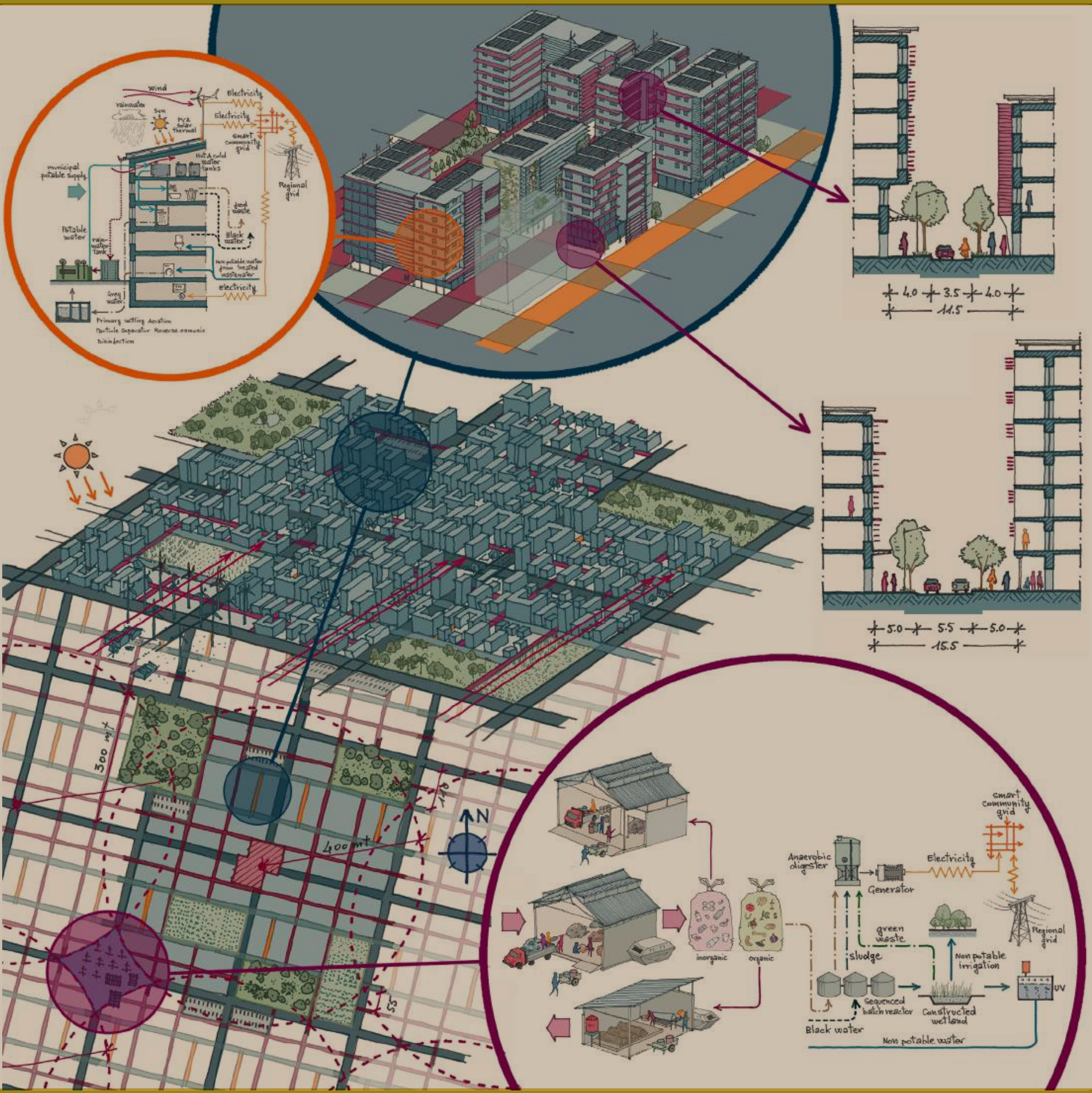
ENERGY AND RESOURCE EFFICIENT URBAN NEIGHBOURHOOD DESIGN PRINCIPLES FOR TROPICAL COUNTRIES

Practitioner's Guidebook



UN-HABITAT
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HS Number: HS/058/18E

DISCLAIMER

ACKNOWLEDGEMENTS

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	Fabrizio Leonforte, *Dept. Architecture, Built Environment and Construction Engineering, Politecnico di Milano, for contributing to the chapters "Minimising energy consumption in buildings" and "Case Studies", and for his general assistance.*
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Printing:	UNON, Publishing Services Section, Nairobi

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03

DESIGN TIPS AND CHECKLIST

In this chapter, tips for urban design have been collected and organized to provide a synthetic guide for the design of more environment and energy-aware urban neighbourhoods in tropical climates in general and more specifically in EAC climates.

The growth of cities in developing countries is unavoidable, but it should be good growth. New developments should follow the principles of sustainability and resilience, simply because the way we build today will last for many decades and will affect the lifestyle of the citizens of the future.

The physical design of neighbourhoods demands special attention. The rules, or tips, for urban design given in the following chapter are based on what has been discussed in the previous chapters and incorporate the UN-Habitat Five Principles (UN-Habitat 2013), relevant literature on sustainable urban planning and design (Alexander 1977, ADG 2010, GTB 2011, LNWAG 2009), and suggestions from the Green Building Council's LEED ND rating system (USGBC 2011).

Of course, there are no absolute values or easy rules to apply without serious scientific investigation of each topic; in fact, even scholars do not always agree on some design values or rules. Be that as it may, it is important to tackle all the points mentioned from the very beginning of the design of a new neighbourhood, even at a basic level: the idea, indeed, is to provide a set of themes which should be included in the concept scheme.

Only short descriptions are provided here in order to make the check-list more user-friendly; more in-depth and detailed information is provided in the previous chapters.

Very different aspects are listed here, and some topics can generate conflicting ideas: looking for the compromise among these is the added value of design, whereby the designer has to justify his/her choice on the basis of his/her values and priorities. This is because of the complexity of the aspects that urban design has to take into account.

Figure 3.1 summarizes some of the interrelations occurring between the built environment and other planning aspects.

The planning and design of new neighbourhoods should respond to performance requirements. Performance requirements in the built environment are mainly the following:

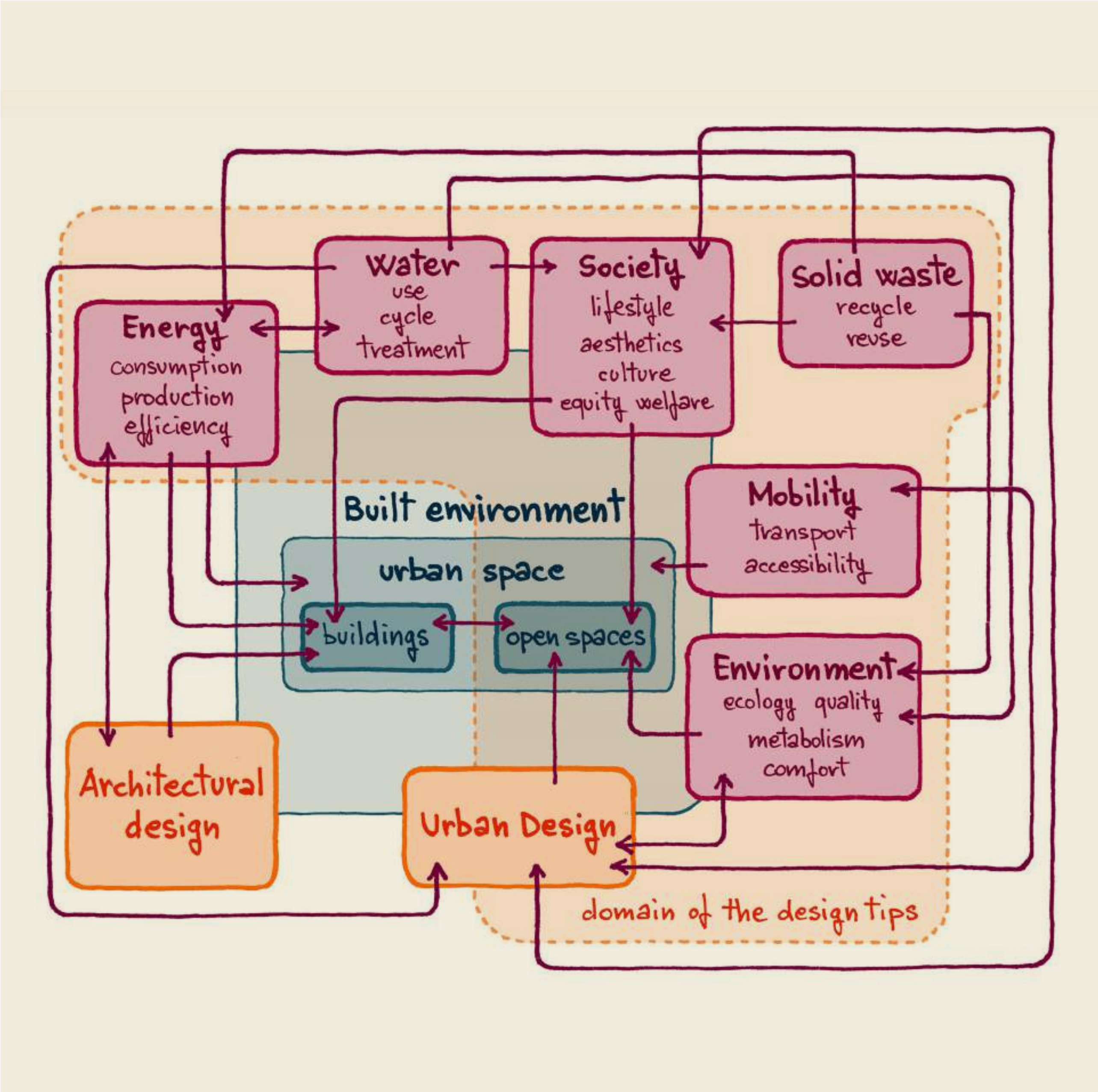
- Well-being, which includes physiological aspects related to human comfort, such as identity, sense of belonging and safety, besides thermal and visual comfort;
- Energy efficiency and clean sources of energy;
- Environmental quality and sustainability, which involves water, sanitation and materials;
- Resilience.

Design has to give a sound response to meet these requirements. The object of the design response and the corresponding effectiveness of a design action can vary in relation to the performance requirement (see Figure 3.2). For instance, different design domains can better respond to performance requirements than others.

The design tips address the following subjects:

- Site layout; location,
- Site layout; planning,
- Climate responsive design,
- Energy supply,
- Urban metabolism and closed cycles,
- Social and economic domains.

FIGURE 3.1 **THE SPATIAL DIMENSION OF THE BUILT ENVIRONMENT – AND THE URBAN SPACE IN PARTICULAR – COLLECTS INPUTS FROM DIFFERENT DOMAINS. THE MUTUAL DEPENDENCIES AMONG DISCIPLINES, BUILDINGS AND OPEN SPACES DEFINE THE COMPLEXITY OF THE WORK.**



The design tips are presented according to the following template:

Design tip background (why it is important)

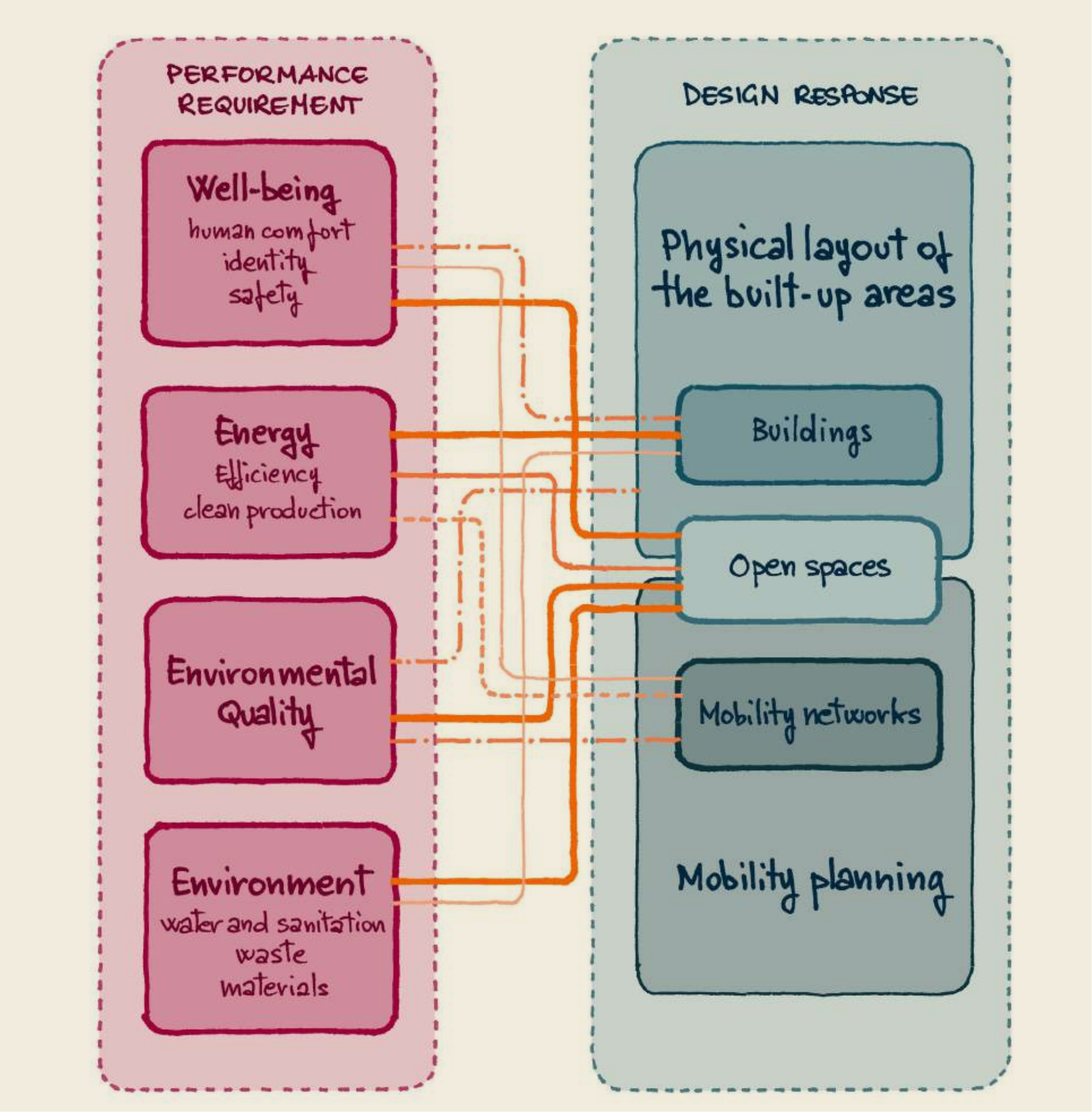
Design tip

Quantitative design values or evaluation methods

The checklist at the end of the design tips is a simple way to verify if the design schemes for new neighbourhoods have included the wide spectrum of relevant environmental and energy topics that will affect urban sustainability in the long term. The large representation of design measures within the design scheme alone is already a very good message.

The tips and checklist can be read as an independent part of the guidebook. In fact, this chapter summarizes the theoretical and experimental knowledge presented throughout the guidebook.

