



RESEARCH ARTICLE

# Establishment of the criteria of the green city for developing cities

*Xây dựng các tiêu chí của thành phố xanh, ứng dụng cho những thành phố đang phát triển*

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Building a livable city is the top objective of local governments. "Green City" is concerned, researched, and constructed effectively in some cities around the world. The paper is to identify a green city's benefits to humans and the environment. Moreover, this study also establishes criteria of the green city according to international standards in emerging cities, especially in 5 criteria such as green space and land use, atmosphere, water resource, and energy supply. Finally, the criteria of the green city established are used for scoring and assessing Vung Tau city. Currently, Vung Tau city has 60.9 scores below a green city's standards with 65 scores; however, it can be changed by proposals in development policies to get 69.3 scores.

*Việc xây dựng một thành phố đáng sống là một mục tiêu hàng đầu của các chính phủ địa phương. Thành phố xanh "Green City" đang được quan tâm, nghiên cứu, và xây dựng một cách hiệu quả tại nhiều thành phố trên thế giới. Bài báo này sẽ làm rõ ràng những chức năng mà một thành phố xanh mang lại. Ngoài ra, nghiên cứu này cũng xây dựng những tiêu chí của thành phố xanh đạt tiêu chuẩn quốc tế tại các thành phố đang phát triển, đặc biệt là 5 tiêu chí không gian xanh và sử dụng đất; giao thông; không khí; nguồn nước; nguồn năng lượng. Hơn nữa, việc ứng dụng các tiêu chí thành phố xanh cho việc chấm điểm và đánh giá Thành phố Vũng Tàu. Hiện nay, thành phố Vũng Tàu được chấm 60.9 điểm, mức điểm này ở dưới tiêu chuẩn của một thành phố xanh là 65 điểm, tuy nhiên trong tương lai gần với những chính sách phát triển phù hợp thì số điểm này có thể tăng lên đến 69.3 điểm.*

**Keywords:** green city; green space and land use, green city index

## 1. Introduction

According to the Asian Development Bank (2012), megacities are facing significant challenges regarding demography and environment. In 2030, the global population is estimated to reach up to 8.32 billion with 60% of the population living in urban areas (ADB, 2012). Appropriate strategies and solutions for urban development are not always considered. High urbanization represents an enormous pressure threatening welfare, especially in rapidly-developing cities in the Asia-Pacific region. The increased immigration in such cities have resulted in the increase of demands for housing, workplaces, infrastructure supplies and other services.

Urban areas need a significant number of services such as energy, water supply, drainage and solid waste disposal. A 70% of the total services are currently designated for urban areas, the remaining 30% for rural regions. Moreover, the crime rate in the cities is also significantly higher than in rural areas. Therefore, it is said

that the cities are the key factor for contributing to climate change and other environmental disasters derived from human activities and development; this severely threatens the community's health and a sustainable city development (ADB, 2012, pp. 1-10).

Furthermore, the negative impacts of climate change cause rapidly-rising sea levels and unprecedentedly precipitation events threatening many cities to be flooded in the coming years. Cities under risk are: Jakarta in Indonesia, Bangkok in Thailand, Dhaka in Bangladesh and Ho Chi Minh City in Viet Nam. Despite their economic growth rate, these cities, without any strategy and plan for the afore mentioned challenges, are unsustainable (ADB, 2012).

In order to improve living standards, the cities should have plans for sustainable development with environmental goals such as decreasing air pollution and solid waste, efficient use of natural resources, saving energy and production of renewable energy. Urban managers and developers, who play a decisive role for

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programs of urban development, are familiar with the “green city” and “green infrastructure” concepts for sustainable land use planning in the grey cities. The urban specialists need to comprehensively realize the benefits of green spaces in cities and the ecological value of green infrastructures in order to be applied in land use planning; it is necessary to turn benefits of green infrastructure into important indicators for a more livable and sustainable city for the future generations (Roo, 2011). In the case of a greener and more sustainable city, urban structure and functional areas have a significant change in land use parameters. This change needs to have a deep comprehension about the roles of green infrastructure, the value of urban ecology, saving sources

and energy, technology and solutions for municipal solid waste (Maria-Laura et al., 2014).

Green city is identified as an appropriate solution for increasing sustainability in areas with a high urbanization rate. This new concept for urban planning is the “green city” in which ecological services are provided by green infrastructure. The concept of “smart city” also leads into a sustainable development of citizens and society. However, a smart city only uses advanced technology and inherits from the availability of a grey city, so sustainability in the smart city is not optimized. In a green city, a natural ecosystem becomes the leading priority and is the key objective for conservation, restoration, and development (Maria-Laura et al., 2014). The components of a green city are shown in Figure 1.

