CHAPTER 3

Eco-Development in the Global Context

While the built environment has a considerable influence on environmental resilience, economic affluence and social well-being, global efforts have been taken in order to change the ways of planning and designing our cities, neighbourhoods and buildings. This especially has become of a major concern since the discourse of global warming was promoted in the 1990s. For example, in 1990, the world's first established tool of assessing and certifying the sustainability performance of buildings, Building Research Establishment Environmental Assessment Method (BREEAM), was published by the Building Research Establishment in the UK. In 2002, the first zero-energy neighbourhood development, BedZED, was completed in London. This chapter aims to present the concept of eco-development in the global context, and some globally known examples at the city, neighbourhood and building levels. This chapter will further explore some of the internationally-used tools and approaches for evaluating the sustainability performance of the built environment at the three spatial levels, respectively. Many of these tools and approaches have been developed in recent years and represent the current best practices of achieving higher sustainability performance through planning and design.

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3.1 Common Threads from the Global Examples

Globally, there have been some examples and success stories that commonly aim to address the goals of sustainable development. One major movement is that of eco-system planning, which has been embedded in the planning agendas of many city around the globe. Initiated by Richard Register back in 1987, an ecologically-sound city development should be resourceful, possess clear future vision and be composed of natural environments and biodiversity. The role of nature-based approaches in the city environments, which is mainly related to the diversity and biodiversity of cities, is highlighted as a healthy factor in urban planning and development. Thus, a large body of urban land is required for natural species of various types in the city environments which can nurture biodiversity in and around cities. Furthermore, an eco-development is resourceful, protects the existing, and nurtures future opportunities. The vision is, therefore, holistic in terms of how a city may develop or redevelop. As presented by Gibson et al. (1997), in the argument on 'putting cities in their place', such a planning approach focuses on ten principles that address all aspects of sustainable development. Nevertheless, an eco-system-based approach in the built environment highlights the significance of nature in the planning process from an interdisciplinary perspective. Such planning enables eco-friendly community transitions towards the enhancement of institutions, and the development of social learning and social capital, building on the community structure and environmental enlightenment; all of which we consider in the discussed four dimensions of sustainability in the built environment.

For the purposes of discussion, it can be opined that the concept of city is very much linked with the 'urban ecology' movement, an initiative that was started in the 1970s by Richard Register and his team. Through their research, they defined urban ecology based on ten principles which were later adopted as indicators of sustainable development. At first, they argued for the revision of land uses and land use priorities in order to allow more room for compact city environments. By doing so, more land could be utilised for diverse, green and pleasant urban environments, some of which could be mixed-use or transit-oriented developments (TODs). By creating such urban structures, we could then revise our transportation infrastructure and priorities. More space can be allocated to walkable and cycleable environments where new developments could then focus on accessibility and enhanced mobility in the city environments. An ecological city would be healthier, with restored urban environments, particularly those natural environments that can be protected and restored where needed. A particular emphasis is given to urban gardening, urban greening development projects and local agriculture opportunities, with which the benefits are threefold and not only environmental. A mixed-development approach is also encouraged as to promote affordability and convenience for the citizens. As part of this movement, social justice and social improvement are also considered as part of the social dimension of eco-development. The other aspects focus on key urban innovations, such as recycling possibilities, technology adaptation, resource conservation and so on. Some of these are addressed to supporting ecologically-sound economic activities and reducing the levels of both pollution and waste. One major part also focuses on environmental education, and increasing the awareness of the general public in regard to ecological sustainability issues.

Another common approach to eco development is ‘green economy’ and working for achieving healthy economies and healthy ecosystems (Vodden 1997). For instance, an earlier sustainable economy initiative in London includes key activities that range from green home and business check-ups, to the development of key enterprises and training that address the environmental education. In addition, environmental entrepreneurship is highlighted in several cases of green economic development. In this respect, we can argue that environmental entrepreneurship, as an industry, has blossomed due to the need for such eco-development. These include the monitory of production, consumption analysis, as well as industries for protection and restoration of the natural environments. Also known as ‘circular economy’, the green economic development is considered to be one of the key pathways to sustainability.

Moreover, the sustainability factors are mainly developed based on current practices and situations. A similar recent approach is the development of Sustainable Development Goals (SDGs), which address the current issues and challenges for a healthier transformation of our societies by 2030. In the case of the built environment, the sustainability factors are also associated with what takes places on the ground. Some of these current practices are discussed in Chap. 2, widely addressing the issues of urban density, transportation, neighbourhood planning, the provision of communication facilities and community spaces, the provision of efficient solutions for our built environments, increased economic efficiency, and the provision of healthy environmental quality in cities.

The following section presents six well-known examples at the three spatial levels, respectively, representing the current global best practices of eco-development. These projects were completed between the late 1990s and the early 2010s, reflecting a key time period in which eco-development moved gradually from theory to practice. They provided exemplary models and principles for developing eco-development in other contexts. For example, BeDZED, Britain's best known eco-neighbourhood, has been exhibited in the 2010 World Expo in Shanghai. China has published its own Passive House Standard in 2015, which draws directly on the practice in Germany. It should be noted that sustainability practice, especially at the macro and meso levels, is contextually based and every city has its own prioritised sustainability issues to address. In developed countries, one main issue is to bring down building energy consumption and car dependency; in developing countries, by contrast, the lack of infrastructure tops the agenda.

3.2 Global Examples at City Level

3.2.1 Freiburg, Germany

In the field of eco-development research, Freiburg is acknowledged to be one of the very earliest initiatives of green- or eco-city projects. Freiburg is a small German city, with a population of approximately 220,000 and covering an area of 155 km^2, bordering France and Switzerland. It is in the very south-western corner of Germany and has a recorded history of at least 900 years. The city has a very strong green economy with substantial environmental progress and preservation (Gregory 2011).