FIGURE 3.2 **THE INTERPLAY BETWEEN PERFORMANCE REQUIREMENTS AND DESIGN RESPONSE OF DIFFERENT DOMAINS OF THE BUILT ENVIRONMENT.**



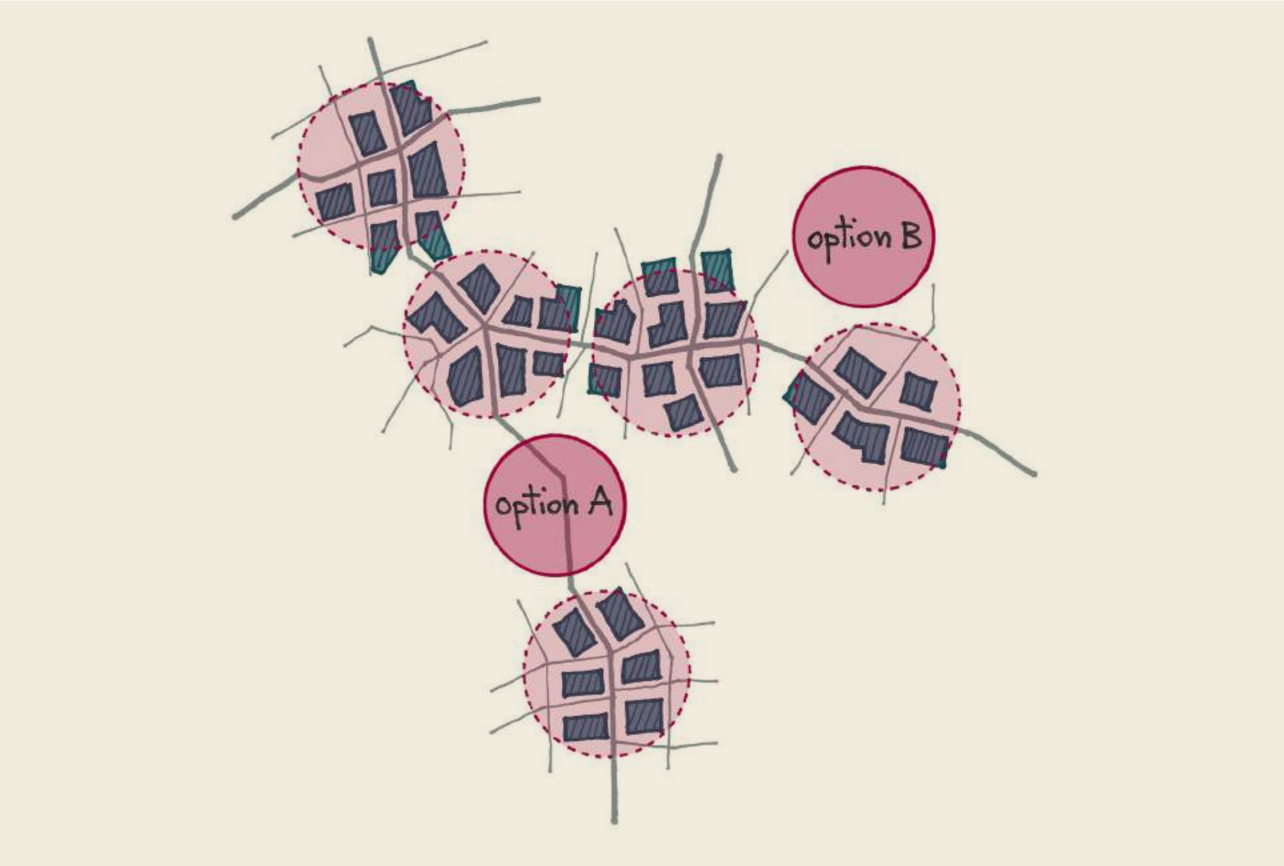
3.1 SITE LAYOUT: LOCATION

The very earliest stage of the decision-making process concerns the choice of the location of the neighbourhood, which is crucial for the future environmental quality, energy consumption and lifestyle of the inhabitants. The choice of a smart location for the new settlement that takes into account the significance of the local climate, is represented by essential checks on our list.

3.1.1 LINKAGE TO EXISTING URBAN AREAS

Most of the time, the choice of location for the new neighbourhood does not depend on the designer or the developer, but is a given condition. Therefore, the following set of tips should be carefully considered by public authorities. Moreover, the choice of location should be taken into account by everyone working on the plan for a new district, because it gives a measure of the starting point conditions and the potential of the new neighbourhood to improve the overall sustainability of the district.

FIGURE 3.3 A NEW NEIGHBOURHOOD SHOULD BE PLACED ON EXISTING INFRASTRUCTURAL CORRIDORS. OPTION A AND B ILLUSTRATED IN THE SCHEME (WITH BLUE CIRCLES) REPRESENT TWO DIFFERENT LOCATIONS FOR NEW NEIGHBOURHOODS: OPTION A IS PLACED ON A MAIN ROAD AND REPRESENTS AN EXAMPLE FOR AN INFILLING STRATEGY (PREFERRED OPTION), WHEREAS OPTION B IS PLACED ON AN OPEN AREA, WITH NO ROUTING ON THE EXISTING MAIN ROAD NETWORK (TO BE AVOIDED).



Locate the new neighbourhood on existing infrastructure and priority development axes, in order to increase its access to main urban functions and reduce commuting time. in this case, special attention is devoted to transit oriented developments (TODs). Give preference to infilling areas inside the existing city, avoid construction on un-urbanized land. In particular, make sure the new centrality generated by the neighbourhood is directly interconnected to existing (or available in the near future) local or regional centralities along an urban or regional corridor, typically (or potentially) served by public means of transit. In fact, high-density nodes can sustain the delivery of public services. If the new neighbourhood is not interconnected to any existing transit corridor, it should itself become the occasion for recomposing dispersed urban nuclei and identify the trajectory for a new mainstream DEVELOPMENT (figure 3.3).

Limit sprawl and avoid building the next 'cathedral in the desert'. Try to build in continuity with urbanized land.

As a measure, you can quantify the percentage of already urbanized land on the boundary of your design area (Figure 3.4), as follows:

$$\text{percentage of linkage to urban land } [\%] = \frac{\text{urbanized perimeter } [m]}{\text{total design area perimeter } [m]} * 100$$

Try to provide a percentage of linkage to urban land ≥ 50%.

FIGURE 3.4 **THE LEVEL OF URBAN INTEGRATION CALCULATED ON THE PERIMETERS OF A NEW NEIGHBOURHOOD: THE HIGHER THE PERIMETER DIRECTLY IN CONTACT WITH THE URBANIZED AREAS THE STRONGER THE INTEGRATION WITH THE EXISTING NEIGHBOURHOODS.**

3.2 SITE LAYOUT: PLANNING

This initial master-planning phase is made up of several steps:

- Identification and analysis of the climatic conditions of the site, which provide natural resources such as sun and wind potential, water availability (rainwater, underground water, water bodies, running water), soil characteristics;
- Identification of important natural constraints (topography, rivers, parks, forests, wetlands, agriculture);
- Identification of environmental and other threats and risk areas;
- Identification of main access points and infrastructure (roads from city to highway);
- Identification of legal restrictions (protected natural areas, heritage sites).

Then, the functional brief with the diverse land uses, the overall density and its distribution over the site and the urban form (which includes street network layout and building typologies design) have to be defined.

Sustainable neighbourhood design should:

- Promote high density urban growth, alleviate urban sprawl and maximize land efficiency;
- Promote sustainable, diversified, socially equal and thriving communities in economically viable ways;
- Encourage walkable neighbourhoods and reduce car dependency;
- Optimise use of land and provide an interconnected network of streets which facilitate safe, efficient and pleasant walking, cycling and driving;
- Foster local employment, local production and local consumption;
- Provide a variety of plot sizes and housing types to cater for the diverse housing needs of the community, at densities which can ultimately support the provision of local services.

UN-Habitat (2013)

3.2.1 PROVIDING LAND USE AND INCOME DIVERSITY

Mixed land use and urban functions are crucial prerequisites to sustainable neighbourhood design. Avoid single use zoning because this will inevitably lead to car-dependence. Specialized citadels like business parks, shopping malls, and so on, always involve large parking lots and encourage private mobility, promoting energy consumption and air pollution. Moreover, outside office or shopping hours, specialised urban areas are empty, dead spaces.

Mixed income housing is also crucial both for social equity and for supporting the operation of decentralised energy, water, wastewater and solid waste systems. The provision of several building typologies and types of dwelling units enables an effective social mix and the creation of varied places where different environmental qualities can satisfy people's different needs.

Scatter work places throughout the district, rather than concentrating them in areas that only contain other workplaces. By increasing the proximity of work and home, we also eliminate the need for workers to use motorised vehicles to travel between home and work.

At least 40 per cent of floor space should be allocated for economic use in any neighbourhood.

Twenty to 50 per cent of the residential floor area should be for low cost housing; and each tenure type should be not more than 50 per cent of the total.

Follow land use rules to enhance mixed use in buildings with high density. Putting Housing on the upper floors and retail units and offices on the lower ones is a good strategy to create urban vitality, to make dwellings more comfortable because they will be better ventilated and, indirectly, to reduce travel demand.

Single function blocks should cover less than 10 per cent of any neighbourhood.

Ensure that a good overall level of mixité is reached by evaluating the diversity and the redundancy of the land uses by analogy with ecological systems.

Check that the value of the Shannon-Wiener diversity index ranges from 1.5 to 3.5, or that the Simpson diversity index is greater than 0.6

At least 15 different land uses at walkable distance from each dwelling should be provided.

3.2.2 CALIBRATING STRUCTURE AND DENSITY

The density of urban plots has a big impact on street width and building height, thus on solar access, on the size of green areas and on local airflows which, in turn, affect outdoor comfort, the liveability of open spaces and – through the impact on indoor comfort – the amount of energy needed for air conditioning. Density also affects mobility and the possibility of making use of decentralised energy production, of wastewater and solid waste treatment systems, of efficient conversion technologies and of urban agriculture. Furthermore, a compact design with higher density housing units, mixed land use, multi-purpose streets, and appropriate grid layout preserves valuable land resources and municipal services can be provided cost effectively. Given the number of parameters involved and the complexity of the system, the optimum density is the result of a trial and error iterative process which also checks whether the space requirements for energy, water and waste systems are consistent with the chosen density.

Start the iterative process, bearing in mind that the new neighbourhood should aim to accommodate at least 150 people/ha in the medium-long term.

Design the neighbourhood around a 5 or maximum 10-minute walk. As a general check, all the housing should be placed within a five to ten-minute walk of the more frequently used services. Hence, all the residential areas should be covered by the ped-shed calculated on the local centres.

Draw the ped-shed, or walkable catchment, from the central spot (where the local civic or service centre should be located). The ped-shed is a map (Figure 3.5) showing the five and ten minute walk accessibility of the neighbourhood, both theoretical and actual. The theoretical five-minute walking distance is a circle with a radius of about 400 m drawn around any particular centre, resulting in a circle with an area of 50 ha. When calculating a ten-minute walking distance, the radius used is about 800 m, resulting in a circle with an area of 200 ha.

The actual walking distance area is obtained as follows:

- *First, draw a circle around the destination with a radius of 400 m. This circle represents the maximum possible walking distance "as the crow flies."*
- *Second, measure the walkable distance (e.g., 400 m.) from a destination along the pedestrian routes. This mapping process identifies the actual walking distance. Note that the 400-metre distance from the destination will probably fall short of the circle mapped in the previous step – this is due to the 400-metre distance being mapped "as the crow flies."*
- *Third, identify the plots, buildings, parks, and other destinations that can be reached within that distance. The area around these features represents the walkable catchment. This is the actual area from which a pedestrian would be able to access the centre along the available streets in a five-minute walk.*

Ped-shed or walkable catchment calculations are expressed as the actual area within a five-minute walking distance as a percentage of the theoretical area (as the crow flies) within a five-minute walking distance (or ten-minute).

BOX 3.1 EXAMPLE - CALCULATION OF THE SHANNON-WIENER DIVERSITY INDEX, OF THE REDUNDANCY AND OF THE SIMPSON DIVERSITY INDEX

With reference to Box 3.2.1, Chapter 3:

1. Calculate the Shannon-Wiener diversity index H for the neighbourhood:

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

2. Calculate the maximum possible diversity $H_{max:}$

$$H_{max} = -ln\frac{1}{k}$$

3. Calculate the redundancy R:

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

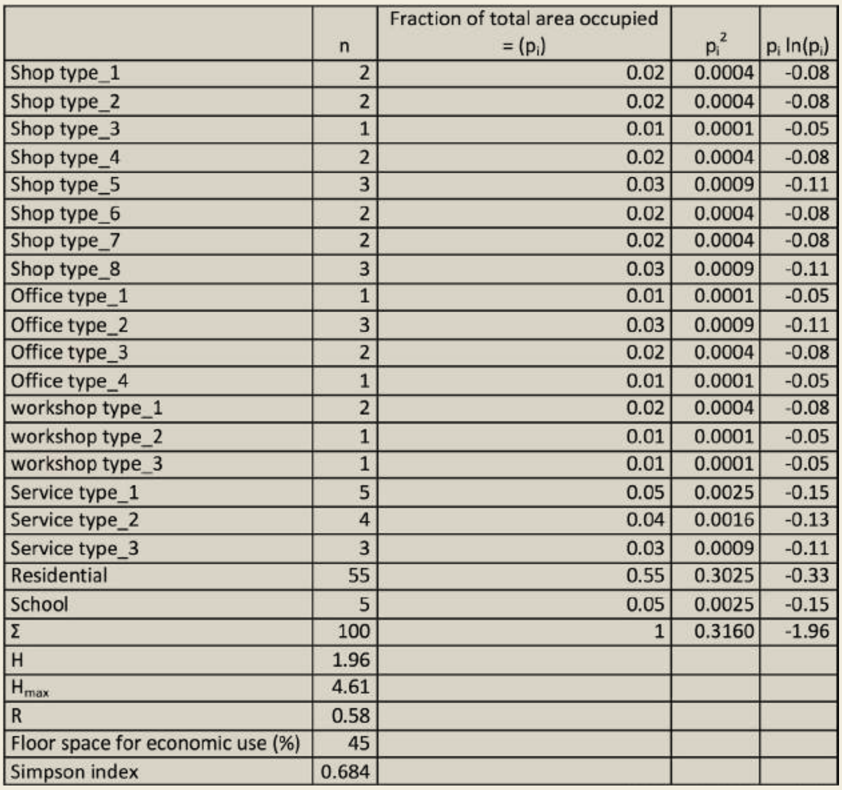
Example:

In a neighbourhood k = 20 different classes of land use functions are present, as listed in column 1 of Table B5.1. Each land use function can be present more than one time, so there are 55 apartments, 1 school, 3 shops type_8, etc., for a total of N, as shown in column 2. In the third column pi = n/N is calculated, i.e. the weight of each land use function. Alternatively, p_i can be used to represent the fraction of the total land allocated to each function if n is expressed as floor area occupied and N is the total floor area of the neighbourhood, as chosen in this example. In the fourth column the values p_i.ln (p_i) are calculated.

