

Promoting sustainability through governance of eco-city indicators: a multi-spatial perspective

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Abstract

The purpose of this paper is to present a case study of the latest practice on urban sustainability in China, focusing on the breakdown of city-wide overall indicators to a more controllable spatial level—i.e. individual land plots and individual buildings. We argue the importance of decomposing the indicators to smaller scales by understanding underlying principles such as indicators and their integration in the process of urban governance, i.e. enhancing multi-level policy coordination as an important and effective approach for developing eco-cities. This can provide a common ground of argument to monitor the progress at multiple spatial levels and form a collective effort to move a city towards sustainability. The novelty of this study is to highlight the role of eco-city development at multiple spatial levels and through urban governance. The local government needs to mobilize various stakeholders involved in the urban development process by providing sustainability targets in a transparent way. A collective effort from various stakeholder groups might be formed by linking them to a set of unified but spatial level-based targets.

Keywords: sustainability; eco-city indicators; governance; multi-spatial; Ningbo China

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1 INTRODUCTION: INDICATORS AND SUSTAINABLE CITY

It is widely recognized that establishing and maintaining a comprehensive program of indicators is a critical activity of measuring our direction towards, or away from, sustainability. This, in particular, is a common practice in eco-city development [1]. An indicator is a part of the information necessary for understanding the world, making decisions and taking actions. The key functionality of indicators is to inform decision-making, which is about the interface between policy and data [2]. Bossel [3] states 'indicators of sustainable development are needed to guide policies and decisions at all levels of society'. Given the context of the urban environment, Alberti [4] stresses that urban indicators are crucial to help local and national policymakers improve their action towards sustainability. Joss *et al.* [5] also emphasize the importance of urban

Indicators that constitute an institutional process of identifying policy, generating knowledge and applying that knowledge in practice.

In short, the use of indicators is a method of simplicity derived from scientific evidence used to inform decision-makers on key directions. This is conducted for the implementation of indicators in decision-making and to achieve the prescribed ecological, social and economic aims in cities. In recent years, many international indicator frameworks have been developed for monitoring and reporting city sustainability performance. Examples include the Siemens Green City Index, the World Bank's Eco2 Cities indicators and the World Wildlife Fund's Living Planet Report that reports the value of the ecological footprint of major cities around the world. At the national level, sustainability performance of the urban built environment has been increasingly evaluated with urban scale rating systems such as the Leadership in Energy and Environmental Design

for Neighbourhood Development (LEED-ND) from the US and the Building Research Establishment Environmental Assessment Method for Communities (BREEAM-communities) from the UK; both represent a larger scale of the built environment beyond single building sites. In addition, some sustainable/eco city projects have also launched their own set of key performance indicators (KPIs) for a more context-specific approach to their locale. Often these local systems are more ambitious and have higher requirements, particularly when compared against national statutory standards [6].

A key problem of developing indicator systems or KPIs, in general, is finding appropriate indicators that are theoretically sound and use empirical data that are practical to collect and useful as a tool of communication with decision-makers [7]. In theory, there are a few representative methodologies related to indicator development for urban sustainability. The first one is the 'system approach', which argues the performance of sub-systems determining the sustainability of the study system. In this approach, the study system itself further contributes to the total system and interacts with other equivalent systems [8]. The second is drive-pressure-state-impact-response (DPSIR) framework, which develops indicators based on causal-effect chain analysis. DPSIR puts more emphasis on existing data to best characterize the state of the environment. The third one involves a method of strengths, weaknesses, opportunities and threats analysis at the macro or city level, where people can identify strengths, weaknesses, opportunities and threats that can be addressed or improved through the process of development [9, p. 6869]. Apart from these, community-based approaches are also used in some cities (e.g. Sustainable Seattle program), which involve extensive consultation with stakeholders to select appropriate indicators. It is possible to combine these approaches to create a hybrid approach. This formation, however, is dependent on the context and how the approaches are applied in practice.

In practice, a pragmatic method derives indicators from a number of widely accepted reference indicator systems as the start point in pursuit of context-specific indicators. Valentin and Spangenberg [10] suggest that the current indicators can be used as a source of inspiration but they cannot be simply replicated. Thus, public participation is often required in order to ensure the selection of the most appropriate and contextual indicators. Public participation can also help allocate weightings to the indicators selected according to the local situations and create/suggest context-specific solutions [11].

A prominent example of using this approach is the development of the KPI system in the Sino-Singaporean Tianjin Eco city (SSTEC) project in China. The system comprises 22 quantitative and 4 qualitative indicators. These KPIs are grouped into four assessment categories—society, economy, environment and resources. The development of these KPIs was led by the Bluepath City Consulting and the system was approved by the local government at first before it was confirmed by the Ministry of Housing and Urban and Rural Development of the central government in 2009. The determination of the KPIs and their values

involved consideration on several reference sources [12], as shown below:

- the national standards and distinctive ecological indicators adopted in China and internationally;
- related policy requirements and their quantitative targets in developed countries, and more developed regions in China;
- international green building rating systems, e.g. LEED and Green Mark; and
- KPI values from current eco city practice in China and internationally.

These reference indicators and their values were then integrated with the current situation in the SSTEC and went through several rounds of expert consultation (including government officials, academics and practitioners from relevant fields in China and Singapore) before they were finally determined for implementation [12, 48]. However, it should be noted that these city-wide overall indicators were not broken down to a more controllable spatial level—i.e. individual land plots and individual buildings. This is also identified as a major practical implication that is addressed in this research paper.

