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Integrating Land Use Planning and Urban Transport for Low Carbon Cities

(Background Paper for Asian Mayors EST Session-4)

Final Draft

This background paper has been prepared by Mr. Santhosh Kodukula, for the Eleventh Regional EST Forum in Asia. The views expressed herein are those of the author only and do not necessarily reflect the views of the United Nations.

Integrating

Land Use Planning

and Urban Transport

for Low Carbon Cities

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1. Introduction

More than half of humanity lives in cities. The world as of date has more cities than a decade or two decades ago. Cities are economic hubs teeming with jobs and opportunities, and thus attract people from various walks of life in becoming urbanites. The rising population in cities increases the demand for basic services including urban space, which is limited.

The United Nations estimates that by 2050 over 68% of the world's population will be urban. This growth is triggered by both an increase in population and by population migrating to urban areas (United Nations, 2018). This means that there will be more demand for urban space and for the provision of services to the growing population. The infrastructure provided now in cities will decide its social, environmental and economic characteristics of the future.

By 2030 the area occupied by urban land could globally triple (Seto, Guneralp, & Hutyra, 2012). Majority of this urban growth will occur in China, India and Africa. In other words, under the current growth trends, our cities will not only grow in their population size but also in the area they occupy. The increase in area of the cities can have a very profound impact on the way we live, work and move.

The unplanned growth in demand to live in cities comes at a cost of deteriorated urban quality of life, loss of green areas and a high demand for movement especially on motorised modes. In order to meet the demands for new residents cities grow in size, usually by engulfing the neighbouring small towns, villages into the existing municipality. In many cases the previously fertile land is transformed into urban land. This phenomenon of unplanned growth in cities is called *urban sprawl*. In some cases, cities authorise new urban development on the periphery of the city to manage demand for housing. These new residential areas are usually far from an urban centre and the residents need to commute to work and leisure to the urban centre. The situation we describe is related to, and a result of, how land in a city is planned and the kind of transport mode serves the mobility needs.

Majority of the migrants to urban areas are attracted by the changing lifestyles in cities and growing income levels. The attraction of cities comes with a great competition and challenge, both to the new migrants and to the decision makers. They face challenges in accessing and providing affordable residential space, mobility that connects destinations, access to jobs and to basic services such as potable water and cleaner urban areas. Some of the important challenges our cities, mainly in emerging economies, face are:

a. Requirement of greater investments in urban infrastructure to meet the growing needs;

b. Increasing economic and social costs due to loss of liveability, both as a result of fast urbanisation;

c. Increasing air pollution and loss of green spaces;

d. Growing social exclusion due to increasing size of urban areas and displacement of people to urban periphery.

Decision-makers and urban planners grapple to provide a safe, affordable, healthy and liveable urban area for all the existing, incoming and prospective citizens of the city. Decision makers are under immense pressure to take fast decisions and the right decisions.

In the rest of this publication we will highlight the concept of urban land-use and its relation with urban mobility. We will highlight the importance of integrating urban mobility and land-use and the positive externalities from such integration. We will draw examples from various cities around the world and underline the importance of human-centric urban planning emphasising the importance of access in an urban setting.

We will also explore the aspects of compactness through land-use policies and connectedness through the integration of urban mobility with land-use. We put forward a preposition that some of the urban issues that our cities are facing, especially in the urban mobility sector, can be addressed through better land-use planning and proper integration with sustainable urban mobility modes.

2. Land Use and Transport

2.1. Land Use

Land is a non-renewable and a limited resource. It is heavily influenced both by political decisions and market fluctuations. To manage land, city planners allocate the available land for various functions i.e. *land-use*. For modernist urban planners, land-use planning involved in allocating certain land for commercial activities, certain parts for residential and industrial activities (Robert Cervero, 2017). While, this planning paradigm (also called segregated land-use planning) worked at the time of its conception, over the recent decades as urban populations grew, lifestyles changed, and innovative mobility modes emerged, the segregated land-use resulted in increased distances between residential and commercial areas. The growth in cities also had a direct impact on prices of the land, making peripheral land cheaper and thus driving prospective home owners farther.

Most cities in developing countries, but also in North America, show a functional classification of land uses varying according to the distance from the city centre (central business district or CBD). In the centre where land prices are highest we find high-rise buildings mainly for offices and some shopping facilities. Some cities still have a traditional core city within the modern CBD. The inner city areas surrounding the CBD show a mixture of housing and commercial activities, typically in block buildings of 4 to 6 floors. In the outer urban areas, older housing areas with detached and semi-detached houses mix with concentrations around sub-centres. Additional housing development concentrates near the outer boundaries of the city, these housing areas are usually of low densities.

In the last century, however, cities have undergone various re-structuring phases. First, manufacturing facilities and other transport-intensive commercial activities have moved from central areas to cheaper locations at the fringes, changing also the directions of working trips. Commuters tend to shift to private cars, when commuting from housing areas to the fringe areas is more complicated by public transport than travelling to the centre, because the transit network has not been designed for it.

The second wave of restructuring of the urban landscape changed the direction and destinations of shopping trips. With increasing car ownership, consumer preferences shifted to larger shopping facilities with extended parking space. Large supermarkets and mega-stores took advantage of the fact that land at the outskirts of the cities was cheap. Public transport only holds minor shares of these shopping trips to the outskirts.

In recent decades, company headquarters and other offices have also moved to the edges of the cities, while CBDs typically retain consumer and business services. Although city centres still attract high volumes of both public transport trips and individual car traffic, a major share of trips are made

from suburb to suburb. In European cities and to a greater extent in North America, public transport cannot serve such dispersed activities without substantial subsidies.

Figure 1: shows the residential densities in various cities across the world. It can be noted that the densities in many cities is high in the core and reduces as cities grow.

