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Study on the Spatial Layout of Park Green Space (PGS) in Maonan City for the Concept of Low Carbon

BY

[1]Zhaoliang Wu, [2]Jiaqiang Peng, [3]Zimou Li, [4]Zhe Zhu & [5]*Ruei-Yuan Wang
[1,2,3,4,5]Guangdong University of Petrochem Technology, Sch Sci, Maoming 525000, Peoples R China

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Corresponding author:

Ruei-Yuan Wang

Abstract

In the background of ecological civilization and new concept of low carbon, this study aims to explore the spatial layout of Park Green Space (PGS) and urban area in Maonan District of Maoming City by means of GIS-based spatial analysis method in combination with forest inventory and related theories of PGS. Meanwhile, using the inventory survey method which have 2705 trees were acquired and measure for assessing the carbon sequestration and market value of the forest in the PGS discussing the contribution rate of carbon sequestration of the park vegetation, conducting quantitative analysis and evaluation, and finally comprehensively assess the relationship between the PGS and carbon sequestration as well as urban spatial morphology. According to the results of spatial analysis, the spatial layout of urban PGS system in Maonan District does not meet the national standards, as well as is showing insufficient and imbalance. In the end, according to the existing problems of urban green space construction and the future development of the city, the corresponding countermeasures for urban PGS construction are proposed. It includes improving the spatial layout of urban PGS, improving the low-carbon economic carbon fixation benefits of PGS vegetation, and building a scientific and reasonable urban green space system to address the problems in the process of urban development.

KEYWORDS: Low-Carbon Concept ; Park Green Space (PGS); Inventory ; Spatial Analysis; Carbon Sink.

INTRODUCTION

With the development of industrialization and the expansion of urbanization, the content of greenhouse gases in the atmosphere has increased significantly. Before the industrial revolution, the concentration of carbon dioxide (CO_2) in the atmosphere was maintained at about 280 ppm, which has now exceeded 415 ppm. The content of CO_2 and methane (CH_4) as well as other greenhouse gases emitted into the atmosphere by human beings is increasing. Climate change has indeed intensified significantly, and droughts, floods, typhoons, and other disasters have become more frequent. Even, a series of environmental problems have emerged in the city, posing serious challenges to the development of urban biodiversity, the physical and mental health of urban residents as well as the sustainable development of the city. Therefore, carbon emission reduction has become an urgent issue of global governance (Li, 2021, Wang et al., 2022).

However, the rapid expansion of China's cities has also brought a series of inevitable negative impacts on the environment, such as urban heat island effect, environmental pollution, and damage to urban ecological and environmental systems (Wang, 2007). After realizing that “green waters and exuberant mountains are the precious property as gold and silver", the development of China's cities has entered the transformation stage and started to pay attention to the problems of urban ecological environment, so the concept of sustainability of low-carbon cities has become the effort trend by the people. Urban parks and green spaces can play a vital role in improving the urban environment and local microclimates, as well as improving the quality of residents' living environment. A complete urban PGS system has good ecological, social and economic benefits, which can provide a certain guarantee for the sustainable development of the city. In recent years, the relevant research on vegetation carbon sinks at home and abroad is mainly aimed at the research on afforestation costs, economic benefits, and value of carbon sinks, and in different carbon sink benefit value evaluation methods, summarizing the shortcomings of carbon sink benefit evaluation is the research focus of the global carbon sink monitoring system in the future (Zhang et al., 2013; Su et al., 2015; He et al., 2018).

Low-carbon concept is applied to practical and environmental issues, in addition to improving energy efficiency and developing clean energy, it can also be achieved by restoring natural ecology and increasing plant carbon sequestration. Studies have shown that green parks make good contributions to improving the urban ecological environment and alleviating the pressure on urban carbon emissions. Compared with the green space area in the urban area, the PGS has the advantages of large coverage area and high vegetation aggregation rate and has become a symbol of low-carbon life in the city. Through improving the urban green space system, it can gain a lot of benefits, such as ensure a safe and healthy modern urban living and working environment, increase the ability of the urban PGS system to optimize the urban environment, build a green and beautiful urban landscape, meet the living needs of urban residents, shape the image of a green and livable city and improve urban biodiversity, and also reflect the harmonious unity of the environment, society and human beings (Mo and Wang, 2022).

At this stage, in the face of environmental problems brought about by the rapid development of cities, the construction of a sound urban PGS system is crucial to the ecological environment, social and economic development of cities. With the in-depth study of urban PGS system, it can be proved that the reasonable layout of PGS can effectively alleviate the damage of urban ecological environment and improve the development of urban green space system, thus the concept of introducing the green space system of urban park into low-carbon has formed an important environmental focus. Based on this, improving the green space system of urban parks is an important prerequisite for improving the urban social-ecological environment, alleviating the pressure of urban greenhouse gas emissions, and further improving the urban ecological environment.