In summary, as relates to eco-city development, indicators and sub-indicators are used to define the problems to be addressed in order to achieve the prescribed ecological, social and economic aims. They constitute an important part of urban governance in eco-cities. They can be used to determine the route or direction towards sustainability, usually based on empirical, quantitative and sometimes qualitative evidence and driven by the project theme [13].

2 IDENTIFICATION OF PROBLEMS

Eco-city has become a global phenomenon since the late 1990s. Many eco-city projects have proposed a set of sustainability indicators to distinguish from conventional urban development models. Joss *et al.* [5] point out that the eco-city indicators can improve urban management at three aspects: (1) urban managers need a tool to evaluate and monitor the progress of urban performance; (2) developers and practitioners need the certainty of clear and consistent criteria of what being required to achieve, especially as they are increasingly exposed to the new requirement of urban sustainability; and (3) the general public need tools to hold urban managers and developers to account.

Moving to eco-city paradigm requires a significant shift away from the conventional planning and design practice. Berry *et al.* [14] point out the shift towards sustainability practice is not only a technocratic exercise but also a social-technical transition, which involves changes within policies, professional norms, national standards, technologies and consumption behaviours, or in short, a new paradigm of urban governance appropriate to the nature of eco-city development is needed to enhance the development. The barriers to eco-development have been investigated in different contexts (see examples of [15–18]). Lack of familiarity with

the new requirements of sustainability is identified as a main challenge in these studies. Linking back to the argument of Joss *et al.* [5], a new and innovative paradigm of urban governance through sustainability indicators should be implemented in order to provide the certainty to developers and practitioners involved in eco-city projects.

In China, the sustainable urbanization concept has proliferated among policy-makers, professionals and academics more than anywhere else around the world [19, 20, 38]. Currently, more than 280 cities have pursued their plan to become an 'eco-city' following the government's demonstration projects [21, 22]. These new 'eco-city' projects are often developed as expanded new zones from existing urban centres, with mass transport links. Many of these projects are top-down initiatives initiated by the national or local governments and carried out through collaborations by state-controlled developers associated with the local governments [23, 24].

To further elaborate, the local government often sets up an administrative commission, which acts as the master developer for the new eco-city development as a whole [25]. Generally, a city-wide master plan is coming up with a series of city-wide sustainability indicators, which is used to guide the development of the new city project. Based on the master plan, the master developer will supervise in three aspects—develop large urban infrastructure and facilities, sell land plots to individual developers through an open tendering market and monitor and evaluate the performance of the new city. Individual developers, after bidding successfully for a neighbourhood scale land plot, will be responsible for developing a plot plan that is further used to guide the design and construction activities within the plot site.

Studies indicate that there is often a gap between the eco-development plan and the project outcomes in the Chinese eco-city projects [20, 26–31]. This is partially attributed to the city-wide indicators that are sector specific and lack of spatial integration to tackle the environmental challenges [12]. Furthermore, as an institutional instrument, city-wide indicators are not reflected at sub-city levels such as land plots and individual buildings, which are largely at the hand of individual developers and practitioners [19, 32]. This, in turn, increases the uncertainty that individual developers and practitioners have to face if the city-wide indicators cannot be translated into the plot and building-level properly.

The conventional Chinese planning focuses on physical planning and spatial issues such as land use types, physical forms, density, plot ratio, building height, green space coverage and setback requirement. These planning parameters are not able to adequately address those newly emerged planning and design issues that are relevant to eco-city development [33], e.g. certified green building ratio, renewable generation, building energy reduction and sustainable urban drainage systems.

The development of land plots largely rests with individual developers and practitioners such as planners and designers. However, the incorporation of new sustainability requirements into the plot level is difficult because many of them are not site specific. Theoretically, the city-wide sustainability indicators

should be broken down to individual plot levels and be part of the planning constraints. Besides, the aggregation of achieving requirements at the plot level will lead to the realization of the overall indicators at the city level. Furthermore, the planning constraints at the plot level can be also used as tendering requirements. Individual developers are required to address these requirements in the tendering document. They need to evaluate the technical feasibility of the project and estimate the costs based on the new requirements. If the city-wide overall indicators cannot be transmitted to the plot level, it will cause uncertainty to both urban managers and developers. On one hand, urban managers are not able to confirm the achievability of the overall urban performance. On the other hand, developers cannot make a clear plan of development at the beginning and may face the cost and technical uncertainties during the course of implementation.

To solve this problem, a key point is an integration in eco-development strategies and planning that addresses the multi-scalar and multi-dimensional nature of urban sustainability [1]. This approach looks eco-city development not only through its horizontal indicators and dimensions (e.g. energy consumption, resource depletion and urban ecology) but also through its verticality of scale, implementation and governance. In other words, eco-strategies can vertically run through the spatial levels (e.g. city, land plot and building), creating a more interrelated process of urban management and integration in planning and design. A potentially greater set of performance gains lies in synergies between the interplay of different spatial levels of the built environment.

The purpose of this paper is not to justify the development of another indicator system for the sustainable urban built environment—which has been already too many—but to present a case study of the latest practice on urban sustainability indicator development in China. The main discussion is oriented around the needs of the local government for better governance of eco-city indicators. The literature review indicates that there is little research reporting in detail the current practice of developing eco-city indicators, and in particular, the translation of city-wide ecologic indicators to smaller spatial levels, e.g. individual land plot that is the basic planning unit in new city development. This can provide a common ground of argument to monitor the progress at different spatial levels and form a collective effort to move a city towards sustainability [1].

