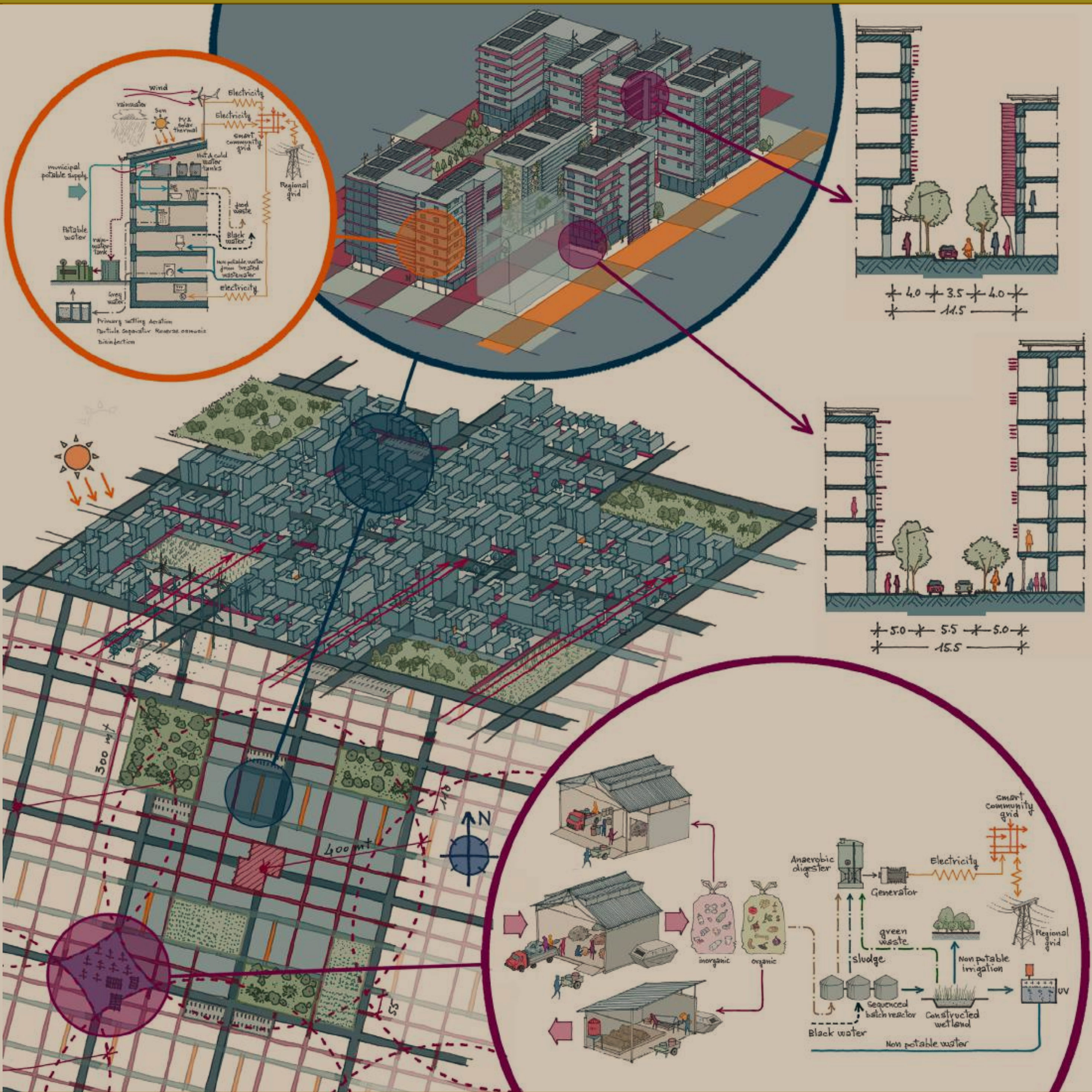
ENERGY AND RESOURCE EFFICIENT URBAN NEIGHBOURHOOD DESIGN PRINCIPLES FOR TROPICAL COUNTRIES

Practitioner's Guidebook



UN-HABITAT
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United Nations Human Settlements Programme (UN-Habitat)
P. O. Box 30030, 00100 Nairobi GPO KENYA
Tel: +254-020-7623120 (Central Office)
www.unhabitat.org

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Project supervisor:	Vincent Kitio
Principal author:	Prof. Federico M. Butera, Politecnico of Milan, Italy.
Contributors:	UN-Habitat staff
	Eugenio Morello, *Dept. Architecture and Urban Studies, Politecnico di Milano, for drafting background papers on "Minimising energy demand for transport" and "Design tips and Checklist", and for contributing to the introduction.*
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2.2 MINIMISE ENERGY DEMAND FOR TRANSPORT THROUGH URBAN DESIGN

The urban transport sector accounts for a large proportion of urban CO_2 emissions. The world transport sector in 2010 was responsible for approximately 23% of total energy-related CO_2 emissions (IPCC 2014), 40% of which were due to urban mobility (EU 2016). Urban transport energy consumption is expected to double by 2050, despite on-going improvements in vehicle technology and fuel-economy; 90% of this growth in urban transport emissions is expected to come from private motorised travel and will largely take place in developing countries (IEA 2013).

Urban design has a great impact on mobility, as the layout of the urban form greatly affects the way we move in the space. The arrangement of spaces and functions can influence the choice of different transport modes, and this choice affects energy consumption because of their different intrinsic efficiency (see section 2.3). Moreover, energy demand for transport is significantly influenced by the urban, district and neighbourhood design, and it is possible to minimise it with appropriate density and mixed land use (work, home and services close to each other) or even by extending the contiguity of the functions at the individual building scale. Provision at neighbourhood scale for facilitating cycling and collective and individual high efficiency transport, for example, are also key to reducing energy demand and consumption.

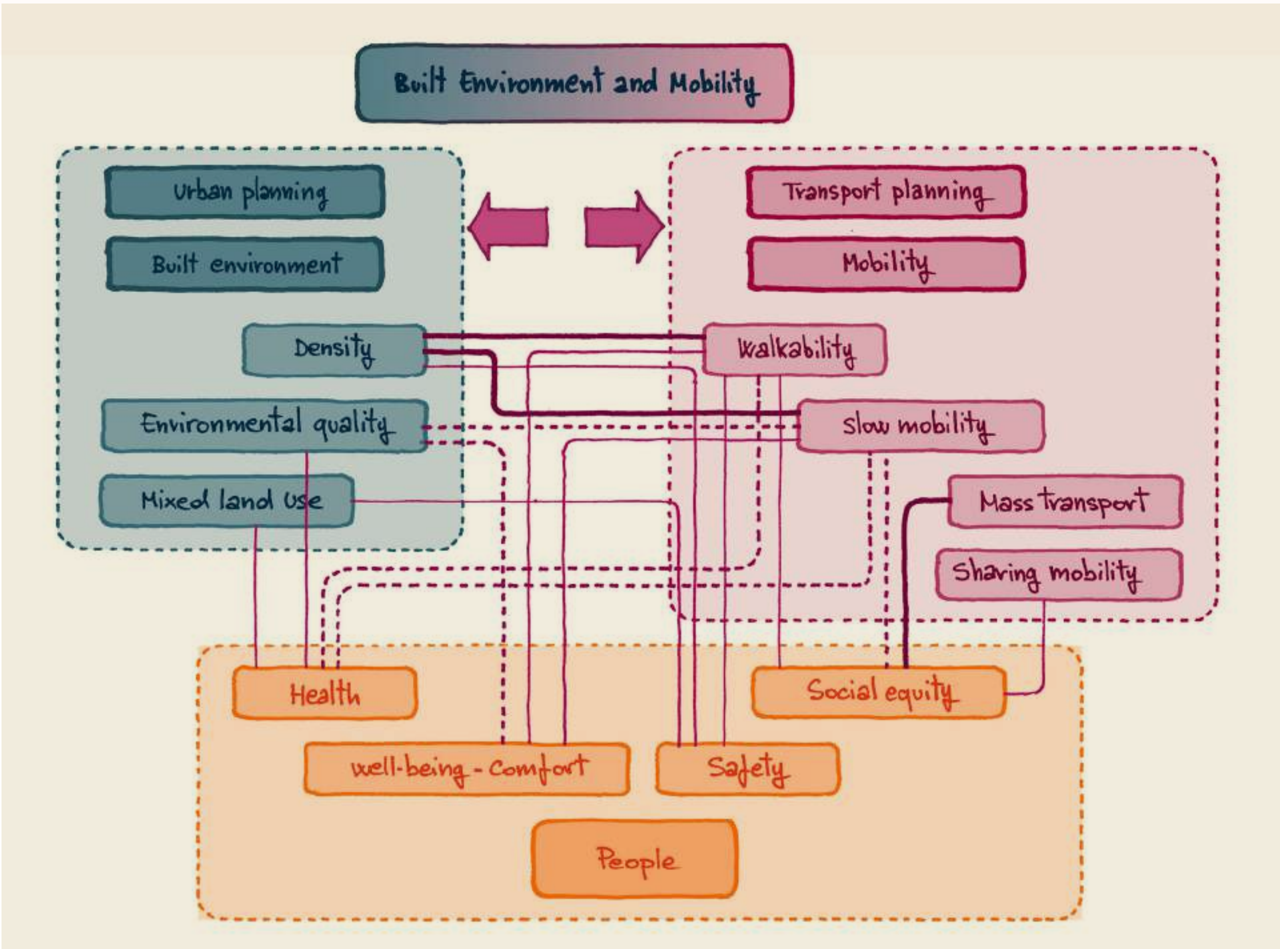
A holistic vision of urban development is required, whereby a genuine integration of transport planning with arrangements of space and function at neighbourhood scale should always be implemented. In fact, transport planning decisions are not a technical matter of engineering choices only, but highly affect the usability of the public realm and urban planning decisions have evident and direct consequences on accessibility and mobility. These decisions are finally implemented in the neighbourhood design, since walking, cycling, public transport and sustainable communities have to be intended "as a single network, and one which replaces the transport idea of providing mobility with a community goal of providing accessibility" (Dittmar 2008).