Based on the above concepts, this study adopts the methods of inventory survey and GIS spatial analysis to conduct sampling survey on the PGS in Maonan District, Maoming City, Guangdong Province. First of all, we selected two parks to measure the trees in order to calculate the carbon sequestration and economic value of the PGS in this area. Then, combined with the spatial analysis method, it comprehensively estimates the spatial patterns covered by its benefits, so as to understand the role of urban PGS in enhancing the carbon sink function of Maonan urban area. Meanwhile, further to realize how it plays an important role in improving the quality of the ecological environment and enhancing the vitality of urban residents.

LITERATURE REVIEW

Low-Carbon Concept, Carbon Peaking, and Carbon Neutralization

With the dual test of urbanization and rapid climate change, urban carbon emissions issue continue to increase, thus urban parks and green spaces are an important green infrastructure which occupy an critical role in terrestrial ecosystems (Conine et al.,2004; Brack, 2002). Studies show that urban PGS plays a unique role in carbon sink capacity, has ecological effects such as regulating local urban temperature, improving urban microclimate, increasing humidity, and providing residents and tourists with viewing landscapes and resting places, and can also increase urban economic effects (Zhu, 2016).

As an important link and reservoir in the carbon cycle of urban ecosystems, urban vegetation can directly or indirectly reduce the content of greenhouse gases in the atmosphere. The direct way is the carbon fixed by vegetation due to its own photosynthesis, and the indirect way is to offset the greenhouse gases emitted from fossil fuel use by urban's vegetation, mainly reducing building energy consumption, guiding green transportation, and alleviating the urban heat island effect (Churkina et al.,2010; Zhao and Liu, 2010). In the current research on urban carbon sinks in China, one of the common methods is based on the estimation of vegetation biomass dry weight, the vegetation and its net carbon storage of urban PGS which has confirmed, and it is found that the evaluation on annual biomass and net carbon storage of urban PGSs have become more and more significantly for realizing the carbon condition (Wang et al., 2010).

With the intervention of the low-carbon concept, the allocation of the urban green space system in China is facing severe challenges. Nowadays, the construction of ecological landscape with low-carbon emissions is the main direction of urban PGS system, and it is also an important means to achieve sustainable urban development for meeting the “dual carbon (carbon peaking and carbon neutralization)” policy (Mo and Wang, 2022). According to the theory of ecosystem material cycle, if cities want to achieve carbon neutrality, they must control carbon emissions, and at the same time, increase urban carbon sinks, such as increasing the area of urban green space and vegetation planting area (Weng, 2012). At the level of planning and design, PGS needs to have a reasonable space allocation, and at the same time, it is necessary to increase the green area and amount of greening, so as to reduce carbon emissions and increase carbon sinks from an ecological perspective.

The Carbon Sink

Carbon sink or carbon storage generally refers to plants absorbing CO_2 from the atmosphere and converts it into carbon fixed in vegetation or soil, thereby reducing the concentration of CO_2 in the atmosphere (Tian, 2010; Hu et al., 2015; Li et al., 2015). In 1997, the Kyoto Protocol referred to the term "carbon sink" for the first time, requiring developed country parties to propose emission reduction targets and measures to support the increase of carbon sink through "afforestation, reforestation, and sustainable forest management". The Kyoto Protocol, which is trying to curb global warming, has established three flexible cooperation mechanisms aimed at reducing greenhouse gases such as International Emissions Trading (ET), Joint Implementation (JI), and Clean Development Mechanism (CDM) (Zhang and Liu, 2009; Li et al., 2009). In 2001, the sixth resumed session of the Conference of the Parties and the seventh resumed session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCC) adopted the Bonn Political Agreement and the Marrakech Agreement respectively, proposing the impact of Land, Land-use Change and Forestry (LULUCF) activities on climate change, allowing developed countries to offset part of the CO_2 emissions from industrial activities through afforestation and reforestation. In 2013, the Warsaw Climate Conference, by adopting REDD+ action, made it clear that it could provide an incentive mechanism for developing countries to take REDD+ action, including five specific actions to reduce deforestation emissions, reduce forest degradation emissions, protect forest carbon stocks, sustainable forest management, and increase forest carbon stocks. In 2015, the Paris Agreement reached at the Paris Climate Conference set up separate forest-related provisions (Wang et al., 2022).

