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Sustainable urbanism: towards a framework for quality and optimal density?

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Abstract

The question of density is closely connected to urbanization and how our cities may evolve in the future. *Density* and *compactness* are two closely related but different criteria, both relevant for sustainable urban development and the transformation of cities; however, their relationship is not always well understood. While a high degree of compactness is desirable, too much density can be detrimental to liveability, health and urban well-being.
The purpose of this article is to report first on an extreme case of hyper-density: the Kowloon Walled City (demolished in 1993), where 50,000 residents led a grim life in one of the most densely populated precincts in the world with intolerable sanitary conditions. While the Walled City was a truly mixed-use and extremely compact precinct, it was neither a 'liveable neighbourhood' nor sustainable. The article then explores some more recent cases of optimized quality density in developments in Singapore, Sydney and Vancouver. This article sets out to answer the question: Since density is key to sustainable urbanism, what are the drivers and different planning approaches in relation to establishing an optimal density? And what is the ideal density model for tomorrow's sustainable cities?
Some of the critical thinking around the high-density cases is replicable and could translate to other cities to inform new approaches to quality density. Medium to high-density living is acceptable to residents as long as these developments also provide at the same time an increase in quality green spaces close by. The article explores which density types could help us to create highly liveable, economically vibrant, mixed-use and resilient neighbourhoods of the future. It concludes that every development requires a careful optimization process adapted to the conditions of each site.

Keywords: Sustainable urbanism, Urban density, Compactness, Kowloon Walled City, Density optimization process

Introduction: the great density debate

As urban populations and economies are expanding, and with increasing numbers of people joining the middle class (earning and spending more), consumption, energy demand and waste generation are all rising [33]. Due to our obsession with economic growth, the GDP-driven growth model and excessive use of finite resources, global greenhouse gas emissions keep rising – despite all the efforts of the last 20 years to reduce them. It appears that there is a growing gap between current urbanization patterns and what would really be needed to shift to more sustainable urban futures [5, 28, 59, 68].

Already half of the world's land surface has been transformed for humanity's use. As more and more people live in cities, the cities have taken centre stage as key players in the future of human populations. City management, governance, urban mobility, liveability and density have all become key themes for politicians and decision makers who are attempting to manage urbanization, but in conditions of rapid urbanization (especially with the dynamic exploding urbanism of Asian cities), controlled sustainable development has not always been achieved; for instance, urban infrastructures are increasingly fragmented [26].

One core challenge for cities in the future will be the tension between urban form, compactness and liveability. A crucial question is: What is optimal density and what sort of urban form (e.g. compact vs dispersed, formal vs informal) and process (e.g. top-down vs participatory) can be utilized to realize it?

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The modern city is also about diversity, which includes varying urban densities for different neighbourhoods in different parts of the city [23, 25, 32, 34, 37, 38, 46, 60]. The diversity of building scales and density types allows different demographic groups to choose how they would like to live at varying stages of their lives; for example young professionals are now streaming back into the city and do not opt to live isolated in suburbs or far away from amenities and their workplace, in the search for a more cosmopolitan lifestyle. On the other hand, high density is frequently blamed for leading to apartment living in towers, which is less suitable for families with smaller children and pets. But cities where residents do not need to drive much and efficient public transport is available have many advantages. It appears that these conflicting demands always need to be balanced through good design solutions.

Review of urban density and compactness

Urban density and *mixed-use* are key factors in determining the sustainability of a precinct or neighbourhood and its urban liveability [1]. Mixed-use neighbourhoods are more likely to offer employment locally. Urban districts have a significant complexity about them, and clearly there is still a need for more research, comparative data and an evidence base on the benefits and detriments of more dense and compact cities, which has frequently been noted by different scholars [3, 6, 8, 16, 21, 24, 27, 31, 35, 41, 47, 49, 56]. Urban density is a term used in urban planning and design to refer to the number of people inhabiting a given urbanized area, and the amount of floor area built on a defined site. It is considered an important factor in understanding how cities function. However, the link between urban density and aspects of sustainability remains a contested and often misunderstood subject of planning theory. And residents do not know enough about densities in cities, but are concerned about potential negative impacts.

Density is one of the key issues in planning that can regularly create all kinds of misunderstandings and tensions, but is an essential driver of our urban futures [7]. We use density to describe the average number of people, households, floor space or housing units on one unit of land, usually expressed in dwellings per hectare. There are different ways of measuring the density of urban areas:

- Floor area ratio: the total floor area of buildings divided by the land area of the plot upon which the buildings are built (also called the *development plot ratio*, used as a measure of the density of the site being developed; the ratio is generated by dividing the building area by the site area)
- Residential density: the number of dwelling units in any given area
- Population density: the number of persons living in any given area.

The *plot ratio* (also called 'floor area ratio', FAR; or 'floor space ratio', FSR) describes the ratio of a building's total floor area (also called: gross floor area, GFA) divided by the size of the site (piece of land or plot) upon which it is built. The term frequently refers to limits imposed on such a ratio, for example the maximum allowable ratio. For instance, a FAR of 3.0 indicates that the total floor area of a building is three times the gross area of the plot on which it is built, as would be found in a multiple-storey building. The allowable plot area has a major impact on the value of the land, as higher allowable plot areas yield a higher land value [9].

