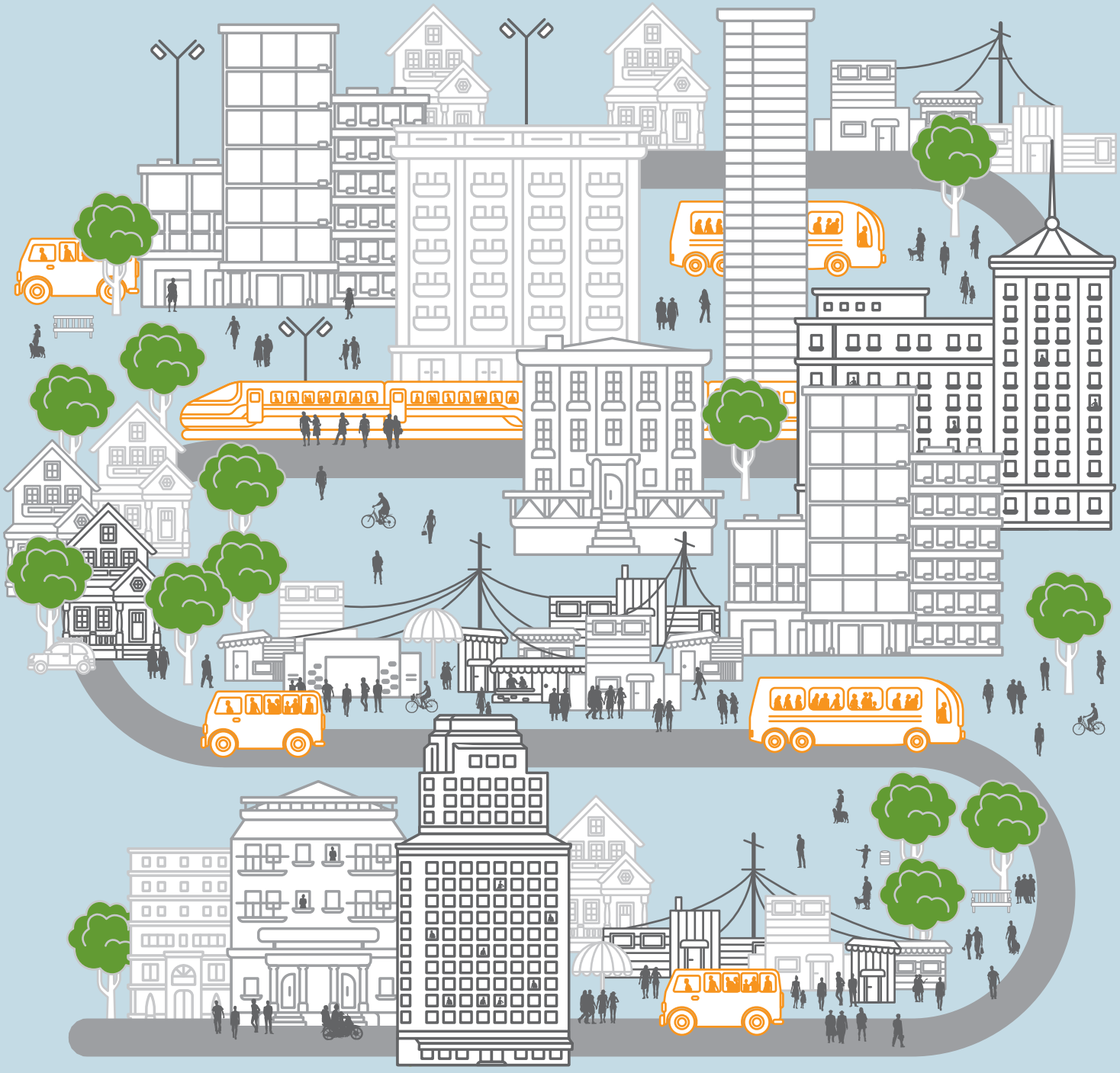
TRANSIT ORIENTED DENSITY FRAMEWORK

TOWARDS A DEEPER UNDERSTANDING OF DENSITY



South African CitiesNetwork

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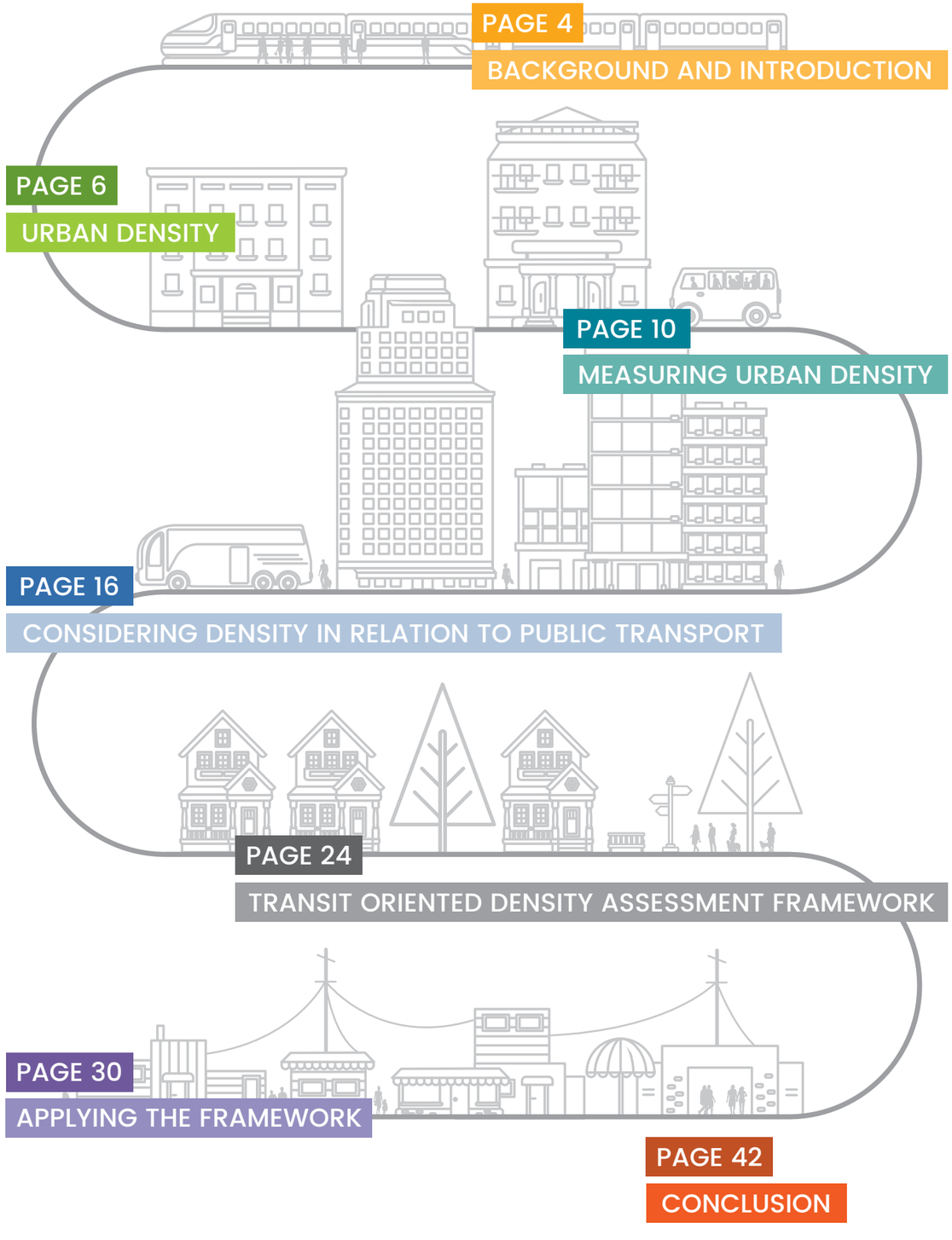


HIGHER URBAN DENSITY IS STRONGLY ASSOCIATED WITH PUBLIC TRANSPORT USE, BUT WHAT DOES THIS 'HIGH DENSITY' ENTAIL?

BACKGROUND AND INTRODUCTION

BACKGROUND AND INTRODUCTION

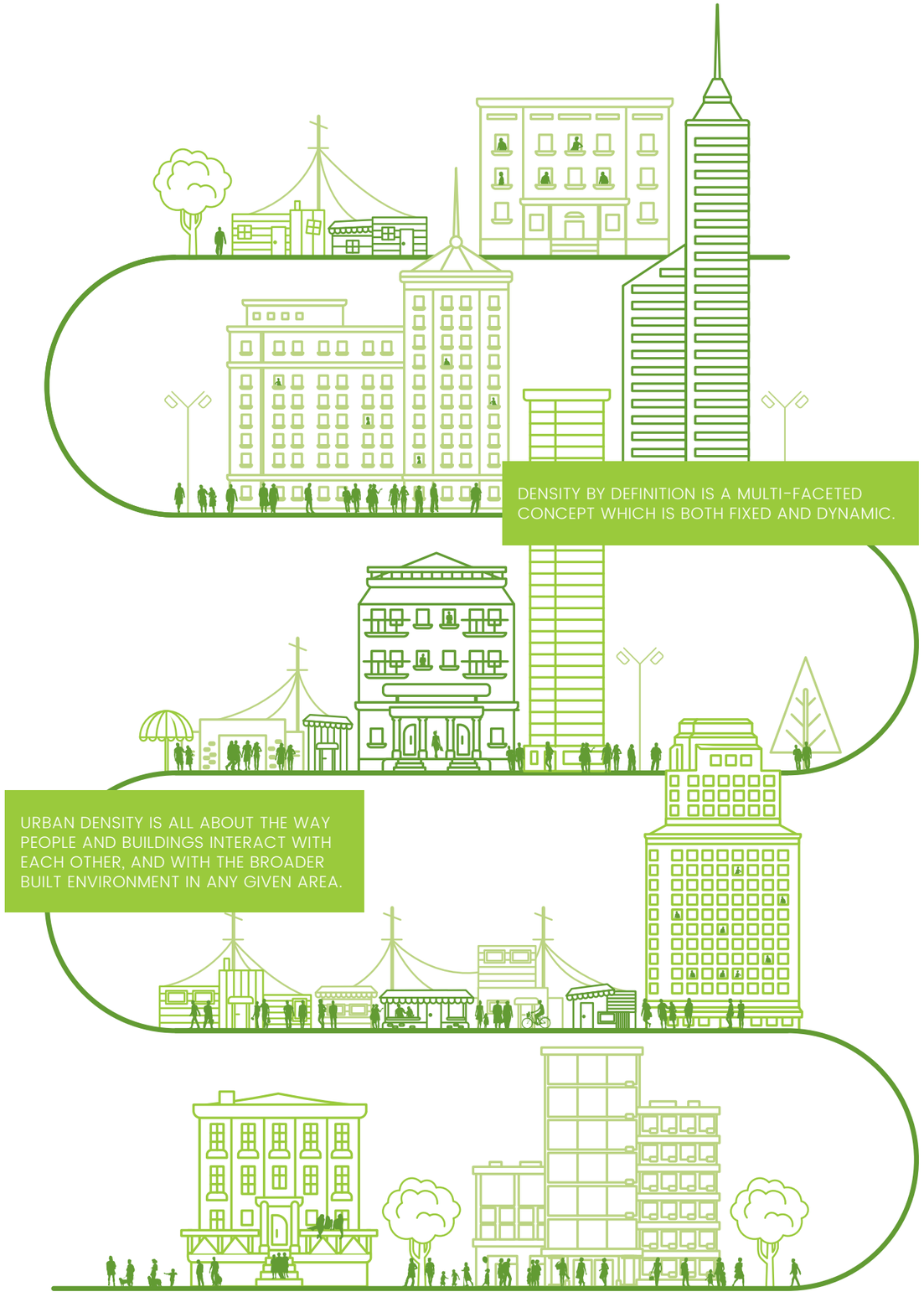
The term 'high density' occurs often in discussions of global urban planning. But what exactly does it mean? There is much support internationally for the idea that high levels of urban density benefit cities environmentally, socially and financially. Compact cities are considered more sustainable. In post-apartheid South Africa, urban policy discourse has constantly included the aim of achieving higher density. Among the expected benefits are greater efficiencies in public transport. The country's focus on increasing urban density is therefore closely linked to the development of public transport systems. This is stated in the National Development Plan (NDP) (2011):

'Strengthen the link between public transportation and land-use management with the introduction of incentives and regulations to support compact mixed-use development within walking distance of transit stops, and high-density developments along transit routes' (NPC, 2011)

The premise is that high density is an essential element in achieving the 2030 vision of the NDP. Specifically, the argument is that locating high density development close to public transport stations will alter the ways in which people are able to travel in the country's cities and towns. Walking, cycling and public transport are favoured over private transport. This envisaged future, with its orientation towards public transport, requires high density urban living. However, what does this look like and how do we know if current developments will achieve this goal?

While much work has been done on urban density generally, there is little information about the relationship between urban density and public transport. This report investigates the links between them. It applies a framework which, in its present or an improved form, may assist municipal officials, built environment practitioners and citizens to assess the extent to which transit adjacent neighbourhoods share a strong functional relationship with public transport.

The report first examines the concept of density generally, and urban density specifically, highlighting its multi-faceted nature. It then discusses the connections between density and public transport to inform the aspects to be included in an assessment framework. Each of the ten measures of the framework is introduced and explained. The outcomes of piloting the framework, in the case of three selected study areas, are presented to test the extent to which the framework assists in assessing how urban density is oriented towards and intrinsically connected to public transport. The report then compares the results that emerged from piloting the framework in three diverse sites in the Gauteng City Region.



URBAN DENSITY

Urban areas, with their physical and social systems and networks, are highly complex and the forms and flows that make them up are multi-layered and interconnected. They are not homogenous, but are made up of smaller localities with different forms, functions and urban fabrics developed at different times and under different conditions. How can density be thought about in such a context? A starting point is to understand the concept of density.

DEFINING DENSITY

Density is a concept derived from physics. In the context of urban development, it can be defined as 'the quantity of people or things in a given area or space'. This definition allows for a multi-dimensional understanding of the concept.