The next sections of this paper will report in detail a new eco-city project in the city of Ningbo, East China, focusing on two aspects: (1) developing the city-wide overall sustainability indicators, and (2) the attempt to reflect these requirements at the individual plot level to facilitate urban sustainability management.

3 PROJECT CONTEXT

The Ningbo New Eastern City (NBNEC) in Zhejiang Province is newly expanded from the existing city centre of Ningbo with an area of 16km^2 . It is projected to accommodate a population of 170 000, including both the existing population and new residents

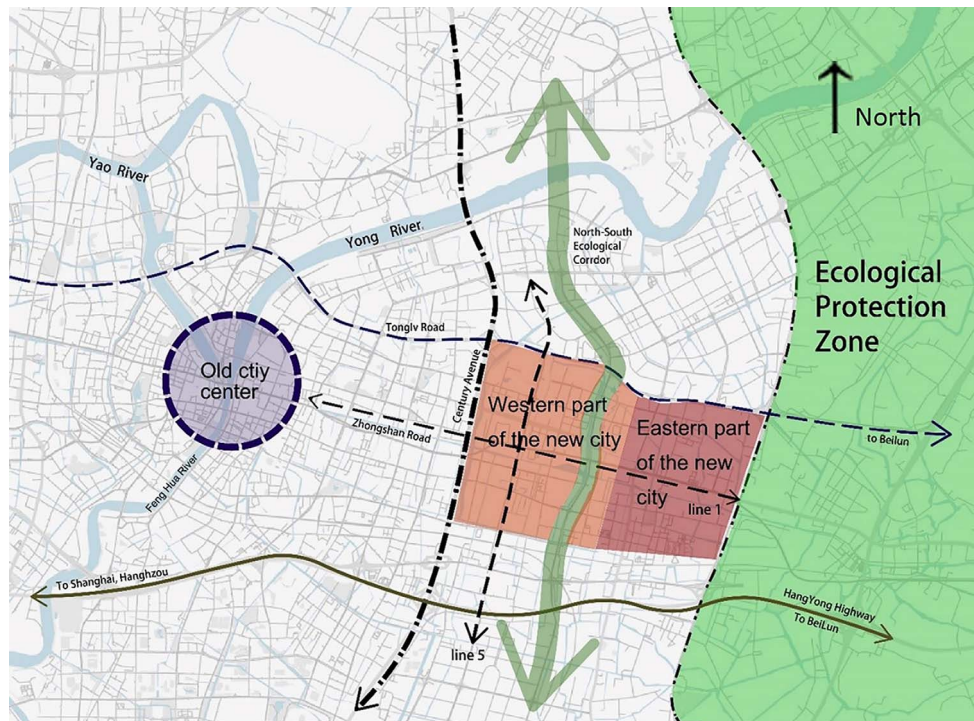


Figure 1. Overview of NBNEC and its geographical linkages.

(see Figure 1). The NBNEC is geographically split into two parts of the western part and eastern part. The site for NBNEC itself is a major development area next to a protected natural zone towards its east with corridors of transportation that are linked to coastal areas of Ningbo City and its major ports. The relatively short proximity of the area to the central part of the city suggests a major strategic linkage between the city and its ports, as well as a new zone of development that accommodates most of the governmental units and new businesses. Apart from the central part of the city, the NBNEC is one of the two central business districts (CBDs) of the City of Ningbo. Hence, it plays a major role as part of not only revitalizing the previously industrial areas into a mixed-use development but also as a major node in the overall network of the city's economy.

In the original development plan, the new city was developed with two phases—completing the western part of the city between 2006 and 2014 as the main CBD of the new area, and the eastern part between 2015 and 2020 as the expansion area with several zones of residential, commercial and public services. The western part was completed as planned in 2014, which was developed with conventional planning and design control criteria. Very little consideration was given to eco-development at that time. As eco-city development has been escalated in recent years and exemplary projects have been widely known, the local government approached The University of Nottingham Ningbo China (UNNC) in 2015 and funded a research project to develop a framework, assisting the future urban sustainability management

in the eastern part. The eastern part of the new city has a total area of 7.48km^2 , comprising 56% land for residential, commercial and office buildings and the rest for open spaces such as roads, vegetation and waters.

When we were approached to conduct research on the eastern part, it was noticed that the master plan of the NBNEC was already done and approved by the municipal government in 2009. This means there was little chance to change the land use pattern as originally indicated in the master plan documents. However, when it comes to the actual implementation phase, the land plots are generally developed by individual developers. Hence, this allows some spaces for improvement at the plot level first and then the eastern part as a whole once the work is taken further for implementation. Embarking from this, the project team, together with the NBNEC Administrative Commission, decided to find a new way to facilitate both urban managers and developers to promote green development through an integrated system.

The project was initiated in November 2015 with the sole intention to improve the ecological performance of the eastern part of the new city by adopting a new system for urban governance. Agreed by the NBNEC Administrative Commission, the key targets of this project were to:

- develop a sustainability indicator system for the eastern part of the new city as a whole and
- the city level indicators are then transmitted to plots of land within the eastern part, which will be sold to individual