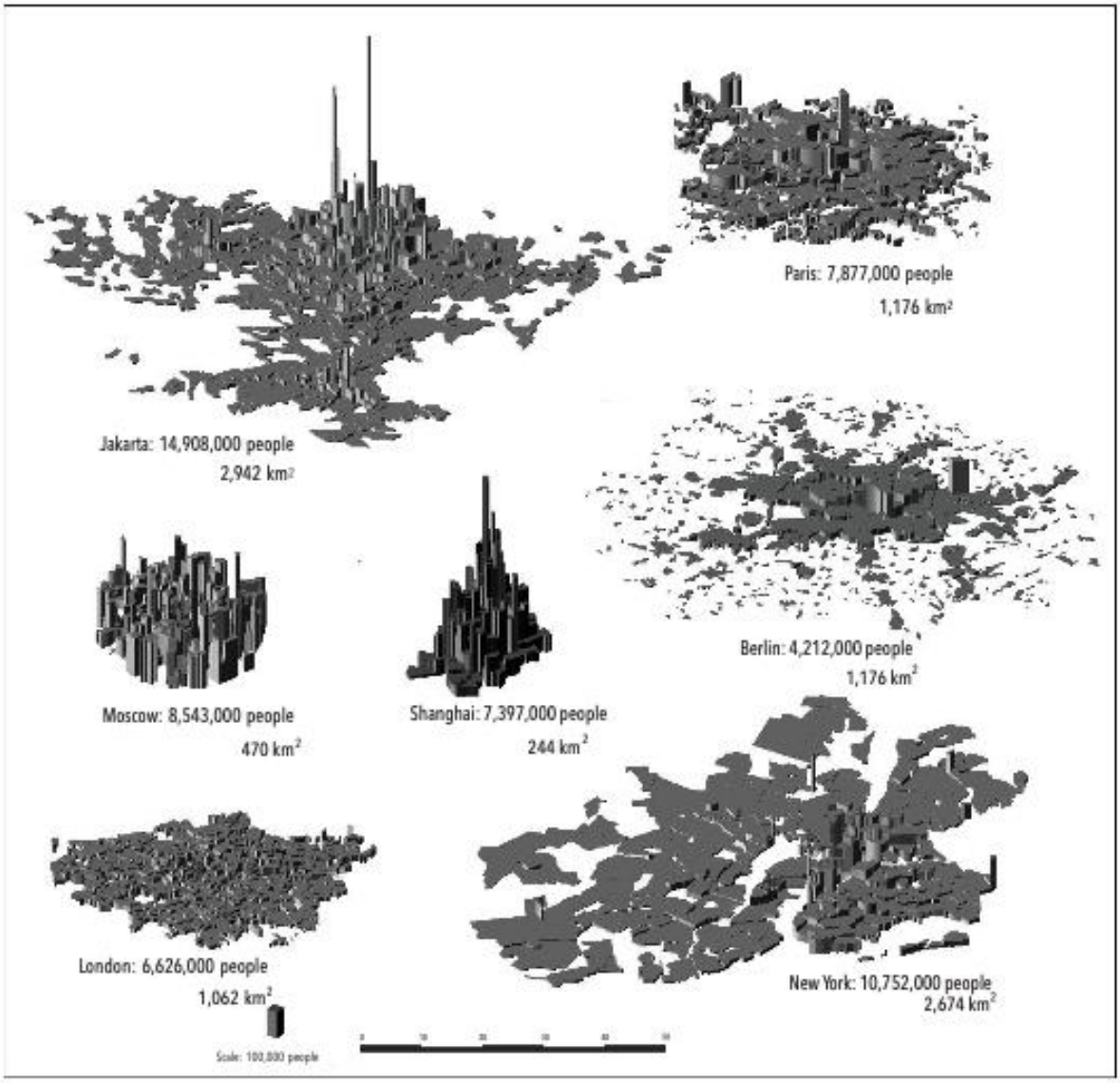


Figure 1: **Residential densities in global cities**

Source: Bertaud, 2001

A city with a greater urban footprint i.e. larger in size, has low density and high demand for resources. Sprawling cities need large investments to maintain and provide basic infrastructure and need longer time to reach destinations. The environmental effects of sprawling cities is also negative due to the high dependence on energy, usually produced from burning fossil fuels.

Research and experience across cities worldwide has shown that if cities are compact and are connected then there is a better chance for cities to be sustainable and address various urban needs with less or no negative effects on the environment, economy and society (Lefèvre, 2009). Compact and connected cities have the potential to greatly reduce the greenhouse gas (GHG) emissions and increase the quality of life. Compact cities will also help countries and cities to save fiscal resources spent on infrastructure such as roads. A study of the World Bank in China estimates that by 2030 Chinese cities could achieve higher economic growth and productivity if compact urban development pathways were adopted (World Bank, 2014). Compact cities create enabling conditions to increase the efficiency of urban mobility systems and reduce travel times to access jobs and services.

2.2. Mobility in our cities

Rising incomes enable people purchase their first automobile, usually a two wheeler. Depending on the income rise and favourable vehicle financing options, people may even purchase a four-wheeler i.e. a car.

Further, the growth in personal automobile use is perceived as a norm of economic development and urban policies tend to encourage automobile use. The traditional transport models and estimates predict an increase in automobile use and a usual prescription is provision of infrastructure that caters for the prospective new motorists. This phenomenon is usually termed as the *predict and provide* method.

Any negative impacts, such as traffic congestion, increased accidents and pollution, and reduced mobility for non-drivers, is considered to be a short-term cost of increased affluence which can be reduced with infrastructure development and technological improvements. The paradigm of solving traffic problems by providing more infrastructure leads to a *vicious cycle* of urban mobility (see Figure 2:).

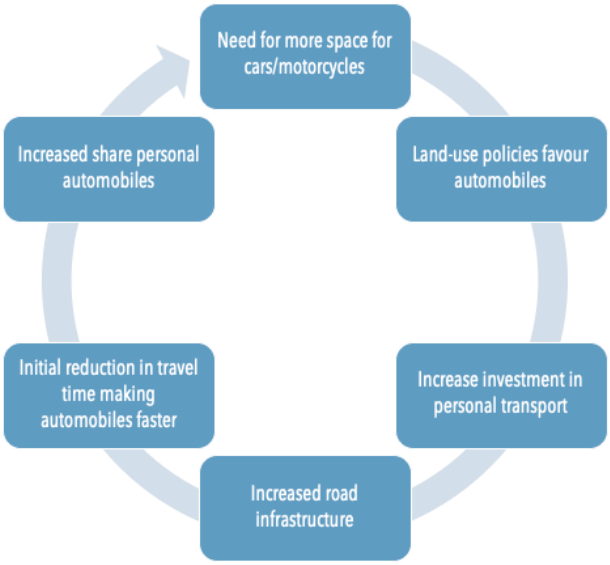


Figure 2: Vicious transport cycle

The provision of automobile friendly infrastructure, for example, wider streets and generous parking, acts as a catalyst for a further increase in automobile growth. A report by the international energy agency estimates that, by 2050 India's need for surface parking will reach 20,000 km^2 (Dulac, 2013), which is approximately 13 times the size of London or 35 times of Mumbai or 2.8 million soccer fields.

The effects of urban automobile growth are not limited to the urban area but also spread in the region and affect global climate. A report from the International Council for Clean Transportation shows that road transport is responsible for over 70% of global transport emissions and of which over 50% is from urban vehicles (see Figure 3:).

The International Transport Forum (ITF) predicts that under the business as usual scenario the CO2 emissions from urban transport will grow by more than 26% between 2015 – 2050 (OECD, 2017). The ITF predicts the majority of the increase in vehicular fleet will occur in India and China. The emissions increase will be mainly from personal cars and motorcycles.