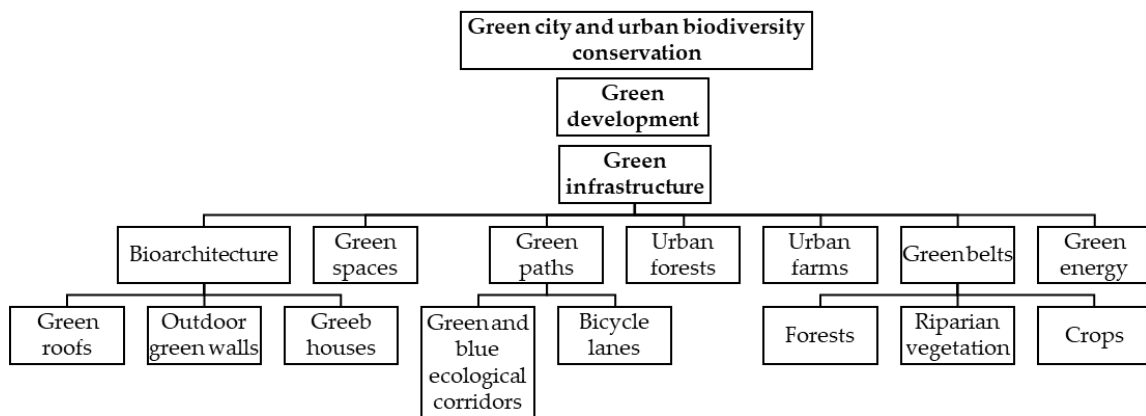


Figure 1: Diagram of urban structure for a green city (Maria-Laura et al., 2014)

In a green city, green infrastructure is one of the most important criteria; it is a combination of green spaces and urban hydrology systems. Moreover, it significantly contributes to nature conservation, biodiversity increments and maintaining the biological process in an urban environment. “Green infrastructure is our nation’s natural life support system, an interconnected network of waterways, wetlands, woodlands, wildlife habitats, and other natural areas” (Mark A. Benedict et al., 2001).

In this work, the criteria and their indicators for greener cities are appropriately filtered for developing cities in Asia which incorporate the three pillars of sustainability. This work takes into consideration the new concepts of green cities from previous literature using the green city index method for a case study in the city of Vung Tau. Moreover, proposals in development policies are looked over modified criteria and indicators to make the city greener and more livable.

## 2. Materials and methods

A new concept in urban development is “Green city”. This concept helps urban developers to have effective solutions for turning urban areas into greener and more sustainable cities. Recent studies focus on methods and tools to precisely assess and score actions and policies for a sustainable urban development. Furthermore,

criteria and indicators for green cities are established to score developing cities which should get over average scores in the green city index. Criteria focuses not only on city’s environment, socio-economic, and infrastructure, but also on development policies, urban re-development, smart technology, and effective adaptability to disasters and epidemics (Ogenis Brilhante & Klaas Jannes, 2018). In addition, the effective use of energy and transfer of renewable energy are considered as key indicators for the making of greener cities. Energy generation and efficiency is an important factor to stimulate and drive the efficient use of natural resources, contributing in the improvement of living standards.

Energy indicators combine many other indicators in urbanization such as transportation, public services, infrastructure, water supply, land use, food production, air quality, healthcare, economic development and climate change (Ogenis Brilhante & Klaas Jannes, 2018). Development strategies of renewable energy and CO<sub>2</sub> emission reduction are strictly implemented in developed cities in Europe (Siemens, 2012). Indicators in green cities have related effects on each other, therefore, an integrated research of a given city has to be implemented comprehensively. Population density indicators considerably affect indicators as green spaces, public transportation, habits to use energy and air quality. The increase of green spaces is also the key factor for green

cities of the abundant ecosystem. Green spaces bring citizens to nature to balance life, work and the environment. These spaces play an important role improving groundwater quality, reducing floods through vegetation, green roofs, urban plants and green corridors. Trees and green spaces contribute to improving citizens' living standards, reducing CO<sub>2</sub> emissions, increasing O<sub>2</sub>, increasing ecological functions and landscape for the cities; they also mitigate climate change, environmental problems, and heat island effects (Ogenis Brilhante & Klaas Jannes, 2018).