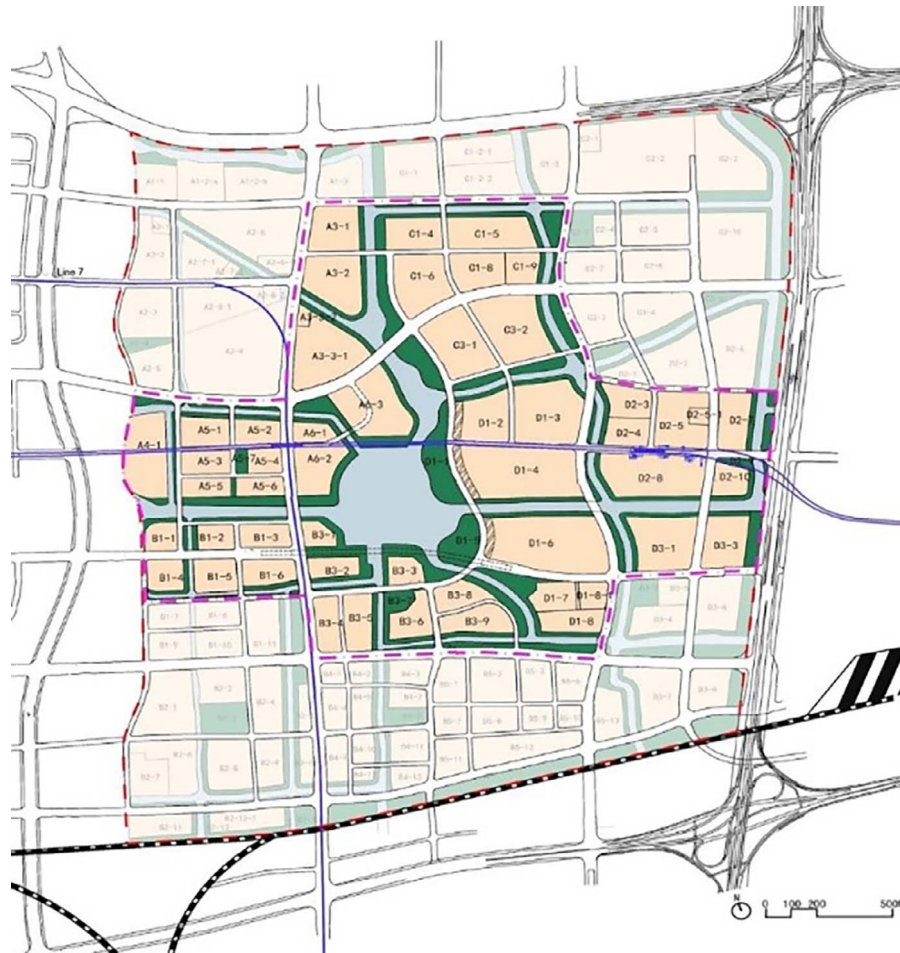


Figure 2. Land plots in the eastern part of NBNEC.

Table 1. Conventional planning parameters of land plot A3.

Plot code	Sub-code	Land use type	Area (hectare)	Plot ratio	Construction area (m ²)	Building height	Note (if there is any)
A3	A3-1	R2	3.30	2.2	72 600	80	Including a kindergarten with 360 attendees.
	A3-2	R2	5.03	2.2	110 638	80	
	A3-3-1	R/B	6.78	2.4	162 720	80	Ratio between commercial and residential area is 2:8, a parking lot with 150 spaces and a public toilet.

Note: R2 is the Class II residential land; R/B is the mixed development land with residential and business components. The number of kindergarten attendees is estimated based on China's Kindergarten Construction Standards (2016).

developers through an open bidding process. These plot level requirements will be incorporated into the tendering document as new planning and design constraints, along with those conventional criteria.

There are 17 land plots within the eastern part of the new city, coded from A1–A6, B1–B5, C1–C3 and D1–D3 as indicated in Figure 2. Most plots comprise sub-plots, coded like A3–1, A3–2 and A3–3. The plots shadowed are full with existing old buildings and are not yet ready on the land market. Others are ready to be placed in the market depending on the varying market situations.

The conventional planning parameters have been already designated to each of the plots. Taking plot A3 as an example, these planning parameters are presented in Table 1. This plot comprises three sub-plots, with a total construction area of 351 000 m². The residential area is 319 000 m², accommodating a total population of 6900 residents. Other planning constraints such as plot ratios and building height control are also given as part of the original master plan documents.

A project consortium team was arranged in November 2015 involving the UNNC as the lead member, as well as the NBNEC Administrative Commission and the Bluepath City Consult-

ing whom are indicator developer of the well-known Sino-Singaporean Tianjin Eco city, as two key members of the project. Supported by the local government, a large group of stakeholders from the government, developers and practitioners were also consulted during the course of proposing the new requirements. These requirements will be broken down and are penetrated through city and land plot levels and correspond to each other. By doing this, the interrelated spatial levels are able to be examined in the same dimension and form a collective effort towards a comprehensive eco-development model. The project outcomes were approved in March 2018 by the municipal government and will be implemented in the urban governance in NBNEC in the future.

4 PROJECT IMPLEMENTATION

The project was implemented between November 2015 and January 2018, which involved three major steps: a selection of overall indicators, determination of benchmarks and indicator decomposition to the individual plots. Each of the steps comprises a few tasks. A flowchart (Figure 3) showing the steps and tasks gives the overall structure of the project. The tasks included in the three steps are listed as:

- Selection of overall indicators: contextual study, site investigation and evaluation, proposal of the initial indicator list, expert consultation and finalization of the indicators.
- Determination of benchmarks: development of benchmarking methods and determination of benchmarks for the eastern part of the new city as a whole.
- Indicator decomposition: identification of decomposable indicators, development of decomposition methods, determination of benchmarks for individual plots and development of plot plans.

4.1 Selection of overall indicators

4.1.1 Contextual study

As a common practice, this study initiated a desktop study of current international, national and local policies and best practices on eco-city and green building development. The review of the current eco-city practices included both the earlier projects (e.g. SSTECH and Caofeidian Eco-city in Tangshan) and the newly emerged projects (e.g. Sino-German Qingdao Eco-park and Beijing Future City) [6].