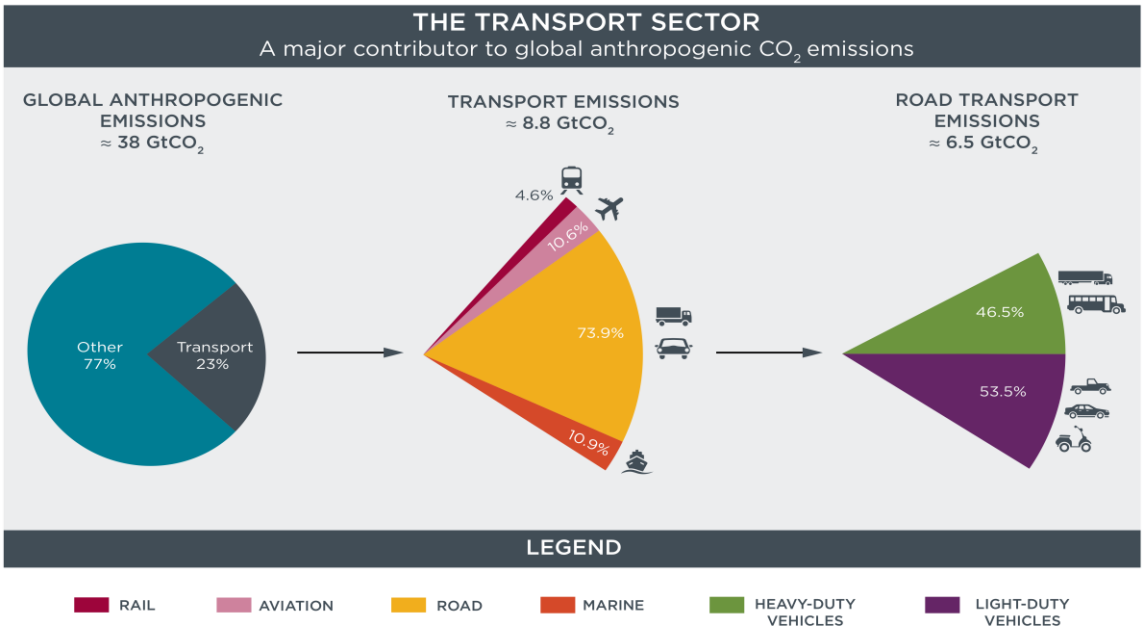


Figure 3: **CO_2 emissions from urban transport**

Source: (Kodjak, 2015)

However, many of the assumptions such as the link between automobile use and economic growth are incorrect. Although a certain amount of automobile travel is efficient and productive, beyond an optimal level, increased driving is harmful overall and reduces economic development, as discussed later in this paper. An optimal transport system is diverse and efficient; it offers travellers a variety of accessibility options, and incentives that favour higher value trips and more efficient modes, so users will select the most efficient option for each trip.

Compact cities prioritise access for people to goods and services. People in compact cities (or compact city centres) have a higher propensity to walk and bicycle, not out of compulsion but because the conditions support walking and cycling. Compact cities, encourage walking and cycling primarily through better land-use policies that favour higher density, diverse landuse and a design favouring walking and cycling. By influencing the spatial structure of locations in the urban environment, land use planning can contribute to reducing vehicle kilometres travelled. Transport policies that encourage walking and cycling, support compact city structure and contain the trips within the city.

2.3. Interaction between land use and transport

Our cities are defined by the kind of interaction between land-use and the kind of mode we use for travelling. Transport policies significantly affect development density and vice versa. Transport facilities (sidewalks, paths, roads, parking lots, rail lines and stations, ports and airports) use a major portion of urban land, ranging from 20-40% in residential neighbourhoods and 40-60% in commercial centres (downtowns, shopping malls and industrial parks).

Studies have shown that cities have a high share of walking and cycling, when high density and mixed land-use is encouraged (Cervero & Kockelman, 1997; Fillone & Mateo-Babiano, 2018; Gerike et al., 2016; Inturri, Ignaccolo, Le Pira, Caprì, & Giuffrida, 2017). Conversely, oil consumption and greenhouse gas emissions will inevitably increase rapidly if transport and land use policies encourage automobile use. Hence, cities can be broadly classified into automobile dependent cities and compact cities.

Automobile dependent cities allocate more space to automobiles and their related infrastructure, than other modes e.g. public transport, walking and cycling. The increased need for space is due to the priority given to automobiles. As travel speeds increase, vehicles require more clearance from other objects, including wider lanes and more distance between vehicles (Kodukula, 2011). Vehicles also require parking at destinations. There are typically two to six parking spaces per vehicle (one at home, one at work, plus various other destinations).

Of course, walking, cycling and public transport travel are generally slower than driving. They provide less *mobility* (users cannot travel as far in a given time period) and so they require more land use *accessibility* (they require that people live closer to where they work, shop and recreate).

In other words, when urban planning prioritises accessibility over mobility opportunities for high density and mixed land-use are immediately visible. Conversely, prioritising mobility over access enables citizens to travel more (i.e. be mobile).

2.4. Interaction between land use and energy

As we have seen above, there is a strong relation between the land use and the kind of transport we use. Similarly, there have been various studies that highlight the intricate dependence between land use and the energy consumed in cities.

International comparative studies have indicated that there are close links between population density, motor vehicle use and per-capita energy consumption in the urban transport sector. The graph below shows the comparison of energy consumed vs urban density. It can be observed that as the urban density increases the energy consumed for transport also reduces (Kenworthy & Laube, 1996). Cities in the developing world are at the lower end of the graph while the heavily car dependent cities from North America and Australia are on the higher end of energy consumption and

have a very low urban density. Further researches (Litman, 2018; Kane & Whitehead, 2018; Schwanen, Dijst, & Dieleman, 2016) corroborated the argument posed by Kenworthy and Laube.