Forestry carbon sinks (storage) are one of the most common and effective forms of carbon sequestration (Zhou, 2003). It usually refers to the process, activities, and mechanisms of absorbing CO_2 and reducing the concentration of greenhouse gases in the atmosphere through afforestation and other measures. Carbon sequestration forms of forest carbon sinks mainly include carbon sequestration by trees, undergrowth plants, and humus, as well as forest products (Mo and Wang, 2022; Wang et al., 2022). The increase of forestry carbon sink is mainly realized through afforestation, reforestation, and forest management. It is precisely because of the special function of forests in adapting to and responding to climate change that the change of forest resources has aroused unprecedented global attention. Because of this, indirect emission reduction through forests has become a common practice of the international community. Therefore, global forest planting and forestry management have the value of improving global warming issues. Based on the above background, it can be seen that the carbon sink of urban PGS can not only effectively neutralize the CO_2 in the air, but also reduce air pollution. Meanwhile, due to its low cost and ability to beautify the environment, it has brought a variety of benefits to the economy and society (Zhou et al., 2013: Cao, 2012). Therefore, the development of carbon sinks in urban parks and green spaces is of dual significance for domestic cities to develop low-carbon economy and fulfill international legal responsibilities for greenhouse gas emission reduction (Liu and Liu, 2011). Compared with controlling urban carbon emissions, increasing carbon sequestration efficiency is an effective measure with low cost and high income, so it is necessary to make full use of urban parks and green space systems to achieve carbon sequestration and increase sinks.

STUDY AREA AND METHODS

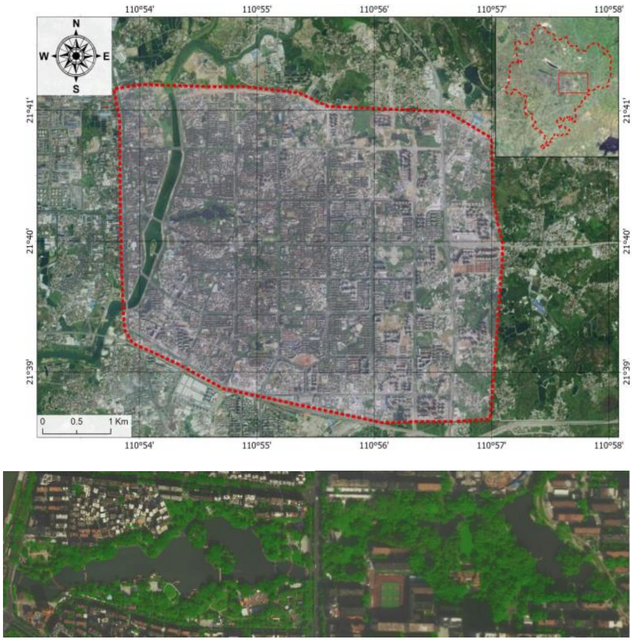
Site Description

The study area is Maonan District, Maoming City, Guangdong Province, which is the political, economic, and cultural center of this area, located between 110°44'-110°58'E and 21°32'-21°49'N, with a total area of 487 square kilometers and a total forest land area of 9675 hectares. The main study area consists of Guandu Street, Zhanqian Street, Hedong Street, and Giejiao Town, Bordering Giethoorn Town in the east, Maoming Railway Station in the south, Xinpo Town in the north, and Xiaodongjiang River in the west, with a total area of 29.3 square kilometers and a population size of 440,000. Maonan District is a planned emerging urban area, so the roads in this area are interwoven horizontally and vertically, showing a grid distribution of tofu blocks. (Show as Figure1)

Through the analysis of the current situation of the green space in Maonan District, according to the greening rate, vegetation growth, and landscape layout of each park, Xinhu Park and Chunyuan Park which have developed more maturely were selected for on-site investigation.

Sample area 1: Xinhu Park, located on Renmin North Road, the sample area covers an area of 22.26 hectares, of which the water area is 10.13 hectares, the green area accounts for more than 95% of the land area, the plant growth is luxuriant, and the tree species are mainly evergreen broad-leaved trees.

Sample area 2: Chunyuan Park, located on Chunyuan 1st Street, Renmin Middle Road, covers an area of 6.65 hectares, of which the water area is 1.93 hectares, and the vegetation density is larger than that of Xinhu Park, but the proportion of coniferous forest is slightly higher than that of Xinhu Park, accounting for about 17% of the number of trees.



Sample area 1-Xinhu Park Sample area 2-Chunyuan Park

Figure 1 Maoming district bitmap (data source: Baidu Map)

By the end of 2021, according to China's current "Classification Standard for Urban Green Space-CJJ/T85-2017" (Beijing Beilin Landscape Planning and Design Institute Co., Ltd.), there are 9 most important PGSs in Maonan urban area, with a total area of 80.02 hectares, and the per capita PGSs area in Maonan urban area is 1.9 square meters. However, which does not meet the standard of no less than 8.00 square meters/person in the "National Garden City Series Standards" and "Urban Land Classification and Planning and Construction Land Standards", meanwhile according to the data statistics of 2019, the per capita PGS in the country is 14.36 square meters (China Urban Construction Statistical Yearbook 2019), so it shows that the level of the current situation of PGS in Maonan urban area is still far from the national average. The distribution and area of PGS in Maonan urban area are detailed in Table 1, the land use map of Maonan District of Maoming City is obtained through Baidu map, and the location of the PGS in the study area is extracted using ArcGIS software (show as figure 2).

