CHAPTER 8

Future Eco-Development in China and Beyond

8.1 Introduction

In recent years, China has experienced a significant shift of focus in its development mode for urbanisation and urban development. Also in these years, most Chinese cities have gone under significant restructuring, some of which have been substantial in modernising the cities. However, the rapid process of development has either already ended or will end soon. Most cities will enter a new stage of gradual development. A similar development trend has already passed to less developed areas and smaller cities and towns, as embedded in the action plans of China's New-type Urbanisation Plan (NUP). Most importantly, however, some of the models and implementation scenarios are either practiced or exported to other countries of the global South, particularly in the regions of South East Asia and the Pacific and in the African context. This also points out the role of China as a successful model of development amongst the developing nations. Nevertheless, Chinese cities are yet to develop further and are still in the process of transitions; whether it would be eco- or green, smart or low-carbon.

If we track the transitions and restructuring of major Chinese cities over the past two decades, it would simply seem incomparable to developed cities of North America and Europe. In a way, we can argue that Chinese cities have benefitted significantly from the ubiquitous trends or concepts of eco- and green development. Why is that so important? And why do we

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see significant transitions in Chinese cities? The answers have already been highlighted in this book, as we gave examples of innovative projects as experimental cases of development, new Sino-foreign initiatives as platforms of knowledge sharing or knowledge transfer, and new directions of development, indicating policy reforms and transitions, from 'business-as-usual' cases to global cases of sustainable development.

It is important to highlight that China has begun its process of eco-development at a later time compared to developed countries. However, over a very short period of time and particularly over the course of the past two decades, it has steadily gained momentum in terms of policy reforms and policy framework development. During this period, it has also gained attention from the central government and local city officials, which ultimately indicates the importance of the eco-/green agenda at various governmental levels. To avoid the high-carbon paths pursued by developed cities during their early development stages, some Chinese cities start to adopt best urban practices (from various global examples) and develop a multiscalar approach to address sustainability at city, neighbourhood/community and building levels.

Furthermore, it is noted that China has learned from global trends of eco-development, from the very beginning of developing its own initiatives. For example, China's Green Building Evaluation System (GBES) initially used BREEAM and LEED models as their reference examples; China has published its own Passive House Standard, mirroring the best energy practice of buildings constructed in Germany. Furthermore, international best practices have entered the country as China provides vast potential of implementation, particularly in the newly built development areas. Today, LEED is the second mostly used tool for assessing building performance in China. At the city level, given the lack of experience in eco-city development and the relatively high associated initial capital investment, some early eco-city initiatives involve international partners. This was mainly done in order to provide support on city planning, urban design, urban management, advanced green building technologies and financial investment. For example, Sino-Singapore Tianjin Eco-city has been benefitted from the Singaporean experience of developing eco-development projects (see Chap. 5).

As a result of a policy shift towards a more eco-development-style approach in recent years, China is now the leading country in (re)shaping the urban environment. It has the highest number of eco-city projects globally, and is the largest consumer of renewable energies. As of 2016, it also has the largest renewable energy capacity. Meanwhile, energy conservation and environmental protection have become strategic industries that are undergoing accelerated development. Apart from the global trends affecting Chinese practice, China has also developed its own vision on eco-development, i.e., the term 'ecological civilisation' that aims to develop a paradigm achieving harmony between humankind and nature and realising social prosperity in tandem. It is hoped that the current eco-development practices in China might provide useful references to other developing countries that are at a similar stage of development. Nowadays, many developing countries look up to China as a successful leading model of development; and potentially a leading model of green development in the near future.

In this chapter, we first look into some of the past and current trends of eco-development, both globally and China-focused. We follow our previous structure of three spatial levels and provide a detailed analysis of eco-development approaches that exist in the built environment. Afterwards, we provide a comprehensive analysis of 'eco-' from a multiscalar perspective. In this section, we investigate issues of climate change and how it effects urban resilience, and, as such, eco-development as our mainstream. We then discuss more about the context of China and precisely explore the importance of the regional context and climatic conditions, stakeholder constellations as part of project development, and traditions as rightful methods for the future. In the last section, we highlight some of the future directions and give an insight into what directions will be suitable in China, if the concept of eco- is going to continue and strive for further development. The concept will not and must not be outdated, but should rather develop into new directions of sustainable development. The examples that we provide in the earlier chapters will simply serve as a forecast to what the future of 'eco-' will be in the context of China, and how some of these may lead into new models of development for the future and also for the existing built environments.

8.2 Past and Current Trends of Eco-Development at Three Spatial Levels

8.2.1 City Level/Macro

Since 2007, there is a great deal of eco-city development projects in China. Since then, nearly all small- to large-scale cities have a green/eco- agenda. Some of the earlier projects are still under construction and due to completion in around 2020 to 2025. These new eco-city projects are aimed to set new methods of city thinking, creating possibilities for the sustainable transitions of cities. Although very new and mostly experimental, these projects provide us a starting point in the field of eco-city development in China.

At the city level, the factor of 'branding' remains a major matter. In fact, such a branding approach can potentially create an ideology of 'ubiquitous eco-cities', where local environmental/ecological agendas are not necessarily the central concern. The focus should rather be in methods of developing the city environments (if not whole cities), in the most harmonious form with the nature. This ideally revolves around creating or adapting the city environments into sustainable models of lower resource consumption, resource reuse, waste recycling and ecologically sound environments; a mode of development that is either inherited naturally or human-produced (Yigitcanlar and Lee 2014). The central question for any development should be a reflection on 'how development takes place'. Minimising the impact of the built environment on the natural environment is essential in answering the question. The more recent methods of nature-based solutions (currently popular in the European continent) signifies the importance of nature as a priority to urban development. The natural or ecological dimension of eco-city development should not be seen as a commodity (if considered as a branding approach) and should rather be utilised as the backbone of development. In the past, we have seen a great deal of development on preserving and protecting the natural environments. Although less attention is given to nurturing and enhancing the nature. In this process of change, the seemingly irreversible development trends, mainly stemming from the post-industrialisation era, impose a major threat to questions of the nature of eco-cities, and what achievements can be expected from them. The term *eco-city* can then be justified as a more ecologically-balanced city.

What we have seen from our city-level cases in this book are a selection of large-scale eco-city projects in the context of China. Regardless of their actors' involvement and governance structure, these new eco-city development projects can be seen as contemporary eco-city cases of China, or in another words 'local lessons learnt' (Cheshmehzangi 2017). It is important to note their lack of maturity at the current stage, but also their experimental nature that has taken place in the past. In this relatively long and ongoing process, there is an increase in awareness. Although the level of attention has not increased as much, current progress indicates transitions on the ground. This increase of awareness is not yet widespread, but it is visible at the local governmental level. This was not the case about a decade ago. The transition has been slow, for several reasons: (a) huge attention has been given to eco-city branding and not as much on actual changes for planning practices and development strategies; (b) eco-city projects are seen as self-sufficient urban zones that are mostly development at a rapid pace; (c) eco-city projects are implemented on a large scale and mainly located on greenfields or reclaimed lands; and (d) eco-city projects have not yet taken on board a comprehensive understanding and integration of multiple dimensions, such as geographical, cultural, economic and social. The environmental dimension alone cannot create a comprehensive framework for eco-city development.

In most city-level projects, there is often a distance between the eco-development plan and the project outcomes, such as final implementations. While it is likely to see planning becoming more diverse, it is not so simple to diminish the role of planning in the process of eco-development, and particularly at the larger scale of city level. While we can argue that eco-city projects in China are physical (i.e., rather than digital in the case of smart cities), there has been no case of a city-wide eco-development so far. However, a rather smaller scale of eco-city projects, mainly in comparison to the scale of cities in China, is mostly successful. Our evidence shows multiple impacts on: (1) Policies—as they change over the years with more emphasis on ecological factors and environmental agenda; a movement that has firstly pushed and then enabled then local governments to change their mindsets and frameworks; (2) Planning criteria—for instance, from 'business-as-usual' cases to more ecologically-balanced or ecologically-friendly projects, a trend that may have completely changed everything, but has questioned previous planning criteria as the starting point to transition; (3) Design certification popularity—where we can witness a rapid increase of green certification projects and a mandatory green/eco- agenda for city developments; (4) Development mode—which we still find slowly progressing, but clearly in a different direction to decades earlier; and (5) Incentives—where attention is given to support and encourage green strategies and eco development cases. Above all, it is important for eco-cities to include an adaptive approach that encourages innovation; and by that we mean a direction that suggests new eco-directions, new eco-strategic plans and new ecologically-balanced development modes.

