

Volume 1, No. 3 (2013)

# **International Review for Spatial Planning and Sustainable Development**



**SPSD Press from 2010**



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### **International Review for Spatial Planning and Sustainable Development**

For investigation regarding the impact of planning policy on spatial planning implementation, International Community of Spatial Planning and Sustainable Development (SPSD) seeks to learn from researchers in an integrated multidisciplinary platform that reflects a variety of perspectives—such as economic development, social equality, and ecological protection—with a view to achieving a sustainable urban form.

This international journal attempts to provide insights into the achievement of a sustainable urban form, through spatial planning and implementation; here, we focus on planning experiences at the levels of local cities and some metropolitan areas in the world, particularly in Asian countries. Submissions are expected from multidisciplinary viewpoints encompassing land-use patterns, housing development, transportation, green design, and agricultural and ecological systems.

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# **International Review for Spatial Planning and Sustainable Development**

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Special issue on "Green City Design in Asian Cities"  
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## Editorial introduction

### *Special issue on "Green City Design in Asian Cities"*

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In this issue, we are attempting to discuss planning system of different Asian cities from a viewpoint of green city design for achieving low carbon city. The principles as well as the design components of “low-carbon planning” have been widely discussed in the world. Urban planning is recognized as an important tool for the low-carbon development of cities. Generally speaking, integrating “low-carbon” concepts into urban planning practices is still in the early stages of an exploratory trial.

In Indonesia, the concept of Green city design has been introduced to the National Long-Term Development Plan and Regional Spatial Planning. In this issue, the concept of green city design is discussed from a view of global warming anticipatory based on open space, green city, pollution, and sustainable city.

In the work of “Planning Review: Green City Design Approach for Global Warming Anticipatory”, Wikantiyoso and Pindo analysed how the concept of Green City Design has been introduced to National Long-Term Development Plan of 2005-2025 and Spatial Planning of Surabaya 2009-2029. Surabaya is designated as the National Development Center of eastern Indonesia and it is in its initial stage to consider how to implement the concept of green city design in planning practice in addressing the current global warming Issues. For the implementation of green city design, Indonesia still requires a long process and the role of urban planning and design has a very large role in the effort to realize or toward green city. However, the authors argues that implementation of green city design in Indonesia is still facing very complex issues, including socio-cultural problems, economically and politically. The methods of implementing the concept of green city design under the existing planning system remain to be studied.

In China, the National Economic and Social Development Twelfth Five-Year Plan, has programmatic descriptions in green and low-carbon development, and has established the direction for recent developments. A series of action plans are organized and implemented at the national level; for example, the program called "low-carbon pilot provinces and cities" has been launched since 2010, which can be recognized as part of the effort to green cities.

In the work of “Integrating Low-carbon Concepts in Urban Planning: Practices in Xiamen and Implications”, Wang et al analysed how Xiamen

city implement bold innovations in low-carbon development policies and planning measurements. By taking Xiamen city as a case study, Wang et al attempts to sketch out the general governance framework for "a low-carbon city in China" in the field of urban planning. Wang et al argued that Low-carbon-oriented urban planning involves some new planning elements and components. It requires some adjustments to existing planning indicators, such as the proportion of clean energy applications, energy efficiency standards for buildings, the density of land development, the coverage of non-motorized transport networks, reductions in motor vehicle parking spaces and increases bicycle parking spaces and so on. They comment that urban planners in China should consciously update their knowledge and adjust their education course offerings and training programs accordingly.

In Taiwan, Eco-city and green building assessments are included in "The Implementation Regulation of Periodical Overall Review of Urban Planning". According to the regulation that has been amended in 2011, the process of conducting overall review of urban planning needs to develop a system of water and green network principles. For this, many local cities in Taiwan have launched "The Eco-city and Green Building Promotion Program."

In the work of "The Application of Vertical Greening to Urban Rehabilitation and Maintenance", Peng focused on exploring how to promote the application of vertical greening that increases green quantity as well as how to regulate maintenance of it in urban renovation. Regarding to the application of vertical greening technology, Peng has summarized the items including plants, vertical greening technology systems, and building external environment as six types of vertical greening technologies in Taiwan. The author believes the integration of vertical greening, urban innovation, and maintenance should have at least the following benefits: creating three-dimensional multi-layer ecological space, humanistic ecology in urban community, and improving green wall and permeable pavement.

Nowadays, the content of the urban design guidelines for green city design is relatively complete and contains the many aspects, such as public green space system, urban landscape system, historical culture protection and utilization, and so on. Environmental design guidelines focus more on regulation details than do the conventional urban design guidelines; the focus is partly on the environmental effects of building material and thermal environmental changes, the wind corridor map, and so on; this makes them complicated to illustrate.

In the work of "Design Coordination Regarding Urban Design Guidelines Using Google Earth", Shen et al reveal three detailed guidelines using Google Earth: traffic, architecture, and environment guidelines. By combining the three guidelines in Google Earth, the space appears more realistic and is easier to understand than reading documents and drawings on each guideline independently. In the local design competition, most design guidelines come from Western countries; thus, the guidelines utilized in this work are not based on the Chinese planning system. In order to solve problems with rapid urban expansion and construction during this time, some regions in China began to emulate foreign city designs. The authors argued that it is necessary to develop a tool for stakeholders to improve their understanding of design guidelines based on urban planning practices for green cities in the world.

The studies collected in the special issue serve as good references for pursuing low carbon development in Asian cities although these works need further refinements in many aspects. Global warming is a phenomenon in

which the global temperature increases from year to year due to the greenhouse effect caused by increasing economic demand and urban land use. The provision of green space in the city can be one of the planning measures for the realization of more human-urban environment, and capable of functioning ecological and low carbon city.

All submitted manuscripts were peer-reviewed. The guest editors would like to thank the reviewers for their hard work, time and valuable comments and suggestions that make this special issue possible.



# Planning Review: Green City Design Approach for Global Warming Anticipatory *Surabaya's Development Plan*

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**Key words:** Eco-city, Global Warming, Urban Design, Spatial Structure and Spatial Pattern

**Abstract:** Environmentally, sustainable development will increase durability to any changes in the environment. Planning and urban design as a form of physical intervention in urban development should anticipate phenomenon of global warming through design decisions. A balanced development between the physical environment of development and environmental conservation should be done to achieve a healthy urban environment for present and future generations. The balance between green space and developed space with an integrated system of environmental infrastructure will increase the carrying capacity of an urban environment. Green city planning and design is one solution to global warming phenomenon. Green city concept was conceived as an answer that emphasizes aspects of environmental sustainability considerations in solving the urban problems ([Murota and Ito, 1996](#)). Green city planning implications in urban planning and design approach is the realization of the overall ecological city (Eco-city). This paper aims to discuss the concept of city planning and design approach that is able to eliminate global warming. Purpose of the discussion in this article was to determine whether the product of city planning has to anticipate problems of global warming became a major issue of urban development. The discussion in this article is the result of a review of the design of Long-Term Development Plan Of 2005-2025 and Spatial Planning of Surabaya 2009-2029.

## 1. INTRODUCTION

This paper aims to review the planning practice in Surabaya from the concept of green city design approach, which is recognized as one of planning measures to anticipate problems of global warming that becomes a comment discussion in urbanization process across the cities in the world. The study was conducted by analyzing the designs of Long-Term Development Plan of 2005-2025 and Spatial Planning of Surabaya 2009-2029 (Hereafter Surabaya's development plan). We are concerned with the aspects of urban planning and design related to the environmental preservation efforts, as well as consistency between development policies in urbanization process in Indonesia.

The increasing number of the world's urban population will increase very significantly. According to Schell and Uljaszek ([1999](#)) about 67% of

the world's population is expected to live in cities by the year of 2025. Urban development is a logical consequence of the urbanization process. The following effect of urban population growth is the increasing number of physical facilities and rapid development of the city. Due to fast urbanization, natural ecosystems are increasingly replaced by urban land use. Urbanization increases the distance between people and natural space ([Li and Wang, 2003a](#)).

In general, economic growth has been contributed to the excessive exploitation of natural resources, which encourage the increase of environmental degradation in both urban and rural areas. The rapid development of the developing countries will fasten global warming and exacerbate resource problems ([Murota and Ito, 1996](#)). Increasing energy consumption is the consequence of the distribution and transport inefficient that encourages increasing carbon emissions, in which triggered the greenhouse effect, increasing geothermal and surface waters, which ultimately leads the climate changes. Based on the data from the International Energy Agency during 2002-2007, it is predicted there will be an increasing number in electric energy demand and carbon emissions in Asia and the world until the year of 2030.

Global warming is a phenomenon in which the global temperature increases from year to year due to the greenhouse effect caused by increasing emissions of gases like carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), Nitrous oxide (N<sub>2</sub>O) and so on. The phenomenon of global warming which leads to climate change has very serious effects toward human life. Intergovernmental Panel on Climate Change (IPCC) states that the Earth's temperature has been rising up 0.15 - 0.13o C since 1990 to 2005. If the condition remains the same, it is predicted that the Earth's temperature will rise at around 4.2 ° C by the year of 2050 to 2070. It will cause the rising of the sea levels to 90 cm higher than today. In addition, this condition will make around 2,000 small islands will sink. Global warming is a serious threat to coastal cities such as Jakarta, Semarang and Surabaya. Urbanization leads the decreasing of the capacity; due to the decreasing numbers of open space area in the city, which has an ecological function. Urbanization also leads to the increased number of vehicles that implies the increase of CO<sub>2</sub> and CO gas into the air ([Murota and Ito, 1996](#)). Exhaust emissions released by vehicles causing major pollution and it is one of the causes of Global Warming.

On the other hand, the provision of green space in the city can be one of the planning measures for the realization of more human-urban environment, and capable of functioning ecological city. Republic of Indonesia mandated Act 26 year 2007 and concerns about the utilization of space that requires 30% green space from the total area of the city. Meanwhile, Indonesia as a maritime country with more than 70% of the territorial waters (coastal, river, and lake) has a challenge and a great potential to save the waterfront area as a buffer zone and conservation of natural environment. Institutions would need a handler to remain subdued conservation function along the waterfront area. The current condition that occurs is the utilization of an increasingly waterside area that is out of control, both in quality and quantity. Actually, the existence of the waterfront area can be optimized as a potential part of green city design through the concept of waterfront as well as substitution of Green Open Space area ([Respati, 2004](#)).

This paper is organized as the following; we firstly investigated literature regarding the influence of urbanization on global warming from a view of green city design. Secondly, reviews on Surabaya's development plan have

been conducted with an emphasis on urban planning studies and environmental planning aspects of open space. Thirdly, we discuss about the concept of green design city in Surabaya's development plan as an ecological approach and some policy interventions in urban space utilization to ensure the ecological functions of the city. The last section is the conclusion.

## 2. LITERATURE REVIEW ON GREEN CITY DESIGN

Some research reports talk about green city design for global warming anticipatory basically from the concept of open space, green city, pollution, and sustainable city, such as Dyer (1994), Li, et al. (2005), Li and Wang (2003b), Bradley (1995), Shafer (1999), Diamantini and Zanon (2000), L'utz and Bastian (2002). Generally, city planning and design is an integrated form of physical intervention, which involves socio-cultural, economic and political unity of urban spaces. Thus, the city is a design product in which urban policies are set out in the framework of spatial arrangement of land use as a solution to urban problems in resource utilization (urban space), as well as the linkages between various urban functions in accordance with the necessary infrastructure capacity (Respati, 2004). Furthermore, the aspects of an effective utilization of an urban open space are a primary consideration, such as how aspects of city life (natural and socio-economic) can be accommodated in the spatial structure. The role of urban planning and design in anticipating the impact of global warming become extremely important in order to protect and create a comfortable living environment and healthy communities through green city design. The planning and management of urban green space development is significance to urban sustainable development (Miller, 1988; Grey, 1996). Urban planning and design decisions have a very strong impact on overall physical context, so that deciding the form of the plan must go through a comprehensive consideration.

As an integrated management tool of urban areas, urban design basically aims to promote the formation of urban regulation that is able to anticipate all aspects of urban development including the impact of global warming. It is also a solution for the constraints of natural and artificial environments. According to Shirvani (1985), in his book *The Urban Design Process*, urban design is a part of the planning process relating to the physical design of urban space and an environment dedicated to the public interest. When viewed from the city-forming element, it's essentially the substance of urban design that actually involves three main elements, they are:

1. Natural environmental factors; natural characteristic is the basic element that will provide the specific characteristics of a region / city. Control of utilization of the natural environment will be crucial in designing the urban environment while ensuring the ecological functions of urban neighborhood to remain alive. These natural factors include: climate, topography, seism city, geomorphology, humidity, air temperature, flora and fauna and so on.
2. Artificial environmental factors, the condition of artificial environment potency as a product of cultural communities that have formed a specific environment which should be a consideration as a whole activity product of society.

3. Non-physical environmental factors, socio-cultural, economic, political, and technological, as a background for the formation factor of human built environment.

Those three factors are a unity that influences each other. The natural environment will determine the structure and patterns of specific cities, as a reflection of patterns of behavior and socio-cultural values, economics and politics behind them ([Shirvani, 1985](#)).

The planning of green spaces is one of the significance towards sustainable urban development ([Teal et al., 1998](#)). Urban green space improves the urban environment, which contributes to the public health and improves the quality of urban life ([Thompson, 2002](#)). The concept of green city design as a form of micro-city neighborhood becomes a global issue now. Green City in the Environment World Days in 2005 is used as a central issue in an attempt to save the environment from global warming. Green City is a response towards urbanization in big cities of the world, which has led to the carrying capacity of an urban environment that is in very poor conditions. Green City is conceived as an answer which puts its' emphasize on aspects of environmental sustainability considerations in solving urban problems. Urban green spaces are an important component of the complex urban ecosystem ([Li, et al., 2005](#)). Parks, forests and farmlands are three main types of urban green space, which have significant ecological, social, as well as economic functions ([Bradley, 1995](#); [Shafer, 1999](#); [L'utz and Bastian, 2002](#)).

Furthermore, green city design is closely associated with the presence of the urban landscape. The urban landscapes as the embodiment of a role entity is functioned to ensure the sustainability of ecological functions of the city. According to Li, et al. ([2005](#)), Landscape ecology is the study of interactions among landscape element. Landscape ecology generates understanding of how spatial pattern affects ecological processes. The main principle of green city design is essentially about urban design efforts by creating an environment that ensures ecological functions of the city. It is also shown by the experience of several cities in the world in an effort to rescue the city environment. Learning from the experience of several countries about the efforts to save the environment should not be done by extreme huge finance, where are successful in the quality improvement efforts in a sustainable environment by maintaining a balance among economic, social and environment in an integrated and sustainability. Here are several successful environmental rescue efforts:

1. In the spirit Mottai-Nai in Japan has successfully implemented the movement of 3Rs (Reducing, Reusing, and Recycling) in an attempt to preserve the environment. Mottai-Nai is a spirit of living habits or behavior that respects and maintains the product by recycling. Japanese Environment Minister in 2003-2005 periods applies that spirit through movement Nai Mottai-3R (Reducing, Reusing, and Recycling) by reducing the waste, reusing old items, and recycle materials that is recyclable.
2. In Switzerland, they have developed a roof garden. The roof of the house used as part of the environment. Make the roofs a green land by planting various crops. Additionally rooftops also developed to absorb solar energy, which is used as a power source, while still laid some green plants underneath.
3. Bogota mayor in 1998-2001 period, Enrique Penalosa implement the Transmilenio programs, high car taxes, tree planting, 1000 redevelopment of parking, bike lanes along the 374 km, and the

pedestrian along 17 km. People can congregate in public spaces such as streets and city parks where all people have equal rights. To build a humanist or city ciudad Humana is appropriate if the users of bicycles and pedestrians should be pampered. For example, Bogota, before there is a special bike lane, cyclists are 4% only. But after there is a special line for bikes, within five years it has risen to 14 percent of total trips by using bicycles. If the available public transport is safe, convenient, punctual, provided a special bike track, safe pedestrian facilities and comfort, then people will choose the facility as a third mode of transportation rather than private car which can stuck in traffic for hours on the road and waste fuel.

Green city design can ensure the ongoing ecological functions of the city, because of the availability of urban adequate green open spaces or within a relatively large proportion. Formal regulations in Indonesia bring the proportion of urban green open space in the Law of the Republic of Indonesia on Act No 26 year 2007 on Spatial Planning, which sets a minimum of 30% green city open spaces of the total city area. Provision of open space that a city can do is through the utilization of demarcation along the river watersheds, beaches, reservoirs, utilization roof garden, as well as planning and design of open spaces other cities.

Implementation of green urban design in Indonesia is still facing very complex issues, including socio-cultural problems, economically and politically. Substantially, products of city planning and design in Indonesia have not fully made the issue of global warming become a strategic issue. The main orientation of urban planning and design ([Shirvani, 1985](#)) of products is still dominated by the orientation of the economy (development orientation), in addition to the orientation on environmental sustainability (environmental orientation) and in the interests of the community (community orientation). In the following section, we review the Surabaya's development plan for understanding how the concept of green city design can be put into planning practice in Indonesia.

### **3. SURABAYA'S DEVELOPMENT PLAN AND URBANIZATION**

#### **3.1 Case study city**

This case study city is Surabaya as the second largest coastal city in Indonesia. In the National Long Term Development Plan, Surabaya is designated as the National Development Center of eastern Indonesia. Therefore, it is very interesting to know how the planning and design of Surabaya in addressing the current global warming Issues.

As shown in Fig.1, Surabaya is the capital city of East Java province, which has a geographic position at 07 021 'south latitude and 112 036' to 112 054 'East longitude, with its boundaries described as follows:

- Northern frontier: Madura Strait
- Southern boundary: Sidoarjo regency
- Western frontier: Gresik regency
- Eastern Boundary: Madura Strait

The study was conducted by analyzing the designs of Long-Term Development Plan of 2005-2025 and Spatial Planning of Surabaya 2009-

2029, in which we are concerned with the aspects of urban planning and design related to the environmental preservation efforts, as well as consistency between development policies.

