

# Sustainable Development and Green Space System Construction

## Sustainable Green Space System Planning Combined With Geographic Information System

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**Abstract**—Green space system was an important part of the urban ecosystem. The functions of the green space system were mainly protection, productive, and recreational. Green space system planning and construction provide an important way for sustainable urban construction in China. Firstly, the green space system was ecological conservation corridor; furthermore, combining ecological technology, storm water and flood management system and domestic wastewater treatment technology, people use green space system as an ecological treatment facility; thirdly, combining the construction of urban slow transport system, green space system could be taken as urban low carbon facility as well as leisure and entertainment park facility. This paper proposed sustainable urban green space system planning based on Geographic Information System, in order to provide experience for sustainable cities construction in China.

**Keywords**-sustainable development; green space system; Geographic Information System (GIS)

### I. INTRODUCTION

China has been undergoing a period of economic reform and expansion since the late 1970s, accompanied by rapid and widespread urbanization [1]. According to the international stage rule of urbanization as well as the four-stage theory of the development of urbanization [2,3], China has been in the phase of rapid growing stage of urbanization (the interim stage of urbanization) since 1996. However, urbanization has also led to serious environmental and ecological problems, both in urban and surrounding areas, including increased air and water pollution [4-6], local climate alteration [7], and a major reduction in natural vegetation cover and production [8].

All cities are confronted with the tough issue of preserving the quality of the environment; while at the same time allowing development occur. The rapid urbanization process creates a greater demand for environmental protection, mitigation of hazardous environmental events and provision of recreational opportunities in Chinese cities [9, 1]. In recent years, many cities in China have proposed building a green city, garden city, eco-city, low-carbon city, in order to promote and achieve sustainable development of the city.

The World Commission on the Environment and Development (WCED) defined sustainable development as development “that meets the needs of the present without compromising the ability of future generations to meet their own needs” [10]. Planners now recognize sustainable

development as development that is profitable, green, and fair [11, 12]. After hundreds of years of Western industrialization and urbanization development, developing urban greenways has proved to be an effective strategy to insure sustainable urban development and counter regional ecological fragmentation [13].

Greenways are considered to be “corridors of various widths, linked together in a network in much the same way as our networks of highways and railroads have been linked” [14]. Greenways have three main functions: (1) an ecological, (2) a creational and (3) a historical heritage corridor [15]. Greenways are an excellent mechanism that balances needs for both conservation and growth [16]. Although the concept of Greenway was an adaptation from the Western World, the Chinese have a history of more than 2000 years of Greenway planning and implementation [17]. Chinese Greenways have been called green space system.

Green space system planning in China was mainly a “top-down” approach, and it often lacked a scientific basis and significant public participation. Traditionally, the functions of the Greenways were mainly protection and productive, with little concern for human uses such recreational uses of cycling and hiking [17]. Now, greenways have evolved into a resource that can meet the public’s needs for recreation, environmental protection, and alternative transportation. There has also been a shift of focus in greenway planning: from a single-objective paradigm of environmental protection or natural conservation to a multi-objective process [16].

In this paper, the practical theory and technological basis of green space system planning was explored, the approaches of green space system planning for a sustainable city were studied, the steps of sustainable green space system planning based on Geographic Information System (GIS) were proposed, to provide a theoretical basis and reference for a sustainable city in China.

### II. THE PRACTICAL THEORY AND TECHNOLOGICAL BASIS OF GREEN SPACE SYSTEM PLANNING

#### A. Greenways

The greenway literature of the past decade consistently names Frederick Law Olmsted as the father of the greenway movement in America [18]. The word ‘greenway’ was first used in print by Frederick Law Olmsted in the mid-19th century. Greenway was green space network that linking up

open space with green ecological corridors artificially [19]. Greenway ideology offers critical reference for reviewing the Chinese territory and urban planning, the planning of land utilization, the urban overall planning and green space system planning, especially, it has significance for urban green space planning.