As part of the initial desktop study, new trends and new requirements were identified, for example, the requirement on utilization of prefabricated (or modular) elements was rarely appeared in China's eco-city projects before 2012, but now it is a strategy by the government to promote energy and resource efficiency in the building sector. Also, with the spread of smart technologies in cities, the word 'eco-city' is now often combined with 'smart-'. Hence, technologies that are able to monitor and measure the urban and building performance are required in some later projects. The project team also paid attention to the recently

upgraded China Green Building Evaluation System (GBES) and its urban scale version and also other building and city-related regulations, standards and benchmarks. The purpose is to ensure the indicators proposed and their benchmarks are more rigid than these mandatory requirements.

4.1.2 Site investigation and evaluation

Site investigation involved collecting and reviewing existing planning document including the 13th Five-year Plan of the new city, the master plan, the controllable detailed plan, the land use plan, hydrologic plan and the statistical yearbooks of Ningbo municipality. Interviews with local government officers from the planning, environmental management, urban management and water management sectors were also conducted as part of the overall site investigation and planning evaluation.

To evaluate the ecological performance of the eastern part of the new city, we have estimated its carbon footprint (CF), assuming the project was complete according to the master plan. The carbon footprint has become a widely used concept for communicating both the causes of climate change and the opportunities to reduce greenhouse gas emissions [34]. The estimate of the CF can give us a snapshot evaluation on some possible directions of improvement. The CF estimate is conducted based on the International Panel on Climate Change [35] methodology, which covers four main emission sources in a city without agricultural activities—building sector, industry sector, transport sector and infrastructure sector (e.g. street lights, water supply, sewage treatment, etc.). On the other hand, carbon sequestration from vegetation should be deducted in the estimation. The estimate can be expressed as below:

$$CE_{city} = CE_{building} + CE_{industry} + CE_{transport} + CE_{infrastructure} - CE_{vegetation}. \quad (1)$$

According to the land use plan (see Figure 2), there is not industrial plants in the eastern part of the new city. Hence, the carbon emissions from industrial activities ($CE_{industry}$) is removed from the formula. In addition, the estimate of the carbon reduction from low to high is based on three scenarios: business as usual, improved and optimal. Each of the scenarios has respective assumptions in the four relevant sectors—building, transport, infrastructure and green coverage (see Table 2).

Assuming the carbon emissions in the business-as-usual scenario is 100%, the estimate shows the improved scenario and the optimal scenario and are about 85.3% and 77.3%, respectively. Fenner *et al.* [36] point out the carbon emissions associated with the built environment represent the dominant fraction of the total carbon footprint of society. The building sector is much more significant than the transport and infrastructure sector based on the calculation and measurement, as shown in Figure 4. Hence, taking measures such as increasing building energy saving levels, increasing green building rating levels and installing solar PV panels may have significant impact on the future performance of the development.

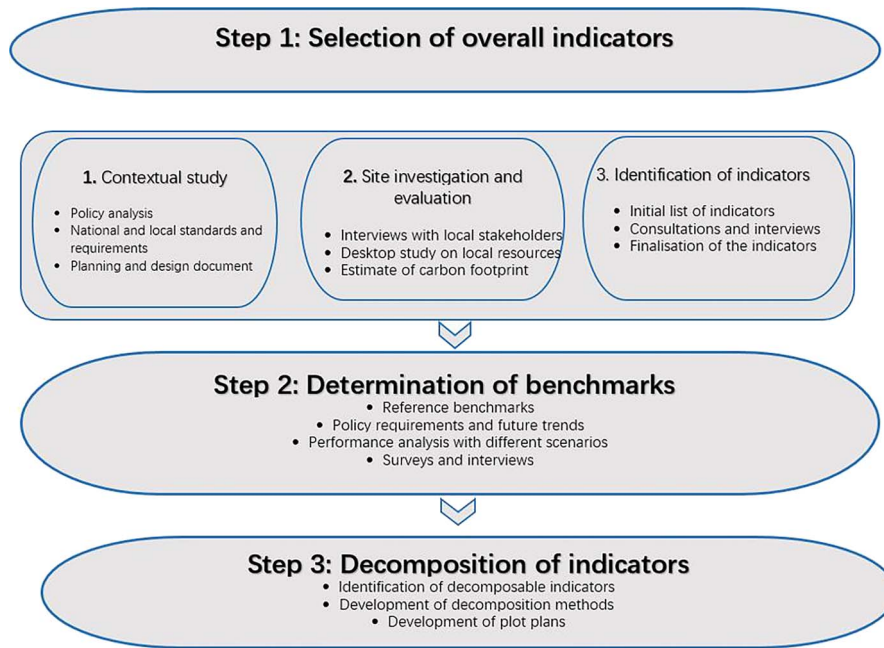


Figure 3. Main steps and tasks in the project implementation.

Table 2. Scenarios used to estimate the carbon emissions in the eastern part of NBNEC.

	Business as usual scenario	Improved scenario	Optimal scenario
Building	Comply with current statutory requirements (50% energy saving), 10% roof area of public buildings for PV power, 10% roof area of residential buildings for PV thermal.	Building energy saving increased to 65%, 20% roof area of public buildings for PV power, 20% roof area of residential buildings for PV thermal.	Building energy saving increased to 65%, 50% roof area of public buildings for PV power, 50% roof area of residential buildings for PV thermal.
Transport	The 50% green trip, all vehicles driven by fuels	The 50% green trip, 50% public buses and taxis driven by electricity or liquefied natural gas (LNG).	The 80% green trip, 50% public buses and taxis driven by electricity or LNG, 50% private vehicles driven by electricity or LNG.
Infrastructure	Water supply, wastewater generation and domestic waste output in accordance with relevant design standards.	Reduction of 30 l water use per person.	The 60% non-conventional water use, 10% reduction of domestic waste output.
Green coverage	Based on the control plan of the eastern part of the city.	Based on the control plan of the eastern part of the city.	Based on the control plan of the eastern part of the city.

