CONTEMPORARY CONCEPTS IN PHYSICAL PLANNING

EDITED BY
LAYI EGUNJOBI

VOLUME 1

16

DENSITY

Samuel Medayese, Valda E. Martins and
Nelson T. Abdrazack

16.1 Introduction

Density has a wide range of application, in urban form, population studies, transport studies, residential development, commercial development, in architecture and a varied range of professions. This chapter is, however, tailored towards identifying the significance of density to urban and regional planning. The aim of the chapter is to appraise the importance and the areas of application of density as a contemporary concept in the field of urban planning, both in the practice and education of the profession. The objectives which shall help to achieve this aim include: to identify various scholarly meanings of density in relation to urban planning; to examine the typology of density applicable in urban planning; to appraise the intrinsic relationships between urban planning and density both in space, form and population; and to identify strategies to help in the incorporation of density into planning education and practice towards achieving a sustainable urban space and form. The concept of urban density is basic to Western urban planning. Most urban jurisdictions regulate, in some way, the density of population, dwellings or land use activities within urban space. Yet the influence of density on urban

functioning is also one of the most contested dimensions of contemporary urban planning (Churchman, 1999).

Therefore, it is important to assert that the questioning and discussion of density must be socially informed, not simply scientifically or technically framed. It can be argued that, this insight, which is something of a social scientific 'truism' for any technical policy debate, is yet to be applied to the issue of density. Abram (2005) observes that, technical debates are often 'politics by other means' and it is applicable to the technical contestation of urban density. Davison (2006), therefore, warns that, planning risks becoming 'stuck in a cul-de-sac' if it is unable to reconcile the struggle over density and move towards a more constructive and broadened form of engagement with urban challenges. However, this chapter is not aimed at resolving this intellectual and guiding principle conundrum by arguing in favour of a particular density regime. Three things are paramount to this chapter:

1. The social and historical conditioning of debate about density, in combination with equivocal scientific evidence about the influence of density on human environments, renders deeply problematical any deterministic approach to urban form;
2. In view of the above, the influence of density cannot be measured or forecast in a manner isolated from context: density is one dimension of a complex ensemble of conditions and activities that shape particular urban contexts in unique ways;
3. The emphasis dedicated to urban density in Nigeria's planning schemes, both historically and in the present, neglects or underestimates the environmental and social significance of other urban conditions and activities and thus risks diverting conceptual and practical energies away from potentially more fruitful avenues for the achievement of sustainability.

Dodson (2007) opines that planners' contemporary uses of density concepts in part reflect contemporary urban concerns. In periods when a quite different array of urban concerns confronted urban planners a set of quite different qualitative characteristics were ascribed to different urban densities. This initial observation that the planning meanings ascribed to density as a spatial concept vary over time suggests that there is an important, perhaps even primary, sociological dimension to the concept of density. This assessment, in turn, implies that urban density can be perceived not only from a physical or technical perspective, but also from a critical sociological perspective.

Surprisingly, there has been little recent scholarship that has considered density as a sociological concept. The planning literature is replete with technical and empirical perspectives that attribute various social, economic and environmental effects to particular densities of urban form, many of which have been prominent in urban social science.

This chapter is divided into six major sections, with various subsections. The first section is introduction, which encapsulates the basis of the chapter, aim to achieve and the objectives. The second section deals with conceptual review/theories and models of density, with specific consideration of Ebenezer Howards Garden City, Le-Corbusiers' "Radiant City", and other model cities such as compact city. Section three describes the typology and element of density. Section four captures the principle of density, such as density and space, and density and urban morphology. Section five seeks to map the nexus between density and urban planning, while section six is devoted to conclusion.

16.2 Conceptual Issues and Literature Review

The definitions of density are as many as the different fields of its application, as the term is not exclusive to a specific field of human endeavour. Ophardt (2003) defines density as a physical property of matter, as each element and compound has a unique density associated with it. Density, defined in a qualitative manner, is the measure of the relative "heaviness" of objects with a constant volume. The symbol most often used for density is ρ (the lower case Greek letter rho). Mathematically, density is defined as mass divided by volume: *Merriam-Webster Dictionary (2014)* views density as the quantity of something per unit volume, unit area, or unit length. Dictionary.com (2014) views it as the number of inhabitants, dwellings, or the like, per unit area.

To the urban planner, three concepts are used to address the issue of density and how density affects people's lives: density, perceived density, and crowding (Alexander, 1993). Density is a term that represents the relationship between a given physical area and the number of people who inhabit or use that area. It is expressed as a ratio of population size or number of dwelling units (the numerator) to area units (the denominator). Density is an objective, quantitative, and neutral term. It is neutral in the sense that one cannot know immediately whether a given density level is positive or negative. Psychologists distinguish between spatial and social density. Spatial density is created by a given number of people within different size spaces. Social density is created by different

numbers of people within the same space. The argument is that these two types of density are experienced differently (Baum and Paulus, 1987; Russell and Snodgrass, 1987). This distinction is similar to Hitchcock's (1994) analysis of the difference between increasing density by reducing residential land area for the same number of people or by increasing the number of people in the same residential land area. Perceived density and crowding are based on the principle that the same density can be perceived and evaluated in very different ways, by different people, under different circumstances, in different cultures and countries. Thus, even though planners operate on the level of density, they must be cognizant of the fact that people experience and live in a multilevel situation that manifests itself in interactions between densities and the perception and evaluation of density.

The industrial revolution urban planner Ebenezer Howard tried to repopulate the countryside with less dense and greener environments than the growing industrial city could offer. His interest towards a combination of town and country derived from his visit to the United States in 1872- 1876, fascinated by the newly populated towns. The result was the emergence of his publication. *The Garden City of Tomorrow* in 1898, a manifesto against the growing industrial city. The cities of today, however, still continue to grow and we have to question our approach towards the future urban planning and the shape of our cities.

Is it a compact urban development that provides answers to global sustainable urban growth? Because less urban sprawl leads to reduction of energy and pollution or a low-density urban area, which promotes extensive car use and will become unsustainable long before fossil fuels run out. This chapter shall strive to provide information on density in an urban context from a historical and personal points of view and draw a clearer picture on identifying density as a planning tool for shaping the future city.

Jacobs (1961) raised the debate towards dense urban living with the publication of *The Death and Life of Great American Cities*. Her argument was for the more dense urban form and attacked the tendency inherited from the Garden City movement and the modernist planners of the 20th century. In her opinion, a sufficient density would strengthen the diversity of a city on its streets as in its districts, taking a cue from the low-density and its characteristics. A density of 12 dwellings per acre (or 30 to 40 dwellings per hectare) was the typical Garden City model. At such low densities, the semi-suburb area is destined to become a grey area as the city around it continues to grow and its exclusiveness

and closeness to nature get lost; in contrast, urban density varies from city to city- as in quantity and in quality.