Using such zoning regulations, municipalities have found it unnecessary to include height limitations for buildings when using maximum floor area ratio calculations. The plot or floor area ratio is used in zoning regulations and planning guidelines to limit the amount of construction in a certain area. For example, if the relevant zoning ordinance permits construction on a site, and if construction must adhere to a 0.10 FAR, then the total area of all floors in all buildings constructed on the parcel must be no more than one-tenth the area of the parcel itself. An architect can plan for either a single-storey building consuming the entire allowable area in one floor, or a multi-storey building which must consequently result in a smaller footprint than a single-storey building of the same total floor area.

Urban planner Andres Duany [18] has criticized the use of FAR regulation and argued that 'abdicating purely to floor area ratios (market forces) is the opposite of aiming for enhancing a community or neighbourhood and for diversity of ownership, as it is a poor predictor of physical urban form'. He argues that instead of pure FAR the traditional design standards (building height, lot coverage, setbacks or build-to lines) should be used, as these enable anyone to make reasonably accurate predictions, recognize violations, feel secure in their investment decisions and are likely to deliver a better urban form outcome [19].

Urban population densities vary widely from city to city [22]. Asian cities have some of the highest densities (frequently over 10 000 people per square kilometre, and sometimes even over 20 000 people, such as in Mumbai and Hong Kong, where a large proportion of the buildings are high-rise apartment towers). The historical European cities have lower densities and are usually based on the 'European compact perimeter block' model, with densities in the range of 3 000 to 6 000 people per square kilometre. In the US, Canada and Australia, urban population densities are usually much lower, and can range from around 1 000 to 2 500 people per square kilometre [41, 57].

Hence, there are three clearly identifiable city typologies that have their own characteristics, density profiles and historical evolution:

- the European compact and polycentric mid-rise city with the traditional perimeter block (examples include Barcelona, Paris, Berlin and Athens): 3 000 to 6 000 people per sqkm
- the Asian high-rise city with distribution of individual towers (examples include Shanghai, Beijing, Tokyo and Bangkok): often around 10 000 people per sqkm
- the North American and Australian low-rise and low-density city typology with an urban downtown core surrounded by extensive urban sprawl (examples include Los Angeles, Phoenix, Melbourne and Perth): only 1 000 to 2 500 people per sqkm.

A 'high-density intensified city' is therefore a city that has high average population density, high density of mixed-use built form, high-density sub-centres and high-density forms of housing. Many researchers have argued that a denser, more compact city is a more sustainable city [27, 29, 35, 50, 55]. Susan Roaf notes that 'high density (not high-rise) is probably the inevitable urban future' ([58], 37).

What exactly is a *compact city*? A compact city is a mixed-use spatial urban form characterized by 'compactness', which defines a relatively dense urban area linked by easy access to public transport systems and designed to have minimal environmental impact by supporting walking and cycling (while low-density suburbs are incapable of supporting walking, cycling and public transport infrastructure). The compact city with four- to eight-storey urban perimeter blocks represents the optimum use of space [8]. However, the compact city concept is still controversial and there is no single model that can be replicated as all cities are different.

Today, most experts agree that compact living is sustainable living. While a more compact city is more sustainable, expanding the city footprint farther and farther into critical habitat areas, precious agricultural land and green spaces is now understood as environmentally unacceptable [42]. Cities like Portland, Oregon have successfully established a growth boundary that curbed the sprawl. Recent research shows that compact city design can typically reduce average car use by as much as 2000 kilometres per person per annum [65].

There has been plenty of evidence that more compact cities with higher densities encourage the use of public transport, support closer amenities, increase efficiencies of infrastructure and land use, conserve valuable land resources and are likely to reduce the carbon emissions of the urban dweller [12, 21, 27, 35, 40, 58, 66]. We should not be confused by the different denominations that have emerged to describe the 'compact city', which is sometimes also called green urbanism, sustainable urbanism, ecological urbanism, among others – it all means the same thing.

My research recommends compact building shapes with a surface area to volume (A/V) ratio of 0.7. Irregular forms or dispersed city forms are energy inefficient [41].

The compact city also increases efficiencies in urban infrastructure and services through shorter distribution networks. Higher density cities encourage reduced transit through shorter trip lengths, since most amenities and public transport are more closely located. Churchman [14] defines compact city policies as policies that aim to intensify urban land use through a combination of higher residential density and centralization, mixed land use and limits on development outside of a clearly designated area (an urban growth boundary) [35] outline three aspects of the compact city: it is high density, mixed use and intensified.

Urbanist [61] defines 'urban intensity' through a formula with four factors:

$$\text{Urban Intensity} = \text{Density} + \text{Diversity} + \text{Connectedness} + \text{Compactness}$$

However, making neighbourhoods more compact and dense needs careful consideration and a process of optimization to balance potential adverse effects; higher density is beneficial at appropriate locations, but not always in every case. All urban areas have their particular social and climatic conditions as a result of complex urban microclimates, and density affects urban wind speeds. The interplay between higher density and the increased risk of the urban heat island effect (which increases cooling energy needs) must be properly researched and taken into consideration. Density directly influences the urban microclimate. Negative effects on the urban climate can be improved by increasing greenery and vegetation, and choosing materials and surfaces that minimize solar heat gain and increase the albedo effect.