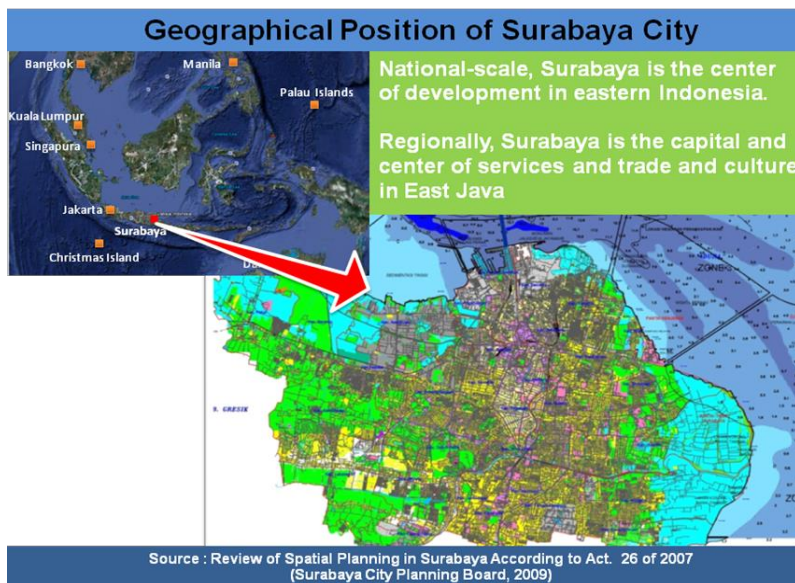


Figure 1. Geographical position of Surabaya city as Case

### 3.2 Urbanization in Surabaya

Regarding land use utilization and environmental conditions, indication of compliance on Surabaya's Development Plan looks at the suitability of different types of land uses and public facilities. Based on the data analysis of Surabaya long-term planning, extensive land is used for the settlement of  $\pm 12184.71$  Ha. The need for residential land in Surabaya will reach approximately 13553.36 hectares or 41.01% of the total land area of 33 048 hectares. The total housing land requirement is expected to accommodate about 556 542 housing units. So that the needs of residential land is estimated for the year 2029 about 1368.66 acres use of land for public facilities (educational, health, worship, government, culture and recreation) reaches  $\pm 7.718\%$  or 2550.58 Ha. Commercial activities (trade and services) are expected to reach approximately  $\pm 7.721\%$  2551.76 Ha of the total area of Surabaya city. Industrial and warehousing activities are estimated at  $\pm 3264.92$  hectares or 9.879% of the region consisting of the Industrial and Warehouse industry and households scattered in the city of Surabaya. Special area of activities (military) is expected to reach 771.13 Ha or  $\pm 2.33\%$  of the total area in Surabaya city. While the area is built, which was directed in the form of a green open space (protected areas, parks, sports facilities and grave yards) is estimated at  $\pm 7481.35$  hectares or 22.638% of the city. Wide roads of 2512.39 hectares or 7.602% and the river reached 362.51 hectares or 1.097%. This condition suggests that the city of Surabaya will experience rapid growth where land-use estimates for each designation tends to increase along with the population growth.

Uncontrolled numbers of migrants increased in Surabaya city which can lead to the emergence of solid areas and slums in the city center, near the coast, on the railroad and along the river border. Urbanization will have a negative impact if the development efforts can't be controlled. Mobility of commuters each day to Surabaya has contributed in creating a point of

congestion in the streets of Surabaya during the work hours. The use of mass public transit systems and inter-mode system that connects the center of activity is expected to reduce both traffic density and congestion due to commuter mobility, and internal mobility of citizens of Surabaya city. Utilization of the railway line to parse downtown congestion in the city center would be optimal.

Furthermore, the socio-cultural gaps as a result of urbanization will confront the government of Surabaya within the next 15 years associated with the demographic problem is the increasing number of population (Fig.2), mainly for the productive age (15-64 years), the implications of which require an increase in the fulfillment of educational facilities, health and expansion of employment and business opportunities. Increasing the number of migrants as a result of successful development, particularly in education will bring socio-cultural issues that must be anticipated to social vulnerabilities that always accompany the development of metropolitan cities.

Progress and development of the city of Surabaya will bring even higher attraction for the community in Surabaya. It is difficult to avoid urbanization so that unemployment will rise. If this is not anticipated by implementing various control measures of urbanization, population growth and expanding employment, the problems will be very complex.

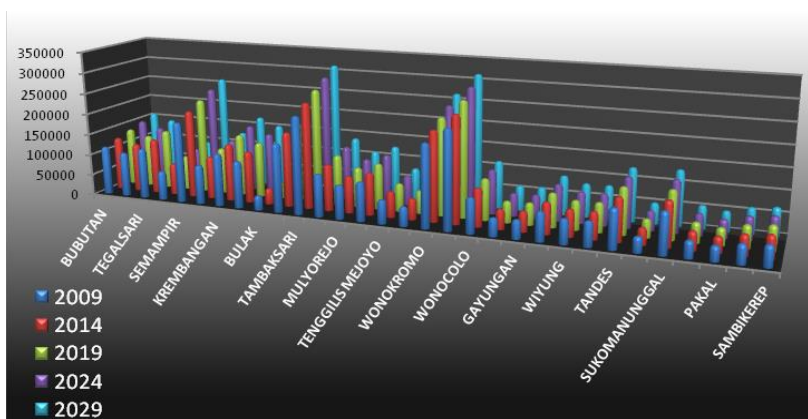


Figure 2. Graph of Surabaya Population Prediction per Sub Region to 2029  
(Source: Surabaya City Planning Board 2010)

### 3.3 Planning issues in urbanization process

Surabaya's development plan attempts to find solutions of various planning issues in its urbanization process. Integrated spatial patterns between the city center (urban) and the suburbs (suburbs), between Surabaya with the surrounding area, supports the function as service centers in Surabaya Metropolitan Area context and Germakertanusila (Gresik, Madura, Mojokerto, Surabaya, and Sidoarjo Regency). As an indirect result of the high intensity of land use, the conversion of land can't be avoided. The challenge is the increasing conversion of agricultural land use or land change function of cultivated area. Zoning for urban green space is largely determined in the Eastern region city of Surabaya (Fig.3.).

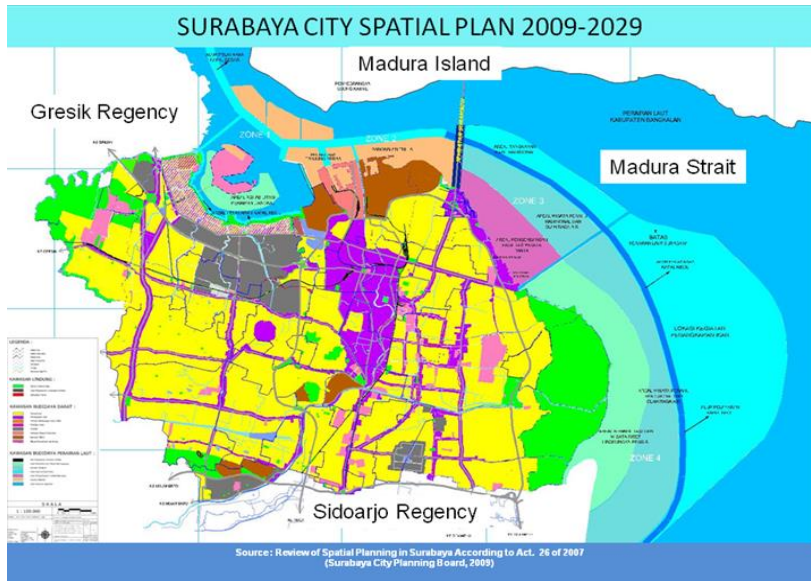


Figure 3. Surabaya City Spatial Plan 2009-2029  
(Source: Surabaya City Planning Board 2010)

The high dynamics of the city of Surabaya developments resulted in a high intensity of land use in Surabaya downtown. This led to the economic value of land that is increasing. The high economic value of the land encourages utilization of services trade both urban and regional scale (Fig.4.). Yet, the increase in the economic value is also an impact on the utilization of open spaces to green open space of diminishing returns. Current percentage of green space compared to the overall size of the city is 20.84% according to Surabaya City Spatial Plan 2009. Average building density is high (more than 50 buildings / Ha).



Figure 4. Major Opportunity Development of Surabaya 2009-2029  
(Source: Surabaya City Planning Board 2010)

Several projects should be done is to protect the area along the riverbanks Kalimas. The river is very important to keep the city from the threat of flooding; it must have to be revitalized in order to function properly (Fig.5.). Surabaya is a coast city, so the waterfront area should be maintained properly. East Surabaya region needs to be developed for the



green barrier, mangrove reforestation, and keep the area from tidal waves (Fig.6).

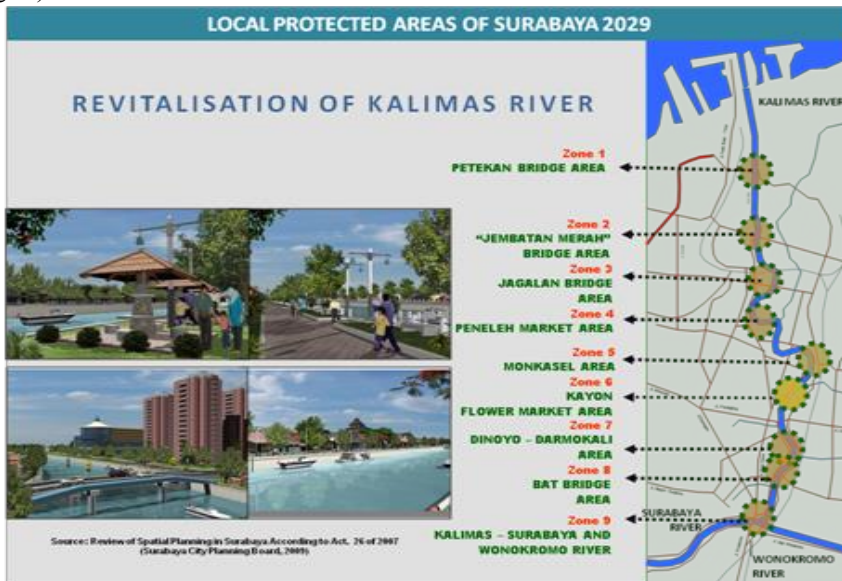


Figure 5. Local protected Areas of Surabaya 2029 (1)  
(Source: Surabaya City Planning Board 2010)

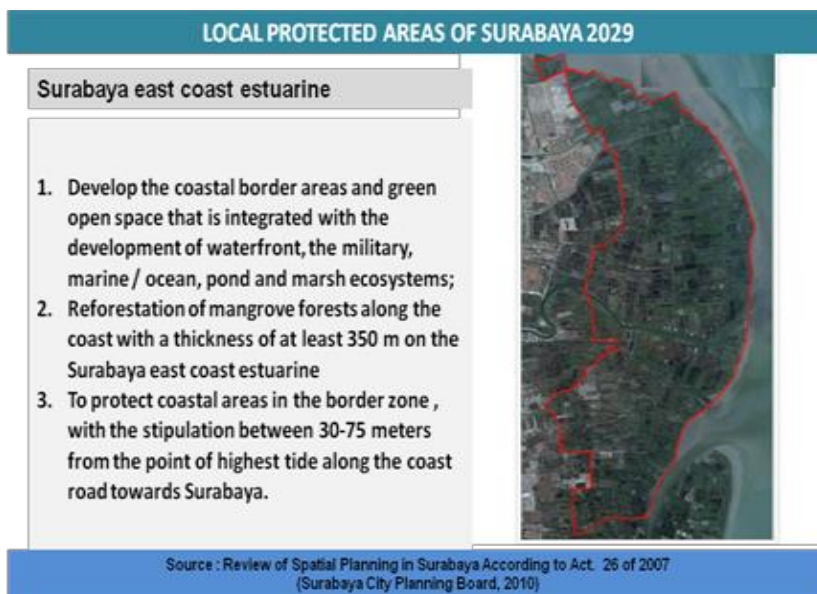


Figure 6. Local protected Areas of Surabaya 2029(2)  
(Source: Surabaya City Planning Board 2010)

Until 2025, the city of Surabaya faces the problem of life quality in its urbanization process. Quality of life of a region is influenced by complicated factors including health, education, security, economics and so on, which are multidimensional, not just about the size of income. Various measures of empowerment, care, rehabilitation, and social protection to vulnerable communities including the social welfare problem have been done, however, the number of social welfare problems are not diminishing in number. The problem of poverty in the city of Surabaya is still a threat that needs to be handled carefully and seriously.

Beside of those issues regarding land use pattern and life quality, statistics have a tendency to decrease the incidence of fire, because there are many sources of water that can be taken to extinguish the fire. Water

resources are one of the taken advantages of unused land that is not supervised and not be used, which is precisely also trigger the emergence of illegal settlement.

## **4. GREEN CITY DESIGN IN ECOLOGICAL SYSTEM OF SURABAYA**

### **4.1 Ecological system**

According to Diamantini and Zanon (2000), the new ecological indicators should be developed for urban planning for sustainable development. Comparison between the areas of green open space can assess the quality of urban planning, although it can't reflect the quality of green open space. As the research conducted by Dyer (1994), the author mentioned that range limits of many plant species are expected to shift dramatically for climatic warming, driven by the release of greenhouse gases, occurs in the next century. In this case, Surabaya City is a center of the Eastern Indonesia development. As shown in Fig.7, development of Surabaya coastal areas became national scale port is a dilemma dealing with conservation of coastal areas. Areas of coastal water ecosystems are dynamic ecosystems and have a wealth of diverse habitats, both on land and at sea as well as interact with each other. Besides having great potential, coastal ecosystems are also vulnerable to the impact of human activities. General construction activities are directly or indirectly, will adversely impact on coastal aquatic ecosystems. River Lamong project activities in the North Coast region Surabaya will create an international harbor and a waterfront city. However, this activity will threaten the existence of mangrove ecosystems that exist, although the region is only 10% of the sea, but holds nearly 90% of marine life.

Mangrove ecosystem damage also occurred in the East Coast of Surabaya. Triggered by events other than reclamation on river and coastal pollution levels, environmental declaration program protects the mangrove ecosystem in the region East Coast of Surabaya is very important to keep the environment sustainability. Conservation of East Coast of Surabaya will save the biodiversity and ecotourism potential of the region. A review of 2008 is known that the condition of 40% or about 400 acres mangrove forests in the region of East Coast of Surabaya is in damaged condition. There was a 29.8 km long coastline of mangrove in the region of East Coast of Surabaya, now only 8.7 km of mangrove vegetation is overgrown with a thickness of not more than 50 meters. This is very different from the situation in the 1990s, where the thickness of the mangrove forest can be more than 50 meters and they grew up along the shoreline in the East Coast of Surabaya.

### **4.2 Toward green city design: spatial structure and patterns**

In accordance with the laws of spatial No. 26 of 2007, the development of Surabaya city should refer to the long-term development plans of national, provincial and city of Surabaya for ensuring the proportion of green open space. In the design of long-term development plan of the town which contained 8 Surabaya's development missions. One of the Surabaya's

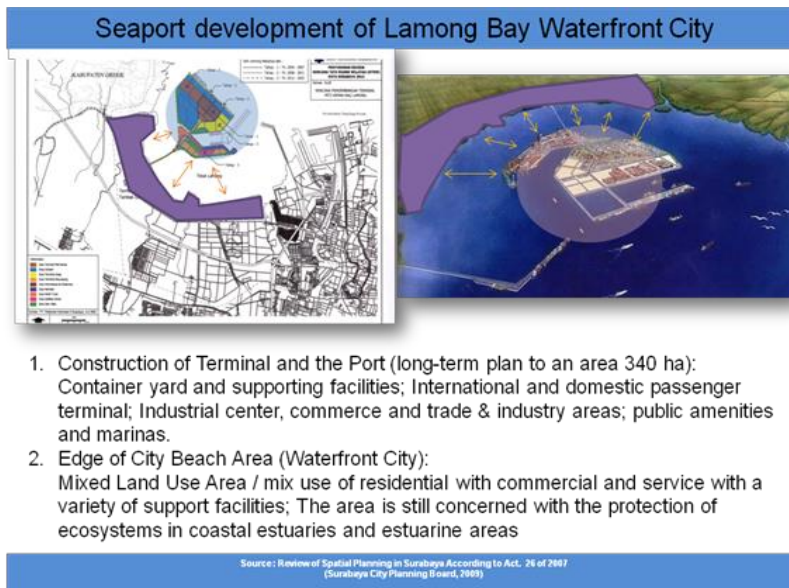
urban development missions is making environmentally spatial planning and put its orientation to the principles of equitable and sustainable way to achieve the eco-city Surabaya. Indication of the success of this mission is characterized by the preservation of green open space and increase the percentage of its range, decrease in the slums, the reduced extent of inundation/flooding, increasing the quality of the environment (land, water, air), the establishment of conservation of water catchments areas, the increase of natural resources can be utilized, and reduced marginal lands due to excessive water uptake, increasing the coverage status of basic infrastructure services settlement environment, the increasing coverage of water services, reduced levels of pollution in watersheds and coastal areas, the use of zones and areas of integrated coastal zone management and sustainable, less mangrove ecosystems and biological resources are damaged, increasing the contribution of the fisheries, the increasing role of the community, the increasing number of proposals for large-scale projects that use the concept of green city, green architecture, as well as the concept of sustainable development concept.

In the description of this mission there are 11 described the efforts in achieving this mission, namely:

1. Planning, utilization, control the intensity of land coverage, focused on efforts to control land uses that do not pay attention to the portion of green open space to built space.
2. Control of land conversion, control efforts directed at converting open spaces into green productive land up.
3. Slum reduction, aimed at reducing slum area, both in the city center, near the coast, along the border on the edge of the river and railroad tracks.
4. Reduction in disaster-prone areas, aimed at reducing disaster-prone areas, both flooded / inundation or fire.
5. Integrated Management and conservation of coastal areas.
6. Increased use of environmentally friendly energy is directed in an effort to diversify the sources of primary energy with renewable energy is more environmentally friendly.
7. Utilization of Natural Resources Renewable, aimed to increase the carrying capacity of nature and environmental preservation and welfare. Restrictions on the use of natural resources are directed to maintain stability and carrying capacity of nature to be done correctly.
8. Utilization of renewable natural resources is directed at meeting the interests of the carrying capacity of nature and environmental conservation and social welfare.
9. Water Resources Management, aimed to improve water resource management of surface water that provides justice for the community to meet the various needs of the conservation, utilization and control the water resources.
10. Housing and Settlement directed to fulfill the needs of the home as well as the formation of a healthy environment and appropriate allocation function. The project will also be directed to improve the distribution and dispersion of population and development.
11. Increase community participation in climate change mitigation and adaptation

In Surabaya's development plan, the planning measures are suggested from the views of spatial structure and spatial pattern as the following:

- 1) Spatial structure: Establishment of service centers and sub centers in hierarchical service as national and international service centers, service centers and regional cities, Sub City Centre and the Centre for Development Unit (UP) and ocean zoning to be four zones to support the development of a knot trading activities and services based on the characteristics and potentials of marine areas as well as policy development is an integrated network system between the system of transportation networks, energy network system, telecommunication network systems, ecological network systems including green open space and water resources, urban infrastructure systems.
- 2) Spatial Pattern: the establishment of protected areas with the establishment of various protected functions of the city and the integrated conservation area covers the protection against the employee; local protected areas; nature reserves and cultural reserves; area of green open space; disaster-prone areas, and coastal areas marine areas as well as by improving the function of each area in the city of Surabaya, including residential areas; areas of trade and services; office area; the industrial area; the area of tourism; non green open space areas; the evacuation chamber; the allotment of space for informal sector activities and the other designation.