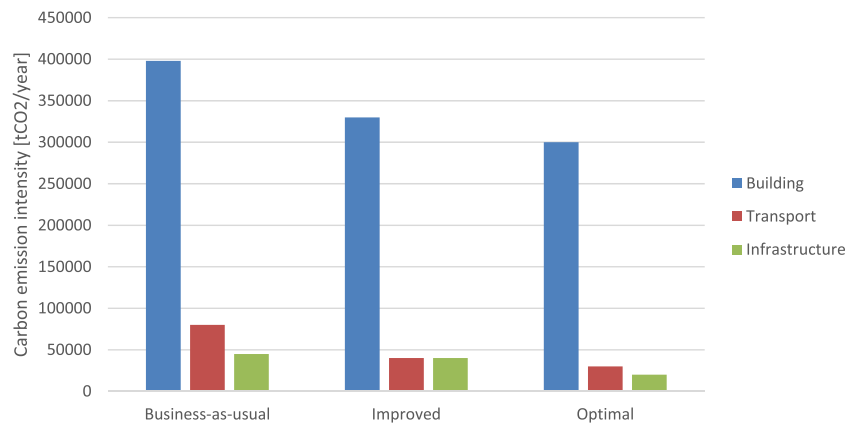


Figure 4. Comparison of carbon emissions in different sectors in the eastern part of NBNEC.

Table 3. Indicators selected and benchmarks assigned.

Code	Indicator	Type	Unit	Benchmark
1	Green building proportion	Threshold	%	100 (★★★ ≥ 10; ★★ ≥ 70)
2	Underground space utilization proportion	Threshold	%	≥30
3	Renewable energy utilization proportion	Threshold	%	≥10
4	Building energy efficiency	Threshold	%	Residential building ≥75 Public building ≥65
5	Energy consumption per floor area	Threshold	kWh/m ² ·a	Residential ≤35, office ≤70, shopping ≤90, gym ≤100, school ≤40, hospital ≤90, hotel ≤110
6	Rate of prefabricated construction	Threshold	%	≥35
7	Rate of local building materials utilization	Optimal	%	≥95
8	Vertical greening and roof greening	Optimal	%	100
9	Green construction process	Optimal	%	100
10	Local plants	Optimal	-	≥0.9
11	Indoor thermal comfort	Optimal	%	2 public buildings selected for demonstration (WELL certification)
12	Intelligent performance monitoring	Optimal	%	2 buildings selected for demonstration

Note: ★★★ is the three-star green building certification; ★★ is the two-star green building certification.

4.1.3 Selection of indicators

According to the purpose of the indicator selection exercise, a few principals were proposed. These included the following:

- The number of indicators should be limited.
- The indicators should be plot-limited—they should be controlled by the developers, i.e. developers should be able to implement measures to achieve these indicators in the plot plan.
- They should be able to incorporate into the project tendering and management.
- They should be measurable with available data sources.

This approach further involves three tasks—proposing initial indicators, conducting expert consultations and finalizing the indicators. Twelve indicators were finally determined based on their merits and compatibilities. Notably, six indicators were classified as threshold ones—the requirements of these indicators must be met. The other six indicators were optimal indicators—i.e. they should be addressed in the preparation of tendering document but not necessarily achieved. This would give flexibilities to developers to choose the ones that are more applicable, and also are the ones that can be implemented in practice. The 12 city-level overall indicators and their corresponding benchmarks are shown in Table 3.

4.2 Indicator decomposition

4.2.1 Identification of decomposable indicators

Excluding indicators 11 and 12, the rest 10 indicators selected for the city level were grouped into two categories. Six of them were plot specific—the requirement of a particular plot may be different from the others based on its specification, thus they need to be broken down to the individual plot for the implementation phase. The other four indicators were not land plot specific and the requirements were directly applied across different plots identically (Figure 5).

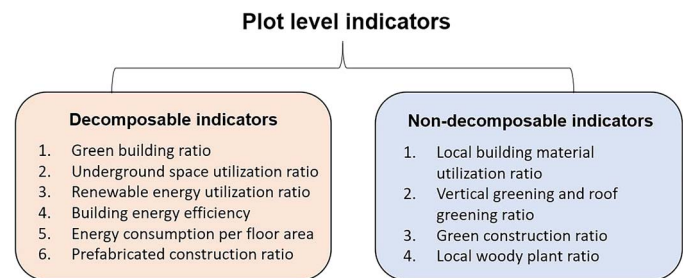


Figure 5. Indicators that are decomposed or applied directly to the plot level.

4.2.2 Development of decomposition methods

Since the nature of the six decomposable indicators varies greatly, decomposition approaches were different between them. Taking 'Green Building Ratio' as an example, it is defined as the ratio between 'the construction area of certified buildings' and 'the total building construction area'. The China GBES is a major tool to certify green buildings in China, which has three levels of certification from one-star to three-star. The overall requirement is (see Table 2): (1) all buildings must be certified by GBES, (2) minimum 70% construction area must be certified at GBES 2-star level and (3) minimum 10% construction area must be certified at GBES 3-star level. According to the local policy, since July 2016 all new buildings must be certified at least at a one-star level, and two-star certification is required for public buildings. In order to assign a rating level to a particular plot and its sub-plots, a weighting system has been proposed, which is used to evaluate the conditions of a particular plot and its sub-plots. The weighting system comprised four factors as shown below:

- Building height: the higher the building height in a plot, the lower green building rating level required. The rational is low-medium-rise building is relatively easier to achieve high-level certification.