In many places there are limits to how dense cities of the future will become. For instance, Edwards notes: 'Commercial buildings need space for cooling and ventilation, over-compaction can lead to an increase in energy use, especially with global warming, and not the reduction that we see in residential neighbourhoods.' He continues:

As densities increase there is a corresponding reduction in access to renewable energy – sunlight and wind. Too much physical closeness can reduce daylight in buildings and limit access to solar energy.

> *Over-compact cities also suffer from air-pollution … So, although there are benefits to increased density, these benefits are limited and vary according to climate, land use type, culture and latitude.*
> ([20], 144)

Living in apartments is often the more sustainable solution, and urban perimeter blocks share circulation systems, separating walls and roofs, therefore requiring less materials during construction. In the US and Australia, researchers have now collected and analysed the actual energy-use data for a large number of residential units; and there is emerging evidence that living in inner-city high-rise buildings is a less energy-intensive lifestyle – all other things being equal – than in equivalent low-rise buildings in suburbs, despite the need for elevators. This is mainly due to two factors: the suburban house is usually larger and very energy intense because of air-conditioning and other energy-consuming devices; and the other reason is the need to commute by car to the workplace.

But when is a city getting too dense, and at what point is a precinct over-developed? For instance, tall towers require extra energy for ventilation and elevators, they cast shadows over the surrounding cityscape, reduce other buildings' access to daylight and solar energy, are expensive and complicated to maintain, have a high proportion of circulation and technical space, can generate damaging microclimates and contribute to the urban heat island effect.

Each time, higher densities require an optimization process as higher densities can create challenges for planners and designers, for instance, to avoid over-shading, over-looking, loss of daylight and the loss of privacy, which demands clever design solutions. There are a number of other arguments against high density, which include the risk of increasing traffic congestion in the area and a potential increase in noise disturbance. We can also point to districts where densities were developed too high and these developments failed, because the lack of natural ventilation or daylight created unhealthy and unhygienic conditions.

One of the most well-known examples of such hyper-density was the extremely dense 'Kowloon Walled City' in Kowloon (Hong Kong), which was demolished in 1992–93 because of the many issues that arose out of the extreme hyper-density of the precinct. It is estimated that over 50,000 people lived in squeezed conditions in dark cramped flats, on only a small parcel of land [39]. Kowloon Walled City was a functioning urban community; but was it a sustainable place to live?

Remembering hyper-density: the case of Kowloon Walled City in Hong Kong

Poorly managed (or neglected) and badly planned density can lead to overcrowding, overdevelopment and lack of daylight, as was the case with the Walled City. For a long time Hong Kong's extremely high density has led to apartments which have never seen a ray of sunshine and to narrow streets described as 'airless canyons' [2]. The lack of natural ventilation and cooling breezes in the city at pedestrian level has increased the urban heat island effect and brought serious health impacts by changing the urban microclimate (a fact that has been researched extensively by [48, 51, 53, 62, 63, 69]; and other urban scientists).

Ungoverned, uncontrolled and unregulated, the Walled City was a huge block of around 300 interconnected buildings ranging from 10 to 14 floors, on a small site of only 2.2 hectares. According to Ian Lambot's documentation in 'City of Darkness' [39], Kowloon Walled City began as a fortress used by the Chinese to defend the city against the British invasion in the middle of the nineteenth century and later served as a hiding place for gangs and criminals. An amazing labyrinth of passageways, small rooms and courtyards, it contained a great variety of functions: a mixed-use, hyper-dense block that was home to around 25,000 families and businesses living in high-rise buildings, frequently in windowless cramped flats, and all constructed without a contribution from a single architect (Figs. 1a, b, c, d).

I visited the Walled City in 1989 and I remember the maze of dark corridors and laneways formed within the 'superblock'; an extreme outcome of dramatically increasing population and a laissez-faire attitude by the government in the 1960s and 70s, leading to unhealthy conditions and intolerable sanitary conditions. Some residents never left the superblock as everything they needed was at hand, and inhabitants walked the narrow alleys with umbrellas to shield themselves from the constant dripping of water pipes above.

Opium parlours, prostitution and unlicensed dentists alongside kindergartens, tiny factories and food stalls – the infamous Kowloon Walled City was once one of the densest places on earth. With a population density of 1.2 million per square kilometre, the settlement had no government enforcement from the Chinese or British. The population burgeoned with refugees from mainland China and the area became a haven for vice, controlled by triads. 25 years have passed since it has been erased from the Hong Kong landscape and converted into a park, while some hold onto the memories of such extreme conditions of population density. As well as being the location for Hollywood films, such as *Crime Story*, the infamous settlement has even been recreated as a theme park.