One of the most compact cities in Europe is Barcelona, which is highly praised for its high density of physical form and its quality public spaces. Barcelona has a district with an average of 400dwellings per hectare and is referred to as an example (Catalan for extension), which was realized in the nineteenth and early twentieth century by urban planner Ildefons Cerdá. Similar to Ebenezer Howard, Cerdá was concerned with the living conditions in Barcelona. He was pursuing key factors in his design, such as natural lighting and ventilation in homes and the need for green environment in people's surroundings without neglecting the public realm. The main characteristics of his plan were the long straight streets in the grid pattern crossed by wide avenues and square blocks with chambered corners. Cerdà wanted to design an egalitarian city where some neighbourhoods are not differentiated from others by the living conditions imposed. The same services were planned for every corner evenly. However, sprawl development, such as in Barcelona is pretty uncommon when it comes to urban planning.

The idea of density as a tool for urban planning was recognized and implemented in the planning policy in the United Kingdom since the year 2000 with its PPG-3 (Planning Policy Guidance on Housing). The PPG-3 was a result of the British research group Urban Task Force, chaired by Architect Sir Richard Rogers. The British government asked him to analyse urban conditions in Great Britain and propose solutions to improve the quality of towns. The report covered a wide range of suggestions; one of them entitled "Density and Intensification". In general, they proposed urban neighbourhoods designed to higher densities than it was allowed by planning regulations in order to create more lively conditions for residents. The Task Force established that the post-war British towns were built at a standard of 25 dwellings per hectare. If the standard would reach a level of 30 - 40 dwellings it would allow greater amenities and transport facilities to be located at walking distance. High density can become intolerable when it reaches seventy per cent of land coverage. In that case, the land has to be interlaced by frequent streets, lively parks and a mix of non-residential buildings. Each of these devices will contribute to the relief from the high coverage, but at the same time generate diversity and vitality of an area. A city has to choose between the destructive effects of low-density car-oriented suburbs and higher densities that create more lively conditions for its residents.

In order to investigate the importance of density within an urban framework

and the kind of benefits it generates for its users, it is essential to define the concept of density. The idea of urban density has been discussed since the Garden City model in the United Kingdom at the end of the 19th century. In the 1920s this discussion continued influencing urban development. Density is a term regarded as representation of a physical area and the number of people who inhabit it, but it has often been associated with overcrowding. The housing problem was one of the major debates in the beginning of the 20th century. Urban planners were persistent to improve the living conditions in densely overcrowded metropolitan areas. For a long period of time, density was considered one of the major ills of the city and, in response, the urban planners saw low density as the salvation of their own city. In 1898, Ebenezer Howard proposed the urban Garden City model, which included only low-density dwellings in its master plan, preventing further overcrowding of the city by also restricting the residents to 32,000. Ebenezer Howard looked at the slums of London, which had too many dwellings per acre and too many people per dwelling unit. However, it is important to clarify that high density and overcrowding are not the same thing.

The significance of these terms is strictly separated. High density means there is a large number of dwellings on a piece of land. A good example would be the city of Amsterdam, which has a very high density due to its plot usage law. Overcrowding means there are too many people in a room or dwelling. For instance, fifteen years ago, the average space for a person in Shanghai was 6 square meters, which means that a dwelling of 30 square metres could accommodate five people, which fits the description of overcrowding, because too many people are present in a dwelling unit. The overcrowding of dwellings or rooms is still persistent in our world and is a symptom of poverty or discrimination. The Garden city movement did not make the difference between overcrowding and high density. The Garden City planners put these two terms in the same category. The confusion continues until recently, with the script by Sir Raymond Unwin, one of the Garden City planners, titled *"Nothing Gained by Overcrowding". The text is promoting the benefits of the Garden* City Model, which was the response to the overcrowded city.

The text generally presents examples, and benefits, of how to keep land coverage at an efficient ratio in order to prevent overcrowding. To say that an *x* number of dwelling units per acre will prevent overcrowding is absurd, because one thing has nothing to do with the other. The Garden City Movement recognized overcrowding of dwellings by people and overcrowding of land by

buildings as the same, an unhealthy environment for citizens. Therefore, a combination of city and countryside was convincing and attractive. We need to refer to the French architect Le Corbusier and his scheme "Radiant City" from 1935. The Radiant City was considered as high density, because its skyscrapers had a high-density core, meaning that each building had a high coverage of inhabitants. However, the Radiant City is low-density, because the land usage is in the proportions of five per cent dwelling units and ninety-five percent open land and transport. The conception of low-density in both cases is absolutely identical. Low-density Garden City and Radiant City have the same character; they just use different ratios when it comes to land usage.

Obviously, urban density and overcrowding are different terms and cannot be put in the same context. However Danish architect and urban design consultant Jan Gehl dedicates a chapter in his book *Cities for People*, to this issue, arguing that density is not the main catalyst for city life. He rejects the wide belief that a lively city needs high building density. Gehl describes several situations where high densities affect the quality of city life, such as New York City's Manhattan, with its skyscraper clusters with dark and unattractive streets at their base. Instead of developing high rise and high density building areas, Gehl suggests that the level of density should be combined with quality in the form of good city space.

16.2.1 Typology of Density

(a) Residential Density

Residential density is the ratio of a population to residential land area. This measure can be further classified in terms of net and gross residential densities based on the definition of the reference area. However, there is no consensus on the definitions of net and gross areas; they vary across cities and countries. In the UK, net residential area refers only to land covered by residential development, along with gardens and other spaces that are physically included in it; this also takes into account half the width of adjacent roads (TCPA, 2003). In Hong Kong and some states in the US, net residential area only consists of the parcels allocated for residence where internal road, parks and other public lands are excluded (Churchman, 1999; Hong Kong Planning Department, 2003).

The measure of gross residential density considers the residential area in its entirety. In addition to the area allocated for residence, it also takes into account non-residential spaces, such as internal roads, parks, schools, and community centres, which are meant to serve the local community. Nevertheless, in

practice, it is difficult to clearly define the extent of these residential areas. Some developments may take into account lands for purposes of serving a wider neighbourhood and others may include non-developable land, such as steep slopes. This inconsistency of inclusion leads to great ambiguity in gross density measurement and, in turn, makes comparison difficult.

(b) Occupancy Density

Occupancy density refers to the ratio of number of occupants to the floor area of an individual habitable unit. The reference habitable unit can be any kind of private or public space, such as a dwelling, office, theatre and so on. However, the reference area usually refers only to an enclosed area. Occupancy density is an important measure in building services design, as it provides an indicator for estimating the services required. For instance, the electricity demand, space cooling and heating load, provision of fire safety facilities, and so forth are estimated based on the occupancy density. Occupancy rate, which is the inverse measure of occupancy density (i.e. ratio of floor area of individual unit to number of occupants), is commonly used as an indicator of space available for individual occupants, while higher occupancy rate means larger habitable area for individual occupants. Regulation of minimum occupancy rate is often used in building design to safeguard the health and sanitary condition of habitable spaces.

16.3 Philosophy and Principles in Density

16.3.1 Measures of Building Density

(a) Plot Ratio (Floor Area Ratio)

Plot ratio is the ratio of total gross floor area of a development to its site area. The gross floor area usually takes into account the entire area within the perimeter of the exterior walls of the building, which includes the thickness of internal and external walls, stairs, service ducts, lift shafts, all circulation spaces, and so on.