Indirectly, a walkable environment that encourages slow mobility solutions is also a healthy place (Brown 2009). Today, energy dense food, sedentary lifestyles and motorized mobility all together inevitably have a significant impact on health (see section 2.9). People in walkable cities have more occasions to conduct healthy lifestyle choices and move more. Studies reveal that denser urban environments have less obesity rates than suburbs (Li 2009). Furthermore, mixed-use planning and the presence of a variety of destinations not only promotes walking but also increases the sense of community or social capital through the facilitation of interaction between residents on the streets (Heart Foundation 2017).

Hence, walkable neighbourhoods can have a positive impact on social costs for the care of the person, on people's happiness and on a number of social aspects.

In the following, the interplay between the design of the physical space and mobility is highlighted (Figure 2.2.1), with the focus on new neighbourhoods. "When there is significant new development, then it will be important for transport and land use to be developed together" (Department for Transport, UK 2007).

FIGURE 2.2.1 **INTERPLAY BETWEEN BUILT ENVIRONMENT, MOBILITY AND PEOPLE: SIGNIFICANT THEMES AND RELATIONSHIPS**



2.2.1 SITE LAYOUT, MIXED LAND USE AND MOBILITY PATTERNS

New neighbourhoods should become vibrant urban spaces where people enjoy spending their time: the public realm should represent a strong attractor, where people feel safe and develop a true sense of belonging, and where everyone can find a number of services to satisfy their daily needs. A mix of uses and services is the key for a successful urban strategy, and is closely connected to mobility patterns. For instance, if a neighbourhood offers attractive spaces and services, demand for travel can be reduced.

Commuting, traveling from home to work, can be partly affected by the design of new districts, if we take into account the fact that some people will choose to settle close to work if the environment is attractive and the cost affordable. Nevertheless, as demonstrated in literature, an increase of mixité does not always correspond to a reduction in travel demand: be that as it may, it can help and offers an additional choice to people who want to live close to their jobs.

In addition, secondary travel for daily shopping and leisure can be reduced by appropriate neighbourhood design: if services are concentrated in a small portion of the territory, these can be easily accessed by sustainable means of transport or on foot.

It should be considered that urban design has a big influence on people's behaviour in a space, because living in different environments enables different uses of space and different mobility patterns. Hence, designers can approach mobility design with the idea of also providing an environment where people are naturally – almost unconsciously – encouraged to behave in a certain way. In this case, the spatial setting of a neighbourhood is a facilitator for a series of actions whose aim is to support modal shift and reduce people's need to travel.

In general, two main, interconnected design principles are crucial if we are to respond to the multiple dimensions of sustainability: diversity of both land use and types of environment and sufficiently dense places.

Taking into account these two principles, district-wide energy and environmental performance as well as mobility performance, can be satisfied. Moreover, dense and diverse places create a strong identity, thus a greater sense of belonging and use of space.

BOX 2.2.1 **DENSITY**

Density is inversely correlated with the energy consumption of the transport sector: the higher the density, the lower the energy consumption (Kenworthy 2008; Lefèvre 2009; UN-Habitat 2013a). Density is also related to soil consumption: the lower the density, the higher the amount of land converted from green to build, thus the higher the contribution to global warming because of the reduction of the amount of CO2 absorbed by vegetation,

Positive effects of high density are also (UN-Habitat 2013b):

- Reduced public service costs. High density neighbourhoods tend to decrease the costs of public services such as police and emergency response, school transport, roads, water and sewage, etc.;
- Support for better community service;
- Provision of social equity;
- Support for better public open space;
- Increased energy efficiency and decreased pollution.

High density is a feature of cities at different development levels and contexts. A target value of a minimum of 150 p/ha is recommended by UN-Habitat (UN-Habitat 2013b), suggesting however that cities that are land rich may set a lower target and work progressively towards increased density.

Another principle is self-sufficiency. Transportation is one of the sectors (one of the most crucial, especially in developing countries) where entropy is generated and that should be tackled and minimised, aiming at the double dividend of the minimisation of both the entropy production of the settlement and the resources input, without impairing (indeed improving) its functions.

It should be noted that the principle of diversity should not be applied only at the scale and scope of the urban functions (dwellings, shops, offices, etc.) but also within each function and extended to the economic and social aspects, with many positive side-effects (SCRG 2017):

- A mix of housing densities, price level, and building type - interspersing affordable housing with higher priced housing - will help to attract a diverse population making the community culturally and socially diverse;
- Community diversity will help to create a 'sense of place' that will make the community memorable. A memorable community will be viewed as a desirable place to live;
- The introduction of a variety of housing building types will aid in the inclusion of affordable housing creating a socio-economic mix. A variety of housing types also helps to fulfil the needs of a variety of family types.

Consistent with the need for diversity, to build a sustainable neighbourhood, UN-Habitat (UN-Habitat 2013b) suggests:

- *Mixed land use* - Distribution of the total floor area: 40-60% for economic use, 30-50% for residential use and 10% for public services
- *Limited land use specialisation* – Single function blocks should cover less than 10% of any neighbourhood
- *Social mix* – 20-50% of the residential floor area should be for low cost housing, and each tenure type should be not more than 50% of total.

2.2.2 WALKABILITY: THE FIVE-MINUTE-WALK SHED

Walkability is for all. The same levels and opportunities for accessing urban places and services assure the principle of equity within a neighbourhood. The fundamental rule of thumb in designing a new neighbourhood is that the main services and transit nodes have to be reached in a five – maximum ten - minutes' walk (400-800 m, Figures 2.2.3 and 2.2.4); the application of this simple rule alone already supports urban walkability and generates the so-called cities of short distances; or, better, is the conditio sine qua non other more expensive measures are meaningless. In other words, designers can integrate most of the actions presented later in this chapter, but if the core services are not easily accessible and close to households, none of the actions introduced later can be really effective or applicable.

The five-minute-walk shed, the so-called pedestrian shed or simply ped-shed, was the natural growing pattern of human settlements before the era of cars. In the past, people had a limited travel budget time and were not available to spend more time (and money) for covering long distances. In reality, the travel budget time itself did not change so much over time: in fact, the willingness of people to travel is still more or less the same, but the distance we can cover today has radically changed. For instance, if commuters traditionally – yesterday and today – are willing to spend a maximum of two hours for a daily home-work round-trip, the distance that can be covered today has dramatically increased thanks to modern means of transport. The car revolution has completely subverted the natural tight relationship between urban and transport planning: after the 50ies limitations due to travel budget time was revolutionized by the "miracle" of the car.

BOX 2.2.2 **DIVERSITY AND REDUNDANCY**

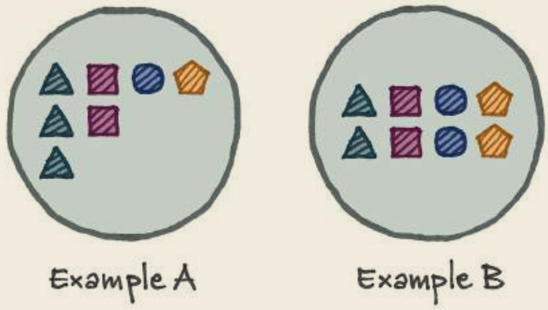
The concept of diversity was first introduced in ecology, where a relationship between diversity and an ecological system's resilience was found. Biological diversity can be quantified in many different ways. The two main factors taken into account when measuring diversity are richness and evenness. Richness is a measure of the number of different kinds of organisms present in a particular area. The more species present in a sample, the 'richer' the sample. Evenness is a measure of the relative abundance of the different species making up the richness of an area.

Species richness as a measure on its own takes no account of the number of individuals of each species present. It gives as much weight to those species which have very few individuals as it does to those which have many individuals. Evenness, on the other hand, takes into account the relative weight of each individual species. As species richness and evenness increase, so diversity increases. A community dominated by one or two species is considered to be less diverse than one in which several different species have a similar abundance. The same approach can be used to evaluate the "mixité", or multi-functionality, of the neighbourhood, where diversity is defined as the number of different types or classes of land use activities that exist in a specified area, taking into account both the richness (the total number of classes of activities that exist in the neighbourhood) and the evenness (the relative contribution of each class to the total number of activities), see Figure 2.2.2. Several diversity indexes have been developed in ecology (Odum 1993), and some of them have been transferred to urban planning; among them the most common are the Shannon-Wiener Index and the Simpson's Index (D). The Shannon-Wiener (or entropy) diversity index H is a widely accepted and commonly used index for representing the land-use mix (Kajtazi 2010). It is derived from the information theory and is expressed as:

$$H = -\sum_{i=1}^{i=k} p_i \ln(p_i)$$

where p_i= n/N is the proportion of activities found in the ith class of activity, n is the number of the activities in the ith class, N is the total number of the activities in all classes and i = 1, 2, 3....k, being k the total number of the different classes of activity; ln is natural logarithm. The value of H can range from 0 to H_{max} = -ln(1/k), which is the value of H when the activities are evenly distributed thus all pis are equal).