*Figure 7.* Seaport development of Lamong Bay Waterfront City  
(Source: Surabaya City Planning Board, 2010)

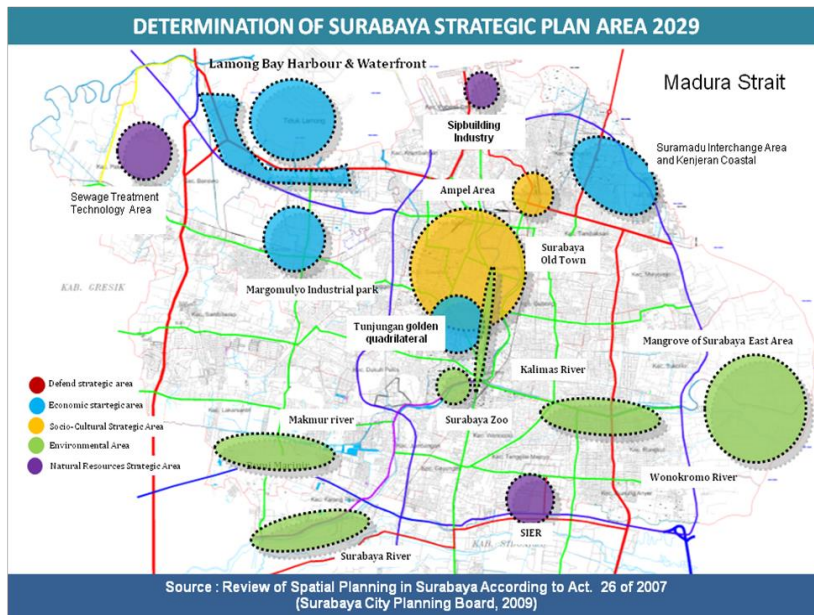


Figure 8. Determination of Surabaya Strategic Plan Area 2029  
(Source: Surabaya City Planning Board 2010)

Spatial strategic planning based on economic aspects, the functions and carrying capacity of the environment, social, cultural, and high technology; and the development and/or limitation of function are shown as intended spatial structure and spatial pattern endorsed in Fig.8 strategic areas in urban and regional scale.

### 4.3 Discussion on Surabaya's planning practice

In Surabaya's development plan, an ecological approach to urban planning became a very important approach in anticipating global warming. Approach to effective functioning of open space (ecological, social and economic) into new approaches was taken into account in Surabaya's development plan. Effective use of urban space becomes a challenge in implementing the concept of green city design in this city. The city should be viewed as an ecosystem of dynamic interaction between social life community and nature environment, which becomes a major mindset in urban planning and design approach.

In the case of Surabaya's development plan, it can actually be done with physical intervention through urban planning and design in order to anticipate global warming in urban development. Urban planning and design that puts the interests of environmental sustainability is recognized as a guarantee of sustainable development not only for the current generation but also for future generations. Some policy interventions in urban space utilization are considered to ensure setting the urban policy development and management from the following points in the case of Surabaya city:

1. Urban development should be continuing to be supported by the city's infrastructure (transportation, sanitation, drainage, etc.) that are environmentally friendly and adequately supporting the environmental sustainability efforts.
2. Efforts to use space should be done by reducing vulnerability environment, so that the environmental carrying capacity can be maintained to avoid the threat of rising sea levels, flooding, abrasion, and other natural hazards.

3. The design of urban areas should be able to sustain the ongoing ecological processes essential for life support systems and biodiversity, so that the ecological functions of the city remain stable.
4. The city government needs to apply the principles of good governance, so that the integration step between the public, investors and government can participate synergistically in creating a comfortable urban environment, and sustainable. Bottom-up approach emphasizes the role of the community (participatory planning process) in the implementation of urban development in a transparent and accountable to be more accommodating to the various inputs and aspirations of all stakeholders in the implementation of development, especially in conserving the natural environment.
5. Law enforcement is consistent and consistently – both government regulation, decree, or local regulations to avoid unilateral interests and for the implementation of role sharing a 'balanced' between the elements of stakeholders in creating a healthy environment and sustainable cities

As discussion above, a city is a very complex ecosystem consisting of natural, socio-cultural subsystems, and the economy. In addition to natural factors, socio-cultural aspects, and economics play an important role in planning and managing urban green open space, and wider urban environment. The success of urban planning and design is actually not located in a beautiful design outcome, but rather on how urban planning can be implemented. The city planners who have an important role to realize the product planning and urban design, with the involvement of all stakeholders, coordinate the city government. Increase the participation of all stakeholders, and better coordination of planning agencies are critical to the success of urban planning and design. Thus, it is still a long way to the goal of Surabaya's development plan.

## **5. CONCLUSION**

This study is the result of reviewing the Long-Term Development Plan for 2005-2025 and Spatial Planning of Surabaya in the period of 2009-2029 from the view of green city design. In the Surabaya's development plan, the phenomenon of global warming, which will give a direct impact on coastal cities such as Surabaya, underlies the importance of making anticipatory efforts through urban planning. Some planning works anticipate a solution designed to provide input to the Government of Surabaya city including the revitalization of the river Kalimas, mangrove reforestation, solution development of green areas in the east of the city, and port development projects. But it all depends on the local government through anticipatory planning.

Substantially, products of city planning and design have become the major objectives in spatial strategic plan in Indonesia. However, for the implementation of green city design, as described above, Indonesia still requires a long process and the role of urban planning and design has a very large role in the effort to realize or toward green city. Besides, implementation of green city design in Indonesia is still facing very complex issues, including socio-cultural problems, economically and politically. This research report is expected to assist policy makers in the planning and

design of the city of Surabaya, so as to anticipate global warming issue at this time.

## 6. ACKNOWLEDGMENTS

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# Integrating Low-carbon Concepts in Urban Planning: Practices in Xiamen and Implications

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**Abstract:** Cities are critical battlefronts in the struggle to mitigate climate change crisis. Urban planning is widely recognized as an important policy and technology tool for the low-carbon development of cities. However, the methods of integrating low-carbon concept into the existing planning system and practices have yet to be studied. More cases are still needed to examine the existing wisdom. By taking the Chinese city of Xiamen as a case study, this study attempts to show a city's efforts to make itself "a low-carbon city in China" in the field of urban planning, to sketch out the general governance framework that make those efforts work, and meanwhile to analyse the problems existing in the process, in the hope of providing some references for those who are concerned about low-carbon city development.

## 1. INTRODUCTION

Global warming and its related symptoms of climate change have become one of the most pressing issues facing the world. According to the Nobel-Prize-winning Intergovernmental Panel on Climate Change (IPCC), most of the observed increase in average global temperatures since the mid-20th century was likely caused by an increase in anthropogenic greenhouse gas (GHG) concentrations ([IPCC, 2007a](#); [2007b](#)). Therefore, reducing anthropogenic GHG emissions has been widely recognized as an essential countermeasure to mitigate climate change. Lowering the carbon footprints of human activities and reducing carbon emissions, measures that are inherent to the term "low-carbon", are especially critical, because carbon-related CO<sub>2</sub> and CH<sub>4</sub> are two sorts of most important anthropogenic GHGs. These two together account for over 90 percent of global anthropogenic GHG emissions.

Normally, GHG production is described by sector, such as residential and commercial buildings, transportation, industry, or agriculture. "But this division (by sector) obscures a fundamental point: cities are responsible for 80 percent of all GHGs - caused by the way we build and arrange our buildings, by all the stuff we put in them, and by how we move from one building to the next" ([Condon, 2010](#)). This implies that cities are critical battlefronts in the struggle to mitigate climate change. Since the problem is



caused primarily by cities, cities should therefore be responsible for the solution ([Gurney, et al., 2009](#)).

Although the climate issue is conventionally seen as the province of nation states and international negotiations, the success of climate change action depends on concerted local support ([ICLEI, 1995a; 1995b](#)). The actions taken to reduce GHGs are and will remain to be local efforts in cities ([Agyeman et al., 1998](#)). Studies from a number of countries show that city governments have critical roles in adapting to climate change as well as GHG emission mitigation ([Coenen and Menkveld, 2002; Groven and Aall, 2002; Lindseth, 2004; Climate Group, 2009](#)). Cities exercise key power over many activities that create sources or sinks of GHG emissions, including decisions governing urban form, transportation, energy use, production and distribution, waste and waste-water management, and forest protection ([ICLEI, 1995a; 1995b](#)). Notably, these activities fall within the scope of urban planning. In reshaping urban form and environment, planning tools can be used to influence the energy use of buildings, the amount of travel and modes of transportation, the distribution of carbon sinks, and a host of other decisions that can either advance or hinder climate change mitigation. Low-carbon-oriented planning is therefore a key technology for the development of low-carbon cities ([Gu, et al., 2009](#)).

A number of studies have explored the planning strategies for climate change mitigation. Condon ([2010](#)) summarizes the planning strategies for a post-carbon world as "seven rules": (1) restore the streetcar city; (2) design an interconnected street system; (3) locate commercial services, frequent transit, and schools within a five-minute walk; (4) locate good jobs close to affordable homes; (5) provide a diversity of housing types; (6) create a linked system of natural areas and parks; (7) invest in lighter, greener, cheaper, smarter infrastructures. In *Urbanism in the Age of Climate Change*, Calthorpe ([2011](#)) argues that combining sustainable urbanism – community designs that consider the traditional tenets of urbanism with added emphasis on conservation and regionalism – with renewable energy, conservation techniques, and green technologies offers a solution that can lower carbon emissions, conserve resources, and generate community life. In fact, the main principles of New Urbanism and Smart Growth, which are regarded as "the pioneering reforms before sustainable urbanism" ([Farr, 2008](#)), have already constituted a set of planning strategies to increase resource efficiency and decrease energy demand (thus reducing carbon emissions) in urban areas, including "compact urban form", "mixed land use", "pedestrian-friendly built environment" and "transit-oriented development" ([CNU, 2000](#)).

To a large extent, pioneering studies, including those referenced above, have laid out the principles of sustainable urbanism as well as the design components of "low-carbon planning". However, the methods of integrating these principles and design components into the existing planning system and practices remain to be studied. In general, integrating "low-carbon" concepts into urban planning practices is still in the early stages of an exploratory trial. The planning tools to facilitate low-carbon development have not yet been mastered by city planners and decision makers. Urban planners and local decision-makers need good examples from which to learn and a "learning-by-doing" process to gain a more thorough understanding of low-carbon planning. Besides, integrating low-carbon concepts into urban planning relates to a broader context of urban governance and national strategy in addressing the global challenge of climate change. It is also

important to understand the supportive regulations and policy framework; moreover, the adoption of low-carbon-oriented planning should also fit well within a local development agenda ([Satterthwaite, 2008](#)). In rapidly urbanizing regions (mostly developing countries), the process of urbanization and coping with climate change individually and collectively is an ever-growing challenge to regional and urban planners ([Clark, 2009](#)). On one hand, city planners and decision-makers need to make efforts to accommodate the growing population and economic activities, while cutting down carbon emissions on the other. This is a challenge to city planners and decision-makers, and also a meaningful issue for researchers.

After decades of rapid economic growth, hampered with high-energy consumption and low-efficiency resource utilization, China currently faces some of the most serious energy and environmental problems. Since 2000, China has generated two-thirds of the globally increased carbon emissions ([Garnaut, 2008](#)). In fact, China has recently overtaken the USA as the world's largest CO<sub>2</sub> emitter. China is therefore under great pressure to make developments in energy conservation and GHG emission reduction. Actively cutting carbon emissions to mitigate climate change is not only China's obligation as a responsible major country, but also the only way to achieve sustainable development of the country ([NDRCC, 2007](#); [Xie, 2010](#)). Since China announced its goal of "40-45% reduction of carbon emissions by 2020 based on the 2005 level" at the 2009 Copenhagen Climate Change Conference, pressure has been placed on local authorities at all levels to set and meet their own carbon reduction targets. Actively and effectively reducing carbon emissions without impeding local economic growth is now a central agenda and major concern for all levels of Chinese government. Studying the experiences of low-carbon city development would contribute to the theoretical explorations of both so-called "neo-urbanization" (also known as the "new form of urbanization") and urban planning theory in China ([Dai, 2009](#)). By taking the city of Xiamen as a case study and looking into the field of urban planning, the presented study attempts to show the city's efforts to make itself a low-carbon Chinese city, to draft the general governance framework that makes those efforts work, and to analyze the difficulties and problems existing in the process.

This paper is organized into five sections. Following the introduction, the major challenges to Xiamen's low-carbon development are described in the second section in order to provide a thorough background. In the third section, the strategic framework governing the low-carbon development of Xiamen is illustrated in terms of guiding regulations and higher-level plans, the development objectives, and the deployment of major projects. Next, three low-carbon-oriented planning cases recently conducted in Xiamen are analyzed in details in the fourth section, with a focus on the "low-carbon elements" are integrated into these plans. Finally, in the fifth section, the problems existing in the process and their implications for urban planning are discussed as a conclusion of the paper.

## **2. MAJOR CHALLENGES TO THE LOW-CARBON DEVELOPMENT OF XIAMEN**

### **2.1 Rapid Economic and Population Growth**

The city of Xiamen is located on China's southeast coast (117°53' E - 118°27' E; 24°25'N - 24°55'N). It is one of the earliest four Special Economic Zones (SEZs) in China and a major city on the Taiwan Strait's west bank, with a total administrative area of 1573.16 km<sup>2</sup>. The 131 km<sup>2</sup> of Xiamen Island is the earliest developed area and remains the central city today.

Like the vast majority of cities in China, Xiamen's economic and social developments have been in a state of rapid growth since the country's reform and opening up. According to the data released by Xiamen's Bureau of Statistics, the city's GDP was only 741 million Yuan in 1981 when the Xiamen Special Economic Zone was newly established. It then surged to 253.6 billion Yuan in 2011, with an average annual growth rate of more than 16%. Notably, the city's GDP crossed the 100 billion Yuan mark in 2006, and the 200 billion Yuan mark in 2010. That means its GDP nearly doubled in just five years. Xiamen City's gross industrial output has continued its growth for many years. The total annual industrial production increased from 111.15 billion Yuan in 2002 to 466.47 billion Yuan in 2012.

At the same time, the population of Xiamen City is also growing rapidly. According to the Sixth National Census data, the resident population of Xiamen City was 353.13 million as of 12am on November 1, 2010. Compared with 205.31 million at the Fifth National Census in 2000, there was an increase of 147.82 million people. This is an increase of 72% over 10 years. The average annual growth rate was 5.57%, significantly higher than Fujian Province's annual average population growth rate of 0.61% during the same period. The rapidly expanding populations brought Xiamen City from the least populated city of the province's nine prefecture-level cities to the fourth largest populated city, after Quanzhou, Fuzhou and Zhangzhou City. In fact, the population growth rate was even far beyond the expectations of Xiamen municipal authorities.

Rapid economic and population growth will inevitably result in an increase of energy demand. Although Xiamen City has been committed to optimizing industrial structure and energy efficiency improvements, and has achieved rather good results (for example, in 2010 Xiamen City's energy consumption per every ten thousand Yuan GDP was 0.569 tons of standard coal, equivalent to 54% of the national average and 71% of the province's average; the industrial added value per ten thousand Yuan was 0.408 tons of standard coal consumption, equivalent to 36% of the province's average). However, the city's total energy consumption still shows continuous growth. As shown in Figure 1, the total energy consumption of Xiamen City in 2004 was 548 million tons of standard coal, increasing to 10.77 million tons of standard coal by 2011. Provided that carbon-based fossil energy structures have not fundamentally changed, this means that urban carbon emissions continued to grow.

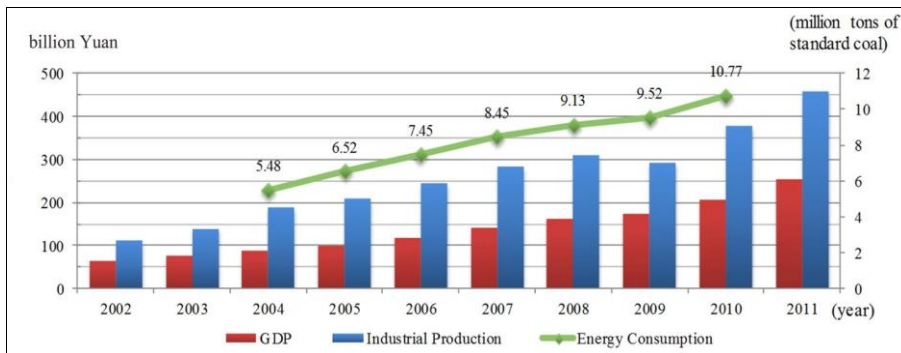


Figure 1. Economic growth and energy consumption increase in Xiamen during 2002-2011

## 2.2 Spatial Sprawl towards a “Bay City”

Since the reform and opening up, cities in China have been experiencing rapid growth and remarkable restructuring. So has the case study city of Xiamen.

The spatial structure of Xiamen city is undergoing a strategic shift and unprecedented change from an "Island City" to a "Bay City". Since the latest revisions of the overall urban planning of Xiamen City (2004-2020) in 2003, Xiamen City has come to the establishment that the development focus would shift from the Xiamen island to outside of Xiamen island. The spatial development strategy is to build Xiamen City into a bay city that has "one heart, two wings, four auxiliaries, eight areas." Among them, "one heart" refers to Xiamen Island with an area of 131 square kilometers (i.e. the Xiamen Island); "two wings" refers to the bays on the east and west sides of the island; the "four auxiliaries" refer to four new towns outside Xiamen Island (auxiliary towns), namely Haicang, Jimei, Tong'an, and Xiang'an; "eight areas" refers to the eight key development areas in the four new towns. Xiamen City has also established the objectives of its comprehensive transportation system planning, which are (1) to service long-term development goals of the bay city, (2) to support Xiamen City's functions as the central city in "Western Taiwan Straits Economic Zone", and (3) to coordinate the city's economic and social development. Under the guidance of this master plan, massive urban development and construction has kicked off in an area several times larger than Xiamen Island; Xiamen City's future traffic patterns expand from the center of the island to new towns outside of Xiamen Island. The demand for motorized transport and its traffic mileage would increase substantially; travel across the sea to and from the island is expected to reach more than 500,000 passengers per day (one-way). With the pace of development in the Western Taiwan Straits Economic Zone, the commute between Xiamen and its east and west wings, Quanzhou and Zhangzhou, will be closer. Guiding and grasping the unprecedented structural adjustments and spatial expansion for Xiamen City is a major issue in front of city policymakers, planners, and researchers.

## 2.3 Ever-faster Car Boom

While the overall urban form is getting larger and increasingly fragmented, the spatial patterns of people's daily lives have also changed. Working and living are getting separated by housing commercialization (it is

worthy to note that many commercial houses are built in a city's newly developed outskirts) and the disappearance of former "work-unit compound" structures (i.e. welfare housing or factory dormitories). More and more people therefore have to deal with long, frustrating commutes on a daily basis. Meanwhile, urban facilities (such as shops, hospitals, schools, and public transport) are either totally or partly "commercialized", resulting in certain service vacancies where the resident density is not high enough to make those services profitable. Together with the increase in people's income and the inducement of car advertisements, more and more people are choosing to buy a private car when they can afford it ([Wang, 2013](#)). As a result, there has been a surge in automobile purchases in Chinese cities in recent years. In fact, China has become the world's largest automaker and seller since 2009, with two-digit annual growth rates. The yearly sale of cars in China has reached 19.31 million in 2012, once again setting a new world record.

The situation in Xiamen is similar. According to the data released by the Department of Traffic Police, the number of motor vehicles in Xiamen has reached 0.92 million by the end of 2012, of which 0.52 million are private cars (56.14%). The number of newly increased motor vehicles in 2012 was 107226 (8935.5 a month on average). Noticeably, the number of newly increased private cars in 2012 was 92125, accounting for 85.92% of the new vehicles. And the latest data shows that the number of motor vehicles in Xiamen has exceeded 0.95 million in March 2013 (0.54 million cars therein) and is projected to surpass one million in July 2013. Although these numbers seem still modest compared to 94 cars for every 100 people in the USA, the speed at which automobile use is expanding is alarming. The traffic jam has become so serious that the average vehicle speed has fallen to 20 km/h below at peak time, over half of intersections are at the saturated condition, and public parking lots are seriously in shortage. The casualties and economic loss of traffic accident also keep growing, not to mention a series of other negative consequences, such as environment pollution, oil shortage, greenhouse gas emissions, extrusion of public space, access problems for car-less people, and worsening of personal mobility and quality of life. These circumstances not only challenging the city's efforts towards becoming "a role-model of low carbon city" but also damaging its image as "an eco-garden city" and its attractiveness to talents and tourists ([Wang, 2013](#)).