Table 1 The PGS of Maonan District

Name	Location	Category	Area（hm^2）
Xinhu Park	Renmin North Road	Comprehensive park	22.89
Chunyuan Park	People's Middle Road	Comprehensive park	6.65
Cultural Square	Oil City 8th Road	Square land	15.59
Renming Square	Guanghua South Road	Square land	11.62
Guandu Park	Guandu 5th Road	Comprehensive park	10.81
Nanxiang Park	Xiyue South Road	Comprehensive park	5.21
Jiangbin Park	Binhe South Road	Comprehensive park	2.45
Central square	Guanghua North Road	Square land	2.09
Qiaobei Park	Koto Garden East	Community Park	2.71
Total			80.02

Figure 2 Spatial distribution maps of PGS in Maonan District

Methods

In this study, a framework for analysis of the relations between carbon sink and the spatial pattern in the Maoming area was proposed. In terms of carbon sink evaluation, this study adopts the inventory method to survey trees in the park and incorporation with ArcGIS software to calculate the sample parks' distributions pattern of spatial. Then, the market value with the relation to the spatial was comprehensive analysis (shown as Figure 3).

GIS Spatial Analysis

Using the ArcGIS software, the spatial kernel density analysis (KDA) and network analysis were carried out on Maonan urban area of Maoming City for finding out the spatial pattern and service coverage existing in the current situation of PGS allocation in Maonan urban area, and inspecting the existing problems to make suggestions (Nicholls, 2001).

Trees Inventory

Through the distribution, development history, greening rate, and vegetation growth of local parks, two representative parks were identified for on-site investigation. The height, breast diameter, and growth of trees in the PGS were investigated on the spot, and the carbon sink of trees was calculated by related formula. During the survey, the data is classified according to the different varieties of trees, and because the amount of carbon sequestered by different tree varieties is different, it is necessary to classify and sort. According to the data measured by the on-site survey (Xu, 2014), it is calculated for evaluating carbon sinks and market value, and then it can refer to the results and conditions, as well as use a variety of methods to reasonably analyze and evaluate the Maonan City Park in Maoming City.

In the end, the results of the spatial analysis conducted by ArcGIS software are combined with the data of tree carbon sink and market value from the field survey of the park sample area to conduct a comprehensive evaluation, and the problems presented are discussed and considered.

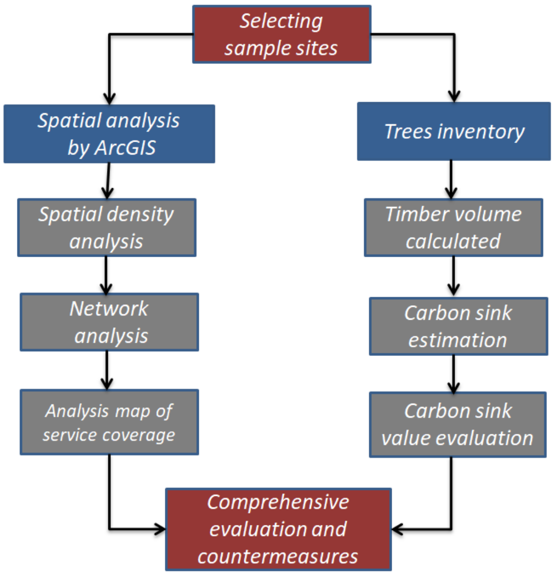


Figure3 The Framework of Analysis Methods

ANALYSIS AND RESULTS

Spatial Kernel Density Analysis

As a vital part of the green space system in the urban environment, PGS is also an important indicator to show the level of urban social-ecological environment and the quality of life of urban residents (Lian, 2010). According to the first law of geography proposed by Waldo R. Tobler in 1970, "Everything is related to everything else, but near things are more related to each other". Thus, the spatial distribution of PGS is an important indicator to measure the level of urban development and an important basis for judging the degree of harmony between urban people and land (Zhang et al., 2020). The spatial layout of urban PGS is a specific and quantifiable index, which can evaluate the service capacity of urban PGS to its surrounding residents and provide a theoretical reference for the layout planning of urban PGS.

Kernel density analysis (KDA) is a relatively wide range of spatial syntactic result processing methods, which can improve the quality of visualization and clearly identify the evolution trend of density according to the obtained results (Cai et al., 2012). In the beginning, this study based on the ArcGIS software, the use of satellite images, land use maps of Maoming City, and fishing net tools combined to capture the residents in Maonan District, the results are shown in Figure 4, it can be seen that the residents are decreasing from the central to the surrounding suburbs.

Figure 4 Map of residents' distribution in Maonan District

Secondly, according to the captured research area, kernel density analysis (KDA) was used to simulate the spatial distribution of population density in Maonan urban area, and the results are shown in Figure 5. At the same time, the kernel density analysis of the spatial distribution of PGS in Maonan urban area is carried out, and the results are shown in Figure 6.