Site area refers to the total lot area of the development, which, in most cases, is precisely defined in the planning document. Since the definitions of both floor and site areas are relatively clear in the measurement, plot ratio is considered as one of the most unambiguous density measures. In planning practice, plot ratio is extensively adopted as a standard indicator for the regulation of land-use zoning and development control. Different plot ratios for different types of land uses are often specified in urban master plans as a provision of

mixed land use. Furthermore, maximum plot ratio is often controlled in the master plan in order to govern the extent of build-up and to prevent overdevelopment. In building design, plot ratio is widely used in design briefing and development budgeting as it reflects the amount of floor area to be built and, hence, can be used to estimate the quantity of resources required for construction; consequently, it can forecast the financial balance of investment and returns.

(b) Density Gradient

Density gradient is defined as the rate at which density falls (according to distance) from the location of reference; therefore, a positive density gradient denotes a decline of density away from the reference location. The density gradient is usually derived from densities measured in a series of concentric rings at a 10 m or 20 m width, radiating out from the location of the reference (Longley and Mesev, 2002). Density gradient is a composite measure of density. Comparing the changing pattern of density gradients over time can review the process of spatial evolution.

Two changing patterns of density gradient exists: (a) a process of progressive decentralization with decreasing population density in the urban centre and increasing density and boarders towards the outskirts; (b) a process of centralization with growing population density in both the urban centre and outskirts and, at the same time, enlarging borders towards the periphery. Between 1800 and 1945, the North American metropolis exhibited the former process of decentralization, while the European counterparts resembled the latter process of centralization (Muller, 2004).

16.3.2 Perceived Density

Perceived density is defined as an individual's perception and estimate of the number of people present in a given area, the space available and its organization (Rapoport, 1975). Spatial characteristic *per se* is important in the perception of density; but in addition, the interaction between the individual and the environment as a whole counts even more. Individual cognitive attributes and socio-cultural norms are also factors that contribute to this interaction (Alexander, 1993). Furthermore, perceived density not only addresses the relative relationships between individual and space, but also between individuals in the space. For example, suppose there are two spaces with the same occupancy rate of 3 square metres per person in one case, there is a group of friends in a

clubroom, while in another there are several unacquainted people in a small lobby. Clearly, these two situations are very different in social and perceptual terms, even though they show the same physical density (Chan, 1999). In order to distinguish between these two different aspects of perceived density, the concept of spatial density and social density was introduced. Spatial density refers to the perception of density with respect to the relationship among spatial elements, such as height, spacing and juxtaposition. High spatial density is related to environmental qualities, such as high degree of enclosure, intricacy of spaces and high activity levels, in which all of these qualities tend to result in higher rates of information from the environment itself.

Social density describes the interaction between people. It involves the various sensory modalities, the mechanisms for controlling interaction levels, such as spacing, physical elements, territorial boundaries, hierarchy, the size and nature of the group involved, its homogeneity and rules for behaviour, in which all of these qualities affect the rates of social interaction (Chan, 1999). In general, for high spatial density, the primary problem is too little space; while for high social density, the primary problem is too many people with whom one must interact. Perceived density, therefore, is subjective as it relies on individual apprehension; nevertheless, it is also neutral, as it does not involve any personal evaluation or judgement. Crowding, on the other hand, refers to the state of psychological stress that is associated with a negative appraisal of density (Churchman, 1999). Density, although a necessary antecedent of crowding, is not a sufficient condition for causing the experience of crowding. Apart from physical conditions, crowding also involves the evaluation of situational variables, personal characteristics and coping assets (Baum and Paulus, 1987). Research suggests that, as far as crowding is concerned, the influence of social density is more significant than spatial density (McClelland and Auslander, 1978). However, the experience of crowding would be intensified as a consequence of limited space since the freedom of adjusting one's physical proximity to others is reduced (Mackintosh et al., 1975).

16.3.3 High Density

Rapid urbanization since 1950 has exerted tremendous pressure on urban development in many cities and has been confronted with the scarce supply of land in urban areas; densification has also become an important agenda in planning policies around the world. High-density development has consequently been a topic of increasing interest worldwide; it represents different notions in

different countries, across different cultures and to different people.

The meaning of high density is a matter of perception; it is subjective and depends upon the society's or individual's judgement against specific norms. Hence, societies or individuals of different backgrounds and under different contexts come up with different definitions of high density. For example, in the UK, residential development with less than 20 dwellings per net hectare is considered low density; between 30 to 40 dwellings per net hectare is considered medium density; and higher than 60 dwellings per net hectare is considered high density (TCPA, 2003). In the US, low density refers to 25 to 40 dwellings per net hectare; medium density refers to 40 to 60 dwellings per net hectare; and high density refers to development with higher than approximately 110 dwellings per net hectare (Ellis, 2004). In Israel, on the other hand, 20 to 40 dwellings per net hectare are considered low density, and 290 dwellings per net hectare are considered high density (Churchman, 1999).

The term 'high density' is always associated with overcrowding; however, the notion of high density expressed in terms of building density has little to do with overcrowding. High building density measured in terms of plot ratio, for instance, refers to a high proportion of built-up floor area. In the case of larger dwelling size and smaller household size, higher plot ratio may lead to lower occupancy density and, therefore, more habitable area for individuals, in turn mitigating the crowding condition. For instance, the plot ratio of government housing development in Hong Kong rose from about 3 during the 1970s to about 5 in the 1980s; accompanied with this growth in building density, the living space for occupants increased from about 3.2 to 5 square metres per person (Ng and Wong, 2004). Thus, higher building density, in this case, actually helped to ease the problem of overcrowding in dwellings.

The phenomenon of overcrowding has resulted from the lack of space for individuals; thus, it is more about high people density. However, as illustrated in the example above, the relationship between building density and people density is not straightforward and depends, to a great extent, upon how people density is measured. Again, Hong Kong may be taken as an example. The average residential density of government housing projects completed during the 1970s was approximately 2300 individuals per hectare; during the 1980s, it was 2500 persons per hectare (Lai, 1993). Hence, although higher building density reduced occupancy density within the dwelling, it also increased the overall people density on the site. In short, the phenomena of high building density and high people density represent very different issues; complicating

the matter even further, an increase in building density can have opposite effects on people density, depending upon how the latter is measured. Nevertheless, this vital concept is vaguely addressed in the debate concerning high-density development.

16.3.4 Building Density and Urban Morphology

Building density has an intrinsic relationship with urban morphology; it plays an important role in the shaping of urban form. For instance, different combinations of plot ratio and site coverage will manifest into a variety of different built forms. The building transforms from a single-storey building to a multi-storey tower as the proportion of site coverage decreases. In a similar vein, urban development of the same density can exhibit very different urban forms. There could be settlements with the same residential density of 76 dwellings per hectare, but in different urban forms: multi-storey towers, medium-rise buildings in central courtyard form, and parallel rows of single-storey houses. The three layouts are different in many aspects; nevertheless, in terms of urban land use, the proportion and organization of ground open space is of particular interest.