In urban settings, this has resulted in density being interpreted differently depending on specific focus areas. Architects tend to focus on buildings while planners have tended to focus on housing units. To simplify the many types of density, two major categories have been conceptualised: perceived density and physical density.[1] Physical density can be further broken down to fixed and activity density.

PERCEIVED DENSITIES

Perceptions can be as powerful as reality, with people's perceptions of density informing their opinions. To argue, as does the National Development Plan, that increased densification is required leaves open to interpretation what this means.[2] For those living in detached houses with large gardens, three-storey apartment buildings could seem high density. For those living in blocks of flats, high density could mean skyscraper apartment buildings like those found in Hong Kong. Such definitions of high density refer only to buildings' character. Some will understand high density to characterise areas that they perceive to be dense.[3] They might think of overcrowding, run-down buildings, stressed and poorly maintained infrastructure. Others may associate it with new and modern apartment living, coupled with great parks and vibrant and busy streets. Yet others may understand it as 'slum' type conditions with large numbers of people tightly packed into informal housing units with poor infrastructure.

This report sets out to present a more nuanced view of density, not necessarily associated with any particular set of living conditions.

PHYSICAL DENSITIES

Physical densities are those which actually exist. They are tangible, measurable and located in space. They can further be categorised into fixed or activity densities.

Fixed densities

Fixed densities are permanently located in space over at least the short to medium term.

Activity densities

Activity densities are in flux throughout short periods (usually daily but sometimes, for example, seasonally) and refer to people, cars, resources and so on.

PERCEIVED	PHYSICAL
	FIXED
	ACTIVITY

Figure 1: Categories of density

[1] Cheng (2009)
[2] Cheng (2009)
[3] Forsyth (2003)

URBAN DENSITY

TEXTBOX 1

The illustration below shows an aerial view of a tree on a hectare of land. The density measure is 1tree/ha. This is a fixed density measure as trees generally have relatively long life spans.

1 TREE PER/HA

However, things can grow in, inhabit and visit the tree, with their numbers varying at different times. For example, the tree may contain leaves, birds and peaches. Hypothetically, it may have a maximum capacity of:

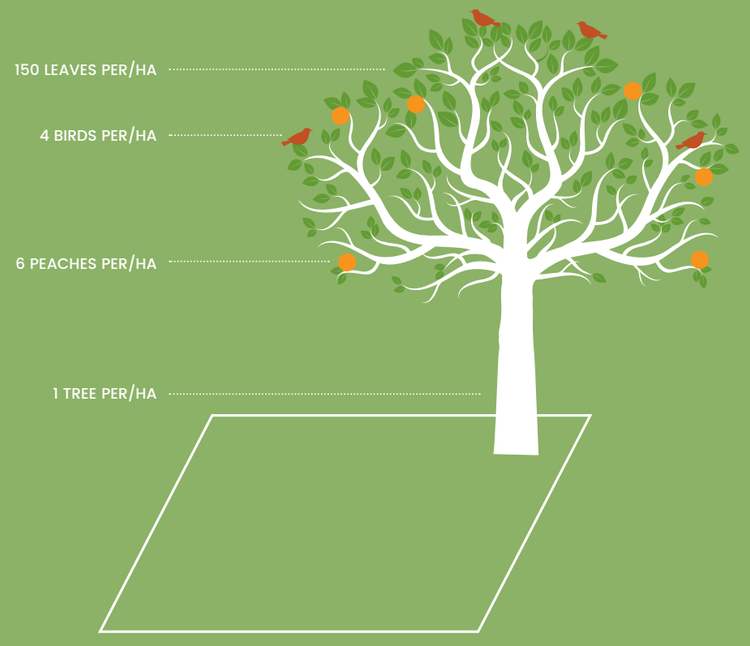
- **200 leaves**
- **50 birds**
- **100 peaches**

If there are 150 leaves, 6 peaches and 4 birds on the tree, this indicates the activity density (dynamic flows of measurable items in and out) at that time.

The density level of 1 tree/ha remains true. However, a broader measurement of density gives the following results:

- **1 tree/ha (fixed density)**
- **150 leaves/ha (activity density)**
- **4 birds/ha (activity density)**
- **6 peaches/ha (activity density)**

Each of these measures is correct. Together, they give a more informative picture of the dynamics within the area. However, the fact that these activity levels can increase or decrease, up to the maximum capacity levels, makes these dimensions difficult to track and measure. Nevertheless, if they are measured they can provide important insights into the pressures on and requirements of the tree and the surrounding area.



'URBAN DENSITY IS NOT A PROPERTY OF BUILDINGS OR PEOPLE BUT OF SPATIAL RELATIONS BETWEEN THEM; BETWEEN BUILDINGS, BETWEEN PEOPLE AND ALSO BETWEEN PEOPLE AND BUILDINGS. THE MULTIPLYING COMPLEXITIES HERE MAKE IT CLEAR THAT NO SINGLE DENSITY MEASURE OR VARIABLE CAN BE CONSIDERED APART FROM THE LARGER ASSEMBLAGE.'

Dovey and Pafka (2014).

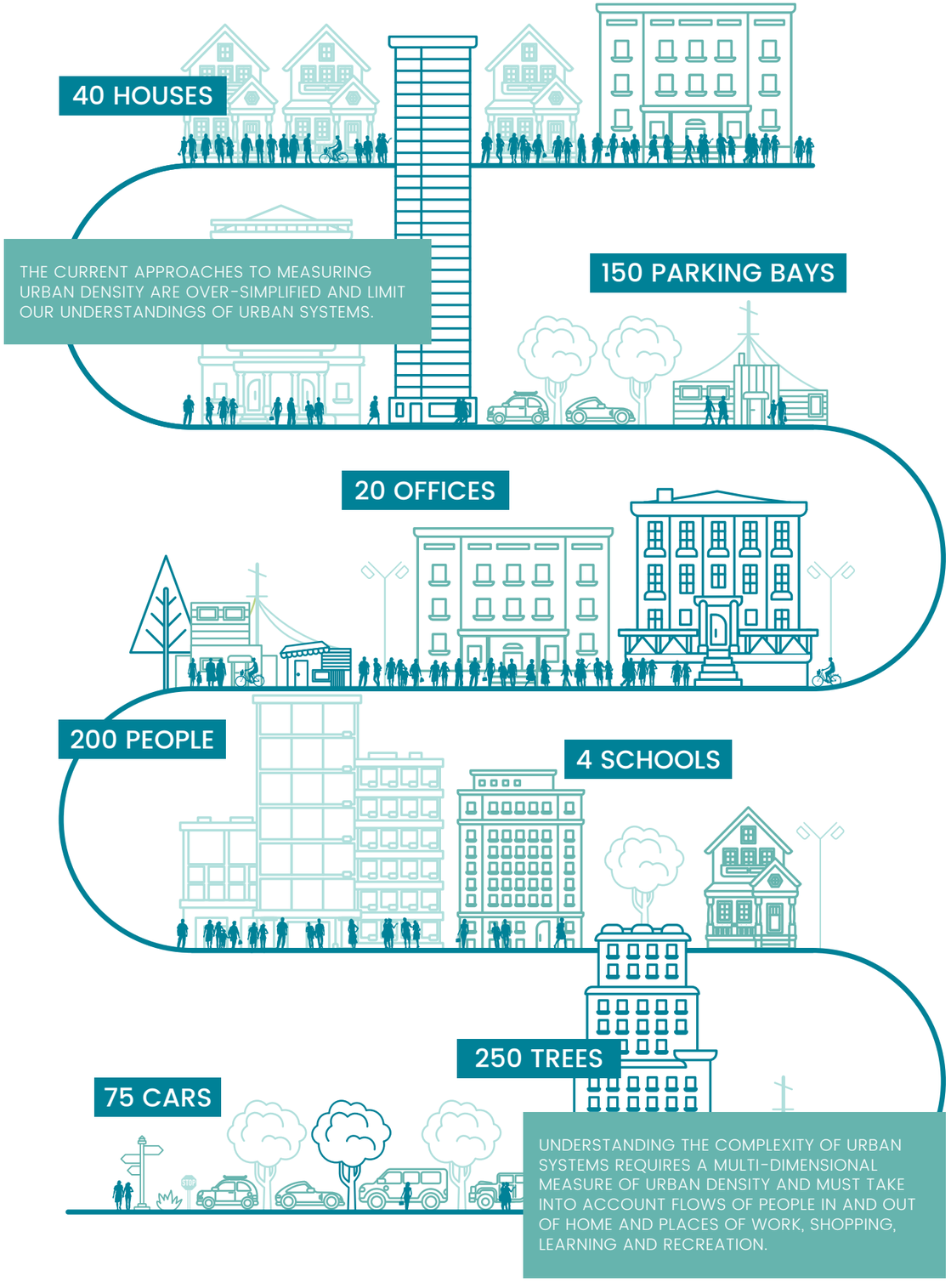
DENSITY IS MULTIFACETED

By definition, density can include many different understandings and has been used to think about urban environments.[4] The complexity of urban systems and natural environments means that it is almost impossible to measure precisely and to monitor the density levels of all facets of a particular context.[5] The tree in Box 1 illustrates the multiple, overlapping and interacting dimensions of density. The same principles apply in urban environments.

Although there have been many investigations into the concept of urban density, a scan of the literature shows the ambiguity of the term, with some authors expanding the concept to include a range of aspects some of which include the likes of various land uses and flows of people and resources.[6] This report argues that a full appreciation of the densities associated with urban life needs to take into account not only buildings and population but working, learning, shopping, consuming and moving.

There is a clear argument for such an approach because if density is taken to be 'the quantity of people or things in a given area or space', it is obvious that urban density can be measured in a multiplicity of ways. As has been illustrated by the example of the tree, density is a complex, multi-faceted concept which is both fixed and dynamic. Thinking about urban systems and the multiple flows of people, goods and resources and how they interact introduces a more insightful way of thinking about urban density and how it can be measured.

[4] Roberts (2007)
[5] Dovey and Pafka (2014)
[6] Boyko and Cooper (2011); Doherty, et al, (n.d); Cheng (2009); Roberts (2007)



THE CURRENT APPROACHES TO MEASURING URBAN DENSITY ARE OVER-SIMPLIFIED AND LIMIT OUR UNDERSTANDINGS OF URBAN SYSTEMS.

UNDERSTANDING THE COMPLEXITY OF URBAN SYSTEMS REQUIRES A MULTI-DIMENSIONAL MEASURE OF URBAN DENSITY AND MUST TAKE INTO ACCOUNT FLOWS OF PEOPLE IN AND OUT OF HOME AND PLACES OF WORK, SHOPPING, LEARNING AND RECREATION.

MEASURING URBAN DENSITY

'DENSITY IS OFTEN DEFINED IN TERMS OF POPULATION PER SQUARE MILE (KM), BUT SUCH A CRUDE MEASURE MAKES IT DIFFICULT TO UNDERSTAND THE RELATIONSHIP BETWEEN DENSITY AND CITY LIFE. WE NEED TO THINK ABOUT URBAN DENSITY BY INCLUDING THE DENSITY OF JOBS, SCHOOLS, AND SERVICES SUCH AS RETAIL, TRANSIT, AND RECREATIONAL FACILITIES'.

Tuesday, et al (2014)

One of the most frequently used measures of urban density is people or units per area (Roberts, 2007). Another is building measures, such as Floor Area Ratio (FAR) and coverage. Doherty et al (n.d.) point out that most population density numbers are derived from an assumed population number per residential unit. This means that often population density figures are static residential population estimates. Unit density has thus taken on particular importance in planning policy, and frequently refers to residential or dwelling units. While each of the three measures has a particular purpose, alone or even combined they do not necessarily lead to a good understanding of urban density as measured by buildings and/or static populations.

These approaches to density assessment ignore other land uses and activities. Using a residential unit or associated population measure to assess density, a large proportion of workspace in an inner city would not feature at all. This can be misleading for those making decisions based on recorded density levels. Dovey and Pafka (2014) explain that building measures covering such office nodes mainly relate to the mediating of building height negating the importance of human and resource interaction with buildings.

Furthermore, many of the established approaches to measuring urban density remain appropriate only for formal urban settings where plot sizes are measurable and where approvals are required for property developments. Partly because of separationist town planning, these measurements tend to relate particularly to residential areas. It is because these density measures have a limited ability to measure other land uses such as open space, office, retail, education and recreational space that there has been debate about their effectiveness.

Density measures can provide both a planning and monitoring function, and a multi-faceted set of measures can help with understanding and measuring a project's objectives and progress.[8]

'DENSITY MEASURES ARE USEFUL TOOLS FOR PLANNING AND DEVELOPMENT PRACTITIONERS, TO HELP ENSURE PROJECT OBJECTIVES ARE MET.'

Landcom (2011)

[7] Floor Area Ratio measures the total amount of floor space in a building relative to the size of the plot on which it stands; coverage is the percentage of the plot covered by the footprint of the building.

[8] Landcom (2011).