### B. Landscape ecology theory

Since 1980s, landscape ecology has gradually developed into a discipline with independent theoretical methods, and has formed the theory of landscape pattern including a corridor [20]. The objects and contents which landscape ecology studies can be summarized in three basic aspects. ① landscape structure, namely landscape composition unit type, diversity, and their spatial relationship; ② landscape functions, namely interaction between landscape structure and interaction of ecological processes, or interaction between landscape structure units; ③ landscape dynamics, namely the changes of structural and functional aspects of landscape over time [21].

### C. Ecosystem theory

The word 'ecosystem' was first used in print by A.G. Tansley [22] in his well-known paper on vegetation concepts and terms. An ecosystem is a community of living organisms (plants, animals and microbes) in conjunction with the nonliving components of their environment (things like air, water and mineral soil), interacting as a system [22]. All the living organisms and their living environment on the Earth constitute ecosystems. Energy flow, material circulation and information delivery are the three basic functions of the ecosystem, and they work together to maintain the normal functioning of the ecosystem. Ecosystem together constitutes the abiotic environment and producers, consumers and decomposers, whose structure mainly includes three aspects of the component structure, space-time structure and trophic structure. The types of ecosystem can be generally divided into natural ecosystems and artificial ecosystems, including water ecosystems, terrestrial ecosystems, farmland ecosystems and urban ecosystems. One of the important characteristics of the ecosystem is the ability of self-regulation in the interior. The more complex the structure is, the larger the number of species is, and the stronger the ability of self-regulation is. There is a balanced relationship among organisms and between organisms and environment of the ecosystem. When the balance is destroyed, a new balance would be gradually formed. However, if the balance of the ecosystem is severely damaged, it would cause permanent imbalance. Green space system is an important part of the urban ecosystem, affecting the function and structure of the urban ecosystem. Therefore, based on ecosystem theory, to carry out urban green space system planning, to maximize the integration and protection of the natural resources and environment has important significance for the maintenance of the balance of the ecosystem and realization of sustainable development.

### D. Ecological technologies

Currently, ecological engineering techniques have been more and more widely applied in environmental management, including ecological processing technology of constructed

wetland, artificial floating islands and stormwater ecological management techniques.

Constructed wetlands are artificially designed and built, engineered wetland systems for wastewater treatment, are the analog and strengthening of natural wetlands. Constructed wetlands are comprehensive ecosystems, which apply the principle of species symbiosis, material recycling and regeneration and coordination of structure and function of the ecological system. On the basis of promoting virtuous cycle of wastewater pollutants, constructed wetlands give full play to the resource production potential to prevent environmental recontamination, and gain best value of sewage treatment and resource.

Artificial ecological floating islands, also known as the artificial drift island or ecological floating beds, based on ecological engineering principles, are against eutrophic water to degrade COD, nitrogen and phosphorus content, are functional landscape with both landscape and ecological purification. They are raft-like artificial floating bodies, cultivated aquatic plants like reed on them, placed in the water and floating on the water surface. Artificial floating islands can be divided into two patterns: dry and wet pattern, and those plants contact with water are wet pattern, those plants have no contact with water are dry pattern.

Stormwater management refers to a series of countermeasures taken when rain falls on the ground, including drainage, collection and utilization of infiltration processing of stormwater. It draws precipitation into the natural water cycle as much as possible, in order to maintain the ecological balance, and to purify water and reuse rainwater.

## III. GREEN SPACE SYSTEM PLANNING AND SUSTAINABLE DEVELOPMENT

Green space system planning as a strategy of sustainable development needs to be understood, realized and adopted by the local governments in order to plan and create the metropolitan greenways in China.