From the density map of residential areas in Maonan urban area, it can be seen that the overall distribution characteristics of residential in Maonan urban area are as flowing: the central part is more dense, followed by the southwest and south, and the eastern and northern areas close to the suburbs are sparse. From Figure 6 the density map of Maonan's urban PGS, it can be seen that the green space of Maonan urban park forms the characteristics of "two veins and one point", along the two longitudinal trunk roads of Renmin Road and Xiyue Road, forming an ecological corridor, and large areas such as the central longitudinal, eastern longitudinal, southwest and northwest are in low-value areas.

Through analysis, it is obviously found that the current structure of the PGS system in the Maonan urban area is insufficient. There is no corresponding allocation of PGS in the central longitudinal populated area. There are vacancies in the newly developed areas in the northwest, southwest, and east, and the overall spatial pattern has not yet reached the ideal structure.

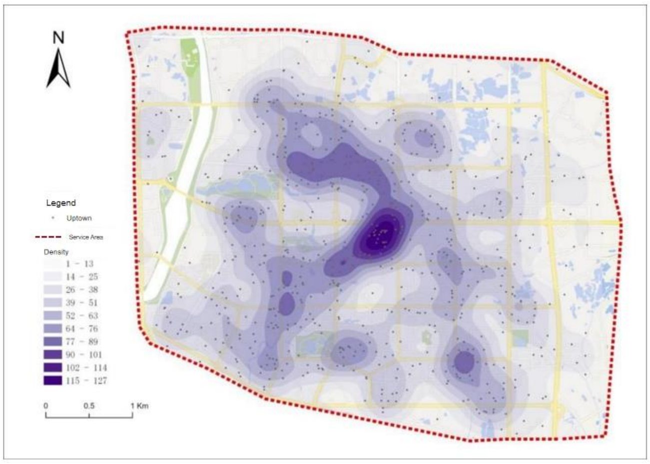


Figure 5 Density maps of residential areas in Maonan District

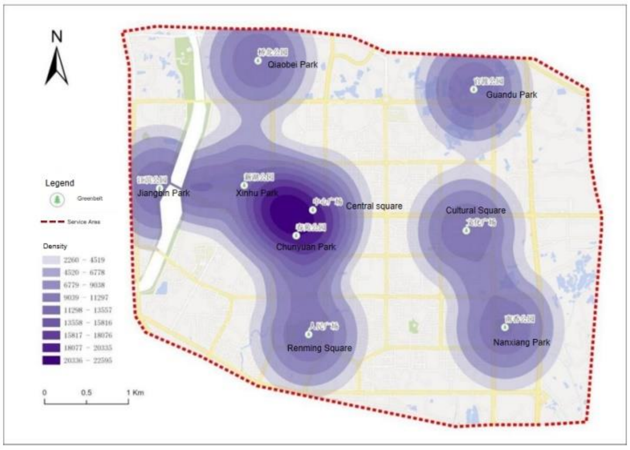


Figure 6 Map of green space density in Maonan urban park

Network Analysis for Service Radius Coverage of PGS

The service radius reflects the recreation service capacity of urban parks and green spaces (Neuvonen et al., 2007), and it is generally recognized that the area within the service radius meets the demand, and vice versa, it is a service blind area that does not meet the demand. The service radius of urban PGS is the basic parameter for evaluating urban PGS (Wang and Shi, 2015).

According to the provisions of the "National Garden City Series Standards" and the service radius of PGS in Maonan urban area is analyzed. The rules such as the service radius coverage of urban PGS should meet the requirements of "the service radius of PGS covering an area of more than 5,000 square meters (inclusive) is 500 meters, and the assessment service radius of PGS covering an area of more than 20,000 square meters (inclusive) is 1,000 meters". Based on above rules, due to the residential land area in this area is 29.3 hectares, the service radius of Maonan urban area is analyzed by network analysis, starting from the spatial location of the park, through the distance cost, thus taking the park 500/800/1000 meters as the service radius, so the service coverage area map of each radius of the park is obtained (shown as Figure7), and the specific coverage area is shown below as Table 2.