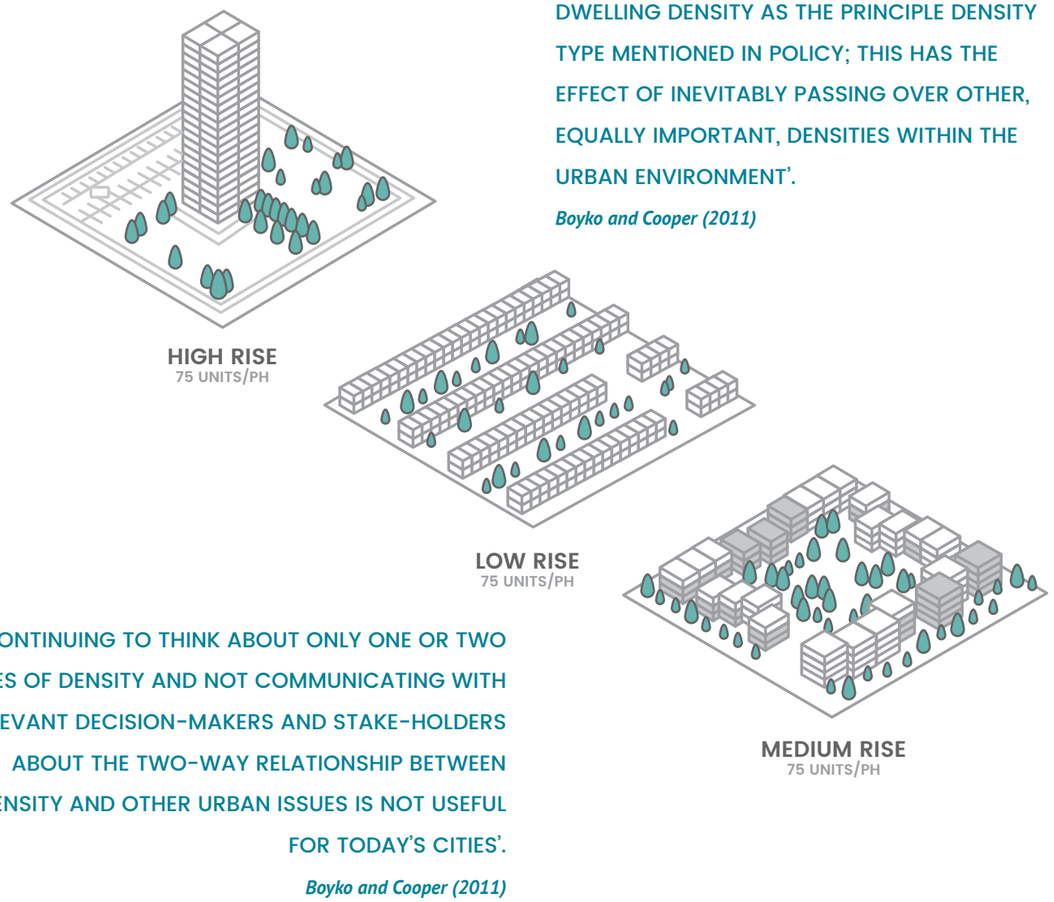
Thus, using a single measure can result in significantly different conclusions than if other density perspectives are used. Figure 2 demonstrates that a unit/ha density target of 75 units/ha could be interpreted in various ways and can result in significantly different coverage levels and promote different types of person interactions, with the population/ha varying significantly depending on the average occupancy levels per unit. If unit occupancy levels are high (say, 5 people per unit) in the high rise scenario and 2.5 people in the low rise scenario, the population/ha would range between 188 and 375 people/ha.

A multi-dimensioned approach is therefore critical for understanding urban density in relation to life in the city and to the many systems which interact in the urban environment.

The Density Atlas, a resource for comparing urban densities around the world, shows that layering density measures together can create a better picture of density.[9] The Atlas focuses on what the report presents as the the three most common density measures: unit per area, population per area and FAR and coverage. These are explained later in this report.

'THERE APPEARS TO BE AN OVER-EMPHASIS ON DWELLING DENSITY AS THE PRINCIPLE DENSITY TYPE MENTIONED IN POLICY; THIS HAS THE EFFECT OF INEVITABLY PASSING OVER OTHER, EQUALLY IMPORTANT, DENSITIES WITHIN THE URBAN ENVIRONMENT'.

Boyko and Cooper (2011)



'CONTINUING TO THINK ABOUT ONLY ONE OR TWO TYPES OF DENSITY AND NOT COMMUNICATING WITH RELEVANT DECISION-MAKERS AND STAKE-HOLDERS ABOUT THE TWO-WAY RELATIONSHIP BETWEEN DENSITY AND OTHER URBAN ISSUES IS NOT USEFUL FOR TODAY'S CITIES'.

Boyko and Cooper (2011)

Figure 2: different development typologies with the same unit density/ha
Urban Task Force, 1999 (http://www.rsh-p.com/), redrawn by the illustrator

[9] www.densityatlas.org

SCALE AND CONTEXT

Scale and context are extremely important elements to consider when attempting to understand or measure density.

Most commentators agree that scale and context are two vital elements to consider when investigating urban density, and that assessing how the 'micro' fits into the bigger picture is essential when considering it.

SCALE

Scale is important because it relates to the extent of the area of study. The wider the area, the greater the opportunity for diversity and complexity, with differing conditions becoming evident the more the heterogeneity of its built environment is studied. Density measures tend to overcome the issue of scale by extrapolating conditions in a smaller area to a larger one. However, this undermines the ability to understand the actual situation at the larger scale and can lead to overgeneralisation. In reality, the situation at site level may be very different to that at neighbourhood or precinct level; conducting measures at these various scales could therefore result in significantly different findings. It is therefore always critical to be aware of the scale at which a density measure has been conducted.

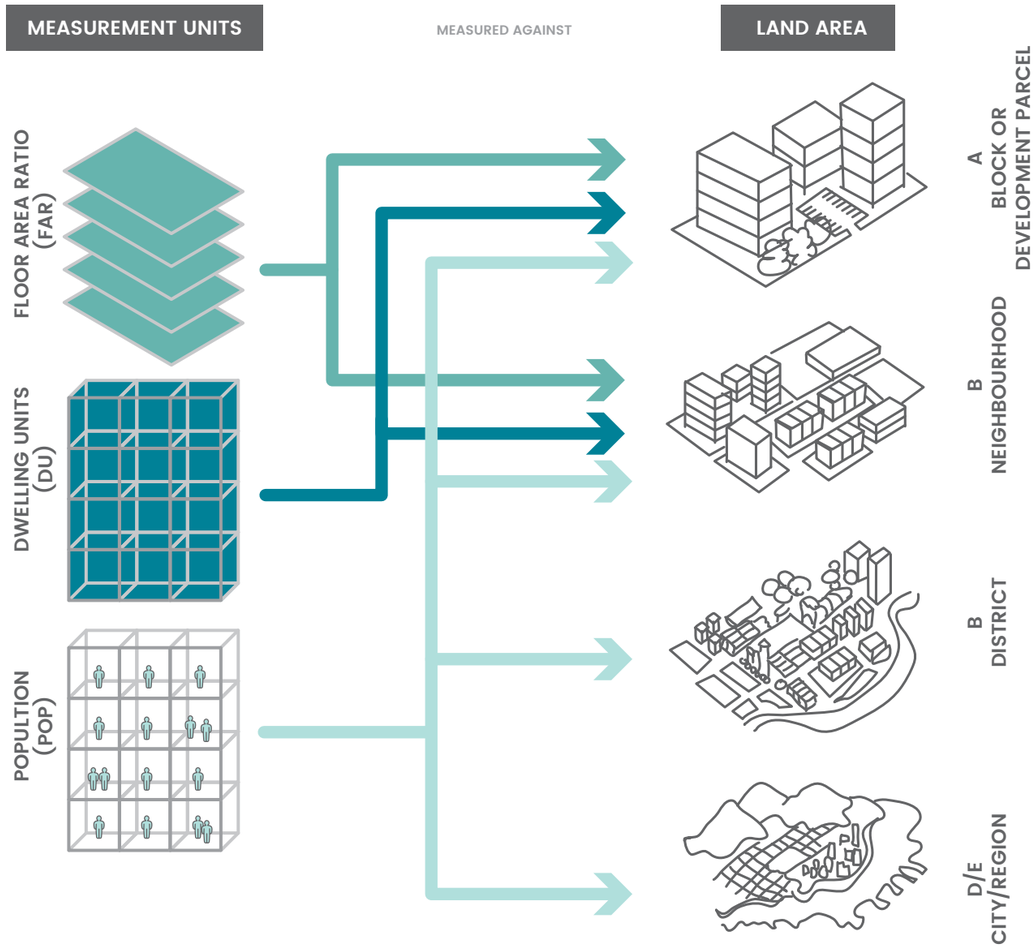
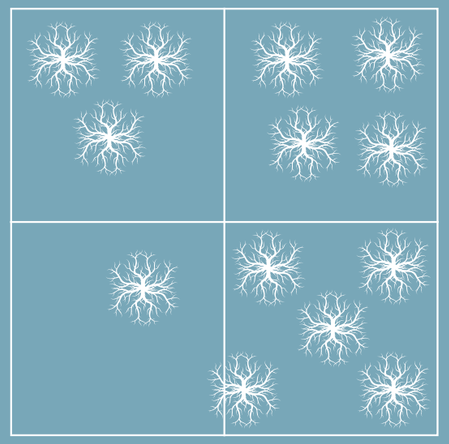


Figure 3: Different scales of measurement
Source: www.densityatlas.org, redrawn by the illustrator

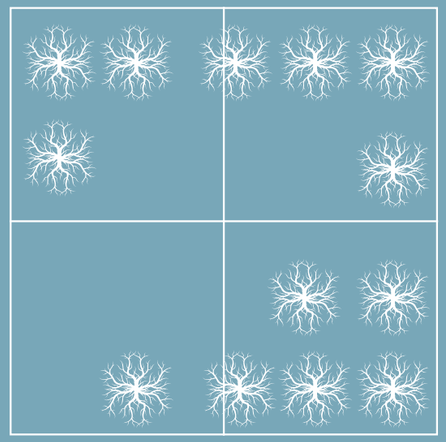
TEXTBOX 2

Drawing on the tree example used earlier, the question can be asked as to what would happen if surrounding areas (a wider scale) were included in the measurement and the number of trees per area was changed.

NOTE: LAYOUT AND DESIGN MATTERS



Although the number of trees/ha varies for each ha, the average density of the 4 ha combined is 3.25 trees/ha. However, the activity density is more difficult to predict as each tree will have different occupancy levels of peaches, birds and leaves throughout the day and the year. Each tree is located in a context of other trees, and together they affect the system and environment within which they exist. In this regard, how the trees are positioned is important.



In the illustration above, the average density remains the same at 3.25 trees/ha. However, there is something different about the look and feel of the overall area, with the trees creating an open square in the centre of the area.

It could be argued that this is not a measure of density but of design. However, it is clear that simply using a unit density measure could give the same result for very different arrangements. This qualitative aspect should therefore be included in density understandings.[10] This report makes use of qualitative investigations of density which move beyond simple numbers. It also takes into account the fact that the history of an area may have been an important force in shaping what it is today. In the examples above, the trees would have been planted in different places a number of years ago much as the buildings in a city would have been built at particular times and under specific conditions. The historical decisions which informed location, position and layout are influencing factors which need to be considered in density understandings.

[10] Boyko and Cooper (2011)

'THE BIGGER PICTURE IS ALWAYS IMPORTANT TO CONSIDER WHEN ASSESSING DENSITY. THE MANNER IN WHICH SITE OR BLOCK SPECIFIC CONDITIONS COME TOGETHER TO FORM NEIGHBOURHOODS, REGIONS AND CITIES ULTIMATELY DETERMINES THE CHARACTER AND FUNCTIONALITY OF PLACES.'

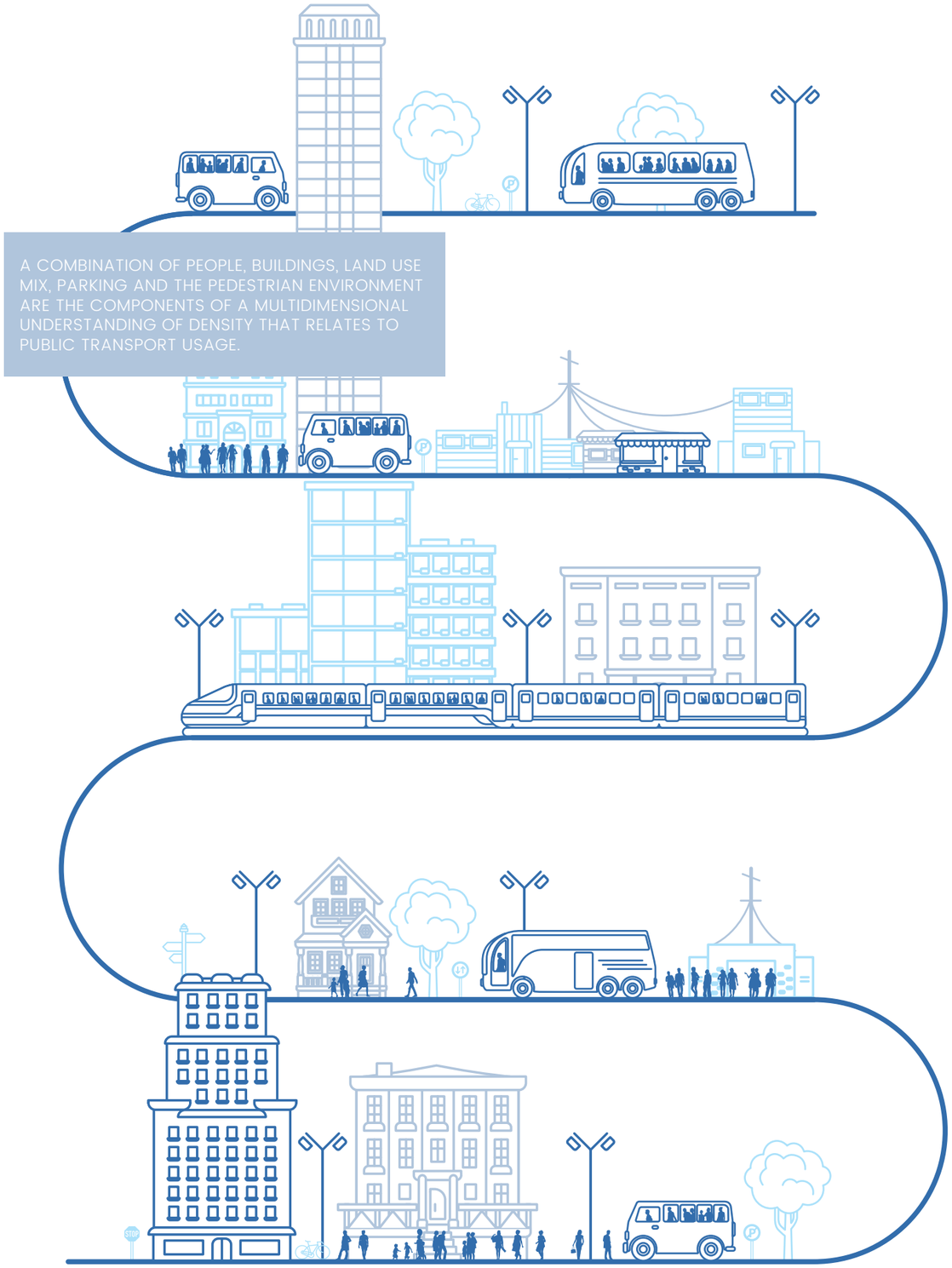
CONTEXT

Urban development is evolutionary and there are critical contextual elements which underpin its growth and change over time.[11] Old European cities often exhibit the type of urban density which is considered to be most liveable and efficient. However, these urban fabrics were developed at times of vastly different conditions to the current ones. Barcelona in Spain has been presented as a good case of human scale density which is people-oriented and achieves urban efficiencies.[12] Yet Barcelona developed for centuries without the influence of the private vehicle, in a context where people relied on walking and public transport to move around. Those centuries of development have been entrenched into a city fabric which is very difficult to alter even in a private vehicle era. Thus, changes to and investment in the built environment made at a particular point in time have long term effects and can set a city, or area within a city, on a particular path of development.

