we have shown that density, like cities, are more than just houses and people, and that if we want to plan our urban environments better so that they are sustainable and promote better physical and mental wellbeing, we have to be thinking outside the box. We also have to think more broadly about what we use to make density decisions, as a combination of formal and informal/social tools, techniques, methods and resources can help us get a more nuanced answer to questions like, "Is building higher densities in the inner ring road developments the right way to go?" and, "How can we better design our neighbourhoods so that we get the right mix and density of shops, homes, offices and green spaces?".

Furthermore, when and where we make decisions about density in the development process is important, as we need the right people and the right information at the right time to be making those decisions. From what built environment professionals in our survey told us, there is a disconnect between when they make decisions and when others make decisions. This implies that density decisions are not happening at the right time. We need to change that.

What drives people to do something about density—mostly around trying to increase it in cities—appears to be consistent with what local authority planners and developers want. However, if the development process is supposed to be more open and transparent, and density is seen as an important topic to discuss, perhaps we should be trying to hear from other people about what they think the drivers of density should be. It seems that involving people living and working in the neighbourhoods where increases in density are to happen as well as the people who actually design these neighbourhoods would be smart.

It also makes sense that, when we talk about low, medium and high density, we are all on the same page. What is low density for some is high density to others, and this can create problems when different groups think they understand each other, but ultimately do not because they misinterpreted what the other meant. Trying to create a metric that is both standard and contextually-specific is, no doubt, hard, but doing so may help everyone when the above terms are discussed throughout the development process.

Finally, too often, decision-makers come up with ideas to solve a particular built environment problem that seem to work, but the ideas are too focussed on the short-term. This may result in quick-wins, but are these quick wins sustainable in the medium- and long-term and for whom are they sustainable? Through the Urban Futures methodology, we showed how we can take current ideas to solve built environment problems and 'future-proof' them so that they are more resilient to whatever the future holds.

This little book is really a primer for thinking about density in new ways and from different perspectives. Hopefully we will have given you some interesting things to consider. We also hope that it will inspire you to think more broadly about density the next time you are designing, planning and managing the urban environments in which all of us inhabit.

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Appendix
Study 1: Relationships among the dimensions of density

In this Appendix, we present more in-depth findings of the relationships between the dimensions of density and a number of variables from the 75 studies found in our *Progress in Planning* paper.[8] If you would like to see even more details about the studies, please take a look at our journal article.

People

The relationships between people-based density types and other variables are both moderate and mixed. Because a lot of studies involved this type of density, we thought it best to divide the findings into smaller categories, like population density, neighbourhood density, household density and organisational/employment density:

Population density

- At a social level, it appears that higher population densities lead to less satisfaction with privacy, less cognitive development, less casual neighbouring, less wage inequality and less personal and property crime. It also leads to more crowding and perceptions of crowding, depression and withdrawal, greater incidences of hospitalisation for men with schizophrenia, more frequent contact with unfamiliar others, greater regulation of contact, more suburban diversity and more susceptibility to the negative aspects of globalisation, particularly in developing countries
- From an employment perspective, higher densities attract people from the creative industries as well as lower upgrade costs for using the Internet; however, Internet-based firms prefer lower-density areas
- From a transportation perspective, higher population densities increase the number of transit options available, especially public transit use, and decrease car ownership and use, fuel consumption, urban car travel demand, vehicular accidents and public transit operating costs
- From a health perspective, higher population densities lead to greater

8 Boyko, C. T., & Cooper, R. (2011). Clarifying and re-conceptualising density. *Progress in Planning, 76* (1), 1-61.

resistance to pathogens (e.g., tuberculosis)

- From a utility perspective, there is a moderate relationship between higher population densities and greater energy use and outdoor access space
- From a governance perspective, a study has shown that government expenditure per capita was greater when population densities were higher, and infrastructure expenditure was both higher and lower depending on the population density (higher expenditure with populations over 500,000 and lower with populations less than 500,000)
- From a biological perspective, higher population densities may result in greater concentrations of bacteria and lower water quality

Neighbourhood density

- Neighbourhood density is positively and relatively moderately associated with *having* neighbours as friends. However, it is negatively associated with *liking* neighbours as friends
- High neighbourhood densities are negatively related to neighbourhood attractiveness, good maintenance and infrastructure, and good parking facilities
- In high-density neighbourhoods with heavy commercial uses, employment opportunities will be greater, but people's sense of safety will be low and there will be fewer opportunities for social interaction

Household density

- Higher household densities lead to a greater amount of leisure time spent with household members. However, people reported a lower quality of family life and more of a desire to leave their present home and neighbourhood
- The higher the household density, the more likely it is that one will *recognise* one's neighbours. However, higher household densities also suggest that people will less likely *get to know* one's neighbours

Organisational

- Higher employment densities in an area resulted in more patents per capita, more pedestrian casualties and more public transit and walking trips (i.e., when employment densities were between 50-124 employees per hectare and greater than 186 employees per hectare)

Built form

As with people-based density, the relationships between built form and other variables are mixed. And again, we thought it best to separate the findings into smaller categories, such as dwellings, non-dwellings and infrastructure.