In general, we can argue that eco-cities are concerned with both process and the sustainable agenda. Globally, and in China in particular, there is an upsurge of eco-city development that put into practice some of the earlier conceptualisations and visions of the eco-city idea. These practical initiatives are seen as part of an urban sustainability agenda (Joss 2011). Through this, eco-city projects would then revolve around the 'convergence of ubiquitous technologies and city planning megatrends' (Yigitcanlar and Lee 2014, p. 108), which neglects the ideals and situations of the local context. Unlike the more recent smart-city movement, there is a higher chance of approaching eco-city development from the grassroots and a consideration of the social dimension. However, this still offers high potential and we can only see a few smaller-scale cases of success in China. The so-called bottom-up approach would then enable not only new directions of eco-city development, but also leads towards behavioural changes in the general public, development of the social infrastructure, the integration of multiple dimensions in the process of transition, and a consideration of human-centric eco-development. In our conclusions, we highlight some of these further.

8.2.2 Neighbourhood/Community Level: Meso

Although very important, the community level of eco-development in China is relatively weaker than the other two spatial levels. This importance is very much based on its small and manageable scale that can provide pathways to scaling up projects. By this, we simply mean the expansion of projects' ideals or the projects themselves, from a small-scale development zone to a larger scale. Unlike the other two spatial levels, at the community level, the social dimension is more robust and appear to be central to eco- or green development projects on the meso scale. This spatial level can therefore be regarded as the most people-centred level of eco-development.

At this level, the education dimension is significant, and feeds into the increasing awareness of the general public. For instance, the recognition and formalisation of simple—but yet effective—eco-/green factors, such as the increase in recycling, rainwater collection, energy saving, renewable energy usage, public transportation usage, natural cooing and passive methods, and etc. Some of these, although more connected with the micro level, are in fact more effective at a communal setting of community level. To elaborate further, we can just map some of these factors at the meso scale: recycling often covers a larger scale even beyond the community level; or rainwater collection and reuse can be more effective if we consider a larger area of outdoor public places, in between spaces of buildings, and larger bodies of surfaces and storage spaces; or energy saving that is more significant at a larger scale than at the building level alone; or renewable energy usage that often requires a larger area for production and storage, and is less costly when it covers a community rather than just a smaller number of buildings; or public transportation that feeds directly into our spatial patterns, urban forms, and land-use planning; or natural cooling/passive methods that are much effective in cases of district energy systems for cooling (and heating). These are just a few examples to highlight the importance of meso scale solutions for eco strategies.

At the meso scale, we also have a good range of typologies, and we have covered at least four of them in this book. We also found that there is no defined boundary of this spatial level, as it can simply vary from a small residential district to a large-scale development zone. Moreover, it can also vary in terms of functionality, i.e., mixed, or singular use. For instance, for a typical residential compound or district, households are adhered to the community level and cannot necessarily become individual models of eco-development. In such a community setting, the impacts on the ecological infrastructure include the three attributes of building, neighbourhood and location (Yang et al. 2016). Similarly, a typical eco-industrial park is often characterised as a compact area of industries and enterprises having shared resources, operating with synergies of sustainable industrial development, with a low-carbon agenda (Qiu and Huang 2013; Gonela et al. 2015; Xiao et al. 2017). This method of industrial development serves, therefore, as a replacement to sustainable industrial practice (Bansal and McKnight 2009). From its clustered nature of development, the neighbourhood level propose for more implementable strategies of eco-innovation. As such, we can argue in favour of policy instruments available at this spatial level, which improve environmental quality (e.g., very visible for the case of eco-industrial parks), and can ultimately boost technological changes and transitions towards environmentally-friendly development.

One major policy change can be connected to development of benchmarking and rating indicators at the community level, particularly for residential models. In the last decade or so, in China, many new benchmarking criteria are put in place for new development projects across the country. Their lack of presence before indicated 'business-as-usual' for developers, which is now very different in major first- and second-tier cities in China.

The benchmarking at the neighbourhood level, often carried out with rating systems, is an added value of sustainability to any project of the same scale. Simple factors that are highlighted in these rating systems can create tangible and widespread changes. For instance, there is a linkage between household energy consumption and the enhancement of living conditions (Yang et al. 2016), enabling a better reflection on people's lifestyles, and ultimately behavioural changes. It also can create pathways of transitions towards sustainable development, as such, we can refer to the transition of industrial structures, from traditional and high-polluting industries to low-carbon and high-tech zones.

We can see not only policy changes and mechanisms in place, but also changes to planning criteria and design specifications. For instance, we can refer back to the idea of eco-cell development of Sino-Singaporean Tianjin Eco-City, which in fact is a planning model at the smaller scale of neighbourhood level. Also, unlike the current examples of macro-scale projects, the neighbourhood level provides more potential to implement retrofitting projects that include a higher chance of energy efficiency and resource saving (Shahrokni et al. 2014). In this respect, as expressed by Weber and Reardon (2015, p. 114), eco-districts often meet three core goals: '1. To act a basic urban developments that add to the building stock, meeting the need for housing and business space; 2. To include environmental goals going beyond current legal mandates; 3. To test and promote a wide array of eco-innovation: particularly in terms of building and infrastructure engineering and design, as well as new business models and planning processes'. In this respect, we can see substantial transitions of policies and planning criteria. For example, in China, there is now a major agenda on low-carbon transitions of industrial zones towards the development of a green economy. It has also become mandatory for major cities to achieve green development goals and use rating systems in any new development of public buildings. This will soon cover other typologies, and particularly residential as the majority. These directions provide us with a clear understanding on the growing awareness from multiple levels of the government in China, and particularly the local governments that require to interpret and utilise the national-level agendas (Cheshmehzangi et al. 2017a). Finally, we can see many new mechanisms at the local level, focusing on incentive opportunities, new policy frameworks, new local or localised benchmark and rating systems, and multipartnership collaborative practices of eco development at the meso scale.

8.2.3 Building Level/Micro

Energy consumption is largely dependent on the development of socioeconomic and improvement in the quality of life. With the increase in living standards in China, the building energy consumption has been growing dramatically in the past twenty years at an annual growth rate of 10%. People have been demanding more energy consumption to provide a more comfortable indoor environment, e.g., space heating and cooling, hot water, and high-power household appliances.

In 2014, the Ministry of Housing and Urban–Rural Development (MOHURD) developed a long-term roadmap, which set out a time schedule for building energy efficiency improvement during the period 2016 to 2030. In the roadmap, developing net (or nearly) zero-energy buildings (ZEB) become a key target to be achieved by 2030 (Feng et al. 2016). The Passive House Standard, originally developed in Germany in 1990s, is the world's most rigorous energy-based building standard. It requires maximum 15 kWh/m^2 per year for heating or cooling demand in buildings to maintain a comfortable temperature at around 21–22°C (see Chap. 3). Passive House is widely seen as part of the drive to achieve nearly zero-energy buildings (NZEB) (Wu et al. 2015). In November 2015, China released its own version of the Passive House Standard, the 'Ultra-low Energy Passive Green Building Technology Guide', marking a significant step towards zero-energy buildings (Xu 2017). This new standard is perceived to be an intermediate stage towards achieving net zero energy by 2030, and is more economically feasible for the current economic and cultural context of China (Wu et al. 2015). More discussion on ZEB and NZEB is given later on in this chapter.

In addition, a few key issues should be also addressed in the next step of building energy conservation in China. These issues include increasing thermal comfort in the hot summer and cold winter regions, increasing building code compliance and improving energy efficiency in rural buildings.