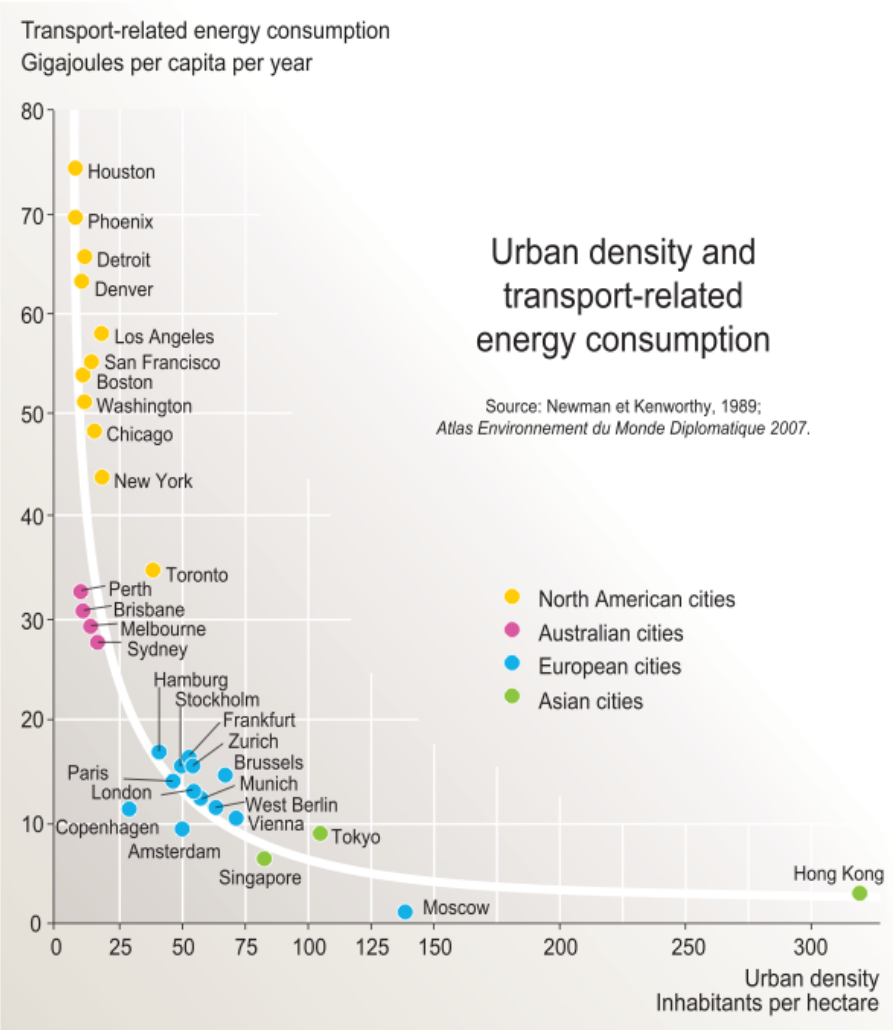


Figure 4: **Urban Density vs vehicle kilometres travelled per capita in cities**

Source: Adaptation from (Kenworthy & Laube, 1996)

International climate discussions, including the Conference of Parties (COP), have unequivocally highlighted the role of urban transport in contributing to climate change. These discussions have percolated to sub-national and local levels. City officials in some countries are starting to look at urban mobility from a different perspective i.e. to shift from personal automobiles to public transport, walking and cycling in an integrated manner, through the Avoid-Shift-Improve approach (will be discussed at length in Chapter 5).

Though, North American and Australian cities were heavily influenced by a car-centric urban planning that prioritised mobility over accessibility, recent trends have shown a reversing trend. Cities in Australia and North America are increasingly prioritising walking and cycling and are

transforming their city centres and public spaces (Robert Cervero, 2017). Yet, the actions from the past in urban planning carries the burden in providing extensive public transportation and rapidly correcting the planning structure of the past.

Increasing urban density is imperative to reduce dependence on energy consumption from urban transport as the number of motorised trips will reduce, while there would be an increase in walking and cycling trips. This leads to the question on how to increase the urban density and what are the constituents of a functional urban land-use that supports sustainable mobility. To answer this we need to know how cities are formed and grow.

3. Urban patterns

In many of the growing cities the reason for the growth of the cities is triggered due to the popularity of a destination, in many cases this is the location where major amount of jobs are located. Bertaud argues that the concentration of jobs drives the way cities grow or densities are arranged. He suggests four different models of cities namely, the monocentric, dispersed, composite and the utopian urban village (Bertaud, 2001).

In the ***monocentric model***, Figure 5: , all the trips are towards the centre of the city where the jobs are located, also called the central business district. In this kind of a city there are high densities in the centre of the city and the densities and the densities lower as the distance from the centre increases. While this model of the city is beneficial for transport provision as all the trips are towards the centre of the city. When land and real estate markets are almost free of regulation the cities tend to grow as the cost of land reduces when farther from the CBD.

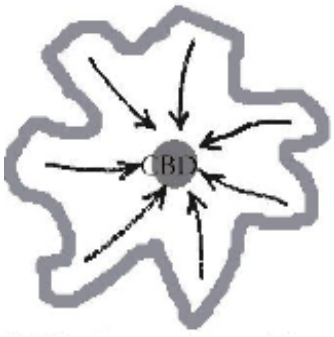


Figure 5: Monocentric City Model

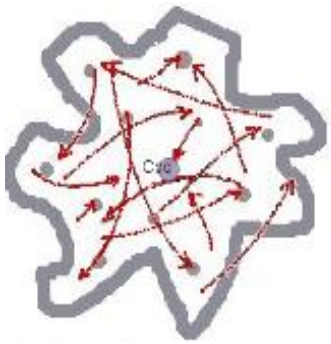


Figure 6: Dispersed City Model

Figure 7: Composite City Model

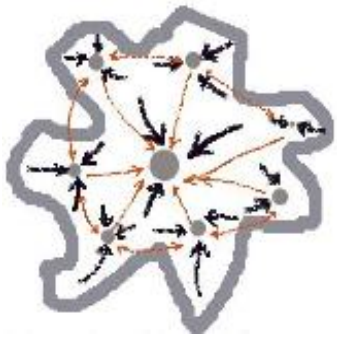


Figure 8: Urban Village Model

The dark lines represent strong links and the brown lines represent weak trips.
Source: Bertaud, 2001

A ***dispersed city model,*** Figure 6: , on the other hand does not have a core central business district but rather multiple centres and hence increases the number of trips as the trips in a dispersed model

city originate almost at a random from the entire urban area. Hence, trip lengths in a dispersed city are longer than a monocentric city.

In the ***composite model,*** Figure 7: , a city has a strong CBD yet also has suburban areas that have smaller activity centres. This is kind of a structure in many European, South Asian and Chinese cities. Trips originate from the suburban areas. For example, Paris being a composite model has over 70% of the trips between suburban areas. These cities are a result of "moving" central business districts, triggered by the cost of land, the land profile (being flat) and importantly motorisation.

The fourth model proposed by Bertaud is the ***urban village model,*** Figure 8: . Bertaud argues that this is a utopian model that is in the mind of planners. In this model a city will have multiple centres with their own trips contained in a specific catchment area. Majority of these trips are short and can be completed by active mobility modes, longer trips are performed by public transport.

3.1. City form and transport mode

While Bertaud's city models are good in explaining the influence of city growth on number of trips the models, arguably, do not focus on the kind of transport modes or transport technologies. Newman and Kenworthy mention the influence of transport modes on the size of the city. They point that traditionally cities were designed for walking, the walking city, these cities were compact and the trip in these cities was accomplished by walking and cities had very high densities. This is still can be seen in many developing cities in Asia, where the core city is designed around walking.

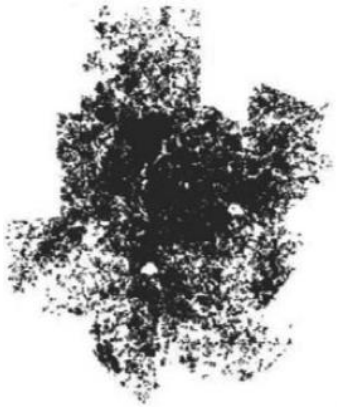
The advent of public transport enabled people to travel longer distances with public transport and hence the city sizes grew and population densities dispersed. The densities were higher along the public transport corridors and the centre of the city was still a high density area with majority of the trips in the centre being on foot.

With the advent of the personal automobile, the growth of cities was accelerated. Cities were planned such that residential locations were away from the CBD and the trips was performed on personal automobiles. This led to a drastic increase in city size, overtime results in multiple low density areas and there by leading to dispersed cities described by Bertaud. People wold live in the outskirts of the city and the jobs and other important destinations (e.g. schools, supermarkets etc.) are located in various centres in the city (Newman & Kenworthy, 1996). Due to long trip lengths it would not be economical for local governments to build and operate a vast public transport system.