Dwellings

- While dwelling densities can be higher in areas with a geometric grid layout (e.g., Manhattan), which also can promote less car ownership and use and more walking and travel walking, it does not promote everyday travel and leads to greater travel by plane
- Higher dwelling densities may be associated with better environmental quality (although only at low and high dwelling densities), lower energy and greenhouse gas use, less heat loss and allow for the greater introduction of sustainable technologies into developments, such as energy-efficient washing machines
- While death rates are lower in higher-density dwellings, stress-related health is worse, as is disturbance from noise
- Overlooking is another issue that is perceived as both positive and negative, depending on views into or out of dwellings and the number of bedrooms in the dwelling
- While higher dwelling densities often have a greater proportion of affordable homes, thus creating more options for housing mix (as opposed to, say, single-family housing), the integration of low-income groups and better access to facilities and amenities at the neighbourhood level, incomes are often lower, access to the nearest greenspace is limited and little to no economic premium is placed on these dwellings or areas
- Higher dwellings densities create fewer opportunities for solar and daylight penetration

Non-dwellings

- Higher densities of buildings where people can buy unhealthy food and drink, particularly when located in low-income, lower socioeconomic status and heavier trafficked areas, are moderately associated with poor health and socio-economic conditions, such as increases in adolescents' body fat, excessive alcoholic drinking in adults and increased chances of developing metabolic syndrome for those with decreased systolic blood pressure

Infrastructure

- The larger the city—and, hence, the higher the density of pavement—the less friendly are its residents

Natural Form

Within *Natural form*, there appears to be a strong, positive association with flora/fauna and density. For example:

- The higher the plant or animal dwelling density (i.e., where plants or animals 'live'), the greater the beneficial impact on the surrounding environment, whether it is cooler temperatures, a higher quantity of exotic and non-invasive plants, greater species richness or diversity or the size of an animal's territory
- When there is a higher density of CO_2 in the atmosphere, plants suffer

Mobile & Static form

For both *Mobile form* and *Static form,* the greater the density, the stronger the relationship with the variable under study:

- Higher densities of people mean that pedestrians move faster
- Higher densities of traffic suggest that there are greater amount of heavy metals and dust in the atmosphere
- Higher densities of alcohol-related advertising hoardings result in greater alcohol consumption in adults

Miscellaneous density

In some studies, more than one type of density was examined in relation to other variables. These are summarised here and, no surprise, the relationships are diverse, with none showing very strong, positive or negative connections (each type of density is mentioned in brackets):

- At the social level, there is more psychological strain (household and building), noise (dwelling and population) and pupil attainment (school and population); stronger—yet fewer—social relationships (dwelling and population) and social sustainability in developing countries (household and population); and less housing affordability and access to greenspace (both dwelling and population; the former also involved perceived neighbourhood density)
- People living in higher densities (in the Midwest of America) are more likely to be Caucasian, married, have a college degree and own a home and a car

- From a business perspective, higher densities lead to more innovation and patent activity (both urban and population) as well as greater employment opportunities (dwelling and population)
- From a transportation perspective, higher densities lead to more pedestrian casualties (population, employment and traffic node) and personal business trips (population and employment); greater travel behaviour and walking for transportation (dwelling, population, population and employment, employment, lot coverage and bus stop); more walking, cycling and public transportation use (dwelling, population and perceived neighbourhood); and less car use, non-work trips (both dwelling and population), walking for leisure purposes, travel walking (both, see 'greater travel behaviour') and travel to work (dwelling and population)
- From a functional perspective, higher population densities suggest less floor space per person, greater infrastructure efficiency (dwelling and population) and environmental performance (dwelling, address, building, buildings with addresses and population)
- From an environmental perspective, higher densities are positively associated with air and water pollution (dwelling, population and perceived neighbourhood), water quality degradation and electrical conductivity in streams (both road and septic tank)

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