China's hot summer and cold winter (HSCW) region is one of the five climate zones in the Chinese building thermal design standard. This region is mainly located in the Yangtze River Basin with a high temperature and humidity in the summer, cold temperature and low solar radiation in the winter. The hottest month usually has an average temperature between 26.5°C and 30.5°C with approximately 80% humidity. The coldest month usually has an average temperature between 0°C and 8.6°C with less than 750 MJ/m^2 or even 400 MJ/m^2 solar radiation. The region covers an area of 1,800,000 km^2 with a population of 550 million people. It is the most populous and economical-developed area of China, producing 48% of the gross domestic product (GDP) of the whole country. This particular climatic region, similar to the other four regions, require specific and localised sets of standards and policies. Therefore, a homogeneous approach to eco-/green building strategies is simply unfeasible in the case of China. For historical reasons, buildings in this region are not well insulated and do not have centralised urban heating systems in winter, according to the Chinese design regulations. These lead to a low indoor thermal comfort in this region. The average indoor temperature in winter is usually below 10°C, and often above 32°C in peak summer (China Society for Urban Study 2016, p. 93). People have increasingly relied on local electric heaters and air conditioners to improve their indoor thermal comfort. Because the buildings are poorly insulated and the heating and cooling equipment has low efficiency, energy consumption has increased substantially in recent years in this region, especially with regard to heating demand.

There is a major debate in recent years about whether urban centralised heating systems should be installed in this region. However, many experts have different opinions. During one interview, Yi Jiang, a member of the Chinese Academy of Sciences in the area of building energy conservation, argued that providing centralised heating systems to the cities in the Yangtze River Basin is both environmentally unacceptable and economically unfeasible. He insisted decentralised or localised heating installations are the future way for increasing indoor thermal comfort in the region. Building energy efficiency technologies, specifically for this region, have been listed as a key area of innovation by the MOHURD in the 12th Five-Year Plan (FYP).

In recent years, China has been forced to achieve higher-level compliance rate of building energy codes to improve the building energy efficiency. Addressing code compliance is required and will be reviewed and approved by the local construction authorities. The MOHRUD has established an annual inspection system to check the compliance rate. Official inspection data show that both design and construction compliance rates have been improved, from 53% and 21%, respectively, in 2005 to 100% and 95.5%, respectively, in 2011. However, these extremely high compliance rates, argued by Bin and Nadel (2012), should be regarded as an indicator of the compliance status of new medium and large building construction projects located exclusively in urban areas, and they do not represent the compliance status of the general population of new buildings in China. The main reason is lack of a clear definition of compliance rates, and a narrow scope of inspection. Nevertheless, the official building energy code compliance rates would seem to indicate a positive, upward trend of improvement in recent years.

Some news reports also show the actual compliance rate can be much lower than initially anticipated. The current practice has been focused on reviewing energy-efficiency proposals at the design stage. However, changing design in the construction stage is often found, for example, increasing the window-to-wall ratio to make the building more attractive—this may accordingly compromise heat loss coefficients and thus violate the building energy code. It is estimated by some experts that the actual compliance rate may be less than 50% (China Property 2017).

Furthermore, the low compliance rates in recent years imply a large share of existing building stock, which is not energy efficient; particularly those buildings completed before the energy efficiency code came into effect for residential buildings in 1995 and for public buildings in 2005, respectively. Retrofitting of the existing building stock in the urban areas is a more daunting task facing the Chinese construction industry in the near future, and was regarded as the next step of policy priority implemented in the end of the 13th Five-Year Plan period.

Rural buildings have accounted for 51% of the total building area in China, and accounted for 39% of total building energy consumption (He et al. 2014). Rural buildings consume more energy than urban buildings to achieve the same level of comfort. This is attributed to several reasons: lack of building codes, lack of professional planning and design, lack of insulation, low-quality materials, and low-quality construction techniques. Energy efficiency in rural buildings is still largely overlooked. Not until 2013 was the first national building energy code for rural buildings—Design Standard for Energy Efficiency of Rural Buildings—issued by the MOHURD. Later, the requirements for energy efficiency of rural building were mentioned in the 12th Five-Year Plan for Building Energy Conservation. However, a comprehensive policy package of incentivising energy conservation in rural buildings is still lacking. Without this, building energy consumption in rural areas, will grow continuously along with the increase of living standards.

8.3 Benefits of 'Eco' from a Multiscalar Perspective

8.3.1 Urban Resilience to Climate Change

Climate change impacts on cities include more heatwaves, extreme rainfall and intense cyclones, harsher fire weather on peri-urban fringes and more severe storm surges associated with rising sea levels. The impacts of such change on the built environment and major infrastructure networks like transport and energy could have immediate and damaging effects on urban communities, the urban environment and a city's productivity (Norman 2016). The role of urban resilience appear more important than ever, particularly that it directly addresses the goals of sustainable development in practice.

The new US administration pulled out of the Paris Climate Agreement in April 2017, which is a major international climate change mechanism. While the decision casts uncertainty over US efforts to rein in emissions, China, the world's largest emitter of greenhouse gases, released its 13th Five-Year Plan to control GHG emission in November 2016. This indicated China's commitment to do its part in combatting global climate change. The key paths are to ramp up renewable energy and curb its use of coal. It just halted the construction of 103 new coal-fired power plants, and its energy agency at the start of the year announced plans to pour more than $360 billion into renewable energy by the end of the decade (National Geography 2017). As part of the Paris Agreement, China aims to peak its carbon emissions and get a fifth of its energy from non-fossil sources by 2030. Some reports suggest it is already ahead of schedule on the former (National Geography 2017).

In order to achieve these targets at local levels, there is a need for further detailed action plans on eco-development at all three spatial levels: city, community and buildings. A broad range of adaptation policies and management strategies has emerged rapidly for managing the risks of climate change. However, their success depends on their uptake by local communities, which to date remains a significant challenge according to some surveys in China. Overcoming barriers to community engagement with adaptation policies, and particularly with follow-up actions, will remain a challenge in some communities until a particularly severe climate event delivers a warning (Cunningham et al. 2016). At the city scale, especially in dense precincts like the central business districts (CBDs), hard surfaces of a city can further increase the impacts of warmer conditions through the 'heat island effect' (Norman 2016). Urban warming carries both health and economic penalties since the urban heat island (UHI) effect reinforces the influence of global warming. Infrastructure is particularly at risk from heating as well as other outcomes of global warming.

Many antidotes to anthropogenic urban heating have been proposed. Technology-based solutions include the use of phase change and photosensitive materials as well as reflective and cool roofs for buildings (e.g., Santamouris 2015). More conventional approaches, being applied widely, consist of increasing the quantum of green space in cities generally, as well as adding green roofs and walls to urban areas. Improving the ratio of ground-level, green open space is a particular challenge given rapid increasing urbanisation and rising densities in countries such as China. Theeuwes et al. (2014) used a meso-scale model to measure the impact of green vegetation and water surfaces on the urban heat island of several Dutch cities. They found that each 10% increase of vegetative cover reduced temperatures by 0.6°C while Coutts and Harris (2013) suggest that a 10% increase in vegetation cover could reduce daytime urban surface temperatures by 1°C. Increasing green coverage is seen as a key strategy to improve urban performance in some Chinese cities. For example, Guiyang is implementing planting programmes in the prioritised areas, including bare mountains, central urban districts, railway corridors and highway corridors.

8.3.2 The Regional Context

As discussed earlier, the context of China is comprised of five very distinctive climatic zones; and this alone can create complexity for eco-development strategies across the country. This means we cannot necessarily foresee a single model or set of policies for eco-development strategies. In contrary, this can partially reduce the ubiquitous character of eco-development projects, depending on the local context and climatic conditions. This can perhaps be seen as a positive attribute for eco-development projects in China. Hence, we see a variety of projects happening in various parts of China that often differ from each other depending on their locations (i.e., being located in cold climatic conditions of North or in hot and humid regions of South China).