The calculations show that the Shannon-Wiener diversity index is H = 1.96, the redundancy is R = 0.58, and that 45% of floor space is allocated for economic use; the values of both the diversity index and the redundancy are within the limits characterising healthy ecosystems and, by analogy, resilient neighbourhoods. The value of the Simpson index D for the same example is:

$$D = 1 - \sum_{i=1}^{i=k} p_i^2 = 1 - 32 = 0.68$$

TABLE 3.1 **THE EXAMPLE WITH 20 DIFFERENT CLASSES OF LAND USE FUNCTIONS IS USED.**



	n	Fraction of total area occupied = (p_i)	p_i^2	$p_i \ln(p_i)$
Shop type_1	2	0.02	0.0004	-0.08
Shop type_2	2	0.02	0.0004	-0.08
Shop type_3	1	0.01	0.0001	-0.05
Shop type_4	2	0.02	0.0004	-0.08
Shop type_5	3	0.03	0.0009	-0.11
Shop type_6	2	0.02	0.0004	-0.08
Shop type_7	2	0.02	0.0004	-0.08
Shop type_8	3	0.03	0.0009	-0.11
Office type_1	1	0.01	0.0001	-0.05
Office type_2	3	0.03	0.0009	-0.11
Office type_3	2	0.02	0.0004	-0.08
Office type_4	1	0.01	0.0001	-0.05
workshop type_1	2	0.02	0.0004	-0.08
workshop type_2	1	0.01	0.0001	-0.05
workshop type_3	1	0.01	0.0001	-0.05
Service type_1	5	0.05	0.0025	-0.15
Service type_2	4	0.04	0.0016	-0.13
Service type_3	3	0.03	0.0009	-0.11
Residential	55	0.55	0.3025	-0.33
School	5	0.05	0.0025	-0.15
Σ	100	1	0.3160	-1.96
H	1.96			
H_{max}	4.61			
R	0.58			
Floor space for economic use (%)	45			
Simpson index	0.684			

FIGURE 3.5 **PED-SHED MAP. ACTUAL REACHABLE AREA WITHIN FIVE MINUTES: 60% OF THE THEORETICAL; WITHIN TEN MINUTES: 40%. ADAPTED FROM LNWAG 2009.**

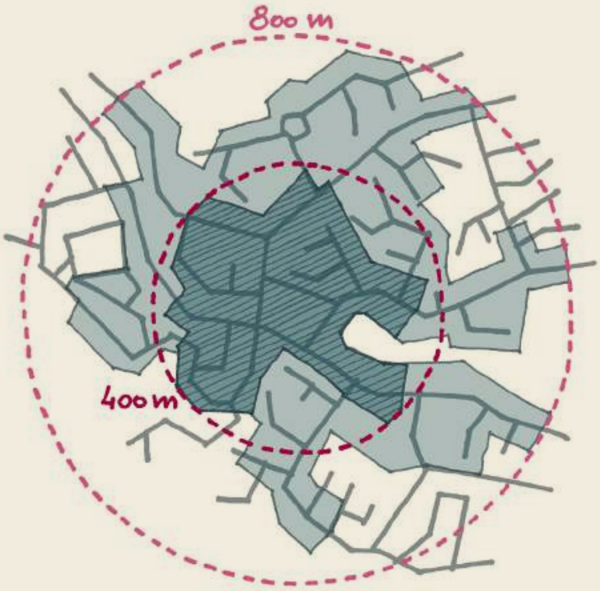


TABLE 3.2 **USES REACHABLE WITHIN 5 MIN WALK**

Food Retail
Supermarket
Other food store with produce

Community-Serving Retail
Clothing store or department store selling clothes
Convenience store
Farmer's market
Hardware store
Pharmacy
Other retail

Services
Bank
Gym, health club, exercise studio
Hair care
Laundry, dry cleaner
Restaurant, café, diner

Civic and Community Facilities
Adult or senior care (licensed)
Child care
Community or recreation centre
Cultural arts facility (museum, performing arts)
Educational facility
Family entertainment venue (theatre, sports)
Government office that serves public on-site
Place of worship
Medical clinic or office that treats patients
Police or fire station
Post office
Public library
Public park
Social services centre

A good target is to have 60 per cent of an area within a five-minute walk, or a ten-minute walk to a transit station.

Note that the walkable catchment should always count the area of land used for dwellings but not include the public open spaces contained in the accessible area.

Locate and/or design the project such that at least 50 per cent of its dwelling units are within a 400-m walking distance of the number of diverse uses in Table 3.2, including at least one use from each of the four categories (USGBC 2011).

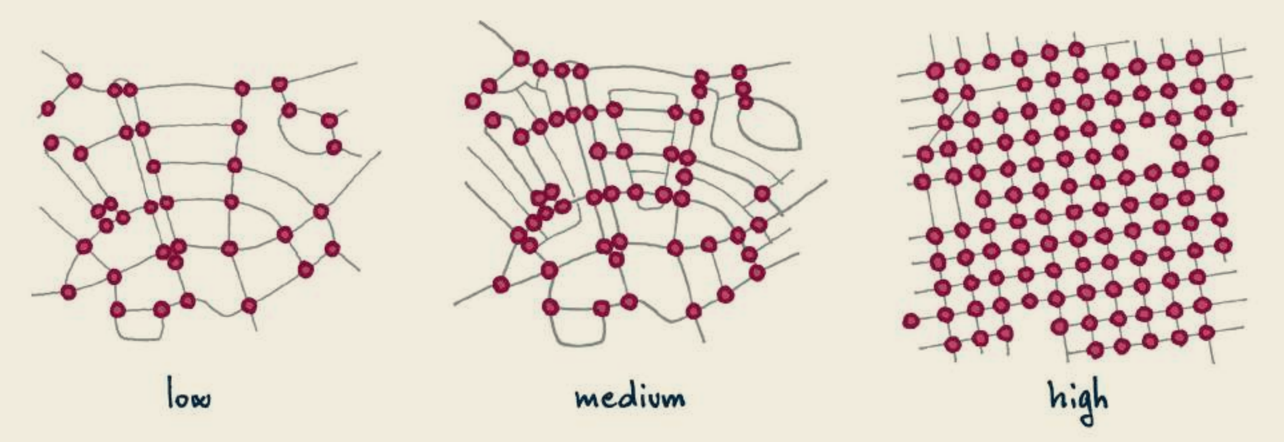
3.2.3 WALKABILITY

Walkability is the key to promoting a sustainable city. Building a neighbourhood of short distances where people can reach most of the services to satisfy their daily needs is the most effective way to improve energy efficiency for mobility, i.e. through energy savings from the reduction of travel demand.

Walkability is supported by the connectivity of the street network and by a pleasant and comfortable urban landscape that should be diverse and rich in experience in a sufficiently dense space.

FIGURE 3.6 **NEIGHBOURHOOD'S CORE SERVICES, INCLUDING PUBLIC TRANSPORT, REACHABLE IN FIVE MINUTES' WALK**

FIGURE 3.7 **INTERNAL CONNECTIVITY (COMPUTED AS NUMBER OF NODES IN THE GRID).**



Place the community's core services at the centre of the neighbourhood, close to other communities and public transport nodes in order to recreate an urban mixed-use setting (Figure 3.6).

Ensure that services and retail outlets are located along home-to-work routes, so that it is convenient for commuters to do their shopping and leisure activities as part of their daily routine, and additional, time consuming trips can be saved. Provide comfortable street landscapes

Consider the canyon's aspect ratio (see section 3.1.1) to provide shadowed pathways and cycle lanes to make walking and cycling more pleasant.

Provide internal connectivity[32] of the street network inside the new neighbourhood (Figure 3.7). to promote walkability, planners should provide a street network which is rich in opportunities for movement.

Make sure that at least 100 intersections/km² are provided internally and close to the new neighbourhood (UN-Habitat 2017); the more, the better.

$$Street\ Connectivity = \frac{Number\ of\ intersections\ [-]}{Area\ of\ reference\ [km^2]}$$

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[32] *Connectivity is the degree to which the movement networks interconnect. It refers to the directness or ease of moving between origins (e.g., households) and destinations along the movement network.*

3.2.4 SUSTAINABLE MOBILITY

Direct strategies to tackle transport refer to solutions for sustainable mobility. These refer primarily to non-motorised mobility solutions, then to the limitation of car usage. Discouraging car mobility, especially the use of private vehicles, is a way to promote different lifestyles, where the ownership of a car is no longer seen as a status symbol. Of course, there is a long way to go, but perhaps sustainable lifestyles will become more attractive, once people understand that these increase the quality of life.

Increase opportunities for sustainable mobility by creating space for cycle lanes or cycle-friendly streets (that do not provide dedicated lanes, but a safe environment for cycling) and safe, enclosed storage places for bicycles in each building.

Count the total linear extension of cycle lanes and cycle-friendly streets and compare it to the total motorised linear extension. They should be at least equal.

Car parking should not occupy the ground floors of buildings, especially those spaces facing streets with high urban potential. Two options for car parking are preferable: firstly, diffused parking lots at street level, mainly dedicated to car sharing and electric vehicles (hence with charging stations that make use of on-site solar energy); main roads with shops and services could eventually benefit FROM PARKING spaces along the street, but as a general rule, try to limit car parking at street level. Secondly, mainly for residential use, give preference to concentrated parking areas possibly not directly facing streets, in multi-storey buildings or underground.

Present standards for parking lots inside the development are usually not consistent with the principles of sustainable mobility. Today, providing a minimum number of parking spaces per inhabitant or household is mandatory in numerous urban codes. If this is the situation, use the minimum allowable value.

Make sure the pedestrian route from home to the parking lot represents a direct, attractive, safe and comfortable experience for people.

Provide shaded and rain sheltered pedestrian and cycling paths, including parking lots with trees or urban furniture to promote low energy mobility

Consider the possibility of creating car-free residential areas at the borders of which are a number of parking lots

Look ahead, make provision for the new trends in urban mobility, based on electric car sharing (conventional or self-driving), which will entail a number of small parking lots distributed within the neighbourhood, at walking distance from residences and SERVICES, PROVIDED with charging stations.

3.3 CLIMATE RESPONSIVE DESIGN

Climate is the main driver of energy consumption for heating or cooling, and the urban form plays a significant role in determining the amount of energy needed. Geometry, size and materials (including vegetation) have a big impact on outdoor and indoor comfort and liveability, and consequently on indoor energy consumption. The design scheme of a neighbourhood impacts both on people's behaviour (mobility habits) and on the performance of buildings (shading, ventilation, vegetation and infrared radiation are the drivers of the energy loads in indoor spaces, Figure 3.8).

Strategies for controlling outdoor comfort (i.e. mitigating the UHI) in a tropical climate are:

- Manipulate the geometry of the neighbourhood, i.e. the three-dimensional volume formed by buildings to minimise radiation trapping and enhance shadowing;
- Manipulate the street layout and building shape to favour wind access;
- Control the thermal properties of urban surfaces, i.e. colour and mass;
- Maximise evapotranspiration loss with vegetation and water bodies.

3.3.1 URBAN CANYONS

The primary design strategy is to manipulate urban geometry (height and width of buildings, street orientation and street width) to enhance self-shading of buildings and shading of public spaces, to increase urban albedo and to exploit the cooling potential of wind. This strategy should be combined with - and enhanced by - the shading potential of trees in the streets.

Appropriate design of urban canyons (i.e. their depth and orientation) is the most crucial step, as they dictate the width of the streets and the height of the buildings.

Consider that orientation of the street network and the aspect ratio of the urban canyons are crucial factors for shadowing and ventilation, AS THEY have a significant effect on outdoor comfort and the liveability of the streets, and the thermal and visual comfort achievable indoors.

North-South oriented streets provide the maximum shadowing at pedestrian level, provided that the canyon's aspect ratio, H/W, (building Height/street Width) is between 2 and 3. Lining the streets with trees is recommended, as it provides further shadowing during the central hours of the day.

In order to favour both ventilation and shadowing, in lowland EAC climates, other than hot arid, where monsoon winds are active, moving the orientation of these streets from NS to NNE-SSE or even to NE-SW improves the comfort of pedestrians (Figure 3.9).

FIGURE 3.8 **CLIMATE RESPONSIVE NEIGHBOURHOOD DESIGN**

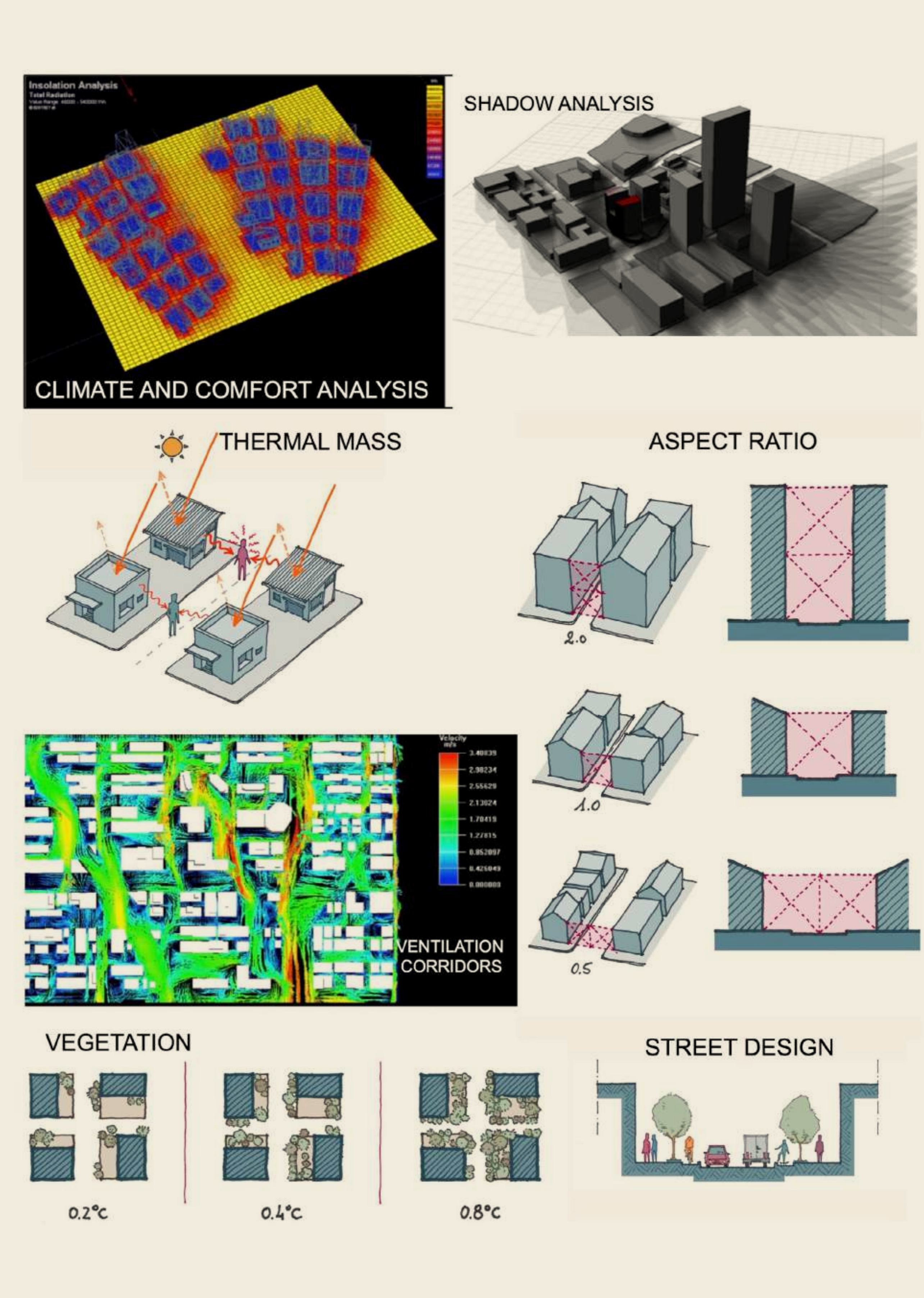
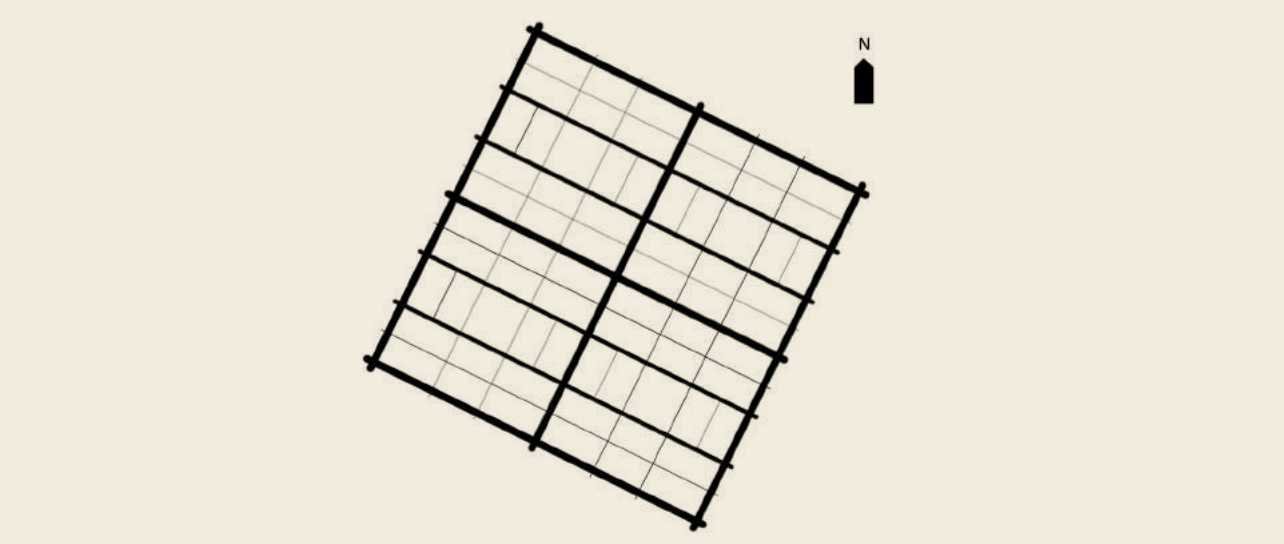


FIGURE 3.9 **OPTIMUM NEIGHBOURHOOD GRID ORIENTATION IN LOWLAND EAC CLIMATES, OTHER THAN HOT ARID, AFFECTED BY MONSOON WINDS.**



East-West running streets are more critical, and require supplemental choices, such as the planting of trees to line them and high albedo ground and wall surfaces.