FIGURE 2.2.2 **THE DIFFERENCE BETWEEN RICHNESS AND EVENNESS. ON THE LEFT-HAND IS EXAMPLE "A" WITH FOUR DIFFERENT CLASSES OF ACTIVITIES, EACH HAS DIFFERENT NUMBER OF ACTIVITIES. ON THE RIGHT-HAND IS EXAMPLE "B" WITH FOUR DIFFERENT CLASSES, EACH HAS SAME NUMBER OF ACTIVITIES. THE RICHNESS IS THE SAME IN BOTH EXAMPLES; EVENNESS IN EXAMPLE "A" IS LOWER THAN ON EXAMPLE "B" (KAJTAZI 2007).**



It was found that in ecological systems the value of the Shannon-Wiener index ranges from 1.5 to 3.5 (MacDonald 2003) rarely surpassing 4 (Margalef 1972). Being the ecosystems present on Earth, the result of an evolutionary process reaching a final optimum configuration, we may use this range of values as a first approximation guide for the mixed land use in neighbourhood design.

Simpson index of diversity D is expressed as: $D = 1 - \sum_{i=1}^{i=k} p_i^2$

Where p_i, i, n, N and k have the same meanings as in the previous formulas. D ranges between 0 (no diversity) and 1 (maximum diversity). It should not be lower than 0.5 (USGBC 2016) . The system's redundancy R is calculated as (Pierce 1980):

$$R = 1 - \frac{H}{H_{max}}$$

Redundancy ranges between 1 and 0: the lower the diversity the higher the redundancy. In ecological systems, and we may infer likewise in urban systems, redundancy protects against destabilisation caused by unpredictable perturbations; it makes the system more resilient. Redundancy has a cost: the more redundant the system, the less efficient, but also the more resilient.

FIGURE 2.2.3 **REASONABLE DISTANCE BETWEEN HOME AND SERVICES**

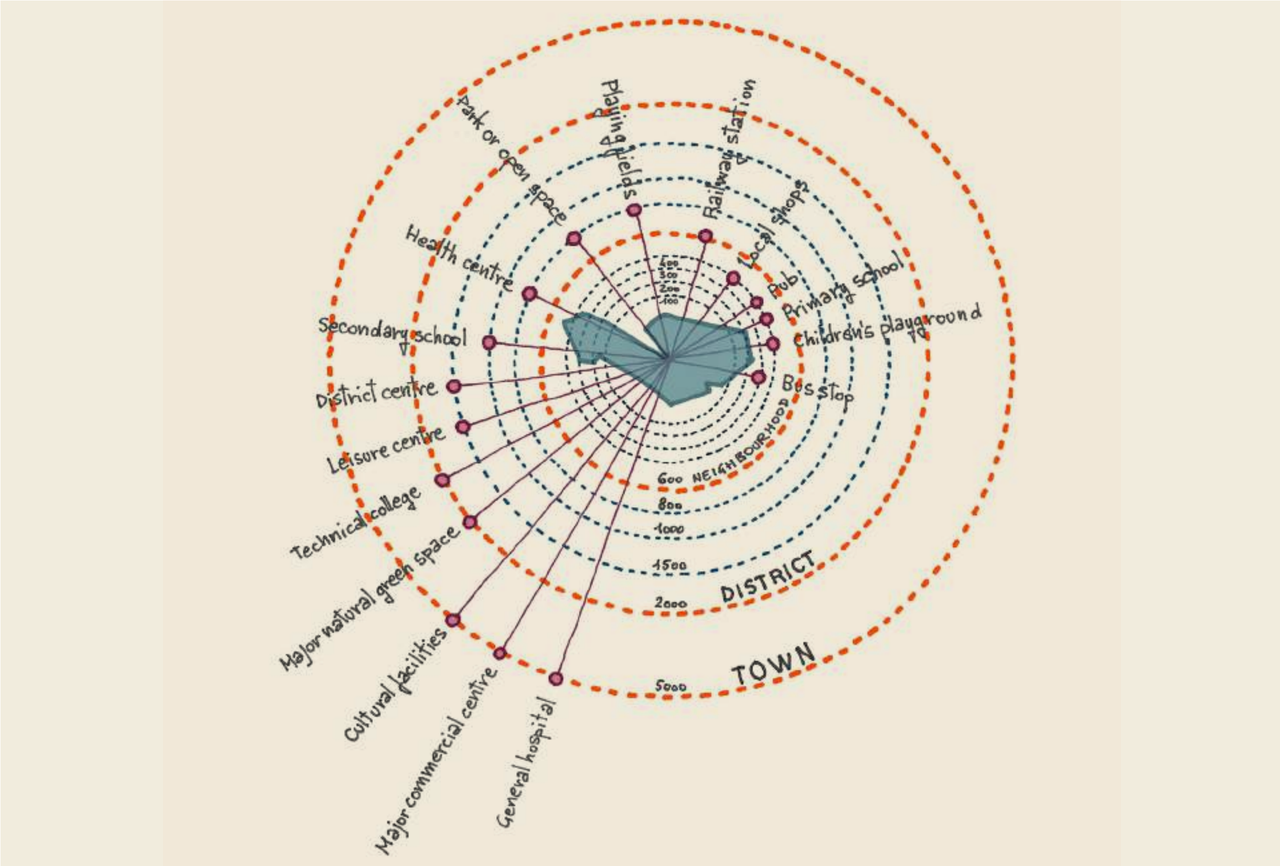


FIGURE 2.2.4 **CATCHMENT AREAS FOR SEVERAL TRANSPORT FORMS (UN-HABITAT 2013B)**

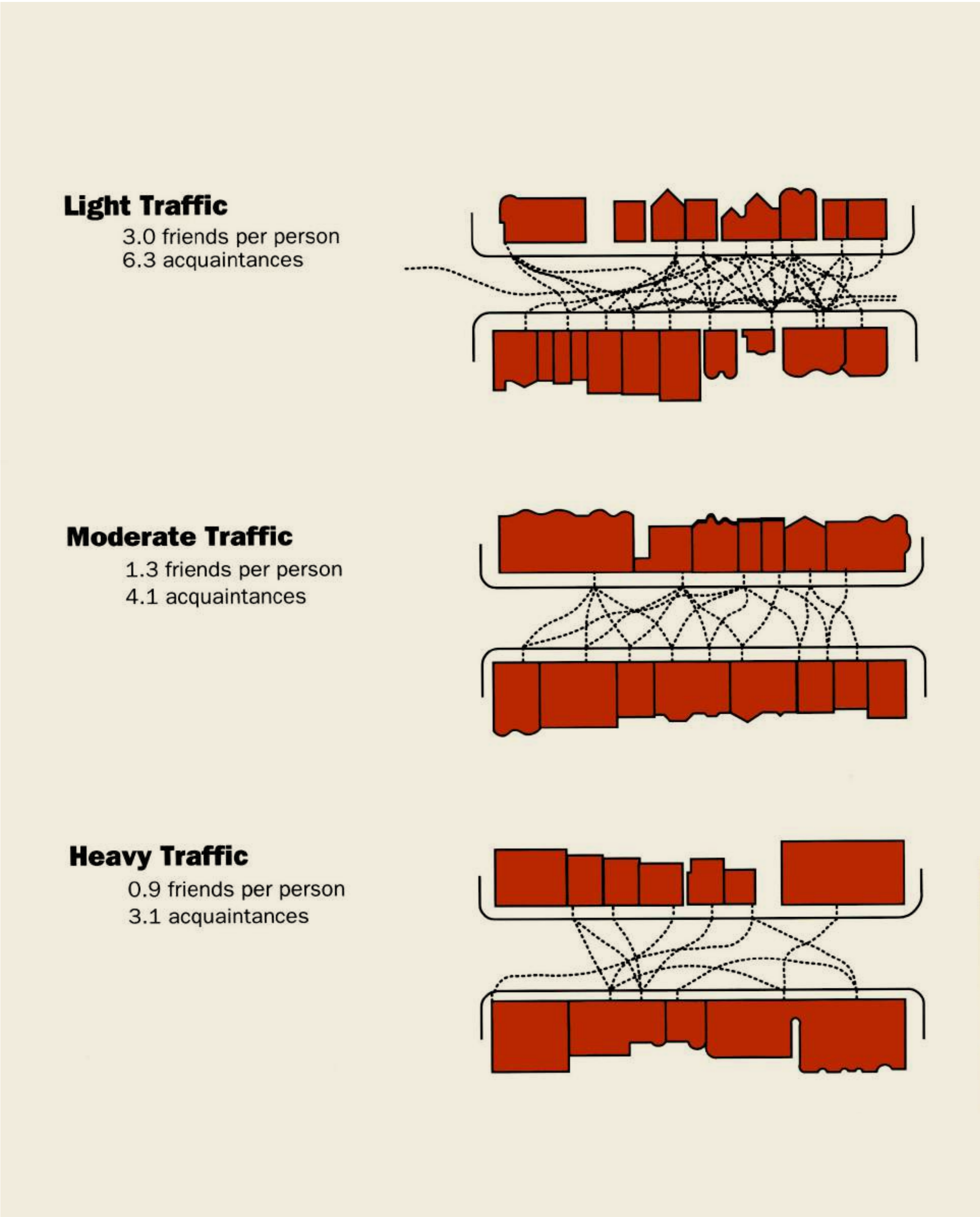
	INTERVAL (M)	CORRIDOR WIDTH AREA SERVED	CATCHMENT PER STOP
Minibus	200	800	320 - 640
Bus	200	800	480 - 1,760
Guided Bus	300	800	1,680 - 3,120
Light Rail	600	1,000	4,800 - 9,000
Rail	1,000+	2,000+	24,0000+

A parallel dynamic happened with the introduction of mechanical ventilation in buildings: the invention of artificial cooling and the availability of easy and low-cost heating completely replaced site-specific attention to the weather and climate conditions of places, and as a consequence, modern architecture could overcome limitations dictated by nature. In both cases, i.e. transport and architecture, forgetting about the nature of places and people was never a wise solution: in fact, with the increase in the costs of energy (and gasoline) and with the recent awareness of climate change and of the proper use of limited resources in a limited world, parsimony has become a paradigm of sustainable design. In fact, the same targets can be achieved using less energy without reducing peoples' quality of life. On the contrary, designing walkable communities increases the chance of getting healthier citizens and enhances relationships (Figure 2.2.5).