As the ecological capital of Germany, Freiburg's approach towards the improvement of liveability and sustainability offer a variety of eco- or green initiatives. Some of these initiatives or projects include the improvement of eco-farming, waste utilisation facilities, hydro energy and water recycling programmes, energy-efficient buildings and green living environments, solar and green industry, and etc. The city's vision and process towards sustainable development started back in the 1970s, with major initiatives on the development of alternative-green movement and towards the later 'Local Agenda 21' that later set the city's sustainability targets and adaptation of them in policy and practice (Freiburg website). Freiburg is also well known for its progress and process of natural preservation which has established a major sustainability goal for the city's clean production and preservation. One of the main key eco-features of Freiburg is its compact planning approach that has ultimately provided pathways for 'urban agriculture, forests and community gardens, as well as excellent public transport systems and high levels of walking and cycling' (Kenworthy 2006). Moreover, the city has introduced and provided several environmental technologies, such as energy-efficient buildings, bio energy, hydro energy, renewable energy technologies and the localised management of water (Kenworthy 2006). These eco-developmental activities have therefore established Freiburg as one of the greenest cities in the world.

Freiburg's most renowned project, the Vauban Neighbourhood/District, is one of the world's most well-known eco-development projects. Vauban's construction began in 1998 as the 'the largest car-free development in Europe' (Melia 2006) and continued offering green living style and green technologies for the new neighbourhood. Its green transit-oriented development (TOD) is described as a successful linkage between a typical TOD and green urbanism which has gained substantial attention as a sustainable development model of the future (Cervero and Sullivan 2011). Scheurer and Newman (2009) also argue in favour of Vauban, noting how it has managed to bridge the gaps between green and brown agendas. This concept is regarded as the neighbourhood's *green-brown integrated vision* (ibid.), which focuses on several key aspects of sustainability, including: buildings (to be compact, energy efficient and self-governed); waste (for the reductions of material use, embodied energy and daily consumption); open spaces (for the enhancement and integration of recreation, biodiversity of the environments and water management which is localised); transport (with priorities given to green spaces and reduction of car use/dependency); energy (with focus on renewable technologies and with two distinct objectives of centralised and distributed systems); and governance (as a bottom-up approach and with promotion of community engagement in the whole process of development).

3.2.2 Curitiba, Brazil

The city of Curitiba, Brazil is one of the world's most well-known early eco-city initiatives/projects. It is renowned for its advanced integrated and innovative public transportation system, which have significantly improved the environmental quality of the urban environments as well as the quality of life in the city (Macedo 2004). One of the main sustainable features is the city's extensive bus rapid transit (BRT) system, which indicates one of the key success stories of any eco-development project (Lindau et al. 2010). The future plans are for a further expansion of the BRT system and for its improvement through the use of 'advanced traffic management and user information systems' (ibid.).

The Curitiba green or eco-development project can be traced back to the early 1980s and it developed some of the early and most influential concepts of the eco-city. Located in the southern part of Brazil, Curitiba is home to almost two million people at the municipal level (and over 3.2 million people in the metropolitan region), covering an overall area of 430.9 km^2. Curitiba is the capital of Paraná and has a strong agricultural background as one of the country's key administrative and political centres. Curitiba is a major trade hub which enjoys significant environmental features such as mixed forests, botanical gardens and greenhouses as well as major water catchments, including rivers and streams. The city is also an important trade and services centre with a strong focus on developing a green economy.

Early studies of Curitiba highlight the city's relatively high average of green spaces per inhabitant as one of its major environmental advantages (Herbst 1992; Rabinovitch 1992) and the city's overall development plan has proven to indicate alternative routes towards sustainable urban development (Moore 2007). The city's planning process demonstrates a successful integrated planning approach to sustainable development, in which Curitiba's public transportation system plays a major role. The city's public transport system was developed significantly during the 1970s, when the new urban design structure was emphasised on 'linear growth along structural axes' (Rabinovitch 1992), which then enabled shaping the overall structure of the city. The low-carbon transport and green growth of the city supports the reinvention of mixed-use characteristics of Curitiba that are supported by linear corridors alongside the BRT systems in an integrated highly efficient development approach (Bongardt et al. 2010). This is effectively visible in the city's progressive approach to the integration of land use and transportation planning. Moreover, this has enabled the protection of environments, forming a bicycle path network and supporting flood control (Rabinovitch and Leitman 2004).

Overall, the integrated urban planning of Curitiba can be viewed as a successful representative model of a low-carbon eco-city. The city's environmental protection programmes have two objectives of preservation and addition, which is indicative of the strong green agenda of the city.

3.3 GLOBAL EXAMPLES AT THE NEIGHBOURHOOD LEVEL

3.3.1 *Beddington Zero Energy Development, London, UK*

Beddington Zero Energy Development (BedZED) is the largest eco-village in the United Kingdom, having been designed by architect Bill Dunster and developed by the Peabody Trust. BedZED comprises 82 homes, office space and live-work units. The village has a mix of social housing, shared ownership, key-worker homes and private houses for sale at prices that are comparable to those of more conventional homes in the area.

The key features of BedZED's planning and design are summarized as follows (BRE 2002):

Mixed-use development: A mixed-use development offers the opportunity to work locally and provides an increased sense of community resulting from the layering and interaction of different activities and occupation patterns. Building mixed-use developments at high densities can also reduce the need to develop greenfield sites.

Home Zone regulation: At BedZED, 'Home Zone' principles are designed to involve measures including reducing car speeds, giving priority to cyclists and pedestrians, having safe and convenient cycle routes and providing secure cycle storage facilities.

Public transport and car sharing: The BedZED development is located on a major road used by two bus routes, which connect to local centres. BedZED has also established a car club to reduce car ownership.

Site ecological conservation: A Biodiversity Plan was developed to maximise spaces for wildlife in the urban environment. Existing features of the site have been retained or enhanced to increase biodiversity and natural amenity value.

Energy efficiency design of the buildings: First, energy efficiency can be increased through considered zoning of activities. Second, insulation levels are considerably higher than those required by the Building Regulations. Third, triple-glazed, krypton-filled windows with low-emissivity glass, large panes and timber frames further reduce heat loss.

Energy efficiency appliances: 'A'-rated domestic appliances (including light bulbs) were specified throughout the development. Such appliances can cost a little more to buy, but return considerable energy savings and reduced running costs.