In highlands climates East-West running streets with aspect ratio H/W ≤ 1 may be beneficial for passive heating during the cool season.

Use deep N-S, NE-SW oriented canyons for comfortable pedestrian pathways, shops, coffee houses, small artisan workshops, as the sidewalks will be in shade almost all day if the street is tree lined. In such canyons, sidewalks should be wide enough to allow for outdoor activities (leisure or productive). The upper floors should contain residences, as the height above street level favours ventilation.

Use east-west oriented streets mainly for vehicular traffic and leave north-south oriented streets mainly for pedestrians. Consider the possibility of making use of horizontal overhangs appropriately dimensioned and spaced along the height of the walls: they protect canyon walls very effectively from direct exposure to the sun, reduce solar radiation reflected by the walls towards the canyon floor and the heat flux through the walls towards the indoor space (see Appendix 4).

Consider that, due to the sun paths characterising the tropical latitudes, it is impossible to have all the points of the ground level of an urban canyon shaded all day or all year, and that around noon only horizontal sun protections can provide shade.

Avoid large public squares; when they are too large, they look and feel deserted, and it is not comfortable to cross them on a hot day. Do not make a public square wider than 20 m on its shorter side. In general, the dimensions of the open space should be no less than twice the average height of the surrounding buildings and have a proportion no narrower than 1 unit of width to 4 units of length.

Pay attention to the mass and surface colours of materials: both influence comfort in both urban canyons and open spaces. Avoid dark surfaces, especially horizontal ones.

Albedo values of opaque surfaces should be higher than 0.4 (see section 2.1 and Appendix 1).

Control the mass of walls (heavyweight in a hot dry climate, lightweight in a hot humid climate, medium weight in a highland climate)

Be cautious about using glazed or reflective materials for canyon walls: the comfort (thermal and visual) conditions in the street are significantly worsened, unless appropriately designed devices shadow the façade.

In order to control the excessive reflection due to glass surfaces, Window to Wall Ratio (WWR) should not exceed the value 0.3, unless the window is fully shadowed all day (Figure 3.10).

$$Window\ to\ Wall\ Ratio\ WWR\ [0-1] = \frac{area\ of\ windows\ [m^2]}{total\ area\ of\ the\ facade\ [m^2]}$$

Consider using vegetation on streets, as it significantly improves outdoor comfort and reduces energy consumption indoors.

Provide as many green areas as possible, compatible with other design needs. A green area is not only beneficial for the buildings directly around it, but also induces – because of its lower air temperature and thus lower pressure in comparison with the built-up areas – mild air movements that, with appropriate street and building design, can significantly improve outdoor and indoor thermal comfort.

FIGURE 3.10 **WINDOW TO WALL RATIO (WWR) CALCULATION**

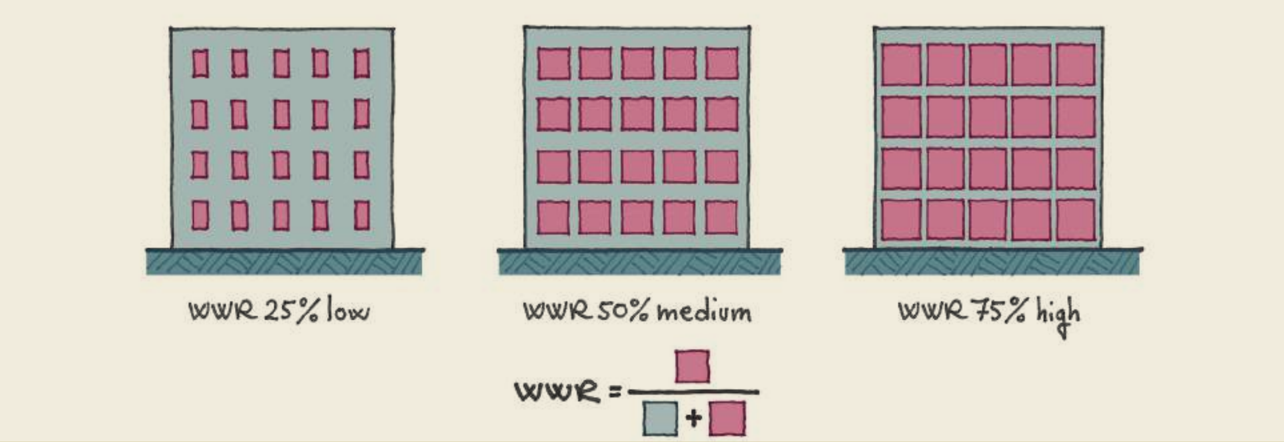
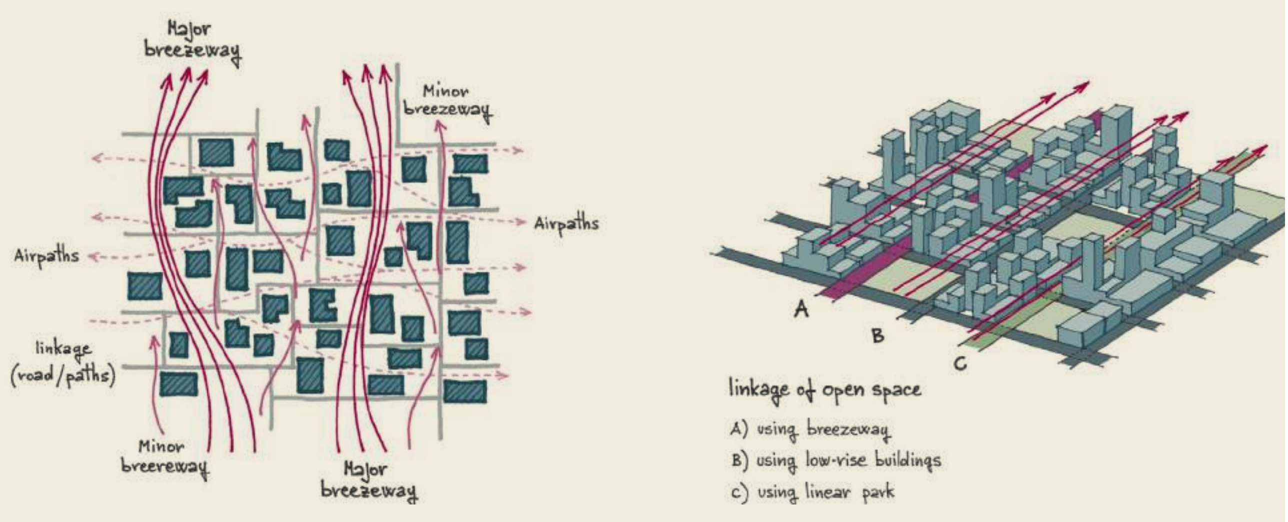


FIGURE 3.11 **BREEZEWAYS**



Check that the design choices deriving from climatic drivers do not conflict with the choices promoting the reduction of motorised mobility. In the tropics, a large part of the anthropogenic heat production is due to motorised mobility. The reduction of motorised mobility would be indirectly beneficial in further reducing the heat island because of the reduction of pollutants in the atmosphere, which cause an increase in the long-wave radiation from the sky and a decrease in the radiative heat losses towards the sky. there is, of course, also an impact on health.

Encourage easy channelling of the prevailing winds. Wind has a multiple positive effect in tropical climates: it improves outdoor thermal comfort, removes the sensible and latent heat and reduces air pollution.

Encourage wind penetration (see section 2.1) by creating breezeways. Breezeways can be in the form of roads, open spaces and/or low-rise building corridors through which air reaches the inner parts of urbanised areas (Figure 3.11).

Closely packed buildings impede air flow. Building front permeability equivalent to 20% to 30% is a good starting point for neighbourhood design. Permeability to wind P is calculated as (figure 3.12):

$P = S/(S+L)$

Widening the setback of buildings setback improves permeability.

If streets are aligned to the prevailing wind direction, wing walls in the buildings' façades should be considered to enhance indoor ventilation.

Avoid uniformity in building height, canyon width and canyon length; uniformity reduces eddies, thus ventilation. Variation in Building height across the neighbourhood with the height decreasing towards the direction of the prevailing wind should be adopted to promote air movement (Figure 3.13). a Staggered arrangement of the blocks allows the blocks behind to receive the wind penetrating through the gaps between the blocks in the front row.

FIGURE 3.12 **PERMEABILITY EVALUATION AND IMPROVEMENT**

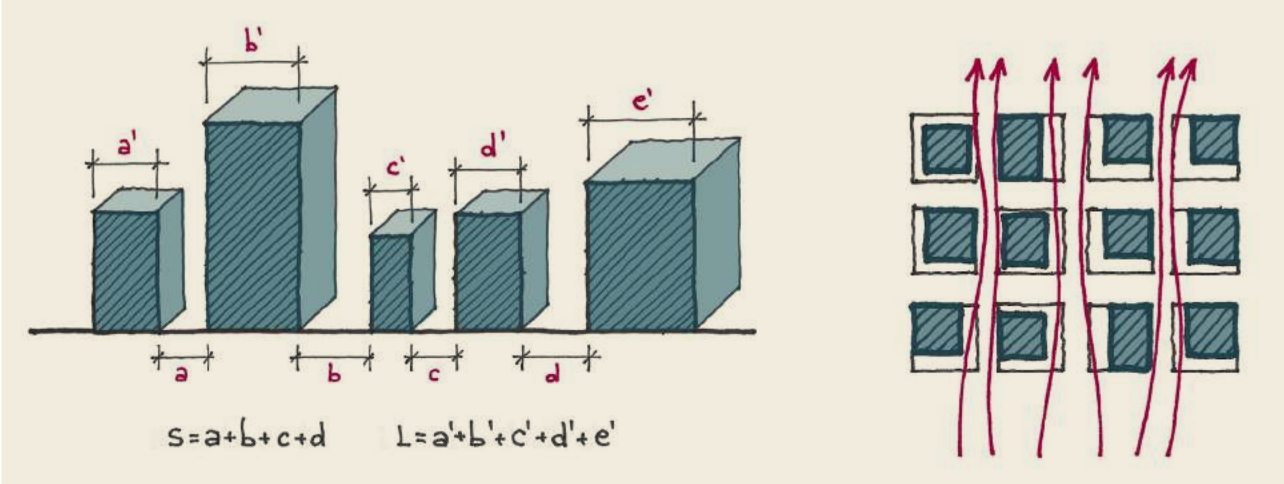
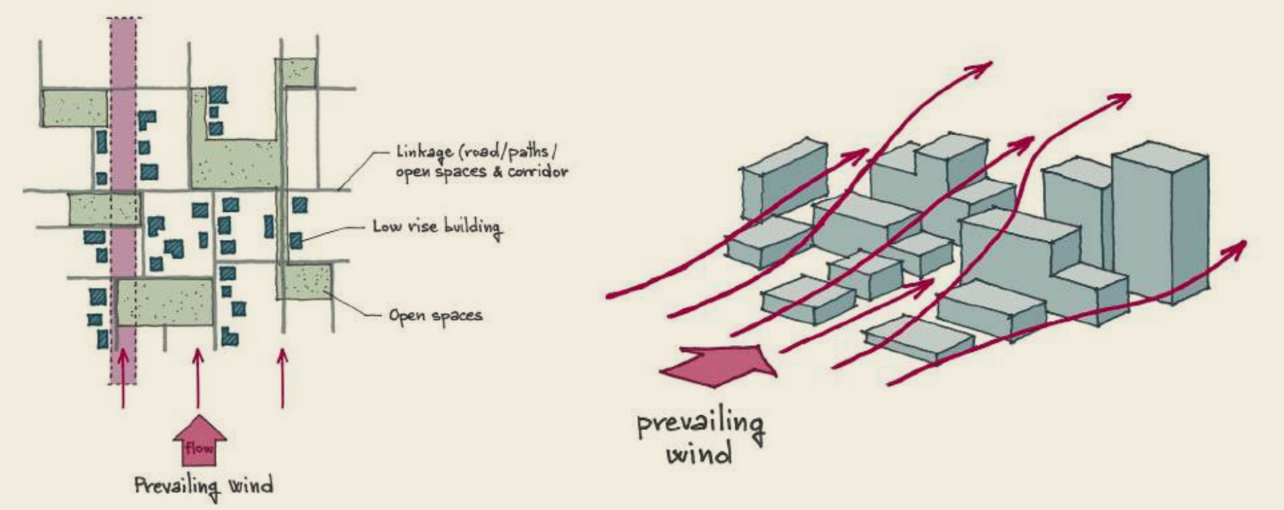


FIGURE 3.13 **VARIATION IN BUILDING HEIGHT**



Keep the length of street canyons as short as is practical, to promote flushing at street intersections by corner eddies.

When a neighbourhood is by a waterfront, properly orientated air paths connecting to the waterfront or open spaces are effective in bringing in air ventilation.

Open spaces in the urban area allow the above roof-top wind to flow into them and benefit pedestrian air ventilation.

3.3.2 STREET DESIGN

Street design entails two decisions a) the street grid and b) the street width.

The orientation of a perpendicular street grid is driven by the need for shadowing and ventilation, but topography should also be carefully considered. Roads should also be perpendicular or parallel to the direction of the slope, so that water can run off the street. In this case, a compromise is necessary.

The spacing of streets is first of all determined by their hierarchy.

In a simple, square, road grid (Figure 3.14), the spacing recommended by UN-Habitat (UN-Habitat 2016; UN-Habitat 2013), according to the road hierarchy, is:

- *Major streets – 300 m*
- *Connector streets – 110 m*
- *Access streets – 55 m*

The main decisions about street width are driven, besides the street hierarchy, by the need for solar protection of the pavements, which depends on the orientation, and the aspect ratio H/W. The aspect ratio, in turn – given the height constraints of the buildings deriving from energy and water self-sufficiency (see sections 3.4.2 and 3.5.2) – is constrained by the minimum street width compatible with its function (connector, access, pedestrian only).