Mixed land use is a necessary but not by itself sufficient condition to promote a neighbourhood's walkability. Two more design strategies can lead to successful walkable neighbourhoods, i.e. places that are accessible and attractive for people:

1. ***Accessible, safe, high-quality and comfortable environments*** - The first strategy refers to the design of physical places that guarantee an urban setting with sufficient standards of quality to convince people to spend more time in the public realm. Accessible, safe, high-quality and comfortable environments are the main identified qualities that walkable neighbourhoods should give. Accessible environments have to be designed for all, including people with disabilities or reduced mobility: 'Universal design' principles have to be guaranteed. Reduced speed as foreseen by traffic calming measures will deliver safe

FIGURE 2.2.5 **WALKABLE NEIGHBOURHOODS REDUCE THE DEPENDENCE ON CARS FOR MOBILITY, THUS THE CAR TRAFFIC, WITH A BENEFICIAL EFFECT ON HUMAN RELATIONSHIPS. RESEARCH IN SAN FRANCISCO CONFIRMS THAT URBAN TRAFFIC UNDERMINES A STREET'S SENSE OF COMMUNITY. IN A SINGLE NEIGHBOURHOOD, THREE STREETS WITH DIFFERENT INTENSITIES OF TRAFFIC ARE COMPARED. AS TRAFFIC INCREASES SO CASUAL VISITS TO NEIGHBOURHOODS DECLINE. (SOURCE: ROGERS 1997)**



places where weaker members of the population can also feel protected. Safety has to be guaranteed when different means of transport interact, mainly through pedestrian crossings and parking lots. High-quality and comfortable environments are the plus factors that make people want to choose to spend their time in local public areas and streets, instead of attending other urban or indoor spaces. If places have all the above-mentioned features and, in addition, they also offer a great sensory experience, there is no doubt that people will be happy to enjoy such a space close to home. High-quality and comfortable spaces (i.e. shaded and ventilated) guarantee well-being, are diverse and capable of satisfying all the specific needs of people, and finally offer a perceptually pleasant urban scene.

2. ***Attractive paths with active frontages*** - Besides the design of a pleasant and accessible urban layout, decisions concerning land use are crucial. Which functions and services and where and how to distribute them are the big questions. Diversity in terms of social experiences and human interactions is a way to invite people to experience places. Hence, the control of ground levels is the main device for providing a vibrant urban scene. For instance, close to the centre of the neighbourhood and on main roads, the concentration of retail activities and urban services is convenient and creates a continuous and dense sense of urbanity. The street landscape, everywhere in the neighbourhood, has to offer frontages with an osmotic permeability between private and public spaces and should be able to guarantee natural surveillance, with grocery shops, repair workshops and cafes serving the inhabitants of the surrounding area.
3. ***Design or configuration of the centre*** – Big-box, car-park dominated retail shopping centres with large parking areas and all the shops facing inside, increase car reliance whilst simultaneously constraining pedestrian activity through a failure to provide a pleasant or easy walking or cycling environment. This increases motivation to drive to the centre, even if people live within a close and comfortable walking distance. Instead, street-fronting mixed-use buildings with small setbacks and 'active' ground floor uses extending onto the street (i.e., café seating areas, external shop displays) encourage walking and cycling access.
4. ***Appropriate employment to housing ratio*** – The employment to housing ratio indicates whether an area has enough housing for employees to live near employment centres and sufficient jobs in residential areas; an imbalance in jobs and housing creates longer commute times, more single driver commutes, loss of job opportunities for workers without vehicles, traffic congestion, and poor air quality; an employment to housing ratio in the range of 0.75 to 1.5 is considered beneficial for reducing vehicle kilometres travelled (UN-Habitat 2017).

To sum up, the walkable neighbourhood is the first and the most important principle to take into account while designing a new neighbourhood. All the daily urban services, including retail and access to transit, have to be provided within five to ten minutes' walk from home in order to reduce car travel. In a walkable neighbourhood all local services should always be accessible within short distances. In fact, people adapt their travel budget according to the type of service (see Figure 2.2.3): for instance, for their daily needs people are able to cover short distances, whereas for special services or city-scale functions (hospital, theatres) that are rarely used, travel budget time can be higher.

2.2.2.1 THE WALKABILITY INDEX

Walkability is a measure of the conditions of an area that promote walking, and the ped-shed, even if most important, cannot give a complete picture. Several indexes have been developed for measuring the walkability of a neighbourhood in a comprehensive way. One of them is particularly suitable for new neighbourhood design (Frank 2010), and is based on four sub-indexes, namely:

- Residential density; an indicator of the density of the neighbourhood.
- Commercial density; an indicator of the amount of businesses, restaurants, retail shops and other commercial uses that are located in the area.
- Intersection density; the connectivity of the street network, an indicator of the density of connections in path or road networks and the directness of links.
- Land use mix, or entropy score; the degree to which a diversity of land use types are present in a block group.

The residential density is measured as the ratio of residential units to the land area devoted to residential use.

The commercial density is measured by the Retail Floor Area Ratio, the ratio of the total, or gross, area designated for commercial use within a neighbourhood to the total area of the lot on which the buildings hosting the commercial activities stand.

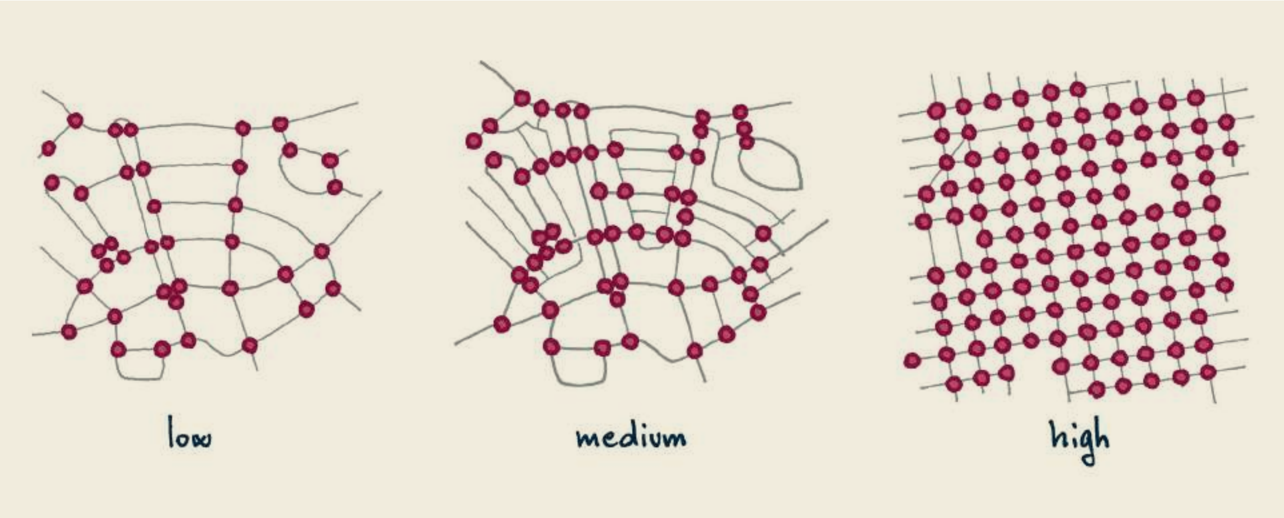
The intersection density, or connectivity index is measured by the ratio of the number of true intersections (3 or more legs) to the land area of the neighbourhood (Figure 2.2.6).

The land use mix is measured by the Shannon-Wiener diversity index H (see Box 2.2.2) applied to the land use types present in the neighbourhood.

Calculating the four values and normalizing them using a Z-score, the Walkability index WI is given by:

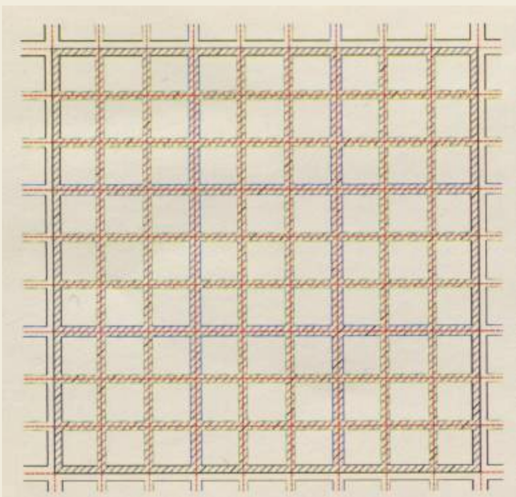
WI = [(2 x z-intersection density) + (z-net residential density) + (z-retail floor area ratio) + (z-land use mix)]

FIGURE 2.2.6 **FROM LEFT TO RIGHT: INCREASING CONNECTIVITY INDEX. A WELL-CONNECTED ROAD OR PATH NETWORK HAS MANY SHORT LINKS, NUMEROUS INTERSECTIONS, AND MINIMAL DEAD-ENDS. AS CONNECTIVITY INCREASES, TRAVEL DISTANCES DECREASE AND ROUTE OPTIONS INCREASE, ALLOWING MORE DIRECT TRAVEL BETWEEN DESTINATIONS.**



For encouraging walkability, UN-Habitat (UN-Habitat 2013b, UN-Habitat 2017) suggests 100 intersections/km^2 and a street grid where (Figure 2.2.7), in a one square kilometre area, the distance between two adjacent collector roads is 111 m, the distance between local streets is 55 m, and the total street length is 18 km, encompassing at least 30% of the land. Figure 2.2.4 suggests also that the distance between two adjacent arterial roads should be between 800 and 1,000 m.