Mixed land-use planning, combined with social activities, stimulates an effective development for cities. A city of land compactness has a specific urban structure with elements such as population density, greenery, social mix and Transit-Oriented Development (TOD); those are practices aiming to increase the green city index. In compact cities, many areas are planned for green spaces. Citizens are accommodated into many apartment blocks while services and production are focused on mega buildings. Demands of housing, infrastructure, and work are guaranteed. Moreover, in a compact city, the public transport system is developed effectively and the use of energy becomes more effective. Using a mixed approach aims to develop multifunctional areas meaning integrated settlements, workplaces, schools, commercial and entertainment areas where citizens can approach by bike, walking or by public transportation friendly to the environment (Ogenis Brilhante & Klaas Jannes, 2018).

According to the United Nations Development Program, a "green economy" not only benefits human happiness and social equity, it also reduces environmental risks and ecological crisis (UNEP, 2011). A green economy is the economy of the lowest carbon amount, saving natural resources, utilizing renewable energy, providing job and social equity. Therefore, a green economy is an economy based on sustainable development and eco-economic comprehension. Environment-friendly activities in the green economy creates profits and beneficial values to lead community development in terms of cultural and living standards. In green economies, the three pillars (economics, socio-cultural and ecology) are taken into account for sustainability in which poverty reduction and improvement of the living standard are effectively implemented (UNEP, 2011).

## 2.1. Development of methods

According to recent studies, the green city index method is effectively used for scoring and assessing whether a city is classified as a green city or not. This method has been implemented in many cities around the world, with over 30 indicators in the criteria of emission, land use and green space, transportation, energy, water, air quality and others. For developing cities, indicators are appropriately reduced to have effective policies and strategies to make these cities greener and more livable based on their

current situation. The criterion of energy is considered as the most common factor in green cities in which indicators of electricity consumption and the ratio of renewable energy are measured. Most of the green cities lead to developing renewable energy to avoid overexploitation of fossil fuels and CO<sub>2</sub> emissions. In developed cities in North America, Europe, and Australia, advanced technologies, stimulating policies and financial supports for projects reducing emissions are key indicators. However, the majority of developing cities in a tropical climate have an abundant forest ecosystem, landscape, agriculture, green spaces and solar radiation. Moreover, congestion and environmental problems are always emergent topics for development strategies and planning.

The huge differences between developed cities and developing cities are the demography of age structure, consumption behavior and environmental awareness. This article establishes ten indicators of green cities for developing cities, including population density, green space per capita, urbanization rate on green fields, percent of people using private transport, vehicle number per household, air quality index, water consumption, electricity consumption and renewable energy. From the method of green city index, cities are scored based on weighted criteria and indicators. This study also applies statistics, comparison and estimates on a study case in order to comprehend common trends.

## 2.2. Criteria, indicators, and weighting

To increase the green index's credibility and comparability, cities are chosen for their size and importance without dependence on the requirements of the city government. With over 30 indicators, a minimum of eight to nine indicators are chosen for each specific city; the Green City Index includes the criteria of CO<sub>2</sub> emission, energy consumption, green spaces, land use parameters, transportation, water and sanitation, waste management, air quality, and environmental policies. For each criterion, half of the indicators are considered by statistic data from official sources, such as CO<sub>2</sub> emission per capita, water consumption per capita, recycling rate, and air pollutant concentration. The rest indicators present characteristics and trends about the environmental policies of the city, such as the government's commitment to using more renewable energy, the policies for reducing congestion and improving air quality. To be measured together, the indicators are based on the prevailing environment conditions and the intentions of the city.

Particular indicators have a slight difference from each other with consideration of usable data and the challenges in each region (Siemens, 2012). Each city has the same appropriate criteria group for scoring the green city index, nevertheless, each one has the private strengths for different indicators. For developed cities in

Europe, the criteria of CO<sub>2</sub> emission, energy consumption, and environmental governance are weighed strictly. For example, 68% of the population in Stockholm uses a bike or walk, while in Kiev, 74% travels by Public transportation. In Oslo, the share of renewable energy is at 65%, in Amsterdam water leakage is about 4% and Helsinki recycles 58% of its waste; so, it is seen that most cities focus on CO<sub>2</sub> reduction through the above programs.

Nevertheless, most developing cities in Latin American and Asia focus on reducing the water loss, widening green spaces of the abundant ecosystems and turns into renewable energy systems. In detail, Latin American cities have the best green spaces rate of about 255 m<sup>2</sup> per capita; the rate is significantly higher than those in Africa and Asia (74 and 39 m<sup>2</sup> per capita respectively). Asian

cities have the most dynamic growth rate with a population density of 8,200 capita per square kilometer, twice higher than North American cities (Siemens, 2012). According to Brillhante et al. (2018), indicators for each criterion will have a corresponding maximum number of benchmarks.