An eco-development of any scale has its own barriers and drivers. In the earlier round of eco- projects in China, the lack of sufficient legislation and political guidance is evident. Over time, this has changed to some extent, and policies have become more supportive of eco-development strategies over the years. There is also a potential high cost in any of these eco-developments, especially that some projects are still at their experimental phase. At a smaller scale, the high cost of refurbishment projects does not attract developers or project managers for their practice methods; hence most of the current projects are either renewal projects or completely new (e.g., over previous greenfields, marshlands, brownfields, and etc.). However, our evidence shows that improvements in resource efficiency can have a positive impact on the market value of the projects. Moreover, in general, we see a high demand for green development (such as green certification projects), but less user acceptance in comparison. The economic performance is still questionable for both users and developers, and hence long-term planning is required to provide specific stakeholders with directions and future profitability. Most large-scale eco- development projects are aimed to create welfare and new healthy environments in which people to work and live. However, there is still a lack of progress in reallocating people to new eco-city projects or districts. As a result of this maladministration of population growth, some of the large-scale projects are either deviated into real estate projects for people's investment or have not met their initial target plan. Although it is questionable if the ecological impacts are minimal, we can at least argue in favour of reduction of GHG emissions, better energy use patterns, reduction in material use and resource, and ultimately reduction of ecological footprint through the process of construction and post-occupation.

Nevertheless, some of these above challenges come directly from the lack of regional thinking or regional planning. For instance, for the case of eco-cities, we see a trend of new urban and suburban enclaves (Hodson and Marvin 2010) that are often designed for the wealthy end users. In some cases, the new projects are become the ecological zone of their nearby city or township area. Most importantly, however, it seems worrying to see their lack of integration with their surrounding and nearby development areas. Apart from their physical connections, mainly through new transportation links, there is a lack of regional connections, such as for social development, energy efficiency plans, and environmental factors. The main regional factor that we can see in most cases is the economic factor, which is often related to the linkage with nearby industries. As a result, some of the projects are then built as transit-oriented development (TOD) projects, and often appearing as a business core or residential centre between several nearby industrial zones. At the neighbourhood level, we also see a lack of integration between one community and its nearby blocks or urban environments. Once again, the eco-community project may then appear as an ecological enclave and not necessarily creating a major impact on reduction of environmental impacts and ecological footprints. This depends, of course, on the location of development, and whether or not it is surrounded by high-polluting neighbourhoods. For the cases of micro-level, eco- and green buildings often appear as new models of development (if not landmarks) in their vicinity. This can, in the long run, have a positive effect on trends of development in a particular urban area. However, such an effect is more likely if the same developer or a same group of stakeholders get involved in any nearby development projects.

In summary, we would like to highlight the significance of regional context in eco-development projects. The meaning of 'region' or 'regional' is dependent on the context of development, and how it is interpreted in its process. This can mean climatic conditions, or creating a network of people mobility, and even a possibility to encompass strategies for material use reductions, carbon reductions, and integrated energy systems on a large scale. By doing so, the strain from urban competitiveness may also ease, which can ultimately allow for a network of ecological zones and eco-development projects, rather than just development of a singular ecological enclave amongst a region of other development projects. The questions here are that: are we really living in the *Anthropocene* epoch? And, if so, are our relatively small experimental projects creating enough impact to reverse some of our past and current unsustainable trends? And what future directions are ahead if eco-development is ever going to last longer and progress? In the next section, we aim to address these questions by simply providing some future directions, few of which we find as necessities for the future of China's eco-development.

8.3.3 Stakeholder Constellations

Balancing the profitability across various stakeholder is always a major challenge of any development. It is even more complicated in the process of eco-development. However, there are often signs of motivation and vision of those developing and living in eco-communities (Lovell 2012, p. 3) that include: 'the desire to distinguish themselves from others by actually engaging in environmentally and socially sustainable lifestyles and practices; staying ahead of anticipated changes to housing policy and regulations; and the opportunity to exploit new business opportunities. Motivations vary according to the type of institution involved (community-based, social housing, private housing developer, government, etc.'. Through our case study research studies, the highest level of desire is witnessed at the local governmental level. The main drivers for this desire come from the main factor of urban competiveness, as well as feeding into the national-level agenda and frameworks, and increasing the growth of GDP in comparison to any nearby rival cities, districts or towns.

In China, and as show in our case study sections, the eco-development projects include multiple actors and stakeholder constellations. For instance, at the city level, we have recorded a range of eco-city projects from local development, to national flagship projects, and to international or joint cooperation; hence our case study categorisation is focused on this situation of actors' involvement. Similarly, at the neighbourhood level, many projects (e.g., eco-industrial parks, eco-villages, and eco-community projects) include international partners or are jointly done with various local actors. At the building level, the stakeholder constellations are less complicated and may include multiple stakeholders (such as international actors) only depending on the status of the building or the importance of the project at a higher level. However, in contrast to the other spatial levels, building projects are not regarded as Sino-foreign collaboration projects.

In general, and regardless of spatial levels, the involved stakeholders have their own set of interests that may often be in conflict with one another. In most cases, we have seen more overlaps between them than actual conflicts. In this section, we consider some of these stakeholder constellations, namely governmental authorities or governance, developers and project managers, planners and designers, and communities and the general public.

8.3.3.1 Governance

The role of authorities and governance is very much in evidence in China's eco-development projects. This relies heavily on the development of policies, frameworks and best practices that are often developed as experimental projects. In this process, there is a major need for the introduction of innovative forms of governance, such as the existing model of multifaceted governance. The relationship of governance to both market and society is dependent, then, on future directions, potential reforms and policy developments. To achieve a genuine eco-development, regardless of its spatial level, a visionary leadership is highly required and recommended. The ideals of *eco-* would then lead towards the development of new eco-systems. In China, we anticipate the emergence of a more matured-up local governance set up in the coming year. The maturity is already visible in most cases where transitions are already progressing and where national-level policies are interpreted, contextualised and adapted to the local demands. This adaptability characteristic of the local governments promotes their position as key actors of change and transition.

8.3.3.2 Developers and Project Managers

Very much similar to any other country, developers play a major role in the delivery of eco-development projects in China. These can include local developers, state-owned developers and international developers. Their role is important, since they are not necessarily the end users, but often just developers of the projects. In our studies, we found out that multi-partnership projects are often more successful in their delivery, since such a mechanism enables the developers to strengthen their strategies, save costs and increase their revenues (EURObiz 2013; Cheshmehzangi et al. 2018). In smaller-scale projects at the meso and micro levels, this may be more difficult to achieve as multiple partnership is often narrowed down to a team of project contractors and subcontractors. More importantly, related regulations and policies in regard to green and eco- development should be in place to allow for a greener development. Without these, developers would select the 'business-as-usual' scenarios and often go with the most profitable options. To avoid this, we stress the requirement for comprehensive and directive planning and design regulations, monitory mechanisms and incentive opportunities (Cheshmehzangi et al. 2017a). The effect should potentially encourage innovative thinking for green and eco- strategies amongst engaged industry stakeholders and towards the promotion of sustainable development.

8.3.3.3 Planners and Designers

The role of planners and designers is perhaps the most difficult in practice. Their positioning between the developers and end users makes their role even more challenging. However, they are also in the professional position to advocate the authorities and developers, and suggest alternative design and planning solutions to cases of ‘business-as-usual’. It is perceptible that over the years, the Chinese practices and China-based foreign practices have grown maturely by undertaking some of the concepts from integrated design thinking, urban ecology, landscape planning, green assessment techniques, modelling simulations, and so on. Their global network and their professional insight in new development opportunities, puts planners and designers in a stronger position to define and refine the pathways to sustainable development. Globally, we can see substantial change in the role of planners and designers as part of the sustainable development agenda, highlighting the fact that theirs is a flexible role in the process of urban change and transition. In China, we anticipate to see a more effective role of planners and designers in future green and eco-development projects.

8.3.3.4 Communities and the General Public

This group of stakeholders is generally known as end users. Yet what we see globally is a change to this discarded thought and towards an ideal that communities are more than just the end users. The importance of grassroots and human-centric development, has been one of the central arguments of the national government in China. Also we can see traces of such change in China’s national New-type Urbanisation Plan (NUP), since its inception in March 2014 (Cheshmehzangi 2014). Therefore, there is still room for policy development and enhancement of community-oriented strategic plans. As described by Shi et al. (2016), proper policies can motivate the participation of the local community in the sustainable neighbourhood development. This will then lead to a strengthening of the the institutions, community engagements and public participatory scenarios. It is also argued that with such policies in place, we can encourage the community residents and representatives to take a more active role in recognising their responsibilities for sustainable development and enable them to contribute as active users (Zhang 2011) and not just end users. Hence, it is always important that in China we consider the role of communities and community representatives central to achieving eco- and green goals of sustainable development.