The evolution of cities' densities may also encapsulate socio-political conditions. Hillbrow in Johannesburg is a good example of this. During the 1970s, Hillbrow was seen as a 'hip and happening' place for young professionals to live. It consisted mainly of high-rise apartment blocks with shops, restaurants and bars on the ground floors and with many community facilities and parks. Today, unit densities in Hillbrow are similar to, or very possibly higher than, those of the earlier time. However, it is now seen as an area of 'crime and grime', overcrowded and generally perceived to be undesirable to live in, although it is a vibrant economic node for many of Johannesburg's lower income residents.

[11] Boyko and Cooper (2011)

[12] Alter, L (2014) Cities need Goldilocks housing density – not too high or low, but just right. Available online at http://www.theguardian.com/lifeandstyle/2014/apr/16/cities-need-goldilocks-housing-density-not-too-high-low-just-right'



A COMBINATION OF PEOPLE, BUILDINGS, LAND USE MIX, PARKING AND THE PEDESTRIAN ENVIRONMENT ARE THE COMPONENTS OF A MULTIDIMENSIONAL UNDERSTANDING OF DENSITY THAT RELATES TO PUBLIC TRANSPORT USAGE.

CONSIDERING DENSITY IN RELATION TO PUBLIC TRANSPORT

CONSIDERING DENSITY IN RELATION TO PUBLIC TRANSPORT

There is much support for the idea that density shares important links with transport functionality in urban areas.[13] Public transport systems are about the flows of people in and out of areas in the urban system. Thus both fixed and activity density insights provide useful linkages to public transport operations. There is an existing understanding that low densities provide weak support for or even undermine public transport, and tend to favour car-based development. High density, by contrast, favours the operation and use of public transport. However, some argue that high density (in terms of the parameters that planners have traditionally used of people, dwelling units and buildings) alone does not necessarily lead to public transport efficiencies. The key question therefore is: given the multi-dimensional nature of density, what does urban density which best supports public transport entail and how can it be assessed?

It is to answer this question, and to achieve stronger land use-public transport integration, that the idea of Transit Oriented Development (TOD) is being increasingly drawn on. A number of attributes make up TOD environments:

- Medium to high density (not always well defined but taken to mean units/population/buildings)
- A mix of land uses
- Reduction in parking provision
- A high quality public realm which facilitates strong pedestrian access to buildings, open spaces and public transport stations.

[IF] 'CITIES ARE TO BECOME MORE SUSTAINABLE, IT IS IMPERATIVE THAT VEHICLE KILOMETRES TRAVELLED RATES OF INCREASE ARE STABILIZED, BUT THIS CAN ONLY BE ACHIEVED BY A FUNDAMENTAL SHIFT IN POLICIES RELATED TO URBAN DENSITY, DESIGN AND PUBLIC TRANSPORT'.

Roberts (2007)

Even in this list of criteria, density is taken to refer to static population or dwelling unit density. However, as has been noted above, it is possible to assess density from a number of perspectives. Theoretically, each of the above listed characteristics of TOD can be assessed through a density lens. The sections below examine how each of them relates to public transport and why it is important to consider them all equally.

[13] Alter, L (2014) Cities need Goldilocks housing density – not too high or low, but just right. Available online at http://www.theguardian.com/lifeandstyle/2014/apr/16/cities-need-goldilocks-housing-density-not-too-high-low-just-right

MEDIUM TO HIGH DENSITY (BUILDINGS/ UNITS/ POPULATION)

High concentrations of people and buildings increase the potential for high levels of public transport ridership, creating the conditions for large flows of passengers utilising the system. Each public transport service has a maximum level of capacity (number of passengers) that it can serve throughout the entire day. The more people there are in the catchment areas surrounding stations the more opportunity there is for the capacity to be realised. The more a transport service is used by passengers the more financially sustainable the provision of the service becomes.

Every time someone boards a bus, they pay to use the service. Thus, going from 50% to 90% occupancy has a major impact on the financial sustainability of the service.

Coupled with this is the increase in social interaction that will take place as more people make use of the public transport service.

In complex urban environments where people use multiple modes of transport to access various activities dispersed across large areas maximising capacity levels can be challenging. However, in theory the principle still applies. For a mass transit system to be utilized close to carrying capacity, large volumes of people need to be within locations where they can easily access the system. This can be done by providing housing options for people in close proximity to public transport stations. Likewise, the destinations to which people are travelling, such as offices, schools, shops and parks, need to accommodate high volumes of people in close proximity to public transport stations.

Figure 5: People density and transport

MIXED LAND USE

When urban land use transport systems are viewed on a regional scale, the multiplicity of density measures becomes even more important. A residential area, for example, no matter how dense in terms of units per ha will probably have low levels of activity between 09:00 and 17:00, as people leave for work or school outside the area. For transport systems, such density patterns drive tidal or mono-directional flows making it difficult to ensure ridership efficiency per public transport trip. Because public transport fleets have to circulate for viability, a single vehicle will make a number of circular trips in a day. In a land use environment where all passengers travel in a single direction and the return trip in the morning peak has no passengers (Figure 6), the financial performance of the total circular trip is 0 as the outbound trip is cancelled out by the empty return trip. This type of relationship typifies South African urban patterns, with exceptionally full buses, minibus taxis and trains heading into business districts in the mornings and empty vehicles and carriages heading out of them shortly afterwards.

However, if a different land use pattern were to emerge where commercial, residential and educational land use were all located in a given area, it would mean that people would be travelling in both directions in the morning and the evening. Some level of revenue collection takes place on the return journey in this case. It is not easy to achieve equilibrium of travel demand patterns across a region, but mixed land use patterns which make all areas travel origins and destinations help to create greater equilibrium of travel demand.

Mixed land use in a region produces an even more financially viable transit operating environment because 'seat renewal' begins to occur. This takes place when a person's destination arrives before the end of a full trip (terminal station to terminal station) and another person boards at that point to get to the area at the end of the trip. In Figure 7, this is shown by areas A, B and C which all consist, in various degrees, of a mix of land use with A the most residential and C the most commercial. The figure shows the demand for travel from and to each of the areas from each of the other areas. The reason seat

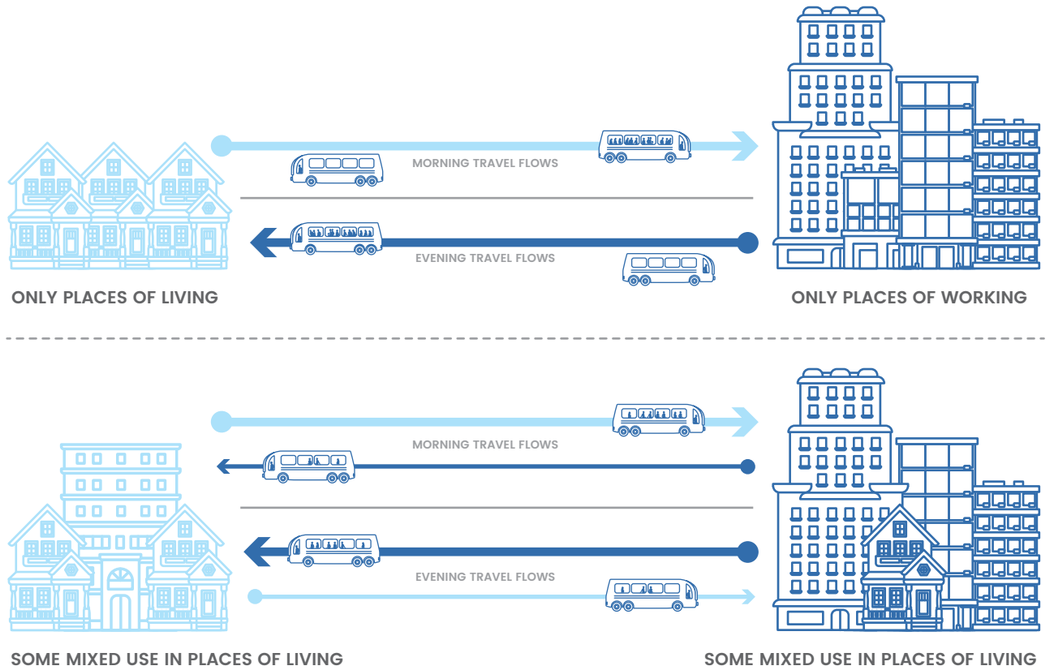


Figure 6: Land use and transport flows

renewal is so sought after for public transport operators is that people travelling shorter distances tend to pay a higher fare than people travelling the entire distance of the line (this depends on the fare structure but in South Africa such a fare policy would be sensible given the many poor people living on the periphery). This means that if a single seat can get two or more people to occupy it during a single full length trip then more revenue is collected per seat for a single full trip than had only one person occupied the seat. Once the people from area A alight at area B, the people waiting there board and take their seats; this is seat renewal. Mixed land use thus tends to result in more short trips and to create origin and destination points in each area. Coupled with the objective of high people density, many passengers begin making short trips between multiple areas of mixed land use throughout the day.

'HIGHER DENSITIES, ACCOMPANIED BY INCREASED POPULATION THRESHOLDS AND MIXED-USE DEVELOPMENT, SUPPORT THE EFFICIENT FUNCTIONING AND VIABLE PROVISION OF PUBLIC TRANSPORT SERVICES, ESPECIALLY ON MAJOR LINE-HAUL ROUTES FOR MASS AND RAPID TRANSIT'.

City of Cape Town (2012)

Worldwide, few public transport services are financially self-sustaining. However, land use arrangements help reduce the subsidy required to run frequent and reliable services throughout the day as each area becomes a hub of origins and destinations.

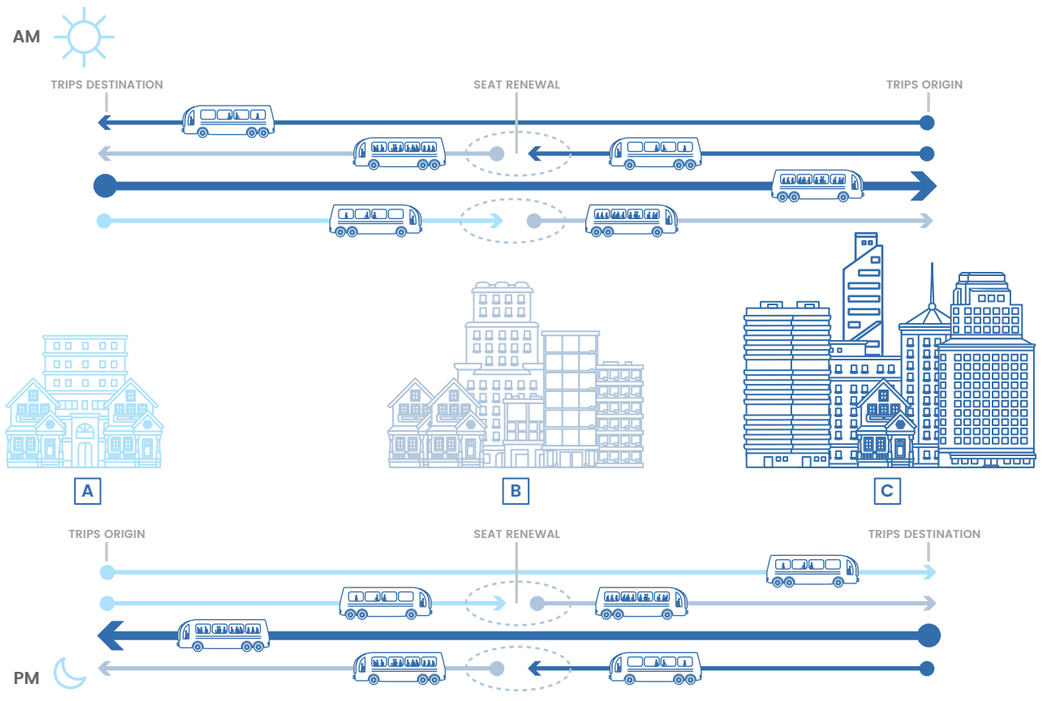


Figure 7: Land Use Mix and Seat Renewal

CONSIDERING DENSITY IN RELATION TO PUBLIC TRANSPORT

REDUCTION IN PARKING

Parking information is an aspect of urban systems which is not readily available largely because it is often poorly tracked and measured and does not feature in mainstream density measures. However, it is an integral component of urban systems today and is strongly associated with formal development planning and investment decisions. The level of parking available within a building, precinct or region gives a good indication of the extent to which access and mobility is vehicle or transit oriented. Cities with less parking exhibit lower levels of car use and tend to rely on public transport; the opposite tends to be the case where there are high levels of parking. There is much support for the argument that public transport based cities are more efficient than vehicle based cities, in terms of land consumption, fossil fuel use and financially. If an area is well served by public transport, assessing the extent and use of parking capacity provides a good indication of the extent to which the area is oriented towards public transport. Measuring parking density can be done in two ways: by calculating the fixed number of parking bays available, and by measuring occupancy levels of parking bays across periods in the day. For example, if a building has 100 parking bays but is used by a maximum of 40 cars during the day although the building is full of people, the space is being used inefficiently and it appears that the majority of people are not driving themselves to work. If, on the other hand, 115 cars are attempting to use this parking area, there would appear to be a heavy dependence on vehicle travel and the building is unlikely to be transit oriented. This can result in more investment in parking spaces, and further entrenchment of the building's vehicle dependence. It is also important to note that the cars parked at such a workspace have parking in various locations across the city 'waiting' for them. Someone who drives will have a parking space at home, at work, at school where they drop and fetch their children, at the shops and virtually anywhere else they go. Parking consumes vast amounts of urban space and this could be better utilised for more productive activities. Parking also drives up the costs of development and property. Public transport based cities require significantly less parking and tend to utilise their space more productively.