The high-rise layout creates large areas of open land that are suitable for expansive communal facilities, such as libraries, sports grounds and community centres. Nevertheless, without efficient land-use planning, these spaces can run the risk of being left over, not properly managed and end up producing problems. The proportion of open area resulted in the medium-rise courtyard form, although it is less than that of the high-rise layout. However, unlike the former, the courtyard space is enclosed and clearly defined. It can be shaped as the central stage of the community and, thus, encourages full use of space. The single-storey houses layout, on the other hand, divides open space into tiny parcels for individual uses. In this arrangement, the area for communal facilities is limited; nevertheless, residents can enjoy their own private open space.

In the face of rapid urbanization, the relationship between building density and urban form has attracted wide interest. Growing pressure of land scarcity as a consequence of increasing urban population has initiated extensive investigation on the spatial benefit of multi-storey buildings. Mathematical and geometrical analyses have been conducted to address the issue, particularly concerning the relationships between building height, plot ratio, site coverage and solar obstruction (Beckett, 1942; Davidovich, 1968; Martin and March, 1972; Evans, 1973). For an array of continuous courtyard form at a given plot ratio, increased

building height will always lead to reduced solar obstruction, as shown in Figure 16.1. Put in another way, provided the solar obstruction angle is kept unchanged, increased building height will heighten the plot ratio. Moreover, the site coverage will decrease concurrently, which will lead to more ground open space. For urban form with an infinite array of parallel tenement blocks, although geometrically different from the courtyard form, the mathematical relationships between building height, plot ratio, site coverage and solar obstruction remain the same. Therefore, the observations obtained from the courtyard form apply to the parallel block form as well.

16.4 Density and Space

Humans have come to use space over time – in some cases judged as too intensely, in others not intensely enough – and the problems connected to this have resulted in discussions concerning the application of the concept of density in urbanism. The use of the concept has varied greatly through modern planning and design. At the beginning of the 20th century, Unwin (1909) claimed that nothing was to be gained from overcrowding in cities; he proposed a standard density of 12 houses per net acre maximum, or 30 houses per hectare. Fifty years later, Jacobs (1961) warned that American slums were not only an issue faced in the inner cities, but also in the low-density, dull areas on the fringes. She suggested that a minimum of 100 dwellings per net acre (250 dwellings per hectare) was a necessary condition for a vital and participatory city life (Jacobs 1961). At present, high densities and the compact city are often seen as prerequisites for sustainable urbanization and economic growth (Florida 2002; Jenks et al., 1996; Lozano 1990; van Kann and Leduc 2008).

The concept of density in urbanism is frequently used to describe the relationship between a given area and the number of certain entities in that area. These entities might be people, dwellings, services, or floor space. However, the simple fact that density is used in, for instance, design requirements, plan descriptions and communication between parties, does not mean that it is used correctly or to its full potential. In the following sections, we describe the origins and the contents of existing concepts, the way these concepts have been used to guide the use of space, and their limitations in doing so.

It is important to make a distinction between urban density used to describe a built environment (descriptive use); and urban density used as a norm in the process of planning and designing the city (prescriptive, or normative, use). Preceding the 20th century, density in cities was merely a

result of the complex process of city development. Building techniques, legal constraints, traditions, the requirements for economic profitability, et cetera determined the possible resultant densities. As a matter of fact, density as a concept in urban analysis and planning probably did not exist until the second half of the 19th century. During this period, high densities in industrializing cities were argued to be one of the major causes of fires, disease and social disorder. Mainly through critical publications in England and Germany, the awareness of the problem grew among legislators and urban planners. As a result, planning controls that prescribed maximum allowable densities were developed (Churchman 1999). The legislative developments were paralleled by the introduction of a scientific approach to the large city expansions that took place during the economic and demographic boom of the second half of the 19th century. In works by Baumeister (1876) and Stübben (1890) in Germany, density played a role in the discussions of the preferred urban form. At first, the regulation of density was more indirect through prescribed maximum building heights and minimal street widths. Later, mainly through building ordinances, maximum densities were explicitly used to regulate the urban plan.

Critics and designers, such as Unwin (1909) and Ebenezer Howard (1898), in England, used density to propagate the advantages of decentralized and self-contained smaller cities. Taking off in the 1960s, extensive discussions took place concerning the issue of urban sprawl and its negative effects on the liveliness of cities, on transportation and the environment. The criticism was not only directed towards the privatized forms of suburban sprawl (low-rise) but also against the relatively low density, high-rise expansions of the Modern Movement that were built after the Second World War. Compact cities were judged by many to be the best response to counter these developments. In many parts of the world, the affluence of societies has been manifested through increased space consumption. In some cases, this has led to calls for regulating the minimum densities of redevelopments and city expansions. During the last century, density has thus been used both to describe the problems of the city (as too dense a century ago, and as too dispersed today) and, based on such diagnoses, as a norm to prescribe alternatives, at times formulated as maximum densities, at other moments as minimum densities. In spite of the practical advantages of the concept of urban density in urban planning, critics have argued – especially since the revolt in the 1970s against the quantitative methods of modernist planning – that the use of density for anything but statistical purposes is questionable, as it is perceived as too elastic

concept that poorly reflects the spatial properties of an urban area. Professionals, as well as researchers, hold the opinion that measured density and other physical properties are independent of each other. Very different physical layouts can have similar measured densities. Previous analyses showed that measured density and other physical factors are quite independent of each other (Alexander 1993: 184).

Often, people confuse density with building type and assume, for example, that detached houses are lower density than attached housing types. While this is generally true, it is not always the case. A high-rise tower with large units set on a park-like site may be lower density than a set of detached houses on small lots (Forsyth, 2003: 4).

One of the problems of defining density in operational terms is the relatively weak relationship between density and building type. The same density can be obtained with radically different building types, and the same type can be used to obtain different densities (Lozano, 1990: 325).

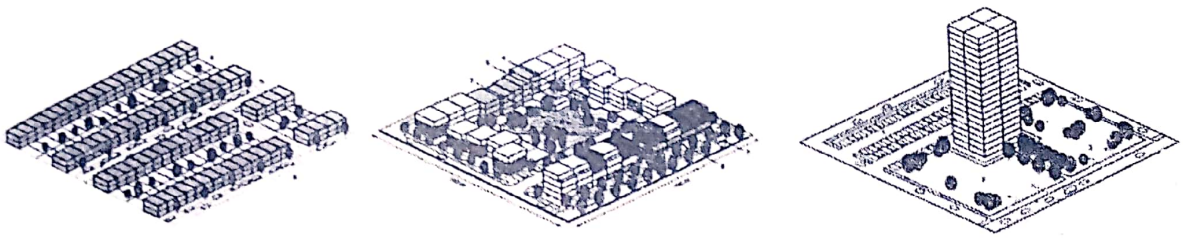

Figure 16.1: Three Areas with 75 Dwellings per Hectare (Fernandez Per and Mozas, 2004)

Besides the argued lack of relationship between density and form, density is also considered with suspicion because of the confusion regarding the definition of plan boundaries and the scale at which these are measured. Although it is common to distinguish between net and gross density, the definitions vary from place to place (Churchman, 1999): parcel density, net-net density, net and gross residential density, general density and community density are some of the units of measure used. For instance, the population density of the municipality of Amsterdam was 44 inhabitants per hectare in 2000 (excluding water). The density of its urbanized areas, however, was 63 inhabitants per hectare, and the gross residential density – excluding large-scale working areas and green areas–was almost three times higher: 125 inhabitants per hectare. Notwithstanding these described shortcomings, there is a pragmatic need to continue to use density during the process of city building. In general, however, the use of density seems to create some discomfort. For one, we continue to use and require the concept

for planning, programming and in the evaluation of urban environments. On the other hand, we are told that the concept of density has very little relevance for the resulting urban form. It is disturbing that the concept comes with a large 'warning disclaimer'. However, what if the definitions and methods that have been used to argue against a relation between density and form have just been ineffective in establishing such a relation?