Renewable energy: The main source of energy in BedZED is a Combined Heat and Power (CHP) plant which runs on chipped tree surgery waste. The CHP has been sized so that over the course of a year it generates enough electricity to provide for all of the development's needs, which makes BedZED a zero fossil energy development.

Water efficiency: By using water efficient fittings and appliances such as washing machines, spray taps, showers and dual-flush low-flush toilets, reductions in mains water usage of 40% are achieved.

Waste disposal: Target for waste during construction was to be set at 5% of total. construction material. Recycling and composting facilities were incorporated at design phase.

Sourcing construction materials locally: 52% of the construction material (by weight) was sourced from within a 35 mile radius of the site, reducing pollution and energy impacts from transportation and to encourage local industry.

Avoiding unhealthy materials: Certain materials have been avoided due to their potential health risks to builders, occupants and future generations.

BedZED has received considerable attention since its completion and it continues to be an often-cited case study (Keeler and Burke 2009, p. 224) in discussions of sustainable neighbourhood development. The monitoring of BedZED's performance indicates that, compared to the current UK benchmarks, it secures a reduction in hot water heating of 45%, electricity consumption is 55% less, and water consumption about 60% less (Twinn 2003). In an ideal situation, a four-person BedZED household can reduce the overall eco-footprint from 6.19 hectares (typical UK lifestyle) to 1.90 hectares (Twinn 2003).

3.3.2 Hammarby Sjöstad, Stockholm, Sweden

Hammarby Sjöstad has been developed on a brownfield site, an industrial area close to Stockholm harbour and covering a total area of 200 hectares (494 acres). This sustainable neighbourhood uses a closed-loop holistic approach defined as an 'Eco-city model' at a district scale to create self-sufficient neighbourhoods. The Hammarby Model has demonstrated a "closed-loop urban metabolism, accounts for the integrated infrastructure systems of energy, water and waste from the very beginning" (Ignatieva and Berg 2014). It targets to accommodate 11,500 residential units with 26,000 population by 2017 and 20% of the total housing stock is devoted to social housing (Tsenkova and Hass 2013). This project has won international recognition, being copied around the world—e.g., in the Caofeidian Ecocity development in China (Gaffney et al. 2007).

Based on Ignatieva and Berg (2014), Gaffney et al. (2007), and Tsenkova and Hass (2013), the key features of Hammarby's planning and design are summarized as follows:

Compact with sizable green space: Hammarby Sjöstad has been planned with a dense settlement structure with typically 4–5-storey buildings in a compact neighbourhood outline, but with reasonably spacious green courtyards.

Mixed development: Hammarby provides 200,000 square metres of commercial space providing jobs for 10,000 people. The ground floors of nearly all the buildings have been designed as flexible spaces, suitable for retail, leisure or community use.

Community centre and environmental awareness: Hammarby has launched extensive efforts into educating and encouraging its residents to make full use of the project's environmental programme. The community centre—the Glass House—functions as a space to showcase technical solutions, and to advise locals on environmental issues. Residents have a display in the kitchen where they can see, in real time, how much they have used for heating, electricity and water.

100% renewable power supply: The Hammarby model includes energy conservation measures in which the goal is to reduce heat consumption by 50% and to use electricity more efficiently compared to the Swedish average. Furthermore, energy supply will be based solely on renewable sources. The electricity content will be based on solar cells, hydropower and biofuel technology. Solar panels have also been located on roof tops and solar cells cover building façades harnessing the radiation energy of the Sun and transforming it into electrical energy.

All heating obtained from heat recovery from waste combustion and sewage water purification process: All wastes from the area will be sent to the incinerator to produce both locally generated heat and co-generated electricity. Sewage water is cleaned and purified at a large sewage plant just outside the area and the waste is then recycled into natural gas. Heat produced through this purification process is then recycled for use in a district-heating unit.

Sustainable drainage design: The rainwater from surrounding houses and gardens is led by an open drain system that drains out to the attraction channel. The water then runs into a series of basins, where it is purified and filtered through sand filters or in the artificially established wetlands of the area. Roof gardens are also installed widely in the community to reduce roof run-off during storm events.

Diverse transport means: More than 95% of the residents travel to work by sustainable public transport, such as ferry, bus, on foot or by bicycle. Other features of the sustainable local transport system include networks of pedestrian and bicycle routes, and a large carpooling system.

3.4 GLOBAL EXAMPLES AT THE BUILDING LEVEL

3.4.1 The Crystal, London, the UK

One of London's new landmarks is home to an exhibition on sustainable development and global knowledge hub, owned and operated by Siemens. The Crystal building is a single-standing mixed-use (public and office) building, located on Royal Victoria Dock in East London. The building is part of the 'Green Enterprise District' policy in East London and is open to public as a showcase platform for the latest technologies on infrastructure and sustainable cities. The overall size of the site is 18,000 m^2. The building uses solar power and ground source heat pumps as the main means of generating energy. The Crystal is already a major iconic building of East London with several sustainable technologies that set a high benchmark for sustainability. The building was opened to the public in 2012 and is known to be the world's first building to achieve two of the highest sustainable building awards from two leading accreditation bodies, LEED and BREEAM. The crystal has achieved 'Platinum' and 'Outstanding' awards from the two accreditation bodies, respectively. The building has also achieved maximum sustainability and efficiency in terms of both building design and construction.

The crystal was designed in two crystal-shaped sections and was designed by Perkins+Will (Fit-Out, design leader) and Wilkinson Eyre Architects (shell and core design). The building and civil engineers on the project were Arup Group Limit and the exterior spaces and public realm of the building was developed by Townshend Landscape Architects. The combination of project teams indicates a project of multiple experts for one of the most sustainable public buildings in the globe. It exhibits state-of-the-art technologies for building efficiency, sustainable cities and Siemens' Environmental Portfolio.