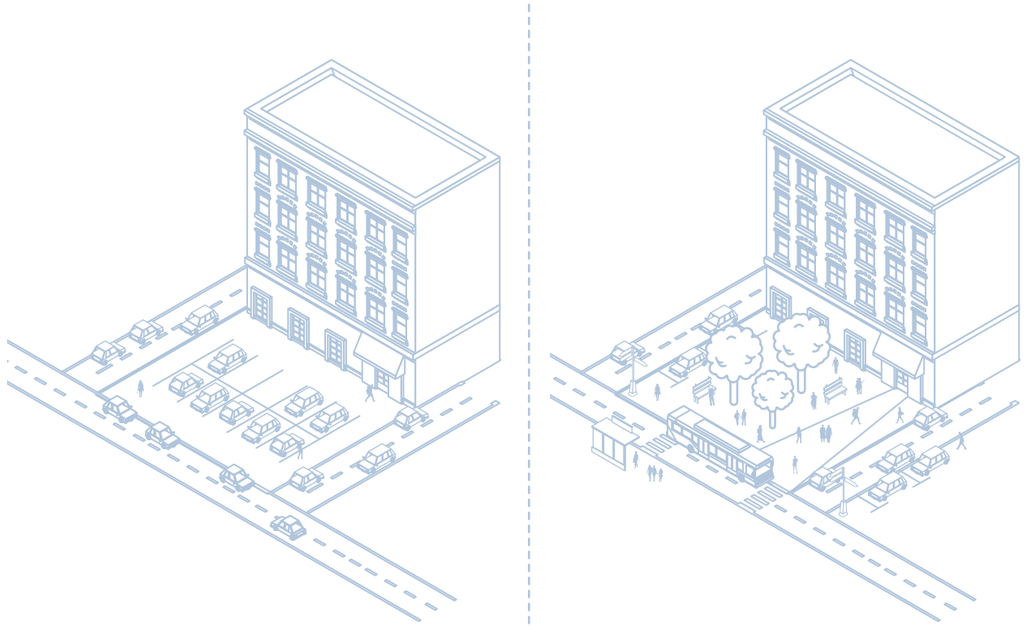


Figure 8: Reduction in parking

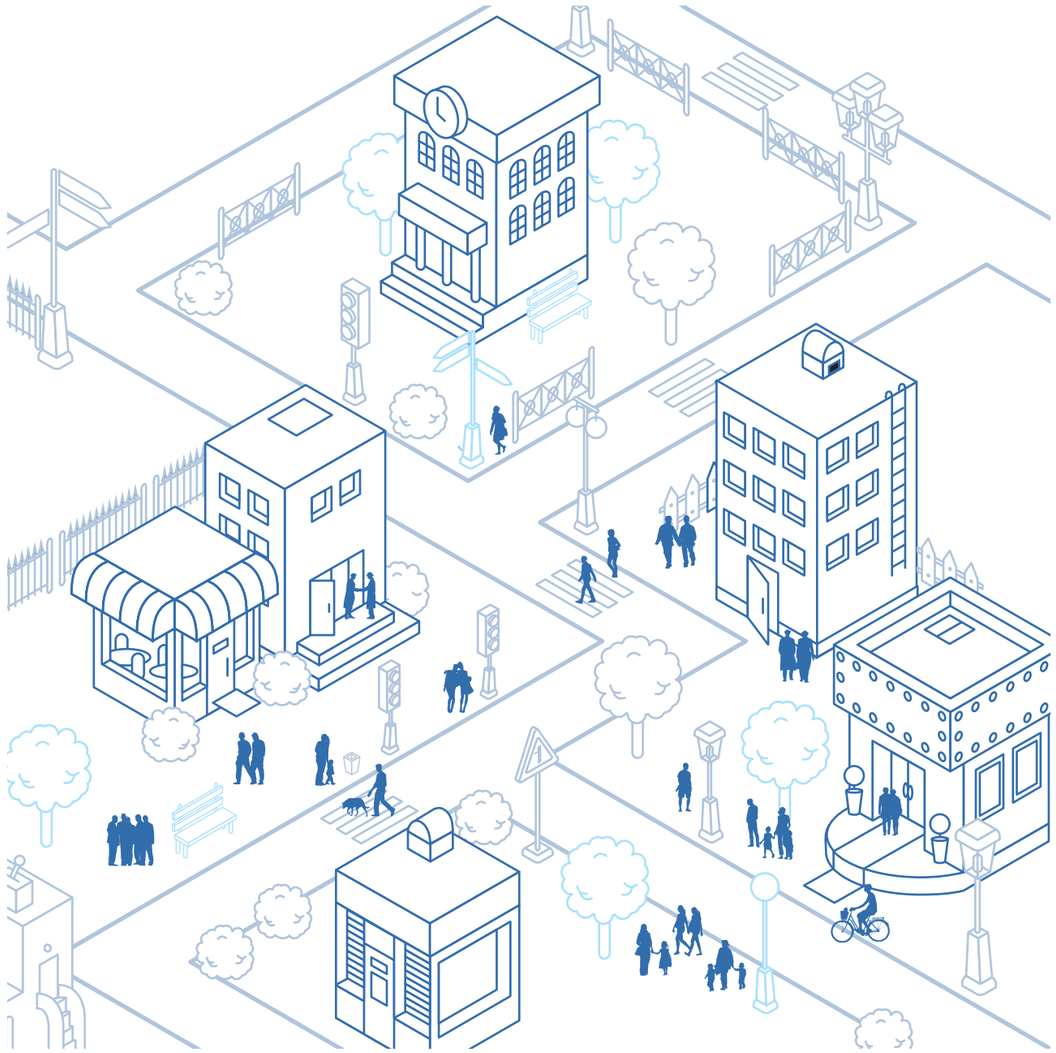
HIGH QUALITY PUBLIC REALM WHICH FACILITATES STRONG PEDESTRIAN ACCESS TO BUILDINGS, OPEN SPACE AND THE PUBLIC TRANSPORT STATIONS

How often are the quality of the public realm, and access conditions from the perspective of the pedestrian, measured and assessed? This principle encompasses the aspects which stitch the land use-transport integration idea together in space. The quality of the pedestrian environment often provides a strong indication of the extent to which an area is transit oriented. Ensuring that pedestrian connections to public transport stations are as convenient, safe and comfortable as possible is a key driver in getting more people to use public transport systems. Assessing these issues requires moving beyond proximity measures, numbers of people and cars and land use availability, and provides a qualitative sense of the environment experienced by pedestrians coming from or walking to a public transport station. Conditions which enhance this experience and facilitate easy and effective access to the destination are important for ensuring that the urban area is transit oriented in nature. Aspects to consider but which are often overlooked include pedestrian lighting and street fronting buildings for safety; shading trees; benches; level and walking-friendly paving for comfort; and dedicated pedestrian traffic signals with sufficient and prioritised crossing time and demarcations for convenience and safety.

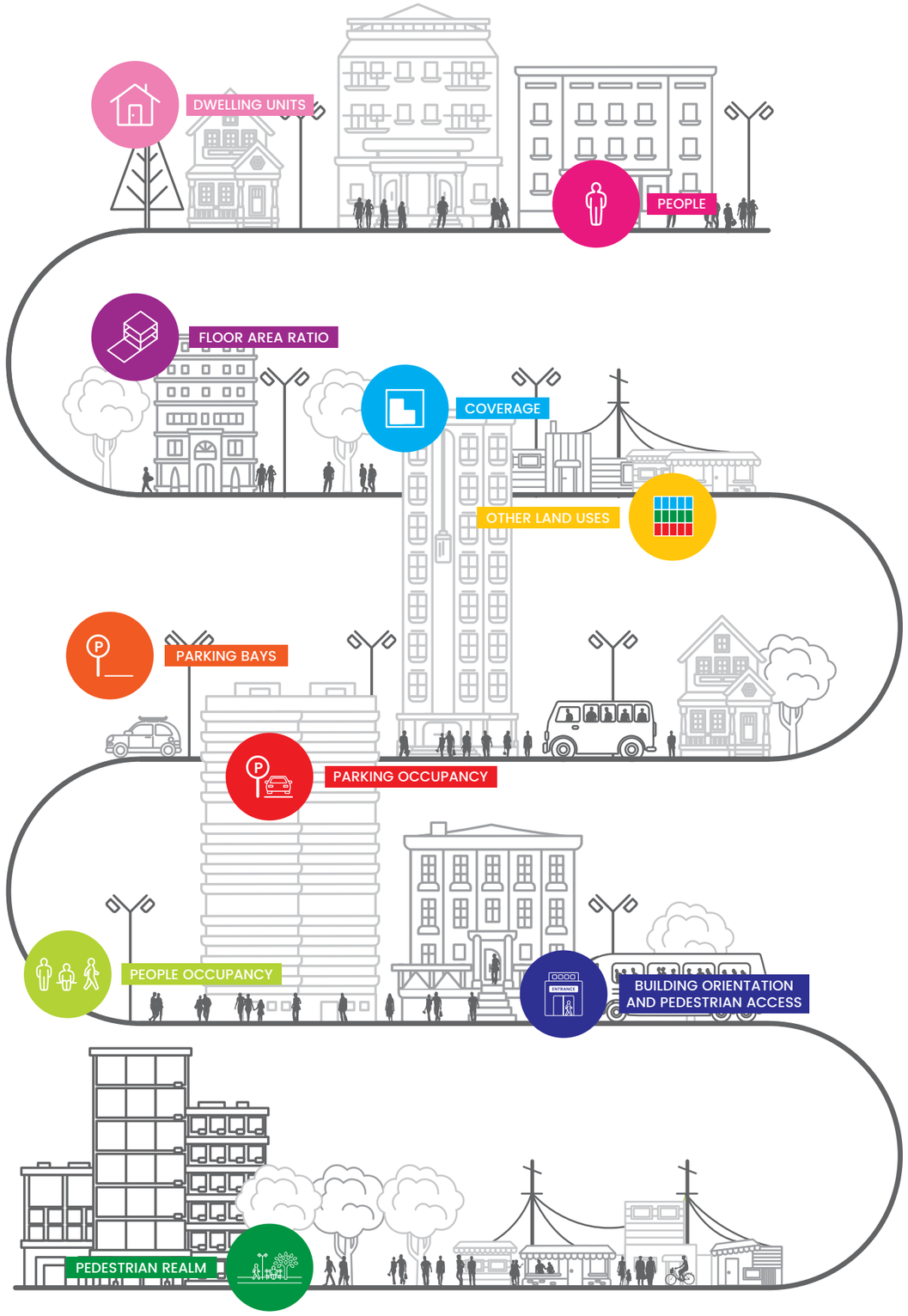
Figure 9. Pedestrian realm

The point regarding the frontage of buildings is important as it focuses points of activity towards the street. This makes walking distances seem shorter and creates improved safety conditions as more people are able to survey the streets.[14] The manner in which a building is oriented and provides access can provide significant indications about the access, focus and functionality of buildings, blocks and entire areas.

This section has outlined how each of the attributes of TOD environments share important links with public transport and has argued that they need to be considered within a public transport based density framework. From the perspective of public transport operations as well as the user, taken together the TOD characteristics have an impact which in isolation they will not have. Developing a single framework which brings each of these areas of density together and provides layered insights into them should enable a broader understanding of density.



[14] Jacobs (1961)



TRANSIT ORIENTED DENSITY ASSESSMENT FRAMEWORK

Central to the development of this framework is Boyko and Cooper's (2011) view that urban density is multifaceted and complex, and requires framing to make it easier to understand. They also state that the everyday dynamism associated with city life needs to be captured through 'hard' measurement approaches but must not overlook the important qualitative elements of interactions between people and their environment. Thus, both quantitative 'hard' measures and qualitative components have been used in creating the following ten-point framework for understanding transit oriented densities.

QUANTITATIVE CHARACTERISTICS

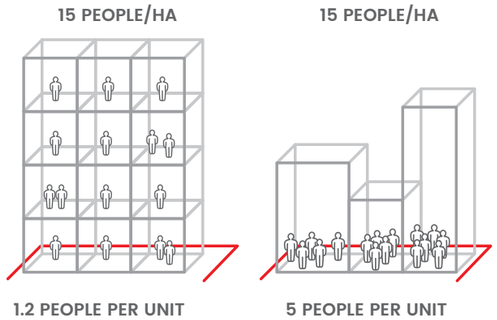
1. DWELLING UNITS/HA

Dwelling units per hectare provides a measure for the number of residential units in a given area. It does not take into account variations in unit size, only the numerical value. Residential units are the traditional measure of unit density. This has formed the basis of both unit and population density understandings.

APPLICABLE SCALE: Site[1] , Block, Precinct, Regional

2. PEOPLE/HA

People per hectare provides a measure of the number of people residing in any given area. Population density is a popular measure used for density at a regional or city level, but it can also be used at smaller scales. It is derived from an estimated number of people per dwelling unit, thus its formulation relies on the residential unit density measure. Thus, a prominent commercial area regardless of bulk building density would reflect limited density in terms of population.



APPLICABLE SCALE: Site, Block, Precinct, Regional

3. FAR

The Floor Area Ratio measures the intensity of physical property in any given area and is another frequently-used measure of density. It is a ratio of the total floor area of a building relative to the site or land parcel floor area. Important to note are the various land uses which can be contained (but are not captured in FAR) in the total floor area, either in the number of residential units or in office, recreational and retail floor areas. FAR gives a sense of the number of times a site or land parcel area has been packed onto a given site.

APPLICABLE SCALE: Site, Block

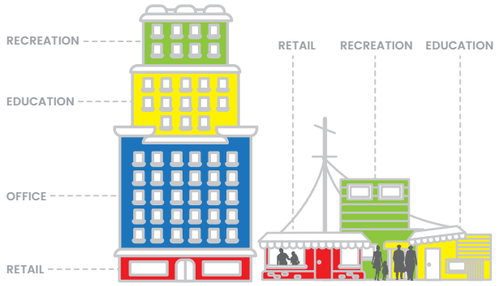
4. COVERAGE

Coverage measures the extent to which building footprints occupy a site or any given area and goes hand in hand with FAR indicating how much of the site or land parcel is covered at ground floor level. This is usually measured as a percentage. Coverage is important as it indicates the amount of site left for non-built up space that pedestrians can interact with at street level. Sites with low coverage have more opportunities to provide public or open space and incorporate the site into the wider public realm.