### A. Green space system provide ecological protection for sustainable development

Natural greenway includes natural open space, natural reserves, parks, central greenbelts, patches, rivers, lakes, wetlands, mountains, etc. As the protection facility of urban ecology, Green space system could protect animals, plants, riparian ecological system, wetland ecological system, and forestry ecological system. Greenways can be powerful makers and shapers of urban form [23]. Searns [24] explains the greenways as an adaptive urban landscape form evolve from axes, boulevards and parkways and trail-oriented recreational greenways into multi objective greenways that address recreation, beautification, such areas as wildlife habitats, promoting urban flood damage reduction, enhancing water quality, providing a resource for outdoor education, and other urban infrastructure objectives.

### B. Green space system provide environment protection for sustainable development

With the accelerating process of urbanization, floods, waters polluted by runoff and damage to the ecological

environment and other issues are increasing. Currently, more mature foreign ecological measures include stormwater wetlands, bioretention devices, vegetation shallow trench, vegetation filter strips, etc. These ecological measures are based on ecological processing technology; imitate nature in the maximum degree, and restore the natural state, which are economical, efficient and environment-friendly, and in line with the requirements of sustainable development. It not only reduces the occupation of land resources, but also can combine with the landscape, to achieve treatment of source pollution. Also stormwater ecological drainage management technology can significantly reduce the cost of its development and construction, reduce the area of impervious pavement and curb drainage construction, reduce the use of drainage channels and inlet facilities, eliminate or reduce the size of the large-scale stormwater tanks; effectively slow down the flood peak so as to reduce the loss of combined sewer overflows (CSOs) and sanitary sewer overflows (SSOs), save costs of constructing large centralized facilities. Besides, by applying stormwater ecological drainage management technology, the ultimate effect is very close to the original natural hydrological function of the area, and water balance of local runoff, storage, evaporation, percolation, groundwater recharge can be maintained; through stormwater ecological drainage management technology, the negative impact of runoff on the water quality and volume of receiving waters will be reduced, and base flow can be maintained close to the original level..

**C. Green space system provide low-carbon protection for sustainable development**

The urban planning of slow traffic system can be integrated with green space system planning, i.e. constructing walking, running and cycling lanes and fitness facilities in the greenways, which will provide the green traffic way, as well as outdoor leisure facilities for residents. This would be one of the effective ways to create a low-carbon and sustainable city.

**IV. SUSTAINABLE GREEN SPACE SYSTEM PLANNING COMBINED WITH GEOGRAPHIC INFORMATION SYSTEM (GIS)**

Based on existing research, sustainable green space system planning framework combined with Geographic Information System was proposed. The model as procedures for green space system planning is developed on the basis of the literature and field surveys as follows (Figure 1).

**A. Step 1: Identify the areas for green space system**

The areas for green space system are referred to the existing protected areas and the planned and priority areas for protection. This step needs geography information system (GIS). The majority of the data needed was in a format compatible for import to it. The data that could not be incorporated into GIS required additional processing.

Sub-step 1a: Identify the existing protected areas for green space system: To identify such areas as parks, green lands, rivers, and significant historic and cultural sites which are already protected.

Sub-step 1b: Identify the planned and priority areas for protection: To identify the areas which have not been legally protected yet but critical to the protection and sustainable

development. They may be parks, green lands, rivers, river banks, wetlands, and historic and cultural sites.

**B. Step 2: Overlay the areas identified**

To have a composite map of existing protected areas, planned and priority areas for protection. Through this we could make a map that presents all the identified existing protected areas and planned and priority areas for protection.

**C. Step 3: Create the green space system**

Propose new green space system. In this step, the spatial data acquired in the first step were imported into a vector-based GIS system for analysis. Each output raster was multiplied by the weight values of the corresponding factors and was overlaid using the GIS overlay tool. A green space system suitability map was constructed through the overlay.

**D. Step 4: Vision the framework of a regional green space system network**

To show the picture of the framework of a regional green space system network in the future.