3.2. The tale of two cities

The urban form of a city has a direct influence on provision of sustainable mobility options and thereby influence the energy consumption in a city through reducing the number of motorised trips.

It also becomes cumbersome for economical and physical infrastructural reasons to implement public transport in sprawling cities. Further, as short trips are limited to certain neighbourhoods an integrated transport strategy is difficult to implement.



Atlanta	Barcelona
Population: 5.25 million Urban area: 4,280 km^2 CO2 Emissions from urban transport: 7.5 T CO_2 /ha/yr (public + private transport)	Population: 5.33 million Urban area: 162 km^2 CO2 Emissions from urban transport: 0.7 T CO_2 /ha/yr (public + private transport)
About 500,000 public transport trips / weekday	About 953 million boardings/year or about 2.6 million trips / day. Based on data from EMTA report

Figure 9: Comparison between Atlanta (United States) and Barcelona (Spain)

Atlanta and Barcelona have a similar demographic and GDP, yet the area occupied by the cities is drastically different. Barcelona is 26 times smaller than Atlanta and has a much higher urban density. In terms of urban infrastructure, Atlanta is well known for its car friendly infrastructure and provision of multi-lane freeways for free movement of cars. Barcelona on the other hand is known for its dense and grid city network. The city is formed in a grid pattern with wider-streets being served by public transport and the narrower streets cater for walking and cycling trips. Due to the compact nature of the city providing public transport is much more efficient in comparison to Atlanta. The metropolitan transit provider in Atlanta or MARTA, reports that there are about 500,000 trips per weekday in Atlanta (MARTA, 2018), while the counterpart in Barcelona reports about 953 million trips per year or 2.6 million trips per day.

The dependence on public transport in Barcelona results in 11 times lower CO_2 emissions from urban transport in comparison to Atlanta (Lefèvre, 2009). While, urban density is not the only factor for lower CO2 emissions, it is a factor for enabling a higher use of sustainable transport modes such as walking, cycling and public transport. Walking and cycling are negligible or even not recorded in Atlanta's case and in Barcelona over 30% of the trips are either on foot or a bicycle in the area served by public transport and this number is more than 45% in the main city area (EMTA, 2018).

The plan of Barcelona provides an opportunity for cities in the global south to retain their high densities but to direct city planning towards dense, diverse and designed with a focus on activity of people. The planning needs to enable reduction of motorised trips and shift personal motorised trips to public transport, walking and cycling to gain climate benefits through CO2 emission reduction.

4. Density, Diversity and Design: The 3 Ds of land-use and transport integration

As we have seen until now, land-use impacts the way we live in cities and the way we move. The three important elements that decide the efficiency of urban space use can be categorised into density, diversity and design.

4.1. Density

Density is usually measured as the number of people living in a unit of land area, usually in hectares or km^2. When density is measured for a city or an urban area it is termed as *urban density.* Urban density plays a crucial role on the way we live and decides the form of our cities. Cities are planned either with high density or low density, depending on the activities in the planned area such as, residential, commercial, industrial etc.

Traditionally cities in North America and Australia were heavily influenced on lower density, possibly due to the large availability of land resources. Coupled with the ease of mobility by a personal automobile the distances between the destinations was initially not an issue. As countries developed and lifestyles changed there were more personal automobiles. Low density together with segregated land-use lead to an increased number of trips on personal automobiles. The increase in demand for urban space had to be met by sacrificing precious agricultural land and forest areas. Thus, resulting in the loss of environment.

On the contrary, cities in Asia have a high density, European, Latin American and African cities have medium densities. Based on a comparison of 49 mega cities, Bertaud argues that urban density does not depend on wealth , but rather on the ease of access to the activity centre such as jobs (Bertaud & Malpezzi, 2003). The paper also argues that there is a strong influence of labour markets on maintaining the urban densities. Urban development that favours mixed-land use and higher density will have an impact on the number of motorised trips, as we have seen in the case of Atlanta and Barcelona. The diverse land use brings together jobs and residential functions and thus reduce the motorised trips.

4.2. Diversity or Mixed Land-Use

Diversity in land-use arises from using the urban space for multiple functions, e.g. mixing commercial and residential. When residential and commercial activities are mixed and linked with high density living, it has a direct impact on the number of trips people make.

The concept of mixed land-use or diverse use has been forgotten in cities when automobile centric planning took over. As we have seen in Chapter 3, cities were traditionally built around walking. The

advent of faster moving transport means had an impact on the distances we covered. The industrial revolution further encouraged cities to be planned in a segregated way as wealthy middle-class found it unfavourable to live close to heavy industries. Further, the automobile made a profound impact on the way we move, and the availability of “cheap” land enabled the growth in city size (Kusumastuti & Nicholson, 2018).

Influenced by writings of Jane Jacobs ((Jacobs, 1969), (Jacobs, 1961)) made a great impact on how cities were planned. By the 1980’s several literatures started to mention the importance of mixed-land uses and the role it played in reviving neighbourhoods. Some of the various arguments that mixed land-use bring to cities, valid even to this day are summarised as follows (Grant, 2002):

- Mix land use enables optimum infrastructure use;
- Mixing housing types can increase affordability and cohesion;
- Mixed use areas can reduce motorised trips and increase active mobility and public transport use;
- Mixed use neighbourhoods create lively public places when proper design is applied.

Compared to a segregated land-use where one has to make two separate trips (usually motorised) for purchasing groceries and to work, in a diverse mixed-land-use urban area, the trips can be reduced to one, as the groceries or work are located in the new diverse area.

4.3. Design

In addition to densifying cities and brining mixed land-use, designing these new centres in a people friendly manner increases the use of the urban space. A well designed urban space caters for the needs of the people and their movement and less on allocating space to for automobiles.

Many developing countries have a high share of walking and cycling. The reason for such high shares is that these cities have a high density living and a diverse land-use. Yet, it can also be seen that there is an increasing trend of personal motor vehicles in the developing world. While, a part of the reason can be attributed to the status image of a personal automobile, the other part can be attributed to the way cities are transformed and new agglomerations are designed.

In many wealthy European cities such as Zurich, Amsterdam, Copenhagen, urban design favours mixed land-use and priority is given for public transport and active mobility (walking and cycling), this results in a higher uptake of these modes and many of the city trips being performed by these modes as the street design also supports this.

Further, a research studied the impact of urban design and land use on public health. The researchers modelled a compact city scenario where a higher number of trips were made by public transport and there is more diversity of land-use and urban design increases the access to sustainable mobility. The results show that a compact city model provided health benefits in all the 4 studied cities (Stevenson et al., 2016). The research also suggests that decision makers need to favour active mobility and public transport, and better urban design favouring these modes.