APPLICABLE SCALE: Site, Block

5. OTHER LAND USES (M²/HA)

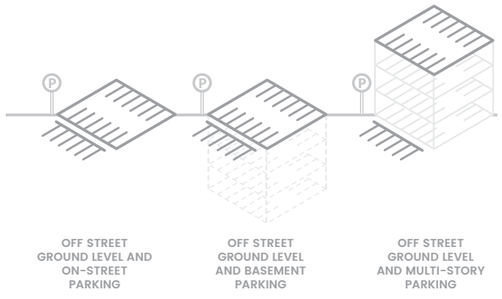
Other land uses provides a measure of the amount of space in any given area providing for land uses other than residential units. It is determined by measuring the floor area of parks, offices, shops, schools ect. found in the study area. Such measures are not captured in either unit or population densities. However, these uses do accommodate people throughout the course of the day and are important to consider in relation to public transport as, along with retail, educational and recreational space, it is a driving destination for the demand to travel. This measure refers to the actual use of the land rather than to zoning.



APPLICABLE SCALE: Site, Block, Precinct

6. PARKING BAYS (PER HA)

Parking bay density is a measure of the number of parking bays provided in any given area. It is important for understanding the extent to which a building, block or area is linked to public transport. A building or area with many parking spots may incentivise the use of cars. Similarly, fewer parking bays may serve as a disincentive to vehicle use.

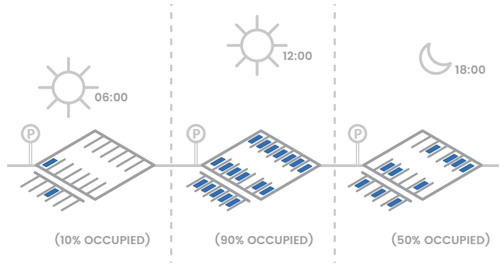


APPLICABLE SCALE: Site, Block, Precinct

TRANSIT ORIENTED DENSITY ASSESSMENT FRAMEWORK

7. PARKING OCCUPANCY (TIME SPACE)

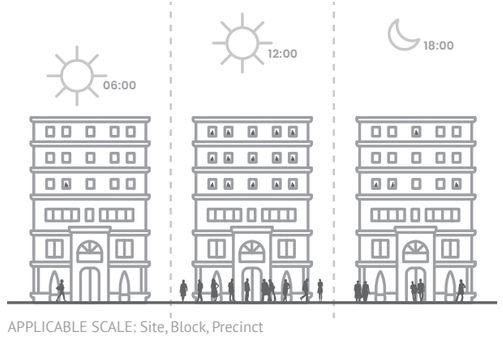
Parking occupancy is a time space (activity) density measure and indicates the different occupancy levels of parking bays throughout the course of the day. Understanding the extent to which parking bays are occupied during the day is important. In areas or buildings of mixed use, parking bay occupation would tend to be better spread throughout the day than in areas of single use. If an area or building is busy with people activity but parking bay occupancy is low, this may indicate that alternative modes of travel are servicing the site or area effectively.



APPLICABLE SCALE: Site, Block, Precinct

8. PEOPLE OCCUPANCY (TIME SPACE)

People occupancy is a time space (activity) density measure and indicates the changes in the number of people occupying the area of study throughout the course of the day. Rather difficult to measure accurately it is calculated by counting or observing and recording the number of people in any given area at selected times of the day. It is an important consideration for public transport as it is closely related to the demand to travel.



APPLICABLE SCALE: Site, Block, Precinct

QUALITATIVE CHARACTERISTICS

9. BUILDING ORIENTATION AND PEDESTRIAN ACCESS

This is a qualitative measure of the extent to which a building is oriented towards would-be public transport users. Its measurement is based on an assessment of the extent to which the building(s) in the study area maximises accessibility for pedestrians in their positioning and their entrance and exit points. An important consideration is where the parking bays are provided on the site and how pedestrians access the building. This measure is usefully supported by images and observations.

APPLICABLE SCALE: Site, Block

10. PEDESTRIAN REALM

This qualitative measure relates to understanding the pedestrian environment linking an area or site with a public transport station. It is relatively subjective, but can be assessed based on the quality of sidewalks, street crossing conditions, lighting, shading and signage for example. This measure is usefully supported by images and observations.

APPLICABLE SCALE: Site, Block

BRINGING THE POINTS OF THE FRAMEWORK TOGETHER

The purpose of a multi-dimensional framework is to understand how the measures come together to give a more informed and broader understanding of density. Figure 11 provides a 'score sheet' outlining how the various areas of measurement can be presented. This will carry through into the next section of the report in the case studies.

Figure 10. The points of the framework

QUANTITATIVE

FIXED

1. DWELLING UNITS/HA

500 / 0 — Varies, but between 100-400 is liveable higher density

2. PEOPLE/HA

1000 / 0 — Varies, but between 250-450 is liveable higher density

3. FAR

25 / 0 — Varies, but between 2 and 5 is 'liveable higher density

4. COVERAGE

100% / 0 — Varies, but 25%-75% is liveable high density

5. OTHER LAND USES (M²/HA)

Varies significantly between different areas and sites within a city or region. No set standards. A 'healthy' mix of other land uses to residential uses is good

6. PARKING BAYS (PER HA)

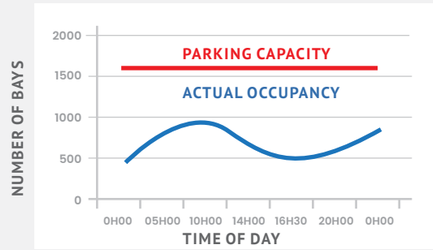
300 / 0 — Varies significantly, with set standards differing according to parking policy.* Lower levels are good

**Parking ratios for specific land uses exist and are applied to determine the amount of parking required per development*

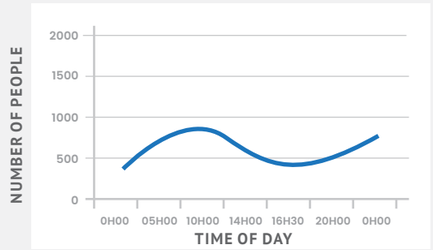
Note: The results indicated above are based on a scan of existing levels globally, these are not definitive and more research is required to establish relevant liveable and good density levels for the various contexts in South Africa

ACTIVITY

7. PARKING OCCUPANCY (TIME SPACE)



8. PEOPLE OCCUPANCY (TIME SPACE)



QUALITATIVE

9. BUILDING ORIENTATION AND PEDESTRIAN ACCESS

10. PEDESTRIAN REALM (WIDTH, TREES, LIGHTING, SURFACE)

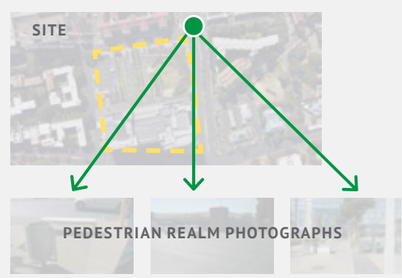
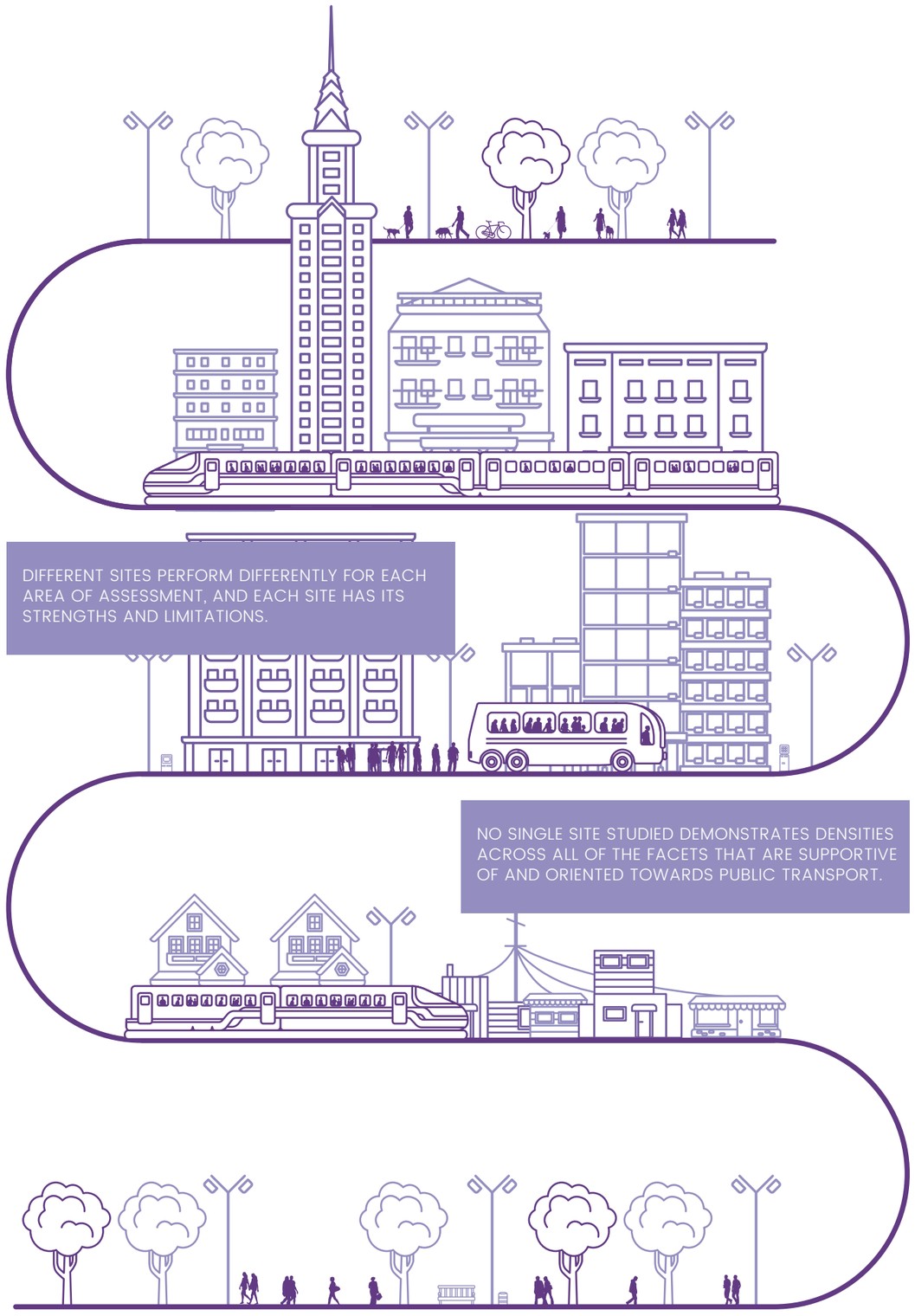


Figure 11. The framework score sheet



APPLYING THE FRAMEWORK

APPLYING THE FRAMEWORK

The framework provides an assessment tool for establishing the extent to which urban density is oriented towards public transport systems. This section of the report presents the findings of applying the framework to three different land sites in Gauteng which are in close proximity to public transport stations. The site level (smallest scale) has been selected to ensure the field research process is manageable. Carrying out the assessment at a wider scale might have provided different results; it is recognised that scale and context are important in informing the link between density and public transport. However, the main purpose of piloting the framework was to get an indication of the kind of results that the framework would produce, and its general feasibility. Its use was therefore exploratory. The case study sites assessed simply demonstrate what the framework is able to indicate about the current density profiles of urban environments surrounding existing public transport stations, and should provide the basis for further discussion and exploration.

Figure 12. Study sites in Gauteng context

STUDY AREAS

The case study sites[15] for the application of the framework are in Johannesburg, Tshwane and Ekurhuleni, the three metropolitan local municipalities in Gauteng. The sites are: the Standard Bank building in Rosebank, close to the Rosebank Gautrain station and on the corner of Oxford Road and Bolton Road; the National Research Foundation (NRF) office building in central Pretoria adjacent to the A Re Yeng BRT Central Station on Nana Sita Street; and a portion of Xubene, a neighbourhood of Tembisa, Ekurhuleni. Tembisa is north of Kempton Park and Xubene is located in close proximity to the Oakmoor Metro Rail Station. The framework has thus been applied at sites close to parts of the region's mass public transport systems. These sites were chosen for their widely differing contexts and urban conditions.

METHOD

Generating and accessing the data to populate the framework was the greatest challenge in applying this multi-dimensional assessment tool. The varying locations and contextual realities compounded this challenge, as information was not available in the same format for each site. An important insight from the study is the limited extent to which data is generally collected and available on a range of urban aspects. Various methods were thus used to populate the framework including a combination of desktop searches, aerial photograph analysis, contact with relevant property managers in the case of Rosebank and Pretoria, researcher observation during site visits and primary data capture and verification. The following table gives details about the techniques used to obtain the information per measure for each site.

[15] All of the case studies have been conducted at the site scale. This is considered to be a single erf or a similar sized land area comprising of a number of smaller erven.