The building site includes a public realm and the building itself. The external shape of the building leads to the creation of fascinating internal spaces, which include office spaces, conference facilities, meeting rooms and an auditorium. There are also several exhibition spaces in the building, which is an all-electric building with its own independent energy generation source. Solar power generation is strongly adopted by the building design and is major source of the building's energy production. Moreover, the building also incorporates many other sustainable technologies, such as 'rainwater harvesting system, black water treatment, solar heating and automated building management systems' (The Crystal official website). The project also incorporates several intelligent and integrated active and passive design elements, including heating, air-conditioning and ventilation systems, a weather station, lighting controls, a solar thermal hot water system, a fire alarm system, an evacuation system and a photovoltaic system.

As a result of the building's efficiency and operation of its ground source heat pumps, the building is self-sufficient for heating and cooling energy production. This energy system works with 199 pipes, totalling 17 kilometres in length, which are put into the ground at the depth of up to 150 metres. These are supported by two ground source heat pumps that generate both cold and hot water, which are then pumped back to the under-floor pipes for energy use. Cold water is then transferred to a ceiling-mounted beam which is then used for cooling purposes when needed. Moreover, the overall building energy is improved by the utilisation of 'thermal wheels'. In this process, approximately 60% of outgoing heat or cooling energy are recovered (Siemens document 2013). Furthermore, lighting and ventilation are both integrated in design and operation of the building. The building has self-shading façades which make use of high-performance solar glass technologies. This allows an overall visible light penetration of 70%, while keeping 30% of the solar energy. This particular triple-glazing solar glass includes an Argon cavity for insulation purposes. The use of such insulation systems increases the efficiency of the building energy performance. The building design also make optimal use of natural daylight in most of its internal spaces. The minimal artificial lighting system of the building uses a combination of 65% fluorescent lights and 35% LED lights with some of Siemens' advanced control and adjustment systems (e.g., detectors for dimming or switching off lights when they are not required).

The Crystal also includes a Building Energy Management System, which is one of the building's smart technologies used to detect indoor and outdoor climatic conditions. This system is utilised for control and monitoring use, energy-efficient ventilation and an intelligent lighting system. As a result, the CO_2 emissions for the Siemens offices in the Crystal are 70% lower than average for a UK office building of a similar size. In addition, water systems are among the key sustainable features of the building. Rainwater collection comes directly from the building's roof or other accessible area. The collected water is then stored in an underground storage tank and is treated by ultraviolet disinfection and filtration processes. The collected water is then recycled and used for irrigation, general cleaning and toilets across the site. It is also noted that approximately 80% of the building's hot water is heated by solar thermal water heating generated from both the roof and ground source heat pumps (Siemens document 2013).

The Crystal is a renowned building for its dual green certification. Yet the integrated technologies of the building play a major role in achieving such a status. The building, which is built on a brownfield site, utilises its surrounding conditions and adopts several energy systems and technologies. The building construction process was fully monitored to include the following three key aspects: a reduction in the use of materials; a reduction in waste production; and material recycling and re-use. In addition to the use of permeable materials for exterior surfaces, the building's green roof system also provides a key stormwater management component, which also serves as a habitat for a variety of plants and animal life. Overall, as a mixed-use building , incorporating both office spaces and public exhibition spaces, the building offers a robust platform for green building technologies and sustainable energy systems.

3.4.2 Passive House in Germany

Passive house is a building standard that was first developed by the Passive House Institute in Germany in the 1990s. Unlike many other green building certifications, passive house is focused on building energy performance only. It is considered to be the most rigorous energy-based standard in the design and construction industry today. Passive house has gained recognition in particular in Germany and other European countries such as Austria and France. In recent years it has expanded beyond Europe, for example, China and USA both published their own passive house standard in 2015. The main features of passive house are:

- Solar passive design, e.g., orientation, shape, window size and shading.
- Super-insulation: U-value of envelope less than 0.15 $W/m^2.K$ to minimise heat exchange between the indoor and outdoor environments. Designing out thermal bridging is key to achieving such a low u-value.
- Super-airtightness: air infiltration less than 0.6 air change per hour.
- Mechanical ventilation with heat recovery to recover heat from indoor exhausts.
- Renewables: solar PV or ground source heat pump may be installed if the above measures cannot achieve the annual target of heating and cooling load.

Passive houses make efficient use of the Sun, internal heat sources and heat recovery, rendering conventional heating systems unnecessary throughout even the coldest of winters. Similarly, during the warmer months, passive houses make use of passive cooling techniques such as strategic shading to keep comfortably cool. In terms of performance measuring, passive houses allow for space-heating and cooling-related energy savings of up to 90% compared with typical building stock and over 75% compared to average new builds (PHI 2017). Passive house requires maximum of 10 W/m^2 for heating or cooling demand (equivalently 15 kWh/m^2.year) in residential buildings. This is a significant improvement compared to conventional residential buildings in Germany, which often employ a centralised hot water heating systems consisting of radiators, pipes and central oil or gas boilers and has an average heating load of approximately 100 W/m^2. In a passive house, traditional heating (or cooling) systems are not needed. Figure 3.1 shows an abstract model of a passive house that is well insulated and airtight. Heat exchange occurs between fresh air and indoor exhaust air in a heat exchanger, thereby greatly reducing ventilation heat gains/losses.

The world's first passive house, Darmstadt-Kranichstein, was built in the city of Darmstadt in Germany in 1991, and comprises a row of four houses, with each accommodation unit having a floor area of 156 m^2. As the first building of its kind, it was not very economical at the time because the building components had to be manufactured individually and were therefore expensive. The houses were also equipped with highly precise data monitoring devices in order to check the achievement of the objectives (Passipedia 2017).