5. What needs to be done?

5.1. Avoid-Shift-Improve

Avoid-Shift-Improve (ASI) is an approach initiated by the GIZ and has since been adopted and endorsed by various urban mobility advocates. The central idea of the strategy is:

Avoid unnecessary motorised trips in a city, these are trips that can otherwise be performed easily of foot or on a bicycle. An avoid measure is successful when the whole project is well thought through, i.e. through urban design changes the distances to common destinations such as groceries and commercial areas are reduced. This enables the short trips to be completed by foot or bicycle rather than a car.

Shift is the the collection of instruments that seek to encourage people ti use more efficient modes of transport i.e. when distances are longer and cannot be completed by foot or bicycle, public transport is used.

Improve component is a collection of instruments and the improve the efficiency of the existing vehicles. For example, by reducing the size of the car, making cars lighter and using alternative fuels the efficiency of motorised trips can be improved.

While, the above framework give a practical approach to address urban mobility it has to be noted that for positive results the policies need to complement each other.

5.2. Push and Pull strategies

In the section above we have seen the ASI approach. The approach provides policy makers the theoretical basis for adopting sustainable transport yet in terms of implementation cities will need incentives and disincentives. We call them here ***push and pull*** strategies.

The push strategies are policies and measures that discourage the use of personal automobiles. Some of the popular push strategies include congestion pricing, electronic road pricing, low emission zones, t-charge etc. it has to be noted that push strategies are not just fiscal instruments, there exist also measures that fall under push strategies but are not related to pricing. Such examples include on-street parking reduction, street closures, pedestrianisation of city centres etc. Urban design can play a vital role in reclaiming space from automobiles and creating people friendly cities.

The pull strategies on the other hand provide incentives for people to move away from personal cars to sustainable mobility. Some common pull strategies include installation of segregated bicycle lanes, wide footpaths for walking, promoting public transport, fiscal incentives for low emission vehicles etc.

Box 1. Common pitfalls with push and pull

It is commonly seen that many cities after implementing bicycle lanes and improving public transport do not see an expected increase in use of these modes. The likely reason for this is that a disincentive for personal automobiles is not properly implemented and enforced.

Several cities are hesitant to have car restraint policies as they quote the inefficient public transport. These cities also acknowledge that public transport needs to be improved and related projects are undertaken.

It would be more beneficial for cities if the innovative and attractive public transport improvements are supported by car restraint policies and measures in parallel to promoting walking and cycling.

5.3. Transit oriented development

Land use and transport with a major focus on public transportation is popularly termed as Transit Oriented Development or TOD. The TOD concept is built around giving major importance to public transport (or transit) and working in manageable sections of a city.

A neighbourhood developed with TOD concepts is designed around increasing the walkability in the area, provides space and facilities for cycling. The walking and cycling elements are integrated with a high speed and high capacity public transport system which functions as the chief mobility mode in the neighbourhood. In addition to mobility, a transit oriented neighbourhood also consist of high density mixed residential and commercial land-use.

The densities are highest around the public transport station (see and reduce as reduce as the distance from the public transport increases. Having high densities around the public transport increases the access to quality public transport for a majority of people.

A mixed land-use for residential and commercial purposes reduces the need to travel and increases the use of public space. Typically, single use areas are desolate during non-working hours and become areas for unsocial activities and might harbour criminal activities. Desolate urban areas are often seen in many North American and Australian cities (e.g. Perth and Canberra), where traditionally single land-use planning was favoured.

A mixed land-use further enables and encourages a longer use of public spaces. When effective place-making strategies are employed, mixed-use neighbourhoods can become convivial and economically attractive for businesses.

Figure 10: Transit Oriented Development area of influence

Source: Somerville by Design.

TOD also encourages more efficient space utilisation by reducing parking areas for cars. Through people friendly public space design and reducing on street parking and properly managed off-street parking, people in a transit oriented neighbourhood can also benefit from more urban space for recreational use.

While TOD is best implemented at a neighbourhood level, a larger city level strategy needs to be adopted to increase the effectiveness of a TOD. When successfully implemented across neighbourhoods connected by a high speed public transport system (see Figure 10:) such as a Bus Rapid Transit or a Metro rail, TOD can encourage compact neighbourhoods that a less dependent on personal motor vehicles.

The Institute for Transportation and Development Policy has published a TOD Standard publication that highlights the major components of TOD. More information on Transit Oriented Development and the TOD Standard can be obtained from TODStandard.org.

5.4. Active Mobility improvement

Whilst improving public transport active mobility or non-motorised transport is often forgotten. Bus priority lanes are laid and bicycle lanes, bicycle parking and footpaths are ignored. This neglect of active mobility leads to a reduced performance of the project on whole. Including active mobility into the public transport projects could result in a higher ridership of public transport.

For example, in Bogota, where bicycles were practically extinct, the local authorities built, in just a few years, over 300 km of bicycle lanes, i.e. the largest network in the whole of Latin America. The modal share of bicycles grew from 0.4% to 3% of travel as whole, in that short time (Lefèvre, 2009).

By providing Safe, Prioritised, Attractive, Comfortable and Enjoyable (SPACE), pedestrians and cyclists can be made welcome in urban areas. Automobile friendly urban areas provide all these features for automobiles and hence attract more cars and motorised two wheelers.

5.5. Land Use regulations, taxation and infrastructure

The local decision makers have a very small range of options available to influence land use in cities. Such measures are linked to either regulating the existing land-use, adjusting the taxation on land, and provide infrastructure such as roads.

Land use regulations support local governments in allocating urban space through various measures such as zoning to limits governing the amount of built area, this is also called floor area ratio (FAR) or

the floor space index (FSI). Many critics point that the current regulations in many cities are complex and need to be simplified. As cities have minimum plot sizes and maximum density and built ratios. As a result of the minimums stipulated by cities, prospective home owners need to buy larger plots than they need and poorer echelons are driven out of the city in search of affordable land. Also, the higher real estate prices in the core city area also drive people away from the city.

Instead of deregulating land in the outskirts of the city to “control” rising real estate prices, cities would benefit if there is a controlled land expansion led by the city. In this case, the city will plan future development areas, after demarcating the nature areas (lakes, forests and protected areas), align the new development with transport networks. This gives the opportunity for the cities to plan a TOD when planning for the new development areas. The development also gives financing opportunities for cities through land-value capture schemes.

6. Examples of integrated land-use and transport

6.1. Copenhagen

Copenhagen is known for its bicycle infrastructure and the city is often mentioned in the news as one of the greenest, safest and happiest cities in the world. The success of Copenhagen lies in the urban planning concept developed in 1947. The city developed a “Five Finger Plan” in the 1947’s, the plan has been the basis for urban development of the city since. The Five Finger plan provided the basis for urban development in the form of a hand (Figure 11:). The urban development occurred along the *fingers of the hand* and the space between the *fingers* was allocated for the green areas. Rapid transit based on rail (s-tog) was the base for major mobility needs, over 170 kms of s-tog lines serve city along with a growing mini-metro system which currently has about 5 lines. the train system is supported by a extensive bus system and a bicycle network of over 400 kms fulfilled additional mobility needs for shorter trips. The result is that more than 40% of people in Copenhagen use bicycles daily for work and study (City of Copenhagen, 2017).