INDICATOR	ROSEBANK	PRETORIA	TEMBISA
1. DWELLING UNITS/HA	There are no residential units on the site. This was verified through a site visit and asking the property manager.	There are no residential units on the site. This was verified through a site visit and asking the property manager.	This required a site visit to speak to people living in the study site to find out how many units it contains. This was supported with aerial photography analysis accessed from Google Earth.
2. PEOPLE/HA	There are no residential units at the site, as confirmed by the interview with the operations manager, who also confirmed that there is no one living in the office space.	There are no residential units in the site, as confirmed by the interview with the operations manager, who also confirmed that there is no one living in the office space.	This required going to the site and counting (through observation) the number of people living on an erf. Interviews were also conducted with residents of individual units and with neighbors of residents who were not at home.
3. FAR	The square meterage was obtained through interviews with the operations team, who had the information on hand.	The square meterage was obtained through interviews with the operations team, who had the information on hand.	The square meterage was estimated from Google Earth. A site visit was required in order to verify the measurements by observation. This method was required because residents did not know the square meterage of their residential units.
4. COVERAGE	The square meterage was obtained through interviews with the operations team, who had the information on hand.	The square meterage was obtained through interviews with the operations team, who had the information on hand.	The coverage was estimated from Google Earth and verified by a site visit.
5. OTHER LAND USES	This required a site visit and an interview with the operations team, who had the information on hand. The site visit was for verification processes but was restricted to three floors. Therefore acquiring this information was strongly dependent on information provided by the building operations team.	This required a site visit and an interview with the operations team, who had the information on hand. The site visit confirmed that the building provides only office space.	Obtaining this information was strongly dependent on observation and on gathering information from interviews with residents who may have various land uses in their yards. It therefore required door to door interviews, supplemented by information from Google Earth to determine the square meterage of the various land uses.
6. PARKING BAYS	This information was gathered through an interview with the operations manager, who had the information on hand.	This required a site visit to physically count the number of parking bays.	The number of parking bays in this case has been referred to as parking facilities. This required a site visit to do a physical count of the number of garages and possible parking facilities in each yard.
7. PARKING OCCUPANCY	Access to the parking facilities is not permitted. It therefore required an emailed request for the number of parking bays occupied throughout the day to be counted.	This required a site visit to conduct a spot count of the number of vehicles parked at various times throughout the day. In addition, interviews were held with office security and the operations manager to verify if cars are parked overnight.	This required a site visit to conduct a spot count of the number of vehicles parked in a yard or 'parking space' at various times throughout the day. In addition, interviews were conducted with residents to determine the number of vehicles owned in the study area and the times that the cars leave the area and return in the evenings.
8. PEOPLE OCCUPANCY	Information was gathered through observation at different times throughout the day. Interviews also took place with the operations manager to establish the time that people start work and leave the building.	Information was gathered through observation at different times throughout the day. Interviews also too place with the operations manager to establish the time that people start work and leave the building.	Information was gathered through observations carried out at different times throughout the day. Interviews were also conducted with residents to determine when people return from work, when they leave in the morning and when children are picked up from day care.
9. BUILDING ORIENTATION AND PEDESTRIAN ACCESS	This information was gathered through a site visit to determine the various access points into the building and the nature of the building's orientation.	This information was gathered through a site visit to determine the various access points into the building and the nature of the building's orientation.	This information was gathered through site visits to determine the various access points into the building and the nature of the building's orientation.
10. PEDESTRIAN REALM	This required a site visit to take images of the quality of the pedestrian realm and to understand the movement patterns from the site to the station.	This required a site visit to take images of the quality of the pedestrian realm and to understand the movement patterns from the site to the station.	This required a site visit to take images of the quality of the pedestrian realm and to understand the movement patterns from the site to the station.

CASE STUDY OUTCOMES

The following section of the report describes the outcomes of applying the framework in the three areas of enquiry shown in the table above. A brief contextualization of each site is provided, followed by the findings of the research exercise.

Standard Bank Building, Rosebank

Rosebank is a suburb in the north of central Johannesburg and is characterized by low densities and large residential stands typical of the city's early northern suburban expansion (Beavon, 2001). Rosebank has a long history of being served by public transport. The tram and trolley bus systems of the early 1900s ran through it along Oxford Road. The area's development was thus strongly informed by the presence of public transport. Later municipal bus services, a minibus taxi rank and most recently a Gautrain station have re-enforced Rosebank as an area well served by public transport. Under apartheid, the broader Rosebank area was designated as a white local authority. It was home to many wealthy residents and was thus a relatively wealthy municipality. A combination of increased private car ownership and use, and the end of apartheid, led many businesses to relocate from inner Johannesburg to areas previously designated as white local councils such as Rosebank, Sandton and Randburg.

Rosebank thus has a historic relationship with public transport and is one of Johannesburg's most established transit-linked suburbs, displaying higher densities and more mixed land use than many other suburbs of the city. However, the high growth in private vehicle numbers in recent years has resulted in development which maximises vehicle access and parking facilities despite the continued presence of public transport facilities.

The Standard Bank building was chosen as the research site in Rosebank in order to gain insight into this recently developed property close to the Gautrain Station. The building is the result of a redevelopment process which replaced a number of mixed-use buildings on the site. Construction was completed in 2012.

National Research Foundation Offices, Central Pretoria

Map data: Google, AfriGIS (Pty) Ltd

Figure 13. Rosebank, Standard Bank building site context

QUANTITATIVE

FIXED

1. DWELLING UNITS/HA

0

2. PEOPLE/HA

0

3. FAR

5,9

4. COVERAGE

34%

5. OTHER LAND USES (M²/HA)

Office m²/ha	28 081
Retail m²/ha	245**
Education m²/ha	0
Health and Recreation m²/ha	2 366**

** controlled access

6. PARKING BAYS (PER HA)

1 567

OFF STREET / GROUND **47%**

BASEMENT **53%**

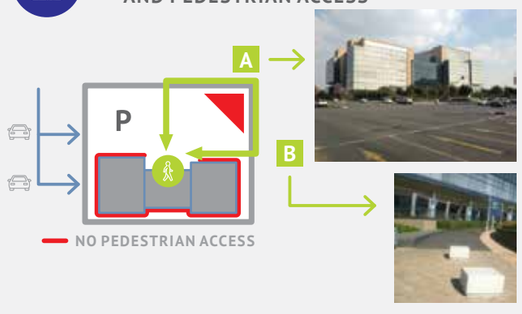
ACTIVITY

7. PARKING OCCUPANCY (TIME SPACE)

8. PEOPLE OCCUPANCY (TIME SPACE)

QUALITATIVE

9. BUILDING ORIENTATION AND PEDESTRIAN ACCESS



10. PEDESTRIAN REALM (WIDTH, TREES, LIGHTING, SURFACE)

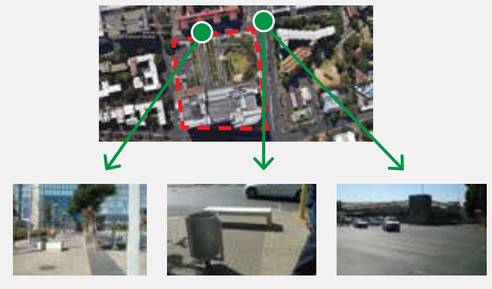


Figure 14. Framework results for Standard Bank case study site

Pretoria is the capital city of South Africa. It was established in 1855 and, like the other cities in South Africa, its development was underpinned by public transport from the late 1800s to the mid-1900s. In 1897, a horse-drawn tram system was introduced, serving short and longer distances. This system was replaced by electric trams in 1910. The routes ran from Church Square to Pretoria Station, the Zoo, Sunnyside, Pretoria West and the Ou Volks Hospital and later to the Union Buildings (Martins, 2014). The site selected for study in Pretoria is in the inner city and would have been in close proximity to the Pretoria Station tram route. It thus has a long-standing urban fabric supported by public transport access. Inner city environments are by nature denser, mixed-use and pedestrian friendly because of their historical relationship with pedestrian and public transport-based travel.

The A Re Yeng Bus Rapid Transit System is a newly-developed mode of transport in the city. The chosen research site is adjacent to the A Re Yeng central station, and is an office building within a block which has a range of land uses. The building, at 211 Nana Sita Street, has existed for a relatively long period. It was previously used as the Science and Technology Museum before being converted to an office of the National Research Foundation.

Map data: Google, AfriGIS (Pty) Ltd

Figure 15. Pretoria, NRF building site context

Figure 16. Framework results for NRF case study site

QUANTITATIVE

FIXED

1. DWELLING UNITS/HA

0

2. PEOPLE/HA

0

3. FAR

0,8

2 STORIES

4. COVERAGE

40%

5. OTHER LAND USES (M²/HA)

Office m²/ha	8 000
Retail m²/ha	0
Education m²/ha	0
Health and Recreation m²/ha	0

6. PARKING BAYS (PER HA)

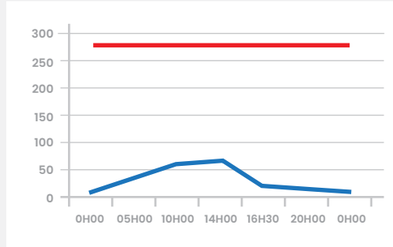
276

OFF STREET / GROUND **47%**

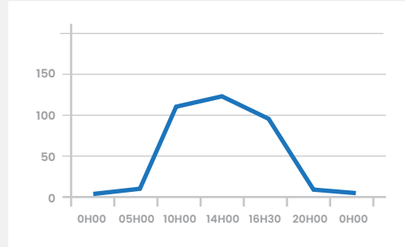
BASEMENT **53%**

ACTIVITY

7. PARKING OCCUPANCY (TIME SPACE)

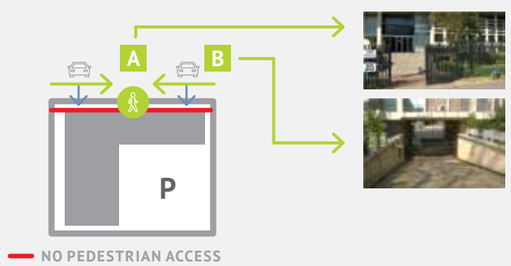


8. PEOPLE OCCUPANCY (TIME SPACE)

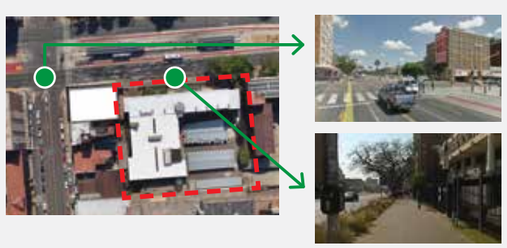


QUALITATIVE

9. BUILDING ORIENTATION AND PEDESTRIAN ACCESS



10. PEDESTRIAN REALM (WIDTH, TREES, LIGHTING, SURFACE)



Portion of Xubene, Tembisa

Xubene is located in Tembisa in the City of Ekurhuleni metropolitan municipality which adjoins Johannesburg to the east. Tembisa was established in 1957, during the apartheid era, when land was purchased to resettle black people from Alexandra and from white areas in Edenvale, Kempton Park, Midrand and Germiston (Moloi 2005). It was at that time categorized as a township under a Black Local Authority. Tembisa is well serviced with railway infrastructure. At that time, rail primarily transported freight to and from mines and industry. It was also a mode of transport used to facilitate, but also to control access to and from, peripherally located black communities. Residents of Xubene, which is located close to the rail station, have a long-standing relationship with train travel.

The area has a vibrant mix of land uses, including formal and informal businesses, residential units and educational facilities. The rail station, along with long and short distance taxi ranks, make Xubene a vibrant and busy hub in the area. The strong access that the site provides has resulted in the construction of numerous backyard rooms and to subletting and informal businesses in the catchment area.

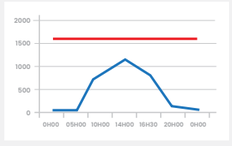
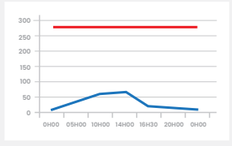
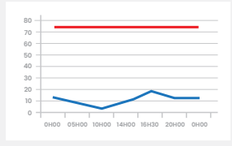
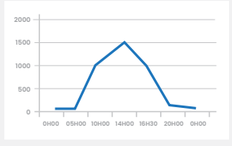
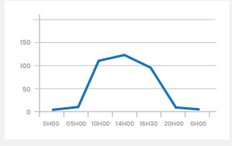
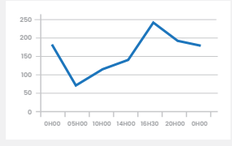
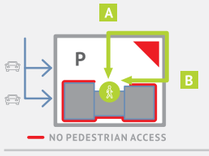
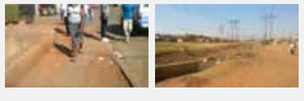
The properties on the study site have been in existence for some time. However, the dynamism of the area means that change is constant and fairly rapid, with many owners upgrading, expanding and converting their properties.

Map data: Google, AfriGIS (Pty) Ltd

Figure 17. Tembisa, Xubene site context

Figure. 18 Framework results for Xubene case study site

Figure. 18 Framework results for Xubene case study site

	STANDARD BANK BUILDING, ROSEBANK	NATIONAL RESEARCH FOUNDATION OFFICES, CENTRAL PRETORIA	PORTION OF XUBENE, TEMBISA
QUANTITATIVE			
FIXED			
1. DWELLING UNITS/HA	0	0	64
2. PEOPLE/HA	0	0	184
3. FAR	5,9	0,8	0,38
	9 STORIES 11 STORIES	2 STORIES	1 STORY BUILDINGS
4. COVERAGE	34%	40%	36%
5. OTHER LAND USES (M^2/HA)			
Office m^2/ha	28 081	8 000	0
Retail m^2/ha	245	0	853
Education m^2/ha	0	0	61
Health and Recreation m^2/ha	2 366	0	0
6. PARKING BAYS (PER HA)	1 567	276	74
	OFF STREET / GROUND 47% BASEMENT 53%	OFF STREET / GROUND 47% BASEMENT 53%	GROUND 47%
FIXED			
7. PARKING OCCUPANCY (TIME SPACE)			
8. PEOPLE OCCUPANCY (TIME SPACE)			
QUALITATIVE			
9. BUILDING ORIENTATION AND PEDESTRIAN ACCESS			
10. PEDESTRIAN REALM (WIDTH, TREES, LIGHTING, SURFACE)			

COMPARISON

As Figure.19 shows, the three sites differ to varying degrees in relation to the ten aspects of the multi-dimensional framework that was developed for and used in the research. For instance, the Rosebank and Pretoria case studies have zero unit density and therefore zero population density. However, the people occupancy measures indicate that, during the working day, up to 2 000 people/ha occupy the Standard Bank building and approximately 110 people/ha occupy the Pretoria building. Assessed individually, these three measures would paint very different pictures of the density of the sites.