FIGURE 2.2.7 **STREET NETWORK MODEL DESIGN (SOURCE: UN-HABITAT 2013b)**



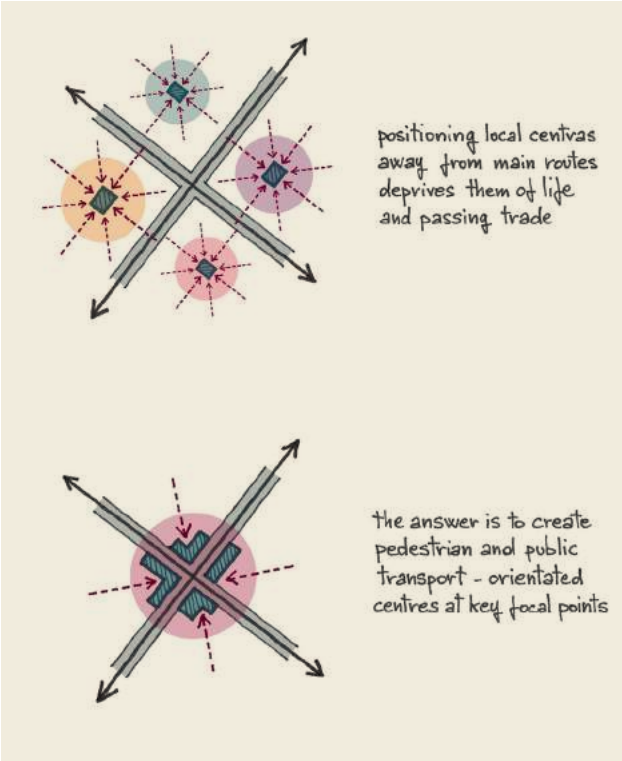
2.2.3 TRANSIT ORIENTED DEVELOPMENTS

A neighbourhood cannot fulfil all the needs of its inhabitants, thus must be connected with the surrounding neighbourhoods and the city centre. To reduce car use and enhance walkability but not compromise the connections with the world outside the neighbourhood, the concept of the so-called Transit Oriented Development (TOD) was developed. A TOD typically includes a central transit stop (such as a train station, or light rail or bus stop) surrounded by a high-density mixed-use area.

In the past, after the invention of the train, the rise of polycentric cities with regional polarities organized around local train stations represented the natural evolution of urbanization. This is what the urban design discipline today aims to recreate, in particular guiding the urban growth by infilling with new urban volumes around major transit nodes and reducing the car-dependent sprawl that completely deleted the principle of developing of cities around corridors of rail transport (Figure 2.2.8). Hence, sustainable neighbourhoods should be placed on major arteries where most of the movements happen to be.

Associated with the TOD concept is the urban gradient principle. A controlled rhythm of building density and distribution of services (mixed use) within an urban district reinforces the local centrality making it visible and readable to people. Again, it is a matter of creating environmental diversity so as to increase the tendency to walk inside the community: a homogenous urban tissue causes lack of way finding and points of reference. Usually, in these cases people do not identify a central place, do not know where to go, hence lose the sense of belonging to places and suddenly give up the idea of walking.

FIGURE 2.2.8 **URBAN SERVICES AND CENTRALITY OF CONNECTORS SHOULD MATCH IN A IN A TRANSIT ORIENTED DEVELOPMENT(ADAPTED FROM: EPHC 2000)**



2.2.4 INTERCHANGE MODALITIES

A transit node is not only a centre of reference for commuting. It also requires a number of very important services in order to engage people to adopt more sustainable mobility practices. We can distinguish two main types of services: services that are directly related to mobility, and others that support the vitality and urbanity of places. The latter are obviously indirectly related to mobility and refer to the provision of urban functions like retail and other forms of daily use services (pharmacies, education, utilities and so on) that increase the attractiveness of local transit nodes. In short, transit nodes should possibly correspond to local urban centralities.

Services directly related to mobility, on the contrary, are the following:

- Bike stations, i.e. safe and controlled parking lots for private bikes used by citizens for home to transit node trips (local residents), or from transit nodes to work trips (city users, workers). If properly designed, this service is crucial to facilitate the paradigm shift towards sustainable mobility. Stations have to offer a pleasant and safe experience, reduce time for commuting and the change in the means of mobility, be cheap and easily accessible;
- Shared mobility services, like bikes and cars, also equipped with nearby stations to improve the usage of the service;
- Smart parking solutions.

These services require dedicated areas that the urban designer must quantify and position carefully.

2.2.5 REVISED CAR ACCESSIBILITY

In the near future, new districts will experience a radical change in mobility patterns. The use of the private car will be drastically reduced (or avoided in cases where car ownership is still not dominant) thanks to three main reasons, namely: the emergence of sharing society principles, the increased availability of public transport and sustainable mobility, and the improved overall urban environmental quality. In such a changing picture, the physical layout of the urban environment cannot remain the same. A revision of current urban design standards has to be tackled and is now possible. If car accessibility will be reduced in the near future, two main solutions should be addressed, i.e. the reduction of car parking lots and the introduction of serious traffic calming solutions. Both measures can be undertaken incrementally, but the current design scheme should already foresee flexible conversion solutions over time according to adaptation principles.

2.2.5.1 CAR PARKING

Significantly reducing the number of car parking lots and privately-owned garages in new neighbourhoods represents the first measure of sustainable neighbourhood planning. Attractive short-distance cities are not flanked by cars parked on streets and garage doors. Moreover, the provision of on street parking lots dilates the size of the public space and consumes precious soil. Walkable streets, on the contrary, advocate for denser forms of urbanization and narrower streets, which are also a prerequisite for outdoor comfort control (see section 2.1).

Reducing car parking and garage doors facing streets can happen from scratch in new master plans, or incrementally over time. The second way may be the only solution in cases where the local urban design code stipulates the provision of a specific number of parking lots per capita (or per dwelling unit) as many urban standards ask for. In many cases, this is the biggest limitation to the development of sustainable streets.

Nevertheless, these standards are not the expression of current trends in slow mobility, and future urban scenarios have to seriously reconsider them.

The new trends in urban mobility, characterised by the shared use of different means of transport, combined with advanced ICT solutions (see BOX 4.2.1), lead to a significant reduction in the number of circulating vehicles and, thus, a significant reduction in the parking areas. Besides, car sharing (or even more importantly the not yet available nowadays but, according to many analysts, just around the corner driverless car) will call for a large number of small area parking spots.

If the provision of surface parking lots in public spaces is mandatory because the urban regulations have not been updated to sustainable urban development, surface parking as a transition solution could be used, so that it can be easily re-integrated into the urban masterplan and converted to other uses. The size of large parking lots should hence be compatible and comparable to the size of surrounding blocks, in order to provide sites for new buildings in the future.

Besides reducing parking lots, another strategy is to remove parking lots from streets and increase the density of those in concentrated places, either underground or multi-storey parking buildings (Figure 2.2.9).

Multi-storey parking areas should firstly provide a different use of the ground level, for example with shops facing onto the street, hence not interrupting walkable sidewalks with blind walls with no function or visual permeability; secondly, particular care should be taken over the treatment of the façade and this is often possible thanks to the limited restrictions and requirements of car parking. In fact, only natural ventilation and light have to be provided (there is no need for thermal insulation), hence attractive building skins can be easily developed with the use of light grid solutions, vegetation, and so on. This suggestion is not just a matter of aesthetics, with evident benefits for reduced impact on the urban streetscape and indirect consequences on the pleasantness and walkability of the local communities which are to be turned into car-free zones; it is also another way to restrict car use, limiting its proximity to homes. In this case, people can still own private vehicles, and access private buildings by car, but these are put together in specific places, functioning as the real gates of the neighbourhood.

However, multi-storey parking buildings should be thought through and designed as transition volumes, i.e. buildings that are used temporarily for parking but can be easily converted to other uses in the future, when car driving will be reduced. Conversion to retail units or apartments and lofts could be a profitable strategy and can only happen if the sizing of the block and the dimensions of the entire structure fit with urban uses.

2.2.5.2 TRAFFIC CALMING SOLUTIONS

The accessibility of neighbourhoods to cars must always be provided for safety reasons and for moving goods and people on special occasions. The principle should be that cars are temporary guests in the public space, where pedestrians are the masters. Numerous examples of traffic calming solutions flourish in urban design handbooks, and it is not necessary to exhaustively report those in detail (see the main types of solutions in Figure 2.2.10). In any case, the principal strategies are aimed at addressing the reduction of speed through the following actions:

- hindering the linear track for cars, making paths less easy (see the woonerf model as in Figure 2.2.11) for cars and introducing artificial curves and road bumps;
- change the materials of pavements, in order to visually reduce the size of roadways (different materials on the margins of the travel lane) and offering a different tactile experience (for instance, stones create vibration to reduce car speed).