After an apparent lack of interest in density in urbanism, the concept recently received attention in a series of Dutch polemical designs: *Point City* (OMA 1995: 888-893) and the publications *Farmax* (MVRDV 1998) and *Metacity/Datatown* (MVRDV 1999). Other examples of the (re)introduction of density in Dutch urbanism are the works of Urhahn and Bobic; Berghauser Pont and Haupt; and Uytenhaak. In two publications, *A Pattern Image* and *Strategie voor stedelijkheid*, Urhahn and Bobic (1996), describe density as one important element of urban quality. Of more recent date is *Spacemate. The spatial logic of urban density* (Berghauser Pont and Haupt 2004), in which the first results of this thesis were published, and *Cities full of Space: Qualities of Density* (Uytenhaak, 2008), which investigates the possibilities of designing and living in more compact cities. Also, attempts were recently made internationally to grasp the relation between density and built form: *Visualizing Density* (Campoli, 2007), *Densité & Formes urbaines dans la métropole Marseillaise* (Brunner 2005), and *Analyse de 50 périmètres batis situés sur le canton de Genève* (CETAT 1986). The number of detailed descriptions in these publications of all facets of the built environment is impressive and useful, but a basic interpretative framework and in-depth research are often lacking. Publications mostly result in an elaborate series of examples.

There is clearly a need for further fundamental research on density. Systematic development of work dealing with the relation between the quantitative and qualitative aspects of space consumption has yet to occur. The concept of density, as such, cannot be blamed for explanatory shortcomings; this is caused more by the formulation of specific definitions and their applications. Formulating another definition of density might help to establish an effective relation to urban form. This research aims to develop such a definition in the form of a multivariable density concept, the Space matrix, and to promote the establishment of a science of density.

There are currently two developments in the process of urbanization that legitimize the study of density. First, recent changes in how city building is organized have created a greater need to relate development programmes to

spatial qualities. Second, the trend in the increase in space consumption and the environmental, economic and social effects associated with this trend point to the need for research into the relationship between the quality and capacity of space. Since the 1970s, the traditional hierarchical sequence of the planning process, starting from national, regional and urban planning, continuing on to urban design and architecture, has largely been reversed. Architecture is no longer an extension of planning, but is now often employed to trigger the planning process. In other words, city development has shifted away from normative master and blueprint planning to more strategic and project based approaches. This has resulted in a process of city development that mainly occurs through negotiations between private and public actors.

This shift is often described as a gradual ideological and practical shift from government to governance, implying a growing role for private actors in public policymaking (Harvey, 1989; van der Cammen and de Klerk, 2003; Wigmans, 2004). The government at both national and local levels no longer takes an arm's-length role, but, through a new approach to governance, has become one of many market parties (Musch 1999). This subject has been extensively described by, among others, Claessens (2006), Meijsmans (2008), van der Cammen and de Klerk (2003), and Wigmans (2004). In addition, a greater demand for selling projects that focus on branding and seductive images, something deemed necessary in the current competitive climate, has caused a shift to a project-based design approach driven by aesthetic values (van der Cammen and de Klerk, 2003) (Notwithstanding this, rational instruments, such as programming, investment returns, and traffic and civil engineering, still greatly condition the development process). Critics address the superficiality of such a project-based design approach, arguing that the urban development has evolved into little more than large-scale architecture. They argue that to deal with this, instruments are needed to link the instrumentally rational to the image, and projects to a strategy for the city or city region as a whole (Meyer, 2005; Claessens and van Velzen, 2006; Meijsmans, 2008).

Furthermore, such instruments should facilitate the negotiation process between private and public actors and enable all actors simultaneously to assess programme and urban form. We claim that urban density could play a significant role in doing so. Another reason why density needs to achieve a more central role in urbanism is that the urban space consumption has increased dramatically during the last century. The average population density of Amsterdam fell a factor of 9, from almost 570 inhabitants per hectare in

1880, to around 65 in the year 2008 During this period, the urbanized territory of Amsterdam grew from approximately 560 to 11,500 hectares (a factor of 20), while the population grew from 317,000 to 727,100 inhabitants (a factor of 2.3). The growth of Amsterdam can largely be explained by the increased spatial demands per person, but only marginally by the growth of the population. This seems to be a general trend in wealthy societies; the number of inhabitants per dwelling unit decreases, dwellings become larger, and the city is less densely built.

The causes of such sprawl of people and activities are complex and the effects multifaceted, but many of the effects are quite generally acknowledged. They include such factors as the increase in car and goods transport, the association of this with the increase in energy consumption, air pollution, noise pollution and the fragmentation in the ecosystems, accompanied by a reduction in the viability of public transport, local amenities and public services, and so forth (Couch, et al., 2007). This trend of increase in consumption of space calls for further research on the relationship between the capacity and the quality of space. How can more compact approaches accommodate future growth? What qualitative measures (specific technical and design solutions) can be used to compensate for and counteract the negative effects of higher densities? To answer these questions, instruments that make explicit the macro-scale consequences of spatial choices made on project level, and vice versa are needed, instruments that assist in predicting and visualizing the impacts of macro-scale programmes on the micro-scale of a project.

16.5 Density and Urban Forms

We have noted that density is one of the most important city planning tools. We have also addressed the importance of exploring the forms of residential density, since it constitutes a contribution to the discussion on contemporary city growth. We will now explore some of the actual meanings of density and if the different authors who have addressed this issue, agree or differ in relation to it. Density is an objective and quantitative measure, which refers to a spatial fact that is typically calculated from the ratio of persons or housing units per surface unit. On the one hand, it is an indicator that allows analysing the urban phenomenon; on the other, it is a formula for managing city growth. However, reasonable feasible to suppose that this is a quite reductionist way of approaching the issue of density, since it is a broad and complex concept.