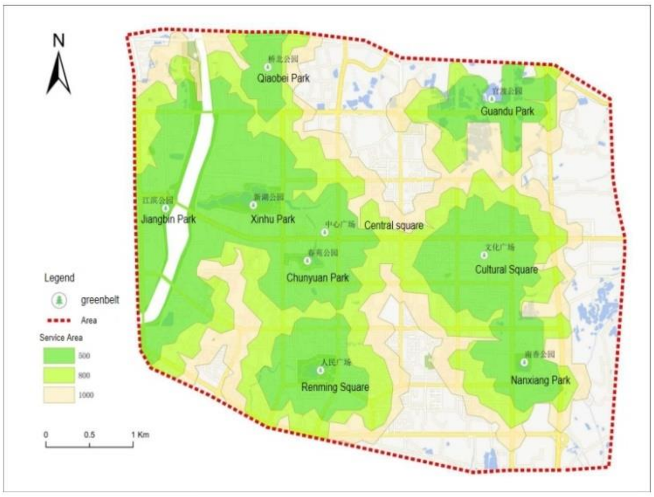


Figure 7 Service coverage maps of PGS

Table 2 The park covers area with a service radius of 500/800/1000 meters

Total area/ hm^2	0-500 area covered / hm^2	500-800 area covered / hm^2	800-1000 area covered / hm^2	>1000 area covered / hm^2
2930	882.03	486.06	388.53	1173.38

According to the “National Garden City Series Standards,” they are not only important indicators for evaluating the accessibility (and service area) of urban PGSs, but also binding indicators for evaluating urban ecological environment. This study, by calculating that the service radius of PGS in Maonan City accounts for 60% of Maonan urban area, this indicator requires that the service radius of urban PGS accounts for 80% ≥of the urban built-up area. The results show that it is obvious the service radius of PGS in Maonan City does not meet the requirements of the "National Garden City Series Standards" and there is a certain gap between meeting the standard.

Spatial Analysis and discussion

Through the analysis on the spatial layout of PGS in Maonan urban area by GIS software, it is found that the number of PGSs in Maonan urban area is lacking as a whole, and the PGS rate is seriously lower than the national standard. The specific questions are as follows:

(1) The number of PGSs in Maonan urban area is insufficient
According to the results of the spatial analysis and investigation, the per capita PGS and the service radius coverage in Maonan urban area fail to meet the requirements of urban residents' lives, thus will be greatly affected in giving full play to the positive benefits of urban PGS to improve the living environment of urban residents.

(2) The urban greening structure is unbalanced
Inspecting the spatial distribution pattern of PGS in Maonan urban area, the overall plan of the urban PGS system is only "two veins and one point", relying on the two longitudinal arterial roads of Renmin Road and Xiyue Road to form an ecological green space corridor in the city. Based on the survey and spatial analysis results, the current structure of the PGS in Maonan City is not strong in systematization, and the spatial layout lacks balance and rationality. Meanwhile, due to the planning of Maoming urban construction and the needs of urban development, the old town of Hexi Area has less green space and without re-planned. Therefore, the overall structure of the PGS system in Maonan urban area is imperfect and systematic, which is not conducive to the daily production activities of urban residents.

(3) The green rate of some PGSs is insufficient
During the survey, it was found that except for Xinhu Park and Chunyuan Park, the grassland in the rest of the park squares is relatively large, and the green shade coverage is low. Foreign studies have shown that by increasing the shade area, local temperature and heat can be more effectively alleviated (Guo, 2010), thereby promoting the absorption of CO_2 by vegetation and soil (David and Daniel, 2002)

Inventory Data Processing and Analysis
The on-site survey time is from January 15, 2022, to February 10, 2022, at first the trees in the selected plots are classified, the main categories are broad-leaved, fine-leaved, lanceolate, and coniferous forest. The outdoor measuring instrument is used to measure and record the height, number and observing its growth status of each tree, and using laser rangefinder to measure the diameter at breast height (DBH) of trees at the height of 1 m-1.3 m in the two sample plots

Through the survey and measurement on Xinhu Park and Chunyuan Park, various types of plants were obtained. In the end, the total number 2705 trees were acquired and measured. Meanwhile, this study collecting analysis data sets as parameters which include trees numbers, average tree height, the average breast diameter, proportion of broad-leaved trees, and proportion of conifers (show as Table3)..

Table 3 Trees data of field survey

Sample site	Trees	Average tree he ight/m	Average breast diameter/m	Proportion of broad-leaved trees	proportion of conifer s
Xinhu Park	1932	11.93	0.33	90.9%	9.1%
Chunyuan Park	773	19.29	0.36	83.7%	16.3%

Timber Volume Calculation
The estimation of the volume of a single timber is calculated by the shape number method, which is multiplied by the average shape number of DBH and tree height. The formula (1) for calculating the DBH and breast height sectional area of each tree is as follows (Wang et al., 2022):

$BA=(DBH/200)^2\times\pi=(DBH/100)^2\times(\pi/4)$ ....(1)
BA—Breast height sectional area of trees (m^2);
DBH—Diameter at breast height (cm);
π—Garden perimeter(3.14159)

The timber volume calculation is based on the general tree species volume formula (2) by the "Standing Timber Accumulation Table for Forest Products Disposal Survey of the Taiwan Forest Bureau"(Wang et al., 2022).

$V=BA\times H\times f=(DBH/100)^2\times 0.7853\times H\times 0.45$...(2)
V—Timber volume per plant (m^3);
BA—Breast height sectional area of trees (m^2);
DBH—Diameter at breast height (cm);
H— Tree height (m);
f— Average number of constant (0.45).