### **3. STRATEGIC FRAMEWORK GOVERNING THE LOW-CARBON DEVELOPMENT**

#### **3.1 Guiding Regulations and Higher-level Plans**

Urban planning is an important mechanism for the government to guide urban development. Low-carbon urban planning is supposed to guide the city in the direction of low-carbon development. Low-carbon urban planning cannot be separated from the wider context of urban policies and public governance. It needs a set of supporting policies and regulations.

At the national strategic level, the Chinese government has recognized the resources and environmental pressure, as well as the threats regarding

global climate change. The country has been taking a positive attitude to participate in the actions taken by the international community to cope with climate change. China, as a signatory country to the United Nations Framework Convention on Climate Change and the Kyoto Protocol, actively participated in the preparation and review of previous climate change assessment reports organized by the IPCC, as well as the international negotiations on climate change. Also, based on the requirements of the national strategies for sustainable development established in China's 21st Century Agenda, China has adopted a series of policies and related measures to address climate change.

In 1998, the Chinese government set up the National Climate Change Coordination Group (hereafter referred to as the "the leading group"), under the direct leadership of the State Council, as the national coordinating body to respond to global climate change and energy conservation, the head of which is the National Development and Reform Commission Officer. The main tasks of the leading group are: (1) to study and formulate major strategies, policies and measures related to the national response to global climate change; (2) to unify in the deployment of work on climate change; (3) to consider and study international cooperation and negotiations; (4) to coordinate and solve major problems in the response to climate change; (5) to organize and implement State Council's principles and policies on energy conservation; (6) to unify in the deployment of energy conservation and emission reduction measures; (7) to consider and study major policy proposals; and 8) to coordinate and solve major issues in the work.

As an important obligation to fulfil the United Nations Framework Convention on Climate Change, the Chinese government enacted China's National Climate Change Program in 2007. This program sets out China's position on the issue of climate change, with clearly formulated specific objectives, basic principles, important areas, and its policies and measures in response to climate change. This program is the first national program enacted in a developing country to address climate change. Remarkably, it declares "to include carbon reduction targets as binding targets into the long-term planning of national economic and social development".

As a comprehensive development plan, the National Economic and Social Development Twelfth Five-Year Plan (hereafter referred to as the Twelfth Five-Year Plan), has programmatic descriptions in energy saving, green and low-carbon development, and has established the direction for recent developments. Among the most noteworthy of these developments is that the clearly stated energy consumption per unit of GDP to decrease by 16%, carbon dioxide emissions per unit of GDP to decrease by 17%, and the proportion of non-fossil energy in primary energy consumption to reach 11.4% as a binding development target during the Twelfth Five-Year period. These binding development objectives will eventually be divided into levels and allocated to local governments.

In addition, a series of action plans are organized and implemented at the national level; for example, the program called "low-carbon pilot provinces and cities" has been launched since 2010. Five provinces (Guangdong, Liaoning, Hubei, Shaanxi, and Yunnan), and eight cities (Tianjin, Chongqing, Shenzhen, Xiamen, Hangzhou, Nanchang, Guiyang, and Baoding) were first designated to be pilot provinces or cities.

National strategies for coping with climate change must ultimately be implemented through local actions. The actions of local implementation can be divided into provincial level and city level. For example, as an

undertaking and implementation of national strategies at the provincial level, the Fujian Provincial Government has formulated and promulgated the Action Agenda for the Sustainable Development of Fujian Province and the 12th Five-Year Plan for the Economic and Social Development of Fujian Province. These planned the long-term direction of sustainable development in Fujian Province, arranging the recent framework for actions, clearly defining energy consumption per unit of GDP to decrease by 16%, and CO<sub>2</sub> emissions to decrease by 17.5% as the binding development targets for the 12th Five-Year period. Similarly, the binding targets will be divided and allocated further to various cities in the province.

Xiamen City, as one of the country's first low-carbon pilot cities, has been encouraged by the central government to implement bold innovations in low-carbon development policies and measurements. In 2010, Xiamen City enacted China's first low-carbon urban planning program, the Outline of the Overall Planning for the Low-carbon City of Xiamen, which has not only set a comprehensive framework for the low-carbon actions of Xiamen, but also provided a reference for the other pilot cities across the country.

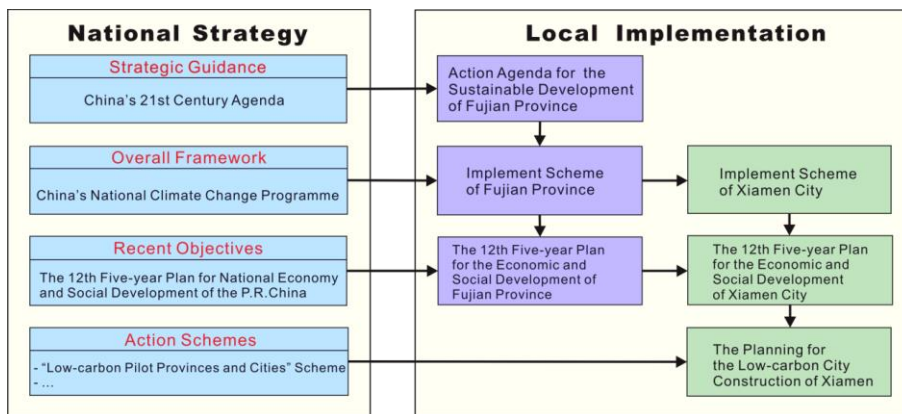


Figure 2. Framework of national strategies and local implementation plans

### 3.2 Development Objectives and Target Architecture

As we all know, China announced its goal of "40-45% reduction of carbon emissions by 2020 on 2005 level" at the 2009 Copenhagen Climate Change Conference. China clearly stated that "carbon reduction targets as binding targets will be included in medium-and long-term economic and social development planning, energy consumption per unit of GDP will decrease by 16%, carbon dioxide emissions per unit of GDP will decrease by 17%, the proportion of non-fossil energy in primary energy consumption will reach 11.4%" in the 12th Five-Year period (2011-2015).

Referring to the objectives in the national 12th Five-Year Plan, Fujian Province also put forward its binding development goals stating that energy consumption per unit of GDP will decrease 16%, and carbon dioxide emissions will decrease 17.5% during the 12th Five-Year period.

The city of Xiamen, as one of the earliest national low-carbon pilot cities and the country's renowned eco-garden city, has reached comprehensive low-carbon eco-city development objectives. Table 1 lists the indicators and targets of the Overall Planning for the Low-carbon City of Xiamen. We can see that the development of low-carbon eco-city city of Xiamen includes many different aspects. It focuses on and starts with three major areas of

industrial production, transportation, and building construction, which account for more than 90% of the city's total carbon emissions. Most notably, the energy consumption per GDP in the industrial section is a mandatory target, which echoes the controlling indicators at both the national level and the Fujian Province level. According to this plan, energy consumption per unit of GDP should be maintained below 0.473 tons of standard coal prior to 2015, and should be less than 0.39 tons of standard coal long-term before 2020, amounting to 40% reduction on the 2005 level. The rest of the guiding objectives and targets, although not enforceable, also have a strong indicative significance for the low-carbon development of Xiamen. The indicators and targets also provide guiding criteria for the transformation of urban development models.

Table.1 Target architecture of the development of low-carbon city of Xiamen

Sectors	Approaches	Indicators	Target Value of Indicators			Attribute of Indicators
			Current Value (2010)	Target Value (2015)	Target Value (2020)	
Industry	Industrial Structure Optimization	Proportion of the tertiary industry to GDP	48.9%	≥ 53.9%	≥ 60%	Anticipated
	Total Energy Consumption	Energy consumption per GDP	0.569 tons of standard coal equivalent	< 0.473 tons of standard coal equivalent	≤ 0.39 tons of standard coal equivalent	Mandatory
Land Use	Land-use Efficiency	Added value per industrial land	1.413 billion Yuan / km <sup>2</sup>	> 3.5 billion Yuan / km <sup>2</sup>	4.5 billion Yuan / km <sup>2</sup>	Anticipated
	Land-use Saving	Use of construction land per ten thousand Yuan GDP	11.2 m <sup>2</sup> / ten thousand Yuan	< 10 m <sup>2</sup> / ten thousand Yuan	< 7.8 m <sup>2</sup> / ten thousand Yuan	Anticipated
Energy	Energy Structure Reformation	Proportion of renewable energy use	-	≥ 5%	≥ 20%	Anticipated
Building	Green Building	Proportion of the green building accounted for the completed buildings this year (Public building)	-	≥ 40%	≥ 80%	Anticipated
	Building Energy Efficiency	Proportion of energy-efficiency building	32.3%	≥ 44.2%	≥ 52.6%	Anticipated
	Renewable Energy Architecture	Proportion of renewable energy architecture	5%	≥ 7%	≥ 17%	Anticipated
	Building Garbage Disposal	Proportion of building garbage disposal	5%	60%	80%	Anticipated
Transportation	Transit Trip	Share of public transport ridership	about 30%	35% - 40%	≥ 45%	Anticipated



	Transit Network Planning	Average commuting time of the residents in central city	-	≤ 35 minutes	≤ 30 minutes	Anticipated
	Non-motorized Traffic	New-built & rebuilt bicycle lane length (or Chronic channel network density)	-	500 km	1000 km	Anticipated
	New Energy Vehicles	Percentage of new energy vehicles	-	≥ 5%	≥ 15%	Anticipated
Eco-system	Environmental Conservation	Forest coverage	42.8%	42.9%	43.0%	Anticipated
	Coordination of the Urban and Natural Environment	Coverage of urban green area	35.56%	39%	40%	Anticipated
Water Resource & Waste Reuse	Environmental Pollution Control	Proportion of the centralized treatment of waste water	91%	≥ 95%	100%	Anticipated
		Decontamination rate of urban refuse	96.93%	100%	100%	
	Green Infrastructures	Utilization of reclaimed water	0.92%	≥ 10%	≥ 20%	Anticipated
	Water Resources Utilization	Water consumption per GDP	-	< 16 m <sup>3</sup> / ten thousand Yuan	< 8 m <sup>3</sup> / ten thousand Yuan	Anticipated
	Household Waste Disposal	Recycling household waste as resource	16.8%	20%	30%	Anticipated

(Source: *Development of Low-Carbon City of Xiamen (2012)*, Xiamen Construction & Administration Bureau.)

### 3.3 Major Initiatives and Key Projects

There are many factors at play in climate change mitigation, including alternative energy sources, green technologies that can increase fuel efficiency or reduce energy demand, and new technologies for carbon capture and storage. But these technological measures alone will not be enough. More profound measures involve shifts in the way we build cities and arrange city-regions, and in the way people live their lives. Therefore, the low-carbon city construction is a complicated system engineering with a whole package of countermeasures.

With the general goal of creating natural, economic, and social common development, Xiamen City has taken on a series of initiatives to implement low-carbon urban construction projects. Eleven major low-carbon development projects have been launched for the 12th Five-Year period:

- ◆ Spatial optimization project
- ◆ Low-carbon industrial transformation project
- ◆ Green building propulsion project
- ◆ Clean energy utilization project
- ◆ Low-carbon transportation project

- ◆ Forest carbon sink project
- ◆ Water recycling project
- ◆ Resource recycling project
- ◆ Low-carbon community demonstration project
- ◆ Low-carbon civilization advocacy project
- ◆ Low-carbon financial supporting project

In the field of urban planning and design and of building construction, the following measures have been adopted:

- ◆ Strict implementation of the building energy efficiency standards
- ◆ Energy-saving transformation of major public buildings
- ◆ Renewable energy demonstration projects
- ◆ Green building promotion
- ◆ Adjustment of urban spatial structure plan
- ◆ Promotion of low-carbon neighborhood design
- ◆ Implementation of fully furnished housing
- ◆ Accelerated utilization of underground space

## **4. LOW-CARBON PLANNING PRACTICES RECENTLY CONDUCTED IN XIAMEN**

### **4.1 Case A: Spatial Governance of Carbon Emissions and Urban Sprawl**

For the purpose of guiding low-carbon industrial layout, protecting the eco-environment, and optimizing urban spatial structure, Xiamen City has initiated the Spatial Control Plan for Carbon Emissions. This plan is based on the spatial pattern of the local environment and meant to facilitate socio-economic development. In this plan, the administrative area of Xiamen is divided into several different zones: zones in which carbon emissions will be strictly controlled, zones in which low carbon emissions will be demonstrated, zones in which moderate carbon emissions will be permitted, zero-carbon emission zones, and others (Fig. 3). These carbon emission control policies were implemented at different intensities in different areas. This plan provides a foundation for follow-up on the effects of low-carbon infrastructure, low-carbon industrial layout, and spatial zoning for traffic demand management (TDM).

At the same time, by adjusting the city's master plan, the spatial form of the city can be oriented to a polycentric and cluster-network pattern. Major adjustments include the following: (1) Strengthening the management of the ecological control line and enhancing the ecological buffer zone between different functional areas in order to improve the control of growth boundaries. (2) Improving the internal structure of each urban section by upgrading neighborhood public services and promoting the job-housing balance in order to reduce large-scale, long-distance motorized commuting. (3) Improving public transit between city centers and outside clusters and increasing the volume rate indicators along the major transit corridor in order to promote transit-oriented development (TOD).

## 4.2 Case B: Regulatory Plan of Xiamen Low-carbon Sci-tech Innovation Park

Currently, there are three large-scale new low-carbon demonstration cities planned in Xiamen. They are the Jimei Low-Carbon Eco-city, the Xiang'an Low-Carbon Industrial Park, and the Xiamen Low-Carbon Sci-tech Innovation Park (hereafter "the Xiamen LCSTP"). This section will focus on the regulatory detailed plan of the Xiamen LCSTP.

The Xiamen LCSTP has a total area of about 4.9 km<sup>2</sup> and is located at the junction of the Jimei District and the Tongan District in the east bay area of Xiamen. The regulatory detailed planning of Xiamen LCSTP was conducted in 2011. It provides a representative case of integrating a set of low-carbon and eco-city elements into the general framework of urban regulatory detailed planning. Its planning indicator system includes a series of low-carbon-oriented indicators, such as "general energy-saving rate", "green building proportion", "underground space development proportion", "coverage of non-motorized traffic system", "star-grade of green building", "renewable energy utilization rate", "energy consumption quota of per unit building area and so on (see Table 2). The planning targets, specifically green building proportions, coverage of non-motorized traffic systems, and proportion of fully furnished housing are all 100% complete.

Table 2. Planning indicator system for the regulatory plan of Xiamen LCSTP

Approach	Indicator	Unit	Planning Target	Target Attribute
Overall	General energy-saving rate	%	15	Guiding
	Green building proportion	%	100	Suggested
Land Use & Transportation	Underground space development proportion	%	≥ 15	Guiding
	Coverage of non-motorized traffic system	%	100	Mandatory
Water Resource Utilization	Comprehensive runoff coefficient	-	0.46	Guiding
	Unconventional water utilization rate	%	≥ 23	Guiding
Physical Environment	Heat island effect	°C	≤ 1.2	Guiding
			1.5	
	Wind environment according with criterion	%	≥ 80	Guiding
Energy Utilization	Renewable energy utilization rate	%	5	Guiding
	Energy consumption quota of per unit building area	kWh/(m <sup>2</sup> ·a)	25~170	Guiding
Green Building	Star-grade of green building	%	At least national one-star grade	Mandatory
	Proportion of whole-decoration house	%	100	Suggested
	Proportion of native plants	%	70	Suggested

(Source: *Development of Low-Carbon City of Xiamen (2012)*, Xiamen Construction & Administration Bureau.)

### 4.2.1 Land Use and Transport :

In the frame of China's urban planning system, regulatory detailed planning has become the key of spatial development control. The transport

planning is always a weak link after the regulatory detailed planning was introduced. How to make a land-use plan with thorough consideration of transport system, especially "the green transport system", is a challenge worthy of exploring.

The regulatory detailed planning board of the Xiamen LCSTP has established a transit-oriented land use and spatial development pattern (TOD model) on the basis of ecological sensitivity analyses and traffic models. The idea is to create a sci-tech park with compound functions and a complete green transportation system with the minimum impact on the local environment. The TOD land use model is built upon an upcoming subway line and a bus rapid transit (BRT) line (Fig. 3). The higher-density developments and urban services are arranged around the public transit stations in order to increase the mixed land use and decrease the need for land development near ecologically sensitive areas. The optimization of public transport is also an important goal. The plan emphasizes the connection between internal and external public transport. Within Xiamen LCSTP, the 300-meter coverage of the transit station approaches 70%, and the 500-meter coverage exceeds 90%. The projected ridership of public transport is over 70%. The plan also gives full consideration to pedestrian and bicycle traffic. The non-motorized slow traffic system covers 100% of the road network within the park. This plan incorporates a bicycle lane system and P+R stations to encourage the use of bicycles and new energy vehicles, and areas are reserved for battery charging stations (Figure 4).

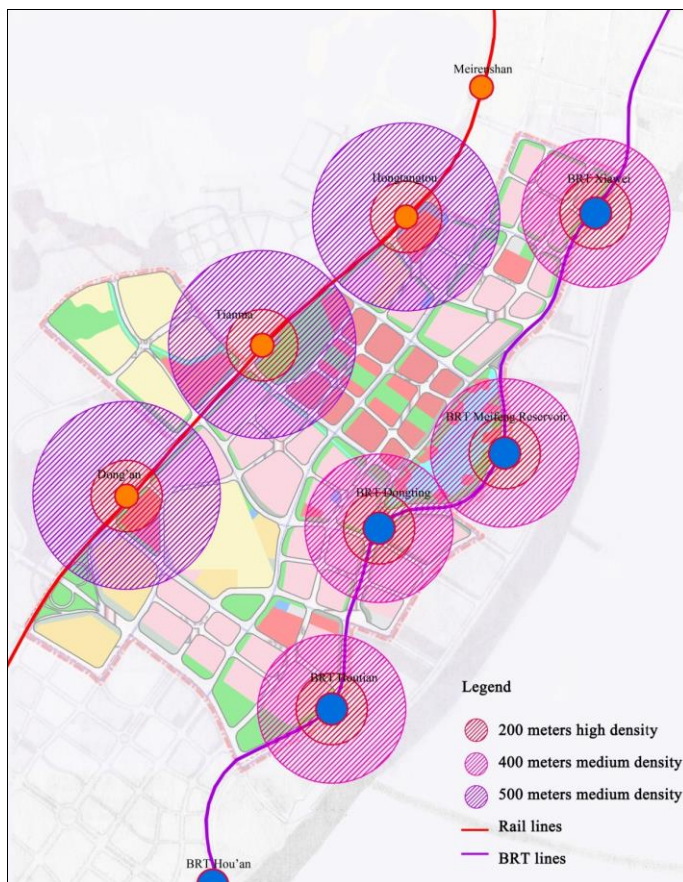


Figure 3. Spatial pattern of development density in Xiamen LCSTP under the TOD concept

(Source: *Development of Low-Carbon City of Xiamen (2012)*, Xiamen Construction & Administration Bureau.)