In universal terms, density is connected with: (1) a pre-condition for urban life; (2) the efficiency in the use of non-renewable resources, such as land and fuel; and (3) in a rather contrary sense, as the cause of negative externalities, such as congestion and pollution. However, when we look at density definitions, the concept becomes richer and gains more complex variables. Certainly, in the concept of density are woven various dimensions, from the explicit quantitative formula to the less obvious, such as the notion of human perception. A first intricacy lies in the difficulty of measuring density, resulting not only in many ways to calculate it, but also in various definitions of the concept: gross and net density, residential density and adjusted density, population density, spatial density, edificatory density and social density, among others. A second complexity lies in the meaning of density and its implications for urban form, which also differ on the scale of analysis. It has been mentioned that, in the regional and city levels, density is a planning tool that guides the growth of urban areas. It is also an instrument for analysing and comparing the processes of development of regions and cities at a national, continental and even a global scale.

At the neighbourhood level, the urban splinter and even the lot, it is a common agreement that density is the most important variable in determining the proviso of "urbanity", which is a necessary requirement to ensure urban vitality, liveability (Decléve, 2009). On this dimension, density is related to some urban functional relations, such as traffic or the provision of public transport and public facilities; as well as to design variables that define the dimensions and arrangement of buildings in the lot. Thus, the concept of density is extended and associated with edificatory conditions, such as floor area ratio, setbacks, height and lot occupation. Different combinations of these variables may be manifested in a variety of urban forms. In this sense, it is interesting how the Dutch firm MVRDV understands density: since density reflects the degree of utilization and exploitation of land, it can be defined as the third dimension of the city. Interestingly, combinations of these variables have historically been a mechanism of spatial segregation, out of zoning ranges of minimum and maximum edificatory densities which separate different social groups in the territory. In such way, when a land use plan imposes high minimum lot sizes, it segregates the population segment who cannot afford those properties.

Density, as a quantitative indicator, is not a term sufficiently descriptive of the condition of urban life, as our perception of density is not necessarily

quantifiable. A third complexity associated with the phenomenon of density is its subjective and qualitative condition, which is possible to explain not only out of the intensity of use and activities, but also from the relation of people with the spatiality of the built environment. Indeed, a residential complex may be perceived as too dense or not, depending on its design features the relationship between public and private spaces, and the surface of green areas, among other morphological characteristics. People's cognitive and socio-cultural characteristics are also determinants of this interaction (Lynch, 1981) which has been defined as social density (Cheng, 2010). Decléve (2009) asserts that density might even be defined as a cultural construct, as the parameters that define what high density is, for example, rely on the activities an urban space defines and our own perception of such space. This reality refers to the relative nature of the concept of density as a state of psychological stress associated with negative perceptions of density.

There is a debate about the concept of density and its implications: among those who seek to reduce urban growth and those who argue that low densities are not only inevitable, but also would be desirable or positive. A better understanding of the meaning and importance of density and the statements that underlie the debate reveals the complexities recently mentioned.

For instance, Echenique (2006) argues that, as population income grows families' demand for space increases. In other words, people demand more square metres, not only in housing, but also in commercial services. In such a way, the decrease in density in the contemporary city is a product of a sum of individual decisions. It is implicit in this argument that state regulations on density are constraints to urban development trends of city growth as a result of higher income residents. In contrast, other authors note that it is required to implement density regulations that preserve the balance and variety of buildings, in order to achieve a hierarchy of density thresholds.

16.6 Density and Population

The answers to important questions in urban economics depend on the density of population, not the size of population. In particular, positive production or residential externalities, as well as negative externalities, such as congestion, are typically modelled as a function of density (Lucas and Rossi-Hansberg, 2002). The speed with which new knowledge and production techniques propagate, the gain in property values from the construction of

urban public works, and the level of labour productivity are all affected by density (Carlino, Chatterjee, and Hunt, 2006). Nonetheless, properties of the distribution of urban population size have been studied far more than properties of the urban density distribution. Chatterjee and Carlino (2001) offer an insightful example as to why density can be more important than population size. In their view, Nebraska and San Francisco have the same population, but urban interactions occur far less frequently in Nebraska because of its much larger area. Although the differences in the area of various cities are not quite stark, there are meaningful heterogeneities in city densities. Much of contemporary economics on population problems has centred on what could be the optimum size and its impact on economic growth and development (see, for example, National Research Council, 1993; Onokerhoraye, 1995; United Nations, 1999; UNDP, 2001; and Onwuka, 2003). This economics originated from the question posed by Malthus (1803) as to whether food production could keep pace with the demand of a growing population and his answer that the power of population is indefinitely greater than the resources on earth to provide the needed subsistence for mankind. The debate triggered by the Malthusian hypothesis points to a lack of universal applicability of his paradigm because in industrial countries, technological advances have spurred increases in agricultural production, which ensures food security for the citizens. For those countries, his predictions are somewhat negated, whereas a large number of developing countries remain trapped under conditions capable of validating them (Olofin, 1996).

The efforts of governments in the developing countries to feed their peoples and also provide quality social services for them are being frustrated by rapid population growth. This growth is attributable, on the one hand, to improvement in human survival associated with the application of modern medical science to health matters, better sanitation and immunization of children, which have caused the death rate to decrease (Ashford, 2001). On the other hand, the traditional beliefs about the value of children, particularly sons, as an asset to be relied upon by their parents in agricultural production and to support them during old age have combined with the practice of polygamy, the fear of child mortality and low levels of female education to encourage high fertility. Moreover, the continuity of the patrilineal decent group and the influence of religions, which teach that children are gifts from God sharply limit the prospects for lowering the birth rate (Renne, 1995; Ainsworth et al., 1996 and National Population Commission, 2003).

Consequently, the world population has been increasing and the increase in the last two decades has been demographically unprecedented, as it rose from 4.8 billion people in 1985 to 6.4 billion in 2004. Much of this increase occurred in the developing nations, as their populations grew from 3.7 billion to 5.1 billion; as against that of developed nations, which grew from 1.1 billion to 1.2 billion over the same period (Population Reference Bureau, 2004). When it is noted that the high fertility countries are mainly resource-constrained with low levels of social and economic development, it becomes obvious why they have accepted responsibility to control the growth of their populations through endorsement of family planning programmes mapped out at various international conferences organized by the United Nations (United Nations, 1998). Nigeria is a high fertility country and there is evidence that its large population inhibits government's efforts in meeting the basic needs of the people. With a population that already exceeds 130 million people and growing at roughly 3 per cent annually (United Nations, 2004), a considerable proportion of the country's resources is, doubtless, consumed instead of being accumulated as capital for development purposes. To that extent, the rate of development lags behind that of population growth, which triggers stagnation in social service delivery. This necessarily impedes whatever progress being achieved in the fight against poverty.

16.7 Density in Urban and Regional Planning

This section provides a review of the ways in which density issues are incorporated into plans in different countries and at different scales (national, regional, and metropolitan). Approaches to residential density vary within and between countries. This is an obvious necessity because of differing historical, political, economic, geographic, physical, social, cultural, demographic, technological, and ecological contexts. However, planners and decision-makers all over the world are also cognizant of the zeitgeist at any given point in time and of what is being done in other countries. Thus, many of the same ideas and approaches are present in some form or another in most of these plans. Contextual differences lead to somewhat different policy goals and measures taken to achieve those goals. Contextual factors also play a major role in motivations for focusing on density. For example, in countries such as Israel, where land is scarce or perceived to be scarce, the primary goal is to make more efficient use of land to preserve agricultural land or natural open spaces (Alterman and Churchman, 1998).