8.3.4 Traditions

In ancient China, people constructed their cities and building based on the principle of ‘harmony between man and nature’. It refers to build a harmonious relationship within human, architecture and nature, which exactly meets the value that the green development aims to deliver today. The wisdom of ancient Chinese architecture is to extract essence from nature, imitate the ecological environment, reduce building energy consumption, and truly achieve the purpose of energy conservation. In addition, the ancient architecture has a simple layout, with particular attention to the surrounding natural environmental coordination. Thus, at present, the knowledge of wisdom from ancient Chinese still helps to build modern and environmental-friendly architectures. For example, Jiangnan Garden—a traditional Chinese construction in the Southern Yangtze River region—brings the mountain, water and forest of nature into the courtyard. Meanwhile, people feel the beauty of simple, fresh and nature (Chen and Wang 2012). It is often much appreciated amongst the general public. Generally, traditional Chinese architecture advocates simplicity. The idea plays a guiding role in the construction of modern buildings, social life and human value.

Evaluating the cases we discussed in the earlier chapters indicates the current eco-developments in China are largely influenced by modern urban planning theories such as new urbanism and compact city, featured with mixed-use neighbourhood, effective public transport, etc. They originated from the western context, reflecting the advanced planning and design knowledge today. However on the other hand, what can we gain when we look back to the Chinese traditional architecture practice, which is largely ignored in those case studies? The Li-fang system has been an ancient urban form in China for thousands of years since the Han dynasty (202 BC). A whole city was divided into a number of Li-fang units and each of them acted as a specific functional zone, such as residential, commercial, religious and political. For example, Chang'an city (the present-day Xi'an city) had 108 Li-fang units (Zhang et al. 2014). The city was constructed as a square, with three gates placed on each side of the boundary wall connected to main streets horizontally and vertically (Zhang et al. 2014). Another example is Suzhou city, which was originally built in 514 BC and experienced a major redevelopment in 248 BC. The main feature was to optimise the waterway network to facilitate transport and protect the city from floods. Since then Suzhou had been away from major flooding events for hundreds of years.

We notice that most residential neighbourhoods in China are enclaved 'small residential districts' (SRD), which is the housing form for the majority of Chinese urban residents. It is a planned neighbourhood where housing is integrated with communal facilities such as kindergartens, clinics, restaurants, convenience shops and communication infrastructure—all under the control of a professional property management company. Some so-called 'super-blocks' may constitute thousands of buildings. For example, Tiantongyuan in Beijing covers eight square kilometres, has over six million square metres of building area and was home to 400,000 people by 2011. Non-residents have to drive around Tiantongyuan, rather than through it. A resident living in the compound may have to walk 20 minutes on its boundary (China Daily 2016). This type of neighbourhood, as argued by Deng et al. (2014), can incur resources waste and urban traffic congestion. Ancient Chinese urban planning and design may shed some light on this issue.

At the building level, we also notice that traditional architecture forms are largely neglected. Here we present two traditional Chinese architecture examples to show what we can gain by looking back to the traditions: China Patio House and Cave Dwelling.

8.3.4.1 Chinese Patio House

The conventional Chinese house roofs have different slopes, resulting in various forms of courtyard-style residential typology. That means the houses of four sides (or sometimes three sides) are being connected together and surround a small courtyard in the central. Around the core patio, we find a hall, bedroom, kitchen and other utility rooms. The form of residence is the so-called 'Patio House'. Outside the patio, there are corridors, railings and decorative openwork windows, causing the change of light surface. Although the houses are enclosed together, this allows sunshine and rain to reach the ground. The demand actually reflects the close relationship between human and nature. For most traditional houses, the patio plays an important role in the daily ventilation and lighting. The patio allows air to flow through and, combined with the open hall and corridor, it forms a ventilation system. To be specific, the Sun illuminates the house during the daytime, leading to the patio temperature rising fast. Then the air in the patio keeps rising and the air pressure is falling. While due to the rooms being covered by roof and floor slab, the air temperature is relatively low and pressure is large inside the rooms. Thus, hot air rises in the patio and cold air from rooms constantly replenish the patio area. This effect increases the air convection between patio and internal rooms. At the time, the patio area, operating like chimneys, has the function of pulling up wind and forming hot pressing ventilation (Chen 2014). At night, the air cools down quickly over the patio; thus, the patio is regarded as cold source and the air pressure is relatively low. However, the indoor cooling is relative slowly, resulting in the higher room temperature and lower air pressure. Therefore, the cool wind flows from patio to each room and the water inside the patio makes wind cooler.

In addition, the surroundings of patio are generally transparent and rooms on both sides are decorated with carved windows, which is effective for ventilation and lighting. At the aspect of rainwater treatment, the roofs of 'Patio House' are normally in the inner slope. Rainwater flows along the roof to the patio, through the rain pipe on the roof comes down to the ground, and then be drained out of the house via the gutters around patio. To sum up, the small patio can prevent exposure to the Sun and keep the house cool in summer. In rainy days, residents will not feel wet due to ventilation. Hence, 'Patio House' shows the full application of natural conditions to create a healthy living environment (Chen 2014). More importantly, such a typology of housing represents one of the best typologies of person-centred development.

8.3.4.2 Cave Dwelling

Cave dwelling is an old way of living, which means to excavate the transverse cave in the loess cliff area as the living rooms. Different from normal traditional Chinese architecture examples, it uses local raw soil as the building construction material instead of wood. Thus, the cost for material transportation can be saved, as well as the construction cost and the use of wood. Since the envelope of caves is loess, it has minimum heat loss and is well insulated. Besides, the shape of a cave dwelling shows arched and its opening generally facing sun; hence, the solar radiation can be fully used for the indoor space (Chen 2014). Thus, it is warm in winter and cool in summer, and is a natural energy-saving building. In addition, the thick soil walls of caves also have a sound insulation effect, which effectively avoids neighbourhood interference. The cave dwelling is simple to construct and durable, it saves arable land, protects vegetation and it does not destroy the ecological environment. Therefore, even at present, cave dwellings are still widely used in the loess area.

In summary, it is worth to look back the traditions and this may give us a different angle of viewing eco-development. Modern architecture, largely transplanted from the West, will be beneficial from such retrospect.

The examples discussed above simply highlight the importance of vernacular thinking and the context in which we should identify and work with certain historic, cultural and environmental characteristics.

8.3.5 Breaking Misperceptions

Technology will not provide all the answers to problems of hyper-urbanisation, but it will bring significant improvements in energy and resources use and will encourage accurate measurement of our progress (or regress) in the quest for sustainability. Clear directions of movement will lend themselves to more clear-cut responses too. Nevertheless, there are still misperceptions regarding eco-development among various stakeholders. It is more a case of obtaining behaviour change by breaking misperceptions.

Developers do not recognise the market returns for investment on the green building development. The most significant factor influencing their decision making is still the incremented initial construction fees. For example, in order to attain green building certification, they need to spend more on energy, water, renewables and other technologies. Currently, this increment is higher than the government subsidies. Furthermore, even they are aware of the lower running cost and other benefits in the long term, developers cannot benefit from the investment on green development, since developers are usually not building managers and therefore are not beneficiaries of less maintenance, higher rent and higher productivity.

Many property buyers or renters also have misperceptions about green buildings. The reasons leading to the phenomenon can be divided into two aspects. The willingness to pay higher for green buildings is still low according to a survey conducted in Nanjing that was discussed earlier on in Chap. 4. In addition, buyers do not have sufficient knowledge about green development as it is still a new concept in China. Many of them think green development refers to large lawns and beautiful landscape. The financial return in the long term is not yet part of their buying decision.

Fostering a green development market is the key to mobilise relevant stakeholders. On the one hand, the government should fully mobilise developers to play the guiding role in the development by increasing both regulatory requirements and subsidies. On the other hand, promoting knowledge on green development, especially the financial feasibility, will have significant impact on buyers' behaviour.

