

# Understanding the evolution of green ecology theory and future trends in urban development

Boxuan Zhao<sup>1, a</sup>, Tongyu Sun<sup>1, b</sup>

<sup>1</sup>College of Architecture and Urban Planning, Tongji University, Shanghai, China.

<sup>a</sup>zhaoboxuan123@live.com, <sup>b</sup>sty@stystudio.com

**Abstract.** The 21st century is known as the 'urban century', sustainable development has become a general consensus of countries all over the world. With global warming and frequent natural disasters, cities have become more vulnerable to external changes than ever, therefore the concept of green and ecological urban development has become the global consensus. This paper discusses the development of green ecological theory in the history of urban development, then provides topics for the future development trend of green ecological cities in response to environmental changes: green infrastructure, resilience, low-carbon economy, zero-energy building, green transportation.

**Keywords:** urban design; green ecological city; Low-carbon development.

## 1. Introduction

In order to improve the human environment, the United Nations convened the first Human Environment conference in Stockholm in the 1970s, which brought environmental issues into international politics for the first time. Meanwhile, the concept of eco-cities was first formally introduced by UNESCO in the 1970s under the Man and Biosphere Programme. Since then, sustainable development was introduced in 1987 in the report of the World Commission on Environment and Development (WCED), and has become a global guideline for long-term urban development. Green ecological oriented city development has gradually become an important strategy for global sustainable development. In face of the challenges of rapid global urban sprawl, explosive population growth, resource scarcity and environmental degradation, incorporating green ecological oriented city building into the sustainable development system has real strategic significance for saving energy consumption, balancing carbon emissions, protecting environmental resources and achieving healthy economic development, as well as being an important strategy for future global sustainable development.

This paper first reviews the green ecological theories in the history of urban development and summarizes them into three stages: the emergence of green eco concepts, rethink urban sprawl, sustainable design. Then summarizes the green ecological development trends under the goal of sustainable urban development: green infrastructure, resilience, low-carbon economy, zero-energy buildings, and green transportation. It is expected to be beneficial to the future of urban construction.

## 2. Tracing the Green Ecological Theory of Urban Development

Humans have been trying to understand their surroundings for a long time, changing the natural environment through technical means of design and construction to create a more comfortable living environment. As early as the 4th century BC in ancient Greece, Hippocrates already described the impact of the natural environment such as air, water and place on human health, followed by Vitruvius in the ancient Roman period, who emphasized that the site of a building should be determined according to the site's solar orientation, temperature and other environmental factors.

After entering the 20th century, the green ecological theory of global urban development went through three stages: firstly, the industrial revolution produced the germ of the green ecological

concept. Although the industrial revolution brought about rapid technological advances, the academia became aware of the pollution caused by industrial development to the environment and began to reconceptualize the relationship between human beings and nature. The second stage was the beginning of a re-examination of the serious consequences of the infinite urban sprawl. With the explosion of population, cities expanded at a rapid rate and mega-cities emerged in various countries, but it brings more resources and energy consumption and environmental pollution. The concept of the eco-city was introduced at this time, and its focus was no longer on one-way environmental factors, but expanded from the initial emphasis on natural ecological concepts to the use of natural resources as a means of minimizing the impact of human activity on nature through urban development combined with site conditions, climatic conditions and natural resources. The third stage was the advent of globalization, when sustainable development became the trend in order to preserve the use of natural and energy resources. The high rate of urban growth is studied in an integrated way, in conjunction with the three elements of environment, economy and society.

## 2.1 Emergence of green eco concepts

Although the completion of the industrial revolution in Britain in the 19th century brought historic civilization and technological progress to the world, it also brought a series of serious environmental problems such as acid rain, fog and haze, waste of resources and energy. Faced with the increasingly serious problems brought about by the spread of urban sprawl, planners and architects began to have the idea on how to make urban development more green and ecological.

The idea of green and ecological city was first originated from Howard's garden city. His vision of green ecological development profoundly influenced 20th century planning thinking. What Howard advocated was a reform idea, that is, the pre-industrial revolution urban development model in which integrated urban-rural development replaced the separate development of cities and urban rural area [1]. In fact, the garden city was essentially a combination of the city and the countryside: both city and countryside had their own characteristics, and that a combined urban-rural approach was used to solve the urban problems of that time, avoiding the shortcomings of both city and urban rural area. In addition, a preliminary exploration of the social city is reached: a cluster of cities composed of several garden cities.