Other countries that do not have a scarcity of land may be more concerned about environmental factors and sustainable development (e.g., Norway) or about economic development (e.g., Australia). Areas with little population growth, such as the City of Newcastle upon Tyne (1993), adopt one approach.

(a) *Importance of Density to Environmental Quality*

The importance of density to environmental quality includes the following:

i. Reducing the need for energy and other natural resources and associated environmental effects (Regional Municipality of York, 1994; City of Newcastle upon Tyne, 1993),
ii. Improving air quality through increased transit use and reduced car trips (Regional Municipality of York 1994),
iii. Saving energy by planning high-density mixed land uses (Stenhouse, 1992),
iv. Protecting farmland and natural resources (Alterman and Churchman, 1998; Faludi and van der Valk, 1994; Regional Municipality of York, 1994; Berridge Lewinberg Greenberg, Ltd., 1991a), and
v. Preserving green open spaces and air, water, fauna, and flora systems within the plan's boundaries (Martin County 1994; Regional Municipality of York, 1994; New York City Planning Commission 1993; Berridge Lewinberg Greenberg, Ltd., 1991a).

(b) *Importance of Density to Transportation Systems*

The importance of density to transportation systems includes the following:

i. Reducing the frequency of use of private vehicles and shortening routes to various land uses (Woodhull, 1992),
ii. encouraging the use of public transportation by improving the quality of public transit systems and by providing easy access to mass transportation systems through high-density development (New York City Planning Commission, 1993; Berridge Lewinberg Greenberg, Ltd., 1991a), and
iii. Increasing the incidence of walking and cycling (Berridge Lewinberg Greenberg Ltd., 1991a).

(c) *Importance of Density to Physical Infrastructure and Urban Form*

The importance of density to physical infrastructure and urban form includes the following:

i. Meeting the need for more dwelling units that results from an increase in the number of households (City of Newcastle upon Tyne, 1993; Israel

Ministry of the Interior, 1992; Berridge Lewinberg Greenberg Ltd., 1991a),
ii. Mitigating the impact of the problem of the gradual depletion of land reserves in specific urban areas (City of Newcastle upon Tyne, 1993),
iii. Increasing the use of urban areas (Martin County, 1994; Manshaden and de Schmidt, 1992),
iv. Creating a hierarchical multi-centred urban structure that enables gradations of density and a variety of residential choices (Berridge Lewinberg Greenberg Ltd., 1991a), Meeting the requirements of particular groups in society, including single-parent families, the elderly (Berridge Lewinberg Greenberg, 1991b), and low- and moderate-income households (Martin County, 1994);
v. Providing a favourable physical environment in terms of maximum building heights with at least minimal spacing between buildings (Wong and Yeh, 1985).

(d) Importance of Density to Social Factors

The importance of density to social factors includes the following:

i. Providing a wide range of housing types and density levels to present choice and meet the needs of an increasingly diverse population (Regional Municipality of York, 1994; City of Newcastle upon Tyne, 1993; New York City Planning Commission, 1993; Berridge Lewinberg Greenberg Ltd., 1991a);
ii. Ensuring a satisfactory supply of apartments in future years (Regional Municipality of York, 1994; Wong and Yeh, 1985);
iii. Creating a liveable urban environment (Berridge Lewinberg Greenberg Ltd., 1991a), possibly as Jacobs and Appleyard (1987) define liveability as a place in which everyone can live in comparative calm in a well-managed environment that is relatively devoid of nuisance, congestion, noise, danger, air pollution, dirt, trash, and other unwelcome intrusions;
iv. Redeveloping densities that are sufficient to recapture neighbourhoods' former vitality (New York City Planning Commission, 1993); and
v. Bringing buildings closer to the street to provide "eyes on the street" for safety purposes (New York City Planning Commission, 1993).

16.8 Conclusion

Judging from the aforesaid importance of density to planning, both in terms of education and practice of the profession, the analysis of density and the spatial

structure is a universal one, since it integrates constitutive elements of urban form, such as the lot size, edification features (height, floor area ratio), public space, and the relationship between them (proportionality, for instance). Therefore, in the density indicator, it is inherently a comparative relation between residential land and the rest of the land uses in a city. It is possible to conclude that the elements that shape spatial form, especially the ones that determine density, such as the minimum lot or dwelling size, constitute an important factor in the city´s social segregation or integration.

Also, we can confirm that, for intense urbanity, qualitative density is more significant than the quantitative one (De Solá Morales, 2008: 148). Variables such as intensity, variety, diversity and connectivity, are determining factors of quality urban space. In this sense, space syntax constitutes a modus operandi that can contribute to the understanding of density as a phenomenon.
Given the complexity of the meaning and use of the term density and the addition of the subjective terms perceived density and crowding, at the most basic level, density measures must be clearly and explicitly defined so that discussions can take place and so that we can learn from each other's experiences. Secondly, real-world complexity and the interrelationships between variables and factors must be addressed in research on density, as it is in practice. Real-world convolution includes a skewed element that is always present in people's behaviours, prospect, and attitudes (including those of decision-makers, planning professionals, and researchers); thus, it must be taken into account.

Therefore, a variety of solutions (different types of settlements, neighbourhoods, housing, and transportation) are essential to meet the needs between and within countries, regions, and towns. Solutions should be based on an understanding of the differences in needs and expectations of relevant groups so that they can offer choices that can meet these needs and expectations.

Finally, more research is needed on the various aspects and ramifications of density. This is particularly true for the relationship between objective density, perceived density, and affirmative or unenthusiastic skewed evaluations. Planners will continue to use the term density because it is too good to resist. This chapter synthesizes the research and practice literature in an attempt to provide a better understanding of the various ramifications of density in more effective density-related planning.

References

Abram, S. (2005). Science/technology as Politics by Other Means. *Focaal: The European Journal of Anthropology* 46: 3-20.

Alexander, E. R. (1993). Density Measures: A Review and Analysis', *Journal of Architectural and Planning Research*, vol 10, no 3, pp181–202.

Alterman, R., and A. Churchman (1998). *Housing density: A guide to increasing the efficiency of urban land use* (in Hebrew). Haifa, Israel: Technion, Centre for Urban and Regional Studies.

Angel, S.Y. (2010). *Making Room for a Planet of Cities. Policy Focus Report.* Cambridge, Massachusetts: Lincoln Institute of Land Policy.

Baum, A. and Paulus, P. B. (1987). Crowding, In D. Stokols and I. Altman (eds.) *Handbook of Environmental Psychology, vol I*, John Wiley, New York, NY.

Bechtel, R. (1997). *Environment and Behaviour: An Introduction.* Thousand Oaks, CA: Sage.

Beckett, H. E. (1942). Population Densities and the Heights of Buildings. *Illuminating Engineering Society Transactions*, vol 7, no 7, pp75–80.

Campoli, J. M. (2007). *Visualizing Density.* Cambridge, Massachusetts: Lincoln Institute of Land Policy.