8.4 Prognoses for the Future

8.4.1 Emerging Trends

Today, most countries, even in the developed world, are still fixated with economic growth as the fundamental criterion for measuring success in society. Thus, when there are conflicts between development projects and environmental goals or social fairness, economic interests are usually favoured. However, at a different level, there is considerable hope that we will move on gradually to a more sustainable pathway. Perhaps a key to our 'redemption' is the advancement of awareness, policy and technology for moving our cities, communities and buildings forward in both developed and emerging nations.

Recognition of difficulties with and pressures from nature's limits comes from all sectors of society. Corporate awareness of the concept of sustainability is growing and as many as 21 stock exchanges across the world could introduce sustainability reporting standards in the coming months. They would join the 17 exchanges that currently recommend listed companies report on environmental, social and governance (ESG) issues. The exchanges go a step further by providing model guidance to participating companies (Khalamayzer 2016). In addition, many managerial elements of government have engaged with goals that pursue sustainability and non-government organisations, academia and interested parties in civil society are similarly concerned about environmental responsibility and social equity. Intelligent and innovative solutions to our challenges from this host of stakeholders are legion (Deng et al. 2017).

Sustainable urban land development and smart growth policies can have significant effects on reducing harmful emissions and the demand for energy. Empirical studies from built environment-travel literature indicate that sustainable urban form—compact, high-density and mixed land use—can reduce per capita vehicle travel, distance, time budget (Vance and Hedel 2007), and results in lower transport-related energy demand and greenhouse gas emissions (GHGs) (Li 2011). For instance, 'residents living a large city (population between 5 and 10 million) in comparison to a small city (population < 1 million) makes 16.4% more expenditure on private and 26% more expenditure on public conveyance (Ahmad and de Oliveira 2016, p. 110). A 10 percent increase in density is associated with 1–1.2 percent decrease in the amount of transport and 0.5–1 percent reduce in vehicle miles of travel (VMT), keeping other variables constant

(Ahmad and de Oliveira 2016). Hence, urban form along with associated negative incentive programs, such as driving restrictions (e.g., 'no driving day'), high parking fees and high taxes on cars, and congestion charges (e.g., London) have been traditionally considered to reduce the use of private transport. Additionally, provision of monthly pre-paid public transport passes (e.g., Seoul and Tokyo), and improved public transportation and mobility (e.g., bus rapid transit, mass rapid transit, bicycle lanes) have been under implementation to drive cities follow a sustainable path.

Research on the relation between human health and well-being and urban planning suggests that urban environments that lack public spaces can encourage sedentary living habits, while the provision of open spaces can facilitate social interaction and provide opportunities for physical activities (Mytton et al. 2012). The likelihood of being physically active may be up to three times in residential environments that have access to green spaces, and the likelihood of obesity may be up to 40% less (Coombes et al. 2010). Natural landscapes are thus vital to urban liveability, and good urban design outcomes always strive for the 'right' balance between urban development and the preservation of natural environments.

Resilient cities address the capacities of built environment and people to adapt to natural and human-induced shocks/threats, such as earthquakes and climate change (Desouza and Flanery 2013). Cities become more resilient if they better address stresses and mitigate risks. A transition from urban sprawl to eco-city or carbon-neutral city will help to reduce automobile emissions, improve air quality, reduce energy demand, and create a resilient urban environment for people (Joss 2011; Roseland 1997). Key features of an eco-city include: planned walkable communities, green transport, adaptive reuse of old buildings, eco-friendly new buildings (e.g., passive solar design, environment-friendly building materials), green infrastructure (e.g., greenways, gardens, green roofs, waterways and community farms), energy efficiency and renewable sources of energy, and effective waste and water management (reuse and recycle).

In recent years, collective civic structures and innovative models of shared economy have been providing an unsurpassed platform for more socially inclusive and environmentally efficient urban communities in cities. Sharing enhances the potential resource, environmental and energy efficiency of cities, while less waste is created as everyday consumer goods and products are shared among a group (Belk 2014). Sharing could also provide an opportunity for a community to enjoy things at an economical cost and save and make money (Agyeman et al. 2013). Globally, 'urban sharing schemes' have multiplied into different dimensions: bike-sharing schemes in London (the UK), Paris (France), Rio de Janeiro (Brazil), Hangzhou (China), Guadalajara (Mexico), Buenos Aires (Argentina), and Providencia (Chile); car-pooling schemes in Lisbon (Portugal), Stuttgart (Germany) and Melbourne (Australia); or car-sharing services such as Uber, Didi, Spotify, Taxify, Cabiday, and Zipcar; sharing apartments and spaces (e.g., AirBnB, Couchsurfing); sharing and swapping consumer goods (e.g., Facebook Market Place, E-bay, Gumtree, Freecycle); sharing privately owned public spaces, such as Zucotti Park in New York City, Dewey Square in Boston, Canary Wharf in London; and examples of sharing power sources, water and sanitation in informal community settlements in cities such as Mumbai (India), Cali de Santiago (Colombia). Moreover, we can argue that sharing will significantly assist governments and policymakers in achieving standards in eco-, inclusive, smart, sustainable, and resilient cities.

Cities will compete globally to make their urban areas attractive both to live and to invest in, and face the challenging task of balancing between competitiveness, environment and quality of life. Making cities sustainable and liveable is the only way to counter the negative effects of the global megatrends, such as globalisation, urbanisation, demographic change and climate change, which often create environmental, social and economic problems for cities. Urbanisation per se can be a welcome phenomenon of change and transformation if the visions of 'sustainable', 'integrated' and 'resilient' concepts and the relationship between people, built environment, and ecosystems are articulated in defining an urban development trajectory.

8.4.2 Burgeoning Building Technologies

New technologies can also bring a host of new processes and vast increases in efficiency and productivity in cities, communities and buildings. Examples include the integrated network of smart products—the Internet of Things (IoT); smart cities and 'Big Data'; advanced robotics and artificial intelligence; accessible renewable energy harvesting technologies and an energy internet (Rifkin 2014, p. 72). Open online education is gaining adherents, there is the decentralisation (and democratisation) of finance and governance, through Blockchain applications, including its applicability to streamlining micro-power grids operating at precinct and neighbourhood levels. The decentralisation of manufacturing through 3D printing is gaining traction too. It uses only 10% of the material involved in traditional manufacturing as well as eliminating the need for lengthy supply chains.

Many green building projects emphasise on technological innovation as the main means of achieving green building vision that leads to adopt more active measures. Of these, a large majority focuses on energy technologies, including renewable energies. However, the adoption of new technologies in the construction sector has been still slow. A recent report by the World Economic Forum (2016, p. 5) states:

> *The Construction sector has been slower to adopt and adapt to new technologies than other global sectors. While innovation has occurred to some extent on the enterprise or company level, overall productivity in the sector has remained nearly flat for the last 50 years.*

This report further identified methods such as information modelling approaches (at various scales of building or city) and prefabricated building elements as recent individual technologies that have the highest impact on future construction practice (World Economic Forum 2016). Other technologies include the 3D printing of components, advanced building materials, and real-time mobile collaboration. Some technologies, while still in their infancy, have been pioneered in China. For example, China has used 3D printing in conjunction with innovative building assembly innovations involving penalisation and modular components to achieve remarkable efficiency levels in the construction industry. A five-storey apartment building was made in Suzhou entirely with a giant long 3D printer, making it the tallest 3D-printed building in the world.

Emerging technologies such as Building Information Modelling (BIM), City Information Modelling (CIM), prefabricated building and 3D printing are attractive partially because they are promoted by the Chinese government. For instance, in Shanghai, BIM is compulsorily required to be used in building design and construction from 2018. A minimum of building prefabrication is also a mandate for new buildings in Shanghai and Zhejiang Province. The strong technology focus in some cases can be explained by the mainstreaming of and the prevalence of mainly technocratic approaches reflecting current regulatory trends.

Technology will not provide all the answers to problems of built environment being as a major energy and resources consumer, but it will bring significant improvements in energy and resources use. It is important for us to identify and utilise the advancing technologies in sectors of building construction, architecture and city modelling, and urban development. We explore two short cases here that have adopted new technologies representing the future technological trend in the industry in China.