FIGURE 3.14 **STREET HIERARCHY AND SPACING (UN-HABITAT 2016)**

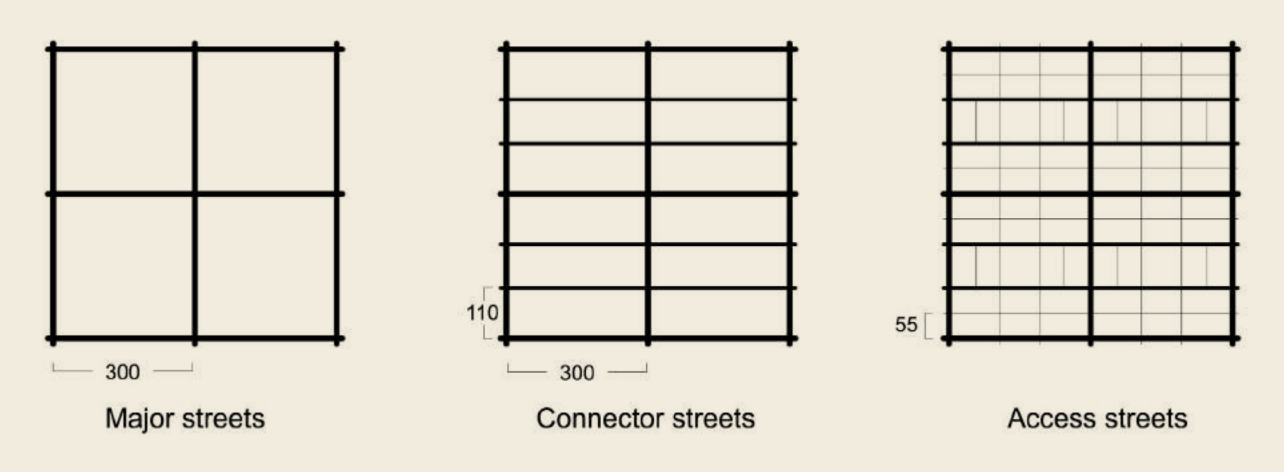


FIGURE 3.15 **PHYSICAL DETERMINANTS FOR STREET WIDTH. ADAPTED FROM LNWAG 2009.**

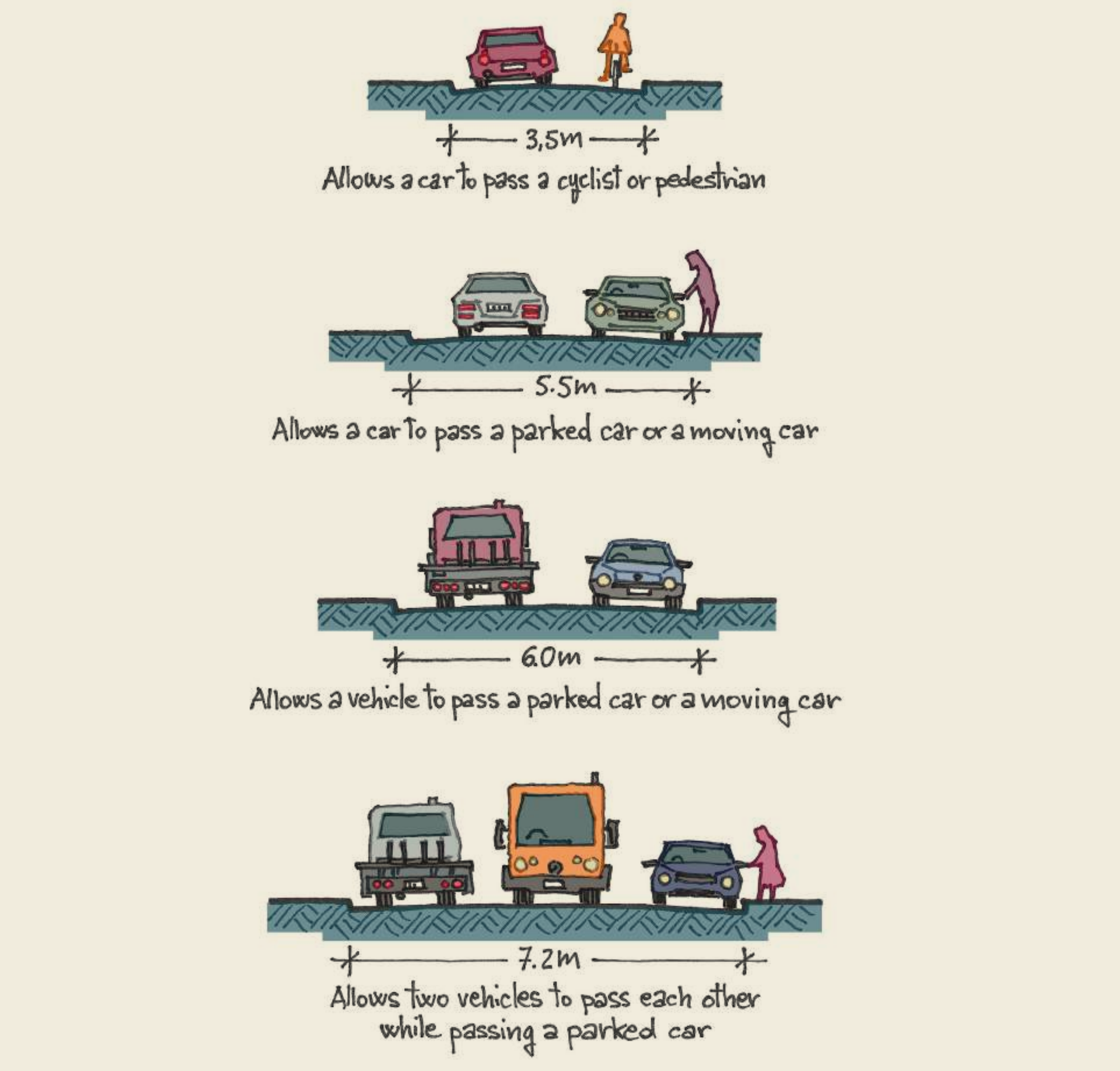
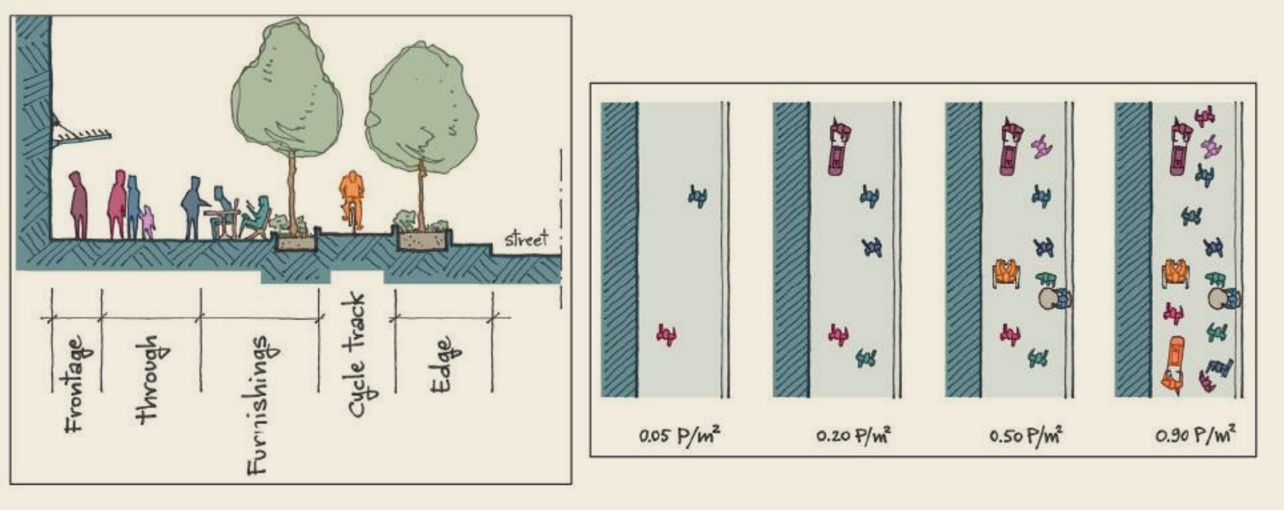


FIGURE 3.16 **MOBILITY PRIORITIES**

FIGURE 3.17 **THE FUNCTIONS OF THE PEDESTRIAN REALM ZONES (LEFT) AND DIFFERENT DENSITIES OF USE FOR SIDEWALKS MEASURED IN NUMBER OF PEDESTRIANS PER SQUARE METER (RIGHT). ADAPTED FROM (ADUPC 2015 AND DTUK 2007).**



When defining the width of neighbourhood streets, consider that:

- **the minimum street width compatible with vehicular traffic ranges from 3.5 m to 7.5 m, as shown in Figure 3.15;.**
- **a sustainable neighbourhood street has to accommodate pedestrians and cyclists, and that they should have priority over all the other forms of mobility (Figure 3.16);**
- **in a walkable neighbourhood sidewalk size is of foremost importance. It depends on the human flows expected on particular streets, and is increased by the activities besides walking planned on the sidewalk (Figure 3.17).**

As a starting point for streets designed according to their function in a sustainable neighbourhood, consider the suggestions deriving from Figure 3.18.

Consider that, for shadowing purposes, when the street width is first defined, street orientation and building height are dependent variables.

In an EAC lowland climate access streets and footpaths or shared path streets are best located in North/South or North-East/South-West oriented streets, with aspect ratio H/W ≥ 2, as they would be very well protected from direct sun and be well ventilated, providing quite a comfortable outdoor environment. Neighbourhood connectors and access streets, on the other hand, should be East/West oriented, as even with aspect ratio higher than 2, they would not be shadowed.

Pedestrian walkways (based on 1.8 m width within the through zone) should be 80% shadowed; cycle lanes and parking 50%; open spaces 65% (ADUPC 2010). Shade calculations must be undertaken on the 21st of the hottest month at 1:00 pm local time. Check the actual shadowing of sidewalks with the graphical method suggested in section 3.1 and Appendices 3 and 4, or with appropriate software. If sidewalks are not sufficiently sheltered from the sun, provide them with arcades or some other sun-sheltering device (Figure 3.19).

Sidewalks should be provided along 100% of the street length.

FIGURE 3.18 **LEFT: NEIGHBOURHOOD CONNECTOR; THESE STREETS SERVICE AND LINK NEIGHBOURHOODS. CENTRE: ACCESS STREET; TO ACCOMMODATE SHARED PEDESTRIAN, BIKE AND VEHICULAR MOVEMENTS. RIGHT: FOOTPATH OR SHARED PATH; PEDESTRIAN AND CYCLIST STREET ALLOWING TEMPORARY ACCESS TO VEHICLES. ADAPTED FROM LNWAG 2009.**

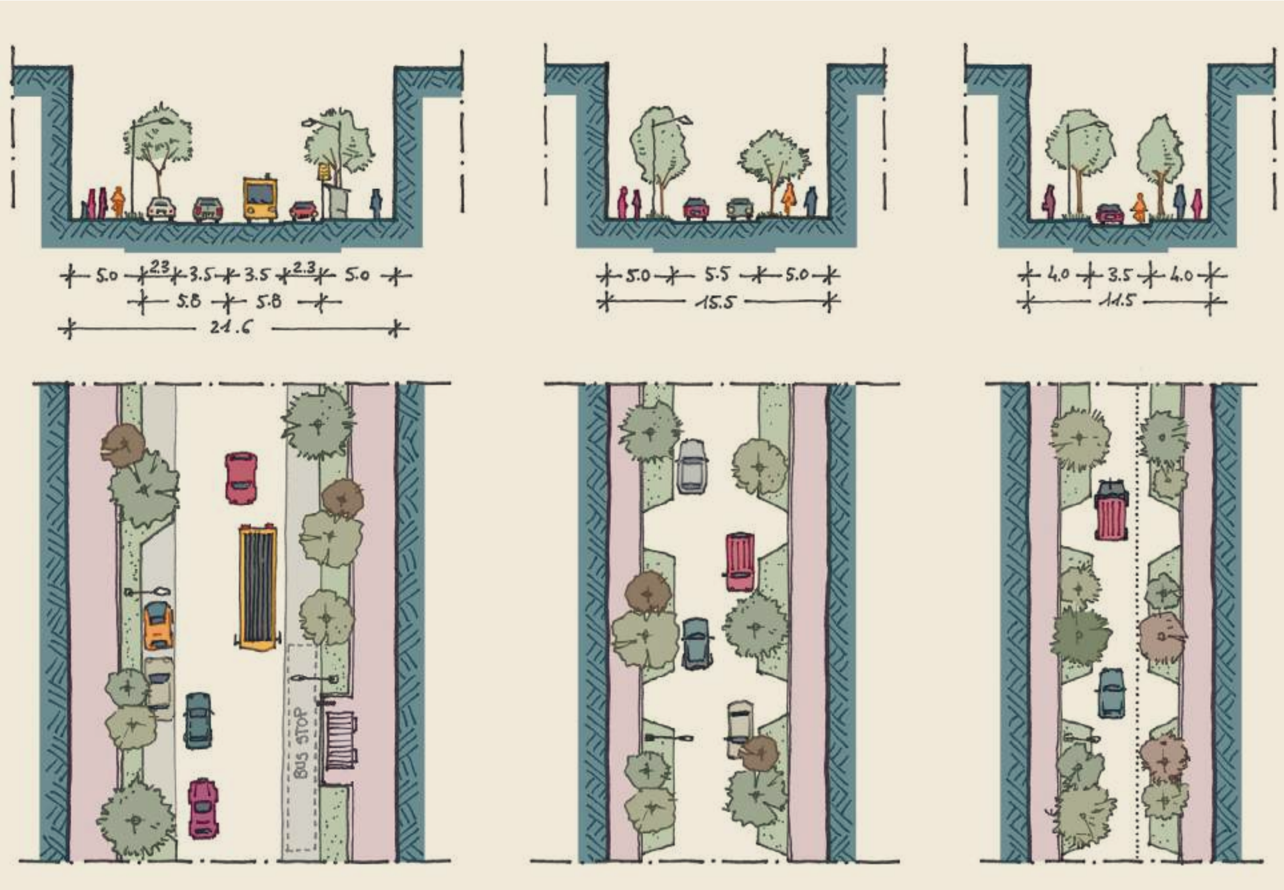


FIGURE 3.19 **SHADOWED WALKWAYS**

Consider that in a sustainable neighbourhood street spacing and width are mutually dependent.

The street network (and parking space) should occupy at least 30 per cent of the land and at least 18 km of street length per km^2 (UN-Habitat 2013), which, for a 30-ha neighbourhood means more than 5.5 kilometres of streets with an average width of 16 m.

3.3.3 GREEN AREAS

Green areas and spots represent another kind of urban material for neighbourhood climate control with fundamental properties such as (1) improving outdoor comfort, (2) safeguarding bio-diversity, (3) providing people with accessibility to nature, (3) providing food.

Differentiate between green area typologies in order to include microclimates and the ecological and social qualities of urban nature. make sure your neighbourhood provides, among others:

- **urban parks;**
- **tree lined streets;**
- **pocket parks with diffused small green interventions (planters, green shelters, roofs and walls);**
- **urban food gardens.**

Define the extent of green areas and spots and their spatial distribution taking into account their cooling effect, which can be checked by means of simulations. As a basic reference value, 15-20% of the neighbourhood land should be allocated for green open areas (UN-Habitat 2016).

Consider that trees and vegetation in general are also a very effective carbon sink.

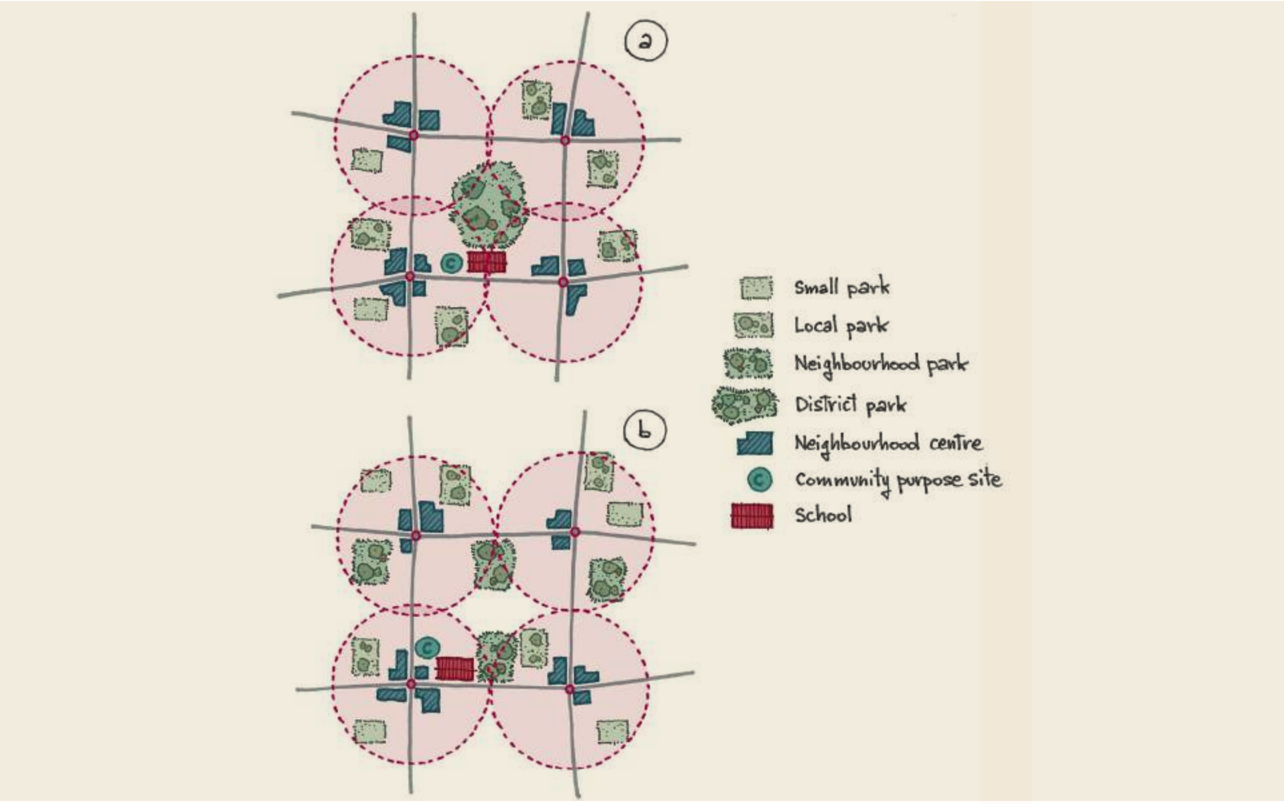
Parks must be the appropriate size to accommodate the activities for which they will be used, not too small, not too large. Besides neighbourhood parks, local parks up to 3000 m^2 should be provided for local children to play in, and should include small intimate spaces which are designed to be places of repose, in order to encourage pedestrian connectivity, and create a sense of place.