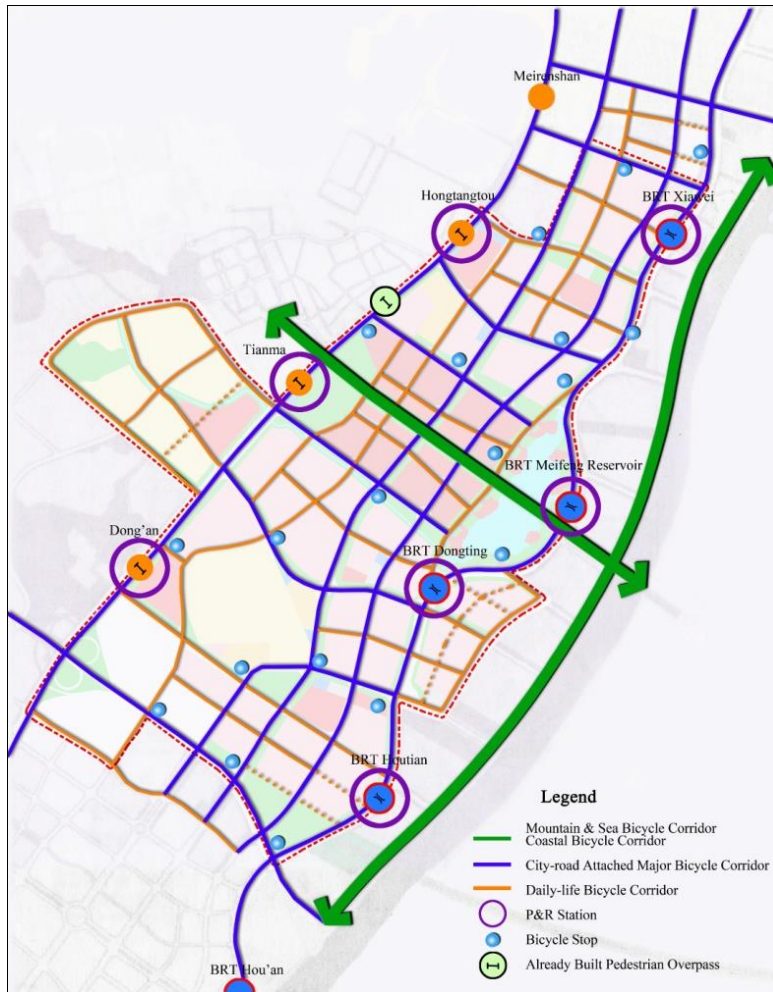


Figure 4. Bicycle corridor and P&R station planning for Xiamen LCSTP

(Source: *Development of Low-Carbon City of Xiamen (2012)*, Xiamen Construction & Administration Bureau.)

#### 4.2.2 Energy Structure:

The regulatory planning of Xiamen LCSTP in particular highlights buildings' energy use, prioritizing renewable energy and efficiency. Solar energy is designated the first-priority renewable energy source, and seawater source heat pumps, surface water source heat pumps and foul water source heat pumps are set as the secondary sources. Renewable energy use is projected to conserve a total of 5824 tons of standard coal, which means it will replace nearly 5% of the buildings' conventional energy use (Figure 5). Residential buildings using renewable energy are planned to conserve a total of 979 tons of standard coal, accounting for 3.32% of the total energy consumption of those buildings. Public buildings that use renewable energy are planned to conserve 4845 tons of standard coal, accounting for 4.02% of its total. In order to ensure effective implementation of renewable energy planning, the plan has set regulatory indicators, specifically renewable energy utilization rates and energy consumption quota per unit building area to strengthen the control and orientation of energy use.

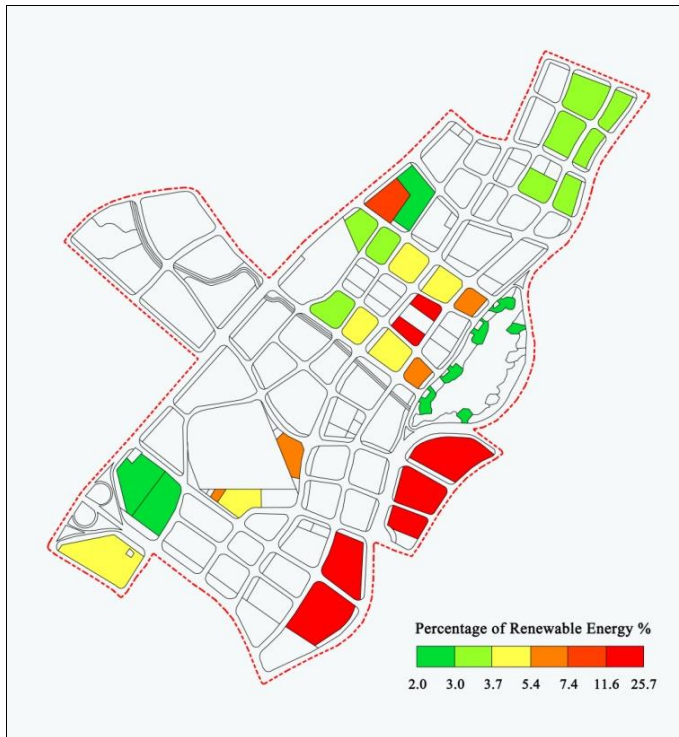


Figure 5. Renewable energy utilization planning for Xiamen LCSTP  
(Source: [Development of Low-Carbon City of Xiamen \(2012\)](#), Xiamen Construction & Administration Bureau.)



Figure 6. Allocation of different levels of green building in Xiamen LCSTP  
(Source: [Development of Low-Carbon City of Xiamen \(2012\)](#), Xiamen Construction & Administration Bureau.)

### 4.2.3 Green Buildings:

Green building technology is planned to be fully implemented in the construction of Xiamen LCSTP. All new buildings in the park are required to rate at least one star on the national green building standards. Different green buildings are planned for different areas within the park. One-star green building plots account for 61.20% of the area of the park, two-star green building plots for 10.86%, and three-star green building plots for 3.4% (Figure 6). In addition, the plan also has specific requirements for different types of green buildings (residential or public) from the perspective of energy conservation, land conservation, outdoor environmental impact, and cost.

## 4.3 Case C: Non-motorized Traffic Promoting Planning in Xiamen

According to the 2050 China Energy and CO<sub>2</sub> Emission Report ([2050 CEACER, 2009](#)), the energy demands of transportation are projected to be grow at an average annual rate of 4% from 2005 to 2050. This means transportation the fastest one among all the energy use sectors in China, and will be the largest contributor to the growth of China's CO<sub>2</sub> emission. Therefore, transportation is a major challenge to mitigating climate change, especially in urban areas where are of the highest concentration of vehicles.

The energy consumption and environmental impact per passenger per kilometer of different types of transportation differ. From least to most, they are as follows: walking → bicycle → rails and subways → buses → taxis → single-occupancy cars. So, to develop an environmental-friendly and low-carbon transport system, a major principle is to promote the non-motorized transport, especially walking and bicycle trip.

As early as 2007, a "Walking for Health" walkway was planned in Xiamen. Research projects on pedestrian and bicycle system planning were also initiated. In 2012, the city of Xiamen was selected by Ministry of Housing and Urban-Rural Development (MOHURD) as a national walking and cycling system demonstration city. As a result, attention and resources are being invested in the improvement of the non-motorized slow traffic systems. Pedestrian and bicycle system promoting plans have recently been promulgated.

### 4.3.1 Pedestrian System Promoting Planning

The macro-structure of Xiamen City's pedestrian walkway system has been designed according to the city's natural geography patterns and spatial form. The entire city is divided into three planning zones: (1) Green Zone: The mountainous background along the periphery of the urbanized area. It is an important ecological open space, and the walking system within it is relatively independent. It is mainly there for the residents' climbing, leisure, sports, and other routine walking activities. Its main entrances are arranged convenient links with public transport. (2) Orange Zone: The urbanized area. This where the residents spend most of their daily lives. This walking system in this area is the most often used. It is therefore the focus of the most planning. (3) Blue Zone: The long stretches of open beach along the sea. These are the most remarkable areas, reflecting Xiamen's coastal nature. It is available for the residents' seaside exposure, entertainment, leisure, and

other types of walking and jogging activities. The walkway systems were designed to emphasize the continuity along the coastline and the connectivity with the walkway systems in the orange zone.

The city's previous walkway planning paid more attention to leisure and fitness, but paid less attention to the problems of convergence with public transport and public service facilities (Wei, 2008). In the latest round of planning, focusing on the Orange Zone (i.e. the built-up area of the city), a two-tiered walkway system will be improved: (1) Mountain-Sea Walkway Corridors— These are the major walkways linking the hillside area to the seaside area, and each of them ends in a public open space or small park. They are also part of the city's leisure facilities. Through careful redesign of the walking paths, a safe, beautiful, and highly enjoyable public walking space can be created. (2) Walkways Attached to City Roads— These mainly consist of the sidewalks on both sides of the roads throughout the city. They are supposed to facilitate walking from place to place, transfer between different types of transportation, traffic evacuation, and access to public facilities. During planning, particular emphasis has been given to the continuity and accessibility of the entire pedestrian network system (Fig. 7). Very specific design guidelines were established for the construction of walkways, sidewalks, pedestrian bridges, pedestrian underpasses, traffic islands, and maximum distance from transit stations.

At the middle-micro level, the Orange Zone is further divided into 96 pedestrian units. According to the primary function of each unit (such as urban centers, residential areas, and industrial areas), more specific requirements and guidelines are made for the construction of pedestrian systems in each unit.



Figure 7. Pedestrian lanes attached to city roads in Xiamen

(Source: Xiamen City Planning Bureau.)



### **4.3.2 Public Bicycle System Planning**

As an important part of the slow traffic system, bicycle traffic has also received a great deal of attention in Xiamen City. The public bicycle system is a project that the city government has been thinking and operating on in recent years. This is particularly relevant due to the surge automobiles, traffic congestion, and related environmental pollution, which have seriously damaged Xiamen City's image as a renowned "Eco-City", "Garden City", and UN's "Livable City". People's concerns about the surge of car traffic are also increasing. The urge to implement a public bicycle system in Xiamen City has grown increasingly stronger. The NPC deputies and CPPCC members have repeatedly raised related proposals at the People's Congress, and CPPCC meetings in recent years.

In 2012 the Ministry of Housing and Urban-Rural Development of China (MOHURD) selected Xiamen as one of the national pedestrian and cycling system demonstration cities. The construction of public bicycle systems has sped up since then. In the same year, the Xiamen Bureau of City Planning announced the Public Bicycle System Development Planning on Xiamen Island and the Program of Recent Pilot Projects (hereafter "the Xiamen PBS Plan")

According to the Xiamen PBS plan, the city will first build a public bicycle system on Xiamen Island. It will expand the previous leisure-and-tourism-based bike system along the beach lines to a bigger public bicycle system to cover the entire island, which is supposed to function as an additional part of the city's public transport system. To this end, a network of bicycle paths covering Xiamen Island will be built (see Fig. 8). They will include 400 public bicycle rental points, and a supporting smart card (IC or SC) system and a bicycle-tracking GPS system.

The Xiamen PBS Plan indicates that public bike rental service points will be the terminal points of public bicycle trips. These points will also link the public bicycle system with other travel modes. The distribution of rental service points is the key to the entire public bicycle system planning. Based on the functional orientation of the public bicycle system, which will be based on the demand distribution pattern, public bike rental service points will be sorted into residential area points, bus station points, commercial center points, public facility points, tourism and leisure points, etc. Through the planned bicycle lanes, all these points are connected into a network.

According to the Xiamen PBS Plan, the public bicycle project on Xiamen Island will involve a total of 16,000 public bicycles. It is projected to serve some 80,000 passengers a day. If each trip per cyclist is approximately 3 km in length, it will conserve 4800 tons of carbon, assuming that all cyclists would otherwise have taken the bus with a carbon emission rate per passenger per kilometer of 0.160 kg. Assuming that all these cyclists would have ridden in single-passenger cars travel at total of 8800 tons of carbon will be conserved, assuming a fuel consumption per 100 kilometers of 13.29 liters and carbon emissions per liter of fuel of 3.08 kg, saving 2880 tons of fuel per year.

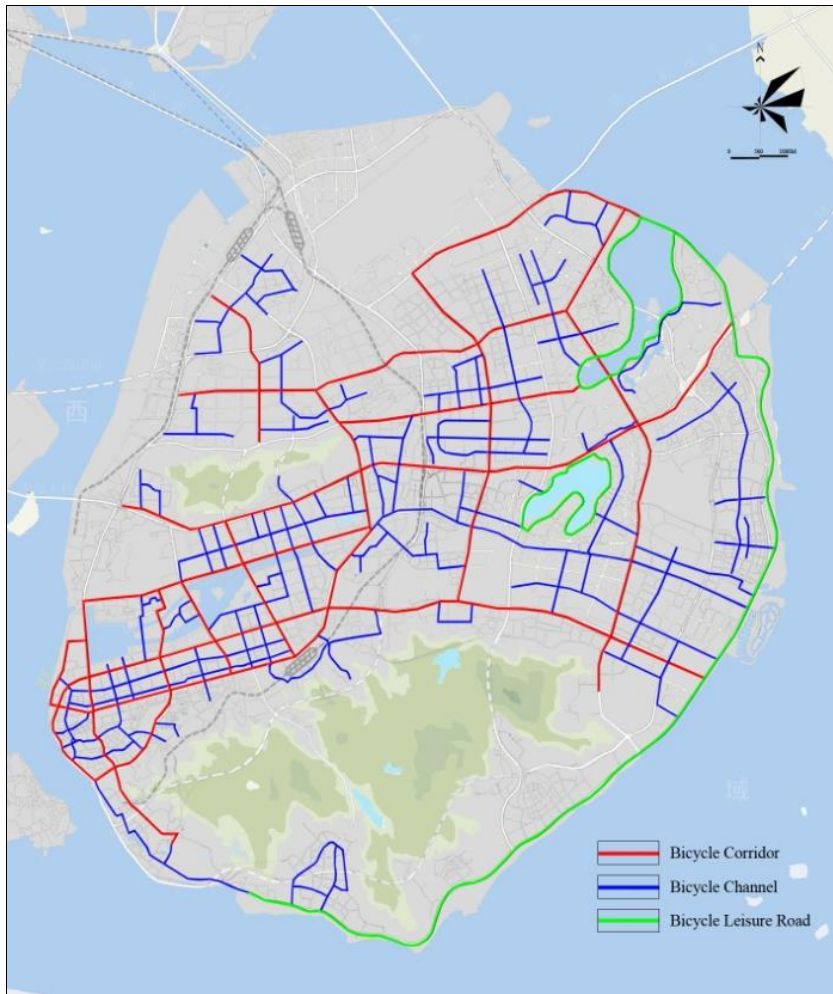


Figure 8. Planned bicycle lane network on Xiamen Island  
 (Source: Xiamen City Planning Bureau)

According to the Xiamen PBS Plan, the public bicycle project on Xiamen Island will involve a total of 16000 public bicycles. It is projected to serve some 80000 passengers a day. If each trip per cyclist is approximately 3 km in length, it will conserve 4800 tons of carbon, assuming that all cyclists would otherwise have taken the bus with a carbon emission rate per passenger per kilometer of 0.160 kg. Assuming that all these cyclists would have ridden in single-passenger cars travel at total of 8800 tons of carbon will be conserved, assuming a fuel consumption per 100 kilometers of 13.29 liters and carbon emissions per liter of fuel of 3.08 kg, saving 2880 tons of fuel per year.

## 5. DISCUSSIONS AND IMPLICATIONS

In the grand context of the global climate change crisis, after China announced its goal of reducing carbon emissions by 40–45% of 2005 levels by the year 2020, the construction of low-carbon cities became a major goal in urban planning and governance. This also involved the national strategy of seeking breakthroughs in resources and environment bottlenecks to

achieve a transformation of economic growth and sustainable development of the country.

In this work, the author has developed a certain understanding of China's low-carbon urban construction, especially of problems in low-carbon urban planning. Problems observed and the implications for urban planning are summarized below:

- (1) The United Nations Convention on Climate Change (UNFCCC), many countries' national climate change programs, and other authoritative documents tend to fail to address the issue on the basis of urban areas. (It is normally addressed in terms of industrial sectors.) In this way, urban planners and decision-makers in general still lack sufficient knowledge and guidance to address climate change mitigation. For these reasons, deeper, region-specific, comprehensive local studies must be performed and summarized. Relevant international instruments and foreign works should also be introduced to China and disseminated in a timely manner. There is a relatively large body of work abroad, most of them have been published in foreign languages, and it is not easy for most decision-makers and planners in China.
- (2) So far, in China, the studies and professional practices involving low-carbon-oriented urban planning are still preliminary. They are still in a fragmentary, exploratory, learning-by-doing form. Low-carbon urban planning involves specialized knowledge and technology, such as the assessment and analysis of the impact of ongoing climate change on urban areas, regional carbon/oxygen balance analysis technology, and technology suitable for the exploitation of various renewable energy sources. The relevant theories and methodologies are beyond the conventional boundaries of urban planners' knowledge, so planning departments often have to outsource some parts of the job to universities or research institutions. This shows that the conventional education and training systems for urban planners cannot meet the requirements of low-carbon city planning. Urban planners should consciously update their knowledge and institutions of higher education should also adjust and update their course offerings and training programs accordingly.
- (3) Low-carbon-oriented urban planning involves some new planning elements and components. It requires some adjustments to existing planning indicators, such as the proportion of clean energy applications, energy efficiency standards for buildings, the density of land development, the coverage of non-motorized transport networks, reductions in motor vehicle parking spaces and increases bicycle parking spaces and infrastructure, reductions in the number of highways, and increases in the density of minor roads. When adjusting these planning indicators to reflect and realize the low-carbon ideas in planning practices, planners may break the current planning regulations or design codes. For this reason, it is imperative to reform the planning regulatory system and relevant professional norms to meet the demands of low-carbon eco-city planning ([CSUS, 2009](#)). This is currently being explored but has not been completed yet. Thus, some of radical low-carbon plans and designs may not be approved because a number of indicators don't comply with the existing regulations or codes.

- (4) The relevant international conventions addressing climate change request that the effects of the energy conservation and carbon reduction measures be measurable, reportable, and verifiable. This widely recognized principle is also considered to be the key of the Copenhagen Accord ([Winkler, 2008](#)). However, measuring, reporting, and verifying the effects of the energy conservation and carbon reduction measures involved in urban planning is very difficult. So far, there has not yet been any standard working procedure or clear roadmap. Planners often feel powerless and helpless when attempting to measure, report or verify the effects of their proposals. It is due to the insufficiency of relevant fundamental research, also again reveals the limitations of planners' knowledge and experience with respect to climate change mitigation.