Li Shiqiao wrote that Kowloon Walled City was associated with anarchy and lawlessness; it was 'the extraordinary example of a physical expression of the city of maximum quantities in an embryonic form'; and he notes: 'It failed

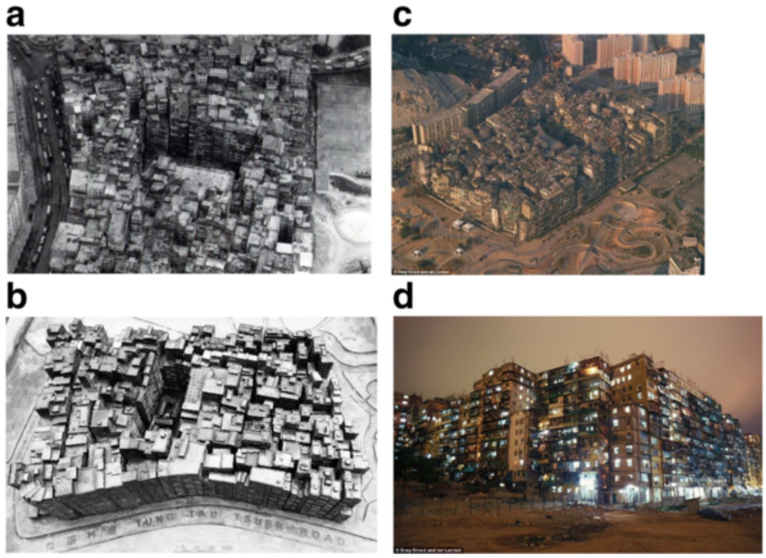

Fig. 1 **a** and **b**: The Kowloon Walled City in Hong Kong, demolished in 1992-93 due to its extreme density and unhealthy living conditions. Left: aerial photo. Right: All that remains today of the Hong Kong legend: the bronze model of Kowloon Walled City in the middle of a public park where it once stood. **c**: Aerial photo of Kowloon Walled City, a compact superblock with over 50,000 residents. (Source: Greg Girard and Ian Lambot, 1980s). **d**: Kowloon Walled City in Hong Kong; it earned its Cantonese nickname 'City of Darkness' (photo around 1989)

because its quantities were never managed by expert knowledge of orderly planning, hygiene and safety' [45].

Good urban design always ensures sufficient daylight for residents and efficient natural ventilation of the spaces between the buildings and rooms inside. This extreme example of hyper-density, an over-densified superblock, could only develop in Hong Kong or in India with a culture of greed and powerful developers, where architecture is reduced to commodity. But it was also a result of the building code: in the 1960s and 70s, the inner-city airport Kai Tak caused a height limit to be set for buildings at 60 metres above principal datum for any development in Kowloon, which led to the typical Kowloon block: a very compact hyper-dense block of 12- to 14-storey buildings.

Very dense and intense high-rise cities tend to be overcrowded and are not the best option. While the Walled City was a functioning tight-knit urban community (and a hotbed for crime), it was not sustainable and the negative impacts of too much density slowly made its residents sick.

The compact city revisited: recent 'superblock' housing experiments in Singapore, Sydney and Vancouver

The following section describes the selected cases: new housing experiments in compact superblocks in Singapore, Sydney and Vancouver that have introduced higher density, each in their own way.

Sustainable urban design can include 'high-tech' design solutions as well as 'low-tech' alternatives. The functional and organizational aspects of sustainable urban design focus on building structures, context-specific issues (such as site and local climate, regional architectural traditions and typologies, context, local building materials, etc.), solar energy, and the recycling and re-use of the existing building fabric.

Some of today's thinking around high-density precincts in China, Singapore or Sydney could translate to other cities and inform new approaches to increasing inner-city density and reducing urban sprawl, while promoting a sense of community. In the US and in Australia, change is happening too: while many residents in suburbs simply live too far away from their jobs, in the majority of North American and Australian cities inner-city populations are predicted to rise, especially on redeveloped brownfield and urban renewal sites, as people want to live closer to the city centre and in the inner suburbs, to reduce their need to commute or look after a large garden.

When you are densifying an area that is already dense, there is a question as to whether the existing infrastructure can cope. One other challenge cities face in their densification strategies is a reluctant public and resistance from residents against higher densities, as illustrated by the case of Vancouver's protesting neighbourhood groups. If done well, higher density does not necessarily decrease liveability (as can be seen in cities such as Singapore, Barcelona and London). Higher density living can be acceptable for residents as long as these developments also provide for new treed parks and urban greenery; but a well-used park a drive away cannot be a substitute for new green space [15].

High-quality urban design can alleviate negative perceptions of density at the metropolitan scale. Higher densities require new better housing typologies, a wider range of compact housing models and innovative design solutions that integrate urban greenery and high-quality public space. Landscaping, green roofs and the design of community spaces must be important elements from the outset of each development ([41], 708–719).

The following selected cases deserve a closer look, because they have successfully introduced denser housing models and tested innovative typologies for urban precincts, where buildings and urban greenery, and public and private spaces, have been combined and intertwined:

- the Interlace and Pinnacle housing developments in Singapore's west,
- the Central Park development in Sydney,
- the False Creek development in Vancouver.

These cases are compact and spatially complex models, featuring medium- to high-density housing typologies, with a fine grain of diversity and complexity, creating a 'vertical city' and matrix of horizontally stacked urbanism that incorporates communal courtyards and double-height balcony spaces.

The Pinnacle and the Interlace in Singapore

The city state of Singapore has a tropical, humid climate all year round, which makes ventilation and cross-ventilation the most important aspects of environmental comfort. The urban design principles that apply to cities in tropical conditions are different from these in temperate conditions. An effective way is to combine active and passive systems to radically improve the environmental performance of buildings. Passive systems include building orientation, compact geometry (a reduced façade area reduces the solar heat gain), strategic positioning and sizing of windows for maximum cross-ventilation, thermally activated concrete slabs for cooling, effective shading, high wall insulation, green roofs and the integration of urban greenery.