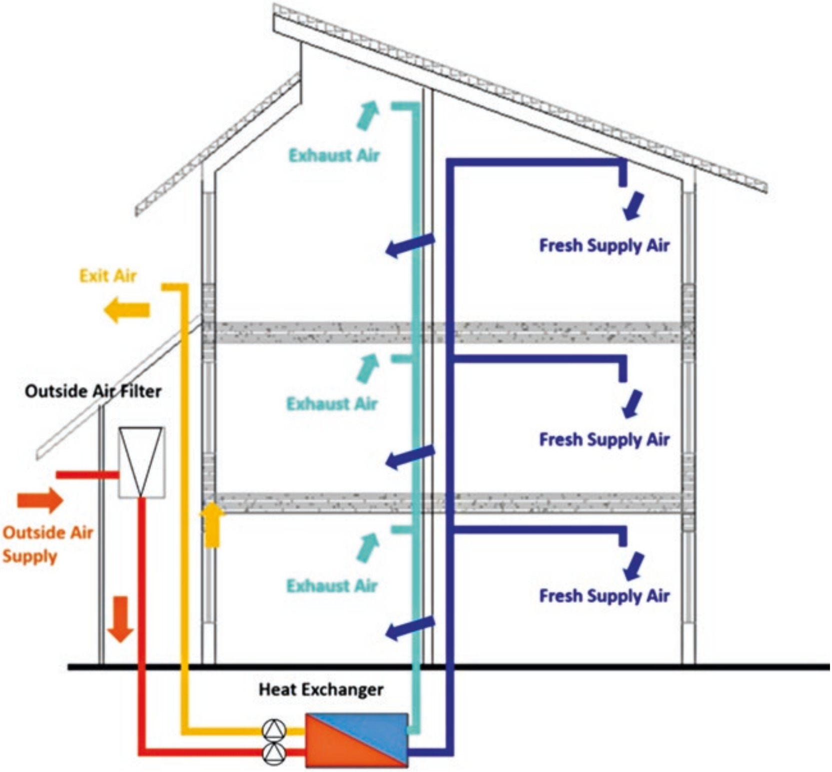

Fig. 3.1 The working of a passive house (redrawn by the authors based on the original building plan)

The house has a well-insulated envelope with u-value less than 0.15 W/m².K and an infiltration rate around 0.3 air changes per hour. The windows have three panes with low emissivity to reduce heat transfer through glass. It is installed with a mechanical ventilation system with heat recovery. Fresh air initially exchanges heat with the ground and then exchanges heat again with the indoor exhaust air before entering the indoor space. Thus the heat loss caused by introducing fresh air in cold winter is minimized.

The passive house in Darmstadt has been inhabited by four families since it was completed. The continuous performance monitoring in 2010, twenty years after its completion, indicates the measured space heating demand remains at 10 kWh/(m^2a). No large maintenance measures have yet been undertaken and all building services remain unchanged from their original configuration. The façade, roof and windows remain unchanged (Passipedia 2017).

3.5 Evaluating the Sustainability Performance of the Built Environment

There is a large number of tools and approaches which have been used to evaluate environmental performance of the built environment, ranging spatially from building materials and products, energy- rated appliances, indoor air quality to whole building assessment, neighbourhoods, districts and cities. This section will give a brief review of these evaluation systems at three spatial levels: building, neighbourhood and city; that is, respectively, at the micro, meso and macro levels of the urban built environment.

3.5.1 Green Building Evaluation

3.5.1.1 A Brief of Green Building Rating Systems

Ever since the 1990s, green building rating systems have been developed to certify building performance using an assessment matrix. Cole (2010, p. 273) points out that green building rating systems (which are voluntary and market-based) have been the most important mechanism in the improvement of building performance over the past few decades. The primary objective of these systems is to stimulate market demand for buildings with improved environmental performance.

The building rating systems have directly influenced the performance of buildings. Examples can be seen in many countries around the world, including Leadership in Energy and Environmental Design (LEED) in the US, the Building Research Establishment Environmental Assessment Method (BREEAM) in the UK, the Comprehensive Assessment System for Built Environment Efficiency (CASBEE) in Japan, and Green Star in Australia. There are also signs that these assessment systems have moved beyond voluntary marketplace mechanisms by being endorsed by public agencies and other organizations as compulsory performance requirements; for example, LEED has been required by many federal agencies, and state, county and local governments as the compulsory requirement for new buildings funded by them in the US (Retzlaff 2008). In Australia, government-funded public buildings also need to meet the requirement of Green Star.

A typical building rating system is composed of a checklist of items organised into categories such as water, energy, siting, planting and indoor environmental quality, some of which may be optional. In most systems, each item is assigned a point value, and users must obtain a certain number of points in each category. The judgement of which item should be included in a system and the assignment of point values are subjective. Ultimately, a building receives a total score to reflect its environmental performance. Often, the scores are used to assign a ranking, such as platinum, gold or silver. Users typically pay to use the system, and in return they receive a variety of benefits, mainly involving market recognition and promotional opportunities. Many of the major building rating systems offer a suite of products, each of which is targeted at a specific building type, phase or situation, for example, commercial or residential, multi-unit residential or single standing residential.

The use of this type of building assessment system is not only for labelling purposes and marketing promotion. In many cases, they have also been used as planning and design tools (Cole 2005; Retzlaff 2008, 2009) because they present a set of organised environmental criteria. By default, they are understood as being the most important environmental considerations by the planning and design teams (Cole 2005). In practice, architects often set a number of certification requirements as design targets and involve green building certifiers during the course of design.

3.5.1.2 A Further Discussion

The sustainability of a building has internal dimensions and is also affected by factors in its surrounding environment. Retzlaff (2008) uses a scaling system of five hierarchies to examine different systems and concludes that most building-level rating systems assess performance on a fairly small scale. These systems tend to assess the building in isolation from the rest of the world (that is, in the neighbourhood and urban contexts). They are limited to building sites and are focused on building environmental performance. To some extent, this may be inadequately explained by the fact that they are whole-building assessment tools, and essentially deal with issues lying within their sites. It may also be because many of the issues related to building impacts (especially social and economic) are difficult to quantify when considered on the basis of a single building and would be more suitably addressed at a neighbourhood or urban level (Lowe and Ponce 2008).