Local parks should be provided within 150 to 300 metres safe walking distance to all dwellings. Neighbourhood parks of around 3000-5000 m^2 should be provided at a maximum 400 m walk from most dwellings (90%). Larger parks (district parks) should be located between or towards the edge of neighbourhoods rather than at the core (Figure 3.20).

Make sure the occupants of all the housing can reach a green area within a 5 to 10-minute walk.

Urban vegetation (trees in particular) should be planted especially in public areas and close to pedestrian and cycle paths in order to make them more comfortable. All the streets should be tree-lined, but care must be taken to ensure that they do not endanger ventilation.

FIGURE 3.20 **TWO OPTIONS FOR SPATIAL DISTRIBUTION OF PARKS AND POSITION OF LOCAL SCHOOL. PARKS AND SCHOOL SHARED BETWEEN NEIGHBOURHOODS, AT AN APPROPRIATE DISTANCE THAT ALLOWS THEM TO BE REACHED IN LESS THAN 10 MINUTES' WALK. ADAPTED FROM LNWAG (2009)**



3.3.4 WATER BODIES

Water bodies have the potential to cool the urban environment due to their thermal and optical properties, although they should be used with great care, as they can be counterproductive.

Constructed wetlands (see section 3.5 and Appendix 7) can be included among the water bodies in addition to the stormwater catchment basins.

To maximise their effect water bodies should be located in every neighbourhood at the northern/southern corner.

Consider the mosquito breeding problem in still water bodies.

3.4 ENERGY SUPPLY

Up to now, energy supply to make the city work has never been considered an issue concerning urban planning. This is no longer the case since we have acknowledged the need to rely mainly or exclusively on renewable energy sources. This paradigm shift, together with the crucial role of energy efficiency, makes the issue of energy supply an important part of the urban designer's work.

The key issue is the decentralisation of energy production combined with the use of renewable energy sources. This approach, besides being a prerequisite for coping with the challenge of climate change, brings additional benefits, such as energy security, improvement of urban air quality (no pollution due to combustion), reduction or elimination of soil contamination due leakages or spills in fossil fuel transport, reduction or elimination of water use for electricity production with thermal plants, creation of local employment and economic activities.

3.4.1 COGENERATION

Energy production and distribution technologies at neighbourhood scale can be economically viable and environmentally sound. In lowland tropical climates cogeneration could work for most of the year for providing air conditioning, making it in some cases very cost effective. The electricity produced can be conveyed to the neighbourhood grid, improving its reliability.

Evaluate the possibility of proposing cogeneration (combined heat and power, CHP) for electricity production and district cooling to supply energy in a more efficient way at the local scale. CHP requires: (1) space for both the CHP units and the absorption chillers; (2) space for fuel storage, if powered with solid biomass; (3) the construction of a network, which is cost-effective only if conceived from scratch in a new development and when servicing non-residential users.

3.4.2 SOLAR AND WIND ENERGY

Renewable energy sources are distributed and usually available with a low power density. This means that in the urban context they need to be integrated into structures designed and constructed for fulfilling other requirements, otherwise they would occupy too much space. This has an impact on the design of these structures.

Minimise dependence on a greater municipal grid for the energy needs of the community. Take advantage of onsite renewable resources to generate the energy required to make the district operate.

Consider that solar PV panels are already a reality in many places in Africa. The success of this technology is related to the fact that they do not need large-scale infrastructure and can be used locally and off grid. This may result in a significant impact on neighbourhood design.

At the latitudes of tropical countries, the optimum tilt angle of a PV panel is 0 degrees (horizontal), up to 15 degrees with no significant reduction in productivity. Hence, vertical arrangements of panels on balconies or facades are not applicable.

PV systems play a crucial role in zero energy buildings and neighbourhoods, and not only in energy terms, as relying on them places constraints on the maximum building height. The reason for this is that there is a relationship between the building's energy demand, the size of the PV system required to supply it, and the roof area available to install it (see Figure 3.21 for a first evaluation in East African Community climates).

Consider that small scale (micro and mini) wind turbines are a very useful addition if coupled with PV panels, because they complement solar production when there is no sun i and they reduce the need for back-up power.

The nominal power of small roof wind turbines is usually between 0.5 and 4 kW; mini wind turbines positioned in open spaces such as parking areas, urban farming plots, etc., can reach 20 kW.

Consider biomass fuelled CHP production based on the gasification process. It can be a very convenient solution because it allows electricity production to be programmed. It requires space for combustion and storage for biomass. The biomass can be provided by the pruning of trees in the streets and parks.

Consider biogas production. Bio-digesters that use organic waste products are another innovative method for achieving local self-sufficiency: organic waste from households and urban agriculture can be used for biogas and fertiliser production, alone or in combination with the organic waste from the local sewerage network. Bio-digestion is convenient

at the local scale as it optimizes the closing of cycles and reduces waste production. Disadvantages are mainly:

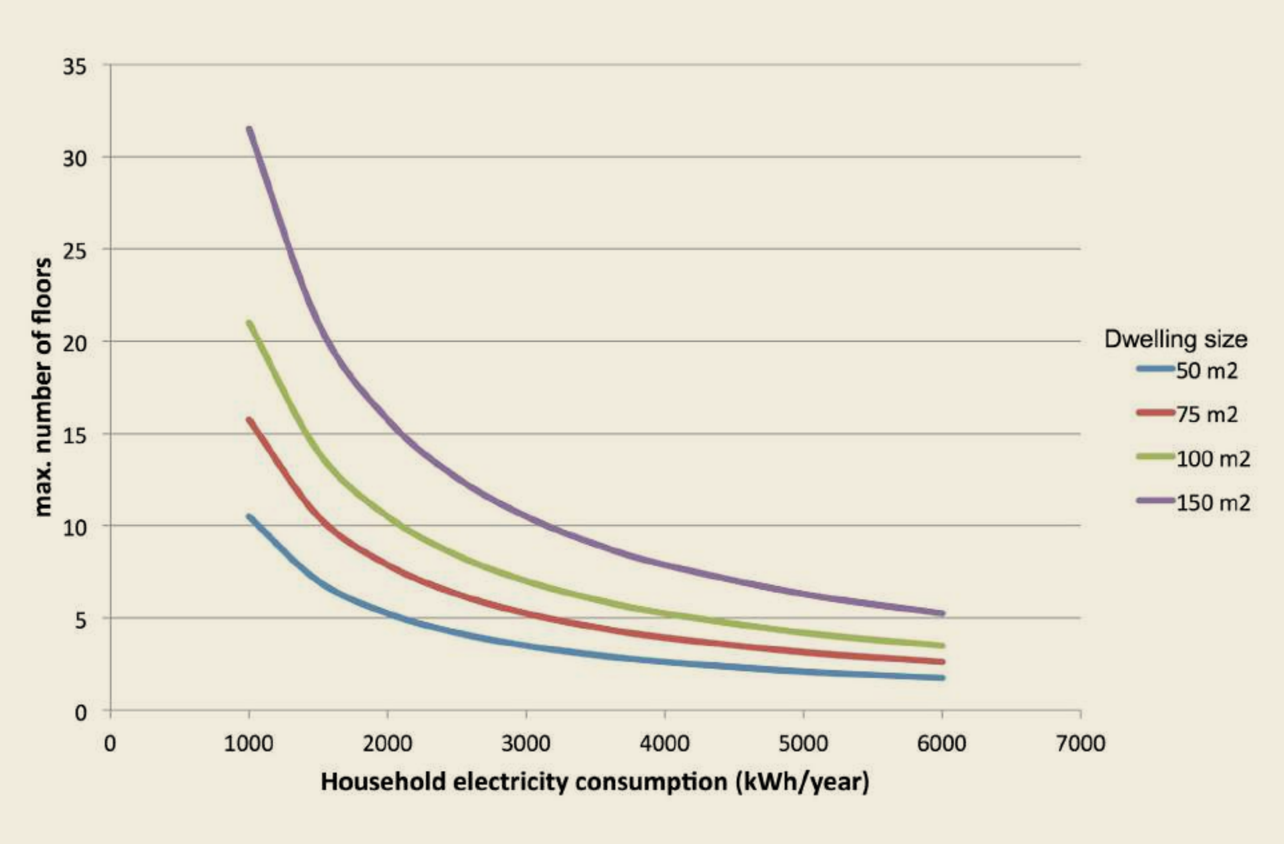
- **design, management and maintenance of the system requires expertise, even if new cheap and easy solutions are emerging;**
- **odour, if located close to the urban context.**

Using black water as input, 15-30 litres of biogas are produced from anaerobic digestion of sludge per person and per day and a low heating value (LHV) of 6.5 kWh/m^3 can be assumed. At household scale, including kitchen waste, the production can reach 30-60 litres of biogas per person per day, which fulfils part of the household's cooking energy needs.

Provide location and space for the slurry deriving from the bio-digestion to be dried and treated for use as fertiliser.

Take into account the possibility of establishing a smart-grid system at the district scale. Smart-grids or micro-grids are a great option if a reliable centralized energy network is lacking or unreliable. Urban planning can lead the transition to new ways of energy production and distribution. Combining the different renewable energy systems, it is possible to provide a complementary, integrated and stable energy system. Storage is the main challenge and is still under rapid development. Smart grid solutions require technical expertise and control systems, and give opportunities to provide new jobs.

FIGURE 3.21 **RELATIONSHIP BETWEEN ANNUAL ELECTRICITY CONSUMPTION OF AN AVERAGE DWELLING[33] IN A BUILDING AND THE MAXIMUM NUMBER OF FLOORS IN THE SAME BUILDING FOR BALANCING THE ANNUAL CONSUMPTION OF ALL DWELLINGS IN THE BUILDING AND THE BUILDING'S POTENTIAL ANNUAL ROOFTOP PV PRODUCTION, FOR DIFFERENT DWELLING SIZES. CALCULATION FOR THE AVERAGE ANNUAL SOLAR RADIATION INCIDENT ON HORIZONTAL SURFACE IN EAC, RANGING FROM 1500 TO 1650 KWH/YEAR PER INSTALLED KW, I.E. FROM 200 TO 220 KWH/M^2 YEAR, ASSUMING 7.5 M^2/KW THE PV AREA.**



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[33] Consider that an average household of 4 people, equipped with high efficiency electric domestic appliances, can have an annual electricity consumption ranging from 3,000 up to 6,000 kWh/year, according to the use of air conditioning and the floor area of the dwelling.

3.5 URBAN METABOLISM AND CLOSED CYCLES

A self-sufficient community is a sustainable one. If a neighbourhood can meet most of its needs through onsite processes, closing energy, water and waste cycles, it reduces dependency on the energy, water, food and materials feeding it, and can transform waste into a resource.

3.5.1 TAKING INTO ACCOUNT THE EMBODIED ENERGY OF MATERIALS

In a sustainable neighbourhood that aims to rely as much as possible on renewable energy sources for its operation, the embodied energy of construction materials becomes the main source of GHG emissions attributable to the neighbourhood itself, and it should not be overlooked.

Use local materials with low embodied energy, such as stone, stabilised bricks, timber and bamboo. Minimize the use of materials that require very high temperature processing for production (steel, glass, cement, aluminium and fire-bricks). Consider the re-use of waste materials from other constructions.

Minimise the use of construction materials, considering the compactness of buildings through the surface to volume ratio (S/V) indicator and trying to minimise it, for two reasons: i) the larger the S/V the larger the area exposed to sun and the larger the area subject to heat transfer; ii) the larger the S/V the greater the amount of material that has to be used for walls, with the same volume, i.e. with the same number of people accommodated, and the more material used, the greater the embodied energy and GHG emissions.

Minimise and recycle construction waste.

Plan the recycling or salvaging of at least 50% of construction waste (USGBC 2016).

3.5.2 DESIGNING DECENTRALISED WATER AND WASTEWATER CYCLES

Water is an especially critical issue in many countries in the EAC, and it is exacerbated by the effects of climate change. River and spring flow is less constant and reliable than in the past; areas that are already dry are more and more frequently subjected to prolonged periods of drought; water tables are more and more overexploited and – in urban and peri-urban contexts – are not replenished because of the impervious covering of the soil. Efficient, circular use of the water resources is an essential prerequisite not only for sustainability but also for the basic liveability of new settlements.

In the same way as for energy, water consumption in cities can be reduced if appropriate choices are made during the early stages of settlement design. Through the provision of infrastructures for decentralised urban water management, decentralised water resource management and water services can work more effectively and sustainably than a system of centralised management.

Sustainable water management embraces: conservation of water sources; use of multiple water sources including rainwater harvesting, storm water management and wastewater reuse; and treatment of water as needed, exploiting the energy and nutrient potential of wastewater, rather than treating all water to a potable standard.

Consider that in a sustainable water cycle at neighbourhood scale the following water flows have to be considered and combined:

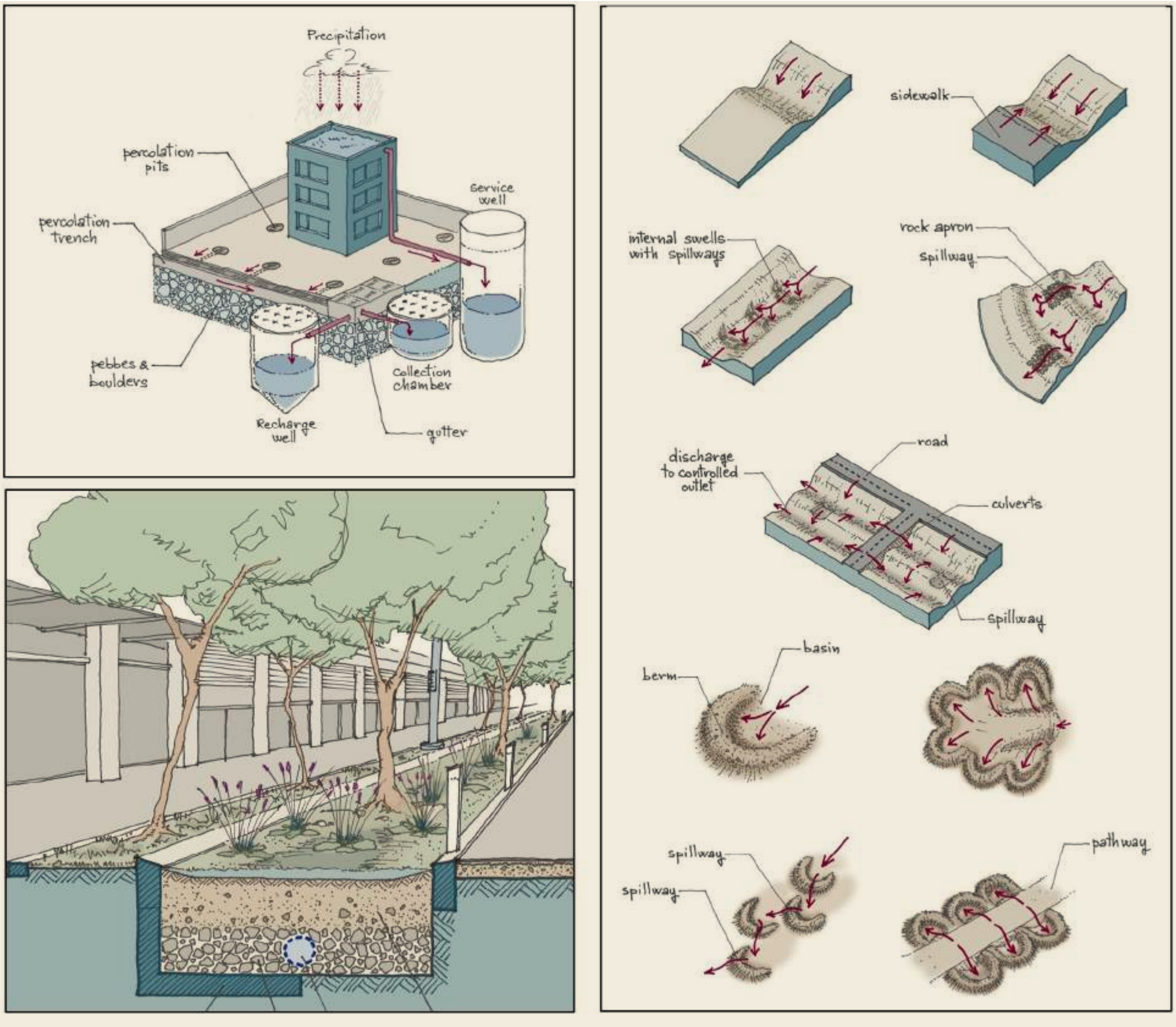
1. Potable water flow from the municipal network, if any;
2. Potable water flow from common neighbourhood wells;
3. Roof rainwater flow to storage;
4. Roof rainwater flow, from storage to domestic uses, i.e. WC flushing, washing machine, irrigation;
5. Roof rainwater flow, filtered and disinfected to make it potable, for domestic uses, i.e. kitchen and bathroom taps;
6. Roof rainwater flow diverted for recharging ground water aquifers;
7. Stormwater flow collected from impervious surfaces;
8. Wastewater flow from households to the treatment system (could be two separate flows, if black water and grey water are not mixed);
9. Treated wastewater flow to green areas (urban agriculture, parks, street greening, etc.);
10. Treated wastewater flow to recharge wells or recharge basins;
11. Treated wastewater flow to water bodies (alternative to flows 9 and 10).