Carlino, G., Chatterjee, S., and Robert M. H. (2006). *Urban Density and the Rate of Invention.* Federal Reserve Bank of Philadelphia Working Paper No. 06-14.

Chan, Y. K. (1999). Density, Crowding and Factors Intervening in Their Relationship: *Evidence from a Hyper-dense Metropolis', Social Indicators Research*, vol 48, pp103–124.

Cheng, V. (2010). *The Understanding of High Density. En E. Ng, Designing High-Density Cities for Social and Environmental Sustainability.* London: Earthscan.

Churchman, A. (1999). Disentangling the Concept of Density, *Journal of Planning Literature*, Vol. 13, No. 4.

Davidovich, V. G. (1968). Interdependence between Height of Buildings, Density of Population and Size of Towns and Settlements, In *Town Planning in Industrial Districts: Engineering and Economics*, Israel Programme for Scientific Translations, Jerusalem.

Davison, A. (2006). Stuck in a Cul-de-Sac? Suburban History and Urban Sustainability in Australia. *Urban Policy and Research* 24(2): 201-216.

De Solá Morales, M. (2008). *De Cosas Urbanas.* Barcelona: Gustavo Gili.

Decléve, B. A. (2009). *Densités Bruxelloises et Formes D'Habiter.* Bruxelles: Direction Etudes et Planification, Administration de L'Aménagement du Territoire et du Logement.

Dictionary.com, (2014). Unabridged Based on the Random House Dictionary, © Random House, Inc. 2014.Cite This Source.

Dodson, J. (2007). The Use of Density in Australian Planning; Paper Presented at the Third State of Australian Cities Conference in Adelaide 28-30 November, 2007, Australia.

Echenique, M. (2006). *El Crecimiento y el Desarrollo de las Ciudades.* En A. Galetovic,

Santiago, ¿Dónde estamos y hacia dónde vamos? Santiago: Centro de Estudios Públicos.

Ellis, J. G. (2004). Explaining Residential Density', *Places*, vol 16, no 2, pp34–43.

Evans, P. (1973).*Housing Layout and Density*, Land Use and Built Form Studies, Working Paper 75, University of Cambridge, Department of Architecture, Cambridge, UK.

Florida, R., (2002). *Cities and the Creative Class*. London and New York: Routledge.

Forsyth, A. (2003). Measuring Density: Working Definitions for Residential Density and Building Density. *Design Brief*, 8. Design Centre for American Urban Landscape, University of Minesota.

Hitchcock, J. (1994). A Primer on the Use of Density in Land Use Planning. *Papers on Planning and Design* no. 41. Toronto, Canada: Program in Planning, University of Toronto.

Hong Kong Census and Statistics Department (2006). *Population By-Census: Main Report, vol 1*, Hong Kong, Census and Statistics Department, Hong Kong.

Hong Kong Planning Department (2003). *Hong Kong Planning Standards and Guidelines*, Planning Department, Hong Kong.

Jenks, M., Burton, E. and Williams, K. (1996). *The Compact City: A Sustainable Urban Form?* London: E&FN Spoon.

Lai, L. W. C. (1993). 'Density Policy towards Public Housing: A Hong Kong Theoretical and Empirical Review', *Habitat International*, vol 17, no 1, pp45–67.

Longley, P. A. and Mesev, C. (2002). Measurement of Density Gradients and Space-filling in Urban Systems, *Regional Science*, vol 81, pp1–28.

Lozano, E. (1990). Density in Communities, or the Most Important Factor in Building Urbanity. En E. Lozano, *Community Design and the Culture of Cities: the Crossroad and the Wall*. Cambridge, Massachusetts: MIT Press.

Lucas, R. E., and Esteban R. H. (2002). On the Internal Structure of Cities. *Econometrica* 70 (4): 1,445–76.

Lynch, K. (1981). *A Theory of Good City Form*. Massachusetts: MIT Press.

Mackintosh, E., West, S. and Saegert, S. (1975). 'Two Studies of Crowding in Urban Public Spaces', *Environment and Behavior*, 7 (2): 159-184.

Malthus, T. R. (1803). *Essays on the Principles of Population*. London: Bensley Publishers.

Martin, L. and March, L. (1972). (eds.) *Urban Space and Structures*, Cambridge University Press, Cambridge, UK.

McClelland, L. and Auslander, N. (1978). Perceptions of Crowding and Pleasantness in Public Settings, *Environment and Behaviour*, vol 10, no 4, pp535–552.

Muller, P. O. (2004). 'Transportation and Urban Form: Stages in the Spatial Evolution of the American Metropolis', In S. Hanson and G. Giuliano (eds.) *The Geography of Urban Transportation*, 3rd ed., New York: Guildord Press.

National Population Commission (2002). *Sentinel Survey of the National Population Programme*: Baseline Report 2000, Abuja.

National Population Commission (2003). *Nigeria Demographic and Health Survey 2003*, Calverton, National Population Commission and ORC/Macro.

New York City Planning Commission (1993). Shaping the City's Future: New York City Planning and Zoning Reports. New York: New York City Planning Commission.

Ng, E. and Wong, K. S. (2004). Efficiency and livability: Towards sustainable habitation in Hong Kong, In *International Housing Conference Hong Kong*, Hong Kong.

Olofin, S. (1996). *Are We Destined for Economic Backwardness in Perpetuity?* A Neo-Malthusian Theory of Underdevelopment, Ibadan, University of Ibadan Press

Onokerhoraye, A. G. (1995). Population Growth and the Provision of Social Services in Nigeria, The Benin Social Science Series for Africa, Benin-City, University of Benin.

Onwuka, E. C. (2003). Linkages between Population Growth, Poverty and Environmental Degradation in Nigeria, in Adekunle, V. et al., (ed): *Challenges of Environmental Sustainability in a Democratic Government, Proceedings of a National Conference Organized by the Environment and Behaviour Association of Nigeria, Akure, EBAN.*

Rapoport, A. (1975). Toward a Redefinition of Density, *Environment and Behaviour*, vol 7, no 2, pp133–158.

Russell, J., and J. Snodgrass. (1987). Emotion and the Environment. In *Handbook of* Environmental Psychology. See Stokols and Altman 1987.

TCPA (Town and Country Planning Association) (2003). TCPA *Policy Statement: Residential Densities*, TCPA, London.

UNDP (2001). *Human Development Report: Nigeria 2000/2001*, Lagos, United Nations Development Programme.

United Nations (1998). *World Population Prospects. The 1998 Revision. Vol. III:* Analytical Report, New York, United Nations.

United Nations (1999). *Population Growth, Structure and Distribution: The Concise Report*, New York, United Nations

Unwin, R. (1909). *Town Planning in Practice.* London.

Urhahn, G. B. and Bobic, M. (1996). *Strategie voor stedelijkheid.* Bussum: Uitgeverij THOTH.

Van Kann, F. and Leduc, W. (2008). Synergy between Regional Planning and Energy as a Contribution to a Carbon Neutral Society: Energy Cascading as a New Principle for Mixed Land-use. Paper Presented at the SCUPAD 2008 Conference. Salzburg, Austria 15-18 May 2008.