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# The Application of Vertical Greening to Urban Rehabilitation and Maintenance

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**Key words:** Vertical Greening, Green Building, Urban Rehabilitation and Maintenance, Eco-city

**Abstract:** Site greening is one of the nine indicators of green building in Taiwan. In built-up urban areas, buildings have been crowded without spare space for planting. Thus, encouraging residents planting perennial vine is a strategy which allows it to self-cling to the building surface or supporting structure so that the amount of green increases. It can reduce the building wall insolation and heat load thereby adapting indoor temperature, saving energy, purifying air, water, and soil, promoting urban ventilation, and reducing noise, and increase eco-efficiency. Taiwan has constructed neither vertical greening specification conforms to subtropical areas nor localized characteristics. The paper aims at exploring how to promote the application of vertical greening that increases green quantity as well as how to regulate maintenance of it in urban renovation. We believe we are benefited from it, and it helps to implement the ideal eco-city. Through the literature review and foresighted design point of view, the paper first introduces the relationship and development between vertical greening and green building and follows by the vertical green technology which increases green space and creates urban green network. Moreover, analyzing issues requires technology and innovation of vertical greening to apply urban rehabilitation and maintenance. At the end, it concludes: way of arranging plants in groups, natural irrigation, rainwater recycling system, reason why we encourage vertical greening, and need of amending the Special Chapter of Green Building Standard or providing Management and Maintenance Regulation of Vertical Greening.

## 1. INTRODUCTION

For the problems of global climate change and global warming in recent years, the countries around the world set low-carbon environment as their goal. The United Nations appealed to the urban and rural development that it is necessary to protect the global environment and focus on the integration of individual and surrounding environment. It is also important to create a healthy, comfortable living environment, emphasis ecological balance on urban and rural planning, biodiversity, resource recycling, renewable energy, and other sustainability issues. As the above, green building and ecological city have become two of the most important trends. In Taiwan, 97% of the buildings are considered as built-up, and their existence generally does not meet the ecological needs ([Architecture and Building Research Institute, 2012](#)). Thus, future urban renovation and environmental planning should

emphasize green building to the ecological city's development and place people at the center of the design process.

In 2008, Taiwan has launched "The Eco-city and Green Building Promotion Program." Eco-city and green building assessments are included in "The Implementation Regulation of Periodical Overall Review of Urban Planning." The regulation has amended in 2011 which said that the process of conducting overall review of urban planning need to develop a system of water and green network principles. Our government has learned that green building and network are important to achieve an ecological city. However, the existed cities are crowded by buildings and artificial facilities. How should the combination of green building and urban renovate? How to apply vertical greening technology to the existed urban building façade?

In order to promote urban rehabilitation and maintenance effectively, government have granted funding to encourage residents to renovate building façade when the walls look bad or leak. It can be classified as "wall face lift" option which we change a normal wall into a green wall and reach urban renovation with ecological landscape. However, the cost of green wall is still being criticized for having an extremely high price; thus, we need to improve qualities, reduce costs, combine renovation with urban renewal mechanism, and promote with government incentives. It would then recondition urban area gradually by green building construction methods of design and innovative technology. Through the literature review and foresighted design point of view, the paper first introduces the relationship and development between vertical greening and green building and follows by the vertical green technology which increases green space and creates urban green network. Moreover, analyzing issues requires technology and innovation of vertical greening to apply urban rehabilitation and maintenance.

## **2. VERTICAL GREENING AND GREEN BUILDING DEVELOPMENT**

The wall which covers with greens by self-clinging or growing on supporting structures is known as vertical greening. Vertical greening, also known as façade greening, green wall, planting wall, vertical garden, living wall, or ecological wall, is essentially a living and self-regenerating cladding system for buildings ([Kingsbury & Dunnett, 2008](#)). Self-clinging plants are used without supporting structure since they attach themselves directly to the building surface. On the other hand, supporting structure greening wall uses wires or trellis which allows plants to "climb."

Vertical façade engineers need to consider the essential elements, sun shine, water, soil, and etc., of greening growth conditions in both cases. It turns out to be that by using natural or pipeline watering to sustain plants' lives, shallow-rooted plants are able to grow in the walls of different angle, and stems and leaves of plants will grow directly or indirectly attached to the building surface. Plants which grow in the surface of building wall can be artistic, improve the urban landscape, increase green coverage rate, reduce indoor temperature that helps to reach efficacy of biodiversity environment and urban greening.

The use of climbers or trained shrubs to cover the surface of a building is long established in practice ([Kingsbury & Dunnett, 2008](#)). Since [Blanc](#)

(2008) announced his work in Paris in 1988, it has created and promoted the art of ecological wall. For instance, Zurich's Maschinenfabrik Oerlikon (MFO) Park set up a giant double-walled, three-sided green wall construction which is built of steel with tensioned cables supporting the climbers as part of the redevelopment of a former industrial area for new uses (MFO-Park, 2012).

The Japanese pots drip irrigation module system was developed in 1990s. They also established Urban Building Greening Plan Guidance and promulgated "Landscape Act" in 2004. Landscape Act, Urban Greening Act, and Outside Advertising Act have been three Acts of landscape which encourage architectural, green design in three-dimension. Aichi Expo in 2005 has set a giant green wall called "Green Lung" to promote its slogan "Love, Earth" declaration, emphasize environmental protection and sustainable development, and show modern green wall technology. In 2007, Seattle, Washington, USA, they issued green performance indicators to study three-dimensional vegetation technology such as green roofs or green walls. Blanc, who was invited in 2007 to the National Concert Hall in Taiwan, announced the first vertical garden in Taiwan. He used a common plant to construct the green wall named "Green Symphonic Poem," and triggered a wave of domestic, ecological green building/wall. Parts of the local government based on the demand of landscape has specified mandates that for any new case of construction, its fence must be built as green wall so that it safeguards the environment during construction. Additionally, it must enclose safe function which will provide a better interaction between pedestrian and city. This is an example which shows international trends for green building and vertical vegetation greening and applies them to urban renovation and environmental planning.

In fact, green building has different names in different countries; for example, in Japan, they call it Environmental Symbiotic Housing; in Europe, they call it Ecological Building or Sustainable Building. Green Building System is the name we use in Taiwan that is similar to the United States and Canada. As they name it differently, definitions and connotation are slightly different. Regardless of the differences, the demands for building development are emphasizing on environmental conservation, sustainable architectural planning, reducing environmental loading, and achieving symbiotic environment. We also focus our improvements on energy efficiency, better use of resources and materials, better indoor environment quality, and carrying capacity. So the comprehensive interpretation of green building can be defined as "The pursuit of human health and comfort, symbiotic environment, and sustainable development of human living environment through architectural designs." The narrow meaning of it refers as "Consuming the least resources, using the least energy, and generating the least waste during a building life cycle which is from production of construction materials, design, construction, management, and dismantling."

In September 1999, Green Building System implemented in Taiwan and was able to bring us and subtropical high temperature and humid climates into harmony. We included four factors: Ecology, Energy Saving, Waste Reduction, and Health, which are so-called green building EEWB evaluation and labeling systems in the early stage. Greening volume, rainwater conservation, water resource, daily energy-saving, carbon dioxide reduction, waste reduction, and improvement of sewage were the seven indicators evaluation system which was developed afterwards. The addition of two indicators, biodiversity and indoor environment, in 2003, it became the "Green Building Nine Assessment Indicators System." Thus, green building



is often interpreted as ecology, energy saving, waste reduction, or healthy building.

In order to promote and enhance the green building standards in Taiwan and encourage private enterprises to adopt comprehensive green building designs, the government revised and augmented "The Grading and Assessment System of Green Building" which graded building into five levels including qualified, bronze, silver, gold, and diamond. The grading system can be used as the basis by government agencies, developers and building designers for determining incentive policies. This followed international trends and enhanced the implementation of green building effectively. Additionally, easing the problems of urban heat island effect and deterioration of environmental quality strengthened green building policies in Taiwan. Our government therefore brought the concept of energy saving and environmental protection from green building into urban planning management. We believed these would promote the sense of green building, ecological communities, and sustainable cities through a comprehensive urban planning, design review and demonstration projects. Based on the above, our government introduced "Eco-city Green Building Promotion Program" in 2008. However, the ways of expanding practical applications with their ranges and creating greater environmental benefits from green building will be the current priorities of development of green building.

### **3. BENEFITS AND ISSUES OF VERTICAL GREENING**

Due to the intensive urban construction and artificial facilities, extensive use of things which absorb or reflect solar radiations such as dark roof, walls, floors, uneven buildings, or impermeable pavement is needed. On the other hand, reducing the use of air-condition, heat emissions from automobile and motorcycle, air pollution, and other human waste heat which cause urban heat island effect is another important issue. In Taiwan, after few decades of rapid economic development and a high degree of industrialization, energy use increased by approximately 20 times, and energy consumption rate per unit area is probably one of the highest in the countries that the overall populations are at least ten millions. Heat island effect may be one of the most significant regions in the world.

The coverage that is affected by heat island effect becomes greater. This may also lead to a regional climate change and should be the urgent environmental problems ([Liu et al, 2003](#)). Based on the fact that tree-crown can absorb or reflect approximately 80% to 90% of the long-wave radiation heat, and transpiration of blades can consume a part of heat, we believed if we can moderately increase vertical green capacity of the city, the rehabilitation area will be able to reduce urban heat island effect effectively.

[Lin \(2010\)](#) pointed out that green walls are capable of reducing wall surface temperature effectively by 10 ~ 14 degree C and indoor temperature by 2.0 to 2.4 degree C. This leads to reduce the use of air-conditioners and improve energy saving. If we take a ton of air-conditioning and operate it without turning it off for 24 hours, the power costs is about NT\$60. If we increase 1 degree C in an air-conditioned room, we can save about 6% from our electricity bills. In terms of office building, the electricity saving will be considerable. Japanese Urban Greening Technology Development Institution's experiments show that the implementation of green wall eases

acid rain and UV damage to buildings and waterproof layers and improves the durability of buildings.

The nine indicators of green building are closely related to plant greening; increasing greening volume, biodiversity, and site water indicators are directly correlated with them. In the past, we barely have any architecture with positively applying green design, rarely regard planting as architectural elements, and hardly consider the effect of vertical greening from an overall view of urban landscape in Taiwan. Through the literature review and analysis, the paper summed up following benefits for urban rehabilitation and maintenance:

1. Dust-proof, lower temperature, noise-proof, and energy-saving: vertical greening can decorate rooms, improve indoor microclimate, lower indoor temperature, increase humidity around 20%~30%, isolate noise, absorb dust, and reduce pollution.
2. Aesthetic and a better three-dimensional vision: green vegetation vertically set in the wall can shape the overall environment artistically, improve creative space effect, and provide social education function. It also gives three-dimensional stereoscopic visual effects from outdoor views by its uniqueness, distinctive kindness, and use of advertisement.
3. Positive impact on human mentality: green walls via advanced greening technology may have plants with various colors, forms, and textures. The natural beauty of it positively enhances landscape, improves residents' psychological feelings, and relieves pressure of modern life.
4. Increase green coverage and economize land: vertical greening can take an advantage of creating three-dimensional space of green network and lead to an increase of green coverage.
5. Create environmental bio-diversity: vertical greening supports the growth of dozens of beetles and spiders. In food chain, beetles and spiders are the best food for birds, and it leads to a positive impact on urban ecological environment.
6. Added value of the real estate market: although cost of vertical greening building is slightly higher than cost of normal building in general, the added value of the real estate market increases since it raises positive benefits such as saving energy spending and a better long-term quality of living environment.
7. Modifying measures and legal system: through continuous research and practical operation, the benefits from greening are the best references for promoting green building and legalization in vertical green measures and norms.

In order to make sure the integrity of the benefits of green building beyond the current assessment indicators and strengthen effectiveness of social, humanistic art, and community empowerment, the paper sums up issues related to technical research and innovation or relevant norms for promoting green building reference ([Peng, 2010](#); [Peng, 2012](#)):

1. Safety concerns of supporting structure: although vertical greening in existing walls is able to improve urban landscape and building energy efficiency, is there any issue regarding compatibility or safety caused by traditional urban planning and architectural design regulations? In Taiwan, we are confronted by typhoon season during summer; thus, there is a need of concerning structural safety and having further norms for legalization.
2. Simple calculation of green building rating: a proposal of grading system which calculates the relationship between effect of carbon reduction and assessment of green building can facilitate the vertical greening promotion.

3. Innovative materials and the development of different types of units of green modules: the necessary measures to promote vertical greening is directly associated with reducing the costs of development and maintenance. Therefore, we need to develop a high strength, durable, weather-proof, and biocompatible vegetation green wall system.
4. Community's expectancy and way of localizing vertical green: in order to strengthen the positive physical and psychological impact given by green wall on residents, it is necessary to explore how residents are affected by green wall practically and psychologically. Also, what are their feelings toward the process of plant growth?
5. Reuse of construction fences: how to effectively promote the application of vertical greening to safety fences in construction sites? How to retain fences and make them renewable after completion rather than dismantling and wastes.
6. Water supply and drainage system: in order to maintain plants healthy condition, water supply, drainage system, and stability should be carefully designed, constructed, managed, and maintained. For instance, how to link feed-water system up with storm-water retention system? How does drainage system avoid pollution?
7. Subsequent maintenance: effective managements including watering, pest management, plant domestication, change plants, and so on are closely related to the sustainability of vertical greening. It is not a good idea to rely completely on costly professional factories. Therefore, how to educate people continuously? How to mold maintenance and warranty measures into management?

Aforementioned issues, derivatives of professional responsibility, acceptable quality standards, and risk of long-term maintenance commitment issues need to be well-arranged by legal system. Interdisciplinary integration from cooperation and practitioners including civil and material science engineering, architecture design, urban design, and law capacity is needed so that it supports our legal system to create better norms to problems.

#### 4. VERTICAL GREENING TECHNOLOGY

Regarding to the application of vertical greening technology, we must consider the environmental characteristics of spaces of green wall and plant selections. Through literature review and field research, the paper has summarized the items including plants, vertical greening technology systems, and building external environment that are directly related to vertical greening technology in the following Table 1:

Table 1. Vertical greening of the building related items with impact factor







Item	Factor	Sub-factor
Plants	category	ground-cover, flower-looking, leaf-looking, climbing-vine
	growth nature	wind-enduring, drought-enduring, wet-enduring, acid-enduring, cold-enduring, shade-enduring, barren-enduring, high temperature enduring, salt--resistant, dust-resistant
	eco-nature	bird-attracting, butterfly-attracting, bug-attracting
	planting method	once planted, no maintenance; planting in batches, and subsequent periodic maintenance
	maintenance method	clipping, water supply, drainage, fertilization, disease prevention

	growth period	flowering period, fruiting period
	sense	the sense of sight (color), the sense of smell (fragrance), the sense of touch (quality)
Vertical greening technology systems	climbing	self-clinging to the building surface, the use of climbers supporting structure
	hanging	drooping from the wall type, drooping from the supporting structure type
	module	overall joining of supporting network, planting module type
Building external environment	building type	traditional courtyard houses (traditional architecture), terrace housing, condominium without elevator, high-rise housing
	greening position	roof, exterior wall, balcony, door, windowsill, fence
	impact factor	space: direction, number of story, effect of surrounding building (smoking hole, reflector, wind-tunnel effect) climate: sunshine, wind power, temperature, humidity, rainfall
	additional substance of facade	air conditioning, grille, canopy, advertising signboard, tube, hanging substance of external wall
	community environment	seashore community, existed plain community, riverside community, hillside community
	material of facade	wood, RC (reinforce concrete), brick, tile, stucco washing finish, cement, SS ( steel structure )
	disaster	typhoon, earthquake, fire

The influencing factors we mentioned above particularly the wall microclimate in wind environment are needed to be carefully handled. It is necessary to find suitable treatments for rising wind, descending wind, and whirlpool and prevent construction side from being stripped by wind. Additionally, illumination of sunshine is going to be influenced by different directions of wall, surrounding environment, and colours of the wall; therefore, we must choose plants carefully. It is also necessary to pay attention to temperature changes and avoid using materials such as metal, concrete, stone, tile, and other materials that absorb heat or have good conductivity. Regarding plant selection, we should treat native plants as priority, pay attention to their firmness, barren-endurance, drought-resistant, and moisture-resistant, be able to properly affix them to wall which its thickness has to be applicable, maintain and replace plants easily, maintain their durability, and manage pest and diseases.

In response to the above, there are quite many vertical greening technologies recently. The paper summarizes them into six types of technologies in accordance with methods and characteristics of vertical greening in the following Table 2:

Table 2. Vertical greening technology types and cases

Case location	Materials and Mineral Resources Building, National Taipei University of Technology	National Concert Hall, Taipei	Park Lane, by CMP, Taichung	Green Gate, National Taipei University of Technology	Hassen Hotpot Restaurant, Taichung	Decathlon Sports and Leisure Goods Center, Taichung
Technique Type	self-clinging	non-woven felt	soilless culture frame	FRP vertical greening	plant-growing tube	1. continuous planting green wall 2. vine-covered green wall
Construction year	1980	2007	2008	2010	2012	2012
Greening Floor	5	2	16	8	2	3
Usage of a building	building of the university	National Concert Hall	department stores	building of the university	restaurant	hypermarket
Greening Type	self-clinging to the building surface	planting on felt layer by soilless culture	hanging planting trough on the insert panel of wall	planting in the soil package made of non-woven, and put in FRP box	planting in the plant-growing tube	planting trough by open, continuous cultivation
Container material	none	non-woven felt	stainless steel, non-woven felt	FRP, non-woven felt	HDPE connected pipe	zinc-plated iron, coconut fiber mesh blanket
Container Size	none	thickness: 5cm stainless steel stern layer: 4cm felt layer: 0.3cm weight: 15 kg/m <sup>2</sup>	thickness: 22cm size: 50x80 cm weight: 75 kg/m <sup>2</sup> (with light media, planting)	thickness: 6cm width: 30cm	length: 125cm aperture: 9-12cm width: 50 kg/m <sup>2</sup> (with light media, planting)	size: 220x120cm width: 50 kg/m <sup>2</sup>
Scale	1,200 m <sup>2</sup>	160 m <sup>2</sup>	1,850 m <sup>2</sup>	1,000 m <sup>2</sup>	125 m <sup>2</sup>	2,000 m <sup>2</sup>
Unit Price (NTD/m <sup>2</sup> )	> 3,000	50,000-60,000	40,000-45,000	8,000	16,000-20,000	picture element type: 8,000 vine-type: 5,000
Irrigating System	irrigating by rainwater	overflow pipe	overflow pipe	penetrating pipe irrigating system by rainwater	automatic detached drip irrigation	automatic drip irrigation
Drainage system	natural penetration	recycled drainage channel	horizontal drainage channel with metal	natural penetration	recycled drainage channel	drainage channel
Planting type	parthenocissus tricuspidata (sieb. & zucc.) planch. & ficus pumila linn.	syngonium podophyllum schott and 51 kinds of common used plants in Taiwan	impatiens walleriana hook. f., lantana camara L., acalypha wilkesiana, nephrolepis exaltata schott., duranta repens etc.	parthenocissus tricuspidata (sieb. & zucc.) planch, pyrostegia venusta (ker) miers, antigonon leptopus hook. & arn., ficus pumila linn.	cuphea hyssopifolia H. B. K., nephrolepis auriculata (L.) trimen, codiaeum variegatum blume	duranta repens 'dwarf type', nephrolepis exaltata schott., asparagus densiflorus (kunth) jessop, asplenium antiquum Makino, chamaedorea elegans etc.
Picture						

As we introduced above, the natural type of self-clinging to building surface is planting traditional creeper which is attached, sucked, and climbed the wall by itself. It hardly climbs once it hits the smooth or high temperature wall. Moreover, this heavily relies on natural growth condition such as its soil layer and relying on air moisture created by rainwater; therefore, it grows slowly; it grows approximately one to two meters per year.