The city also has reclaimed space from automobile by transforming parking space for cars into green areas. The city had 15,800 sq. m of pedestrian area in 1962, which grew to 100,000 sq. m by 2000. The city also has the world longest pedestrian street - Strøget.

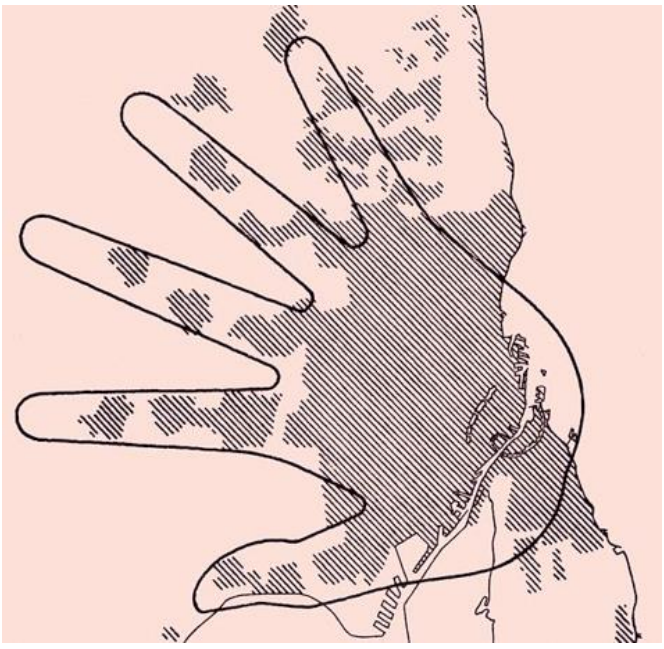


Figure 11: Copenhagen Five Finger Plan

6.2. Amsterdam

This is due to the enormous infrastructure that the Dutch city has invested in cycling and walking over the past decades. The city has made conscious effort to move away from personal automobiles especially cars and give the streets back to the people. Between 1950 until mid1970's bicycling was not a popular mode of transport in the Netherlands (Pucher & Buehler, 2008). A massive impetus from the public and an overhaul of urban planning approaches led to decreasing the use of personal cars in Amsterdam and overall in the Netherlands.

Similar to Copenhagen, Amsterdam is mentioned often as the city friendly for bicycles and bicycle traffic. Almost similar to the structure of Copenhagen, the city was designed in a fan shape spanning from west to east with green spaces in between. This design was the result of a master plan from late 1920's. Over time as the population grew the city authorities emphasised on higher density living and the idea of people living closer to their work and have access to recreational areas . In the recent years the population growth in Amsterdam put a stress on the need for urban land, with strict nature protection areas the scope for new urban development in Amsterdam is less (te Brömmelstroet, 2010). In order to meet the growing demand the city has held consultations with various urban planners and decided that the future urban growth in Amsterdam should be integrated with urban transport. The city plans to densify corridors along public transport

Amsterdam's pride lies in the extensive amount of active mobility in the city. Together, walking and cycling contribute to 60% of the trips. The high share of active mobility was possible as the city integrated urban planning and walking and cycling infrastructure. The city is also one of the most advanced cities worldwide in electric vehicles. The city currently is planning to double the publicly available charging points to 4000 by the end of 2018.

6.3. Zurich

Zurich is Switzerland's economic capital, home to over 400,000 inhabitants and has an urban density of 4,583 inhabitants/sq. km. Zurich is often in the media due to its high rank in the quality of life surveys[1].

Zurich has a very low share of personal automobile trips at only 25%. The majority of trips in Zurich are by public transport (40%) and on foot (27%). Cycling make up 8% of the entire share of trips. In other words, 75% of trips in Zurich are performed by sustainable transport modes. The city has a strong determination to promote sustainable mobility and increase the share of the sustainable transport modes by 2025. Among the strategies mentioned in the plan, the city aims to increase the share of cycling and public transport by creating dedicated infrastructure for cyclists and integrating public transport with walking and cycling.

In 1973 citizens of Zurich city declined the proposal for the underground transportation system for shortest distances. The rationale behind it was to preserve the urban fabric. One of the reasons was also that the underground transportation solution will not effectively solve the traffic problem of the roads and it will also disturb the walkability on streets. In the same year Transit First Policy was approved. It proved to be grassroot policy as it affirmed the improvement in existing tram system.

Public transport development as at the centre for Zurich's success. The 1970's decision by the city council to speeding up active mobility and public transport was followed by speeding up the transit systems. The core aim of these interventions was to increase the attractiveness of public transport as a faster mode of transport in comparison to the private car. Public transport received higher priority through dedicated space on the street and priority at intersections, though redesigned traffic signals and control systems.

Zurich being the economic hub attracted a lot of commuters from the region, the demand for commuting was met by public transport through the formation of a regional transport authority called the *Zuricher Verkehrsverbund (ZVV)*, the ZVV coordinated all the transit operations in the region and integrated fare and timetable structures. Throughout the entire span of activities the ridership of public transport kept increasing (See Figure 12:). In 2017, the ZVV transported about 651 million passengers in the entire region (Kodukula, Rudolph, Amon, & Jansen, 2018) of which about 304 million people on the local trains or S-Bahn within the city limits of Zurich, or in other words a resident of Zurich region uses public transport about 1,193 times in a year.

1. https://mobilityexchange.mercer.com/Insights/quality-of-living-rankings

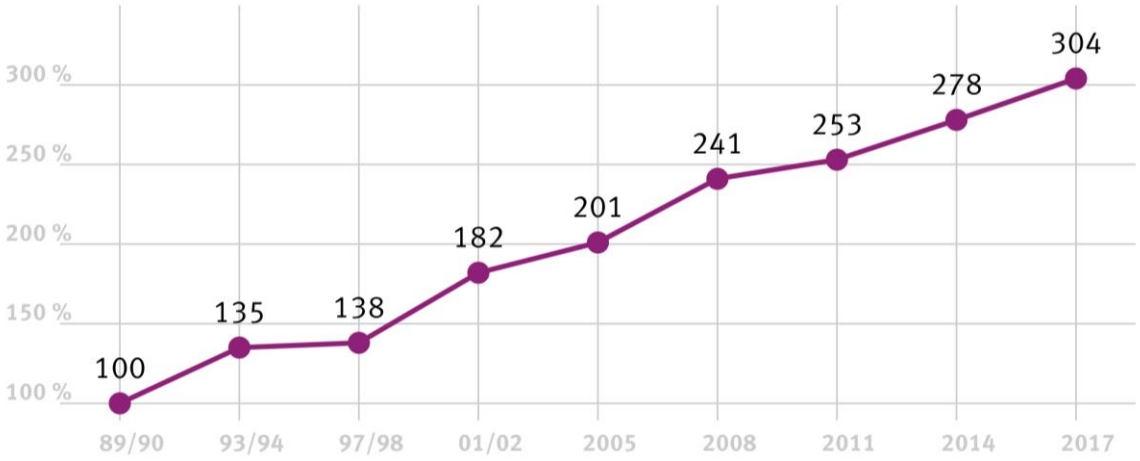


Figure 12: Annual ridership evolution in the city of Zurich on the S-Bahn

Source: Zuricher Verkehrsverbund, 2017[2]