From this it can be seen that many design steps need to be accomplished.

Minimize dependence on the municipal network for the water needs of the neighbourhood. Collect rainwater from rooftops and store it for non-potable uses such as flushing toilets, onsite irrigation or for local farming; use bio-swales and surface systems instead of storm drains whenever possible Figure 3.22.

Consider the opportunity for self-sufficiency of the community offered by rainwater harvesting and local, neighbourhood scale treatment to make it potable, besides using it raw for use in toilets, washing machines, irrigation, and car and street washing.

FIGURE 3.22 **SUSTAINABLE MANAGEMENT OF RAINWATER AND WASTEWATER**



Evaluate the rainwater harvesting potential of a neighbourhood's roofs, on the basis of the local precipitation, and compare this figure with the household water demand. In order to balance the water demand with the harvesting potential of the roofs, it may be necessary to limit the maximum height of the buildings, and this needs to be combined with the height limits deriving from building's self-sufficiency in electricity. This evaluation also allows a first estimation of the storage volumes needed and their optimum location. Involve rainwater harvesting experts from the beginning of the design process.

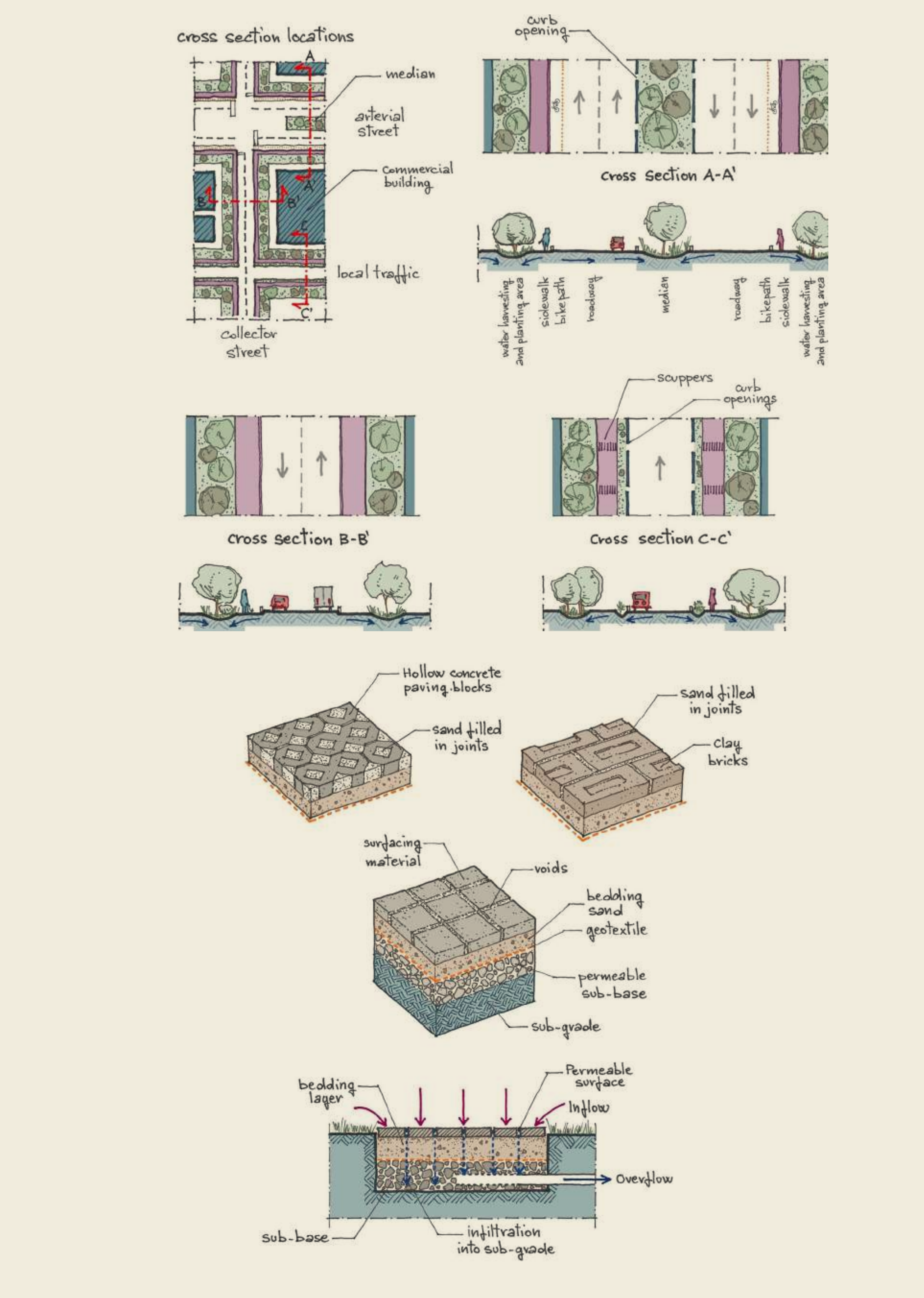
The location and design of a public open space which incorporates urban water management measures should promote the detention of runoff through the use of swales, depressions, contour banks, rock channels, pebble paths, reed beds or other suitable measures without compromising the principal function of the public open space.

Streets should all include runoff mitigation systems such as swales or other pervious surfaces capable of absorbing and storing storm water. therefore, guarantee enough extra space for accommodating sustainable urban drainage systems (Figure 3.23, left).

Try to have the largest pervious areas possible, as they reduce runoff, and thus the danger of flooding (Figure 3.23, right); furthermore, replenishing the water tables via percolation makes a water shortage caused by an interruption of the centralised water supply less critical.

Calculate the percentage of permeable soils. At least 50% permeability should be assured in residential areas. For instance, open parking lots should be permeable where possible, and the width of roads should be limited to the minimum standards for cars to circulate.

FIGURE 3.23 **MAXIMISE PERVIOUS SURFACES**



$$\textit{Soil permeability}\ [0-100]=\frac{\textit{area of permeable surfaces on the ground}\ [m^2]}{\textit{total area}\ [m^2]}\cdot 100$$

Try to achieve such stormwater control as to be able to cope with at least 95% of precipitation events without their resulting in flooding.

Evaluate the potential of the water table to provide a proportion of the neighbourhood's water demand, aiming for the community to be self-sufficient in water, by combining sustainable underground water extraction with rainwater harvesting. Involve a hydro-geologist from the earliest phases of the design process. Evaluate the consequent energy demand for pumping.

Treat all waste on site with biological systems. Reclaim as much water as possible for non-potable uses and harvest biomass for use as fertilizer on local farms. Collect sewage sludge, kitchen waste and yard waste and convert it into gas (Figure 3.23) to be used in combination with energy from other onsite renewable resources.

If proposing a bio-digestion or a composting plant, y plan its size, location and distance to the urban context carefully.

Wastewater is a resource in terms of energy, soil nutrients, irrigation and water table replenishment via percolation; this resource is best exploited at local level. Consider decentralised wastewater treatment as a sustainable option that increases community resilience and creates opportunities for employment. Consider the consequent space needed and the location.

Depending on the total volume and the nature of the wastewater and its temperature, the values given in Table 3.2 may indicate permanent area requirements for setting up a treatment plant DEWATS type. Smaller areas (about 3.5 m2 per cubic meter of treated water) are required for other natural treatment systems such as Advanced Ecologically Engineered System (AEES).

TABLE 3.2 **PERMANENT AREA REQUIREMENTS FOR SETTING UP A TREATMENT PLANT**

Septic tank, Imhoff tank	0.5 m^2/m^3 daily flow
Anaerobic baffled reactor, anaerobic filter	1.0 m^2/m^3 daily flow
Subsurface Horizontal Flow Constructed Wetland	30 m^2/m^3 daily flow
Polishing pond	25 m^2/m^3 daily flow

Treat and reuse at least 50% of wastewater on-site (USGBC 2014).

Evaluate the threat to health that may come from the possible contamination of the water table caused by incompletely treated wastewater. Involve experts in hydro-geology and water-borne diseases.

Treated wastewater enhances the effectiveness of green areas for the mitigation of the local climate, and paves the way for the development of urban agriculture, as it provides water and nutrients; this potential, however, must be exploited carefully, as it may have negative effects on health because of the potential for uncontrolled bacterial contamination and mosquito breeding.

Balance the extent of green areas (both for leisure and agriculture) with the availability of water and nutrients, on the basis of the degree of self-sufficiency in water of the neighbourhood, and size plots accordingly. Evaluate the level of treatment needed to make wastewater safe for use as a fertiliser or for fertigation. Involve an agronomist and a botanist from the beginning of the design process.

3.5.3 INFRASTRUCTURE FOR SOLID WASTE MANAGEMENT

Solid waste management at neighbourhood scale (Figure 2.6.1) is a very effective way of enhancing its recycling potential, of promoting local employment and entrepreneurial activities and of encouraging social inclusion.

Consider the provision of solid waste gathering areas at the local scale, both for waste sorting and recycling.

Include in the plan at least one recycling or reuse station, dedicated to the separation, collection, and storage of materials for recycling. Evaluate the size and position of the collection and sorting area where the neighbourhood's waste will be conveyed.

Consider the possibility of reusing locally both the organic part of solid waste and the vegetation residuals (like leaves) to produce fertilizers, or energy through bio-digestion. Evaluate the percentage of organic waste that can be reused in the neighbourhood for energy production and fertilizer production.

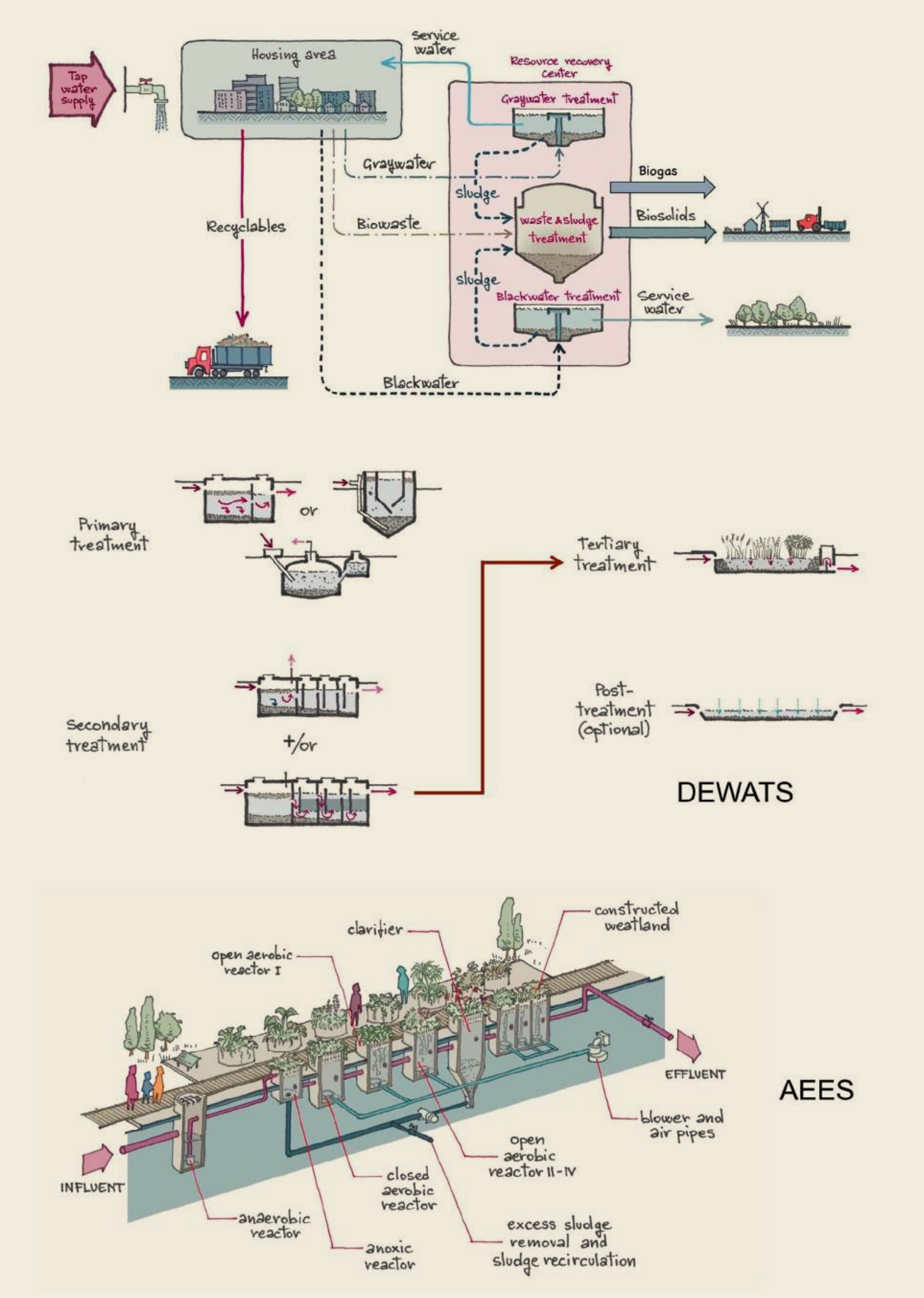
Include in the plan at least one compost station or location, dedicated to the collection and composting of food and garden waste.

3.5.4 ENHANCING LOCAL FOOD PRODUCTION

Much of the food we consume is transported from great distances to get to us. This process is expensive, wasteful of energy, and yields food of diminished nutritional value. Food sourcing at the local scale should be promoted.

Consider that urban agriculture improves the food security of the neighbourhood.

FIGURE 3.24 **DECENTRALISED WASTEWATER TREATMENT SYSTEMS**



Provide adequate space to grow food locally. link urban agriculture with treated and recycled wastewater and with organic fertilisers deriving from wastewater treatment and from the composting of organic solid waste.

Use an iterative process for choosing the land area for urban agriculture, evaluating the potential total demand for vegetables of the neighbourhood (i.e. a sort of food footprint, mimicking the concept of ecological footprint), and checking the consistency of this value with the other conditions, such as the minimum park area to be guaranteed, the availability of usable wastewater and fertiliser produced by the neighbourhood and the density of the neighbourhood.