The weighing scale is calculated and then used for the green performance of each criterion. The total weight of the five criteria will be 100%. From the study of Green cities program methodology, ten typical indicators, most suitable for the above five criteria, are selected to measure living standards and compared with the indicators of developing cities. Ten indicators selected to form the green efficiency of a typical green city according to international standards are shown in Table 1.

**Table 1. Criteria, indicators, and weights**

Criteria	Indicators name	Benchmark (score)	Weighing scale
Green spaces and land use	Population density	26	40%
	Green spaces per capita	41	
	Percentage of urban development that occurs on existing urban land rather than on greenfield land	33	
Transport	Transport modal share in total trips	50	20%
	Average number of vehicles (cars and motorbikes) per household	50	
Air quality	Average annual concentration of PM 2.5	100	10%
Water	Water consumption per capita	50	20%
	Percentage of wastewater	50	
Energy	Share of population with an authorized connection to electricity	50	10%
	Renewable energy provision	50	

To clarify the data displayed in Table 1, it is necessary to assess the levels of good, average, poor of the ten selected indicators and score them from the benchmarks shown in Table 1. These criteria are designed to score and evaluate green cities for developing cities. Tables 2, 3, 4, 5, 6 display the specific assessment of indicators levels

under five selected criteria based on previous studies (OECD, 2016; Brillhante et al., 2018; GGGI, 2016; EC, 2018). This calculation uses the average weight assigned for each green indicator as shown in Table 2, 3, 4, 5 and 6. The above ten indicators show a green performance of a city, considering its green and livable.

**Table 2. Indicators for green spaces and land use**

Indicators	Good	Medium	Poor
Open green space area ratio per 100,000 inhabitants (IADB)	21.5 - 41 scores (more than 10 ha per 100,000 people)	17 - 21.5 scores (7 - 10 ha per 100,000 people)	1 - 17 scores (less than 7 ha per 100,000 people)
Population density (capita per km <sup>2</sup> )	20 - 26 scores (7,000 - 20,000 capita per km <sup>2</sup> )	16 - 20 scores (4,000 - 7,000 capita per km <sup>2</sup> or 20,000 - 25,000 capita per km <sup>2</sup> )	1 - 16 scores (less than 4,000 capita per km <sup>2</sup> or more than 25,000 capita per km <sup>2</sup> )
Percentage of urban development that occurs on existing urban land rather than on greenfield land (according to OECD/ICLEI)	21.5 - 33 scores (more than 40%)	13 - 21.5 scores (20 - 40%)	1 - 13 scores (less than 20%)

**Table 3. Indicators for transport**

Indicators	Good	Medium	Poor
Transport modal share in total trips (according to OECD/ICLEI)	35 – 50 scores (public transport mode more than 50%)	20 – 35 scores (30 - 50%)	1 – 20 scores (public transport mode less than 50%)
Average number of vehicles (cars and motorbikes) per household (according to OECD/ICLEI)	35 – 50 scores (less than 0.5)	20 – 35 scores (0.5 - 1)	1 – 20 scores (more than 1)

**Table 4. Indicators for air**

Indicators	Good	Medium	Poor
Average annual concentration of PM 2.5	75 – 100 scores (0 - 50 µg/m³)	35 – 75 scores (50 - 150 µg/m³)	1 – 35 scores (more than 150 µg/m³)

**Table 5. Indicators for water**

Indicators	Good	Medium	Poor
Water consumption per capita (according to IADB)	35 – 50 scores (more than 90%)	20 – 35 scores (70 - 90%)	1 – 20 scores (less than 70%)
Percentage of wastewater treatment (according to OECD)	35 – 50 scores (more than 60%)	20 – 35 scores (40 - 60%)	1 – 20 scores (less than 40%)

**Table 6. Indicators for energy**

Indicators	Good	Medium	Poor
Share of population with an authorized connection to electricity (according to IADB)	35 – 50 scores (more than 90%)	20 – 35 scores (70 - 90%)	1 – 20 scores (less than 70%)
Renewable energy provision (based on EEA)	35 – 50 scores (more than 20%)	20 – 35 scores (10 - 20%)	1 – 20 scores (less than 10%)

### 3. Results and discussion

#### 3.1. Case study in the Vung Tau city

Vung Tau city is located in the south of Vietnam; it is a dynamic city of tourism and oil industry. The sectors of services and industry have contributed to the majority of the city's growth. The Vung Tau city (150.43 km<sup>2</sup>) holds a population of 417,824 inhabitants (Vungtau Population, n.d.; The Prime Minister of Government, 2019). The current population density is 2,778 inhabitants/km<sup>2</sup>. The city has over 5,867 ha of agricultural land, indicating 1,404 ha of green space for 100,000 inhabitants. In 2020, 659 ha of agricultural land has shifted into non-agricultural land, occupying 11.24% of total agricultural land (Ba Ria-Vung Tau People's Committee, 2020).