8.4.2.1 Example 1: 3D Printing Buildings in China

In August of 2014, WinSun, based in Shanghai, completed 10 houses under 24 hours in Shanghai using a 3D printer (News Atlas 2014). A year later, in 2015, this company has expanded the capabilities of 3D printing, has built a five-storey apartment block, which is the world's tallest 3D printed building, and a 1100 square metre villa with internal and external decoration in Suzhou Industrial Park in Jiangsu province (3ders.org website 2015). The two buildings represent new frontiers for 3D printed construction, partially demonstrating its potential for creating more traditional building typologies and therefore its suitability for use by mainstream developers.

The buildings were created using 6.6 metres high, 10 metres wide and 40 metres long 3D printer which builds up layers of an 'ink' made from a mixture of glass fibre, steel, cement, hardening agents and recycled construction waste. With this technology, the company is able to print out large sections of a building at WinSun's facility, which are then assembled together on site, complete with steel reinforcements and insulation in order to comply with official building standards (Winsun website n.d.). The raw materials as printing 'ink' are mainly construction waste, industrial waste and mine tailings, and the other materials are principally cement and steel, as well as special additives. Through the 3D printing technology, developers can shorten the time required to build a house, save construction costs and materials, and reduce construction wastes. In an interview with China Daily (2015), the president of Winsun estimated 30–60% building materials and 50–80% labour are saved by using 3D printing technology.

8.4.2.2 Example 2: Information Modelling Techniques in Green Building Design and Operation in China

A modelling approach, such as Building Information Modelling (BIM) is a collaborative way for multidisciplinary information storing, sharing, exchanging and managing throughout the entire building project lifecycle, including planning, design, construction, operation, maintenance and demolition phases. This method has been in practice for many years and in various methods and already under practice as the city-level modelling method as well (e.g. City Information Modelling). The Chinese government has announced BIM-relevant policies and standards to boost the development of BIM during the years of 2011 to 2015. The strategy of BIM application in the AEC sector also requires that by 2016, government-invested projects over 20,000 square metres and 'green' building in the provincial level should adopt BIM in both design and construction stages, and by 2020, the industry guidelines for BIM application and government policy systems should be well established (Cao et al. 2017).

BIM not only brings 3D revolution for traditional 2D drawings of AEC industry, but also emphasises the significance of multidisciplinary collaboration for projects. BIM can be integrated with other building energy simulation systems, such as Energy Plus, DOE-2 and Equest. It is therefore, a representation of an integrated model that utilises a multifaceted approach to building construction, or urban development, including the optimisation of low energy design in the planning and design phases, the efficient reduction of energy waste, monitoring and control of building energy use, and etc. (Habibi 2017).

Bund SOHO is located at the interchange of Second East Zhongshan Road and Xinkaihe Road, Huangpu district. The project was completed in 2015 and has a footprint of 190,000 square metres. It is composed of four office high-rise buildings with heights of between 60 and 135 metres. Bund SOHO is a multiple-use landmark containing urban development, comprising offices, commerce and entertainment, enjoys superior location and splendid views of the Huangpu River. It has a gross floor area of 189,449 m^2 and underground parking and space for plant rooms of 776,909 m^2.

BIM implementation plan of Bund SOHO project was officially launched in June 2012. It is the first project in China which uses BIM technology throughout the whole construction processes. In order to ensure the smooth implementation of this project, the developer, together with the design consulting company and other stakeholders, developed a BIM implementation organisational structure specifically for this project. The participants included design consultants, costs control, project management and IT consultants. Other stakeholders, such as modelling and simulation practitioners, contractors and subcontractors, were also involved. At the end of 2012, under the guidance of the developer's BIM team, the BIM test was carried out on the contents of the basement civil construction to ensure a full BIM application can be achieved for the project in 2013 (SOHO BIM project report 2013).

At the conceptual and early design stage, the weather analysis tool EcoTect was used to estimate and ensure the weather characteristic of Shanghai, to optimise the building orientation and reduce the energy load. The main building orientation of this project is facing south-east, the best building direction of Shanghai. Natural ventilation is utilised in summer and external shading is provided to avoid excess solar radiation; sunlight is able to enter in winter, but the wind intake is optimised to reduce heat loss. Energy consumption, water consumption and carbon emissions for the entire building are analysed and optimised based on the conceptual design model. Green Building Studio estimates are made through Revit Subscription by setting geographical information and various energy options in Revit. The energy-saving rate of this project is greater than 50% (ibid.). Therefore, we can argue in favour of such modelling techniques that enable us to utilise data for more collaborative uses and integrated practices.

8.4.3 *Zero Energy Building and Life Cycle Consideration*

Developing net (or nearly) zero-energy buildings (ZEB) become a key target to be achieved by 2030 in a roadmap proposed by the MOHURD (Feng et al. 2016). Currently, there is no strict definition of a ZNB or a nearly zero-energy building (NZEB). Nevertheless, a ZEB or NZEB is an energy-efficient construction, which features the following factors:

- Minimises energy demand through passive design, e.g., insulation, natural lighting, ventilation, airtightness, efficient heating and cooling, and etc.;
- A ZEB requires energy that is fully supplied by either onsite or nearby renewable sources, such as PV panels and ground source heat pumps;
- A NZEB requires a small amount of energy from the grid.

Many countries have developed plans to promote ZEB or NZEB. For example, the European Union (EU) has a major initiative, labelled the Energy Performance of Buildings Directive (EPBD), which requires 'nearly-zero-energy buildings' (NZEBs) target for all EU member countries' new construction by 2019. In the UK, all non-residential buildings must achieve zero-carbon targets by 2016.

Apart from declaring a direction for future building development in the roadmap, other details are not publicly available at present. Xu Wei, the head of building energy efficiency in the China Building Science Institute, proposed the following targets to be achieved by 2030: 30% of new buildings to meet NZEB requirements; 30% of the existing building to achieve NZEB requirements; and renewable technologies to supply 30% of energy in new buildings (Xu 2017).

ZEBs is still a new concept in China, policy instruments, such as certification, information tools, demonstration projects, education and training, and R&D are lacking. By the end of 2015, fewer than ten demonstration projects have been reported (Feng et al. 2016). Most of these projects are not certified as ZEBs by a certification system and mainly used to test their design and building components. The first passive construction was built in Shanghai in 2010 and certified by the German Passive House Institute. However, as the ultra-low passive building is listed as a key technology to promote building energy performance in China, it is expected that we will see more passive buildings developed and tested in the next few years. These practices represent a beginning of ZEBs' development in China and send signals to the construction market of the goal of moving to ZEBs in the long term (Wu et al. 2015).

A more rigorous definition than ZEBs is known as lifecycle energy-neutral building, which requires the building itself to generate more energy than the amount required to maintain its operation. The extra energy generated is used to offset the embodied energy used for raw materials extraction, manufacturing of building materials and elements, transportation and construction process. This often refers to the pre-occupation phase in a building's lifecycle.

To achieve a lifecycle energy neutral building, a lifecycle assessment (LCA) must be conducted to quantify and compare material & energy flows and the related emissions of the built environment at different spatial scales and in different contexts. Building LCA analysis is more complex than for many other industrial products because it requires the aggregate effects of a host of lifecycles of their constituent materials, components, assemblies and systems. This method is mainly used for building materials accounting and is emerging at the level of whole buildings. Several recent computer programmes incorporate LCA methods into tools for design and analysis of buildings such as BEES, Athena and Envest. However, due to data limitations, the large range of construction techniques, material and system choices in buildings, none of these tools are currently capable of modelling an entire building, or computing environmental impacts for all phases or processes (Cole 2010, p. 274).

In China, LCA has been emerging as a new concept. Over the last couple of years, it has been moving from research arena to practical implementation. For example, in July 2016, the State Council requires the construction of a green manufacturing technology system based on lifecycle assessment in the 13th Five-year National Science and Technology Innovation Plan; and in December 2016, the State Council released another policy guidance requiring to construct a comprehensive LCA-based assessment system to label products. However, current LCA policies and practice are focusing on industrial products. There is, at present, very little application of LCA in the construction practice in China. The main difficulties include the lack of a database of energy intensities for various building materials and elements, and a lack of reliable software programs for whole building simulation. Some organisations are trying to bridge these gaps. For example, Sichuan University is establishing a database called CLCD (China Life Cycle Database) and setting an online platform, eFootprint, to promote LCA in China.