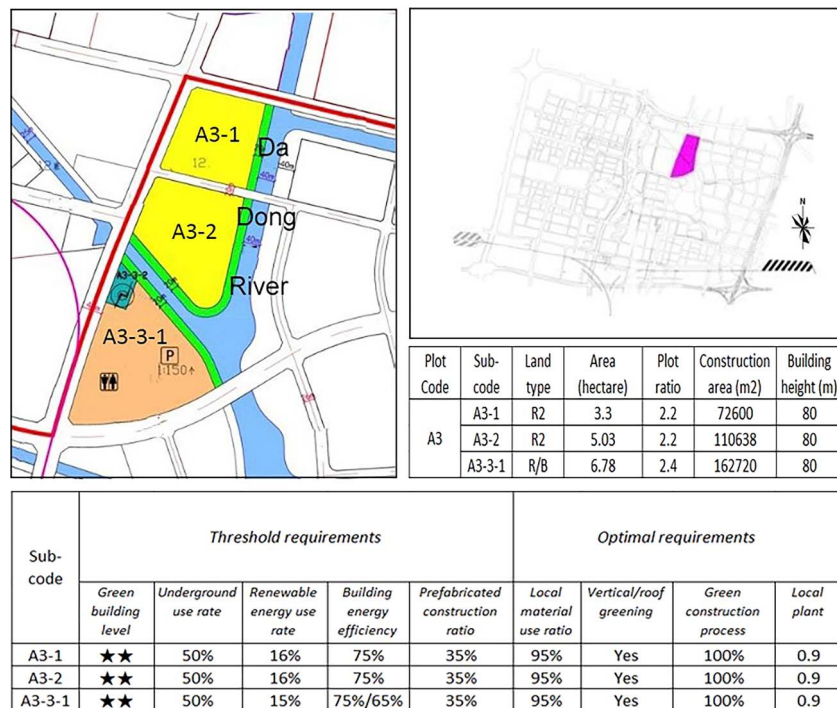


Figure 6. Control plan of A-3 plot as shown in three sub-plots of A3-1, A3-2 and A3-3.

- Plot ratio: it is an indicator indicating the intensity of land use, defined as the ratio between the total construction area within a site and the footprint of the site. The GBES gives more credits to a project with a higher plot ratio. Thus, the higher the plot ratio, the higher green building rating level required.
- Location: the better location, the higher the certification level. The rationale is a plot that is part of the CBD area, or close to water bodies and green spaces, would have higher value of land thus be able to afford the increment costs of developing green building certification.
- Building type: public buildings such as hospitals and schools should be subject to higher level of certification.

Equal weighting was applied to the four factors. Based on the weighting system, all plots/sub-plots were evaluated and scored. Depending on the score obtained, a particular plot or sub-plot will be assigned a certain level of certification. In accordance with the overall requirement (20%, 70% and 10% for one-star, two-star and three-star, respectively), the top 10% plots/sub-plots will be assigned with three-star certification, while the bottom 20% one-star certification. The rest is assigned with two-star certification. By taking plot A3 as an example, which comprises three sub-plots—A3-1, A3-2 and A3-3. The first two sub-plots are categorized as ‘Class II residential land’ with a plot ratio of 2.2 and building height control of 80 m. They are featured with medium density and high-rise residential buildings. The sub-plot A3-3 is featured with mix-used land with 20% commercial area and 80% residential area. The building height control is 80 m, and the plot ratio is 2.4. Based on the weighting system, A3-1 and A3-

2 were score of 5.75, and A3-3 was score of 6.15. All of the scores ranked in the range of 20–90% in the score list. So they are all assigned with two-star certification.

4.2.3 Development of plot plans

After a particular plot/sub-plot was evaluated, a plot plan was developed to show the requirements to be incorporated into the tendering document and future urban governance. It comprises three drawings indicating information such as orientation, location and plot code, and two tables showing conventional planning requirements and new eco-development requirements, respectively. Figure 6 shows the plan of the A-3 plot. Apart from the conventional planning parameters, developers are also required to address the new eco-requirements in the tendering document. These new statutory requirements will be used by the government as a tool to monitor and evaluate the performance of this plot. Hence, other stakeholders such as designers, contractors and building managers need to be responsible as well in their work.

5 DISCUSSION

Richard Register, the cofounder of urban ecology as well as the author of ‘Ecocities: Building Cities in Balance with Nature’ [37], defined eco-city as a conceptual city focused on the governance and living within the means of the natural environment. The need

for this concept and form of governance has been embraced by a myriad of academic policy makers and developers [38]. For example, Joss *et al.* [39] stressed the development and application of eco-city indicators should not just be considered in technical terms but equally in governance terms. From this perspective, indicators can be understood as functioning as strategic instruments to influence policy and determine the route or direction to be taken to promote sustainability in a particular urban context.

From a perspective of geographical scale, eco-city development should be considered in a broader context [6, 29]. The reason behind is simple: the sustainability of an urban setting does not only relate to the urban area itself but also to its surrounding hinterland. A local authority needs to take into account the context of the development opportunities of a geographical area extending beyond its own boundary. Eco-city projects and their regional contexts have been well researched in recent years. For example, Joss *et al.* [39] point out that eco-city indicators should be defined in a way that takes into account wider regional dimensions and interests.