After the success of the Pinnacle at Duxton (the world's highest public housing complex), the government-directed Housing Development Board (HDB) decided to go one step further and experiment with an even more radical housing development. The Interlace is one of the largest and most ambitious residential developments in Singapore, and it presents an approach to contemporary living in a tropical environment by adopting a new residential typology which breaks away from the standard vertical HDB tower blocks of Singapore. The Pinnacle is the world's highest public housing complex, consisting of 7 blocks, each 50 storeys high and connected by sky gardens and bridges on the 25th and 50th floor. The roof garden is an expansive area with recreational facilities for residents.

Up to now, most housing in Singapore has been in unsightly generic tower blocks, but the Interlace is an intertwined 'vertical village' where the apartment blocks are stacked in a hexagonal arrangement around eight courtyards, creating the impression of open space and fluidity. One could say that the Interlace introduces a new typology that could mark the end of generic tower blocks in Singapore. The large-scale complex also provides a more interconnected approach to living through communal spaces which are integrated into its lush surrounding garden (by introducing extensive roof gardens, landscaped sky terraces, cascading balconies and lush green areas).

Thirty-one apartment blocks, each six storeys tall and identical in length, are stacked on the eight-hectare site in a hexagonal arrangement to form eight large open and permeable courtyards: the stacked formation allows light and air to flow through the ensemble and surrounding landscape. While from the point of view of shared communal space it is much better than a tower, the disadvantage is that quite a few of the apartments are always under the shadow of the block directly on top.

The Interlace covers 170,000 sqm of gross floor area and houses 1040 apartment units of varying size, accommodating over 2500 people. The continuous landscape is also projected vertically, from the planting of green areas in open-air basement voids, through balconies and rooftop gardens. The private balconies give apartments large outdoor spaces and personal planting areas that look like cascading gardens, and sky gardens provide panoramic views. The design also incorporates sustainability features through careful environmental analysis of the sun path, wind direction and microclimate conditions on site and the integration of low-impact passive energy strategies. Water bodies have been strategically placed within wind corridors as a means of allowing evaporative cooling to happen along the wind paths, reducing local air temperatures and improving thermal comfort in outdoor recreation spaces. (More information is available at http://www.theinterlace.com/.) (Figs. 2a, b; 3a, b)

The Central Park development in Sydney, Australia

Sydney's Central Park is a major mixed-use urban renewal project located on Broadway in Sydney's centre, very close to Central Station. Building heights range from 8 storeys to 35 storeys. The development is focused on a new public park located just off Broadway of approximately 6500 square metres (70,000 sq ft) in size. The first stage of the redevelopment (completed in 2013) is a tower called One Central Park, a 117-metre-tall residential tower featuring 'vertical gardens' and a shopping centre in its podium on the lower levels. The design features a cantilevered section including a heliostat to provide reflected sunlight to the parkland and roof garden below. The precinct has a population density of around 1000 people per hectare. (More

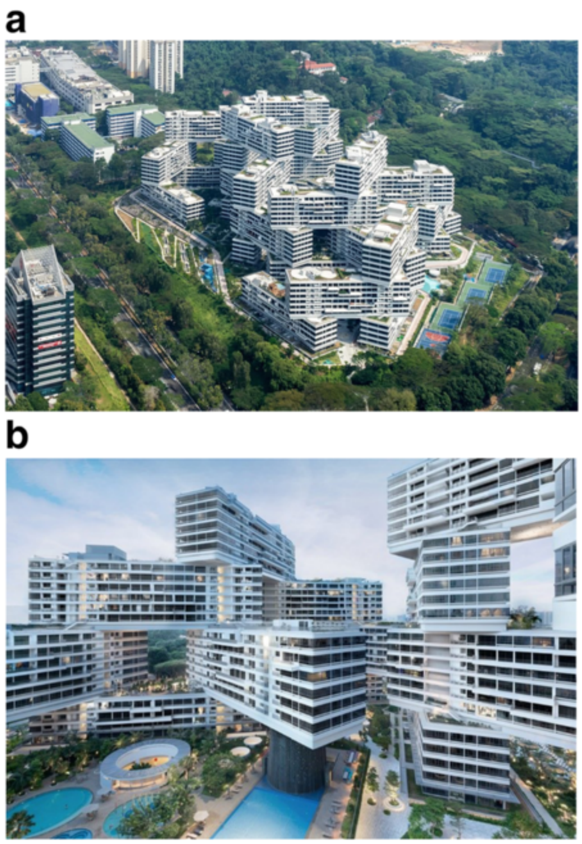

Fig. 2 a and **b**: The housing development Interlace, in western Singapore. This superblock project houses around 2500 people (Source: the architects, 2015)

Fig. 3 a and **b**: The earlier housing development the Pinnacle, at Duxton in Singapore's west, forming a massive 'wall'. (Source: the architects, 2015)

information is available at www.centralparksydney.com.) (Fig. 4a, b).