8.4.4 Nature-Based Solutions

In the past few years, the new concept of 'nature-based solutions (NBS)' have been given significant attention in the European continent. This was initiated by the European Commission in 2013, and, subsequently, it has gained popularity in research over the years. The concept is given a defined place 'within the spectrum of ecosystem-based approaches' (Faivre et al. 2017, p. 509), enabling researchers and practitioners to find innovative solutions with nature to address challenges of sustainability dimensions. A method that can provide us with a holistic approach towards the enhancement of our ecosystems, biodiversity and livelihoods of our environments. It also fits into parts of green economy, providing a range of sustainability objectives, practical implementations, and nature-based strategies.

In their recent studies on 'NBS to address global societal challenges', Cohen-Shacham et al. (2016) suggested five categories of NBS approaches: Eco-system restoration approaches (such as, Ecological restoration; Ecological engineering; Forest landscape restoration); Issue-specific ecosystem-related approaches (such as, Ecosystem-based adaptation;

Ecosystem-based mitigation; Climate adaptation services; Ecosystem-based disaster risk reduction); Infrastructure-related approaches (such as, Natural infrastructure; Green infrastructure); Ecosystem-based management approaches (such as, Integrated coastal zone management; Integrated water resources management); and Ecosystem protection approaches (such as Area-based conservation approaches including protected area management). All these categories of NBS approaches fit directly to the ideals of eco-development, particularly at a larger scale of city/district level, and neighbourhood planning. More importantly, NBS approaches are identified as nature-driven methods to rehabilitate and restore the land as a new method of land management and towards enhancing ecosystem services (Keesstra et al. 2018). This method is based on a system thinking approach, working with innovative solutions derived directly from nature. Therefore, NBS approaches are, in fact, the dynamics of the system (ibid.). Furthermore, NBS is defined as methods of integrated thinking at multiple levels, and often includes a multi-stakeholder dialogue (Nikolaidis et al. 2017) between science, policy, business and society.

In the studies of NBS and the built environment, researchers have so far looked into many cases that ultimately help to improve the urban environments, public health, well-being of the society, economic growth, and the ecosystem services. To name a few, we can highlight recent published studies on: urban natural environments as NBS and their role to improve public health (van den Bosch and Ode Sang 2017), NBS for urban water management and values of green infrastructure (Wild et al. 2017), NBS for well-being in the urban environments (Vujcic et al. 2017), methods of promoting human resilience in cities and against the heat (Panno et al. 2017), and many more. The common factor between all these studies is that NBS approaches are used as tools to achieve sustainable development. Likewise, the concept of eco- or green- should merely be a comprehensive tool to achieve sustainability in the built environment of multiple scales and multiple dimensions.

Although the term eco-development mainly highlights the ecological/environmental dimension of sustainability, it comprises the impacts that environment can have on the other dimensions and vice versa. Unlike eco-development studies, most NBS research is focused on scientific and environmental research and not much on planning. This is anticipated to change as the flow of NBS research meets the needs of urban development, planning strategies, and even eco-development. Moreover, much of existing research on NBS is focused on the European context; but with the growing EU–China collaborations in recent years, the topic is also receiving attention in China. This occurs particularly in the topics of public health, resilience, and climate change which are of national-level interest in the context of China. Therefore, the role of NBS in anticipated to become more valued and visible in China, specifically in the more matured areas of integrated planning from various perspectives (Saleh and Weinstein 2016; Cheshmehzangi and Butters 2017), urban landscape assessments (Fan et al. 2017), marine studies (Kelly et al. 2012), and flood protection studies (van der Nat et al. 2016); all of which are currently embedded in sustainable development strategies of China. The future directions, and as it can be similar for eco-development strategies, can be made based on a combined method of nature-based solutions and technology advancement. The two, if complementary to one another, can provide us with innovative directions towards eco development.

8.4.5 Integration: Concepts of Eco-Innovation and Eco-Fusion

Lastly, what we argue about is the importance of integration in eco-development strategies and planning. This can only occur by consideration of the multi-scalar and multi-dimensional nature of urban sustainability that provides us with models of best practice. Recent studies include various factors and recognition of urban sustainability in practice. This approach can be discussed as part of the Integrated Design Approach (IDA) or purely the integrated thinking in design development of the built environment (Cheshmehzangi et al. 2017b). Based on our case study research in China, we found integration lacking in many aspects. There is still lack of integration of eco- strategies in planning practices, and some of the eco-city projects have evolved into a *greener* real estate projects over the years. It is still anticipated that some of the new planning practices should integrate more of ecological indicators and environmental agenda. However, in some cases we see similar and wide street layouts, high-rise and gated housing compounds, a car-friendly living environments, and strong presence of zoning. All of these issues should have diminished in the process of eco development at large scale. On the other hand, in some cases like Chongming Eco-Island in Shanghai, there still remain some changes to identify and assess what an eco- planning should represent. We refer back to last year's visit of governmental authorities to the site and putting on halt any of the high-rise development projects.

In most of our studied cases at the meso and macro scales in China, we identify a high potential—and still not fully exploited—for integrated design and planning. This would then allow for more opportunities of eco-innovation, not only to be recognised as development of final products but also processes that support the ideals of sustainable development. Some common examples can be related to environmental improvements and technological advancements, as mentioned in our cases of potential future directions. One method towards achieving advanced thinking would then propose for the integration of multiple dimensions, treating the built environment not necessarily as an information-based model, but rather as a platform for comprehensive assessment and ultimately towards holistic implementation. The linkage between innovation and sustainability is emerged as the concept of 'eco-innovation', which was first discussed by Claude Fussler and Peter James (1996). Since then, the term is recognised as a breakthrough discipline for both sustainability and innovation. The later definitions of the concept focused on key factors of sustainability, such as reduction in environmental impact (James 1997) and tools of change towards sustainable development (Rennings 2000). In theory, it can easily be translated as part of eco-development thinking, as it clearly defines the goals of environmental sustainability, technological advancements, eco-planning, eco-design, eco-efficiency, environmental technology, environmental design and sustainable innovation. Nevertheless, the only way forward is to consider how this can be integrated at multiple scales and with the consideration of multiple dimensions. In this case, we suggested for a new integrated model of '*Eco-Fusion*' as an advanced urban sustainability method towards eco development.

Coined by Cheshmehzangi (2016), the term 'eco-fusion' is a representation of integrating eco-development strategies across three spatial levels of the built environment. This approach is a comprehensive tool to achieving eco-development in multiple levels. A tool that offers a blend of eco-development strategies and possibilities that may eventually enhance the current practice of eco-design and planning, comprising three levels of eco-design at three urban spatial levels of eco-city (city/district level), eco-community (neighbourhood level) and eco-building (site/building level). This enables us to consider eco-development not only through its horizontal indicators and dimensions, but also through its verticality of scale, implementation, and governance. In other words, the eco-strategies can vertically run through our spatial levels, creating a more comprehensive process of city management and integration in planning and design.

The case of Sino-Singaporean Tianjin Eco-City partially achieves this by linking the ideals of eco-planning into eco-community design and green-certified buildings. Furthermore, this enables to create a more transparent and effective framework for stakeholder constellations of different levels, e.g., from city/municipal level management level, to district level, and to communities and site management. In this process, we anticipate to see a better information sharing for project data, a more comprehensive management network, and a more enhanced dialogue between the engaged stakeholders. The concept of eco-fusion is purely an approach to consolidate eco-strategies in both horizontal and vertical directions, to enable a better management for governance and adaptability for innovation.

Further to our discussion, we urge to avoid mere 'branding' of the eco-development ideals (Cheshmehzangi 2017) and instead focusing on the application of eco-thinking in practice. This enables us to focus on not fulfilling the eco-branding but rather the methods in which eco- can help us to achieve sustainable environments. To elaborate, we can propose for future hybrids, such as eco-low-carbon city, smart-eco-city, and smart-resilient city (ibid.), not because it seems necessary to create a new branding model, but instead because it is essential to think holistically and considering any possible tool or combination of a few to achieve sustainable development.

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