Consider the type that uses climbers supporting structures, seedlings can be fixed by human like planting droopy ivy so that it climbs through supporting frame. It achieves a better heat insulation effect since air layer forms between supporting frame and wall.

Another type of technology is planting trough directly on the wall. Whenever trough and panels are planted completed, greening is completed. If the wall structure is strong enough, we can apply this on higher floors. Although plant selection is less restrictive in this case, it costs more, and facilities for its completion, maintenance, and replacement must be considered.

As for the type of soilless cultivation, in order to provide water and minerals required by plants, we use non-woven fabric so that plants can gain its needs and grow directly on the fabric. In this way, we must select the

plants which can survive without soil substance. This greening technique fits in regions with stable climate.

The paper then divides each type of greening technology into five levels by its watering, greening, and cost as shown in Table 3:

Table 3. Technical types of vertical greening classification

Grade	Water supply	Configuration	Planting type	Construction prices (NT/m <sup>2</sup> )	Case
★	less	adsorption type or epiphytic type	1~2	<3,000	Materials and Mineral Resources Building, National Taipei University of Technology
★★	little	climbing, hanging system	3~5s	3,000~5,000	Green Gate, National Taipei University of Technology
★★★	medium	frame soil bag, board on frame sash filling	5~10	5,000~10,000	Decathlon Sports and Leisure Goods Center, Taichung
★★★★	plenty	planting trough, potted, Black and soft basin, non-woven felt	10~30	10,000~20,000	Hassen Hotpot Restaurant, Taichung
★★★★★ ★★	numerous	planting trough, potted, Black and soft basin, non-woven felt	> 30	>20,000	National Concert Hall, Taipei Park Lane by CMP, Taichung

Note: More★represent that the higher the grade of technology and maintenance, whereas represent the lower grade.

As the table shows, wall planting trough and potted plants can have many different choices on plants selections since it can be pre-cultivated and then relocated. But because it requires professional technology and knowledge, the cost of its construction and maintenance is much higher. On the other hand, although the cost of natural climbing way is much cheaper, it takes a lot of time to grow. Therefore, higher quality comes with higher price.

## 5. APPLICATION OF VERTICAL GREENING TO URBAN REHABILITATION AND MAINTENANCE

Future urban environment is going to focus on the ecological symbiosis and advocate the coexistence of human being, home, community, city, and nature. Thus, improving the existing urban old building façade by ecological greening will not only better off the old community environment but provide three-dimensional urban green ecological island-hopping network as well as significance of social education. The paper believes the integration of vertical greening, urban innovation, and maintenance should have at least the following benefits:

1. Creating three-dimensional multi-layer ecological space: a combination of community spatial structure and ecology should be diversified. Layered and progressive spaces should be consistent with living environment and provide various levels of biological differences. To improve urban environment, we should create different levels of herbal environment from greening open space to building façade, regulate climate change and

ecological habitats, and provide cross-species environmental elements with different seasons. Community residents can see the interaction of various environmental factors, energy-efficiency and a better quality of life.

2. Humanistic ecology in urban community: ecological significance does not fully imitate natural environment. The concentrated nature in urban environment is also artificial. Urban ecology should be a combination of natural species and urban human life. Vertical greening brings us an opportunity to apply humanity activities into ecological environment.
3. Improving green wall and permeable pavement: the urban environment is filled with artificial sites; thus, ecological community can be a one shining spot with limiting space but largest green resources and reduce urban heat island effect. Community is people-oriented activity space. We should maintain green ecological surface and create unlimited green with limited funding by innovative urban vision.

The current implementation of the urban renewal projects in Taiwan can be categorized by plan content, subsidy receiver, and grant category that are the followings:

1. Urban rehabilitation and maintenance: The New Taipei City Urban Renewal Rehabilitation and Maintenance Grant Program, The Taipei City Urban Renewal Rehabilitation and Maintenance Grant Program, The Taipei Urban Renewal Rehabilitation and Maintenance Planning, Design and Implementation of Funding Grants, The Subsidy for Public Facilities Maintenance Operations of Public Housing Communities of the Kaohsiung Urban Development Bureau.
2. Maintenance of public environment: The Creation of the Urban and Rural Landscaping Demonstration Projects.
3. Cultural preservation and maintenance: Regional Cultural Assets Environmental Preservation Revitalization Plan.
4. Community safety: The Action Program of Promoting the Whole People Forward for Safety – Constructing Safe Community Guidance Plan.
5. Residential fire safety: The Regulation of Subsidizing Congregate Housing for Fire Safety Facilities Regularly Inspection.

Figure 1 is collated from current implementation of the urban renewal program in Taiwan (Peng & Ding, 2009). The paper illustrates the scope and content of plan by a flat simulation and aerial schematic drawing respectively. I can be clearly understood where our domestic program is going to put the subsidy. The grants are closely related to rehabilitation and maintenance of the exterior of the building and external environment. Thus, applications and integration of vertical greening and urban renovation can be promoted in these and create a win-win situation for rehabilitation and preservation.

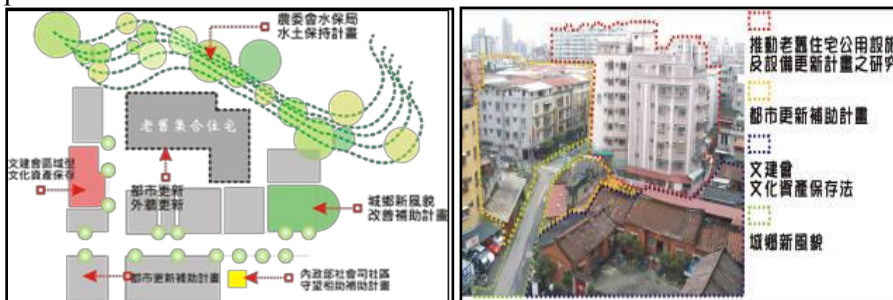


Figure 1. A flat simulation and aerial schematic drawing of implementation of the urban rehabilitation and maintenance program in Taiwan

## 6. CONCLUSION

Fragmented and scarce green space and highly dense urban areas have caused serious urban heat island effect. Vertical greening can increase greening amount, reduce urban heat island effect, improve the quality of outdoor and indoor air, beautify urban landscape, lower indoor temperature, increase energy efficiency, protect building structure, and reduce noise.

In the conclusion, the paper suggests the following points for those who are interested:

1. Different vertical greening system should take advantages from each system such as doing an experiment of planting trough into different segment and recording the improvements of natural growth rate.
2. We should look forward to design a plan for plants to self-generate and reach environmental symbiosis. The priority consideration is that green is naturally watered with rainwater recycling system which reduces maintenance and management costs.
3. In order to achieve a better performance of renovation, we should review the effectiveness of heat insulation and moisture-regulating effect and select the one that suits better according to different environment.
4. Expanding the use of vertical greening is a good way to rehabilitate high-rise congregated house building façade and sustain the green wall system.
5. We should promote local governments to green the construction site fences and strengthen inspection works for periodic maintenance. It aims to prevent plants from wilting which would lose significant amount of green and carbon reduction.
6. The central competent authority should be with the amendments of Green Building Standards Special Chapter or set vertical greening and maintenance regulations so that it can encourage promotions of green wall technology in rehabilitation and maintenance application of the existed building and community.
7. The related architectural regulations and application on vertical greening should be reviewed. How to provide the standards to encourage house-owners to implement vertical greening is important. Perhaps it can prevent secondary refurbishment for exterior wall or prevent owners from wasting space according to the competent authorities.
8. We should have systematic research on vertical greening with investigating related technologies of domestic and abroad. We can also set up green construction methods as well as different vertical greening benefit assessment.

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## Design Coordination Regarding Urban Design Guidelines Using Google Earth

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**Abstract:** Our study targeted representative urban design guidelines to enhance public understanding. In particular, we concentrated on developing a tool for stakeholders to improve their understanding of urban design guidelines determined by related laws and regulations. In this paper, we suggest that Google Earth can not only display a detailed district plan of the urban design guidelines or related documents but can also offer a possible method for stakeholders to experience the planning site from anywhere via the Internet. Stakeholders can refer to other planning projects on Google Earth at the same time. Thus, urban design guidelines can be more intuitive and dramatic to both professional planners and stakeholders.

### 1. INTRODUCTION

In this work, we employed Google Earth as a visualization tool to represent planning and design guidelines of an urban planning site in order to improve the presentation of planning alternatives for public understanding and design coordination with stakeholders. Design coordination through public participation is very important to the success of an urban planning project since any project will ultimately become part of the life of the public ([Kingston et al., 2000](#); [Warren-Kretzschmar and Tiedtke, 2005](#)). The earlier and more involved the public in an urban planning project, the more likely the project will succeed. Greater public participation in the planning process is a political goal in European countries that citizens have grown to expect ([Hetherington et al., 2007](#)).

In European countries, local authorities are increasingly required to make urban planning data available electronically, primarily over the Internet ([Märker and Pipek, 2000](#)). The use of computer science technology has been proven to enhance public participation in the urban planning process ([Lai et al., 2011](#)) by expanding the quality and quantity of interaction between planners and the public. The Internet is undoubtedly the best way of sharing urban planning information and the best platform for participation. Traditionally, the communication of planning proposals was facilitated by the use of paper-based planning drawings in planning meetings. More recently, urban planning documents have been produced in read-only digital

formats such as PDF and made accessible over the Internet. Some urban planning tools such as computer-aided design (CAD) and geographic information systems (GISs) have allowed planning designs to be published as electronic maps, searchable drawings, and other auxiliary documents. The conventional methods above cannot offer sufficient ways for users to experience all of the aspects of the planning sites. Virtual reality (VR) can also be used to represent planning sites on the Internet as reference material for stakeholders. With the latest developments in virtual globe technology, it is now possible to develop a seamless and continuous multi-scale 3D visualization platform to share urban planning information in the public participation process. Both professionals and the general public are used to visual approaches ([Wu et al., 2010](#)).

A computerized virtual environment containing 3D visualization and animation can accurately present a specific imaginary feature to the general public ([Laurini, 2000](#)). Whyte et al. ([2000](#)) presented a process to transpose CAD data into virtual reality data and pointed out several related issues, such as formats for data exchange, commonalities and differences between CAD and VR, and optimization of translated VR models. Dollner et al. ([2008](#)) used a 3D virtual environment to display the planning of a public transportation system. They used digital elevation models and aerial photography to build the terrain and laser scanning techniques to build the architecture model. Some navigation tools were built to let the user interact with the virtual environment to see the world from a different viewpoint.

Many studies are currently researching applications of VR systems using Web technology for planning support. In the past ten years, although designers mostly used drawings and planning documents in business, they have gradually started to use virtual reality (VR) technology to facilitate citizen understanding of the content of urban design guidelines, visualize more design concepts and better design details, and provide greater fun in this field ([Shen, 2003](#)). Shen et al. ([2010](#)) also completed a WEB VR system simulating the district landscape of Nanao City. The Urban Planning Exhibition Hall in Expo' 2010 at Shanghai applied their unique VR system to exhibit the urban design guidelines of the city to the public/citizens so that the people can interact with each other in it, share their experiences, and leave their feedback ([Gao, 2010](#); [Styliani, 2009](#)). In addition, stakeholders can discuss among themselves or with the designers about the virtual world of the city provided by the VR system ([Masatoshi and Takafumi, 2008](#)) through the Internet.

In the planning design process, users can exchange their ideas more easily and accurately by using a virtual environment on the Internet. With effective communication processes, it is possible to enhance public participation as well. As discussed above, the virtual model is effective at improving the information flow and helps disseminate technical knowledge to the public. The implementation of a hydraulic design project in some public hearings resulted in increased interactivity between stakeholders and improved communication efficiency for public participation by the VR system ([Jiang et al., 2003](#)). On the one hand, stakeholders without a professional background in planning and design can learn the content of the urban plan and post opinions. On the other hand, designers and planners can improve their design works based on feedback from the stakeholders.

In recent years, virtual globe-based 3D Web visualization technology has matured to change the way we interact with spatial data. The public can use their home computers and access the virtual globe through the Internet,

which provides the public a new communication platform and expands public participation in the entire planning process, from brainstorming to the completed project ([Drummond and French, 2008](#)). Virtual globe-based visualization has become popular with the general public. It is logical to use virtual globe technology for urban planning information sharing in the future.

Google Earth is virtual globe software and a new potential system with some functions similar to a VR system. As a three-dimensional globe, Google Earth includes all the cities of the world. It is difficult for a conventional VR system to share VR datasets of different cities in the same virtual world ([Meguro et al., 2003](#); [Hamilton et al., 2001](#)). Google Earth, which was released in 2005, is now widely used by the general public and researchers. Wu et al. ([2010](#)) discussed the technical issues of developing a virtual globe-based 3D visualization framework for publicizing urban planning information using Web services and service-oriented architecture (SOA) to support visual planning model sharing and interoperability with Google Earth. Although Google Earth has potential with regard to planning practices, so far there have been only a few reports on the improvement of public participation in urban planning using Google Earth. Thus, we address utilizing the functions of Google Earth for public participation in planning practice by illustrating more planning and design guidelines.

This paper proposes a virtual globe-based 3D visualization environment on the Internet to publish and share urban planning information for public comprehension and participation. We attempted to employ Google Earth to improve stakeholders' understanding of urban design guidelines compared with conventional planning documents and drawings. The remainder of this paper is organized as follows. Section 2 describes the research approach details. Section 3 discusses how to represent design guidelines using Google Earth. In Section 4, a brief conclusion is given, and future work is discussed.

## 2. RESEARCH APPROACH

The present work examined Datong Newtown, China, as an example of typical planning guidelines for the Newtown development project in China. Our study did not consider details on developing the urban design guidelines; we used the proposed guidelines to visualize the planning concept in this area.

The urban design guideline concept in China originates from detailed urban planning and design in the 1980s. In order to solve problems with rapid urban expansion and construction during this time, some regions in China began to emulate foreign city designs to produce the roots of the guidelines ([Gao, 2007](#)). Nowadays, the content of the guidelines is relatively complete and contains the following main 11 aspects: building style and special features, urban land use, urban integral space pattern, public green space system, urban landscape system, historical culture protection and utilization, urban road space, urban activities and support, architectural and environmental space, key area, and incentives ([Kong, 2007](#)). All 11 aspects are part of the comprehensive urban design guidelines in China.

In contrast to a VR system, the Google Earth platform shares a database of information from around the world; we can visualize an urban project over the entire globe and not just within the limited project area. This feature makes Google Earth inherently superior at expressing and sharing urban design guidelines of the world, which aid stakeholders' understanding

by comparing different projects in the virtual world. We utilized Google Earth to represent some urban design guidelines in the Datong region to reveal how efficient it can be to visualize the documents. The whole work comprised three components. First, we proposed urban design guidelines that were developed for the Datong region and discussed the flexible application of Google Earth. In this step, we examined existing urban design guidelines to determine the content for visualization. Second, we discussed how to use Google Series software to visualize the design guideline. Third, we used Google Earth to test our dataset. In the future, it will be necessary to open up the dataset to stakeholders and collect their feedback on the effectiveness of representing urban design guidelines using Google Earth. We did not discuss user feedback at this stage.

The guidelines for Datong Newtown chosen in this research focus on natural environment protection for sustainable development. Therefore, our work on visualizing this urban design guideline involved environmental design guidelines and conventional urban design guidelines, including those for construction, road networks, and land use. In order to utilize the multiple functions of Google Earth, we tried to fully utilize the superiority of multimedia to express the urban design guidelines and replace vague parts with our new explanations.

#### **Using Google Earth to download 3D GIS topography**

Google Earth is 3D GIS software; it is rich in geographic information presented in map formats, and its virtual three-dimensional version was originally called Earth Viewer 3D. It maps Earth by superimposing images from satellite imagery, aerial photography, and GIS 3D global. It is possible to fetch 3D GIS topography as a basement to create a virtual city model using Google SketchUp.

#### **Using Google SketchUp to produce a 3D model**

Many city models already exist in Google Earth. After editing these models on downloaded topography, we can use Google SketchUp to upload them onto Google Earth.

#### **Adding conventional multimedia such as text, images, and links of cities in Google Earth as references**

For some guidelines that are hard to express with a 3D model, we can use texts and charts to add them directly to Google Earth. We can then add conventional multimedia such as outdoor scene photos, audio files, and movie clips along with other information to present the design guidelines in Google Earth.

Using this method, we can have all kinds of multimedia, such as text, images, and photos, to support 3D models that represent urban design guidelines in Google Earth. We can involve all of the previous media in the platform for Google Earth. The completed Keyhole Markup Language, Zipped (KMZ) file format can be used for browsing, watching, commentary, and modification as long as users have a computer with Google Earth software and are connected to the Internet.

#### **Testing and application of urban design guidelines**

There are two conventional methods to show urban design guidelines using this system: showing them to the stakeholders with a projector or touch screen and publishing them through the Internet.

Google Earth has a 3D model database called the Google 3D Warehouse platform. There are many models and information in it about all of the cities' architecture and scenery. Although it has not been verified, it might be one of the biggest free building 3D model databases in the world. Architects and planners update the models and related information in the database every day. The completed Google Earth database can be shared with users around the world on this platform.

### 3. USING GOOGLE EARTH TO EXPRESS URBAN DESIGN GUIDELINES IN DATONG REGION

For Datong Newtown, we reveal three detailed guidelines using Google Earth: traffic, architecture, and environment guidelines. By combining the three guidelines in Google Earth, the space appears more realistic and is easier to understand than reading documents and drawings on each guideline independently. This effect is discussed in the following subsections. The guidelines presented in our work are not the proposed planning guidelines by the campaign planning teams in the local design competition organized by the local government. In the local design competition, most design guidelines come from Western countries; thus, the guidelines utilized in this work are not based on the Chinese planning system.

#### 3.1 Traffic Guidelines

##### Topography map for site layout and traffic network

All of the content for our design guidelines comes from New Design Guidelines—A Step towards Self-Explaining Roads (German Federal Transportation Research Institute), in which urban roads are divided into 21 different types according to cross-sectional constitution, intersection form, road corner radius, largest cubes, and special use form. In this study, we divided all of the main roads in the Datong region into five types and visualized them in Google Earth. The overall topography map and traffic network map are shown in Fig. 1. To present the planning document of road types, a picture in the 3D world of Google Earth is embedded in the bottom left corner of Fig. 1.