As a first estimate, 20% of the neighbourhood's land can be considered for urban agriculture, which is the value proposed in the Kigali Master plan (KCMP 2007).

Provide space for local food markets.

3.5.5 CLOSING ENERGY, WATER AND WASTE CYCLES ON SITE

Energy, water and waste flows, and food production are interconnected. They are intersecting cycles and they must be considered as an integrated system (Figure 2.7.1). The interactions between structure (layout, form, land use, materials, greenery), energy, water and waste can be used for minimising the flow of resources needed for the operation of the neighbourhood and – at the same time – make the neighbourhood more resilient, thus more capable to cope with the challenges of climate change.

Obtaining such a result is a hard task, implying a systemic approach, the involvement of experts in a wide spectrum of fields of knowledge and the capability to integrate all these areas of expertise into a holistic vision.

3.6 SOCIAL AND ECONOMIC DOMAINS

An energy efficient development should also follow the sustainability triangle principles, which include economic, environmental and social principles. In particular, social equity is a crucial issue that indirectly affects people's habits and, consequently energy and resource consumption patterns. As described above, closing cycles at the local scale and designing with the principles of proximity in mind, leads to a more efficient use of resources and saves energy as well. The engagement of the inhabitants in the life of the neighbourhood enables them to create a real sense of community, which is not just the juxtaposition of people, but is about exchanging knowledge and learning from each other, sharing best practices and finally making the shared 'space' become a 'place'.

Sustainability is closely connected to the issue of time. It is not by chance that the word "sustainable" in other languages, such as French, is translated as "durable". This has a great impact on economic evaluations or the cost effectiveness of investments which aim to improve the sustainability of a neighbourhood. The return time cannot be measured in a few years, but in the long term. Moreover, it must be considered that many benefits deriving from sustainability measures are very difficult or sometimes impossible to quantify in monetary terms.

3.6.1 THE SOCIAL REALM

A sustainable neighbourhood is also (see section 3.9):

- a more inclusive neighbourhood, because of the social mix, and leads – through the employment opportunities that it offers - to a more just and equitable community
- a healthier neighbourhood, because of its comfort, its walkability, the availability of fresh food, and the improved access to safe water and to sanitation
- a more gender-friendly neighbourhood

Promote local firms, possibly cooperatives of neighbourhood dwellers, for providing urban services: energy, water, wastewater treatment, solid waste management and transport. These will best tackle resilience strategies and find the most suitable local solutions. decentralized approaches to energy production and provision of environmental services are potential sources for local job creation, according to circular economy principles. People involved in the decentralised treatment of wastewater in the collection of waste, or in the generation of on-site energy, can become local agents, and also reference persons for the community, guaranteeing a social mix in the neighbourhood.

Provide an appropriate number of suitably sized spaces for handicraft businesses: they could become the backbone of the neighbourhood's economy.

Provide an appropriate number of suitably sized spaces for activities related to the shared economy.

3.6.2 THE ECONOMIC REALM

Sustainable neighbourhoods involve benefits that are difficult or impossible to evaluate in monetary terms, such as:

- avoidance of costs due to ill health and those due to the increased resilience of the neighbourhood (lower impact of catastrophic events, such as flooding or water or food shortages);
- amount of money saved on air conditioning because of a climate responsive design;
- overall economic impact of increased employment and of entrepreneurial activity;
- quality of life, created by the availability of parks, by the reliability of basic services, such as energy, water and sanitation and by a reasonable income.

When evaluating the costs and benefits of each infrastructure in the neighbourhood or comparing design options, always consider that these infrastructures, and the final texture and layout of the neighbourhood will be very long-lasting: the economic analysis cannot be based on short term returns. In the economic evaluation of infrastructures for sustainable development, always consider the entire life cycle. Try to evaluate the long-term indirect economic benefits deriving from the investments in sustainable infrastructures.

Evaluate the number of local jobs that can be created and the financial business generated at the community level.

Evaluate the cost of infrastructure for decentralised urban services, and consider their expected life span as the maximum return time: this will be the basis for defining the tariffs and checking if they are compatible with the expected income of neighbourhood's households, allowing for the increase in income resulting from the additional employment. Compare these costs with those of conventional service infrastructures.

3.7 TWENTY BASIC RULES FOR SUSTAINABLE NEIGHBOURHOOD DESIGN IN TROPICAL COUNTRIES

The main features characterising a sustainable neighbourhood in tropical climates can be summarised as follows:

Neighbourhood's form and structure

1. High density; aiming to at least 150 people/ha;
2. Walkable neighbourhood; 400-500 m ped-shed, within which basic services must be reachable, which implies mixed land use and limited land-use specialization: at least 40% of floor space should be allocated for economic use; single function blocks should cover less than 10% of the total land use; at least 18 km of street length per km^2, with high connectivity;
3. Mixed income residential buildings; 20 to 50% of the residential floor area should be for low cost housing; and each tenure type should be not more than 50% of the total;
4. Green public space area 15-20% of neighbourhood footprint;
5. Urban agriculture and local food markets;
6. Small and appropriately distributed parking areas, usable for electric car sharing, with PV canopies for charging;
7. Appropriate space allocation for energy production and storage, water, wastewater and solid waste treatment and management;
8. Layout: north-south/east-west grid with a possible offset of no more than 45° to favour penetration of dominant winds, if appropriate;
9. Urban canyons: aspect ratio H/W of north-south canyons between 2 and 3; possibly not less than 1 in east-west canyons. Streets always tree-lined. No fully glazed facades unless sun protected. Pervious pavements;
10. Net zero energy (nZEB) residential buildings, by means of on-site renewable energy production (PV on roofs and, where appropriate, micro wind turbines); this condition limits maximum building height;
11. Embodied energy minimisation: building shape with low surface to volume ratio; use of low embodied energy materials.

Services

12. Decentralised energy production with renewable energy sources; smart grid and storage;
13. Rainwater harvesting, with two differentiated uses, potable water after treatment, direct use for non-potable (WC flushing, washing machine, plant watering);
14. Stormwater harvested from catchment surfaces and stored in cisterns or conveyed to recharge structure, with potential to restore aquifer extraction;
15. Buildings with dual network for separating grey and black water and provision for grey water recycling;
16. Biogas production from black water treatment system and reuse of appropriately treated water for irrigation (of parks, green spots, trees lining streets, and urban agriculture plots) and aquifer recharging;
17. Solid waste management at neighbourhood scale: domestic organic waste composting or anaerobic fermentation for biogas production; composting of agriculture residuals and landscaping wastes;
18. Wood from tree pruning as fuel for syngas production;
19. Treatment of biogas sludge (from black water and organic waste anaerobic fermentation) for use as fertiliser;
20. Use of biogas and syngas to power electricity generators connected to the mini-grid for contribution to demand-supply matching.

BOX 3.2 LIFE CYCLE COSTING (CRP 2011)

Life cycle costing estimates the capital and operating costs of an entire development over a period of time. It can include an assessment of both public and private costs, and can be defined in financial, social, and environmental terms. They can be used to assess development projects at any scale.

Cost Estimates

A life cycle cost assessment can include capital and operating cost estimates for:

- hard infrastructure (e.g., roads water, sewers);
- municipal services (e.g., transportation, re, police, waste management) ;
- private costs (e.g., commuting/transportation, home heating);
- costs of externalities (e.g., air pollution, motor vehicle accidents).

Cost Assumptions

Costs are calculated based on certain assumptions. These include:

Costing and revenue variables

- Unit costs associated with different components of a development (e.g., the cost per meter of a two-lane collector road).
- Revenue sources (e.g., property taxes generated, development fees)

Physical design elements

- Land use distribution and density
- Street types and lengths
- Transit infrastructure

Demographics

- Household size and composition
- Household income

Life cycle costing models allow different development scenarios to be compared quantitatively over time. Where a basic cost-benefit analysis or development pro-forma may only examine costs in the short term, life cycle costing shows how costs and benefits could change for the development over time.

When in the process it is used?

Life cycle costing is an evaluative tool. Its primary role is in the assessment of site plans and development programs, and it can reveal whether proposal results in acceptable long-term costs, both public and private. If a standard life cycle costing model is adopted for use by a municipality, targets or maximums for certain costs can guide the design process or serve as a means of assessing new development proposals during the review and approvals process. There is a role for these results in the marketing of a new community. Potential homeowners may be interested to know about long-term costs of ownership and potential savings from owning property in a development that uses more cost-effective infrastructure and building construction methods.

BEST PRACTICE

CMHC Life Cycle Costing Tool

The Canada Mortgage and Housing Corporation (CMHC) has developed a spreadsheet-based "Life Cycle Costing Tool for Community Infrastructure Planning," which is publicly available on the CMHC's website (http://www.cmhc-schl. gc.ca).

"The Life Cycle Costing Tool for Community Infrastructure Planning (the Tool) was created to allow a user to estimate the major costs of community development, particularly those that change with different forms of development (for example, linear infrastructure), and to compare alternative development scenarios. The Tool is geared towards estimating planning level costs and revenues associated with the residential component of a development, although financial impacts of commercial and other types of development can be incorporated provided that infrastructure requirements are specified correctly.

The Tool is well suited to assessing development projects ranging in size from a collection of houses to a block-by-block infill development to an entire subdivision. A good measure of the applicability of the Tool to a given project is whether or not alternatives can be conceived that would result in significantly different densities or infrastructure requirements, or make use of different green infrastructure alternatives"

3.8 THE CHECKLIST

The checklist is based on the design tips and is structured accordingly. It provides an initial basis for evaluating a design scheme and its capability of including relevant sustainability topics at the scale of neighbourhood design. It is also a general framework for developing more locally tailored checklists. Hence, the proposed scoring system is purely indicative, and a weighting system based on local challenges and values should be developed: some places might give more relevance to one of the main themes addressed; some places will give the same weight to all of them.

The checklist can also be seen as a support tool to raise awarness of thedesign topics that impact on the overall sustainability of the design of a new neighboorhood. It is simply structured as an organized list of design issues that the designer, the decision maker and evaluator, or even the student of urban design, can use to check if all the relevant topics have been taken into consideration or not.

Public officers could use the checklist as a starting point for the creation of a local evaluation system, based on the values and challenges that their city is facing. Public officers can use this guidebook as a baseline for conceiving a more performance-oriented approach to the implementation of local design codes, where rewarding policies are promoted and special incentives for promoting sustainable technologies are foreseen which will sustain committed actors and diffuse best practices. On the other hand, designers, planners and developers could use the checklist to internalize sustainability values in the conceptual planning phase, as a sort of internal validation procedure.

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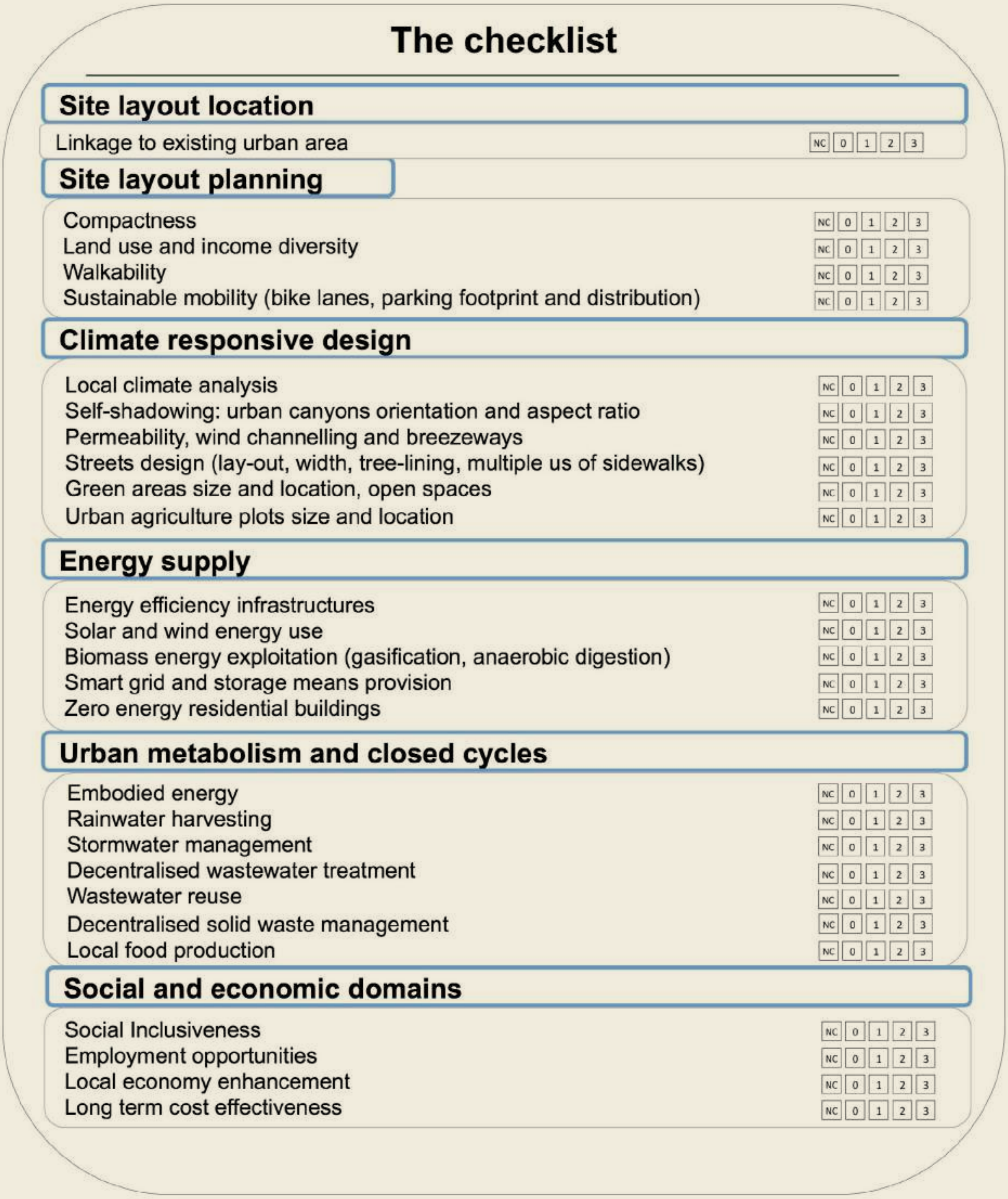
CHECKLIST



The checklist

Site layout location					
Linkage to existing urban area	NC	0	1	2	3
Site layout planning					
Compactness	NC	0	1	2	3
Land use and income diversity	NC	0	1	2	3
Walkability	NC	0	1	2	3
Sustainable mobility (bike lanes, parking footprint and distribution)	NC	0	1	2	3
Climate responsive design					
Local climate analysis	NC	0	1	2	3
Self-shadowing: urban canyons orientation and aspect ratio	NC	0	1	2	3
Permeability, wind channelling and breezeways	NC	0	1	2	3
Streets design (lay-out, width, tree-lining, multiple us of sidewalks)	NC	0	1	2	3
Green areas size and location, open spaces	NC	0	1	2	3
Urban agriculture plots size and location	NC	0	1	2	3
Energy supply					
Energy efficiency infrastructures	NC	0	1	2	3
Solar and wind energy use	NC	0	1	2	3
Biomass energy exploitation (gasification, anaerobic digestion)	NC	0	1	2	3
Smart grid and storage means provision	NC	0	1	2	3
Zero energy residential buildings	NC	0	1	2	3
Urban metabolism and closed cycles					
Embodied energy	NC	0	1	2	3
Rainwater harvesting	NC	0	1	2	3
Stormwater management	NC	0	1	2	3
Decentralised wastewater treatment	NC	0	1	2	3
Wastewater reuse	NC	0	1	2	3
Decentralised solid waste management	NC	0	1	2	3
Local food production	NC	0	1	2	3
Social and economic domains					
Social Inclusiveness	NC	0	1	2	3
Employment opportunities	NC	0	1	2	3
Local economy enhancement	NC	0	1	2	3
Long term cost effectiveness	NC	0	1	2	3

Legend:

NC: not controlled by design and planning; suspended evaluation
0: not addressed; negative evaluation
1: addressed; sufficient evaluation
2: addressed; average evaluation
3: addressed; positive evaluation