Building rating systems vary significantly in how they were developed and how they are applied to buildings. It is interesting to note that vastly different results would be produced when different rating systems are applied to the same building. Slavid (2009) discusses an empirical case study conducted by a Glasgow-based simulation company IES. The purpose of this study was to conduct a comparison between LEED, CASBEE and Green Star. A hypothetical eight-storey commercial building in Dubai is used as the case study. The case study building failed its LEED assessment. Under BREEAM, the building fell into category B for its energy rating, which gave it two out of a maximum of 15 points available. In contrast, under Green Star, the building scored 11 points out of a potential 20. As explained by the research leader, Green Star was designed for a hot climate, and LEED covers all the very diverse US climate zones. Kawazu et al. (2005) also conducted a similar comparative study. Four high-performance office buildings in Japan and one fictitious low-performance building were evaluated using LEED, BREEAM, Green Building Tool (GBTool) and CASBEE. The assessment results showed that BREEAM and CASBEE scored higher than LEED and GBTool. Where the Building Research Establishment (BRE) in the UK evaluated the systems under normalized conditions across all the rating criteria it was found that LEED, Green Star and CASBEE assessments are not equivalent to BREEAM. Accordingly, a six-star Green Star building (the highest Green Star rating possible) is less 'green' than a Platinum LEED building (the highest LEED rating possible) and approximately equal to a 'very good' BREEAM rated building (the second highest BREEAM rating possible). BRE concluded that the four assessment systems cannot be directly compared. Generally building rating tools are all designed for internal comparison between buildings scored under the system, rather than comparisons of buildings appraised under different systems.

Variation may also occur in the same country across different climate zones. Some criteria are relatively easy to achieve in one location, but not in another. Cidell and Beata (2009) have demonstrated that spatial variation in the implementation of the LEED assessment does exist across the US. Variability across criteria and across space underscores the intuitive fact that designers, architects and builders take advantage of the flexibility allowed in the LEED certification process, and that they apply the criteria that best fit the budget, resource constraints and human and physical environments of specific projects (Cidell and Beata 2009).

In recent years, there has been a substantial increase in both the uptake of green buildings and the number of green building rating tools. For example, the World Green Building Council (WGBC) currently has 71 member councils that have given some level of commitment to green building development in their respective countries. Another 31 countries may join WGBC in the near future, as indicated in its official website (WGBC website 2017). LEED is the most commonly used whole-building rating system around the world. Between 2000 (the year of its inception) and the end of 2006, a cumulative total of 5000 projects had been registered with LEED certification across 24 countries. This number has been increased to nearly 80,000 projects across 162 countries at the end of 2015.

3.5.2 Neighbourhood Sustainability Rating Systems

3.5.2.1 Scaling up from Individual Buildings

Building-level rating systems are site-limited and mostly concentrate on environmental issues and related technologies being employed. They are incapable of addressing neighbourhood built environment, as a combination of buildings and open spaces such as roads and parking lot. Buildings are built within neighbourhoods and the spatial arrangements of neighbourhoods have significant impacts on the environmental performance of buildings and incur direct, as well as indirect, costs to households.

Green buildings are closely associated with sustainable neighbourhoods, but individually they do not make sustainable neighbourhoods. The efforts to reduce the environmental impact of individual buildings will be more or less successful depending on the opportunities and constraints of their neighbourhood's development form. For example, a mixed-use neighbourhood development can greatly reduce the use of private cars. Thus, there are incentives to expand building-level rating systems to the neighbourhood scale. Many leading international building-level tools now have a companion neighbourhood-level tool, such as CASBEE-Urban Development from Japan in 2007, LEED-Neighbourhood Development from US in 2009, BREEAM-Communities from the UK in 2012, Green Star-Precincts from Australia in 2012 and DGNB (Deutsche Gesellschaft für Nachhaltiges Bauen)-New Urban District from Germany in 2013. They have maintained a similar assessment structure and procedure, but the assessment scope is broader with focuses on neighbourhood pattern and the interrelationships between people and space.

3.5.2.2 Overview of Neighbourhood Rating Systems

Aforementioned, a neighbourhood physically encompasses multiple buildings and their sites, and the public environment such as roads, open spaces and landscaping features which exist in-between those sites. Neighbourhoods also embrace socio-economic features such as social interactions that are generally more intensive at this spatial scale. It is obvious from the foregoing discussion that, without modification, the current single-building assessments are not capable of dealing with the neighbourhood BE of merged sites and complex socio-economic environment.

Though different names are adopted for these neighbourhood systems, respectively 'neighbourhood development', 'urban development' and 'communities', they all represent a larger scale of the BE beyond single building sites. There are no confines on their application to different spatial scales. For example, LEED-ND defines a wide range of development that may constitute whole neighbourhoods, fractions of neighbourhoods or multiple neighbourhoods. There is no minimum or maximum size for single projects and no strict definition of what would comprise a neighbourhood. The current pilot projects under the LEED-ND programme range from 0.17 acres to over 12,000 acres (USGBC website). The BREEAM-Communities defines the size of developments that fall into its jurisdiction as small (up to 10 units), medium (between 10 and 500 units), and large. These scale definitions actually are open-ended in terms of spatial levels of the BE. They can be applied to any 'organized urban area' that is beyond a single building site and are universally subject to laws, planning regulations and urban masterplans.

3.5.2.3 Neighbourhood Sustainability Labelling

It is evident that both building- and neighbourhood-level assessments focus on different spatial scales, i.e., the individual building assessment concentrates on issues such as indoor environmental quality, thermal insulation and ventilation while the neighbourhood dimension of the tool emphasizes issues such as location, transport and community. An examination of LEED-ND, BREEAM-Communities and CASBEE-UD indicates that they have broader assessment scale than their building versions. On average, 55% of the total criteria examine community and urban issues and 32% address development level. Only 9% of the total criteria are limited to building site level. In general, compared to their building versions, neighbourhood rating systems are more focused on urban issues, particularly on three aspects: open space, social interaction and spatial features (e.g., location, accessibility, urban infrastructure, and so on). The common issues that are covered by LEED-ND, CASBEE-UD, and BREEAM-Communities, includes: Conservation of site ecology; Reviewable energy; Reducing water use; Reuse of rainwater and greywater; Access to local amenities and facilities; Universal accessibility; Urban integrity; Community involvement; Stormwater management; Access to public transport; Public transport capacity; Use of bicycle and electronic vehicles; Transport planning and management; Waste disposal facilities; and Construction code and green building certification. It can be seen that spatial patterns and the interrelationships between an 'area' and its urban matrix are emphasized in neighbourhood-level tools (Deng and Prasad 2010).