2. https://www.zvv.ch/zvv/de/ueber-uns/geschaeftsbericht/2017/kennzahlen.html

6.4. Barcelona

Earlier we have compared Barcelona with Atlanta to demonstrate the impact that the density of Barcelona has on CO_2 emissions. In addition to its urban density Barcelona is also venturing into a new concept in integrating urban planning and transportation. Growing motorisation is also a problem in Barcelona, in order to address this the city released its Urban Mobility Plan in 2014. The central idea of the plan was to take cars off the streets in a planned fashion. To achieve this the city allocates existing space to other modes such as walking, cycling and public transport. The urban density of Barcelona comes to rescue of the urban mobility plan. the dense grid pattern of the city enables the city to implement an innovative concept called *superblocks.*

The superblock model will close certain streets in the city forming a larger no or reduced traffic grid. The plan will be implemented in phases, the initial phase will reduce the traffic speeds to 20 km/hr and will have one way streets for motorised vehicles. Bicycle and pedestrian traffic will not have any restrictions to move. In the second phase the motorised traffic speed will further reduce to 10 km/hr and there will be increased priority for pedestrians, bicycles and public transport.

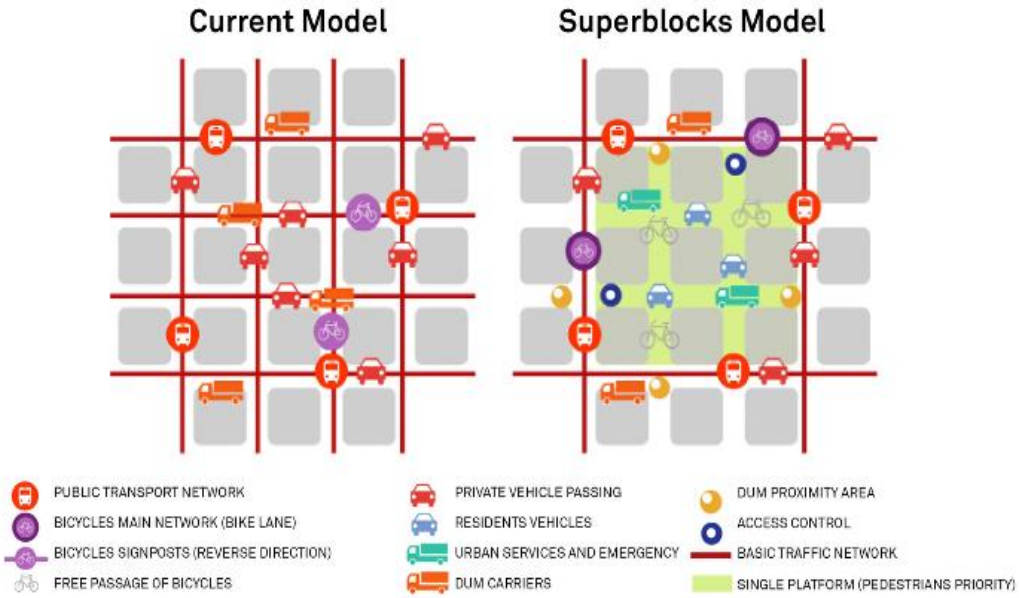


Figure 13: Barcelona superblock model in comparison with the current traffic flow.

Source: Barcelona Municipality, Urban Mobility Plan[3]

3. http://www.bcnecologia.net/sites/default/files/proyectos/pmu_angles.pdf

The city expects that by implementing the superblocks model the city will increase pedestrian space and liveability index in public space by about 50%. The city also aims to increase the public spaces from 74.5 ha to 750 ha. Further, the bicycle network will be expanded to reach about 95% of the population from the current 75%. Additional to the active mobility improvements, the city aims to increase the accessibility to public transport by increasing the bus stops every 3 blocks as a junction, have dedicated lanes for public transport and convert the bus fleet to electric vehicles.

The underlying advantage of Barcelona is the dense gridded city that makes public transport planning easier than a low-density urban area, that needs a very large transport network for the same ridership as Barcelona.

7. Conclusions

Land-use planning and transport are intrinsically linked in creating liveable, compact and people oriented cities. Dense urban areas have the advantage of providing accessible public transport systems and need to take advantage of the urban densities. As we have seen many North American and Australian cities lack the urban densities to provide a good public transport system. The European cities have developed their cities along rail based transport system in the late 60s and many cities maintain the dominance of public transport. For cities that are revising their land-use plans or transport plans we have the following recommendations:

a. **Linking land-use and transport planning**: In many cities land-use plans are drawn separately and so are transport plans. While, they might make sections of a grand master plan for the city, they still do not integrate well. In order to bridge the gap the land-use planners and the transport planners need to work on the plan together. Land-use planners need to demarcate the boundaries for protected areas such as natural areas, water bodies and heritage sites and work with the remaining area with transport planners. Transport planners need to see the existing transport lines and work with land-use planners to take advantage of the existing densities. Whilst, working together both planners can identify the trends of future growth and hence plan accordingly to contain and/or guide the growth pattern.

b. **Do not fixate on public transport mode**: While integrating transport and land-use is the holy grail, the kind of public transport mode can also decide how fast the project can be implemented. It is possible that the land-use plan and the transport plan are well integrated but the public transport mode chosen is very expensive to be realised in the timeframe of the plan. Hence, a decision on public transport mode needs to be based on the expected capacities on the modes, the time and resources available, and the area that the public transport will cover. At the end, the public transport chose will need to compete with a personal automobile in terms of speed and comfort. A transport mode that takes its user faster to the destination is the preferred mode.

c. **Keep an eye on land prices:** One of the major reasons for urban sprawl is the availability of cheap land for prospective owners. While, experience has shown that influencing land prices does not yield in much benefit, land-use planners can decide the future pockets of urban development. By utilising the land owned by the city urban development can be directed towards being dense and diverse. Coupled with the design interventions from the transport planners the future urban areas can be people friendly.

d. **Transit oriented development is not only about transit:** Whilst many cities promote transit and feel that they are doing a transit oriented development, the concept of TOD extends the core idea of transit. A TOD increases the liveability of the area by pedestrian and bicycle

priority urban design. There is no dominance of personal automobiles either by an additional lane or through generous parking.

e. **Know what kind of city you want:** Probably the most important decision that a mayor or the key decision maker in a city will make is the kind of city he/she wants. The entire land-use and transport planning and integration depends on this central decision. This decision when enshrined in a clear, concise, and tangible manner in a Urban Development Plan or an Urban Mobility Plan will give the planners a firm direction in planning. All the cities in our examples have a clear and defined goal for their cities. Hence, they are successful.

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