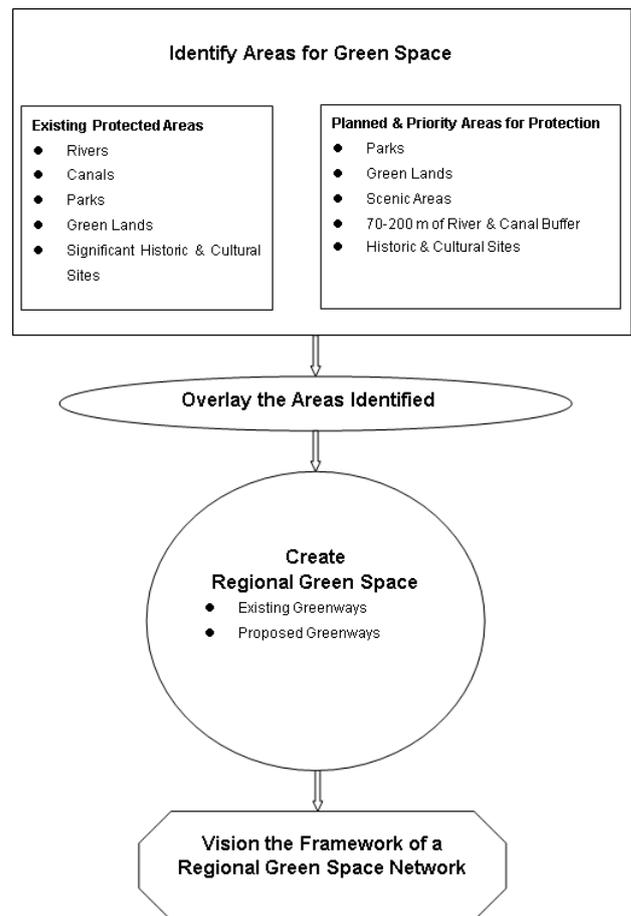


Figure 1. Framework for green space planning with GIS

**V. CONCLUSIONS**

Now urban development two biggest contradictions in urbanization were contradictions between development and environmental protection and contradictions between population growth and land resource constraints. The green

space system not only has functions of protection, productive, and recreational, but also has economic potential. It provides an effective way to solve many urban problems, such as environmental degradation, shortage of land resources, water resources pollution, etc. Green space system planning will effectively construct urban green ecological network, improve urban environment, and motivate urban sustainable development.

Firstly, green space system has ecological functions, which make it an important part of urban ecosystem. A healthy green space system is very important for improving the quality of urban space and the ecological environment; at the same time, many biologists have recognized that green corridors play an important role in the protection of urban biodiversity by; In addition, urban green corridor also have other functions, such as alleviate the urban heat island effect, the change of wind speed and direction, prevent sand, water conservation and increased rainfall, etc.

Secondly, plan and construct sustainable urban green space system with Geographic Information System (GIS) and eco-technology. Conducting a suitability study of green space system planning with Geographic Information System (GIS) in order to provide data base and analysis tools for green space system planning; combining ecological technology, storm water and flood management system and domestic wastewater treatment technology, people use green space system as an ecological treatment facility of managing the urban storm water, flood and urban domestic wastewater to achieve economic environmental benefits; combining urban slow walking system, take green space system as urban low carbon facility as well as leisure and entertainment park facility, such as supplying pedestrian ways, bicycle lanes to realize green walking for residents, reducing the usage of automobiles, energies, lowering the carbon- emission and supplying an environment for outdoor sports and entertainment activities for residents.

Thirdly, green space system planning and construction was an important way to achieve sustainable development. Green space system planning belongs to complicated science which integrates many subjects, the development of green space system planning requires the theoretical guidance of Geographic Information System (GIS), planning, ecology, and geography, and on the other hand it needs ecological technology, storm water management technology, ecological rehabilitation technology, wastewater treatment technology to support. Geographic Information System (GIS) can provide useful suitability analysis. Planning can guide the urban special layout and development, technology can help to construct cities and achieve environment sustainability.

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