The False Creek development in Vancouver, Canada

The Canadian city of Vancouver has a long-established reputation as an urban laboratory for successful experiments in density, downtown living and a strong neighbourhood community spirit. Vancouver's urban transformation and density debate over the last two decades has led to some much celebrated medium-density neighbourhoods in waterfront locations. Southeast False Creek was developed on a brownfield site and has often been criticized for its unaffordable housing prices and 'green overcrowding' (density without amenity). Nevertheless, this development and the wider urban renewal of Vancouver have been a success story: in the past 15 years, 60,000 people have moved to the city's downtown peninsula in medium- to high-density developments; and today, over 40 per cent of dwellings in Vancouver are apartments (this is approximately double the percentage in Sydney).

Since its founding in the 1970s, False Creek South's residents have quietly enjoyed its view of the changing skyline of downtown Vancouver, with incremental increases in density spread over a decade. False Creek South was once a conscious experiment in neighbourhood-scale urban design, since studied and applauded by planners and architects from around the world. Just like in Sydney, as the entire city wrestles with high-value waterfront real estate, skyrocketing housing costs and development pressures, False Creek has been getting densified, and it has been able to absorb some additional density and accommodate some growth without losing the character of its neighbourhood. For instance, False Creek became the location of the athlete housing as part of the 2010 Olympic Village.

The City of Vancouver has plans to see this liveable neighbourhood further developed into a medium- to high-density residential area with housing and services for 11,000–13,000 people. The early parts of the development that date back to the 1970s resulted in a medium-density area with a variety of architectural designs, ownership opportunities, recreational activities, and access to modes of transportation. The original precinct has a modest population density of around 120 people per hectare. Bike paths, parks, unique three-storey homes, a public market

Fig. 4 a and **b**: The new Central Park development in Sydney, a high-density inner-city mixed-use development close to the Central railway station and in walking distance to three universities (completed in 2014). This is one of Sydney's new high-rise precincts with a population density of 1 000 people per hectare. (Source: Frasers Property, 2015)

and the intentional preservation of mountain views distinguish this area of False Creek as one of the earliest conscious attempts to create a liveable medium-density environment, rather than focusing on high-rise efficiency and profitability. However, more recently, the scale has shifted to 6- to 10-storey apartment buildings, and even to 20-storey towers, all located in walking distance to the downtown area.

In a recent conversation with the author, Vancouver's former city planner Brent Toderian commented on the urban transformation, noting:

> *For the last decades the environmental movement rejected cities and focused on pastoral areas. The truth is there is nothing greener than density if you do it well, because it diminishes the pressure on agricultural land, it significantly reduces the cost of growth in a sprawl pattern, and it improves everything from our climate footprint to our health, which has huge economic implications. Doing density well is as much about providing privacy as it is about civic life. Density brings people together.*

With a population density of over 5 400 people per square kilometre, Vancouver is the most densely populated Canadian municipality, and the fourth most densely populated city in North America, behind New York City, San Francisco and Mexico City.

Urban planner Wendy Sarkissian [64] is more critical of Vancouver's 'EcoDensity' policy and argues that strong community concerns and established policies of community engagement were simply ignored by the City Council in the move towards implementation of its top-down EcoDensity Charter. The EcoDensity policy was widely unpopular, and Sarkissian adds that the Laneway Housing initiative, which predated the EcoDensity policy (and which was much more about gentle small-scale densification), failed to deliver a significant increase in density. She argues that the real reasons for EcoDensity were pro-developer and ideological. However, it did not provide affordable housing as promised, and instead drove housing prices up further, enabled more large-scale types of developments and served developers' interests (Figs. 5a, b; 6).

Discussion: a proposed framework and recommendations for "quality density"

The different cases reveal different planning approaches and offer some pointers worth consideration. While the development process of compact urban form to some extent emulates higher densities, the reviewed case studies show a significant inward investment in housing and the property market. In all selected cities a booming property market has so far inhibited the realization of optimal density and urban form, and urban planners have so far not been able to assert their authority over investors. Singapore comes the closest to this goal and has followed a top-down approach to involve multiple design and development companies to create urban diversity with a variety of typologies; while in Hong Kong, the uniformity of the overall scale and high-rise apartment tower typology still remains; while in Sydney, multi-actor participation is only served through designing individual buildings and the outcome is more piecemeal, with high density and low density neighbourhoods next to each other. Here, the higher costs in large scale development projects seems to contribute to a less diverse mix of socio-economical demographics more likely to lead to gentrification. Singapore and Hong Kong both apply a top-down planning hierarchy, where planning decisions are a result of Government's strict development controls.

Vancouver has been successful in its participatory process, community engagement and a more careful, incremental increase of density stretched over several decades. In large scale development projects, Vancouver and Sydney enjoy a planning approach based on activities that are more decentralized to multiple actors, for example in brown-field regeneration or urban infill

Fig. 5 a and **b**: The development around False Creek in Vancouver, British Columbia, has resulted in a compact neighbourhood with a mix of densities, from mid-rise 3-storey buildings; however, more recently, the scale has shifted to 10- to 20-storey apartment buildings. (Source: photos by Daniel Lobo)

developments such as False Creek or Barangaroo South. Until the 1980s, both cities were predominantly low rise suburban sprawl, but since then have transformed with a denser built form. Vancouver has managed to implement a good mix between high-rise and perimeter block developments, not just high-rise towers. It is also the city with most green space per resident (around 30sqm) compared to the other cases, offering a high quality of life.