Patrick Geddes, who was in the same era as Howard, proposed the utopian urban concept of integrating nature into the urban area. He emphasized the interdependence of the city and its surroundings, placed great emphasis on urban surveys, believed that urban planning should be preceded by fieldwork, and specified a series of checklists for natural conditions, transport facilities, industry and commerce, population and urban conditions. In 1915 Geddes proposed a prototype for the concept of the 'conurbation'[2], and his ideas were essentially an ecological approach to urban development that required technological innovation to integrate nature.

Confronted with the increasing industrialization of production brought about by mechanization, Corbusier proposed the concept of the 'Green City', emphasizing the 'artificial' garden city. But there is a fundamental difference from Howard: Corbusier saw this as a highly effective solution to urban problems, unlike the horizontal urban sprawl of the past, he created a vertical garden city.

## 2.2 Rethinking Urban Sprawl

In the first half of the 20th century, after the expansion of automobile, environmental pollution, highway overspread, energy and oil crises, the world began to realize the growing seriousness of population, resource and environmental problems, and paid more attention to the destruction of natural resources caused by the infinite spread of cities. The concept of eco-city was first introduced in the UNESCO Man and the Biosphere Programme in 1970, which further promotes the trend of eco-city development.

Lewis Mumford's humanist-style view of urban development was heavily influenced by Howard's garden city. He advocated Howard's social city, where he believed that there was a limit to the scale of urban development and that any planning beyond its limits had to be converted to

some form of dexterity[3]. In effect, he opposed the disorderly sprawl of the city and the resulting monstrous masses, as well as the aimless expansion of the city. To explore the relationship between site and climate, Victor Olgyay pioneered the bioclimatic design approach, which explores the effects of site selection, solar orientation, wind and air movement, and the thermal properties of materials on the performance of the urban environment [4]. Olgyay has proposed a bioclimatic solution to the problem of industrial urban pollution.

McHarg places greater emphasis on the co-evolution of urban planning patterns and natural processes, and on this basis proposes a theory of ecological planning that explores the influence of nature in man-made environments such as buildings, places and urban spaces [5]. McHarg's ecological planning theory reveals an approach to the integration of design and nature, instead of focusing on the concept of design or nature, McHarg focuses on the word 'integration', emphasize that making the most of the potential that nature has to offer.

Human settlement studies the relationship between people and their environment, and Doxiadis combines his theory of human settlement with ecology study. He believes that the interference and destruction of the surrounding environment by human beings has led to the loss of the necessary balance required to maintain a pleasant environment. It is necessary to use ecological and human settlement perspectives to reduce the impact on the environment to a minimum. [6]. In effect, the solution to environmental problems is to establish a global ecological balance.

The Canadian scholar Oke relied on boundary layer theory to argue that shifts in the thermal radiation, moisture and aerodynamic properties of the atmosphere over cities are responsible for the impact on the environment around city buildings [7]. He pioneered research in the field of urban climate science, noting the independent ecosystems of cities and experimental studies of the urban heat island effect.

### 2.3 Sustainable design

The theoretical exploration of green ecological development in cities in this period was no longer limited to a reliance on ecology, but rather encompassed the comprehensive study of social, economic and natural complex systems.

As the initiator of the first international conference on eco-cities, Richard Register systematically elaborated on the connotations and principles of eco-cities: an eco-city, a healthy city in the ecological sense, and the criteria for an eco-city need to follow the three principles of life, beauty and equity [8]. He considers the city as a three-dimensional composite system and advocates the establishment of ecological principles in the city, opposing urban expansion like a pie. The research covers transport development, land use and biodiversity.

Influenced by McHarg's view of ecological planning, Michael Hough used ecology as the basis for urban research, arguing that the conflict between the long-term separation of humans and self-heat can only be resolved by taking into account both the overall urban natural landscape and urban residents [9]. His in-depth study of the composition of the natural and human environment in cities, involving water, flora and fauna, agriculture and climate, describes the idea of urban areas using different ecological approaches to shape the urban form.

Richard Forman argues that the scientific basis for solving the environmental problems of megacities is landscape and regional ecology. He developed the concept of land mosaics, the core idea of which is the 'patch-corridor-matrix' model, which suggests that all land and urban areas can be spatially divided into these three types, which create a regional ecological network together[10]. He focused more on land use and management, the integration of human and cultural activities with nature, the shape of patches, river and road corridors and internal flows.