Similar to building rating systems, neighbourhood rating tools are regionally specific, and, thus, their focus varies across different systems. For example, LEED-ND gives more emphasis to mixed-use development such as compactness, accessibility and walkability with relatively less consideration given to local and global environmental impact, urban infrastructure capacity and the economic dimension. Density is now considered a critical component in sustainable urban development in North America and is central to many of the credits within LEED-ND (Cole 2010, p. 280). The weight of this issue does not seem to be extremely significant when compared with what is obtainable in CASBEE-UD. This reflects the fact that many Japanese cities are already built at high urban density. In such high-rise and high-density compact cities, the questions could be more concerned with air and noise pollution, limited access to daylight and natural ventilation, and limited space for vegetation. Thus, CASBEE-UD is more concerned with environmental issues such as site ecology, local environmental impact, urban infrastructure performance, and construction management. It places relatively less attention on issues such as project location, street layout, and housing affordability which are emphasized in LEED-ND.

3.5.3 Sustainable City Rating Systems

Since the late 1980s, there are a large variety of urban sustainability toolkits, urban assessment systems, and urban sustainability evaluation systems which have been introduced and implemented in the field of urban sustainability. Some of the most well-known ones are developed and regularly discussed by influential organisations such as City Index, the United Nations Human Settlements Programme (UNCHS), the World Bank, the Organisation for Economic Co-operation and Development (OECD), the European City Index and so on. Some of these toolkits, such as those provided by the International Union for Conservation of Nature (IUCN), the United Nations Conference on Environment and Development (UNCED) and EUROSTAT, are more focused on certain aspects like environmental sustainability (Moldan et al. 2012). These organisations have developed and for long have used their urban sustainability systems for policy development or in practice. In a holistic approach, the urban sustainability assessment systems often encompass three main pillars of sustainability (including environmental, social and economic), while some also include 'governance' as the fourth pillar. Also in most cases such assessment toolkits or systems focus on key individual dimensions, such as environmental (i.e., IUCN as stated above). Any of these approaches leads to development of framework and suggested indicators for the measurement of sustainable development. This is then applied further for policy development and practice implementation.

The measurement of sustainable development is often considered to be a shift from 'measuring economic phenomena'. At an urban scale, this is considered to be a more effective measure as macro-economic indicators (such as GDP) are often significant parts of the city performance evaluation (Joint report by UNECE/Eurostat/OECD Task Force 2013). This also leads to a lack of social development and environmental progress, which can be partly in conflict with mere economic growth. As a result, sustainable development indicators (SDIs) provide a more holistic approach towards achieving urban sustainability and pay more attention to social issues, environmental concerns, quality of life and human well-being. Key factors of climate change, natural preservation, resource use and environmental protection often shape the overall framework of a sustainable development assessment. This is described as an approach to harmonisation (ibid.), leading to the development of performance indicators or sustainability assessment systems that are enabled to promote progress towards a sustainable development or society.

3.5.3.1 Definition and Description

As defined by Phillips (2014, p. 6869), urban sustainability indicators are 'ways to measure the conditions and status of an urban area with a variety of factors'. The main difference between urban sustainability indicators and other types of indicators is in their nature of integration and linkages within sustainability dimensions. Urban sustainability indicators can—to some extent—be interpreted as a method of SWOT analysis at macro or city levels, where we can identify the strengths, weaknesses, opportunities and threats that can be addressed or improved through the process of development. Hence, the system-like nature of urban sustainability evaluation methods enhances the possibilities of making corrections or suggestions for future development. This approach works in an information-based system that generates the progress and happenings of development (Phillips 2003). Rametsteiner et al. (2011) also add that urban sustainability systems are aimed at promoting 'an understanding and insight about how human and/or environmental systems operate; they suggest the nature and intensity of linkages among different components of the studies systems, and they offer a better understanding of how human actions affect different dimensions of sustainability (economy, environment, social issues)'. It is, therefore, important to keep the interconnectedness of indicators or components of key dimensions of sustainability, in order to achieve an assessment system.

An example of such approach is developed by Sustainable Measures (2010), called 'Sustainability Competency & Opportunity Rating & Evaluation (SCORE)', which demonstrates sustainability pathways for enhancement and improvement of policies and practices. Similar to other urban sustainability systems, their approach includes key dimensions of sustainability (social, environmental and economic) with sub-categories of: education, health, poverty and crime (all for social), water quality, air quality and natural resources (all for environmental), and stockholder profits, materials for production and jobs (all for economic). Although this demonstrates a relatively simplified urban sustainability system, it elaborates on the importance of linkages between the subcategories between and across the three pillars of sustainability.

Moreover, the combination of assessment indicators would then feed into a measuring system to monitor information about past trends, current realities and future direction in order to aid decision making (Phillips 2014). Also, according to Cravic (2011, p. 223), a set of sustainability indicators aims to identify issues and suggest necessary actions for resolving or eliminating the problems. This is, however, very much dependent on the availability of data and data provision for analytical and critical assessments. As a result, an information-based platform is a necessity to urban sustainability assessment systems. This is also applied in development of conceptual framework for urban sustainability assessment systems that often have two sides of theoretical application and practical implementation.

3.5.3.2 Conceptual Framework for Urban Sustainability Assessment: Theoretical and Practical

The birth of urban sustainability indicators goes back to Agenda 21, through which urban sustainability assessment was considered as an approach to support sustainability decision making, policy development and sustainable development (Munier 2004). A conceptual framework puts into place a series of sustainability indicators for better management, improvement and development cases. For instance, in its conceptual framework UN Habitat's example of 'Global Urban Indicators' (2009) indicate five key dimensions:

- Shelter;
- Social Development and the Eradication of Poverty;
- Environmental Management;
- Economic Development;
- Governance.