According to studies of the Vietnam institute for urban and rural planning, over 97% of citizens have sufficiently freshwater, wastewater, and electricity services. However, public transportation and non-motorized mobility have

not played a significant role in the city. Despite of having great potential, renewable energy has not been yet planned for the city's energy supply systems.

#### 3.2. Results

Based on the criteria and indicators in tables 1, 2, 3, 4, 5, and 6, Vung Tau city is scored according to the green city index. For the indicator of population density, the Vung Tau city of gets a score of 82 from its 778 inhabitants/km<sup>2</sup>; the city gets the maximum score of 41 for green spaces per capita with 1,404 ha per 100,000 citizens. Vung Tau has a rapid growth rate in which agricultural land rapidly decreases by 11.24%, being replaced by built-up areas, therefore, the indicator only gets a score of 10 (see table 2).

In terms of transportation, the majority of citizens choose motorbikes; however public transportation, walking paths, and bike lanes should be invested and established to improve the scoring for this indicator. The city gets a score of 10 for the indicator of using public transport and

a score of 10 for vehicle owners (see table 3). The city gets the maximum score of 100 in the criterion of water for both indicators, water supply and wastewater discharge, since over 97% of households are connected with the city systems (see table 5). With an average of 2.5, the air quality indicator in the city also gets a high score of 70 (see table 4). Finally, the electricity supply indicator gets the maximum score of 50, however, the renewable energy indicator only gets a score of 5 since renewable energy has not been yet invested and stimulated in the city (see table 6).

### 3.3. Discussions

The green city index of Vung Tau city is 60.9; being lower than 65, the city is not currently qualified as a green city (Table 7). According to Decision No. 586/QĐ-TTg of The Prime Minister of Government (2019), the area of urban development will increase 10.330 ha in 2035. This means

that new buildings will be developed on green fields. Furthermore, in 2035, the Vung Tau city population is expected to reach up to 650,000 inhabitants, increasing population density up to 4,321 inhabitants/km<sup>2</sup> leading into a score of 16 (see table 2).

A proposal states that Vung Tau city needs to conserve and exploit historical and cultural buildings, invest bus routes to destinations and operate walking paths and bike lanes moving into the downtown for commerce and entertainment; this in order to improve the score from 20 to 30. Moreover, to increase the score from 5 scores to 35, renewable energy should significantly be developed to produce up 20% of total energy consumption; this will reduce thermal power plants and the use of fossil fuels. This can also improve the air quality index from 70 to 80. By following these suggestions, Vung Tau city can get a score of 69.3 (Table 8).

**Table 7. Indicators selected to score for Vung Tau City (own source)**

Criteria	Indicators name	Benchmark (score)	Weighing scale (100%)	Score
Green spaces and land use	Population density	10	40%	24.4
	Green spaces per capita	41		
	Percentage of urban development that occurs on existing urban land rather than on greenfield land	10		
Transport	Transport modal share in total trips	10	20%	4
	Average number of vehicles (cars and motorbikes) per household	10		
Air quality	Average annual concentration of PM 2.5	70	10%	7
Water	Water consumption per capita	50	20%	20
	Percentage of wastewater	50		
Energy	Share of population with an authorized connection to electricity	50	10%	5.5
	Renewable energy provision	5		

**Table 8. Modified score for Vung Tau City (own source)**

Criteria	Indicators name	Benchmark (score)	Weighing scale (100%)	Score
Green spaces and land use	Population density	16	40%	26.8
	Green spaces per capita	41		
	Percentage of urban development that occurs on existing urban land rather than on greenfield land	10		
Transport	Transport modal share in total trips	15	20%	6
	Average number of vehicles (cars and motorbikes) per household	15		
Air quality	Average annual concentration of PM 2.5	80	10%	8
Water	Water consumption per capita	50	20%	20
	Percentage of wastewater	50		
Energy	Share of population with an authorized connection to electricity	50	10%	8.5
	Renewable energy provision	35		

## 4. Conclusion

From the results of this research and the scoring indicators of the Vung Tau city, it was shown that ten indicators of 5 criteria: green spaces and land use, traffic, air, water and energy are the minimum requirements that a green city must achieve. The Vung Tau city, or any other city in Vietnam, should focus and implement the adjustment of the general planning to suit the socio-economic development conditions of each region. Important factors are: planned urban development, exploitation of minerals, energy production, domestic water, green spaces, rational use of the land and efficient public transport to analyze and provide the most suitable solutions towards the building of green cities, eco-cities and sustainable development.

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