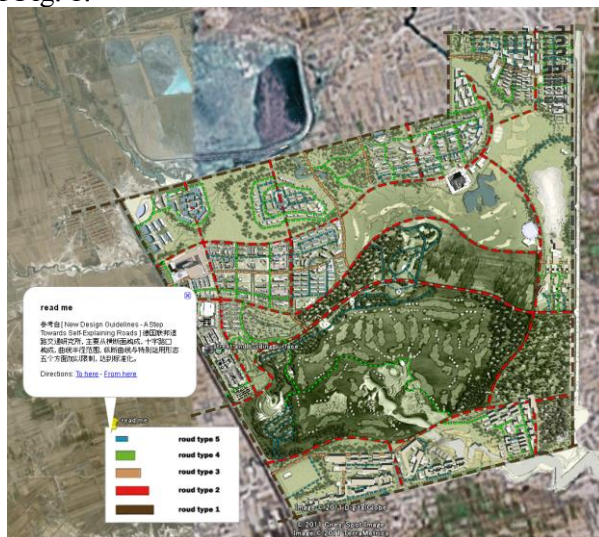


Figure 1. Traffic guidelines for urban traffic network in Google Earth

The urban design guidelines were developed based on a site plan using topography maps, which is intuitive for illustrating the design requirements of the entire site layout. Thus, we need to add the site planning as an overlay to the topography map in Google Earth. Topography maps are characterized by being always extremely close to the ground and undulating. We used the image overlay adding pattern from Google Earth to directly overlap fabricated images onto available topography conditions in Google Earth; this is easier than the expression in a VR system.

**Details of all types of urban roads—3D model and combination of texts and charts**

In the previous VR system, the 3D model can be shown with related papers and html links. However, Google Earth can use its connecting mechanism to place the 3D model and related materials together and promote stakeholders’ understanding through reading and listening.

Table 1 presents the 3D models of sample roads and detailed illustrations with texts and charts. The 3D models in Google Earth are easier and more straightforward to be understood than is the traditional combination of texts and charts when designers explain the planning materials of traffic networks. More pictures of the road section and plane can be added as auxiliary information, as shown in Table 1.

Google Earth uses real-time rendering technology, so the datasets of the 3D model can be changed instantly. Either VR or virtual globe changes the vision angle freely, and the 3D model’s datasets can be changed conveniently. Designers can change the vision angles freely during the model-making stage, and animation and rendering can be done after the designer fixes the vision location or vision route. Google Earth can display any angle from the model-making stage to the final exhibition stage. Although it is not easy for the stakeholders themselves to create the models, designers can now import enough sets of 3D data into Google Earth according to current regulations for urban design guidelines. As the [Road type 1 3D model in summer/autumn in Tab.1], users can exchange datasets and show the urban image for different road types; this allows stakeholders convenient access to the correct information on different road types in the design guidelines.

Table 1. Traffic guidelines in Google Earth

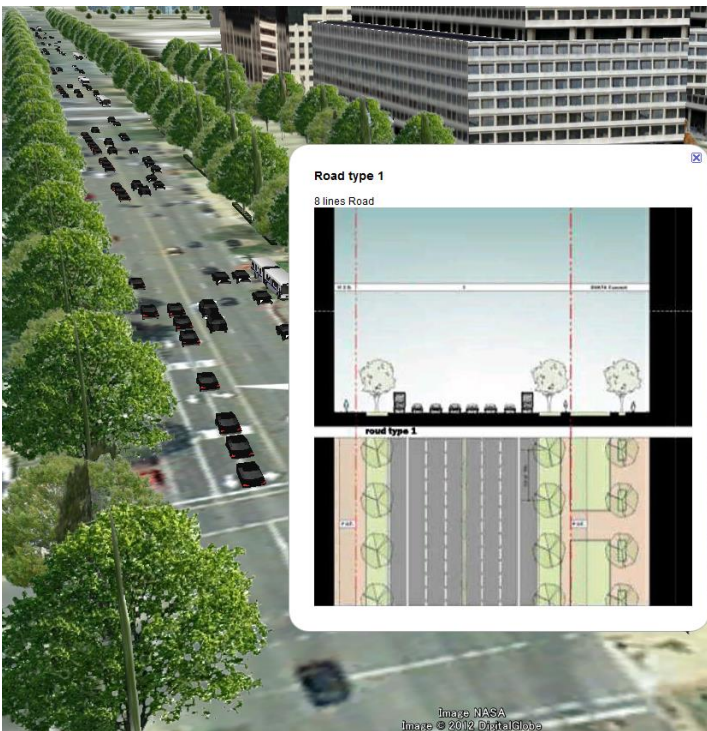
<p>Road types Road type 1 3D model in Summer /autumn</p>	<p>The road types of Traffic Guideline in Google Earth</p> 
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Road type  
2  
3D model



Explanation for Road types  
Road type with planar graph and section drawing

Planning documents for road design embedded in the 3D world of Google Earth



The traffic guidelines reveal a completely new exhibition effect embedded in the 3D world of Google Earth. An analysis table is presented on the effectiveness of Google Earth at representing traffic guidelines. As shown in Table 2, traffic guidelines received an “effective” result. This means that more than half of the guidelines can be understood effectively with Google Earth. However, when more and more images are added, a problem of locating the guideline illustration images emerges; the images frequently overlap with the 3D models. In particular, when people are viewing the model from a certain distance, most of the 3D models on the ground overlap and cannot be seen. Thus, we need to locate the images for architecture and environment guidelines properly: the former has few pictures, but the latter has many.



Table 2. Results of displaying traffic guidelines in Google Earth

Guideline Name	Word	Figure	3D Model	Detailed 3D Model	Advance for Understanding
Traffic network	●	●	○	○	effective
Road type	●	●	○	●	very effective
Roadway dimensions	●	●	○	●	very effective
Vehicle	●	○	○	●	limited
Crossing and Overpass	●	●	○	○	good
Street signs	●	●	◎	●	very effective
Total :					effective

Not to be used or Poor results: ○ Normal results: ◎ Good results: ●

## 3.2 Architecture Guidelines

The architecture guidelines used for Datong Newtown are mainly from the urban design guidelines from the White Flint master plan and downtown design guide in Los Angeles. It focuses on regulations for massing, surface, base wall height, step-back or podium setback, and other architecture issues. We already discussed the topography and 2D maps previously; extra 3D datasets to represent buildings are necessary for the architecture guidelines. Fig. 2 shows the architecture guidelines in detail.

### Building type and massing—images and 3D model

The building type and massing and building facade image are discussed here. Building massing restricts the construction density, building plot ratio, etc. Building facade images refer to outside colors, shapes, and neighboring facilities of the building.

First, we employed pictures to present documents for architecture guidelines on building type and massing. For the traffic guidelines, we embed the guidelines in the 3D world of Google Earth; a different presentation method is used for the architecture guidelines. Fig. 2 shows a “My Places” icon on the left side of the Google Earth main window. Users need to find the architecture guideline sub-item in the “My Places” icon and find the “building introduction.png” file. They double-click this file to see the content of the picture in the right window of Google Earth. The background 3D model can serve as an additional illustration for the picture. For traffic guidelines, we embedded pictures in the 3D world of Google Earth; here, it is difficult to control the direction and position to read the content of the guidelines. Thus, this method resolves the previous issue with traffic guidelines. When a user exits the photo mode, he/she can still freely browse in the space. This is a VR-style illustration of a street-view 3D model with a PowerPoint presentation. This method combines the advantages of the two techniques to make understanding of the urban design guidelines intuitive for stakeholders. If the user would like to know more, relevant links are available for further experience. In short, double-clicking the photo on the left side and controlling the window on the right side make it easier for stakeholders to check the content of the guidelines in planning documents. As shown in Fig. 3, we can express the guidelines for four types of buildings in terms of names, sizes, building plot ratios, construction density, functional regions, and rough effect simulation pictures.

When users exit the photo mode in Google Earth, they can see the locations of different types of buildings in the 3D models by using the

transparent squares with the same color as the building types. This is convenient for users in finding the locations of the four types of buildings. Fig. 4 shows the architecture 3D model for the four types of building samples and the combination effects with the surrounding environment.



Figure 2. Overall image of the city in Google Earth



Figure 3. Building massing picture in Google Earth



Figure 4. Building type samples in Google Earth

**Building facade image and street furniture—3D model**

As shown in Fig. 5, the urban building style is more intuitively visualized using images and 3D models. With delicate and accurate models in very realistic environment scenery, a high-quality visualization effect can be achieved.

Street furniture is mainly rendered from figures and photos using a simple 3D model. We do not necessarily create each complex 3D model for non-critical areas, and there is not enough memory to display so many 3D models in a common personal computer.

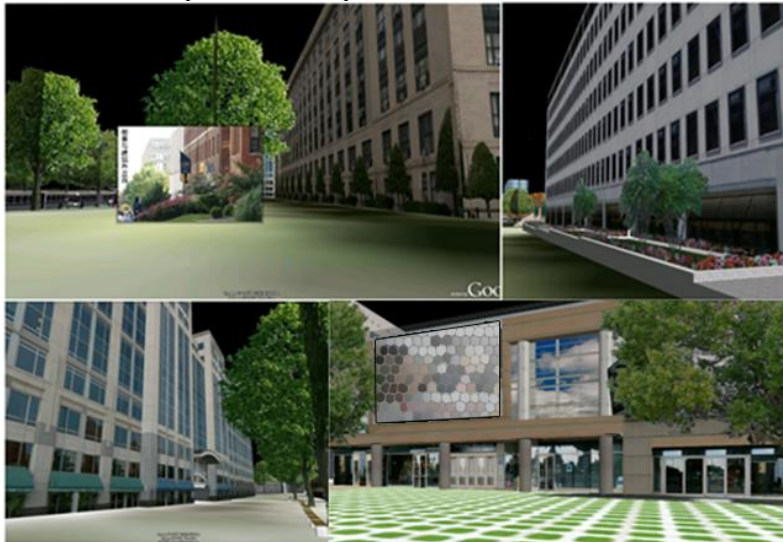


Figure 5. Building facade image in Google Earth

From all the works introduced above, the use of Google Earth to express architecture Guidelines is more intuitive than the use of previous formats because it is more suitable to use the 3D model to illustrate architecture. A questionnaire on the architecture guidelines received positive responses from the respondents, as shown in Table 3. The 3D model effect is more vivid than common VR systems because of the correct coordination information and surrounding urban and nature environment of the virtual globe around the planning site, but it is not as realistic as high-quality renderings done using Autodesk 3ds Max software. By using Google Earth, designers can also see whether a building can coordinate well with the city landscape from a wide view instead of considering the building alone.

Table 3.Result of Architecture Guideline

Guideline Name	Word	Figure	3D Model	Detailed 3D Model	Advance for Understanding
Building height	●	●	●	◎	very effective
Plot ratio and building coverage	●	●	○	○	very effective
Setback/ property line	◎	●	○	◎	effective
City General impression	○	◎	●	●	very effective
Sky line	◎	◎	●	○	good
Building Types	◎	○	○	●	effective
Architectural style	●	○	○	●	very effective
Public space	◎	●	○	●	effective
Building appendages	●	○	◎	●	very effective
Main section	◎	◎	●	●	very effective

Not be used or Poor results : ○ Normal results : ◎ Good results : ●

### 3.3 Environment Guidelines

Environment guidelines focus more on regulation details than do the previous two guidelines; the focus is partly on the environmental effects of building material and thermal environmental changes, the wind corridor map, and so on; this makes them complicated to illustrate. The environment guidelines in this study were obtained from the heat island plans from the Japanese Ministry of Environment. In total, 19 heat island technologies that use low-cost technology to effectively reduce the temperature of the urban environment are described. We used 14, which are presented in Table 4.


#### Partial items of environmental effect—3D model, multimedia, and topography map

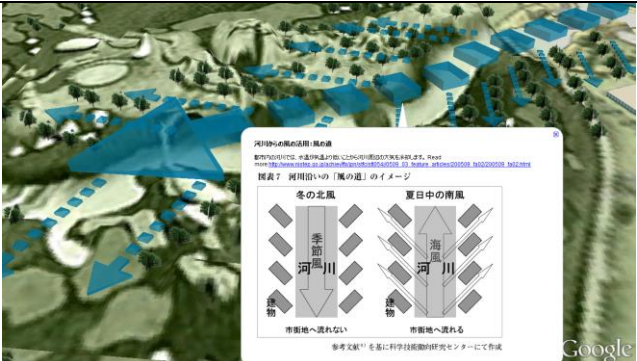
Used alone, 3D models are not enough for stakeholders to understand all the content of environmental guidelines. Thus, we try to represent them using not only 3D models but also multimedia expression, including cross-section pictures and other illustrations. The complete data are presented in Table 5.

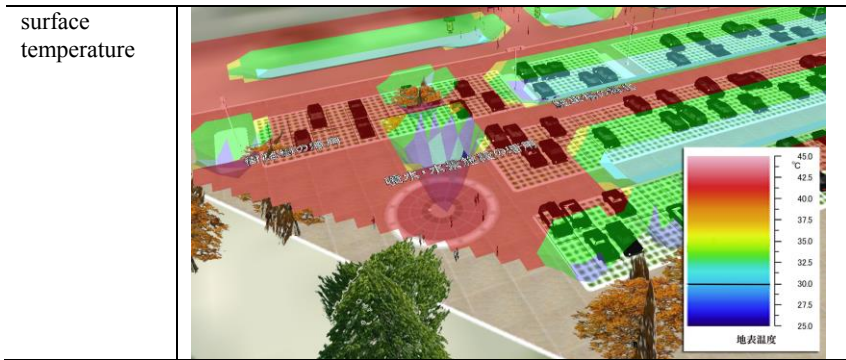
As shown in Table 4, *green coverage*—the region covered by different colors—has strict restrictions on vegetation coverage. The blue region is 90%, the cyan blue one is 75%, and the green one is 40%. This is an approach to showing the geographic division using a topography map, which is similar to the work we did for traffic guidelines.

As shown in Table 4, the flexible application of pictures and 3D models for *river wind/breeze* can help visualize the environmental effect on the planning site. When users double-click the items in the sidebar “My Places” on the left side of Google Earth, Google Earth will skip to its location; users can then read all the detailed information in the photo model with the detailed 3D model. This is the same method we used for the architecture design guidelines. It is also possible to link more pictures to the buildings, street furniture, and ground surface as auxiliary information, as shown in Table 4. This method was used to present the traffic guidelines.

Table 4. Environment guidelines in Google Earth

Name	Environment Guideline date efface in Google Earth
green coverage	

<p>River wind/breeze</p>	 <p>The diagram shows wind patterns around the Tone River (利根川). It illustrates '冬の北風' (winter north wind) blowing from the north and '夏日中の南風' (summer midday south wind) blowing from the south. The text indicates that wind is blocked by buildings ('建物') and does not reach the urban area ('市街地へ流れない') in winter, but it reaches the urban area ('市街地へ流れる') in summer. Source: 参考文献①を基に科学技術振興センターにて作成</p>
<p>Roof greening</p>	



In Table 4, *roof greening* is easily visualized by the 3D model and pictures to show the effect of roof plants and solar disruption. It is possible to link the shape of the roof greening and picture of the guideline to explain the roof greening effect. Accordingly, Guideline Nos. 2, 3, 5, and 6 in Table 5 are easy to understand and are used in the same way in Google Earth.

However, there are still parts that are difficult to present in a 3D model, such as *avoid thermal paving and water retention of paving* in Table 5. For pedestrian streets, designers consider water retention, surface water channels, and *spray devices* for paving in the central part in the street that cannot be covered by trees in order to control the surface temperature to be comfortable for the human body. We created a 3D model of the cross section to show the structure of the pavement, but this alone cannot show people how it works. We think that this is one of the difficult aspects of the guidelines to illustrate in Google Earth. Guideline Nos. 9–14 in Table 5 also have similar problems. We added the construction materials in the 3D models of Google Earth to improve user understanding. Although it is technically possible, it is still difficult to locate those 3D models in Google Earth; this will be one of our future study topics.

### Thermal environmental change—sandbox

We employed the “sandbox” plug-in to illustrate the less intuitive elements numbers. As shown for the *surface temperature* of the ground in Table 5, different translucent colors were used to display the uneven ground. In this case, the surface temperature was reduced by three countermeasures: grass-planting bricks in the parking lot, spraying water, and tress on the street. The reduction in temperature can be displayed by different colors; meanwhile, the translucent shapes accurately show the positions of different surface temperatures.

From the items in the heat island guidelines, not all of the environment guidelines are suitable for visualization in a 3D model. The results of the questionnaire regarding environment guideline results had quite a few responses of “hardly” effective, as shown in Table 5. However, since all of the text and graphs can be imported into Google Earth, it is possible to integrate all multimedia materials to present the guideline. Compared with conventional formats, Google Earth is more effective at helping stakeholders learn about the environment guidelines by illustrating the planning information in 3D models.

Table 5. Results of environment guidelines

No.	Guideline name	Word	Figure	3D Model	Detailed 3D Model	Advance for Understanding
1	River wind/breeze	●	●	⊙	○	effective
2	Park and garden	●	⊙	○	●	very effective
3	Roadside tree	●	⊙	○	●	very effective
4	Parking place greening	●	○	○	⊙	good
5	Residential Area greening	●	●	⊙	●	good
6	roof greening	●	●	○	●	very effective
7	wall greening	●	●	○	●	very effective
8	water spray / waterscape	●	⊙	○	●	effective
9	water retention of Paving	●	⊙	○	⊙	limited
10	water retention of Architecture surface	●	⊙	○	○	limited
11	watering	●	●	○	⊙	good
12	mist spray	●	○	○	⊙	limited
13	Avoid thermal paving	●	⊙	○	○	limited
14	High-reflection roof	●	○	○	⊙	limited

Not be used or Poor results : ○ Normal results : ⊙ Good results : ●

#### 4. CONCLUSIONS

A virtual globe-based and Web service-oriented architecture was proposed in this paper to provide a distributed 3D urban planning information sharing environment for public participation. This virtual globe-based system architecture facilitates public participation through the visualization of urban planning projects at any scale and from any viewpoint. End users can rapidly inspect an urban planning design from the macro-vision to micro-details with their personal computers.

In this research, a set of completed urban design guidelines imported most of the data, such as topography, texts, charts, images, and 3D models, into Google Earth. The topographic map, photo mode, and plug-in sandbox functions in Google Earth were utilized to develop the visualization tools for presenting the guidelines. According to our present work, most of the content of urban design guidelines can be imported into Google Earth. Google Earth has extraordinary exhibition capabilities in comparison to previous traditional formats. Using Google Earth to visualize urban design guidelines can surely improve the stakeholders' understanding of this part.

There are additional advantages to using this tool. First, the information can be shown locally by projectors or a touch screen to stakeholders. This method reveals the value of a common VR system. Second, the dataset of urban design guidelines can be uploaded into Google 3D Warehouse so that distant stakeholders can download it anytime and anywhere on the Internet and give feedback or chat by using communication software such as Skype.

Third, people around the world can access the guidelines through the Internet as reference materials for urban design in local cities. Although we did not complete the study on a multi-user Web environment, we will focus on Google Earth application programming interface (API) technology in the future. We hope that in the near future, this completed dataset can be multi-user, interactive, shared, and recorded according to the regulations of WEB 2.0 using the globe background of Google Earth.

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For investigation regarding the impact of planning policy on spatial planning implementation, International Community of Spatial Planning and Sustainable Development (SPSD) seeks to learn from researchers in an integrated multidisciplinary platform that reflects a variety of perspectives—such as economic development, social equality, and ecological protection—with a view to achieving a sustainable urban form.

This international journal attempts to provide insights into the achievement of a sustainable urban form, through spatial planning and implementation; here, we focus on planning experiences at the levels of local cities and some metropolitan areas in the world, particularly in Asian countries. Submission are expected from multidisciplinary viewpoints encompassing land-use patterns, housing development, transportation, green design, and agricultural and ecological systems.

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