The above dimensions include a selection of sustainability goals and indicators that are then used in a weighting system to measure the sustainability and evaluating the conditions of the urban environments. The recent Sustainable Development Goals (SDGs) by the United Nations—Statistics Division indicates a similar approach towards the future development of urban sustainability assessment systems. As expressed by the United Nations (2015), this is 'a robust follow-up and review mechanism for the implementation of the new 2030 Agenda for Sustainable Development' which is based on a holistic framework of indicators and statistical data 'to monitor progress, inform policy and ensure accountability of all stakeholders'. In this conceptual framework, 17 action points address indicative pathways for the 2030 agenda for sustainable development. A significant attention is given to issues of climate change, environmental degradation and strong instructions.

While city-level sustainability measures are often either too broad or lack a detailed vision/plan, the implementation of such conceptual frameworks is often called into question. The sustainability of city is dependent on several factors that can be in contradiction to one another, i.e., economic sustainability vs. environmental sustainability. As a result, we can argue that urban sustainability assessment systems, while working well at the conceptual level, should be indicative toolkits or indicator systems for sustainable development and growth; e.g., eco-development for our cases here.

Unlike the other two spatial levels of meso and micro, it is difficult to implement urban sustainability assessment systems in practice. Its broad context and measures, although often quantifiable, are not easily measurable at the city scale. While the framework can provide flexibility of use, measuring sustainable development can only occur with the realm of official statistics (Joint report by UNECE/Eurostat/OECD Task Force 2013). As a result of such use, a set of policy developments can occur that would then lead to practice implementation at a smaller scale. However, some particular components of climate change control, environmental protection and economic growth can be applied and supported at the city scale.

In the past two decades, we can track a steady increase of popularity in the development, utilisation and application of urban sustainability systems. This is significantly apparent in research and is, in recent years, more applied in policy and practice. We can also witness more involvement from various organisations and stakeholders in the development and utilisation of urban sustainability systems that are often indicators-based and are used for the assessment of city performance. This signifies the importance of such systems, benefitting substantially from city planning and urban development perspectives. Hence, the push towards policy development at the city level can play a major role in development of urban sustainability assessment systems.

3.6 How Do Global Developments Inform China?

Before we move on to the context of China, it is important to elaborate to what extent global practices and policies previously have, and continue to have, an impact on Chinese practices and policy reforms. Although this chapter has served as our entry point to the concept of eco-development from the global perspective, it also enables us to highlight some of the global–local linkages. It is important to recognise these linkages and evaluate the past and current directions in China. It is also important to note that China has taken a journey of three decades in less than a decade, if we compare China with the developed countries of the West (Cheshmehzangi

2017). The transitions have been immense and in many ways impactful on policy development and practices. This journey is what we can simply refer to as the initial phase of green/eco-development in China. It also appears as a steep learning curve for many stakeholders and actors, who have been involved in, or have taken the leading role in, developing green/eco-projects in China. This initial stage has enabled China to first learn from the global examples and then gather the knowledge gleaned for future practices and policy development/reforms in China. Among these early activities were project visits that were taken by governmental and city officials, practitioners and policy makers who visited and learned from successful, or if not, well-known models of green/eco- projects around the globe. These visits were the breakthrough for Chinese counterparts to observe, evaluate and learn from green practices. Also during this time, many Chinese (including returning overseas Chinese) and international scholars and practitioners have actively studied global examples and proposed for methods and approaches that were later adapted in the context of China. In this process, scholarly findings have grown up and matured significantly, enabling many platforms of research and development, between research, industry and policy making. For instance, the authors of this book are both examples of such scholars whom have continuously worked on the theme of green and eco-development in the last decade in China.

In addition, China has benefitted from many international relations, cooperative and collaborative projects, such as joint research collaborations with global and leading institutes, learning from the know-how and experience of examples and pathways that have previously gained global attention, if not recognition. At first, perhaps we can argue that many of these examples were not entirely adapted to the local context, but were mostly replicated without the comprehensive inclusion of local characteristics, local varieties and local values. Many aspects, such as rich local and historical characteristics, diverse climatic regions, and the top-down willingness to change the business-as-usual cases enabled China to delve into the policy mobility transfer and considering changes in practice. As a result, this trend of replication has weakened gradually over time, enabling many scholars, practitioners and policy makers to seek for localised models and the local refinement of successful examples. This also brought a chance to look back at some of the existing practices in China, of which the vernacular examples are of high popularity to many researchers who study the sustainability characteristics of vernacular forms, models and building design in China. What we anticipate seeing in future is the increase in bilateral and multilateral platforms and arrangements that will enable China to be in mutual communication platforms with project holders and developers of the other countries. China is also expected to take a more active role in the global arena, some of which are already perceptible in major global platforms, such as the well-known Belt and Road Initiative (BRI). The nature of some of these platforms will turn into south-to-south cooperation projects (as it has already instigated), enabling China to export some of its successes to the other regions of the developing world. We also foresee more international cooperation in this route, not only for China to learn from others but to share their experiences globally.

Although the progress has been very tangible, it is believed that China has a long way to go on its journey to become a green nation. Eco-development projects of China are mostly new; collectively, however, they do represent a remarkable achievement of the country's success in its first phase of promoting green/eco-development. The global examples have certainly informed what we can refer to as the first batch or first movement of green/eco-practices in China. The move towards policy reforms and the development of new policy frameworks is already seen in many regions, starting, of course, from the more prominent cities, particularly in the cities of first and second tiers. Some of these examples are further developed as joint venture projects that we see shaping up in many parts of the country. These examples are unique in their nature, experimental in purpose, and effective as large-scale and open laboratories for green/eco- or sustainable development. Several of these examples will be discussed further in the forthcoming chapters (see Chaps. 5, 6, and 7), where we introduce 21 case studies of Chinese projects at the three distinct spatial levels of the built environment.

To summarise, we can argue that China has clearly benefitted from the global examples—some may be direct through policy transfers and then transitions, and practice adaptation; and some are indirect through the review and evaluation of lessons learnt from the others. This benefitting will continue to inform China's own agenda for green/eco-development, but the important question is: will China possibly inform the global context in the future? In the chapters that follow, we will highlight some of the existing examples and models in China and will then focus on how the country will potentially be one of the future global and successful models itself.

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