As apartments, townhouses and units are becoming more important and a common tool for urban infill and the 'making' of density, the challenge for cities is to rein in housing often targeted at investors that is cramped, dark and uncomfortable for residents, and does little to create active streetscapes. For instance, Sydney and Melbourne are now building more apartment towers than ever, but there has so far been insufficient innovation by developers to make high-quality housing. These new residential towers are not done as well as they could, and the drive for yield has often been limiting innovation and experiments; we are still missing good cosmopolitan examples of infill through high-rise residential towers. Most of the recently built inner-city apartment towers rely fully on air-conditioning, rather than natural cross-ventilation, have windowless corridors, and small cramped and dark rooms; they frequently lack private outside space like balconies, and have miserably scaled windows [43]. These towers do not give anything back to the street nor do they give anything to the residents inside. We are still not seeing much innovation in density design.

To minimize adverse negative effects from increased densities, densification strategies should be coupled with high-quality urban design strategies and real community participation, to combat such unwanted effects as increased traffic congestion, overshading and loss of daylight or privacy. Planners and architects need a better understanding of the impact of their design decisions on the overall performance of the precinct system. They also must understand the importance of urban greenery in the

Fig. 6 Different ways that 75 dwellings per hectare can be realized, from rows of terrace houses (left), to a perimeter block (centre), or a single high-rise tower (right). Planners and architects need a better understanding of the impact of their design decisions on the overall performance of the urban precinct system

densified areas. Today, planners and architects can easily visualize and simulate the benefits of various density types to inform policies and decision making.

From the presented examples it is clear that urban densities must remain within a sustainable range. If density is too low, it must be allowed to increase, and if it is too high, it must be allowed to decline, to arrive at an appropriate 'quality density'. However, most of the time, densities are too low in cities around the world and declining, and there is now a concern shared by urban experts worldwide: a concern about declining urban densities in cities globally, exacerbating urban challenges such as sprawl and traffic congestion.

While every city is different, some guiding principles of ideal development with quality density have been identified. These include increasing compactness and the integration of public transport, greenery and mixed usage. Policy makers have now to take decisive, forward-looking steps in urban planning and decision making on density to create room for long-term physical development towards a sustainable city.

In *The Principles of Green Urbanism* (2010) I identified and recommended the following guiding principles of ideal development:

- visionary leadership to shape growth, not driven by short-term market forces;
- a reasonable increase in urban compactness with a focus on walkability;
- efficient integration of transport, energy and cooling systems;
- implementing integrated land-use, transport, energy, water and waste planning;
- re-engineering infrastructure, retrofitting the existing city and gentle densification;
- balancing compact city development at denser transport nodes with new public green spaces;
- knowledge sharing of best practice and training programs.

Based on this early list, a number of components can be identified as prerequisites for appropriate quality density of a compact city:

- a strong alignment of land use and mobility: the efficient public transport city
- connectivity, proximity and 'nearness' to amenities and facilities within walking distance: the walkable city
- to keep cities cool, the integration of urban greenery and green roofs needs to go hand-in-hand with densification: the green city
- high-quality architectural and urban design with more diversity and better examples of residential infill through 4- to 8-storey projects: the mixed-use vibrant compact city
- more innovative design solutions need to be developed to ensure there is no negative impact on neighbouring sites from densification, such as loss of privacy (overlooking), loss of ventilation or loss of daylight (overshading): the city of innovative housing solutions.

The developments described in Singapore, Sydney and Vancouver have enabled residents to live closer to their workplaces; the superblocks are like massive urban infill projects or 'vertical villages'. Such intensification through infill at appropriate density is a sustainable design strategy, as it avoids and counteracts the further dispersion and fragmentation of activity centres and helps to reduce car dependency.

Extreme increases in density can directly influence and negatively impact the urban microclimate, as a denser city is likely to increase the urban heat island effect [44]. Groups of buildings that form precincts are of great interest, as these can support the public realm, with a density of mixed functions, and connect with each other. In all this, the interplay between density and urban heat islands must be well understood.

Therefore very dense high-rise cities are not necessarily the best option; medium-density, compact infill developments of 4- to 8-storey perimeter blocks are the much preferred option and a very useful model towards achieving the compact, green, mixed-use and walkable city. The perimeter block combines a number of benefits, such as:

- smaller building envelopes (good ratio between the area of the facade and the enclosed volume), using less land and reducing heat gain in summer; and heat loss in winter;
- less material used, therefore lower construction impact and reduced embodied energy;
- reduced energy consumption due to shared walls, circulation and roofs.

With a clear focus on the public domain and its connectivity (walking, cycling, light rail), safe biking, with good landscaping and cycle paths, new high-quality public space becomes part of the larger network of interconnected public spaces, accommodating thematic gardens, pavilions and the possibility of integrating various community functions.

While densification can be a tough discussion and needs to involve the community, no city can have a serious debate about being greener, more economically resilient and sustainable without talking about density and developing appropriate densification solutions. Both the skill and urban imagination of architects/planners and the experiences and concerns of the public/community must be taken into account. Their coming together to agree on urban densities involves some friction, but it is worth the effort because it is this encounter and learning from each other's perspectives that makes urban development worth having.

Learning to live in more compact and denser communities

While urban density is extremely relevant, it is of course not the only determining factor for urban form. In fact, urban developments are rarely purely the result of design considerations; rather they are shaped by economic forces, the evolution of policies, and a range of invisible forces such as land-use regulations, codes for floor space ratios and economic power structures. Long-term trends in economies, energy supply and demand, geopolitical shifts and social change are all additional drivers of urban development.