It is also interesting to note that the Xubene and, to a lesser extent, NRF sites show people occupancy significantly outstripping parking occupancy at the busiest times of the day. Perhaps indicating more prominent public transport based access for these sites. Furthermore, the daily people occupancy profile of Xubene demonstrates a much more even spread of people activity throughout the day than is the case with the other two study areas. This can be attributed to its strong mix of publicly accessible land uses.

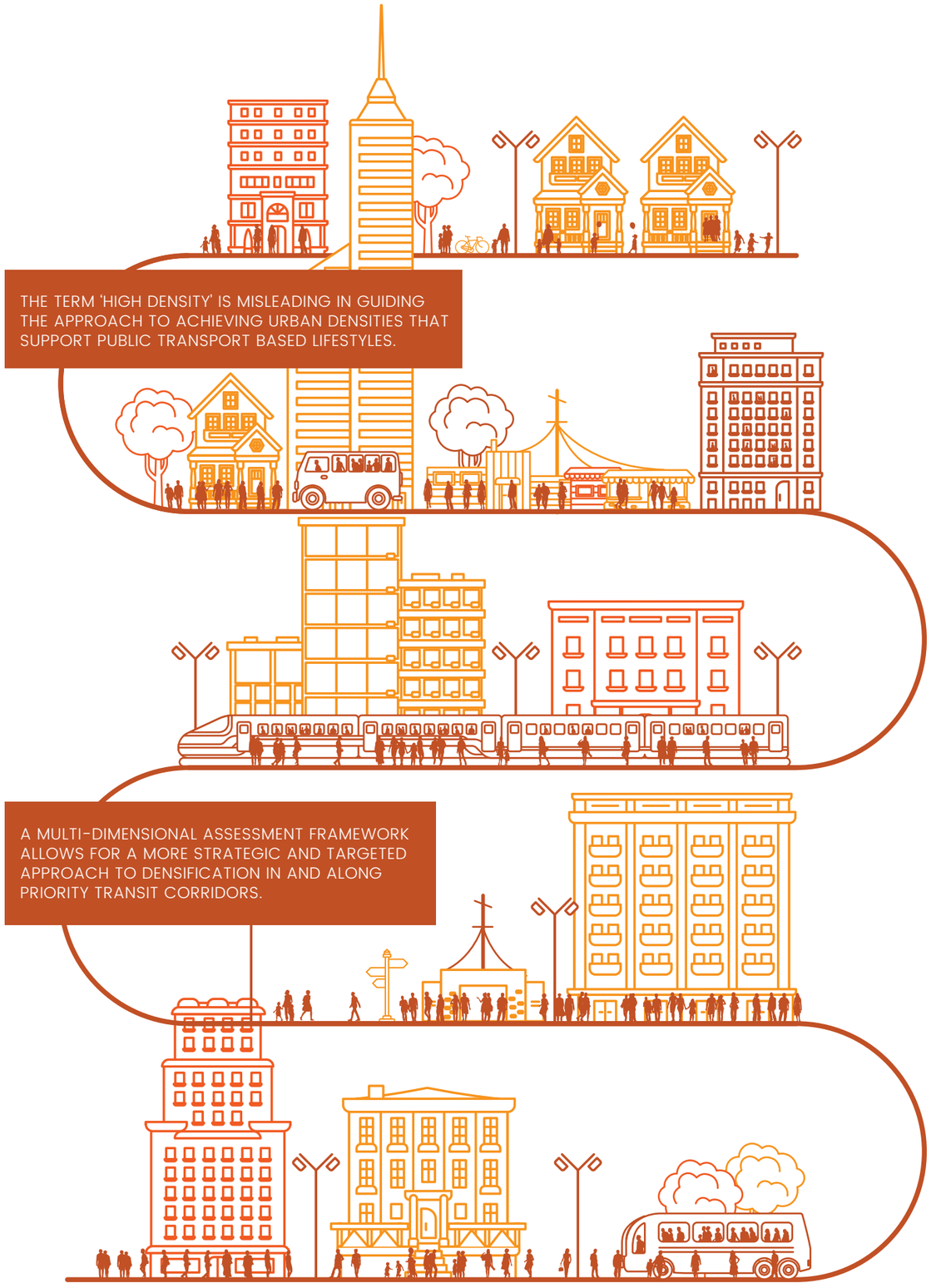
Of the three areas studied, the Pretoria case had the best pedestrian environment in terms of access and quality. This can be attributed to the historical pedestrian orientation of the urban fabric. The Standard Bank building in Rosebank presents a relatively good pedestrian realm, although street crossing conditions, lighting and shade could be significantly improved and from a street frontage and access perspective it could be better oriented towards the station. Xubene presents the poorest quality walking environment, with no paving, shading, lighting or public furniture. However, the building access and street frontage conditions are well oriented to people walking from the station, the other sites buildings do not provide active fronts onto the streets they face.

What do the case studies tell us?

1. The historical context of each of the sites has played a fundamental role in their present links with public transport.
2. The findings that result from using the framework indicate different performances for each of the sites across the ten indicators.
3. No site studied displays density which fully supports public transport.[16] Each has room to improve and the framework may assist in identifying specific areas for improvement.
4. Accessing the data required to populate a multi-dimensional framework is not easy. However, persisting with doing so should result in findings that give an improved understanding of public transport supportive density.

Left: Figure. 19 case study site framework results comparison

[16] This statement is based on the authors' assessment relative to a scan of international conditions more research is required to understand in greater detail the extent of the deficiencies that exist in local areas surrounding stations across South African cities.



CONCLUSION

CONCLUSION

Plans to densify areas have been strongly associated with public transport system improvements in South African cities. This study set out to understand what high density which relates to public transport entails, and how best to assess the extent to which it is being achieved.

Urban density is about more than buildings and static population figures. However, currently these are the measures utilised for assessment and there is widespread agreement that they are limiting. Viewing urban density as multifaceted is a first and important step towards better understanding how people interact with the built environment. If South African cities are to achieve the objectives of more sustainable growth through higher urban density, then interrogating the many layers of density is important. This report has indicated that there is a strong argument for viewing the higher densities associated with public transport as involving more than simply population and housing unit concentrations. A broader definition of density can ensure that assessing an area's built environment looks not only at its structures but more systematically encompasses a range of relevant facets. Drawing on TOD principles, the report has proposed a framework for assessing density in relation to actual or potential use of public transport. This framework represents an exploratory approach to assessing the densities required to support public transport systems.

The application of the framework indicates that there is no single built form which can be defined as 'high density'. Rather, different forms can exhibit similar density characteristics and similar forms can exhibit different density characteristics. What is important to note is that none of the case study sites examined for this study exhibited strong transit oriented densities when assessed across all areas of the proposed framework. Each has areas of strength and areas for improvement.[17] Applying the framework on a broader scale might give different results. However, it is important to consider the human scale when thinking about the framework and how it should be used - What can be accessed within comfortable walking distance from the public transport station? This report suggests that applying this density approach in priority areas may give municipalities a more informed understanding of deficiencies or strengths in the densities of the areas surrounding public transport stations.

This report acknowledges that density, and especially dynamic densities, are not easy to measure accurately. However, using the framework demonstrates that understanding the broad flows of people and vehicles is not only essential but achievable. Data collection and availability can be greatly improved in many of the measurement facets reported in the framework.

The framework presented in this report is intended to provide a broader insight into how we think about the densities associated with public transport. It is hoped that it will assist planners, architects, politicians and community members with better understanding the notion of urban densification along public transport corridors. The ideas proposed here are not 'set in stone' and should be further debated and expanded. What this work has made clear, however, is that the term high density is misleading in guiding the approach to thinking about urban densities that enable public transport based lifestyles to thrive. In this regard there are real benefits in a multi-dimensional approach to assessing density. Ultimately, the goal is to achieve more sustainable land use-transport relationships.

[17] This is considered in relation to the authors' assessment of international conditions.

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GLOSSARY

Coverage	The percentage of the site area that is covered by the building area
Dwelling	A structure where an individual lives with a family or by him/herself
Dwelling unit	A structure or part of a structure that is used as a home
Floor area	Floor space in a building
Floor area ratio	The ratio of a building's floor area to the size of the piece of land upon which it is built
Mixed land use	A combination of different land uses found in a given area
Open space	Non-built up urban land set aside for usage such as parks
Parking bay	Space clearly demarcated for parking a single vehicle
Parking bay occupancy	The number of cars parked in a parking facility at a particular point in time
Pedestrian realm	Areas that pedestrians move in and between, such as sidewalks, street crossings, squares and parks
People occupancy	The number of people on a site or stopping at the site for any reason at a particular point in time
Transit orientated development	Mixed use residential and commercial area designed to maximise access to public transport. Often incorporates features to encourage transit ridership.

ABBREVIATIONS

TOD	Transit Oriented Development
FAR	Floor area ratio
NRF	National Research Foundation

APPENDIX: METHODOLOGY

Site Identification

Three sites were selected in Gauteng, in the Cities of Johannesburg, Pretoria and Ekurhuleni. Each was chosen for its proximity to a transit station. Identification of the sites was done using Google Maps. This was followed by an in-house consultative process and a verification process through site visits. The objective of the consultative process was to attain an opinion of the sites selected and that of the field work to ensure that the site was in proximity to a functional transit station and to familiarize the researchers with the site.

A number of criteria were used when identifying the sites. The public transport stations (Gautrain, Bus Rapid Transit System and Metro Rail) had to be within walking distance. The systems to which they had access varied. Xubene in Tembisa does not have a Bus Rapid Transit System. The Gautrain does not run within walking distance of Xubene's various land uses. Therefore in the case of this study area the relevant transport system was Metro Rail. In Rosebank, the Gautrain was studied and in Pretoria the Bus Rapid Transit System.

Measuring the quantitative

Quantitative measures were collated through Google Earth measurement, site verification and interviews with a member of the facilities operation team. A broadly similar process for gathering information was used at the three sites, although there were dissimilarities. At the Standard Bank Building site, the main method was through sourcing information from the property management personel and City of Johannesburg GIS maps. Raw data was not readily available; therefore, electronic and telephonic interviews with different members of the facilities' operations teams were conducted in order to obtain information. Research at the NRF study site followed a similar process, although acquisition of information was based on a site visit and interviews. The site visit enabled an understanding of the square meterage of the site, later verified by the operations team and Google Earth measurements. In the case of Xubene, a desktop study using Google Earth was carried out. As there is no facility in the sense of those at Rosebank and in Pretoria, there were no interviews with a facilities operations team. However, there were interviews with residents. In addition, the data collected was done through site visit based observation and physical information capturing on the site as per the framework.

The table below summarises how the information was collected. Note that the area of the sites varied and a conversion factor is utilised to allow per hectare comparison.

INDICATOR	ROSEBANK	PRETORIA	TEMBISA	FORMULA
Conversion factor	**0,4**	**2**	**2**	
1. Dwelling Units/ha	Through field interviews and Google Earth. There are no residential units on the site.	Through field interviews and Google Earth. There are no residential units on the site	Through observation, Google Earth and interviews. The research identified 32 houses.	Number of houses/ site area x conversion factor
2. People/ha	Through field interviews and Google Earth. There are no residential units on the site.	Through field interviews and Google Earth. There are no residential units on the site.	Through observation and informal discussion (interviews). The research identified a population of 92.	Number of people/ site area x conversion factor

3. FAR	The operations team and Google Earth concluded the following: • Building area: 144 000m2 • Site area: 24 596m2	The operations team and Google Earth concluded the following: • Building area: 4 000m2 • Site area: 5 000m2	Observation and Google Earth concluded the following: • Built up area: 2 022m2 • Site area: 5 007m2	Total built up area/site area x conversion factor
4. Coverage	The operations team indicated: • Ground floor area: 8 404m2	The operations team indicated: • Ground floor area: 2 000m2	Observation and Google Earth indicated the following: • Ground floor area: 1 809m2 For the number of double storeys, the ground floor area would be multiplied by the number of floors.	Ground floor area/site area x conversion factor
5. Other Land Uses	Observation and telephonic interviews indicated the following: Retail space on the ground floor, park space on the site, 2nd floor, 6th floor and a wellness centre:	Observation indicated that there are no other land uses	Observation, Google Earth measurement and door-to-door interviews indicated a preschool and various trading space amounting to approximately 426m2(squared sign)	Land use area in m^2 x conversion factor/ Ha
6. Parking Bays	Electronic interviews indicated that there are 3 904 parking ays. This multiplied by the conversion factor provides 1587 parking bays per hectare.	A physical count indicates that there are 138 parking bays. This multiplied by a factor of 2 to provide 276 per hectare	An estimation based on the number of households indicates that there are approximately 37 parking bays. This multiplied by a factor of 2 to provide 74 per hectare	Number of parking bays x converstion factor
7. Parking Bay Occupancy	Information received from facilities management indicated activity at various hours	Physical count indicated activity at various hours	Physical count indicated activity at various hours	
8. People Occupancy	Based on observation	Based on observation	Based on observation	

[17] Conversion for Rosebank is 0.40 and for Pretoria and Xubene is 2

Measuring the qualitative

Obtaining qualitative measures is best done through electronic interviews and observation. This required the researcher to be on site for whole days but with a particular focus on peak hours: 05h00-10h00, 12h00-14h00 and 16h00-21h00. Qualitative measures were obtained through observing the use of and movement through the sites. The table below summarises the data collected.

INDICATOR	ROSEBANK	PRETORIA	TEMBISA
9. Building orientation and pedestrian access	Based on observation and aerial photography sourced from Google Earth	Based on observation and aerial photography sourced from Google Earth	Based on observation and aerial photography sourced from Google Earth
10. Pedestrian realm design on route to station	Based on observation and recorded through photographs taken on site visit	Based on observation and recorded through photographs taken on site visit	Based on observation and recorded through photographs taken on site visit

Each research technique aimed at acquiring the most accurate information available. The techniques were used over a two-month period. In addition, there were ad hoc site visits and electronic interviews as needed in order to access additional or missing information.

Assumptions and limitations

It is recognised that the research method made assumptions and had limitations. There was no comparative data against which verify the collected data; and information obtained at Rosebank was predominantly derived from meetings with facility management personal, as access to the building and surrounds was controlled, whilst in Pretoria and Tembisa desktop studies and observation was the primary method for capturing data. The fieldwork reflects the work of a single 'average' working day on site and not of a more extended period.

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