FIGURE 2.2.9 **LIMIT THE ANTI-URBAN EFFECT OF CAR PARKING BUILDINGS: WRAP THOSE BIG BOXES WITH SMALLER UNITS TO CREATE ACTIVE FRONTAGES (LEFT). ALTERNATIVELY, PLACE CAR PARKING UNDERGROUND (RIGHT). (ADAPTED FROM: EPHC 2000)**

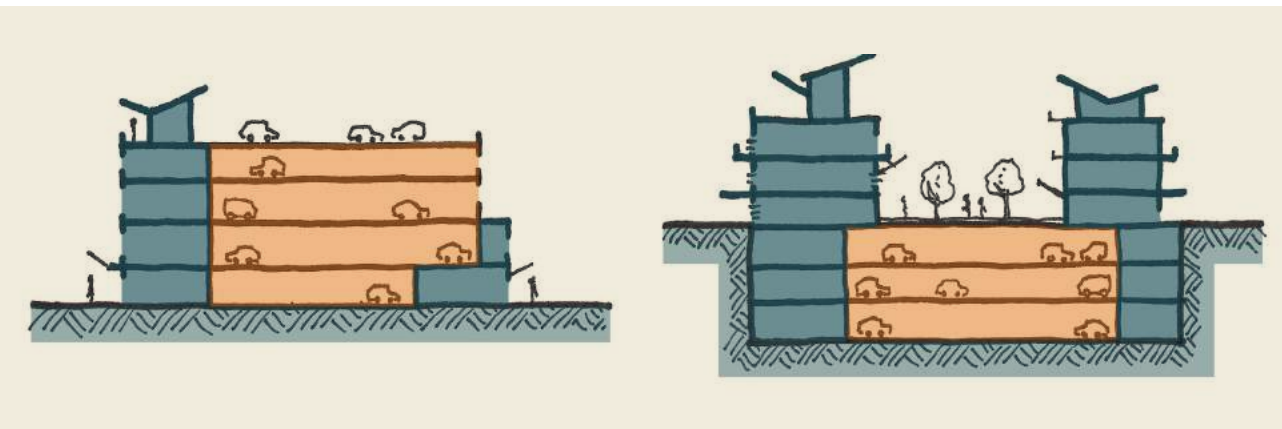


FIGURE 2.2.10 **A CATALOGUE OF TRAFFIC CALMING SOLUTIONS (SOURCE: USDT 2006)**

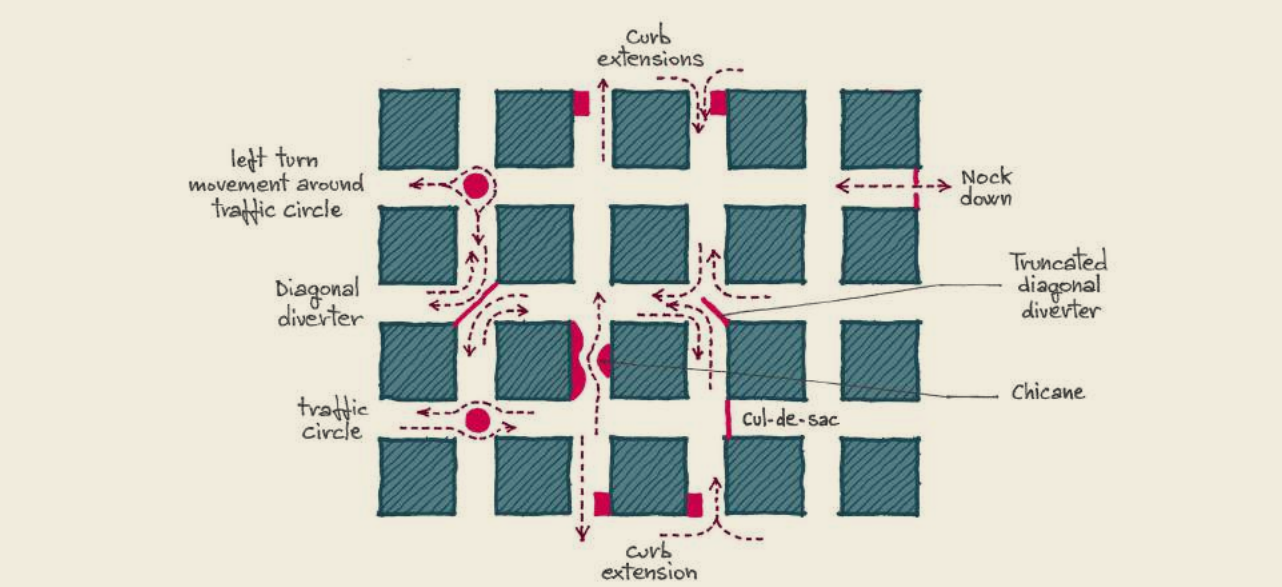


FIGURE 2.2.11 **THE WOONERF SCHEME AND ITS FEATURES (ADAPTED FROM: USDT 2006)**

BOX 2.2.3 **SMART MOBILITY SOLUTIONS**

Innovative solutions for mobility rely mainly on two aspects of smartness: the diffused location-based technologies embedded in our smartphones and the infrastructure network embedded in the urban environment. The first category of smartness enables the sharing of services (optimization of resources use), whereas the second one represents the equipment of the city for enabling the smart use of services. In short, smart mobility and sharing society concepts are tightly bounded and the latter can hardly exist without the first one.

Many scholars agree that demand-led shared transport will be the big challenge in the near future. Sharing mobility is already a diffused reality in numerous world cities. Shared transport requires a convenient sizing of the system, and this is currently possible in large cities where the scaling up of the services allows for a safe return of investment. Big cities represent lighthouses where to diffuse new lifestyles to be exported later to other realities. Maybe in the next future also citizens of smaller cities will change mobility behaviours and allow sharing mobility to successful enter the market.

Bike- and e-Bike sharing is the first type of sharing mobility that was implemented as an urban service. Today, it is a mature and successful measure that creates an efficient urban service, saves carbon emissions and generates revenues to the operators that usually sell advertisement spaces diffused in the urban environmental and in the proximity of the bike stations. Not all the cities are suitable for this system, some of the major obstacles that limit the introduction of bike sharing being:

- Topography of the terrain: cities rich of slopes and hills represent incompatible places for bike-sharing. In fact, the management of the system requires to continuously relocate bikes from the stations in the valleys up to the top of the hills, or to make use of electric bikes;
- Very low urban density that does not make the system profitable: the distance between the stations is dictated by reasonable ride times and the installation of too many stations serving only few people is not convenient.

Car- and e-Car sharing is the next level of sharing mobility. Especially electric sharing could represent a promising solution for cities. Shared electric vehicles are the ideal mean of transport for covering short distances and with a diffused infrastructure of recharging points.

2.2.6 STREET GEOMETRY: DESIGN FOR NEW NEIGHBOURHOODS

As shown in section 2.1, for minimising a building's energy consumption and maximising outdoor comfort in tropical climates, urban streets should be tree lined and characterised by an aspect ratio H/W between 2 and 3. This implies rather deep urban canyons, i.e. narrow streets unless very tall buildings delimit them. The latter is an option that needs to be very carefully evaluated because, as shown in Chapter 3 it may conflict with the possibility of having zero energy buildings, which should be the prerequisite of a sustainable neighbourhood. On the other hand, "to maintain the human scale, residential buildings should be no more than four storeys in height; from this height, people can still walk comfortably to street level, and still feel part of the activity of the street (Alexander 1977).

The requirement deriving from climatic considerations, i.e. narrow streets, is consistent with a walkable neighbourhood, where the car circulation is limited, and thus wide streets are not required.

It is evident that in a holistic understanding, streets are not only a functional space for mobility, but are a social space as well, as they were in the past. Streets should be designed as places, not just as a channel for movement. They should encourage social interactions and create distinct and inviting spaces that people choose to experience: "streets should be places where people walk, shop, play, relax, sit and talk. Hence, the definition of the urban space comes first, and vehicular mobility follows" (Heart Foundation 2017).

The advice presented above on the physical setting of mobility solutions, leads to a reconsideration of current standards for street design. Numerous compendiums for street design offer (almost) universally valid solutions (EPHC 2007). In new, sustainable, neighbourhoods in a tropical climate, new street typologies should be explored, starting from the assumption that, except for the transit routes, streets are for pedestrians and cyclists first, with only sparse and slow motorised traffic.

2.2.6.1 ZONES IN THE PEDESTRIAN REALM

The pedestrian realm is characterised by four zones: frontage, through zone, furnishings, and edge. (Figure 2.2.12): Because interaction occurs between these zones, development of a cohesive design for the pedestrian realm is important. Design must consider the unique conditions associated with each zone as well as how the pedestrian realm interacts with other elements of the street, such as bicycle and transit facilities and junctions. The through zone represents the place where pedestrian flows take place, i.e. the main function of a sidewalk. The other parts can be additional but define the real quality of the street. Frontage, for example, could host outdoor commercial activities (cafes, restaurants, street vendors), and be merged with the furnishing zone, leaving the through zone outside. The provision of trees and grassed swales wherever possible contributes to both thermal comfort and the aesthetics of the pedestrian realm.

2.2.6.2 STREET TYPES

Considering the size of a sustainable neighbourhood, which derives from its 400 to 800 metre walkability, and the significantly reduced reliance on cars, the number of street types is rather limited in a sustainable neighbourhood and, in principle, could be reduced to three: transit, access and local streets. It should be clear, however, that, in contrast to what presently happens, street design should not be dictated only by the requirements of cars, and thus be the same design everywhere, but should also take into account other functions and the climatic, socio-cultural and economic context.

This approach is well expressed in the Street Design Manual for Abu Dhabi (ADUPC 2015), proposing – consistent with traditional Arabian architecture and urban form which, in turn, is significantly influenced by climatic factors - narrow streets (Mushtaraks) and pedestrian passageways (sikkas) shaded by buildings (Figure 2.2.13).

Hence, the hierarchy level of each street type should express the urban character of the hosted functions. Considering the local character of a neighbourhood, we mainly refer to local streets with a high access ratio (Figure 2.2.14a), residential access roads (Figure 2.2.14b) and transit roads (Figure 2.2.14c, d), connecting the neighbourhood with other neighbourhoods and the city centre.