The total timber volume of the whole tree is the sum of the single timber volume (ΣV). Calculating all data by the above formula, the average single timber volume and sum of single timber volumes in the sample plot is obtained, shown as Table 4.

Table 4 Calculation result of single timber volume of plot

Region	Average single timber volume/m^3	sum of single timber volumes/m^3
Xinhu Park	0.47	899.54

Chunyuan Park	0.62	485.53

Assessment Model of Carbon Sequestration

Generally, the method for estimating the carbon sequestration stock per ha of forest trees is based on the trial principle method for estimating CO_2 and carbon sequestration in the forestry sector proposed by the Intergovernmental Panel on Climate Change (IPCC) of United Nations. In which the forest timber volume is converted from the average proportion of trees to forest biomass, and the carbon sequestration stock is estimated by using the conversion coefficient of forest biomass and carbon content. The estimation of CO_2 absorption conversion model can usually be applied to the calculation of CO_2 absorption per hectare after ground survey to obtain the timber volume, which is based on the change of forest growth and storage to estimate CO_2 uptake, and the formula is as follows (Wang et al., 2022):

$C_{plant}=W_E \times C_{con} \times (CO_2/C)$ (3)

$W_E=V_{Stem/ha} \times V_{whole/stem} \times W_0/V_g$ (4)

C_{plant}— CO_2 uptake per ha of trees;
W_E— Biomass;
$V_{Stem/ha}$—Timber volume of per ha;
$V_{whole/stem}$— conversion coefficient of whole plant volume and dry wood volume;
W_0/V_g— conversion coefficient of weight and volume;
C_{con}—conversion coefficient of carbon;
CO_2/C—conversion coefficient of CO_2 and carbon

Among them, the conversion coefficient of the whole plant volume and dry wood volume is generally about 1.3-2.0 times (including stem, branch, root, and leaf), and the average application value is 1.65. The conversion coefficient of weight and volume is 0.49 for pure artificial broad-leaved trees, natural broad-leaved mixed forests, and artificial broad-leaved mixed forests, 0.44 for artificial conifer afforestation, Taiwan cedar afforestation, and willow fir afforestation, as well as for worker conifer mixed forests, 0.46 for artificial coniferous and broad-leaved trees. The carbon conversion coefficient is generally calculated by 0.5. The conversion coefficient between CO_2 and carbon is calculated to be 44/12=3.67 using the molecular weight CO_2=44 and carbon molecular weight C=12.

Since there is a 10.13 ha and 1.93 ha lake in Xinhu Park and Chunyuan Park respectively, and the rest of the area is basically covered by vegetation in the image, the area of the lake is removed in the calculation, and Table 5 is obtained by calculating the CO_2 absorption formula

Table 5 Calculation results of CO_2 and carbon for the parks

Sample site	Green area/hm^2	Timber volume per hectare/m^3	Carbon sink per hectare/t	Carbon sink/t
Xinhu Park	12.76	70.50	104.60	1334.70
Chunyuan Park	4.72	102.87	152.62	720.37

Carbon Sink Value Evaluation

Carbon Tax Law

Carbon tax law is a method widely used to calculate the value standard of carbon sequestration function in ecosystems. According to the carbon tax law, this study adopts the Swedish carbon tax rate R=150USD/ton, taking the exchange rate between RMB and the US dollar of 6.7 yuan/USD (Base date: MAY/2022), that is, 1005 yuan/ton, the specific calculation formula is:

$V_1=C \times P_1$ (5)

V_1 - Economic benefits of carbon sequestration (yuan);
C —Carbon sequestration of trees in the park (t);
P_1— Carbon tax price (1005 yuan/t).

Afforestation Cost Method

Afforestation cost method is using trees as a means for sequestration and storage carbon from the air, by converting the cost of carbon sequestration in the same amount of forest land into the value of other equivalent carbon sequestration methods, its carbon sequestration benefits can be calculated at the same cost according to the cost of planting forests. According to the statistics of the Ministry of Forestry of China, the average afforestation cost in 1990 was 260.9 yuan, using the discount rate formula, the amount is equivalent to the current 739.31 yuan. The specific calculation formula is as follows:

$V_2=C \times P_2$ (6)

V_2—Economic benefits of carbon sequestration (yuan);
C—Carbon sequestration of trees in the park (t);
P_2—The unit price of carbon sink (739.31 yuan/t).

Market Value Method

This study uses the average price of carbon trading market on Shanghai Environmental Energy Exchange from July to December 2021 as the market value standard, and the average market price during this period is 40.01 yuan/ton. The specific calculation formula is as follows:

$V_3=C \times P_3$ (7)

V_3— Economic benefits of carbon sequestration (yuan);
C—Carbon sequestration of trees in the park (t);
P_3 —The unit price of carbon sink (40.01 yuan/t).