However, on the other hand, when we scale down geographically from city to smaller spatial levels—e.g. plot and individual building scale, we found little research or practice to integrate eco-city indicators into policy and regulatory process through different spatial levels within a city. This has been identified by Joss *et al.* [39], as a challenge of governance in eco-city development. Joss *et al.* [39] argue to find a way to strengthen the link between indicators and policy, by trying the use of indicators to statutory implementation mechanisms. If indicators and standards are used as part of a statutory process—for example, in the NBNEC project, to be used as tendering requirements and throughout the urban management process—this provides further certainty and monitoring capacity for both developers and policy-makers [39].

In this study, the authors are not arguing about developing a new definition or set of indicators to guide eco-city development. Instead, we argue the importance of decomposing the indicators to smaller scales by the understanding of underlying principles such as indicators and its integration in the process of urban governance. i.e. enhancing multi-level policy coordination (e.g. ensuring transparency, openness and participation and collaborative planning) as an important and effective approach for developing eco-cities.

Following the 2015 Paris Agreement, China committed to peak emissions around 2030 [40]. To achieve this target, the Chinese government put forward a policy of piloting near-zero carbon zones, including a specific call for 50 near-zero carbon zones by 2050 in the 13th Five-Year Plan [41]. The key principles are similar to the roadmap proposed by the World Green Building Council [42], usually including carbon evaluation and disclosure, reduction of energy demand, generation of renewable energies and improvement of building standards. In recent years, there is a growing interest in China to find a new integrated model for urban development as a whole. The effort to create such a new urban development model is manifested in the form of developing

eco-cities. China appears in the frontline of reshaping and redeveloping the urban environments [20, 43, 44]. Currently, there are around 280 Chinese cities that have declared an ambition to develop ‘eco-city’ or ‘low carbon city’ ([21], p. 10; [45]). However, many of these projects are believed to use ‘eco-city’ or ‘low-carbon’ just as a label, without substantial and implementable contents. Independent estimates say only about 20% of those claims are genuine ([46], cited in [29]).

The majority of the so-called eco-city projects are large-scale greenfield developments—new cities and new towns built from scratch—in the suburbs of large municipalities ([47], cited in [29]). In the planning of these projects, we further argue that the lack of a clear nexus of city-plot building is partly to blame for the current ‘greenwash’ of eco-city initiatives in China. This is because, apart from the theories and definitions, eco-city should be substantialized, which is largely manifested in the targets set and ways of achieving them. This requires the integration of targets into the policy coordination at different spatial levels to form a collective effort by various stakeholders in a transparent and clear way.

Currently, there are two ways of decomposing the city-wide indicators. In the SSTEAC, the 26 overall indicators are broken down into 237 control targets. The decomposition is not linking to the land plot directly. Rather, the control targets were used by the local authorities to grant construction permission (Bluepath [48]). Individual developers were not required to address these requirements in the tendering process in a systematic way. There is not a clear linkage between the plot requirements and the city-wide requirements. These indicators are more like a tool to help on the planning of infrastructure and urban administrative procedure.

Different from the SSTEAC project, NBNEC gave emphasis to developers, considering they are responsible for plot and building development. This approach has several advantages, including:

- As a set of eco-requirements in the land market, developers need to address these requirements in the tendering document.
- The process is more transparent—developers are involved at an earlier stage, thus helping them to create a project plan from the very beginning through a multi stakeholder constellation structure.
- The risk is reduced. It will increase the achievability of city-wide overall indicators when the plot and building level are taken into account.

It should be noted that the consideration for a set of indicators came at a later stage in NBNEC and after the completion of the master plan development phase. Since the consideration is given to developers as a follow-up package after the master plan phase, these indicators are more site specific, focusing on the land use, facility development and building energy efficiency at the planning and construction stage. Other issues such as waste management and transportation were not included because they are

usually out of the control of developers. However, this approach also provides a new way of examining sustainability from the perspective of the developer that is a key player to substantialize the contents of eco-city development, through which we can find better implementation possibilities.

6 CONCLUSIONS

The aim of this paper is not to present another set of eco-city indicators but to report in detail the latest practice of how local government in China making effort towards sustainability through better governance. The case of NBNET in the City of Ningbo was used to discuss these in both theory and practice. The novelty of this study is to highlight the role of eco-city development at multiple spatial levels and through urban governance. Here, the project team brought together academic research, practice and policy in finding a pathway towards green- and eco-promotion at a smaller scale in comparison to larger development projects that happen in China. Very importantly, the local government needs to mobilize various stakeholders involved in the urban development process by providing sustainability targets in a transparent way. This should ideally happen thoroughly since the inception of the project enabling clear directions and comprehensive eco-development to shape with multiple stakeholders. This approach also increases the certainty of achieving the city's overall targets. A collective effort from various stakeholder groups might be formed by linking them to a set of unified but spatial level-based targets. Once again, this highlights the importance of the interplay between the various spatial levels of the built environment, where we can only create potential collaborations between various stakeholder groups of the project.

Future research lies in two directions: first, the methodology of decomposing city-wide overall targets can be further improved through repeated practice and demonstration. The exercise of decomposing the overall indicators should be also contextually based; second, a corresponding administrative mechanism should be established to ensure the compliance with the plot level sub-indicators, not only at the tendering stage but also at the design and construction stage. The findings of this project are expected to support future projects of similar nature and suggest for an earlier integration of eco-development ideas at the master plan phase.

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