2.2.6.3 STREET FURNITURE

Alongside vegetation and water, benches, bus stops, and bike parking are the main items of artificial furniture to be placed along streets in the public realm. This furniture needs to respond to the needs of human comfort especially in tropical climates, in order to make sure that people use public spaces and slow mobility solutions. For instance, sheltered, rain-protected seat furniture should be provided. When placing these features, designers should use a simulation of the solar path in order to optimise the provision of shading devices (see section 2.1 for solar geometry and design tools).

2.2.7 SERVICE COMPONENTS OF NEIGHBOURHOODS

Providing mixed services is the crucial strategy to enable environmental diversity and to minimise the emissions due to motorised traffic, thus some basic rules should be followed:

- Schools and public open spaces should be placed within five minutes' walking distance and intercept the local transit node;
- Buildings should host multiple functions under the same roof: for instance, retail on the ground floor, tertiary uses on the first floor and housing on the upper levels;
- Variety of uses and services can also be generated by offering short frontages and shop windows on the street.

2.2.8 ICTs AND SMART LOGISTICS

In the near future we expect to have smart neighbourhoods with buildings being net producers of renewable energy, connected and optimized transport systems, and electric cars charged with electricity produced from renewable energy sources.

Innovative ICT can enable applications providing more optimized and efficient travel. Moreover, reshaped city spaces designed according to the principles of mixed use and the use of improved virtual interactions can limit the need for travel. Consequently, neighbourhoods will not have to include as much space for vehicle parking and driving, hence freeing space for other functions. ICTs

FIGURE 2.2.12 **THE FUNCTIONS OF THE PEDESTRIAN REALM ZONES (ADAPTED FROM: ADUBC 2014)**

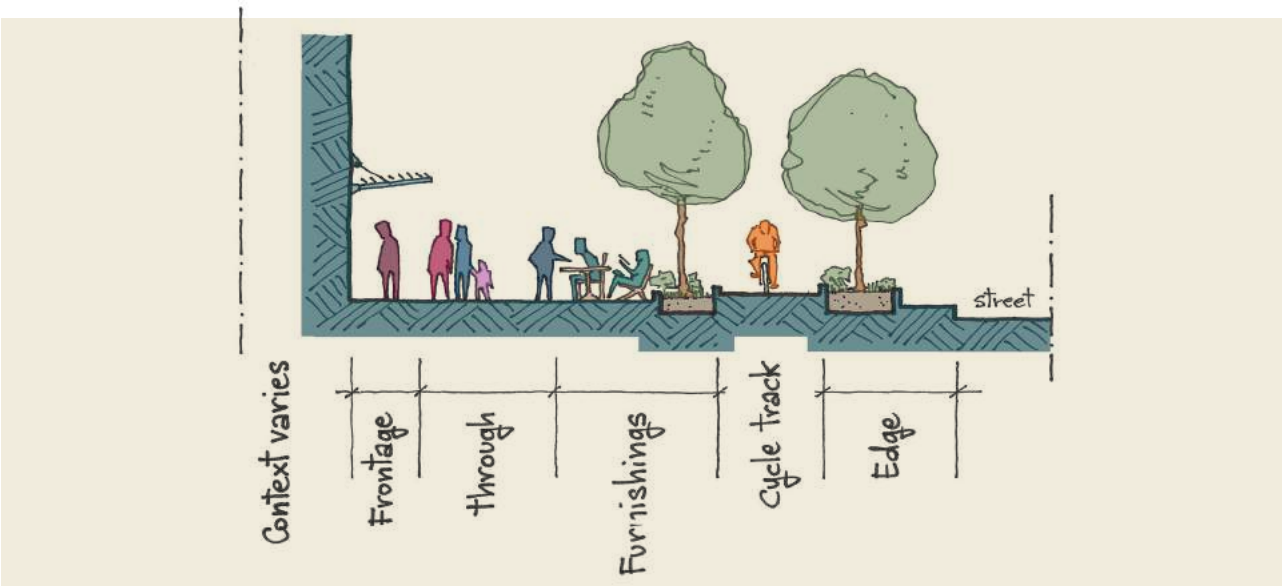
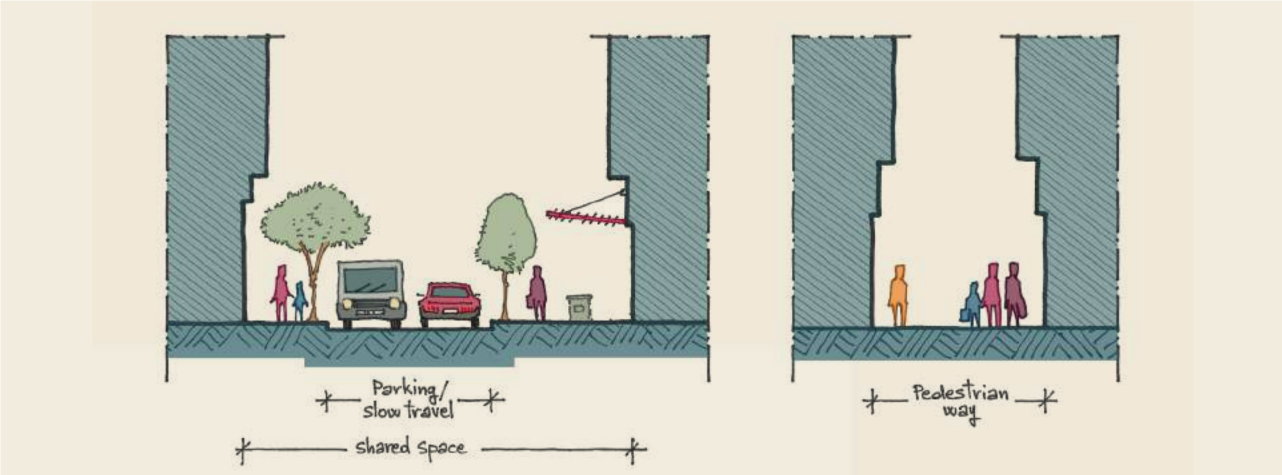
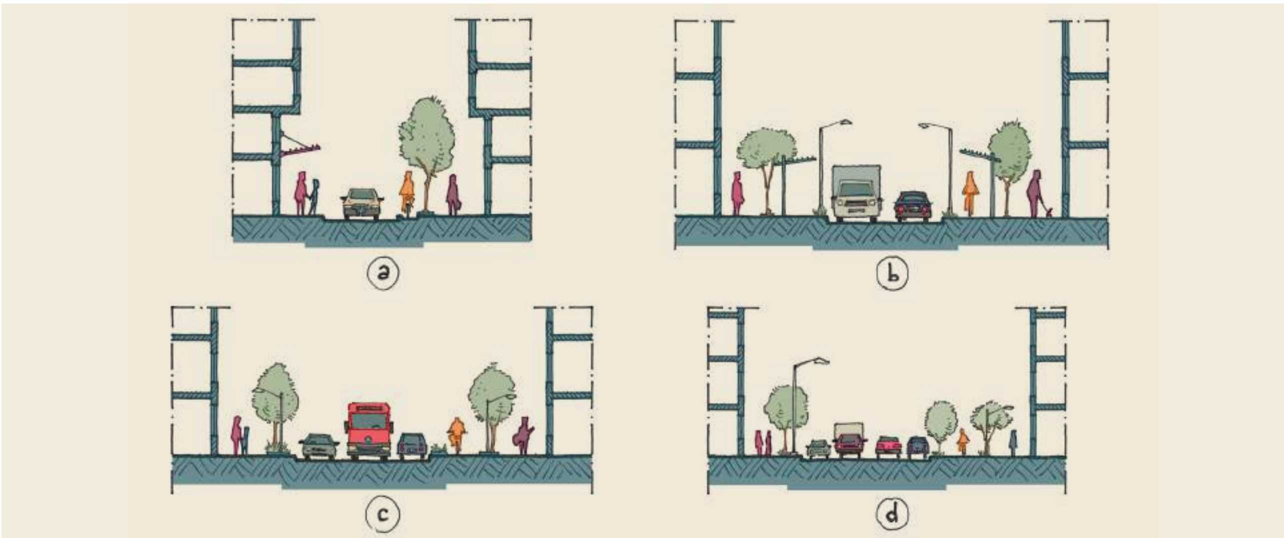


FIGURE 2.2.13 **A MUSHRATAK (LEFT) AND A SIKKA (RIGHT).**



Mushtarak is the Arabic word for a space that is shared by multiple modes: these streets are typically narrower and intended primarily for pedestrian use, but they can accommodate motor vehicles at very low speeds. A Sikka is a pedestrian passageway between properties and is common throughout the Emirate in old and new neighbourhoods; no motor vehicles are accommodated in a Sikka, however cyclists may share this space. The narrow width of the Sikka (typically 2.5 - 5.0 m) increases the amount of shading for pedestrians. (Adapted from: ADUPC 2014)

FIGURE 2.2.14 **EXAMPLES OF STREET DESIGN: a) LOCAL STREET; b) ACCESS STREET; c) AND d) TRANSIT ROADS**



are necessary for the development of the smart grids, for including renewable energy in the electricity grid as well as making existing grids more efficient, reducing losses and increasing speed. ICT can also help make buildings more energy-efficient through smart building control.

Often, planners and designers focus on people only, but the transport of goods is also crucial, especially in dense urban environments. Moreover, the whole retail system and the delivery of goods is rapidly changing because of the shift from physical retail to e-commerce. This revolution cannot be ignored by planners and urban designers, because it will completely redesign the physical space and logistics of our cities in the coming decades, and this urgently requires fresh solutions.