Mike Jenks proposed an compact model of urban development[11], which is, small-scale, regional high-density approaches to land use are promoted, sustainable urban development should consider not only environmental factors, but also economic viability, livability and social equity. Faced with the contradiction between 'growth and environment', Moughtin also gave the solution to sustainable urban development - green dimensions [12]. It is imperative to combine the spatial form,

urban vitality and character, urban atmosphere, moderate development that respects tradition development.

Prioritizing public transport has an important role to play in relieving urban traffic congestion, promoting energy saving and transport decarbonization, promoting sustainable development. The concept of the public transit-oriented development(TOD) model originated from the research of Peter Calthorpe [13]. In terms of transport planning, the TOD model advocates development and construction around public transport facilities, and planning incorporates design principles such as encouraging public space, comfortable distance walking system, mix of land use and compact development, covering multiple levels from community, urban area to regional city. In fact, TOD is not just a transport theory in the pure sense, but a model for the deep integration of urban planning and land use.

TABLE I. Green Ecological Theory in Urban Development

Time	Scholars	Perspectives
The Classical Period	Hippocrates Vitruvius	The impact of the natural environment on health The location of the site is based on the natural environment
Industrial Revolution	Ebenezer Howard Patrick Geddes Le Corbusier	Garden city Ecological area Artificial green vertical city
Early in the 1900s	Lewis Mumford Victor Olgay Ian Lennox McHarg T.R.Oke C A Doxiadis	Social City Bioclimatic impacts Ecological Planning Urban Climate Science Human Settlements
1930s-2000	Richard Register Michael Hough Richard T.T. Forman Mike Jenks Cliff Moughtin Peter Calthorpe	Ecocity Combining City and Nature Regional Ecological Network Compact City Green Dimensions TOD, Walking Pocket

In general, the current development of green ecological theory in cities has roughly gone through three stages: firstly, from the perspective of research content, it has experienced the initial single theoretical exploration to the composite multidisciplinary cross-research. Secondly, in terms of research methods, it has experienced the process of qualitative research to combining qualitative and quantitative research field. Finally, the research direction has experienced the process from urban research to natural ecology to coupling of urban research and natural ecology. (Table. I)

### 3. Green and ecological oriented urban trends

Since its introduction in 1987 in the report of the World Commission on Environment and Development (WCED), sustainable development has become a guideline for long-term development in most countries. Green, ecologically oriented urban planning and urban design reflect the unchanging and innovative direction of global sustainable development. Academics recognize that a healthy natural environment is a necessary physical foundation for urban development and a necessary condition for achieving a balanced ecosystem.

Nowadays, green and low-carbon, environmentally friendly, resource-saving and economically sustainable have become the core contents of green and ecological oriented urban development. With the continuous update of sustainable development requirements, relevant theories have also been given new connotations. At present, the problems faced by the green ecological development

of global cities are: when external environmental disturbances occur, urban development effectively uses natural ecological resources, reduces environmental impact, and maximizes ecological value; In the face of urban internal demand, encourage environmentally friendly construction methods such as green buildings and green transportation, and at the same time improve the urban green space network, promote the green transformation of industries, and maintain the long-term stability of urban spatial structure. On this basis, the research hotspot trends are conceived. (Table. II)

TABLE II. Issues of Green Ecological Trends

Trends	Issues
green infrastructure	artificial green landscape natural landscape urban greening green corridor biodiversity & habitat ecosystem service (provision, regulate, support, culture)
resilience	disaster prevention & management rainwater management & dispose social ecological system resilience Habitat & water body restoration wetland protection
low carbon economy	low carbon industry green consumption ecological industry chain ecosystem service value ecological footprint
zero energy building	intelligent energy consumption minimize water use construction industrialization prefabricated building building reuse building information model technology low impact material green construction
green transportation	transit oriented development walkable street public transport accessibility mix landuse working living distance transfer facilities increase road network density

### 3.1 Green Infrastructure

As an important natural capital, green infrastructure provides the built environment with the ability to provide multiple interrelated ecosystem services[14], organizing the gray and green spaces of the city in an orderly manner, integrating all natural information into a complete infrastructure network. Green infrastructure is a low-carbon mode of construction that provides ecosystem service functions such as provisioning services, regulating services, supporting services, culture services. The composition of green spaces, such as woodlands, wetlands, water corridors and urban parks, can absorb urban emissions, increase carbon sinks, have excellent carbon sequestration capacity and moderate climate change.