Since there is always a multiplicity of complex forces and flows that form a city, the forces that are shaping the city are not limited to the physical spectrum only [54]; today, they also include technologies – smart-city sensors and ubiquitous networks – so the architect or planner, once the agent of change within cities, is now being replaced by the network engineer or urban strategist [10, 11] has explored the impact of the information and network society and how political or technological movements straddle urban space; he explains that our cities are shaped by constant negotiation and conflict between different forces, basically the dominant one and grassroots movements in reaction to it. There are the many invisible forces that shape our urban spaces and their operating system, such as the hidden geographies, logistics and digital information flows of globalization, optic fibre networks, mobile phones and economic flows – all shape immaterial infrastructures which continuously influence the production of contemporary space [13].

But how dense we plan our cities determines how efficiently we use vital resources and it directly impacts on the quality of life of urban citizens. Growth boundaries are an effective tool to contain the footprint of cities, combined with infilling in already built-up areas to avoid urban sprawl, as cities cannot continue to expand their boundaries as their population increases. For a long time, the high infrastructure costs and inefficiencies caused by urban sprawl have somehow been accepted on the wrong assumption that sprawl would provide affordable housing. Now city managers will need to increase the suburbs' densities and transform outdated urban values towards the acceptance of higher densities and public transport.

As an important benchmark for minimum densities of new sustainable developments, the literature gives the figure of minimum 70+ dwellings (homes) per hectare [17, 30, 36, 52]. The case studies in this article have shown that densities should preferably be closer to 100 to 120 dwellings per hectare, especially along transport corridors, to support the integration of public transport, walking and cycling to key facilities, and on-site energy generation.

Conclusions

This article set out to answer the question: Since density is key to sustainable urbanism, what are the drivers and different planning approaches in relation to establishing an optimal density? The author has shown how different planning approaches and urban form influences very different density outcomes.

This article has discussed how different parameters, such as density, building scale and public space connectivity can drive the outcomes of large-scale developments; however, these parameters will need to be studied more in-depth and more research is needed, with consideration of the local context, for a better understanding of the optimal density levels. But it is the incremental development approach stretched over a longer period, as used in Vancouver, which appears to offer a promising alternative for optimizing density and mixed use, as seen with the False Creek development [67].

As this article has indicated, there is definitely a limit to density. Quality city living in a high-density context means that there is a need to balance density increases with more green space and to ensure that natural ventilation remains open through protected urban air corridors. Singapore, for instance, has become denser and (at the same time) more green, creating interesting new public spaces and community gardens (while Gardens by the Bay in Singapore is only a 'quasi' public space that is surveyed and highly controlled by security companies) (Figs. 7a, b). There are numerous socio-economic issues related to high-density cities, high-density living and public space. The fact is that designing for high-density living is not a straightforward planning process, but requires careful consideration and an incremental process. In every case, the main question in the optimization process must be: What is the optimal and appropriate density for this place, neighbourhood or city?

Too much density, such as in the Kowloon Walled City example, can be detrimental to a healthy lifestyle and well-being. It is essential to simulate different densities for developments early in the planning stage, to better judge the impact of the varying density types, using 3-D modelling and visualisation. It is also helpful to categorize the various densities in cities, so people can visit real neighbourhoods and better understand and experience how each density type feels [4, 70]. Therefore, these learning points are offered as conclusions:

- Density types can vary widely, from 1000 to 5000 to 10,000 people per sqkm, and we need to better visualise these different densities to show the multi-faceted nature of density.

Fig. 7 a and **b**: Sydney's Barangaroo South is a brownfield development of a former dockyard. Gardens by the Bay in Singapore is a new entertainment concept for a botanical garden developed on man-made waterfront land. (Sources: open commons)

- We should encourage a variety of density and housing types in different locations to allow the city to consist of distinctive neighbourhoods with their own urban character.
- The need for a more compact city must always be balanced with community concerns; participatory models are helpful.
- It is well established that different demographic groups enjoy living in different types of density at varying stages of their lives.
- Walking, cycling and public transport are a priority, and higher densities support these.
- Higher density buildings are best located close to commercial centres and railway stations.
- Better participatory models are required that involve communities early in the planning stages to participate in decision making that shapes the future character of their neighbourhoods, including questions of density.
- Real demonstration projects (so-called 'Living Labs') are useful as examples, for instance to demonstrate housing alternatives, so the ramifications of different density decisions can be better experienced and understood.

The medium-rise compact city based on the European perimeter block offers a good starting point for a mixture of densities in different neighbourhoods. Can we develop new urban perimeter block typologies that combine the best of suburbia (sun, air, views, and even soil/greenery on roof gardens) with the best of urbanism (population density and programmatic diversity, mixed-use amenities and social interaction)? As the case studies show, new compact urban blocks are the next evolutionary step in the perimeter block typology, to create better options for inner-city living and working. If done well, higher density does not have to come at the price of loss of privacy or liveability.

Arguing for a new ethics of the urban, we can say that the traditional urbanism of the European city's perimeter block (such as in Barcelona, Paris, Berlin and Athens) is also ecological urbanism [41]. Urban density should be embraced more strategically as the answer to a number of problems with today's urban developments.

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