More and more, e-commerce is jeopardizing the distribution of goods inside the city, and this does not necessarily generate a reduction of carbon emissions. On the contrary, if not well organized, trips for the collection and delivery of goods can be even worse than the traditional delivery of goods. Of course, this new approach to goods delivery requires a physical infrastructure that differs from traditional retail spaces. Big, diffused lockers are a way of collecting several deliveries at the micro-urban scale. These storage spaces must be widely distributed, possibly in agreement with a business that is already diffused throughout the territory: for instance, interchange stations of transit or gasoline stations could be convenient places to intercept flows of people without creating extra demand for new trips. Typically, commuters could pick up goods at interchange stations on the way home, thus combining work travel and shopping and optimizing time. The localization of these storage spaces should not reduce the environmental quality and urban nature of the street landscape, hence special attention has to be guaranteed and limitations have to be imposed by local codes.

Even if not directly related to transport at all, a serious side effect of e-commerce and smart door-to-door delivery is the production of wasted packaging, which generates demand for transport for garbage collection. The increase of cardboard in waste collection is noticeable. Strategies to reduce this environmental impact are necessary and could be implemented at the community level, by putting in place new forms of reuse. The establishment of local waste collection islands could be a solution, as mentioned in section 2.7.

2.2.9 REMARKS

Some of the guidelines and design tips presented in this section might be evaluated as distant from the East African context. In fact, talking about smart mobility solutions and mass transport programmes is certainly ambitious, considering the limited resources, lack of government support and the lack of an organized and widespread infrastructure. Nevertheless, urban designers, developers and public officers should take into account best practices and make sure that, through careful planning and design, future opportunities will not be inhibited. For instance, providing space for specific mobility features, and perceiving some of the unsustainable car-dependent solutions as temporary, are some of the best ways to adapt urban spaces in the future. Otherwise, if the new district layout will not be able to adapt to future improvements in mobility, the whole energy and environmental strategy of the proposed masterplans will fail. Think about the design of modern cities in the fifties of the last century, when street design completely matched driveway design and the aim was to facilitate car driving. When they did this, cities lost the social aspect of urban streets, which became purely functional spaces for transport. Today, regenerating and readapting this car-dependent road design into urban spaces is a big challenge because of their size, the segregation of flows, and the complex connections to the network. In short, we are suffering the consequences of a planning mistake which originated in a car-dependent era. We should guarantee that the urban layout of new neighbourhoods is firstly for people, and is able to enhance social encounters and to adapt to future uses and mobility solutions.

Transportation, indeed, plays a major role in the overall carbon emissions of African cities, and special efforts have to be made at all levels

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2.3 MAXIMISE EFFICIENCY OF ENERGY CONVERSION TECHNOLOGIES

Choosing the most efficient energy conversion technologies that are needed for the urban system to work, means optimising energy streams from the exergetic point of view (Vandevyvere 2012). Urban energy consumption is conventionally subdivided into three sectors: buildings (residential and commercial), transport, and industry. In cities in developed countries the building sector usually ranks first, while in cities in developing countries, it is generally the transport sector that ranks first (Figure 2.3.1).

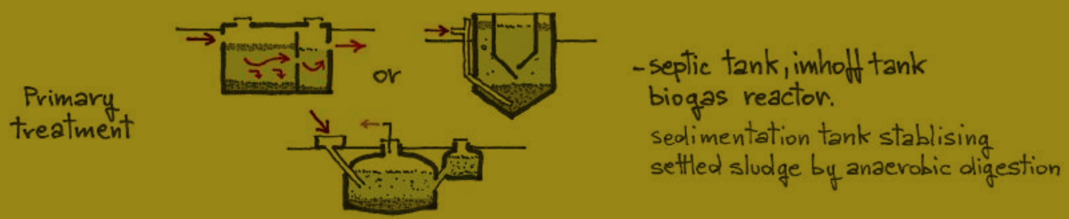
The main reason for this difference derives from the fact that cities in developed countries are – with a few exceptions – located in temperate-cold climates, and heating is the main cause of energy consumption. Space heating is a matter of survival, not just comfort, in cold environments. The issue of cooling in hot environments is less critical, as it is a matter of comfort, rarely of survival.

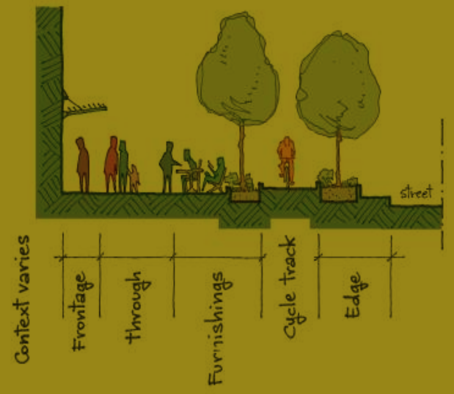
This evidence, coupled with the difference in the wealth of the average household in developed and developing countries, explains why transport, in the latter, weighs more than the building sector, in terms of energy consumption. Improving the economic conditions of households in developing countries will lead to a growing use of air conditioning which, if not mitigated by proper urban and building design and controlled by means of high efficiency equipment, will cause a sharp increase in energy consumption in the building sector.

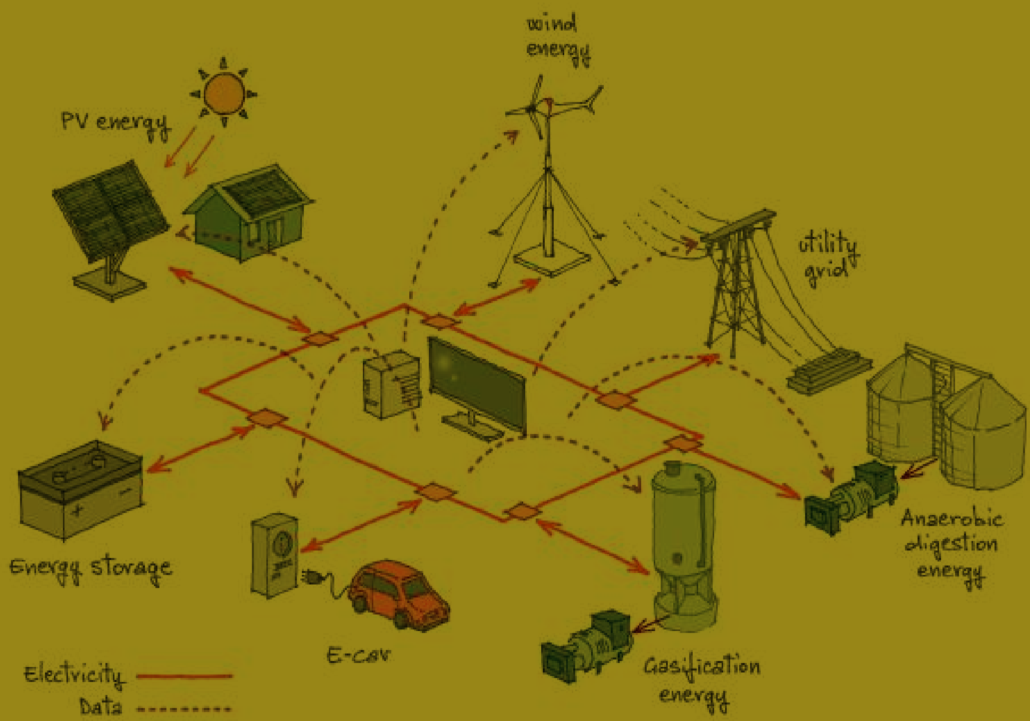
Traditionally, heat is obtained by the combustion of fuel, either biomass or fossil, but this way of producing heat is not always the most efficient, in terms of exergy, as in the case, for example, of providing hot water or space heating. According to the Second Law of Thermodynamics, burning fuel in a boiler to obtain an ambient air temperature of 20 °C or water at 40°C for showering is the most inefficient way of attaining the desired result (because we use high grade, i.e. high exergy, heat when we need it at low grade, i.e. low exergy). On the other hand, the production of electricity with a thermal power plant necessarily implies the production of some low temperature heat. Since we need low-grade heat for heating, why not use the low temperature heat produced by the power plant, which is otherwise wasted? In this way the overall efficiency of the system is significantly improved[21]. This technological approach is named cogeneration, or CHP (Combined Heat & Power).

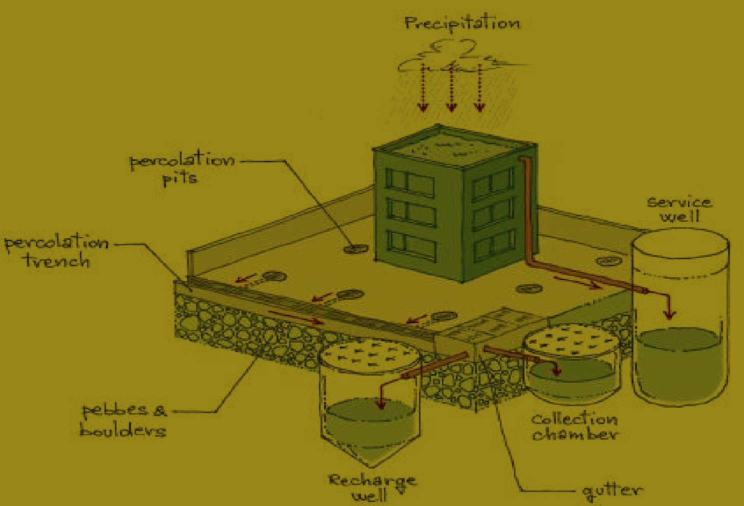
Cogeneration is defined as the sequential generation of two forms of useful energy from a single primary energy source. Typically, the two forms of energy are mechanical (transformed generally into electricity) and thermal energy.

21 Moreover, water consumption – in a world in which water shortage is already an emergency – is greatly reduced. Approximately three quarters of the water consumption in Germany and about 50% in USA is used in the cooling systems of fossil and nuclear power stations for extracting the low-grade heat, wasting it in the atmosphere, in the rivers or in the sea causing the so called thermal pollution (Source: Butera 2008).









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