Landscape is the closest contact medium between people's daily life and nature, and its most direct role is to provide an interface for the integration of the complex network of human activities

and the natural environment. Landscapes are capable of accommodating complex urban activities and reflect the interrelationships between changes in urban spatial patterns and ecological processes [15]. Landscapes provide important scientific evidence for understanding the complexity of urban spatial heterogeneity, biodiversity and ecological processes.

### **3.2 Resilience**

Resilience is seen as a complex and adaptable new socio-ecological system [16]. Resilience emphasizes the absorption of external changes and the ability of anti-interference. In recent years, the vulnerability of cities around the world has attracted attention when facing frequent disasters such as floods, droughts, hurricanes, earthquakes, extreme cold, and heat waves. It is urgent to use resilience theory as a response to extreme urban events, and resilience research needs to pay more attention to the ability to cope with sudden crises in the external environment. Resilience can sustain urban fabric and sustainably safeguard human well-being under dynamic conditions such as climate change, energy scarcity, disease transmission and natural disasters.

### **3.3 Low carbon economy**

The core of low-carbon economy is to control the influencing factors of carbon emissions, achieve the purpose of reducing greenhouse gas emissions through low-carbon production and low-carbon consumption, and balance the contradiction between carbon emissions and economic growth. More attention needs to be paid to the integrated development of industry and cities, the green transformation of industries, the value of ecosystem services and ecological footprint. The integration of industry and city revolves around the relationship between 'industry' and 'city': industry should pay more attention to the mix of use functions, while city emphasizes the reasonable matching of urban structure, through the strategy of allocating basic services and public space, an efficient model of living and employment circle can be formed.

### **3.4 Zero Energy Building**

Zero-energy buildings provide a balance between the contradictions between construction activities and the ecological environment, aiming to maximize the use of material resources while ensuring ecological balance, minimizing energy consumption and carbon emissions in buildings and achieving sustainable urban development. Traditional production methods focus on the quality and duration of the project, with less consideration for resources and the environment, industrialized buildings can change the waste of construction water and construction waste caused by traditional production methods, while shortening construction time and reducing labor costs. In addition, the process of construction often requires the investment of large amounts of material and human resources, resulting in large consumption of construction costs and environmental pollution, green construction methods and construction processes cannot be ignored in achieving zero energy.

### **3.5 Green Transportation**

Transportation is an important source of urban carbon emissions, and the aim of sustainable transportation is to achieve urban carbon balance. Compact development can save urban land, effectively shorten travel distance, and reduce traffic emissions and energy consumption. Transit oriented development can effectively relieve urban traffic congestion and lower transportation emission. Walking has the characteristics of zero emission with no noise and pollution, thus strengthening the construction of walking cities can effectively reduce traffic congestion and save energy. In addition, increasing the density of the road network and reducing the size of the block are the means to achieve the purpose of optimizing the structure of the road network, improving the gradation of the road network, and promoting urban green transportation services.

#### 4. Discussion

The theory of green ecology-oriented urban development has been continuously updated and improved to achieve the goal of zero-carbon city construction, meanwhile, the content of the topic needs to be constantly explored and innovated. To begin with, green infrastructure and landscape elements pay more attention to the intrinsic influence mechanism between ecosystems and human society and solve the contradiction between urban development and the natural environment. It plays an important role in carbon sink, climate regulation, and improving the city's response to external disturbances and maintaining its long-term stability. Secondly, the resilience factor mainly focuses on the city's ability to restore balance after external disturbance, emphasizing the absorption of external changes and the level of anti-interference, including the city's disaster prevention and absorption, reducing adverse interference, adapting to change, and rapid adjustment ability. Then, the building and transportation sector is the largest source of carbon emissions, and green buildings and sustainable transportation are of great significance for optimizing urban structures and achieving carbon neutrality based on green technologies and energy utilization. Last but not least, low-carbon economy promotes the comprehensive green transformation of economic and social development through low-carbon production and consumption, make low-carbon economic development and sustainable environmental resources possible.

#### 5. Conclusion

The development of urban green ecology theory has experienced the process of urban spread at the cost of environmental damage to the harmonious development of the city and the natural environment. For the sustainable development goal, it is necessary to continuously break through the existing concepts, realize the transformation from a crude resource consumption model to a refined low-carbon intensive model. More than ever, we need to pay more attention to the ecosystem service value of green infrastructure and landscape, using urban resilience as a measure to combat climate change, balance carbon emissions from urban buildings and transportation, achieve sustainable economic development goal.

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