Estimating the Economic Value of Carbon Sinks

According to the carbon sink data of vegetation in Xinhu Park and Chunyuan Park is calculated by research. The three methods of carbon sink value estimation described above (Formula 5 ~ Formula 7) were used to calculate the economic value of carbon sequestration which obtained from the sample site, and the results are shown as Table 6.

Table 6 Estimating the economic value of carbon sinks for sample sites

Sample site	Area/hm^2	Carbon sink/t	Economic value of carbon sink /10,000 yuan				Average unit area value /10,000 yuan
			Carbon tax	Afforest-ation cost	Market value	Average	
Xinhu Park	22.89	1334.70	134.14	98.68	5.71	79.51	3.47
Chunyuan Park	6.65	720.37	73.40	53.26	3.08	43.25	6.50
Total	29.54	2054.07	207.54	151.94	8.79	122.76	4.99

It can be seen from Table 6 that the economic value of aborting carbon sinks measured in Xinhu Park and Chunyuan Park total ranges from 8.79~207.54 ten-thousand yuan, and the average total economic value of carbon sinks is about 122.76 ten-thousand yuan. If according to the market value method, the total value of carbon sequestration of the two sites is **87,900 yuan**, which is the lowest economic value of carbon sinks obtained among the three estimation methods. If according to the Swedish carbon tax, the unit price is 1005 yuan/t, and the total value of carbon sequestration in the two plots is **2.0754 million yuan**, which is the highest economic value of carbon sinks obtained among the three carbons sink estimation methods. If according to the afforestation cost method that carbon sinks unit price is 739.31 yuan/t, the total economic benefit of carbon sequestration of the two sites is calculated to be **1.5194 million yuan**. While combined with the three estimation methods of carbon sequestration value, the average value of carbon sequestration of the two sites is **1.2276 million yuan**, and the average economic value of carbon sequestration is about 50,000 yuan per hectare.

Due to the differences and pros and cons of the carbon sink value estimation method used, and the different tree species, area, and vegetation density inside the sample plot, the measured economic benefits will be biased. Therefore, this study uses three different valuation methods to compare and analyze, and calculate the average value to determine the estimated value range.

CONCLUSION

Through spatial analysis and investigation, this study found that the number and spatial layout of the overall planning of PGS in Maonan District are insufficient and unbalanced. In addition, through the ground survey of the trees in the green spaces of the two parks, and the calculation of their volume, carbon sequestration benefits, and market value, it can be used as a reference for an in-depth understanding of the future planning of the city under the low carbon concept. In general, through the analysis of this study, the corresponding problems and parameters are obtained, and the following suggestions are proposed.

(1) The construction of PGS and urban development is needed synchronized

The goal of system planning on urban PGS is to protect urban biodiversity, meet the living needs of urban residents, improve the urban environment, and meet the requirements of health and safety protection, disaster prevention, and urban landscape (He, 2021). Thus, it is needed that based on the current situation of the PGS system in Maonan urban area, combined with the actual situation of Maonan urban area, to create an urban PGS system that is compatible with urban development, according to local conditions and in line with the requirements of urban development, a variety of types of PGS are established, providing an important space carrier for the people's pursuit of a better life in the era of ecological civilization construction, and creating a new type of urban green space with comprehensive functions and unique charm, and harmonious coexistence between man and nature (Wang, 2021).

(2) Increase the construction of urban PGS

The overall number of PGSs in Maonan urban area is small, and it is necessary to strengthen the construction of urban PGS on the basis of the existing PGS system, improving the PGS system in Maonan District, improving the service radius coverage of urban PGS, urban greening rate and urban per capita park rate ground area, improving the quality of existing PGS. Meanwhile, on the basis of the urban PGS rate up to standard, realize the rationality and balance of the layout of the whole PGS, so that the social and ecological environment of Maonan urban area can achieve sustainable development.

(3) Carbon sink increase strategy for low-carbon economy of PGS vegetation

While improving the living environment and climate environment of the surrounding residents, the PGS system also brings comprehensive benefits such as reducing CO_2 content, releasing oxygen, cooling, and dust reduction to the surrounding air. In the requirements for the distribution and construction of vegetation in the park, the combination of arbor shrub and grass should be reasonably matched, which can not only enrich the spatial structure of the park but also effectively improve the carbon sink efficiency of the PGS. To achieve the development of urban low-carbon economy, it is necessary for government departments to improve the construction of PGS and the planting of green trees, vigorously promote the cognition and action standards of low-carbon life, and deepen various measures for carbon reduction and sequestration as well as vigorously support and import high-tech industries with low carbon economy. Meanwhile, it is also necessary to establish long-term carbon monitoring and research mechanisms such as remote sensing and ground survey mechanisms, to obtain practical observation data as the basis for carbon increase, decrease, and improvement measures.

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